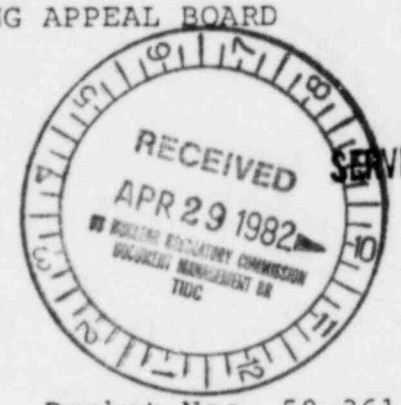
UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING APPEAL BOARD

Administrative Judges:

Stephen F. Eilperin, Chairman
Dr. W. Reed Johnson
Dr. Reginald L. Gotchy



SERVED APR 27 1982

In the Matter of	
SOUTHERN CALIFORNIA EDISON COMPANY ET AL.	Docket Nos. 50-361 OL 50-362 OL
(San Onofre Nuclear Generating Station, Units 2 and 3)	

Messrs. David R. Pigott, Edward B. Rogin, Samuel B. Casey and John A. Mendex, San Francisco, California, Charles R. Kocher and James A. Beoletto, Rosemead, California, for the applicants.

Mr. Richard J. Wharton, San Diego, California, for the Intervenors, Carstens, et al.

Ms. Phyllis M. Gallagher, Anaheim, California, and Charles E. McClug, Jr., Laguna Hills, California, for the Intervenors, GUARD and Carstens, et al., on the low-power operating license motion.

Messrs. Lawrence J. Chandler and Benjamin H. Vogler for the Nuclear Regulatory Commission staff.

DECISION

April 26, 1982

(ALAB-673)

Intervenors Carstens et al., seek a stay pending their appeal of the Licensing Board's January 11, 1982 partial initial decision which authorized the issuance of a

low-power operating license for the San Onofre Nuclear Generating Station, Unit 2 (San Onofre). See LBP-82-3, 15 NRC __ (1982). The stay motion focuses on the ability of crucial power plant safety systems to withstand the most severe earthquake that might affect the plant during its operating lifetime, what NRC regulations term the "safe shutdown earthquake." 10 CFR Part 100, Appendix A, §III(c); Pacific Gas and Electric Co. (Diablo Canyon Nuclear Power Plant, Units 1 & 2), ALAB-644, 13 NRC 903, 913 (1981).[1/]

Intervenors argue that the Licensing Board erroneously foreclosed them from presenting evidence that the Cristianitos fault, located about one-half mile from San Onofre was "capable" -- i.e., susceptible of generating

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1/ Unit 1 was licensed to operate in 1967. Its seismic design is currently being upgraded , generally to that found acceptable by the Licensing Board here. See Southern California Edison Co. (San Onofre Nuclear Generating Station, Unit 1), DD-81-19, 14 NRC 1041, 1043 (1981).

earthquake activity, and hence posed a threat to the plant.[2/] Intervenors also argue that the Licensing Board erred by treating as segmented the principal geologic feature in the proceeding (the Offshore Zone of Deformation, or OZD), with the asserted result that the Board underestimated the magnitude and peak ground acceleration (PGA) of the earthquake the plant must be designed to resist.[3/] Intervenors allude to a number of other claimed factual

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2/ 10 CFR Part 100, Appendix A, §III(g) defines a capable fault as a fault that has exhibited one or more of the following characteristics:

> (1) Movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years.
>
> (2) Macro-seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault.
>
> (3) A structural relationship to a capable fault according to characteristics (1) or (2) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

3/ The acceleration associated with an earthquake is expressed in terms of a percentage of "g" (one g represents the gravitational acceleration of a free falling body). "Magnitude" refers to the size of an earthquake measured instrumentally.

errors that they allege wrongly diminish the designed-against safe shutdown earthquake.

In passing upon intervenors' stay request we apply 10 CFR 2.788(e), which codifies the criteria long ago established by the Court of Appeals for the District of Columbia Circuit in Virginia Petroleum Jobbers Ass'n v. Federal Power Commission, 259 F.2d 921, 925 (1958). See also Public Service Co. of Indiana (Marble Hill Nuclear Generating Station, Units 1 and 2), ALAB-437, 6 NRC 630 (1977); Northern Indiana Public Service Co. (Bailly Generating Station, Nuclear 1), ALAB-192, 7 AEC 420 (1974). The rule calls upon us to consider:

> (1) Whether the moving party has made a strong showing that it is likely to prevail on the merits;
>
> (2) Whether the party will be irreparably injured unless a stay is granted;
>
> (3) Whether the granting of a stay would harm other parties; and
>
> (4) Where the public interest lies.

As we discuss more fully below, intervenors have failed to make a strong showing that the Licensing Board erred in its conclusion as to the adequacy of San Onofre's earthquake design. On the other hand, we entertain serious doubt that

the Board was correct (at least on the theory it propounded) in foreclosing intervenors from fully pursuing the earthquake potential of the Cristianitos fault. This apparent legal error, however, is not of major consequence. There is substantial evidence already in the record to the effect that the Cristianitos fault is not capable, and intervenors were able to put on virtually their entire case with regard to the issue. The practical effect of the Board's ruling was to foreclose intervenors from cross-examining two witnesses on a subject that had not been pursued by intervenors to any purpose with other witnesses. This does not strike us as prejudicial error, especially in the absence of an offer of proof as to what of consequence could have been achieved. In view of this and the substantial body of evidence relied upon by the Licensing Board in support of its conclusion as to the appropriateness of San Onofre's earthquake design, we think the Board's apparently mistaken foreclosure ruling was harmless, and that there is no serious threat of irreparable injury in allowing the power plant to start up during the pendency of this appeal. Absent a serious safety concern, the public interest also

favors this result.[4/] We therefore deny the stay motion.

I. Background

We draw upon the Licensing Board's partial initial decision to set forth the background (15 NRC at __ (slip opinion at 4-5, 2-4):

> Nuclear power plants must be designed to protect the public from the dangers of radioactive releases that might otherwise be caused by an earthquake .... The linchpin for the regulatory scheme is the "safe shutdown earthquake," or "SSE." The purpose of the SSE determination is "to estimate the magnitude of the strongest earthquake that might affect the site of a nuclear power plant during its operating lifetime." The SSE is defined as "that earthquake which produces the maximum vibratory ground motion for which [critical plant safety systems] are designed to remain functional." [10 CFR Part 100] App. A, §III(c).

4/ It is also apparent that the applicant will be harmed to some extent if a stay issues and the plant is forced to remain down. Applicant will incur added costs for alternative fuel, construction financing, and keeping the plant in a standby condition. See Affidavit of Robert Dietch in Opposition to Intervenors' Application for a Stay of Low Power License (filed February 8, 1982) at 4-6. Thus the third factor -- harm to other parties -- also points to denial of a stay.

Large earthquakes only occur on pre-existing active faults. Therefore a particular active fault capable of producing an earthquake, which would in turn generate the strongest ground motion at the site -- sometimes called the "controlling geologic feature" -- must be selected. Taking into account historic earthquake data, the distinctive geology of the area, prevailing stresses in the earth's crust, and other factors, seismologists make expert judgments about [the] maximum magnitude earthquake -- i.e, the "safe shutdown earthquake" -- that could occur on that feature.

* * * *

[T]he San Onofre facilities are located on an 800 acre site within the United States Marine Corps Base, Camp Pendleton, California. The site fronts on the Pacific Ocean and is about five miles down the coast southeast from San Clemente, California.

Levels of seismic activity vary significantly in different parts of Southern California. The areas of highest seismicity are on and near the San Andreas and San Jacinto fault systems, the present boundary between the Pacific and North American plates. Seismic activity generally decreases westward away from the plate boundary. The nearest approach of these plate boundary fault systems to San Onofre is about forty-five miles. The coastal region around San Onofre has experienced relatively moderate seismic activity during the past two centuries for which historic records of earthquakes exist.

