NUCLEAR REGULATORY COMMISSION

ORIGINAL

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:

SOUTHERN CALIFORNIA EDISON COMPANY, et al.	)	
	)	
(San Onofre Nuclear Generating Station,	)	DOCKET NO. 50-361 OL
	)	50-362-OL
Units 2 and 3)	)	

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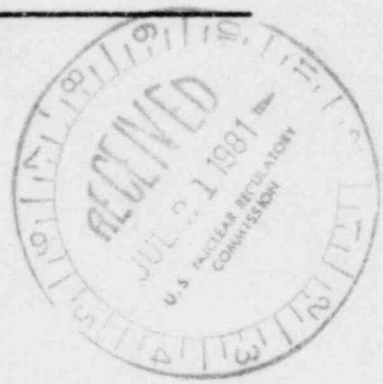

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of:	:	
SOUTHERN CALIFORNIA EDISON COMPANY, et al.	:	Docket Numbers 50-361-OL
(San Onofre Nuclear Generating Station, Units 2 and 3)	:	50-362-OL

Stardust Hotel and Country Club
Tower Room
950 Hotel Circle North
San Diego, California

Thursday,
July 16, 1981

Evidentiary hearing in the above-entitled matter was resumed, pursuant to adjournment, at 9:12 a.m.

BEFORE:

JAMES L. KELLEY, Esq., Chairman
Atomic Safety and Licensing Board

Dr. CADET H. HAND, JR., Member

MRS. ELIZABETH B. JOHNSON, Member

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C O N T E N T S

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PROCEEDINGS

JUDGE KELLEY: Good morning. We are back on the record, and having completed with Dr. Brune yesterday afternoon, Mr. Wharton will present his next witness, right?

MR. WHARTON: Yes.

JUDGE KELLEY: Could you introduce the Witness?

MR. WHARTON: Yes. Intervenors' subpoenaed witness, first subpoenaed witness, is John Gregg Anderson, and at this time I will pass out a resume of John Anderson, which I believe would be appropriate to label as Intervenors' Exhibit, I suppose, for the purposes of the record, and this would be Intervenors' Exhibit Number 8.

JUDGE KELLEY: Yes.

(Whereupon, the document referred to was marked for identification as Intervenors' Exhibit Number 8.)

Whereupon,

JOHN GREGG ANDERSON

having been duly sworn, was called as a witness herein and was examined and testified as follows.

DIRECT EXAMINATION

BY MR. WHARTON:

Q Would you please state your name for the record?

A John Gregg Anderson.

Q Dr. Anderson -- it is Dr. Anderson, I take it?

A Yes.

Q I have before me and you have in front of you, and we have distributed to the parties a resume of John Gregg Anderson. Is this a document that you prepared?

A Yes.

Q Would you briefly summarize your qualifications as set forth in this resume? It wouldn't be necessary to read everything.

A My educational background is a Ph.D. degree in geophysics, in which I specialized in seismology, and I received that at Columbia Univeristy in 1976. Since that time I have worked as a research fellow at the California Institute of technology for one year, then as a research associate at the University of Southern California for about four years and since last August I have been a research scientist at the University of California, San Diego. All of that time I have been working in various aspects of seismology.

Q And what is your highest academic degree?

A It is a Ph.D. degree.

Q And where did you receive that again? I --

A Columbia University.

Q And how long have you been working at Scripps Institute?

A Almost one year.

Q How long? I am sorry.

A Almost one year.

Q Okay, Dr. Anderson, did you investigate or do studies of the Mammoth earthquake -- accelerations which occurred on or about May 27th, 1980?

A Yes.

Q Would you briefly summarize your findings of the results of that earthquake with -- specifically looking toward the magnitude of the earthquake and the peak accelerations found during that earthquake at certain locations?

MR. PIGOTT: I am going to object as not laying a foundation as to the type of investigation that was made, and also as to the questions -- the form of the question that is calling for a narrative.

JUDGE KELLEY: I think it does require a little more foundation before it gets --

MR. WHARTON: Yes, Mr. Chairman. As far as the area of asking for a narrative, I must point out that this is a subpoenaed witness, it is a witness who the Intervenors have little opportunity to review the testimony of the case with, and the nature of the material is such that I believe that some sort of narrative would be appropriate under the circumstances.

MR. PIGOTT: I would -- we will get to it when we get a question, but --

JUDGE KELLEY: Tell me, I need to be a little clearer I guess than I am about your objection to the narrative from this Witness.

MR. PIGOTT: Well, I -- the man, I am sure, has done investigations in this area. The question would you describe your investigations I am not sure goes to the points of this particular case. I think that Mr. Wharton is well enough educated in the issues that are presented to us, that once the investigation has been described, he is then in a position to ask for the relevant evidence that we might use in this proceeding, and that is what I think we should keep directing our attention to in this. As the person who is going to be required to cross examine Dr. Anderson, I would like to have some structure and some semblance of a testimony that relates to this hearing.

JUDGE KELLEY: Well --

MR. PIGOTT: Surely, Mr. Wharton --

JUDGE KELLEY: You do have -- you are going to have an overnight time to prepare your cross. If this seems to wander unduly, I am sure you will object, but I think there is something to be said for a fore-narrative, you know, what did you do about Mammoth Lake? Maybe we can get that out more quickly than through one line Q and A's. So let's go ahead and see how this works.

MR. WHARTON: Yes, I did forget one background

area.

BY MR. WHARTON:

Q Dr. Anderson, are you appearing in this proceeding under subpoena?

A Yes.

Q Have you taken any positions whatsoever on San Onofre?

A No.

Q Would you -- strike that. The -- in the course of preparing for your testimony today, did you review certain documents?

A In the course events that led to my being subpoenaed, Mr. Glen Barlow stopped by my office frequently to find out what I had been doing that might be relevant to the case. And on those occasions he would often give me Xerox copies of various documents which are related to the case.

And I have just given you the copy of that document as --

Q I believe you may still have that.

A Oh, yes, you are right. I do still have it. Okay.

Q Would you read for the record the documents that you have reviewed prior to testifying today?

A It is difficult to say what I have reviewed and what I have only browsed, and what I haven't even looked at

at all. All I have is a complete list of everything that Mr. Barlow gave me.

Q Can you review -- look at those and tell us which ones -- give an estimate as to what you read, browsed or just looked at?

A Well, there is the safety evaluation report, which I browsed through, I guess. There is an affidavit of James Brune, written testimony of Richard Simons, Mark Legg, James Brune. I have read the testimony of Brune. A number of NRC Staff questions and responses. 361.38, 361.44, and I think there are others later on this list. It is not in any particular order.

He has given me the report of the evaluation of maximum earthquake and site ground motion parameters associated with offshore zone of deformation, San Onofre -- Witness I.M. Idriss. Evaluation of peak horizontal ground acceleration associated with the offshore zone of deformation, Witness Lawrence H. Wight. A deposition of Dr. Brune. Report of the evaluation of maximum earthquake and site ground motion parameters associated with the offshore zone of deformation, San Onofre Nuclear Generating Station, Woodward Clyde Consultants, June, 1979.

There was something entitled --

JUDGE KELLEY: Excuse me, Mr. Wharton, I am looking at your trial brief here, and I am looking at the

description of wnat Dr. Anderson is expected to testify to, and we have slip rate and Mammoth earthquake accelerations, and then a point about attenuation models.

Now, in asking Dr. Anderson to go over this list, I gather you are laying a foundation for what he is going to testify to --

MR. WHARTON: That is correct, that he has --

JUDGE KELLEY: But a lot of these -- I am just wondering if it can't be narrowed in some fashion -- if these are indeed the areas you intend to elicit --

MR. WHARTON: Yes. I believe what he has read so far would cover, I believe, enough to establish the foundation for testifying further.

MR. PIGOTT: I am sorry, I haven't heard him say he read them. I heard him read the list. And a couple of things he said he browsed, but so far we have had readings from a list of documents supplied by Mr. Barlow.

JUDGE KELLEY: Well, what I was getting at was is there a convenient way that we can put in the record the Witness's background on these particular points?

MR. WHARTON: I guess we --

JUDGE KELLEY: And that is really --

MR. WHARTON: When I get to those --

JUDGE KELLEY: His general qualifications, it seems to me, are pretty clear from his resume, and I just

wonder if we can't --

MR. WHARTON: Fine, we can do --

JUDGE KELLEY: -- focus this a little bit.

MR. WHARTON: -- when we --

BY MR. WHARTON:

Q Regarding the Mammoth earthquake accelerations, did you perform an investigation of the Mammoth earthquake of May 27th, 1980?

A Yes.

Q In what capacity did you investigate that particular earthquake?

A That earthquake was part of a sequence at Mammoth Lakes. The first strong earthquakes of the sequence -- at least the first ones that I -- that called my attention to the sequence occurred on May 25th in the morning, and after those earthquakes had occurred, I collaborated with Dr. Tom Heaton, who is an employee of USGS for the stations at Cal Tech.

We took a number of strong motion accelerographs and drove up to the Mammoth Lakes area in order to make some temporary installations in the hopes of recording some strong ground shaking data that would be relevant for studying earthquake sources.

Q Okay, did you actually read the measurements of the ground acceleration for that particular earthquake?

A We succeeded in putting out a number of instruments which indeed recorded some strong ground shaking during the magnitude about 6.2 earthquake on May 27th, and -- let me show a viewgraph that shows that particular data set.

MR. PIGOTT: Excuse me, is this the document that was struck from Dr. Brune's testimony yesterday, Mr. Wharton?

MR. WHARTON: I believe it was.

MR. PIGOTT: Could we have a little foundation for it?

WITNESS ANDERSON: This is the corrected version, so you should not --

BY MR. WHARTON:

Q Okay, Dr. Anderson, I have to ask some questions about this particular chart. You have shown up on the viewgraph, and we have passed out to the members of the Board, the parties and three copies to the Reporter, a map showing the Lake Crowley area and showing the epicenter, May 27th, 1980, 1450GMT, which we would mark for identification as Intervenors' Exhibit 9.

(Whereupon, the document referred to was marked for identification as Intervenors' Exhibit Number 9.)

BY MR. WHARTON:

Q Dr. Anderson, have -- did you participate in

preparing this particular diagram?

A Yes.

Q Did anyone else draw this particular diagram with you or is this solely your work?

A It at least is predominantly my work, but it incorporates some results which are not my work.

Q Would you tell us what the purpose of this diagram is to show?

A The -- this diagram shows the vicinity of the May 27th, 1980 earthquake and the locations of the strong ground motion stations which we installed or which other people installed in the temporary array.

JUDGE KELLEY: Just really out of curiousity, about where in California is this?

WITNESS ANDERSON: This is the vicinity of Mammoth Lakes, California.

JUDGE KELLEY: And where is that?

WITNESS ANDERSON: On the eastern side of the Sierra Nevada Mountains, I guess a little bit south of San Francisco -- a little bit south of the latitude of San Francisco.