There are a number of offshore faults in the coastal waters off Southern California, some of which are active. Of greatest concern to San Onofre is an offshore structure beginning with the Newport-Inglewood Zone of Deformation near Long Beach, passing the facility about eight kilometers offshore as the South Coast Offshore Zone of Deformation, and extending south to the San Diego area as the Rose Canyon Fault Zone. This entire structure, extending from near the Santa Monica Mountains to San Diego, is known as the Offshore Zone of Deformation or "OZD." As will be seen, one of the disputed issues in this proceeding is whether the OZD is a single, throughgoing fault,

> or whether it is comprised of separate segments of faults or "zones of deformation."
>
> About one-half mile from the facility the Cristianitos fault is clearly expressed in the sea cliffs. The Cristianitos is the closest significant geologic feature to San Onofre. It proceeds inland from the sea cliffs for about 25-30 miles and appears to die out about one mile offshore. The Cristianitos has long been considered to be inactive [footnotes omitted].

San Onofre is built to withstand safely a magnitude 7.0 earthquake occurring at the point on the OZD nearest the plant (eight kilometers) -- an earthquake that could generate a peak ground acceleration to shake the plant site with two-thirds the force of gravity (0.67g). The Licensing Board examined the propriety of that design basis earthquake looking to the historic record, the characteristics of the OZD, and the various earthquake methodologies that had been developed separately by the licensee and the NRC staff for this case. Having held 25 days of evidentiary hearings -- most devoted to seismic issues -- the Board found, among other things, that San Onofre was conservatively designed. The Board noted that in the opinion of the NRC staff seismologist, Dr. Leon Reiter, San Onofre is probably the most conservatively designed of some 30 nuclear power plants he has reviewed. Id. at __ (slip opinion at 16, 137, 215-16).

II. The Cristianitos Fault

A. The Foreclosure Ruling

The Cristianitos fault did not control the seismic design of San Onofre because it had long been an inactive (not capable) fault. Id. at __ (slip opinion at 4).[5/] The Board did recognize, however, that "[i]f the Cristianitos were shown to be a capable fault, it would certainly be significant, and perhaps crucial to the safety of the San Onofre facility." Id. at __ (slip opinion at 20.[6/]

Intervenors' principal argument on this stay motion is that they were illegally precluded from fully litigating their case that the Cristianitos fault is capable. The

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5/ The finding of inactivity was supported by a detailed analysis set out in the NRC staff's Safety Evaluation Report, and in testimony of applicant and staff witnesses which included an updated analysis since the time the construction permit was issued in 1973. See, e.g., Staff Exh. 1, "Safety Evaluation Report," NUREG-0712 (February 1981), at 2-33 through 2-52 [SER]; Testimony of Dr. Shawn Biehler on Contention 1 at 5-9; Testimony of Dr. David G. Moore on Contention 2 at 11-17; Testimony of Dr. Roy J. Shlemon on Contention 2 at 5-9; Supplemental Testimony of Anthony Thomas Cardone, fol. Tr. 5563, at 4; Supplemental Testimony of Dr. Reiter, fol. Tr. 5566, at 2 and Tr. 5574.

6/ But it is also possible that the Cristianitos fault, even if capable, could not generate peak ground acceleration beyond that already accounted for.

Licensing Board foreclosed that issue because the intervenors failed to make a sufficient showing of changed circumstances since 1973 when the construction permit was issued. Id. at __ (slip opinion at 21). The crux of the Board's ruling was its belief that where an issue, such as the capability of the Cristianitos fault, was known at the construction permit stage and underwent intensive staff scrutiny anyone who could have litigated the issue (even if as here, no one had) was foreclosed at the operating license stage absent newly discovered evidence.

The Licensing Board recognized that its foreclosure ruling went beyond the common law principles of res judicata and collateral estoppel, doctrines which we have held are generally applicable to NRC proceedings. Alabama Power Co. (Joseph M. Farley Nuclear Plant, Units 1 and 2), ALAB-182, 7 AEC 210, 212-16, remanded on other grounds, CLI-74-12, 7 AEC 203 (1974); Houston Lighting & Power Co. (South Texas Project Units 1 and 2), LBP-79-27, 10 NRC 563, 566 (1979), aff'd, ALAB-575, 11 NRC 14 (1980). See also Toledo Edison Co. (Davis Besse Nuclear Power Station, Units 1, 2 and 3),

ALAB-378, 5 NRC 557, 563 (1977).[7] Neither of those doctrines would have barred intervenors from litigating the capability of the Cristianitos fault -- whether or not based on newly discovered evidence or changed circumstances -- because intervenors in this proceeding were neither parties to nor in privity with the parties who participated in the construction permit proceeding.[8]

7/ The Supreme Court has described the doctrines of res judicata and collateral estoppel, as follows:

> Under the doctrine of res judicata, a judgment on the merits in a prior suit bars a second suit involving the same parties or their privies based on the same cause of action. Under the doctrine of collateral estoppel, on the other hand, the second action is upon a different cause of action and the judgment in the prior suit precludes relitigation of issues actually litigated and necessary to the outcome of the first action.

Parklane Hosiery Co., Inc. v. Shore, 439 U.S. 322, 326 n.5 (1979).

8/ See n.7, supra. See also Dreyfus v. First Nat'l Bank of Chicago, 424 F.2d 1171, 1175 (7th Cir.), cert. denied, 400 U.S. 832 (1970). We need not reach the question whether the doctrines would be inapplicable as well because the capability of the Cristianitos fault was not a contested issue in the construction permit proceeding.

As the Board succinctly put its position (Tr. 5192):[9/]

> If, for example, the Sierra Club litigates something in 1973, there is no reason in our view why the Union of Concerned Scientists should be able to litigate the same thing eight years later.

At least from our preliminary review of the matter, it seems to us that the Board's novel foreclosure ruling may be in error. It is at odds with generally recognized judicial principles and is premised upon the belief that organizations or persons who share a general point of view adequately represent one another in Commission licensing proceedings.

We doubt that so expansive a reading of the concept of adequate representation is sustainable. The standard for determining whether persons or organizations are so closely related in interest as to adequately represent one another -- and thus to foreclose further litigation -- is already provided for in the "privity" concept, which requires legal accountability between the two groups or virtual representation of one group by the other. Even in its broadest

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9/ The passage quoted in text is a somewhat stronger case for foreclosure than that which was actually before the Licensing Board because, as noted above, the capability of the Cristianitos fault was not a contested issue at the construction permit hearing.

readings the privity concept has not encompassed the situation of a generally shared viewpoint.[10/] In a related context the Supreme Court has noted that "the burden of making [the] showing [that representation may not be adequate] should be treated as minimal." Trbovich v. United Mine Workers of America, 404 U.S. 528, 538 n.10 (1972) (emphasis added). Similarly, the District of Columbia Circuit has found existing representation inadequate because the parties' interests "may not coincide". Natural Resources Defense Council v. Costle, 561 F.2d 904, 912 n.41 (1977)(emphasis added). In short, we think the judicial doctrines of res judicata, collateral estoppel, and privity provide the appropriate bases for determining when concededly different persons or groups should be treated as already having had their day in court. We see no public policy reason why our administrative proceedings warrant a looser standard.

10/ For a discussion of the privity standard, see generally Southwest Airlines Co. v. Texas International Airlines, 546 F.2d 84, 95 (5th Cir.), cert. denied, 434 U.S. 832 (1977). See also United States v. Trochee-Carson, 649 F.2d 1286, 1303 (9th Cir. 1981); United States v. ITT Rayonier, Inc., 627 F.2d 996, 1003 (9th Cir. 1980); Pollard v. Cockrell, 578 F.2d 1002, 1008-09 (5th Cir. 1978); Expert Electric, Inc. v. Levine, 554 F.2d 1227, 1233 (2d Cir.), cert. denied, 434 U.S. 903 (1977).