JUDGE KELLEY: On the east -- close to Nevada?

WITNESS ANDERSON: Yes.

JUDGE KELLEY: Okay, thank you.

WITNESS ANDERSON: This map shows the epicenter

of the earthquake and the epicenter location is not based on my work. That is taken from a paper by Kramer and Topizada written in 1980, which appeared in Special Report 150 by the California Division of Mines and Geology.

And this focal mechanism, also, is taken from that report by Kramer and Topizada.

The seven sites that are marked on here locate the sites of temporary strong motion accelerographs which we istalled between 25th and the 27th, and below each accelerograph it shows the peak accelerations which were recorded during this particular earthquake. So for example, at this one, the peak vertical acceleration was .21G. The two horizontal components showed .20 and .18G.

BY MR. WHARTON:

Q Okay, looking at the location 3754 at Convict Lake, would you tell us how far away that particular location is from the epicenter?

A Approximately 10 kilometers.

Q Okay, and what were the peak horizontal accelerations recorded at that location?

A The two components recorded .72Gs and .55Gs.

Q Is .72G considered a significant G factor in -- strike that. Is .72G a higher ground acceleration than you as an expert would normally expect from a magnitude 6.2 earthquake at 10 kilometers?

A There is very little data at 10 kilometers, and so I cannot say whether that is higher than I would expect or not.

Q Okay. Two other -- I believe there were two other stations? Strike that. What were the readings of other locations in the approximate same area or same distance?

A Okay, well there is station 1494, which the vertical component on that was misaligned. The two horizontal peak accelerations were .27 and .35G, and station 1454, where the two horizonatl accelerations were .20 and .1G peaks. And those two stations are both also approximately 10 kilometers from the estimate for the epicenter.

Q Have you been able to determine, or do you have any opinions as to why the ground -- peak ground accelerations at .3754 are so much higher than the other location at 1494 and 1454?

A I don't know why they are considerably higher. There is the possibility of focusing of energy toward the North, or the possibility that energy is being focused away from the lower readings. But I think that there is not enough data to -- contained at least from a preliminary looking at the accelerograms to determine exactly why there is --

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tape 2

MR. PIGOTT: Is the fault on that particular plot?

WITNESS ANDERSON: No, there is no fault drawn on this plot.

JUDGE HAND: Would you please repeat that?

WITNESS ANDERSON: I have not drawn the causative fault on this plot. The reason that I don't have it on there is because I am not really sure what fault caused this earthquake.

The earthquake occurred in the vicinity of a fault named the Hilton Creek fault and my understanding of the geology is that the Hilton Creek fault shows predominantly dip slip motion.

The focal mechanism which is shown here, according to Kramer and Topozada's work is indicating primarily strike slip motion which might be inconsistent with the apparent geological movement on the Hilton Creek fault. Therefore, I did not know if this earthquake occurred directly on the Hilton Creek fault or not.

BY MR. WHARTON:

Q Dr. Anderson, as part of preparing for the testimony, did you prepare a viewgraph showing Convict Lake May 27th 1450 GNT, Mammoth Lake chart showing acceleration and time chart?

A Yes, I have prepared a viewgraph showing the three components of acceleration which occurred at the Convict Lake site.

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Q Would you put that on the viewgraph and explain that please?

MR. WHARTON: For the record, Dr. Anderson has put a viewgraph on and we have distributed to the parties, to the members of the Board and three copies to the court reporter, a chart showing acceleration and time for Convict Lake, May 27, 1980, 1450 GNT, which we would label and identify as Intervenor's Exhibit No. 10.

(The document referred to was marked for identification as Intervenor's Exhibit No. 10.)

BY MR. WHARTON:

Q Dr. Anderson, would you explain the chart as it applies to Convict Lake earthquake?

A This shows a copy of the accelerogram which was recorded as Station No. 3754 during the May 27th earthquake. The horizontal scale goes from zero to something over eight seconds. The vertical scale shows accelerations with tick marks at plus and minus 800 centimeters per second square.

In order to obtain this chart, the strong motion accelerogram has been digitized at the digitizing system belonging to the University of Southern California. After it was digitized, a base line was applied to it and an instrument correction for the instrument response has been applied.

Q And can you explain what information we can get

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from this particular chart, what the chart is trying to say?

A It shows the accelerations which were recorded in the vertical direction and at an azimuth of plus-165 degrees and at an azimuth of plus-75 degrees during this particular earthquake.

Let me mention at this point that there is one potential problem with this particular earthquake record, and that is that the instrument had not been bolted down to the ground and therefore there is the possibility that it might have been caused to slide a little bit by the strong shaking and that would have distorted the acceleration slightly.

Q Dr. Anderson, have you performed a review of what is now referred to as the slip rate method for determining maximum earthquakes as set forth in the Woodward Clyde Consultants report of June 1977?

A Yes.

Q What is the first information you received regarding this slip rate method?

I first heard about the slip rate method in May of 1979. At that time I heard about it through some consulting work that I was doing with the TERRA Corporation. At that time Larry Wight sent me a preliminary copy of a report for SCE in which he asked me to evaluate it.

That was a very preliminary report that had ten faults on it with their slip rates. On June 1st I responded

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with a review as a consultant and at that time I called the result impressive and I went on to say that if it is confirmed by later analysis, it could become a very important part of future risk analysis.

After that I said that to establish it for such use, I thought there was a burden to demonstrate there are no exceptions to this method and I think that I indicated a procedure to establish that there were no exceptions. It would be to go and search for all the earthquakes with a strike slip focal mechanism.

At that time I suggested a California data set because the report that he sent me emphasized California, but search for all the strike slip mechanisms and determine the slip rates on each of those faults and determine if they are consistent with that method.

Q Do you know if that was done?

A I don't know if that was done. Since that time it is obvious that a great number of additional faults have been added to it, but I don't know which particular procedure was followed.

Q From your present knowledge of the slip rate method, in your expert opinion, is it a valid method for determining the maximum magnitude earthquake that can occur on a fault?

MR. PIGOTT: Are you asking all by itself?

MR. WHARTON: Yes, by itself.

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MR. CHANDLER: Mr. Chairman, before we get an answer, I would like to note an objection. No foundation has been laid to show that Dr. Anderson has any present knowledge beyond that which he obtained on his first review in May of 1979.

JUDGE KELLEY: I would think that his general knowledge and PhD in Seismology along with his review of that particular material would be sufficient for him to give an opinion.

JUDGE HAND: Mr. Chandler, don't you suppose that if he is going to respond, that he might well tell us whether it is based on his knowledge of the matter of June 1979 or is based on current knowledge?

MR. CHANDLER: I would certainly hope that would be forthcoming and certainly if that is included in the answer I will withdraw my objection.

JUDGE KELLEY: On that assumption, then.

BY MR. WHARTON:

Q Dr. Anderson, have you reviewed the Woodward Clyde's consulting report dated June 1979? It is one of the documents that you referred to earlier.

A I have at least read through it and looked at some of the figures in it very closely. Because of the potential importance of this method for seismic risk analysis, I have been interested in it ever since I first saw it and I have

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been wondering if there might be any validity to it or not.

At the present time I am not convinced that it is valid.

Q What reservations do you have that makes you state that you don't believe it is valid?

A One can follow a relatively simple line of reasoning which considers the mechanics of earthquake faulting which indicates that it might not be valid in general, and allow me to explain that.

First, by considering the very simplest type of situation, when a magnitude 7 earthquake occurs, then something of the order of one-and-a-half meters slip might occur on the fault.

Now if the fault is slipping at a low slip rate, say one millimeter per year, then there have to be something like 1,500 years between magnitude 7 earthquakes in order for that amount of slip to accumulate so that it can be released in the magnitude 7 event.

So that suggests that some relationship might exist between the occurrence time of the maximum earthquake on a fault and the magnitude of the earthquake and the slip rate on the fault.

In considering this -- and these are considerations that I have been pursuing from time to time since then -- I have derived a relationship which indicates that.

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In this particular part, I have been working some with Dr. Lucc, also of UC San Diego. May I show this particular viewgraph?

JUDGE KELLEY: Yes.

MR. PIGOTT: Excuse me, before you put it on, if this is something that is going to become part of the record, I think that we are entitled to have a look at it before you do it.

MR. WHARTON: Let me see which one it is, Mr. Pigott.

WITNESS ANDERSON: Do you have to ask some questions, Mr. Wharton?

MR. WHARTON: I just want to identify it. Dr. Anderson has put on the viewgraph, and we have distributed, a handwritten xerox copy -- a xerox copy of handwritten notations -- starting on the top left-hand corner with the words, from Wallace, 1970, which we would mark for identification as Intervenor's Exhibit No. 11.

(The document referred to was marked for identification as Intervenor's Exhibit No. 11.)

BY MR. WHARTON:

Q Dr. Anderson, this document that we have just identified as Intervenor's Exhibit No. 11, did you prepare this?

A Yes.

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Q What was the purpose of your preparing this particular document?

A I prepared it because I was informed before this hearing that when I got in here I would be asked a question about it.

Q Good thinking.

MR. PIGOTT: When was that, I might ask? When was this prepared?

MR. WHARTON: Mr. Chairman, I am asking direct examination. Mr. Pigott will have some cross. This is the second time he has done this.

JUDGE KELLEY: All right.

MR. PIGOTT: It may not be the last.

BY MR. WHARTON:

Q Do you prepared this to assist in your testimony today; is that correct?

A Yes.

Q Would you explain the purpose of the document and what you want to convey to the Board with this document?

A The purpose of this document is to demonstrate a way to get a relationship between the maximum magnitude on a fault, the slip rate on the fault and the interval between the occurrences of maximum earthquakes. That would be an average interval.

It starts with an equation labled one on the second

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line which says that -- which is a relationship from a paper by Wallace in GSA BULLETIN, 1970.

He derived a relationship between the slip rate on a fault, or he wrote this relationship. The slip rate is S here. The time between maximum earthquakes, which I have called $T(M_{max})$ and the average slip during the earthquake which is $\bar{u}_{max}$ average. The bar indicates an average.

Now this relationship states in a mathematical form what I believe I just said a couple of minutes ago, that the slip rate on a fault times the time interval between maximum earthquakes is related to the slip that occurs during the maximum earthquake with the parameter K in there would be between zero and one to indicate that not all of the slip which occurs on the fault occurs during the maximum earthquake that can possibly occur.

So now that is the first relationship. The second relationship is taken from the Slemmons report, State of the Art for Assessing Earthquake Hazards in the United States. That is the relationship between the maximum earthquake and the log of the peak observed surface displacement during that earthquake.

Now if you assume that the largest observed surface displacement is related to the average slip on the fault during the earthquake, then one can combine equations one and two and come up with the third one, and that shows maximum magnitude

ghp 10

is equal to some constants plus the term in the log of the slip rate plus the term in the log of the interval between maximum earthquakes.