This is not to say that the Commission is legally precluded from placing additional limitations upon the issues that may be litigated at the operating license stage. For one thing, as reflected by recent amendments to its regulations, the Commission may entirely eliminate certain issues from operating license consideration on the ground that they are suited for examination only at the earlier construction permit stage.[11/] Short of that, the Commission has considerable discretion to provide by rule that any issues which were or could have been raised by a party to the construction permit proceeding will not be entertained at the operating license stage except upon a showing of "changed circumstances" or "newly discovered evidence". Our point is simply that, at least insofar as safety issues are concerned, to date the Commission has seen fit to pursue neither of these courses. The fact that the Commission has chosen to act by rule when excluding certain NEPA issues indicates that safety issues not addressed by rule are not now excluded, nor do they carry a newly discovered evidence burden for their litigation. As matters now stand, Commission practice (as established in

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11/ See 47 Fed. Reg. 12940 (March 26, 1982), which precludes litigation of the National Environmental Policy Act issues of need for power, alternative sites, and alternative energy sources unless otherwise ordered by the Commission.

Farley and other cases supra, p. 10) still requires that the litigability of such issues at the operating license stage be determined with reference to conventional res judicata and collateral estoppel principles, which necessitate for their application an identity, or privity, of parties. This being so, we doubt that the Board below was free to bar the present intervenors from raising the matter of the capability of the Cristianitos fault on the ground that the matter could have been (albeit was not) raised by a party to the construction permit proceeding.[12/]

B. Non-Prejudicial Error

1. While the Licensing Board's foreclosure ruling may well be erroneous it had little, if any, impact on the proceeding. Intervenors' counsel advised us at oral argument that the record available for appellate review is deficient only in the absence of cross-examination of staff witnesses Dr. Reiter and Mr. Cardone. Whatever direct testimony intervenors had to present on the capability of the Cristianitos fault is fully set out in the record

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12/ To require a rule change before issues are excluded would also assure that the Commission is called upon to address the specific considerations for dispensing with the opportunity to litigate particular issues before foreclosing a person who was not a party to the previous proceeding. We think this may be preferable to the course chosen by the Licensing Board, which stretches the concept of adequate representation into an unbending exclusionary rule.

(though formally stricken in major part), and intervenors had adequate opportunity to cross-examine the applicant's witnesses. See Appeal Tr. 14-15, 19-22, 93-97 [App. Tr.].

We have reviewed the record material (including that which was formally stricken) and do not find the gap in cross-examination prejudicial. Intervenors did in fact cross-examine Mr. Cardone and Dr. Reiter as to post-1973 evidence dealing with the potential capability of the Cristianitos fault. See generally Tr. 5744-56, 6684, 6718-38. What they were precluded from pursuing by virtue of the Licensing Board's foreclosure ruling was pre-1973 information bearing on the fault's capability. But as to that, intervenors had had virtually no questions to ask when cross-examining Dr. Biehler, the applicant's consultant, whose testimony covered the Cristianitos fault in its full historical range.[13/] And intervenors do not quarrel with the scope of their cross-examination of Dr. Biehler. See p. 5, supra. Nor did intervenors make an offer of proof as to what would have been elicited through cross-examination of Mr. Cardone and Dr. Reiter as to pre-1973 matters. In these circumstances, the Board's foreclosure ruling cannot

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13/ Our review of the transcript reveals only an isolated series of questions relating to the focal mechanism of a 1967 earthquake. Tr. 3992-93. See n.18, infra.

be said to have prejudiced intervenors' case.[14/]

Moreover, there may well be an alternative reason why intervenors could properly be precluded from challenging the capability of the Cristianitos fault with evidence antedating the construction permit. The issue was simply not within the scope of the contentions set for hearing.[15/] Whether or not a person can be foreclosed from litigating an issue that could have been raised in a proceeding to which

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14/ The rule in the federal courts, to which we can look for guidance, is that error may not be predicated upon a ruling which excludes evidence unless a substantial right is affected, and the substance of the evidence is made known by way of an offer of proof or is otherwise apparent. Fed. R. Evid. 103. See generally United States v. Vitale, 596 F.2d 688, 689 (5th Cir. 1979), cert. denied, 444 U.S. 868 (1980); United States v. Callahan, 551 F.2d 733, 738 (6th Cir. 1977); Hochstadt v. Worcester Foundation for Experimental Biology, 545 F.2d 222, 226 n.4 (1st Cir. 1976); See also 1 Weinstein's Evidence ¶103[3], at 103-27 (1981); 21 Wright & Graham, Federal Practice & Procedure §5040 (1977), at 209. Given the line of questioning taken with Dr. Biehler we cannot say that it is apparent what kind of testimony intervenors thought they would have elicited from cross-examination of staff witnesses as to pre-1973 Cristianitos fault matters.

15/ The four seismic contentions dealt with the Offshore Zone of Deformation, the Cristianitos Zone of Deformation (a feature not synonymous with the Cristianitos fault) and the propriety of San Onofre's seismic design in light of post construction permit data and techniques. Prior to the hearing the Licensing Board rejected intervenors' proposed contention regarding the Cristianitos fault for lack of specificity. Revised Prehearing Conference Order (May 28, 1981), at 6.

he was not a party, he certainly can be foreclosed when the issue is not properly raised as a contention in the proceeding to which he is a party.

2. Having reviewed the record materials (as set forth below), we also believe that intervenors have failed to make a strong showing that the Cristianitos fault may be capable. Our view on the merits of that question (and on the seismic issues discussed infra), decidedly influences our view on the issues of irreparable injury and the other stay elements. Our statement in Metropolitan Edison Co. (Three Mile Island Nuclear Station, Unit No. 2), ALAB-486, 8 NRC 9, 46 (1978) when deciding whether to allow continued operation of that plant during the pendency of a reopened hearing, is fully applicable here:

> The standard which perforce governs this determination is an obvious one: will the continued operation of the plant over the period required to complete the additional proceedings be consistent with the requirement that there be reasonable assurance that the public health and safety not be endangered. See 10 CFR 2.104(c)(3); 10 CFR 50.57(a)(3). If not, the facility of course cannot be allowed to continue to operate at this time.

As applied to the case at hand, that standard obviously does not call upon intervenors to show that an earthquake beyond the seismic design of the plant is likely during the pendency of this appeal. It would be enough if apparent inadequacies in the plant's seismic design were sufficient

to raise the question whether plant operation would present an undue risk to the public in the event of an earthquake.[16/] See Pacific Gas and Electric Co. (Diablo Canyon Nuclear Power Plant, Unit 1), CLI-81-30, 14 NRC 950 (1981). Absent a greater doubt than we now have in that regard, there is not a significant threat of irreparable injury if San Onofre is allowed to start up during the pendency of this appeal. We turn to the evidence bearing on the question of the capability of the Cristianitos fault.

3. Prior to the 1973 issuance of a construction permit for San Onofre, the applicant had undertaken a comprehensive geologic investigation of the site region including detailed examinations of excavations along the Cristianitos fault, geologic mapping, and field examinations. The Cristianitos fault was seen to be a north trending, west dipping normal fault located along the eastern margin of the Capistrano Embayment. The west side of the fault was formed in association with the development and opening of the embayment during Late Miocene and Early Pliocene time (i.e., between about four and ten million years ago). Unbroken terrace deposits at least 125,000 years old overlay the Cristianitos fault and showed that the fault had been inactive for at least that time. SER at 2-34, 2-49;

16/ The facts of this case are not so close as to compel us to define how much risk is undue.

Testimony of Dr. Perry L. Ehlig on Contention 4 at 28; Testimony of Dr. Moore on Contention 2 at 16-17, 44; Testimony of Dr. Shlemon on Contention 6 at 8-9.

After issuance of the construction permit and at the staff's request, the applicant undertook a series of further investigations. These included a detailed investigation of two small earthquakes of magnitude 3.3 and 3.8 which occurred on January 3, 1975 near San Juan, Capistrano.[17/] The earthquakes were of concern to the staff: had the Cristianitos fault generated them it would constitute significant evidence that at least a portion of the fault was capable. The applicant's investigations included a geomorphic study, an evaluation of microseismic events, a study of focal mechanisms, the construction of a subsurface contour map, an updating of historic seismicity, and geophysical surveys. SER at 2-38.[18/] Through calibration

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17/ The strong motion instruments at San Onofre, approximately 20 kilometers (km) away from the earthquakes, were not triggered, indicating that ground motion had attenuated to less than 0.01g. So too a field survey along the Cristianitos fault did not locate any ground surface rupture. Testimony of Dr. Biehler on Contention 1 at 5.