The particular constants in this equation could be moved about by selecting different relationships, different values, but I think that the general principles which this equation demonstrates are valid.

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Q Would it be fair to state, then, that the slip rate method, in your opinion, is not valid for determining the maximum magnitude, but is a -- I am sorry, did you want to say something else?

A In order -- well, before you come to that, could I explain what the consequences are of this third equation?

Q Yes. Go ahead.

A Okay. From this third equation, if one were to pick an interval between maximum earthquakes, say 2,000 years, then one has an equation between the slip rate and the maximum magnitude, and I have prepared another viewgraph which shows that plotted on one of the figures from something that has been prepared for the San Onofre plant.

Q Dr. Anderson, would you -- you have put another viewgraph up, and for purposes of identification. it is identified lower right-hand corner, as figure 361.45-2, data range analysis, geological slip rate versus historical magnitude for strike-slip faults, and this would be identified as Intervenor's number 12.

(Whereupon, the above-mentioned document was marked as Intervenor's Exhibit No. 12 for identification.)

BY MR. WHARTON:

Q By way of background,this chart as you have put on

the viewgraph, did you obtain the chart itself from the Woodward Clyde report of 1979?

A I obtained it from one of the documents associated with San Onofre, but I am not sure which one it was. Probably that Woodward Clyde report.

Q And the --

JUDGE KELLEY: Well, I think at some point, we should establish just exactly where this did come from.

MR. WHARTON: I believe that we could probably identify this from the Woodward Clyde report, if we can get a copy of the report, and compare it as --

MR. PIGOTT: I would submit that that is something that should be done.

JUDGE KELLEY: I think so. I think perhaps over the coffee break, that this should be nailed down. Go ahead for now, but it needs to be identified.

MR. WHARTON: Okay.

BY MR. WHARTON:

Q And there are lines on here that are labeled 2,000 years, 5,000 years, 10,000 years, did you draw those lines on this?

A Yes.

Q Would you explain what this chart shows?

A Okay. The lines on there are equation 3 from the previous chart, plotted with T-max equal to 2,000, 5,000,

3g

10,000, or 100,000 years, so now in my opinion, what this indicates, is that if on a fault one can demonstrate that the maximum earthquake never occurs more frequently than once every about 2,000 years, then the maximum magnitude would always occur to the left of the 2,000-year line.

On the other hand, if one can demonstrate that on a fault, the maximum magnitude might occur more often than once every 2,000 years, then one would necessarily expect that it would fall to the right of the 2,000-year line.

The -- I do not yet know of any general physical principles or any studies which have indicated that the maximum earthquake on a fault can -- is constrained to occur less than once every 2,000 years, and as a consequence, I am not convinced that the 2,000-year line drawn on here, or any other line which is drawn to bound the data in a similar manner can be used as a valid method to predict the maximum magnitude on a fault.

Q Very good, thank you. Now, looking at this chart also, which we, again, will have to identify, your review of the Woodward Clyde study and the slip rate method and review of the data used, in your opinion, is the data set used in the slip rate chart sufficient, in your opinion, to show a definite pattern, or to show that which it intends to show?

A The data set which is included on this particular chart would not necessarily be sufficient to demonstrate that

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any line comparable to the 2,000-year line which I have drawn here is sufficient to -- to establish the 2,000-year line as a physical upper limits to a magnitude that can occur at a given slip rate.

If one considers, for example, just the vicinity of -- of the fault number 7, which I suppose is the Newport-Inglewood fault, at 0.5 millimeters per year, then this chart indicates that the recurrence time of an earthquake, with magnitude greater than seven, if such an earthquake can occur, this chart would imply that it would only occur once every 10,000 years or less frequently.

Now, since there is only 50 years of a data sample on the Newport-Inglewood fault, I really doubt that -- we would have to have been extremely lucky to have caught an earthquake of magnitude greater than seven, if such an earthquake can occur.

MR. WHARTON: Thank you. I have no further questions at this time. I would like to move that Intervenors Exhibits 8, 9, 10, 11, and 12 be entered into evidence.

JUDGE KELLEY: I would just like to ask a question about the chart that is up there, as long as it is up there, and I should say that I am far from an expert chart-reader, but let me just ask you, doctor, the lines you have drawn over there, if you go over to the 100,000-year line, does that suggest that over that interval, earthquakes 9 and greater are

to be expected?

WITNESS ANDERSON: No, it does not suggest that.

JUDGE KELLEY: It doesn't say that?

WITNESS ANDERSON: What it says is that if the maximum earthquake on the fault occurred only once every 100,000 years, then one could have -- well, and for these larger slip rates, that you would expect them to be in the vicinity of magnitude greater than eight, but this chart does not say anything about how -- it does not imply that once every 100,000 years an earthquake of this size will occur at the corresponding slip rate. It only says that if they do occur, then in order for the slip rate on the faults to be balanced with the amount of slip that occurs in such a large earthquake, one would expect the magnitude to be in that range.

JUDGE KELLEY: Have there been any magnitude 9 earthquakes in recorded instrumental history?

WITNESS ANDERSON: It depends on what magnitude scale.

JUDGE KELLEY: Take the moment, if I understand that one correctly.

WITNESS ANDERSON: From the moment magnitude, if I recall correctly, there have been at least two, the 1960 Chile earthquake, and the 1964 Alaska earthquake, but in that case -- on that -- for those cases, the maximum

earthquake apparently occurs far more frequently than once every 100,000 years, and --

JUDGE KELLEY: Those earthquakes have MS values, but they are saturated, is that right?

WITNESS ANDERSON: Yes.

JUDGE KELLEY: So you can say it is seven point something, but it is not really that, because it is saturated, is that --

WITNESS ANDERSON; The MS scale saturates someplace between magnitude 8 and 9, I guess, and he moment magnitude scale is designed supposedly so that it does not saturate.

JUDGE KELLEY: Thank you. You had moved admission into evidence of --

MR. WHARTON: Yes.

JUDGE KELLEY: -- the various charts that have been up there, the numbers, what, eight, nine, ten and eleven?

MR. WHARTON: It was eight through I believe number 12.

JUDGE KELLEY: Twelve?

MR. PIGOTT: Subject to verification of the source of 12, I have no problems with the previous eight through 11, but I would object to 12 at this time.

JUDGE KELLEY: Well, subject to establishing that,

then those exhibits will be admitted with the understanding that we have to nail down number 12.

MR. WHARTON: That is correct.

JUDGE KELLEY: All right. Does this look like a coffee break time?

MR. WHARTON: I believe so, and I will look for the Woodward Clyde report.

JUDGE KELLEY: Fifteen minutes.

(Brief recess)

JUDGE KELLEY: Back on the record.

MR. WHARTON: I went to the FSAR Volume I, Responses to NRC Questions, and took out of there Figure 361.45-1, entitled, San Onofre Nuclear Generating Station Units 2 and 3, Empirical Plot, Geological Slip Rate versus Historical Magnitude for Strike Slip Fault.

I gave this particular document to Dr. Anderson at the lunch break to compare that document to the document that he had testified to and asked to be admitted into evidence.

MR. PIGOTT: The results of his comparison?

MR. CHANDLER: Mr. Chairman, I think the document that Mr. Wharton has just identified is at least at odds with the enumeration of the document that he handed out. I have figure 361.45-2.

JUDGE KELLEY: That is what I have.

MR. WHARTON: Yes, you are right. Dr. Anderson has in front of him 361.45-2 and the document he was reading from was 361.45-2.

JUDGE KELLEY: Of the FSAR?

MR. WHARTON: Of the FSAR, yes.

JUDGE KELLEY: Well, that seems to identify it.

MR. WHARTON: I had asked Dr. Anderson just to review the data points and confirm that they are the same.

BY MR. WHARTON:

Q Dr. Anderson, have you reviewed the document --

I forget the number now -- from the FSAR that I have given you, compared that to the document that you testified from this morning?

A Yes, I have compared the figure which you have identified as Exhibit No. 12 and 361.45-2 and the figure is identical. The data points on the figure are identical.

MR. WHARTON: I would submit it into evidence.

JUDGE KELLEY: This is Intervenor's Exhibit No. 12?

MR. WHARTON: Yes.

JUDGE KELLEY: Any objection?

MR. PIGOTT: No objection.

MR. CHANDLER: No objection.

JUDGE KELLEY: That provides satisfactory identification and it is admitted.

(The document identified as Intervenor's Exhibit No. 12 was received into evidence.)

MR. WHARTON: Thank you.

JUDGE KELLEY: Are you through with your direct, then, for Dr. Anderson?

MR. WHARTON: Yes, I am.

JUDGE KELLEY: Dr. Anderson, Dr. Hand is unable to be here tomorrow and has, I think, a few questions that he would like to put to you.

JUDGE HAND: If you go back to your Intervenor's

Exhibit No. 9 which was the map showing the epicenters on the stations where the recordings were taken --

WITNESS ANDERSON: Yes?

JUDGE HAND: At the time you set these stations after the episode or the quake of the 25th -- sometime between then and the time this recording was made -- had the epicenter already been identified?

WITNESS ANDERSON: No. There had been a preliminary epicenter that was given by the seismolab at Cal-Tech which was for the earthquakes on the 25th which was someplace north of the epicenter that is shown on this Exhibit No. 9.

I think that the epicenter was actually very close to the point where we put Station 3679. That was a preliminary location and I think that later locations of that same earthquake was moved a bit farther south.

JUDGE HAND: So then what I was staring at, looking at this chart is, it is very close to a 10 kilometer arc, if you draw an arc based on the epicenter, through 3754, 1494 and 1454. That just happened that it just came out that way? This wasn't planned?

WITNESS ANDERSON: That is entirely coincidence, yes.

JUDGE HAND: The other thing I did was, I drew a line from the epicenter to 3754 to 1418 and they are very nearly in a straight line, and from the epicenter to 3679 to

0822 are very nearly in a straight line, and from the epicenter to 1525 to 1494, only slightly out of line. So it just happened that way?

WITNESS ANDERSON: That is correct.

JUDGE HAND: Okay, that clarifies that a little bit. With the help of Ms. Johnson's calculator, we did some quick ratios between the vertical accelerations and the horizontal accelerations and that row of stations that goes from 3679 and 0822, there is a very high ratio for the .15 acceleration horizontal as compared to the .25 vertical ratio we derive of 1.67. Using the other vector, the .30, you get a number something like .833.

They are not in awfully good agreement with the ratios at the station beyond it, and yet they are very much in a line. Is there any reason for that kind of lack of agreement? The numbers are smaller and I suppose that is attenuation, but the relevant values of those numbers change and I don't understand, if they are related as well as they are to the epicenter, if they are as close in a line as they are, why should the relevant vertical to horizontal ratio be bouncing around that way?

WITNESS ANDERSON: I actually don't see any good theoretical reason why the ratio should remain a constant as a function of distance so I find nothing surprising about the ratios changing as we go along.