18/ A geomorphic study deals with surface features; focal mechanisms describe the manner in which the ground moves during an earthquake. See generally Tr. 3652-53.

blasts Dr. Biehler developed a model to locate more accurately the epicenters of the small earthquakes and to fix limits on their hypocentral depths.[19] The difference in faulting style and spatial separation from the Cristianitos fault led him to conclude that the events could not be associated with that fault. Testimony of Dr. Biehler on Contention 1 at 7-8.[20] These and other investiga-

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19/ The epicenter is the point on the ground surface directly above the source of the earthquake (the hypocenter) from which seismic waves first emanate.

20/ The motion of the two small earthquakes was strike-slip with a significant thrust component, while one would expect dip-slip movement from the Cristianitos fault. (In a strike-slip fault, the ground on one side of the fault moves horizontally and parallel to that on the other side; in a dip-slip fault, the movement is perpendicular to the strike of the fault. See generally 13 NRC at 917-18; Glossary of Geology (2d ed. 1972)). Moreover, the two earthquakes were oriented along the trend of Trabuco Canyon, a significant geomorphological feature, and oblique to the trend of the Cristianitos fault. Beyond differences in faulting style -- simply as a matter of geographically locating the earthquake -- it was unlikely that either earthquake lay on the Cristianitos fault plane even assuming the shallowest possible dip for the Cristianitos fault. Testimony of Dr. Biehler on Contention 1 at 7-8.

tions [21] confirmed the applicant's and staff's opinion that evidence gathered since the construction permit issued did not disturb the earlier conclusion that the Cristianitos fault was not capable. See generally SER at 2-34 through 2-35, 2-49 through 2-50; Testimony of Dr. Moore on Contention 2 at 15-17.

Intervenors presented two witnesses on the capability of the Cristianitos fault. The principal witness, Mr. Richard S. Simons, attempted to show that a number of low magnitude earthquakes could be geographically associated with the Cristianitos fault, thus indicating its activity or capability. [22] He plotted the location of instrumentally determined earthquake epicenters in an area surrounding San

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21/ A number of other investigations were conducted after the construction permit issued to resolve questions bearing upon the capability of the Cristianitos fault. For example, at the staff's request the licensee undertook trenching to expose the base of Holocene alluvium (i.e., recent (in the last 10,000 years) stream deposits). The alluvium showed no evidence of fault displacement, nor did the overlying terrace deposits show any evidence of shearing. See Testimony of Dr. Shlemon on Contention 2 at 8-9; SER at 2-34 through 2-39.

22/ Because the Licensing Board apparently considered Mr. Simons' testimony dealing with pre-1973 earthquakes to be intertwined with later developments, it applied its foreclosure ruling to the entirety of his testimony. His testimony was also excluded for lack of probative value. 15 NRC at __ (slip opinion at 17).

Onofre,[23/] drew a circle about each epicenter the radius of which was equivalent to the error in the position of that epicenter, then drew a line representing the position of the Cristianitos fault. Twenty of the circles intersected the Cristianitos line. This, Mr. Simons asserted, was evidence that the Cristianitos fault should be considered capable.

This evidence is not convincing. Mr. Simons' plot of earthquake epicenters reveals a generally random

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23/ These data were obtained from a catalog published by the Seismology Laboratory at the California Institute of Technology for the period 1932 through 1980. Written Testimony of Richard S. Simons, attached as Exh. 1 to Intervenors (sic) Carstens et. al. Application for Stay of Low Power License (filed January 27, 1982) [Stay Motion], at 2. That catalog includes an estimate of the error to be associated with the position of each epicenter in terms of distance. The area considered by Mr. Simons was roughly a square, 55 kilometers to a side, containing 127 epicenters.

distribution of epicenters throughout the region.[24/] Seemingly any line drawn on that plot comparable in length to the Cristianitos fault (approximately 40 kilometers) would be intersected by a number of earthquake epicenter error circles. Following Mr. Simons' reasoning, any such line would define a capable fault. Had Mr. Simons in fact demonstrated that the line representing the Cristianitos fault was intersected more frequently than other randomly

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24/ On cross-examination, Mr. Simons acknowledged that the arrangement of earthquake epicenters in the vicinity of San Onofre was generally random. Tr. 4820-21. Indeed, if anything, there is a clustering of epicenters in the northeast quadrant of Mr. Simons' Figure 1 and away from the location of the Cristianitos fault and San Onofre.

Randomness is inherent in the notion of a "halo of seismicity," a concept Mr. Simons recognized as applicable to California and which characterizes the random disposition of small epicenters not associated with known faults. Tr. 4842. Seismicity this low yields peak ground accelerations so small that the design of the plant, 0.67g, can easily cope with them. For example, the 1975 earthquakes 20 kilometers distant from San Onofre produced a peak ground acceleration at San Onofre of less than 0.01g.

Also appearing in the record is a mapping of earthquake epicenters of magnitude 3 and above for the entire Southern California area. Testimony of Dr. Stewart W. Smith on Contention 4 at 5 and Figs. SWS-A,-B, and -C. These figures also demonstrate the generally uniform distribution of small earthquake epicenters throughout the region, as well as concentrated clusters of events associated with faulting. The San Onofre and Cristianitos regions stand out as areas of low seismic activity.

drawn lines of comparable length his methodology might provide some basis for associating the Cristianitos fault with earthquake activity.[25/] But Mr. Simons did not show this, our scrutiny of his plot does not indicate that carrying out this procedure would support his thesis, and more thoroughgoing investigations undertaken by the applicant and staff showed the Cristianitos fault to be inactive. See pp. 20-22, supra. We conclude that the Licensing Board did not err in not crediting Mr. Simons' testimony.

Intervenors' other witness on the activity of the Cristianitos fault, Mr. Mark R. Legg, relied upon Mr. Simons' analysis for predicating the fault's activity. See Tr. 5204-05. What we have said of Mr. Simons' testimony

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25/ As noted supra, p. 20, applicant did conduct further investigations regarding the issue, especially into the 1975 small magnitude earthquakes. These investigations included calibration blasts recorded by 11 seismographs to develop a local crustal velocity model for the purpose of fixing limits on the earthquakes' hypocentral depths, and a comparative analysis of their focal mechanisms with that of Cristianitos. Mr. Simons' far less sophisticated error-based analysis did not distinguish between the Cristianitos fault and any other randomly located comparable plot.

therefore, is fully applicable here as well.[26/]

Additionally, Mr. Legg sought to show that inactivity of the Cristianitos fault should not be inferred from the fact that the regional stress field has changed from the time the Cristianitos fault was formed.[27/]

The point is a tangential one, and in any event Mr. Legg conceded on cross-examination that he had no evidence in the history of geology that a listric normal fault (such as the Cristianitos is thought to be) had later undergone left lateral oblique thrust, the type of movement his view

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26/ The Licensing Board struck approximately one paragraph of Mr. Legg's prepared testimony in accordance with its ruling that intervenors were foreclosed from litigating pre-1973 information regarding the Cristianitos fault. Tr. 5237-41. The excluded testimony was, in essence, a summary of Mr. Simons' testimony. Its formal rejection was therefore not prejudicial.

27/ The Cristianitos is a dip-slip fault, oriented west-southwest. In mid-Pliocene times (five to six million years ago) the tectonic setting of the region changed from east-west extension to the present stress field which is north-south crustal shortening or compression. Tr. 5204-05; Testimony of Dr. Moore on Contention 2 at 16. Applicant's witness Dr. Ehlig was of the opinion that the present tectonic regime would remain unchanged for at least the next 100,000 years. Tr. 994.

posited. Tr. 5246-47. See also Tr. 6392-94.[28/]

Lastly, intervenors point to the uncertainty associated with Dr. Biehler's location of the 1975 earthquakes and argue from that, that their location on the Cristianitos fault cannot be excluded. Dr. Biehler had testified on cross-examination that if one assumed the shallowest possible vertical projection for the Cristianitos fault, and used the maximum standard deviation on hypocentral depth, one of the two events comes very close to the projected line at a depth consistent with the deepest portion of the vertical error bar. Tr. 3965. However, Dr. Biehler also testified that the focal mechanisms of the 1975 earthquakes are inconsistent with that of the Cristianitos fault, and his position was endorsed by the NRC staff seismologist, Dr. Reiter. Tr. 5745-46. Moreover, Dr. Biehler was of the opinion that the hypocentral location of the 1975 events was two to three kilometers above the position of the Cristianitos fault. Tr. 3969-70. Dr. Reiter concurred that it would require an arbitrarily great shallowness of the Cristianitos fault, in disregard of its focal mechanism of a steeply vertical dip-slip fault, to associate the 1975 earthquakes with it. Tr. 5746.

28/ A listric normal fault is a fault in which the hanging wall moves downward, usually concluding with a concave-upward surface of fracture. Glossary of Geology (2d ed. 1972).

From our review of the record thus far, we think the great weight of the evidence supports the view that the Cristianitos fault is not an active fault. Intervenors have not made a strong showing that they are likely to prevail on that issue by the end of our appellate review. Moreover, the factual controversy is not so close that there is a significant risk of irreparable injury in allowing San Onofre to operate during the pendency of the appeal.

III. The Offshore Zone of Deformation

A. Background

Intervenors other major argument for a stay is that the Licensing Board erred in treating as segmented the Offshore Zone of Deformation, (OZD), which is the geologic feature that controls the design basis earthquake for San Onofre. This segmentation, we are told, was contrary to an understandin among the parties to assume that the OZD was a continuous throughgoing feature, and had the effect of underestimating the maximum magnitude earthquake for which San Onofre should be designed.

We think that intervenors have misread both the understanding of the parties and the Licensing Board's decision. All understood that the geologic characteristics of the OZD and their relevance to earthquake magnitude were contested matters for the Board to decide, so long as the controversy stayed within the confines of the description of the OZD posited by the NRC staff and its geological

consultant, the United States Geological Survey (USGS). As explained below, nothing in the Board's decision contravened the staff and USGS position that, for purposes of conservative nuclear design, the three segments of the OZD should be considered related in some fashion and capable of an earthquake the magnitude of which could be commensurate with the length of the zone.[29/]

B. The Parties' Understanding

At the construction permit hearing the parties stipulated as an issue:

> [w]hether, assuming the geologic model set forth in the Regulatory Staff's Safety Evaluation, 0.67g is a reasonably conservative design basis earthquake for San Onofre Nuclear Generating Station Units Nos. 2 and 3.

Southern California Edison Co. (San Onofre Nuclear Generating Station, Units 2 and 3), LBP-73-36, 6 AEC 929, 931 (1973). With regard to the OZD, the staff's model indicated

> [t]he existence of a zone of deformation about five miles offshore from the [San Onofre] site which extends from the Newport-Inglewood fault zone to the north and cannot be disassociated from the Rose Canyon fault zone to the south. The present evidence indicates an extensive, linear zone of deformation, at least 240 kilometers (km) long extending from the Santa Monica Mountains to at least Baja, California. We and our consultants

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29/ The three segments of the OZD are, from north to south, the Newport-Inglewood Zone of Deformation (NIZD), the South Coast Offshore Zone of Deformation (SCOZD), and the Rose Canyon Fault Zone (RCFZ).

> [USGS] consider this zone of deformation to be potentially active and capable of an earthquake whose magnitude could be commensurate with the length of the zone.

Safety Evaluation of the San Onofre Nuclear Generating Station, Units No. 2 & 3 (October 1972), at 15-16. The safety evaluation went on to recommend that the design basis earthquake for the plant be based upon an acceleration of 0.67g from the maximum earthquake likely to affect the site. Id. at 16.

While the applicant was of the view that the USGS model for the OZD was unduly conservative and at odds with its geologic characteristics, it nevertheless "agreed to accept the Staff's more conservative view as the basis for their design." 6 AEC at 943.[30/] That agreement carried

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30/ In fuller explanation the Licensing Board there stated (6 AEC at 943):

> It has become apparent to the Board, both from the record existing at the start and from the testimony during the hearing, that an honest difference of opinion exists between the experts on the two sides as to the proper geological model to use, i.e., whether there is a long continuous zone of deformation near the site which must be considered as the potential location of a major earthquake, or whether the nearby zone constitutes only a smaller, isolated fault and one need consider only a smaller earthquake commensurate with that shorter fault and larger earthquakes on

(FOOTNOTE CONTINUED ON NEXT PAGE)

through to the operating license hearing. Though reiterating that "the Applicants have never accepted as a matter of substance the throughgoing nature of the offshore zone of deformation", counsel for the utility nevertheless represented that "[w]e are not attempting to relitigate that particular question at this time and it does not appear in any of the issues." Tr. 1046.

30/ (FOOTNOTE CONTINUED FROM PREVIOUS PAGE)
more distant faults. The Applicants ultimately (prior to the hearing) agreed to accept the Staff's more conservative view as the basis for their design. Accordingly, they agreed to the stipulation cited in Paragraph 51, supra, which specifies that the adequacy of the design basis earthquake will be litigated in the framework of "the geological model set forth in the Regulatory Staff's Safety Evaluation." This model, of course, is the one set forth by the USGS in the quoted sections of report [sic] in Paragraph 59, supra. The Board has reviewed the information in the record and the Staff's evaluation of that information and finds that the Staff's model is the appropriate one for use in evaluating the effect of these facilities on the health and safety of the public. We note the Applicants' reluctance to concede that the Staff's model is a true representation of the situation. This was indicated by their effort to introduce prepared testimony attempting to counter the Staff's model and specifically stated in the Applicants' reply to the Staff's proposed findings. As we stated above, the interpretation of the geological data is susceptible to differences of opinion and future discoveries may well prove the Applicants' interpretation to be correct. Indeed, there may even be a small preponderance of evidence presently in their favor. The importance of the matter from a safety point of view and the lack of overwhelming evidence that the Applicants' interpretation is correct, however, require this Board to adopt the more conservative position, i.e., that the Staff's model is the one to be used in evaluating the propriety of an 0.67g design basis earthquake.

The parties also agreed that USGS witness Mr. James F. Devine had correctly outlined the meaning to be attached to the model of the OZD. App. Tr. 24. That the zone of deformation should be considered potentially active and capable of an earthquake the magnitude of which could be commensurate with the length of the zone was not to be taken as indicating that the offshore zone of deformation was a fault zone, or capable of rupturing at the same time in a single event. Rather, as Mr. Devine explained (Tr. 5333):31/

> [w]e specifically avoided the term "fault zone." We called it a zone of deformation because there are indeed segments which are not faulted, but instead deformed, folded, for example.
>
> And so when attempting to describe then the earthquake potential one should assign to such a feature, we argued that the three discrete zones should not represent individual fault zones and earthquake magnitudes dependent on each of those

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31/ In tracing the history of the USGS position as it developed at the construction permit review, Mr. Devine noted (Tr. 5332-33):

> The Applicant maintained that there were three discrete components, and put forth an argument that there was not sufficient evidence to cause them to be linked and considered as one fault, and on the other side of the scale, we were not able to demonstrate that they were indeed one fault.
>
> However, in our review at that time, we insisted that for purposes of nuclear design, and for margins of safety and levels of conservatism as we understood them, we felt it appropriate that for that purpose they be considered to be one zone of deformation . . . .

> individual segments, but instead should consider them all in one segment, for the purpose of estimating earthquake size.
>
> Q That is not the same, however, as saying for example that you are suggesting a single fault capable of rupturing at the same time in a single event, is it?
>
> A No. As I recall, none of us had the opinion or the position that the entire length could rupture at once, but only that there was indeed some relationship, probably at depth, of these three segments, such that it all should be considered one zone.

In sum, the parties were free to put on evidence about the geologic characteristics of the three OZD segments and the effect of those characteristics on the maximum magnitude earthquake for San Onofre's design, so long as account was taken of the fact that there was indeed some relationship among the three segments.[32/] Intervenors do not contend that the staff or applicant did otherwise. App. Tr. 25. What the understanding barred was the position that each

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32/ Contention 4 in the proceeding specifically put the geologic characteristics of the OZD in issue. It reads:

> Whether based on the geologic and seismic characteristics of the OZD, including its length, assignment of M_s 7 as the maximum magnitude earthquake for the OZD renders the seismic design basis for [San Onofre] inadequate to protect the public health and safety.