JUDGE HAND: Why, from station to station, do you get differences in vertical versus horizontal movement? What is going on?

WITNESS ANDERSON: As you go out to greater distances the mixture of the types of waves which are being recorded changes. At a more distant station, the angles of incidence of the waves may be different.

One type of wave may be attenuated more rapidly than another type so something different might be causing the peak accelerations.

JUDGE HAND: If there were another magnitude 6.2 quake at that epicenter and your instruments were in the same place, do you think you would get the same readings?

WITNESS ANDERSON: Probably not. I don't know for sure, but if another 6.2 earthquake were to occur at the same place and we had the instruments at the same place, I would be surprised if all of the peak values turned out the same.

JUDGE HAND: What is the substrate here? What are these waves traveling through? Is this solid granite?

WITNESS ANDERSON: The epicenter is located within the Sierra Nevada granite batholith. Convict Lake station is in a valley which is entirely surrounded by the granite. It is sitting on some sort of sediments which I would presume to be very shallow within this valley.

The other stations are -- well, let's see, stations

3679, 1480 and 0822 are a little bit farther north and they are in a section which I believe geoligists label as the Long Valley Caldera which is a caldera which has been left behind by a large former volcanic explosion.

Those stations are all sitting on sediments within the valley floor.

Stations 1494 and 1454 are also located on sedimentary deposits which are in a relatively flat broad valley to the east of the Sierra batholith.

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JUDGE HAND: All right, and on your Exhibit 10, you made a comment when you were talking about those recordings that were from station 3754, that the instrument wasn't bolted to the ground, and it could have distorted the acceleration, is that pretty much what you said?

WITNESS ANDERSON: That is essentially what I said, yes.

JUDGE HAND: Distorted it how? Too high readings, too low readings?

WITNESS ANDERSON: That is hard to say. If the instrument -- the instrument was sitting on a concrete patio, rough concrete, directly behind a ranger station residence. If the strong horizontal shakings had caused the instrument to lose friction and slide, then it is possible that the ground shaking might have even been stronger than what was recorded, so the instrument felt three-quarters of a G, but because it lost friction, the ground shaking might have been stronger than three-quarters of a G.

JUDGE HAND: All right. Can you tell me just a little more about this Hilton Creek fault? Would it be on this map if it were drawn, or is it just -- what is it, it is a known mapped fault?

WITNESS ANDERSON: If it had been drawn, it would be on this map. It would be going directly through station 1525, station 1525 was almost directly on the surface

expression of that fault. It is more or less north-south, except I think it veered a little bit to the west as one -- this is the surface expression, as it enters the Long Valley caldera, which was just north of the Convict Lake station.

But the mapped surface traces of that fault, in the Long Valley caldera, it is no longer mapped on -- as just a single fault, but rather there are a number of splays which appear on the geological maps.

I am thinking particularly of the map by Jennings in 1975, which is prepared by CDMG, called "A fault map of California."

MR. PIGOTT: I think this is very useful information, Dr. Hand, and I don't mean to interrupt, but could I suggest that the witness indicate on the viewgraph, and then in that way those of us who have the exhibits could perhaps actually designate on them.

JUDGE HAND: Do you have your viewgraphs with you, or --

WITNESS ANDERSON: No, I don't. I can get them.

MR. PIGOTT: Both the fault and your question concerning the epicenter, I would find it useful if you would designate it on the map.

JUDGE KELLEY: Yes.

WITNESS ANDERSON: I don't have anything that -- to write on this, I don't think.

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JUDGE HAND: Well, that is all right. I think if you will talk and show us while we are watching the viewgraph, that we can see what you mean.

WITNESS ANDERSON: The expression of the Hilton Creek fault is just maybe ten degrees, approximately north-south, just maybe ten degrees west of north, and going about like this, across the graph. So, about between this curve and the road, and site 1525 and maybe about where this "M" is in "GMT," and then about here, even with this point in Lake Crowley, several splays appear to come out, going maybe one like this, and another like this, and another something like this, but I think there were several others. There is another splay mapped up in this area, and in general, within the Long Valley caldera, there were a large number of regions where some sort of surface disruption was identified during this earthquake sequence.

I could make one other comment, though. It is not clear to me that one should automatically associated the surface disruption that occurred during this particular earthquake, or the -- it is not good -- I don't think it is right to associate all of the surface disruption which occurred during the earthquake sequence with this particular earthquake.

On the 25th, when we drove up there, we saw surface fractures on Highway 395, near site 3679, and on the

26th, when we were driving around in the Caldera, to put in this station, especially, 0822, we saw a number of other places where surface disruption had already occurred..

The two earthquakes on the 25th, which both had magnitudes comparable to this one which occurred on the 27th, had epicenters located here, and here, about.

JUDGE HAND: And those are reasonably competent locations, I mean -- or confident locations?

WITNESS ANDERSON: Those are the locations given by Cramer and Topozada, and I have not personally investigated them. I think that they had quite a large number of stations to locate them, so I think that they felt that they were confident locations.

JUDGE HAND: So there have been -- there were three quakes, and there were surface ruptures that were associated with the first two?

WITNESS ANDERSON: The surface ruptures, or at least part of the surface ruptures which occurred around here, and which occurred here near the site 1525, were already existent prior to the occurrence of this earthquake on May 27th.

JUDGE HAND: And was there visible surface rupture associated with that third quake on the 27th?

WITNESS ANDERSON: I do not know if there was any additional rupture which has been identified. This

entire area, these two stations, 3754 and 1525, are locations which are as far into the Sierro batholith as we safely dared to go during the earthquake, because the earthquake was causing large numbers of landslides, and in that region, since the topography is extremely steep, even small earthquakes such as aftershocks might have set off some considerable landslides, so the area in the vicinity of the epicenter would have to be considered inaccessible for all practical purposes.

It was inaccessible to car completely, and it wasn't safe to hike in there to look around for surface faulting, so right around there, I don't know if there was any additional faulting.

JUDGE HAND: And you said that the Hilton Creek fault is a dip-slip fault?

WITNESS ANDERSON: That is my understanding of the geology.

JUDGE HAND: Do the kinds of recordings that you get for your vertical and horizontal accelerations, are they typically different for dip-slip faults, as compared to other kinds of faults?

WITNESS ANDERSON: They -- I can't answer that.

JUDGE HAND: All right. And one last bit of help for me, if you will go to your Intervenors' Exhibit 12, that chart of slip rates and magnitudes, when you drew those

new lines on that figure, how did you determine what slope to use and where to locate that first line, 2,000 years? Why is located where it is? Why doesn't it have a steeper slope or shallower slope, and why isn't it to the right or the left? How did it get where it is?

WITNESS ANDERSON: Let me go back and put up Exhibits 11 and 12. Okay. This was Exhibit 12, and here was Exhibit 11, and now Exhibit 11 went through a rough derivation using one equation from fault mechanics, one equation from empirical observations, to obtain equation three.

Now, the lines in Exhibit 12 are exactly those lines which have been derived from equation three. Equation three says that the maximum magnitude and the slip rate and the frequency of occurrence of the maximum magnitude are physically related.

The -- so now equation three, with 2,000 years substituted, gives a relationship between the slip rate and the maximum magnitude.

JUDGE HAND: So you solve it for a series of points and plot this?

WITNESS ANDERSON: And so I would substitute a number of points for the slip rate, calculated M-max, and in that way derived this line for 2,000 years.

JUDGE HAND: All right. That is fine. Thank you.

I do understand that.

JUDGE KELLEY: Finished?

JUDGE HAND: Yes.

JUDGE KELLEY: Okay. Elizabeth, do you have any questions?

JUDGE JOHNSON: Just a couple of trivial points. I understand that you don't personally, of the accelerograms that you had, the posts, were these the only ones that were put into the area so far as you know?

WITNESS ANDERSON: No, they are not the only ones. There are -- let us see. The California Division of Mines and Geology had some recorded records from three stations which were in this vicinity. One was over here, one just about between these two sites, between 3679 and 3754, and one was over just off the east of this map, on the north side of Lake Crowley.

Let me review my data on those. No, I am sorry, I mislocated the one. The one was over here at -- I think it was at Mammoth School. I forget the name of the station. But to the west of the map, and a little bit south of the "O" in Old Highway.

That one recorded a peak vertical acceleration of 0.26 G, and the peak horizontal accelerations of 0.33 and 0.26. Let us see, the reference for these accelerations is California Division of Mines and Geology, special report

number 27, I believe. Special report on the peak accelerations. The second station was located between 3679 and 3754, so it is located about here, and the peak vertical acceleration there was 0.20 G. The two peak horizontals were 0.33 and 0.27.

The station over here was located just about here, on the abutment to a dam for Lake Crowley. The geometry of that station, the dam which forms Lake Crowley is in an east-west flowing river, and there is a north-south dam.

The station is located north of the dam, north of the extension of the dam, and I think something like 60 feet into a relatively flat plane. In any case, the accelerations there, the horizontal is 0.32 Gs and the -- no, I am sorry, the vertical is 0.32 Gs, and the two peak horizontal accelerations that they list in their report are 0.41 G and 0.99 G.

Now, that 0.99 G is an an exceptionally high value, and I have personally looked at the record, and I have also shown the record to two or three other people, and I doubt that there is any genuine validity to that particular point.

The 0.99 G peak occurs as an extremely high frequency spike, which -- and there are several other extremely high frequency spikes at similar points in the record that make me suspect that there is some sort of problem

with either the instrument or the way that the instrument is fastened to the ground, or something like that, so I personally distrust that high value.

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JUDGE JOHNSON: While we have this viewgraph, you identified the possible epicenter of the events of the 26th very close to the plus that you have close to station 3754.

WITNESS ANDERSON: Yes.

JUDGE JOHNSON: Is there any significance to the one -- the other plus that is between 1480 and 822?

WITNESS ANDERSON: Yes, those pluses in there are at points where map latitudes and longitudes intersect.

JUDGE JOHNSON: That is all. It was just a coincidence on this one then?

WITNESS ANDERSON: Yes.

JUDGE JOHNSON: Thank you. One more question. You discussed the possible movement of the detector you had on the rough concrete at the ranger station at 3754.

WITNESS ANDERSON: Yes.

JUDGE JOHNSON: Do you have any reason to think that you recordings from any of the other stations suffered in any manner because of their not being bolted or fastened --

WITNESS ANDERSON: No.

JUDGE JOHNSON: -- firmly?

WITNESS ANDERSON: No. 1454, 1494 and 1480, were in fact all bolted down very well. The 3679 and the 822 also were not bolted down. Those two stations were located directly on sedimentary deposits, and sort of worked into

the ground so it would be difficult for them to slide, and also those two stations have sand bags placed on top of them, which would also have tended to make them more permanent. So 3754 is the only one that I have some concerns about.

And the concerns at 3754 arise because of -- because under accelerations of .27G, there is the -- because of the large accelerations, rather than anything in the record or anything like that.