M_s stands for "surface wave magnitude". It is a measure of magnitude used to describe earthquakes of about magnitude six and above. See 15 NRC at __ (slip opinion at 64-65). See also 13 NRC at 930-31.

particular segment of the OZD should have an assigned maximum maghitude earthquake derived from the assumption that an earthquake rupture could not proceed from one segment to another.

C. Licensing Board Consideration of the OZD

Intervenors are not likely to persuade us on the merits that the Licensing Board decision was inconsistent with that model. First, intervenors' argument is inherently implausible because its underlying premise is that the Licensing Board took a fact-finding path inconsistent with the evidence presented by all the parties.[33/] Second, intervenors' argument is refuted by the Licensing Board decision itself. The Board summarized its findings as follows:

> The Intervenors persistently attempted to show that the OZD was controlled by a major, throughgoing fault capable of rupture along its full length. But apart from Dr. Slemmons testimony (Tr. 6317) that he believed the OZD could be interpreted as a single continuous fault, there was virtually no evidence to support this theory. In our hearings the OZD was repeatedly characterized by other witnesses as a segmented zone. The SER and the witnesses for the Applicants, the USGS and the Staff all characterized the OZD as a discontinuous zone divided into three segments, the NIZD, SCOZD and RCFZ. Witness Allen testified that the zone does not contain a single, continuous well defined fault zone (Tr. 4732). The evidentiary record supports the description of the

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33/ We again take note of the fact that intervenors do not contend that the staff's and applicant's evidence was inconsistent with the OZD model. See p. 33, supra.

> OZD as some 240 km long, composed of a series of discontinuous, short, en eschelon [sic] fault segments, drag-fold anticlines and synclines, which progressively changes its style of faulting from north to south. Of major significance for us was the uncontested evidence of the San Joaquin Structural High which interrupts or terminates the NIZD at its southern end, a fact which emphasizes the unlikelihood of a throughgoing rupture of the OZD.
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> 51. The Board's findings on the OZD rest heavily upon the exhibits and testimony presented by the Staff and the Applicants. The Intervenors' primary witnesses had not made independent studies of the San Onofre area and that fact was testified to by Dr. Brune (Tr. 4207-4208) and Mr. Legg (Tr. 5156). Nor do the Proposed Findings of Fact of the Intervenors challenge the findings we have presented other than in their attempt to mischaracterize the OZD as a structure controlled by a single, continuous fault capable of rupture along its full length.

15 NRC at ____(slip opinion at 77-78). Nothing in the Licensing Board's findings strikes us as inconsistent with the understood OZD model. As Mr. Devine emphasized, the OZD is not a single throughgoing fault but rather a zone of deformation. Nor was the USGS of the opinion that the entire length could rupture at once. See p. 33, supra.

IV. Other Challenges to the Adequacy of the Seismic Design Basis

A. The Maximum Magnitude Earthquake

Intervenors argue that the Licensing Board erroneously accepted the views of staff witness Dr. David Slemmons, who calculated the "mean" rather than "the properly conservative mean plus one standard deviation (84%)" earthquake that

might be expected on the OZD. Stay Motion at 7. Intervenors argue that the properly conservative magnitude range is from M_s7.3-7.9, and that the M_s7 figure accepted by the Board [34/] means that half the earthquakes that occur on the OZD will exceed the magnitude premised for San Onofre's design.

1. Intervenors' argument is refuted by other testimony in the proceeding and stems from what appears to be an improper use of Dr. Slemmons' testimony. As a matter of recorded history the largest earthquake anywhere on the OZD is the 1933 Long Beach earthquake of M_s6.3. [35/] Nowhere along the OZD is there good evidence of the amount of surface displacement that has resulted from a single major past earthquake. Testimony of Dr. Heath on Contention 4 at 22. Dr. Smith concluded that earthquakes larger than M_s6.5-70 could not have occurred very often over the last

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34/ 15 NRC at __(slip opinion at 104).

35/ That earthquake occurred on the Newport-Inglewood (NIZD) segment. To assign that earthquake to the South Coast Offshore Zone of Deformation (SCOZD) nearest San Onofre is conservative because (1) the NIZD is closer to the area of high stress at the interaction between the San Andreas fault system and the Transverse Range than are the other segments of the OZD to the south, (2) it has the most prominent surficial anticlines and short but prominent fault scarps, (3) it is coincident with a Mesozoic basement rock discontinuity not known to exist beneath the other segments, and (4) it has a higher level of historical seismicity. Testimony of Dr. Edward G. Heath on Contention 4 at 17.

million years without producing more impressive geologic deformation than has been seen in the region of the OZD. Testimony of Dr. Smith on Contention 4 at 7. To contend that half the earthquakes that will occur on the OZD are expected to exceed the safe shutdown earthquake for San Onofre is totally at odds with these observations.

2. Intervenors' adaptation of Dr. Slemmons testimony fails to take into consideration the conservatism in his methodology. As we explain below, Dr. Slemmons derived estimates of a maximum magnitude earthquake for the OZD by conservatively extrapolating from the maximum earthquakes that had been recorded on similar faults. Thus it would not be appropriate to adjust his final result by yet another standard deviation.[36/]

Dr. Slemmons' preferred method of estimating maximum earthquake magnitude made use of the observation that, for faults similar to those in the OZD, only a fraction of the

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36/ The standard deviation is a measure of the variability in a set of observations. The mean plus one standard deviation for a normal distribution, by definition, encompasses 84 percent of the observations. Technically speaking the standard deviation is the square root of the average of the squared distances of the observations from the mean. R. Levin & D. Rubins, Applied Elementary Statistics 95-96 (1980).

Another statistical measure sometimes used is the standard error of estimate. It measures the scatter of observations around a regression line -- a line used to estimate the association or relationship between two or more variables. Id. at 410, 426. See n.38, infra.

total fault length would rupture in an earthquake. The table on page E-14 of his testimony summarizes the historic data for those strike-slip faults he selected. Staff Exh. 1-DBS at E-14. Of 22 earthquakes on 10 major strike-slip faults varying from 272 to 1380 km in length, he selected the 10 maximum rupture lengths to determine the mean of the maximum fractional rupture and its standard deviation.[37/] His calculated average maximum fractional rupture was 22.1 percent, with a standard deviation of 7.45 percent.

Dr. Slemmons then applied these calculated values to various hypothesized total lengths of the OZD. Assuming the OZD ran 190 km from the northern Santa Monica fault to San Diego Bay yielded an anticipated maximum mean rupture of 44 km (22 percent of 190 km) and a predicted maximum magnitude

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37/ He did not consider the 12 other earthquakes on these faults for which shorter rupture lengths had occurred.

earthquake of M_s6.9.[38/] The maximum mean rupture length plus one standard deviation corresponded to a 57 km rupture and a M_s7.0 earthquake. Dr. Slemmons also made calculations for an OZD assumed to be 250 km long which he considered "an extreme length assumption." Staff Ex. 1-DBS at E-13. For a maximum mean rupture of 22 percent, he calculated a maximum magnitude of about M_s7.0. Adding one standard deviation to the maximum mean rupture length, yielded a maximum magnitude of about M_s7.1.

Dr. Slemmons also pointed to further conservatism in his methodology in that if his determination of the maximum percentage rupture for strike-slip faults were restricted to faults of a length comparable to postulated lengths of the OZD, lower values for magnitude are adduced. Tr. 6285. See Staff Exh. 1-DBS at E-14. An inspection of the data presented in Dr. Slemmons' table on page E-14 reveals that

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38/ Earthquake magnitude was calculated from the length of fault rupture through a formula Dr. Slemmons derived in his 1977 report utilizing data from 31 strike-slip faults. The general equation he derived was $M_s = 0.597 + 1.351 \log_{10} L$, where L represents rupture length in meters and M_s is the earthquake magnitude from surface waves. Dr. Slemmons did not believe it was appropriate to use the standard error of the estimate for that set of data, 0.694, in conjunction with the method described in the text which already accounts for estimates of error. Tr. 6230-31. Dr. Slemmons also noted that his most recent work would reduce his 1977 standard error of estimate of the maximum magnitude from 0.694 to about 0.2. Tr. 6192, 6307.

the fraction of total fault length which ruptures is greater for longer faults than for the shorter ones. For faults nearer in length to the OZD, the Licensing Board noted that the fractional rupture length was only 15-16 percent rather than the 22 percent calculated as the average for all lengths. 15 NRC at ___ (slip opinion at 100-04). Applying this percentage to ruptures on the OZD would obviously lead to lower earthquake magnitudes than Dr. Slemmons calculated. Id. at __ (slip opinion at 101).39/ Dr. Slemmons concluded that he has "high confidence in the [choice of a] magnitude of 7" earthquake for the design basis of San Onofre. Tr. 6323.

In sum, Dr. Slemmons' methodology (1) chose the mean of the maximum magnitude earthquakes that had occurred on similar faults, (2) assumed the OZD to be a throughgoing fault, (3) added a standard deviation to the calculated earthquake rupture length, and (4) included in his data longer length faults that had the effect of overstating magnitude. We do not think that intervenors have made a strong showing that it is correct or reasonable to add an

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39/ This Board notes that restricting the data to faults of 410 km or less results (on that limited data base) in a maximum percentage rupture of about 14.2 plus or minus (±) 3.4 percent. For an assumed 240 km OZD, that maximum percentage rupture plus one standard deviation yields an estimated magnitude of M_s6.8.

additional standard deviation to the earthquake magnitude he estimates, or that the M_s 7.0 magnitude obtained was erroneous.40/

B. Peak Ground Acceleration

The determination of the maximum magnitude earthquake that might affect San Onofre is only one step toward the most critical portion of the seismic design, establishing the ground motion properties of the site. This latter determination is meant to express the impact at the plant

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40/ The choice of a M_s 7.0 safe shutdown earthquake for San Onofre is amply supported by other expert testimony in the record. Thus applicant's expert, Dr. Heath, found the area surrounding the San Onofre site to have one of the lowest historic levels of seismicity in Southern California, with every expectation of remaining so. Testimony of Dr. Heath on Contention 4, Figures EGH-F and EGH-G. He thought that the M_s 6.3 1933 Long Beach earthquake on the Newport-Inglewood zone of deformation may be close to the maximum for the zone. Id. at 20. Dr. Heath also carried out an analysis by which he related the maximum magnitude earthquake expected on a strike-slip fault to the geologic slip-rate on the fault. Though it appears that this is a somewhat new approach, the results support assigning M_s 7 as the maximum earthquake on the OZD. Id. at 23-28 and Figure EGH-M.

So too, as already noted supra, pp. 36-37, Dr. Smith concluded that earthquakes larger than about M_s 6.5-7.0 could not have occured very often over the past million years without producing more impressive geologic deformation than what is seen in the region of the OZD. Dr. Ehlig, another applicant witness, concluded that the features of the OZD -- its geologic strain rate, regional tectonic setting, and "[t]he absence of extensive and/or throughgoing fault ruptures in near-surface strata along much of the OZD" -- all support earthquakes of less than about M_s 7. Testimony of Dr. Ehlig on Contention 4 at 21-22.

site of the maximum earthquake should it occur at the point on the controlling fault nearest the site. Ground motion properties are usually summarized through the choice of a peak ground acceleration (PGA), or "g" value, expressed as a percentage of the acceleration produced by gravity. Once the peak acceleration is determined it becomes the anchor point for the design response spectrum for the plant.41/

The Board discussed at length the testimony relating to ground motion for the San Onofre site and the related matters of peak ground acceleration and response spectra, concluding that the seismic design bases set at the

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41/ The plant's seismic design is based on a response spectrum that is a graphic representation of how a structure or component will respond to earthquake motion that includes the assumed peak ground acceleration.

The peak ground acceleration is not in and of itself of significance because the anchor point on the response spectrum is typically at or above 33 cycles per second, a frequency beyond the natural frequencies of a nuclear power plant or its mechanical systems. The importance of PGA relates to the fact that the accelerations at lower frequencies -- those within the range of concern for a nuclear power plant -- are derived from the response spectrum anchored at a specific PGA. See generally, NRC Regulatory Guide 1.60 (Rev. 1, December 1973). The higher the PGA, the higher will be the response of structures at other frequencies of interest.

For further discussion of response spectra in general and with specific regard to San Onofre, see Testimony of Dr. Robert L. McNeill on Contention 4 at 6-19. See also Pacific Gas and Electric Co. (Diablo Canyon Nuclear Power Plant, Units 1 & 2), ALAB-644, 13 NRC 903, 923-25, and nn.40, 43.

construction permit hearing were adequate. 15 NRC at ___ (slip opinion at 106-52).[42/] Intervenors contest that conclusion, alluding to several claimed errors affecting the plant's design: (1) inadequate weight was given to the testimony of USGS scientist Dr. David M. Boore that for a M_s7 earthquake the peak ground acceleration could be as high as 0.83g; (2) a vertical motion spectrum anchored at two-thirds that of horizontal motion is unduly low; (3) Dr. Enrique Luco's higher peak ground acceleration estimates were wrongly rejected, and (4) the effect of seismic wave focusing which, if credited, also would have resulted in a higher peak ground acceleration, was ignored. We discuss each point in turn.

1. Dr. Boore's Methodology

Intervenors claim that the Licensing Board "misused, misconstrued, and did not give sufficient weight to" the

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42/ The seismic design criteria for San Onofre can be summarized as a site specific response spectrum for horizontal motion, anchored at a high frequency acceleration of 0.67g, with a vertical spectrum set at two/thirds of that for horizontal motion (i.e, vertical anchor point acceleration 0.44g). At the construction permit stage for San Onofre this characterization was established to represent ground motion associated with an Intensity X earthquake. For the operating license proceeding, consistent with more recent practice, the NRC required the applicant to show that the maximum reasonable earthquake associated with the OZD would be one of magnitude M_s7, having the same ground motion properties discussed above (0.67g etc.). See SER at 2-50 through 2-51, 2-66 through 2-68.

testimony of Dr. Boore of the USGS, whom they characterize as the "only truly independent witness" on the subject of peak ground acceleration.[43/] Dr. Boore was co-author of a paper that predicts PGA at various distances from earthquakes of different magnitudes. Interv. Exh. 28. For San Onofre, situated eight km from a possible M_s7 earthquake, Dr. Boore's method yielded a mean PGA of 0.46g, and a mean plus one standard deviation value of 0.83g. Tr. 6559. [44/]

Our review of the record and the Board's decision leads us to conclude that the Board fairly considered Dr. Boore's testimony and adequately explained why his predictions were not reliable for San Onofre. Dr. Boore and his co-author themselves stated that "[f]or distances less than 40 km from earthquakes with M greater than 6.6 the prediction equations are not constrained by data, and the results should be treated with caution." Interv. Exh. 28 at 17. In discounting the reliability of Dr. Boore's model the

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43/ As noted infra, p. 45, the USGS position (as opposed to Dr. Boore's position) was that 0.67g was an appropriate PGA for San Onofre.

44/ Dr. Boore also considered it appropriate that these values be reduced by dividing them by a factor of 1.13 (i.e, to 0.41g and 0.73g) in accordance with the practice of using the average of the two components of recorded horizontal peak acceleration. Tr. 6559-61.

Licensing Board correctly noted that an appropriate model of peak ground acceleration should be "chiefly controlled by the data rather than by assumptions in the model." 15 NRC at __ (slip opinion at 124).45/ When Dr. Boore on cross-examination was asked what the effect would be of eliminating the data beyond 50 km, he stated that the correlation revised in that manner gave predictions for San Onofre conditions of 0.31g for mean PGA, and 0.57g for the mean plus one standard deviation. Tr. 6609-10. These values are not greatly at variance with other witnesses' predictions.46/

45/ Applicant's witness Dr. Smith suggested that Dr. Boore's correlations for PGA were controlled by data at large distances from the earthquakes. Testimony of Dr. Smith on Contention 1 at 4-7; Tr. 3261-74.