JUDGE JOHNSON: So the type of surface the others were on was what you would consider adequate for making the measurements you intended to make?

WITNESS ANDERSON: That is all. Thank you.

JUDGE KELLEY: Thank you, doctor. I may have something more tomorrow, but not today. So I think we can excuse you for this morning anyway. Thank you very much.

(Whereupon, the Witness was excused.)

JUDGE KELLEY: Mr. Wharton, your next witness?

MR. WHARTON: Yes, at this time I would like to call Dr. Clarence Allen.

Whereupon,

CLARENCE ALLEN

having been first duly sworn, was called a witness herein, and was examined and testified as follows.

MR. WHARTON: Mr. Chairman, I want first to thank Dr. Allen for being here, and he did express an interest

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to me if it would be possible for him to be finished today, that is, whatever cross is to be done today. Mr. Pigott indicated and we have agreed that it would be over two days. I think that you will find the nature of my questions of Dr. Allen are fairly general, and I would just ask, if Mr. Pigott could look at it towards possibly this afternoon. It is certainly up to him, and we are not changing anything, but if he could look towards it after my cross -- I mean my direct, to see if he might want to do cross this afternoon since it is fairly general.

JUDGE KELLEY: We did have an understanding. Why don t we wait and see how it does develop?

DIRECT EXAMINATION

BY MR. WHARTON:

Q Dr. Allen, I again would like to thank you for appearing here today. Would you please state and spell your name for the record, please?

A My name is Clarence R. Allen, A-l-l-e-n.

Q And are you here under subpoena?

A Yes.

Q That is, you are not a voluntary witness?

A That is correct.

Q Would you please describe your educational background, degrees and professional experience?

A I have a Bachelor's degree from Reed College in

physics, a Master's degree from Cal Tech in geophysics, and a Ph.D. from Cal Tech in structural geology and geophysics.

Since graduated from Cal Tech I have taught at the University of Minnesota, then returned to Cal Tech where I am now a professor of geology and geophysics. One of my primary responsibilities now is as supervisor of the Southern California seismographic network, which at least Cal Tech is part of that. Cal Tech runs that in cooperation with the U.S. Geological Survey.

Q Okay. Were you one of the authors of a report by the Panel of the National Academy of Sciences on earthquake problems relating to the citing of critical facilities?

A Yes, I was. I was a member of the panel that wrote this report.

Q Would you give us some background of the purposes of the formation of that panel and the manner in which this report was prepared?

A Well, as I recall, there was a feeling that there was a need for some direction of the areas of research that were particularly important to the problems of citing critical facilities, and particular nuclear reactors and dams being among the two most important critical facilities, so the purpose of the panel was to recommend particular areas of research that it felt were important in trying to do this more adequately than had been done in the past.

The panel met on several occasions and in particular, a long meeting at Wood's Hole during the summer of a couple of years ago, and various parts of the first drafts were written by various members of the panel for various parts of the report, and these were gone over, and the report, I think, represents a concensus of the entire panel, although I can recognize in the quotations that Dr. Brune has in his testimony a number of things in which I happen to be the person who wrote the first draft.

Q That is one of the things I was getting to. We would be going through some of the testimony of Dr. Brune and specifying whether these are particular portions which you wrote and that you presently agree with.

A As I say, I wrote the first draft, and in many cases these were modified to some degree by the panel, and I think it is fair to say that the report represents a concensus by the panel, not of a series of individual opinions.

Q Going to the report itself and the quotes that Dr. Brune cited in his testimony, Dr. Brune cited the following in his testimony and I would ask you -- I will read this and ask you if you would endorse the statement as contained in this particular publication.

It states, "We do not now have the optimal information base that is required to cite all critical facilities to protect the citizens of the United States from

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the hazards posed by earthquakes, surface faulting, strong shaking ground failure and tsunami. As a consequence, many facilities are overdesigned, undoubtedly, other are underdesigned to resist seismic effects."

Do you basically -- do you agree with that particular statement?

A Yes. I might say the quotation leaves out a semi-colon, and thereby destroys the correct grammar of the previously statement, but basically yes.

Q Does leaving out the semi-colon change anything in the meaning?

A No. Well, there should be a semi-colon after the word overdesigned, after the quotation mark. But I don't think that changes the meaning.

I might point out that there was considerable discussion in the panel of this particular statement, and I would attach particular importance to that word optimal. We had a great deal of discussion about how this sentence might be interpreted, and I hope it is clear that we have not -- we do not say that we do not have adequate information. What we say is we do not have optimal information, and our purpose I think in making this statement was to indicate that further research indeed would be very helpful to get an optimal situation. But that word optimal, I think is a very important part of that sentence and it was a subject of considerable

debate in our panel.

JUDGE KELLEY: Excuse me. I would like to get clear the direction that we are going on this document. It is a collegial document. What is concerning me here, Doctor, is that certainly you participated and you can certainly say whether you agree with this sentence or that paragraph.

Let me ask you -- I don't understand, however, that you are here in any sense as an official spokesman of that panel.

WITNESS ALLEN: Not as far as I am aware.

JUDGE KELLEY: We had the very same problem with the ACRS as I think any participant knows. It is a collegial body and they have said what they have said. And you cannot, just as an illustration, Doctor -- there have been attempts in the past -- do you know what the ACRS is? The NRC's ACRS?

WITNESS ALLEN: I served as consultant to the ACRS, yes.

JUDGE KELLEY: Well, there have been attempts to subpoena the chairman and say, okay, what does the ACRS think and objections are sustained because nobody can speak for them. They just speak for themselves. And I am a little concerned about where we go on this document. I mean it is quotes -- quotes from it are in the record, and certainly you can ask Dr. Allen about his agreement with portions, but I don't see him as here speaking for the panel in any sense.

MR. WHARTON: I hadn't intended that, Mr. Chairman.

JUDGE KELLEY: Some of it kind of sounded that way, and that is why I interrupted.

MR. WHARTON: Well, I don't want it to be construed that way. Dr. Allen is one of the most highly regarded in the field. This -- he testified that he has written the draft of this particular document, and I am asking him regarding his thinking on the current state of the art, and basically in fairly general terms, and this --

JUDGE KELLEY: Go ahead.

MR. WHARTON: -- has to do with critical facilities.

MR. CHANDLER: Mr. Chairman, I will object to his characterization that Dr. Allen prepared the draft of this document. I think Dr. Allen indicated he prepared the draft of portions of the document.

JUDGE KELLEY: Does it really matter for our purposes?

MR. CHANDLER: I am not sure. I don't know what line of questioning Mr. Wharton is going to --

JUDGE KELLEY: Go ahead --

MR. CHANDLER: -- pursue.

JUDGE KELLEY: -- Mr. Wharton.

MR. WHARTON: Thank you.

BY MR. WHARTON:

Q Dr. Allen, one of the questions that was raised, I believe Dr. Hand may have raised them, regarding the paragraph that I just read -- is as a consequence many facilities are over-designed and undoubtedly others are under-designed to resist seismic effects. Do you have any knowledge, personal knowledge of a percentage or a knowledge of which facilities may be over-designed or under-designed in a general sense, or is this a gut feeling or something that you know about?

A Let me answer that partly by turning our attention to the second quotation, the one that is on page 21 of the NAS report where we say "major gaps exist in our knowledge of seismic phenomena."

Q Yes.

A Seldom can all three of these questions be answered anywhere near -- with anywhere near the confidence we desire. I would like to go on and quote the following sentence in the report, where we say, "as a result, some structures with a deficient resistence have undoubtedly been built, although probably more often, critical structures have been built using excessive conservativism to compensate for our acknowledged ignorance. Improved answers to these questions should therefore serve not only to increase our confidence in the safety of critical structures, but this knowledge

should also permit such structures to be built more economically without the waste that is necessarily inherent in over-conservatism."

So I think the feeling of the panel was that more often critical structures have been built with excessive conservativism. That is the sentence following the quotation that you have on page eight of Dr. Brune's testimony.

Q Right. You have commented, I believe, already on major gaps exist in our knowledge of seismic phenomena. Going to page 23, bottom of the page, in commenting on specification of maximum earthquakes the panel comments, "such events have been called maximum credible earthquake, maximum expectable earthquake, or with regard to special facilities safe shutdown earthquake, or simply the design earthquake. None of these terms has been precisely defined in a usable way, and what is credible or expectable to one person, may not be to another."

Now, is this one of the paragraphs that you drafted yourself?

A As I recall, I wrote the initial draft of that, yes.

Q Okay. Would you explain further what you mean when you say that none have been precisely defined in a usable way?

MR. PIGOTT: Are we calling for Dr. Allen's

personal opinion now at this time?

MR. WHARTON: Yes, I am calling for his personal opinion.

WITNESS ALLEN: In my opinion, the word maximum credible earthquake has not been precisely defined, because what is credible to one person is not credible to another, or may not be credible to another, and one of the points of our report, I think here, and I agree with that, is that gradually we should be trying to get away from these terms and instead talking about degrees of fault activity, rather than capable faults or active faults, inactive faults, because they are all gradations of these various kinds of features.

Maximum expectable earthquake is a word that has been used by the Geological Survey and I really don't know what they mean, because it is not really an earthquake they expect, but it is some sort of a maximum earthquake they are speaking about.

Indeed the word safe shutdown earthquake has been precisely defined, I think, as used by the Nuclear Regulatory Commission, but not in a very usable way, it seems to me. This problem of one movement and 35,000 or more than one movement and 500,000 years has turned out to be not terribly usable, and I think that is the one criticism I would have of that particular expression.

Also, I think, it is quite clear that the -- particularly the 35,000 year number came from the limit of carbon 14 dating and really has nothing to do with acceptable risk, and yet it is used to sort of define a safe versus an unsafe fault.

ghp 1

Q Do you have any suggestions or different terms that you call these events or different ways of defining what we should be looking for?

A Well, I think, and what I think I said in the report was, that we must be working toward trying to find faults on the basis of their degree of activity, recognizing that there are faults that are very active, faults that are very inactive, faults that apparently are dead, and there are all gradations in between.

It is really rather arbitrary to somehow draw a line between a capable and an active fault and one that is inpotent or inactive.

One point, of course, that we have made in here and many other people have made is this -- the decision as to how active a fault must be or how often an earthquake must occur to be of concern in a critical facility, is really a decision that involves acceptable risk and a decision that should be made not necessarily by the scientists and engineers alone.

In other words, is an earthquake that occurs once in a million years something that we should consider or not? That is something involving what the acceptable risk is in a particular facility and the one thing I would like to see is, I would like to see that decision separated from the decision of fault activity.

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That is, hopefully a scientist can state what the degree of fault activity is or how often an earthquake of a particular magnitude might occur. Then, having said that, let someone judge -- not a scientist or engineer judge -- whether that particular earthquake is of sufficient concern to be considered, say, in the design of a particular plant.

As it is right now, it seems to me we have a definition of a capable fault or an active fault where we have sort of confused acceptable risk and scientific probability in the same definition and I don't think in the long run that is a very satisfactory state of affair.

Q Also Dr. Brune quotes -- and I would like to quote it at length because you did mention before the quote about major gaps:

Major gaps exist in our knowledge of seismic phenomena and nowhere is it better illustrated than an attempt to specify the locations, frequencies and maximum sizes of future earthquakes that might effect critical facilities.

The question of where, how often and how big, seldom can all three of these questions be answered near the confidence you desire.

MR. PIGOTT: May we have a cite for that?

MR. WHARTON: I am sorry, I was taking it from Dr. Brune's testimony, page 8, page 21 of the report.

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BY MR. WHARTON:

Q My question as to that paragraph is, if we can get a better idea of what you mean by, near the confidence we desire.

A Well, I think the mere fact that we have hearings like this indicates that we cannot answer these questions as satisfactorily as we would wish. There are honest scientific differences of opinion on these questions of how big, how often and where.

As a result of these, of course, we are forced to be exceedingly conservative and I think as we state right here, and I agree, probably more often than not we are being unduly conservative because of this acknowledged ignorance.

Hopefully as time goes by, and I have said this for many years, given this document you quote in 1967, hopefully as time goes by and our knowledge increases, we can be less conservative.

Q You also state in the report that --

MR. PIGOTT: The report also states -- objection.

JUDGE KELLEY: Sustained.

BY MR. WHARTON:

Q The report also states that efforts must be made to separate the evaluation of scientific likelihood of potentially disastrous events and the assignment of the risks that society is willing to accept for a particular critical facility.

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MR. PIGOTT: Could we have a reference?

MR. WHARTON: It is page 9 of Dr. Brune's testimony and the report, page 24.

BY MR. WHARTON:

Q The question I have regarding this particular sentence is, is it your opinion that scientists such as seismologists are not really qualified to make the kind of assignment of risk that society is willing to accept?

A I don't think I have said that. I don't think that it is fair that they alone should be asked or expected to make this particular judgement. Certainly I think that as citizens we have just as much right to participate in decision of what represents an acceptable risk.

I think ultimately that decision ought to be reached by a broader section of society than simply geologists and engineers.

Q Are you currently a member of the scientific panel that is analyzing earthquake hazards, geologic and seismic hazards at the proposed LNG facility in Southern California?

A I am a member of the review panel that the California Public Utilities Commission has set up to advise the Public Utilities Commission on seismic risk at that site, yes.

Q In your opinion, the methods being utilized in analyzing the earthquake hazards and seismic hazards for the

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proposed LNG facility, do those methods meet most of the criteria that you point out in this report?

MR. PIGOTT: Objection; I don't see any relevance as to what they are doing at Point Conception at this hearing.

JUDGE KELLEY: Nor do I. Maybe you want to expand on it, Mr. Wharton.

MR. WHARTON: No, I will move on.

JUDGE KELLEY: All right, thank you.

BY MR. WHARTON:

Q Finally, from that particular report -- this is from page 9 of Dr. Brune's testimony --

MR. PIGOTT: Could we just have the cite to the document itself?

MR. WHARTON: I am looking for it now, Mr. Pigott.

MR. PIGOTT: Use of Dr. Brune's testimony is offensive enough.

MR. WHARTON: I can't seem to find the sentence. In Dr. Brune's it starts with, the statistical base of ground motion data is extremely limited at present. These estimates of ground motion are subject to considerable uncertainties reflecting the limited historical data base and lack of detail, quantitative knowledge of the influence of physical factors on ground motion.

Data are particularly limited for near-field and large magnitude earthquakes. Unfortunately such events pose

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the greatest hazard to structure.

MR. PIGOTT: Do you have the reference?

MR. WHARTON: I have not been able to find it in the document itself. I am looking for it again.

WITNESS ALLEN: I did not write the first draft of that sentence so I do not have it marked in my copy.

BY MR. WHARTON:

Q Would you have any disagreement with that particular statement?

MR. PIGOTT: I am going to object until we have established that it is in the report.

JUDGE KELLEY: Why don't we take five minutes and take it.

(Brief recess.)

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JUDGE KELLEY: Okay, we are back on the record. Mr. Wharton, go ahead.

MR. WHARTON: Yes.

BY MR. WHARTON:

Q Dr. Allen, thank you for your patience for my not finding the cites. I should have those. Going to page 33 of the report, the second paragraph, the last sentence states, "Even so, the statistical base of ground motion data is extremely limited."

Going to the last paragraph, and reading it in context, if I may go through all of it, "In the design of critical structures and facilities, after the design earthquakes have been selected, it is necessary to estimate the ground motions that are to be used in design. The ground motions that are estimated typically include the transient peak accelerations, velocities and displacements, the duration of strong shaking, and in some cases the frequency content.

"At present, these estimates are subject to considerable uncertainties, reflecting the limited historical data base, and the lack of detailed quantitative knowledge of the influence of physical factors on ground motion. Data are particularly limited for near field and large magnitude earthquakes. Unfortunately, such events pose the greatest hazard to structures."

Turning to page 34, "There are several aspects

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regarding the details of ground motions for which data are generally lacking. These aspects which of great importance in the design of structures include the variation of ground motions with depth below the surface, important for deeply embedded structures such as nuclear power plants."

Did you write the passages that I just read?

A No, I did not. The first draft of those, no, I did not.

Q Excuse me?

A No, I did not write the first draft for those passages.

Q Did you review the draft of these passages?

A Along with all the rest of the report, yes.

Q And did you have basic agreement at that time with the passage that we just read?

MR. PIGOTT: I am going to object to this line of questioning. I really feel if you are setting a predicate to ask Dr. Allen's opinion, I wouldn't have any objection, but I think you are getting back into the processes of the group that he was a member of, and --

JUDGE KELLEY: Let me ask what the purpose of the questions are. Are you trying to establish anything other than whether Dr. Allen agrees today with that statement?

MR. WHARTON: Well, I want to see if he agrees, first, agrees with the statement himself, and whether he can

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comment on a statement regarding lack of data, especially lack of data regarding the details of ground motion, several aspects regarding details of ground motion for which data are generally lacking, and it refers here to the aspects which are of great importance in the design of structures, including the variation of ground motions with depth, and I wanted to see if he has particular -- if he was knowledge regarding that statement that he could pass on that would be relevant to these proceedings.

That is, what is the extent of knowledge regarding this particular information?

JUDGE KELLEY: Both those points seem legitimate, but I don't understand why we have to ask him whether he reviewed graphs and believed it then, and so on.

MP TON: Well, I was just trying to --

JUDGE KELLEY: I would rather you just asked the question.

MR. WHARTON: Fine.

JUDGE KELLEY: Let me just say, Mr. Pigott, that this issue first -- we first looked at these questions in connection with Dr. Brune's testimony, which had a short section, and with respect to which there was a motion to strike on grounds of relevance, which we denied, but it is, it seems to us, while important, rather second-order relevance if you will, and I think it should be -- it doesn't need -- it

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is very general material, and does not need to be probed in great detail.

MR. WHARTON: This is my last question in this area.

JUDGE KELLEY: Okay, go ahead.

BY MR. WHARTON:

Q Dr. Allen, do you generally agree with this particular statement that I just read?

A Yes, I generally agree with it. Certainly the statistical base of ground motion is not as limited as it was at the time the report was written, but it still is limited. I particularly agree that our biggest -- or one of our major lacks is in the strong motion recording from the near field of strong earthquakes, and I think all engineers, as far as I know, would agree with that statement.

I would also point out that the area of ground motion is not my field of expertise, and although I agree with the statement, I don't pretend to talk with any great expertise in this field.

Q I am not going to be asking you any more about ground motion, other than the lack of data, or how much data there is regarding it. I am most specifically looking towards where the statement says there are several aspects regarding the details of ground motion for which data are generally lacking. Does that particular sentence mean that there --

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sic

it is not just a sparsity of data, but there is not very much data at all, could that be qualified --

A Certainly the problem of near field recording and one in which there is a great sparsity of data. There is no question of that, I think, although this has been improved considerably in just things as the 1979 Imperial Valley earthquake.

Q What about the area of variation of ground motions with depth, below the surface? Is this an area where there is very low data?

A I have no particular knowledge of that area.

Q Thank you.

Dr. Allen, did you write a paper called "The Geological Criteria for Evaluating Seismicity?" Let me give you a copy.

A Yes, I did. The copy you gave me is a chapter of a book which essentially is reproduced verbatim from the original that was published in the Bulletin of the Geological Society of America in 1974.

Q So this publication is 1974, is when this was --

A The original publication in 1974, yes.

Q Was this report adapted from an address which you gave as the retiring president of the Geological Society of America?

A Yes, it was.

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Q Turning to page 32, the third paragraph, you state, "It is significant that the earthquake catalogues of those parts of the world with the longest historical records are the very ones which give us the greatest pause in extrapolating these records into the future. This should be a lesson in terms of the temptation to draw far-reaching conclusions from the relatively short seismic history, such as characterizes North America, and from relatively short seismic history, and from such single events as Charleston and New Madrid earthquakes."

Could you explain what you -- the significance of that particular sentence and what you mean by that?

A Well, I think particularly when we look at those areas with very long seismic histories, and the Middle East and China I think are among the most significant areas here, we see that there have been events occurring very infrequently, on some faults, for example, that would not have been noted if we had had a much shorter geologic history, or recorded history.

We also see that particularly in the case of China, there seem to have been some major changes in seismic activity over a period of several thousand years, and what I am trying to emphasize is that in those areas where we have these very long histories, we see things that should tell us something about looking at areas with very short histories,

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and should be very careful in drawing hasty conclusions from areas with very short histories.

For example, here in California, we have faults such as the Garlock fault that within recorded history have never had a major earthquake on them. One might be inclined to say, well, that means that fault is safe, and all I am saying is, as we look at areas with very long histories, we realize that there are areas that -- where events have occurred very infrequently. We should be very careful in looking at areas in this country with very short recorded histories.

Also, we see areas such as the Middle East, where -- or say, the area of the Dead Sea rift, where earthquakes apparently were very common up to about 1200 years ago, and then -- 1200 A.D., and then stopped and we have had very little activity since that time, and these things, I think we have to look at very carefully, when we are considering an area such as almost all of the United States, where our recorded history is very short.

Q In that paper on page 33, there is a figure 3-1. Is this figure in here to show -- to illustrate the principles you were just speaking of?

A Yes. This is a figure taken from the work of Mrs. Mei in China, showing the cumulative strain release or seismic activity, so to speak, in all of north China from

466 B.C. to the present, and I showed it to indicate that from the years, well, 200 to about 1000 A.D., the level of activity was very low, although this was preceded and followed by areas of relatively high activity, and I have talked to Mrs. Mei about this, and she feels quite clear this is -- quite certain this is not just a matter of deficiencies in the historical record, which would be the first question one might have.