46/ The 0.67g peak ground acceleration value for San Onofre was first set on the advice of the USGS at the construction permit hearing and was adhered to by the USGS for the operating license proceeding. See 6 AEC at 942-45; SER, Appendix G at G-5.

The applicant's primary basis for a PGA value was an analysis of 192 PGA recordings from 22 earthquakes by Dr. Lawrence H. Wight. The study resulted in a mean PGA of 0.33g and mean plus one standard deviation value of 0.52g. Testimony of Dr. Wight on Contention 4 at 6-7; Appl. Exh. 11. A similar analysis by applicant's witness Dr. I.M. Idriss yielded a mean plus one standard deviation value for PGA of 0.63g. Testimony of

(FOOTNOTE CONTINUED ON NEXT PAGE)

Further, applicant's witness Dr. Idriss was of the opinion that the standard deviation computed in Dr. Boore's paper was too great for predictive confidence, particularly for close-in locations. Tr. 1737-38.

2. High Peak Vertical Accelerations

Intervenors claim the Licensing Board erred in not being concerned that during certain recent earthquakes, most notably the M_s6.9 Imperial Valley earthquake of 1979, peak vertical accelerations had been recorded which were greater than two-thirds of the horizontal peak acceleration, the ratio chosen for San Onofre's design.47/ Again, we think the Board adequately explained its reasons for believing that high peak vertical accelerations were not significant for the structural safety of San Onofre.

The reasons were three-fold. First, the vertical peaks were of very high frequency, and had little structural damage associated with them. Second, the design of San

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46/ (FOOTNOTE CONTINUED FROM PREVIOUS PAGE) Dr. Idriss on Contention 4 at 7-13. The applicant also used theoretical modeling techniques to determine ground motion characteristics for the site resulting from M_s7 events on the OZD. Testimony of Dr. Gerald A. Frazier on Contention 4 at 3-21. These results were consistent with those of the empirical studies of Drs. Wight and Idriss. Id. at Figs. GAF-C and -D.

47/ The design peak vertical acceleration for San Onofre is anchored at 0.44g, or two-thirds its peak horizontal acceleration of 0.67g. See n.42, supra.

Onofre assumes that the significant ground motion from all components occurs simultaneously while in fact the recorded high vertical peaks occured early on, before the maximum horizontal motions. Testimony of Dr. Frazier on Contention 1 at 15-21.[48/] Third, Dr. McNeill, who derived the spectra used for San Onofre's design, noted that acceleration values, rather than acceleration ratios, are the values of design significance. The design spectra for San Onofre, horizontal and vertical, lie above that associated with the Imperial Valley earthquake of 1979 at all frequencies for relevant distances. See Tr. 4008-09, 4024.[49/] We find that the Board's explanation suffices for rejecting the significance of the higher than anticipated ratio of vertical to horizontal motion associated with the Imperial Valley earthquake of 1979.

48/ Dr. Frazier also noted that in soft sediment there is an upward bias in recorded velocity peaks. Those soft sediment soil conditions are closer to the conditions at Imperial Valley than to the more rock like conditions at San Onofre. Testimony of Dr. Frazier on Contention 1 at 15. See also SER at 2-66.

49/ The data indicate that even a mean plus one standard deviation vertical response spectrum formed using the near-field data for the Imperial Valley earthquake of 1979 only exceeds the vertical design spectrum for San Onofre at a few frequencies. Appl. Exh. 1, Response to NRC Question 361-64.

3. Dr. Luco's Testimony

Intervenors also claim that the Board ignored the testimony of Dr. Luco, a Board witness who was called to testify on the earthquake modeling results submitted by the applicant. See, e.g., Testimony of Dr. Frazier on Contention 4; Appl. Exhs. 21, 24. In summarizing his criticism of Dr. Frazier's model, Dr. Luco suggested, without elaboration, that it is possible to have peak ground accelerations of 0.8g from a M_s6.5 earthquake, a factor of two higher than Dr. Frazier's model would have predicted.[50/] Tr. 4996-97. However, Dr. Luco was unwilling to recommend that or any other "g" value for San Onofre, in view of what is in his opinion, an uncertain definition of acceptable risk in NRC regulations.

Because of the considerable amount of evidence and analysis in the proceeding specifically on the matter of peak ground acceleration (see pp. 44-46, supra) we accept, at least for purposes of this stay motion, the Licensing Board's judgment that the weight of the evidence does not support Dr. Luco's position. 15 NRC at __ (slip opinion at 131-34).

50/ Dr. Luco buttressed his opinion by referring to the results from two published sources. Tr. 5006-07. One of the reports referenced by Dr. Luco, USGS-Circular 672, has been superseded by later USGS publications that predict lower values of PGA. See Tr. 5065.

4. Effects of Focusing on Peak Ground Acceleration

Finally intervenors claim that the Board unduly minimized the effects that focusing would have to increase earthquake ground motion. Again, we find the criticism wide of the mark.

Focusing is the compression of seismic waves in the direction that a fault ruptures. The Licensing Board noted that the witnesses did not dispute that focusing is a real, observed phenomenon. Instead, the dispute centered on how much higher peak ground accelerations might realistically be expected to result from focusing. 15 NRC at __ (slip opinion at 148). As to this, applicant's witnesses testified that the maximum spread between the focused and "defocused" peak ground accelerations would be approximately a factor of two which was already accounted for in their calculations. Tr. 3255-60(Dr. Smith); see also Testimony of Dr. Frazier on Contention 4 at 12-13. Intervenors' witness, Dr. James N. Brune, thought it was possible that focusing could lead to PGAs five times higher in the direction of rupture than in the defocused direction. Tr. 4365. However, he noted that at the frequencies of interest for San Onofre, so large a disparity has never been borne out in any kind of large earthquake, and the observed effects have been in the range of a factor of two as applicant's witnesses testified. Tr. 4365-67.

The Licensing Board also took note of Dr. Smith's testimony that the San Onofre facility does not stand directly in the path of the OZD, the controlling geologic feature, but is eight kilometers off to the side of it and hence not positioned to experience the effects of focusing. The Board summarized its discussion of the issue as follows:

> All of the available evidence indicates that where focusing does occur, the resulting differences in high and low PGAs will be about a factor of 2, and that lesser differences will obtain between median and high PGAs. Moreover, there are no major active faults in the site vicinity "focused" -- i.e., aimed at -- the site. Furthermore, the Intervenors' concerns about focusing are based in the record on little more than its possibility, and an alleged lack of sufficient data. They have failed to advance a plausible theory supporting these concerns.

15 NRC at __ (slip opinion at 152). We cannot say that intervenors are likely to prevail on their critique of the Licensing Board's handling of focusing.[51/]

* * * *

51/ Intervenors also allege that the Licensing Board wrongly relied on the theory of saturation of earthquake ground motion to decrease PGA. Intervenors are mistaken. To the contrary, the Licensing Board said that "given the meager and rather confused record on saturation, [we do] not ascribe substantial significance to the [saturation] phenomenon." 15 NRC at __ (slip opinion at 147). While we do not necessarily agree with the Licensing Board's characterization of the record on the matter of saturation, we find no harm to the intervenors in the Board's assessment of the concept.

In view of the extended length of time it takes for a nuclear power plant to proceed from fuel loading and testing to achievement of criticality -- some three to four months -- we have been able to gain a greater familiarity with the record and the issues than is normally the case when ruling upon a stay motion. Our review at this juncture leaves us with the belief, explained in the preceding pages, that the asserted errors advanced by intervenors in their stay motion do not cast serious doubt on the propriety of San Onofre's seismic design. Nor has the one questionable Licensing Board ruling -- that on foreclosure -- worked, in practice, to prejudice intervenors' case.

For all the foregoing reasons, intervenors' motion for a stay pending appeal is denied.

It is so ORDERED.

FOR THE APPEAL BOARD

C. Jean Shoemaker
Secretary to the
Appeal Board