She feels that the historical records are adequate in this area to indicate that there indeed has been a change in seismic activity over periods of hundreds of years in this part of North China.

Q In the same paper, on page 65, there is a statement at paragraph three on that page, okay, that is -- number three states, "Those parts of the world that have the longest historical records of earthquakes are the areas that should give us the greatest pause in extrapolating that history in the future, because it is clear that even a 2,000 or 3,000-year history is not a sufficiently valid statistical sample to use as a firm guide to overall activity. In such areas as California and Nevada, where our historical record barely exceeds one century, we must be exceedingly cautious in extrapolating from this very short history."

Do you still endorse this particular statement?

A Yes, I do.

Q And would you agree that in Southern California we do not have a long enough historic seismicity record to allow for valid extrapolations of future earthquake activity?

A I would say we must be exceedingly cautious in doing this. Certainly some parts of Southern California such as the Imperial Valley, I think we have a much better statistical base that other areas where earthquakes occur less frequently, so I think this is an area where we must indeed be very cautious.

Q Do you know of the amount of statistical base for the area known as the California borderlands?

A This is an area where the degree of earthquake activity has been relatively low over the past 40 or 50 years for which we have any reasonable record, and consequently that is an area indeed where our statistical base is not very good.

Q So you would say the data base in that particular area is one of those that you have to be extremely cautious?

A The data base from seismic events.

Q Yes.

A Is certainly an area where we have to be cautious, yes, exceedingly -- what was the term I used? We certainly must be very cautious, yes, there is no question about it.

JUDGE KELLEY: Can you indicate just roughly where

the California borderland is?

MR. WHARTON: Yes, the California borderland --

MR. PIGOTT: Excuse me, could we have the -- perhaps we could have Dr. Allen explain where the --

MR. WHARTON: I think that would be better.

JUDGE KELLEY: Doctor?

WITNESS ALLEN: I assume what you mean by this, and you were the one that used the term, not me, is primarily the offshore area from the southern peninsula ranges offshore to the edge of the continental slope.

MR. WHARTON: That was my understanding of what I was talking about.

JUDGE KELLEY: Does that include San Onofre?

WITNESS ALLEN: I would assume so, yes.

JUDGE KELLEY: All right.

WITNESS KELLEY: And of course, this is one of the reasons that I have argued, in fact the whole point of this paper is to argue that we must be very careful in looking at the geological record, to try to go farther back in history than we can by looking at the very short seismic record.

BY MR. WHARTON:

Q Could you turn to page 34 of -- and it starts with section 3.2, California, and runs on through page 35, page 3.2, it states, "The seismicity of California is related

to motion along the plate boundary between the North American and Pacific Plate."

Would you describe the motion along the plate boundary in Southern California and Northern Baja, and I will refer you to a viewgraph of a regional tectonic model, which was produced by the consultants to the Applicant, and was distributed in this proceeding as figure 361.66-7, that is from the FSAR?

I would ask you, from this particular diagram, from the FSAR, could you describe the motion along the plate boundary in Southern California and Northern Baja California?

MR. PIGOTT: In all its aspects, or the -- we could be here for several weeks, I think.

MR. WHARTON: Not from what I know about it.

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WITNESS ALLEN: Grossly, of course, it is a big plate that is moving northwest with respect to the North American plate. That is reflected, of course, predominantly in the San Andreas fault.

As one comes into Southern California, of course, the San Andreas fault breaks into a number of branches so that movement is apparently spread and distributed between a number of branches and is a matter of continuing scientific debate, as a matter of fact, as to where that strain is predominantly now located.

Certainly within the past 80 years or so, most of that has been taken up, at least in terms of the seismicity we see, most of it has occurred along the San Jacinto fault, which is, perhaps, the major active branch of the San Andreas fault in this area.

There are, of course, many different faults in this area. The exact way in which the strain is distributed in between these is still a matter of a good deal of research.

I might say this map does not show anything to speak of east of the San Andreas fault and of course there are many active faults between Nevada and the eastern Mojave Desert and then part of the plate motion, apparently, is being reflected in those faults as well as in the main fault to the west.

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gbp 2

BY MR. WHARTON:

Q With this plate boundary in motion, would you agree that some of the plate boundary in motion is being distributed onto the offshore fault zone?

A Insofar as we have seismic activity out there, insofar as we have faults that appear to be reasonably active, the answer, I think, is yes.

Q Does that have any significance as far as increasing the likelihood of earthquakes in the immediate future based on the knowledge of the plate boundary motion at the present time?

MR. CHANDLER: Mr. Chairman, I am getting a little concern that we are treading into an area in which Dr. Allen may have been involved as a consultant to the ACRS in the earlier aspects of this proceeding.

I think one of the cautions that we had recommended to the Board in our earlier motion may be advisable, certainly, at this time.

JUDGE KELLEY: Yes, you mentioned earlier that you had been a consultant with the ACRS and I don't think at that time it registered. This was in this very case?

WITNESS ALLEN: I am still trying to refresh my own memory. I was a consultant to the ACRS for, I think, two or three years before it became too time consuming back around the early '70's, it seems to me.

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Although my memory is very vague back there, I think one of the things that came up for consideration at least part of the time I was consulting for the ACRS was the San Onofre situation.

I don't remember very much about that, but I think it is true that I was a consultant to the ACRS during some of those considerations and I was talking this morning about it, trying to refresh my memory on that.

JUDGE KELLEY: Well, Mr. Chandler, you are just reflecting concern, are you not, about the collegial process and getting into that not, I would take it, about whatever Dr. Allen may know about the geology of California.

MR. CHANDLER: Certainly not. His own personal knowledge, I think, is something that he can talk about. It is going to be a hard area to split, I am sure about that.

MR. PIGOTT: It is our understanding that Dr. Allen was, in fact, on ACRS as the time the San Onofre 2 and 3 construction permit proceeding was going through ACRS.

JUDGE KELLEY: What I am saying is, I don't see why it is so hard. Maybe I don't appreciate its complexity, but if Dr. Allen knows of his own knowledge that there is a fault someplace of a certain activity, the fact he may have told that to the ACRS, he can tell us too, can't he?

MR. CHANDLER: Yes.

JUDGE KELLEY: What we are concerned about, I

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thought, was a witness coming in and getting asked, what did you tell the ACRS and why did they say this in their letter and this sort of thing.

MR. CHANDLER: That is certainly my primary concern, Mr. Chairman.

JUDGE KELLEY: Given the sheer passage of time, I think we are somewhat insulated from ACRS deliberations, so with this in mind, let's go ahead.

MR. WHARTON: I believe I had a question pending. Maybe I will state it again.

JUDGE KELLEY: Will you restate it?

BY MR. WHARTON:

Q Dr. Allen, you have testified as to seismicity in California as related to motion along the plate boundary between the North American and Pacific plate, and I believe the question was -- then we had a question also whether you agreed that some percentage of plate boundary motion may be distributed to the offshore fault zone. If you could go back and answer that particular question again?

A When you say some percentage, I think the answer is yes. I think it is true of any earthquakes or any active fault in the State of California or even Nevada, but mechanically those earthquakes and the movements on those faults are somehow related to this overall plate motion.

Insofar as we have earthquakes and active faults

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offshore, I assume they share in that plate motion.

Q Based on your knowledge of the motion along the plate boundary at present, would you say that the likelihood of motion along the plate boundary is higher now than it has been, say, 50 years ago?

A I don't quite understand.

Q I am probably not phrasing the question very well. I am asking if the motion along the plate boundary at the present time, between the North American plate and the Pacific plate, whether your knowledge of the state of the plate motion at the present time would indicate that the chances of an earthquake along the plate boundary are more now than they were, say, 50 years ago?

A It depends on what you mean by motion. I think we have every reason to believe that the plate motion itself is going on at a fairly constant rate and I don't know of any evidence that that has changed over the past 50 years.

Insofar as that is reflected in specific earthquakes, I think it is true that we have a major seismic gap, so to speak, in the Southern San Andreas fault, which of course is a major element of the plate boundary in Southern California, and I think all seismologists and geologists agree that a major earthquake -- a great earthquake -- in the Southern San Andreas fault would come as no great scientific surprise any time now.

ghp 6

The chances of that happening now are greater than they were 50 years ago, yes. But that is not to say that the overall plate motion has changed.

Q You answered the question I wanted answered without me asking the question properly and I thank you for that.

Now this increased likelihood of earthquake motion on the San Andreas fault, would this also contribute to an increased likelihood of earthquakes on the offshore fault?

A I don't think we can say that, not that I am aware of.

Q Are you familiar with the work by Kerry Sieh from Cal-Tech in which he analyzes trenches along the San Andreas fault to estimate recurrence intervals?

A I am generally familiar with that, yes.

Q Is it true that he estimates it to be the recurrence interval for an earthquake with a magnitude greater than 8 on the southern segment of the San Andreas fault? That is, has he made estimates regarding that?

A He has made estimates of the recurrence interval of earthquakes at Pallet Creek, the specific locality where he dug his trenches southeast of Palmdale and I think he assumes that the earthquakes he is looking at are large earthquakes. I don't recall whether he puts a number 8 on it, but he assumes they are earthquakes comparable to the 1857 earthquake which, indeed, was a great earthquake.

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JUDGE KELLEY: Mr. Wharton, could you spell out what you are referring to, the work?

MR. WHARTON: Mr. Chairman, could we possibly break for lunch right now? I have more to do and I want to go over some of these areas with Mr. Barlow.

JUDGE KELLEY: Very well, let's break until 1:00 o'clock.

(Whereupon, at 11:52 a.m., the hearing was recessed to convene at 1:00 p.m.)

AFTERNOON SESSION

1:03 p.m.

JUDGE KELLEY: We are back on the record.

Mr. Wharton, you can resume.

MR. WHARTON: Yes, I have finished questioning this morning on earthquake research for safer citing of critical facilities. The document had been identified and authenticated by Dr. Allen, and I at this time would like to identify it as Intervenors' Number 13, and move that it be submitted -- accepted into evidence.

(Whereupon, the document referred to was marked for identification as Intervenors' Exhibit Number 13.)

MR. PIGOTT: I am going to object to it being accepted into evidence as an exhibit, as a probative exhibit on which we were expected to rely for purposes of the issues of this case. I don't think it goes to a particular issue in this case. Although Dr. Allen is certainly one of the members of the panel, I don't think he was here to speak for the panel. In fact, I think that was specifically stated earlier, and as such I would be surprised if he is in fact sponsoring this document to be a piece of evidence in this proceeding, so I would object on the grounds of relevancy and lack of proper foundation and sponsorship.

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MR. WHARTON: Mr. Chairman, I don't -- the document requirements such as this are -- my understanding is that they be authenticated, that the person who participated in the authoring of a particular document, Dr. Allen, has testified that he did a draft of the document and then reviewed the document and agreed with the findings of the document. While he is not testifying for all members of the panel, we have the authentication and every indication of the trustworthyness and reliability --

JUDGE KELLEY: Well, I don't think -- let's all stipulate that that is a genuine document. I don't --

MR. PIGOTT: No problem there.

JUDGE KELLEY: Okay. It is the report of that panel. Okay.

MR. WHARTON: As far as the relevancy of the document itself, it -- I think a very good statement of the consideration that should be looked at and it is a consideration of the criteria as put together and agreed to by a highly qualified committee on seismology. They do discuss the citing of critical facilities and geology and geophysics major problem areas, and basic needs for earthquake research.

As such, I think the document is probative of the very issues that this Board has to decide, and may help the Board in reaching their decision by looking at some of the areas that the experts in the field say you should be

looking at for citing critical facilities.

JUDGE KELLEY: Does the Staff have comment?

MR. CHANDLER: We would object to the admission for the same reasons basically as the Applicant. Primarily on grounds of relevancy we oppose it.

JUDGE KELLEY: Well, earlier we had some quotations from this report and Dr. Brune's testimony, and overruled a motion to strike or much the same grounds as to that two pages or so. It is a matter of hearsay law. Looking for example at the federal rules of evidence, and things like this, it can be admitted, but the Board has some concern -- I have been very grateful that so far the parties have not come in with great stacks of article reprints to prove their cases, and you know, if you literally applied the federal rules of evidence in this regard, there wouldn't be much one can do that under those rules, which again, we are not bound by, but we can look at for guidance --

Mr. Wharton, I just wonder whether the entirety of this report has that much to do with what we are after here. I did overrule that motion the other day with respect to two or three quotes. But it seems to me to be another thing to go to the whole document.

MR. WHARTON: Mr. Chairman, I would address your attention to the section number six, which we haven't gotten into on direct examination for purposes of brevity, because

I believe what is in there pretty much speaks for itself, but it is an area that is in contention here, and that is whether or not there has been adequate study of these areas and this sets forth the recommendation of this particular body of the needs for earthquake research.

I believe that, again, along with the section four and five, adds credence to the relevancy of this particular document, and I believe what assists the Board in directing their attention to the areas they have to consider in deciding whether to grant the operating license.

MR. PIGOTT: Mr. Wharton indicates a use of this document far worse than I had ever suspected, that he -- although we have one of the people who participated in its preparation, we are not sort of being put on notice that certain chapters would be relied on for their probative value, and with all due deference, I think a couple of them are out of the areas that Dr. Allen professes to have his particular expertise, and yet we would apparently be faced with this as probative evidence to be used in coming to a decision in this matter, and that is, I think, totally inappropriate, and I would -- if on no other ground than the hearsay rule.

MR. WHARTON: Dr. Allen is available for cross examination.

JUDGE KELLEY: Well, but the very amorphous nature of these issues makes that rather difficult.

Mr. Wharton, we are going to deny your motion to put this entire report into evidence for lack of any other term -- better term, just lack of specificity. Now if you want to come back and you want to earmark, and we can have some further argument if you think it is worthwhile, over particular portions of the report that are especially relevant, then we can leave the door open for you to do that.

Once again, the quotes in Dr. Brune's testimony from this report make the point that it is an area of uncertainty and where there isn't enough data, and I expect you could get people to agree to that almost by acclamation. Where you get differences is in degree.

I don't think putting this report in adds great deal to the record or our knowledge of these points, and does get us into a rather lengthy document, the relevance of much of which is dubious, so I will leave the door open for you to come back later with the specification of parts, if you want to do that.

MR. WHARTON: Very well.

I have just distributed to the parties, the Board, and to the Reporter an article entitled Relationship Between Seismicity and Geologic Structure in the Southern California Region by C.R. Allen, Pete St. Amand, C.F. Richter and J.M. Nordquist, which I would at this point identify as Intervenors' Number 14 for identification.

(Whereupon, the document referred to was marked for identification as Intervenors' Exhibit Number 14.)

BY MR. WHARTON:

Q Dr. Allen, first of all, did you participate in writing this particular article?

A Yes, I did.

Q Turning specifically to page 791, starting at page 790, implications for seismic zoning, going down to number four, it states there, "shallow aftershocks of a major earthquake may do more damage in a local area than the main shock itself, and aftershocks of a major earthquake are distributed over a much wider area than many people appreciate. For example, a local aftershock of the 1952 Kern earthquake caused far more damage in the city of Bakersfield, than did the main shock 40 kilometers away, one month earlier. A more dramatic example of this phenomena is illustrated by figure 12 which shows the major aftershocks of the 1960 Chilean earthquakes," and then it shows a figure 12.

Did you write this particular part of the article?

A I recall preparing this particular diagram, and I suspect that I probably wrote at least the first draft on this particular section, yes.

JUDGE KELLEY: Excuse me, does Chile look that

much like California?

MR. WHARTON: We will get into that.

JUDGE KELLEY: Okay.

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Q Turning to that paragraph you say, for example, aftershock of 1952 Kern County earthquake. Do you recall what the size of that Kern County earthquake was?

A The main shock itself was magnitude 7.7M_s and 7.2M_l. The aftershock that occurred about a month later was somewhere around magnitude 6, as I recall.

Q Turning to Figure 12, which is up on the viewgraph, would you explain what you are trying to show by that particular figure?

MR. PIGOTT: I would make an objection. I would like to know what counsel is trying to show. I think we have a real relevance problem with this whole line of questions and would object on that ground.

MR. WHARTON: Mr. Chairman, this goes into the area of aftershocks after a major earthquake and I believe we have agreed that a 7.0 earthquake is a major earthquake.

The distance away from the source of the major earthquake that historical records have shown, you can find aftershocks close to the particular site of the initial earthquake and that these particular aftershocks may go anywhere from five kilometers to 40 miles to, as shown in this particular map which is the projection of the aftershock in the Chilean earthquake projected on a map of the State of California for purposes of illustrating the extent of aftershocks after a very major earthquake.

JUDGE KELLEY: I just would like a little better notion of where this goes. Does this take us -- for example are you going off the OZD and over to the San Andreas or something?

MR. WHARTON: For example, we are getting into whether there is a 7.5 on the OZD, could you have aftershocks at the plant 8 kilometers away.

JUDGE KELLEY: When I see 40 kilometers, that surprises me. I didn't know that and then I wonder if we are going off to some entirely different fault structure.

MR. WHARTON: No, I am hoping to lay this out as a principle and then connect it, if we can, with Dr. Allen regarding the OZD.

MR. PIGOTT: We certainly are, Mr. Chairman, off the OZD. The Kern County earthquake obviously is many miles distant and it may, in a very general sense, be related to the Southern California tectonics, but we are apparently getting mixtures of aftershocks in Kern County, views of aftershocks from an earthquake in Chile from a completely different type of a fault, and if that is to be related to the OZD, I still fail to see the relevance of that.

JUDGE WHARTON: If I understand Mr. Wharton, he is first getting into the phenomena of aftershock scatter, if you will?

MR. WHARTON: That is correct.

JUDGE KELLEY: Well, I think the economical way right now is to go ahead. I can see this as having possible relevance and rather than arguing about it any longer, why don't you pursue it for a while.

BY MR. WHARTON:

Q Could you explain what you are illustrating by Figure 12?

A I made a statement in the article -- or remade a statement -- that the aftershocks of a major earthquake are distributed over a much wider area than many people appreciate.

The purpose of this illustration was to point that out, that is, to illustrate for a truly great earthquake, such as the Chilean earthquake, that the distribution aftershocks indeed covered a very wide area equivalent to the entire State of California.

I should point out, of all the things in this article, this particular diagram is the one that has been criticized the most and several of my colleagues said it would some day come back to haunt me.

I very strongly believe the statement I made, namely that aftershocks of a major earthquake cover a larger area than many people visualize and I fully subscribe to the fact that the Chilean earthquake aftershocks were indeed spread over an exceedingly wide area, much larger than people realize.

Having planted that map on the State of California,

many people say it is not quite fair.

Now I made the statement later on page 791. I say, inasmuch as great historical earthquakes in California have not been associated with breaks as long as the 1,000-kilometer length of the Chilean earthquake, such widespread aftershock distribution for great California earthquakes is probably unlikely.

Figure 12 does emphasize the fallacy in predicting seismic hazard solely on the locations of active faults or the epicenters of great earthquakes themselves. I will stand by that statement.

I might say that at the time this was written back in the early '60's, there was still some debate about the focal mechanism of the Chilean earthquake. At that time there were several people who claimed the Chilean was a strike slip earthquake comparable to earthquakes that had occurred on the San Andreas fault.

So it was not immediately obvious that the Chilean situation was really irrelevant to California. We now know, of course, that the Chilean earthquake was not a strike slip earthquake in any sense whatsoever. Instead, it related to subduction processes.

We now have a better idea of how that subduction zone looks and indeed the factor of the aftershocks which were widely distributed is a major part, we think, related to the

fact that the fault plain is a rather shallow and dipping fault plain extending underneath the Chilean continent, and this is certainly not the case in San Andreas.

So I tend to agree that the map itself could be misinterpreted. Nevertheless, I emphasize I do stand by my statement that aftershocks are distributed, at least in some earthquakes, over a much wider area than has been appreciated and there are certainly areas where aftershocks have caused more local damage than has the main shock itself.

We do not fully understand this situation. We had an earthquake in Parkfield on the San Andreas fault in 1966 where essentially all of the aftershocks fell right square on the same fault plain that broke during the shock itself and there was very little areal distribution of aftershocks.

On the other hand, two years later we had an earthquake in the Morego Valley area, also on a branch of the San Andreas fault, also a strike slip, of about the same magnitude and the aftershocks were spread over a very wide area.

So the distribution of aftershocks is something -- why they are different from one earthquake to the next, we do not fully understand.

However, the idea that there could be an earthquake in California on the San Andreas fault that would have aftershocks distributed as is shown on this map, I think is utterly incredible and I think we essentially stated that at this time

I think I would reinforce that now.

Q I am looking more toward the smaller scale, I belive in the 1952 Kern County earthquake where you stated it caused more damage in Bakersfield than the main shock 40 kilometers away one month earlier. Could you describe the damage from the aftershock as compared to the original earthquake? What was the difference?

A Well, it simply caused more damage to the buildings in the Bakersfield area than did the main shock itself. I assume the intensity of shaking, at least at frequencies that were damaging those structures, were simply greater during this aftershock than during the main shock itself.

I might say the classification of that shock as an aftershock again is a matter of some debate because the word, aftershock, has never really been very accurately defined.

I would consider it an aftershock. I suppose someone might argue that that was sort of an independent earthquake because it was some 40 kilometers away, which is a fairly surprising distance away from the fault for this to happen. Nevertheless, I think they are mechanically related.

That is, the fact that we had this aftershock a month after the main shock somehow was mechanically related to the fact that we had the main break 40 kilometers away on the White Wolf fault. It was not on the same fault.

Q Was the aftershock in Bakersfield on a specific fault?

A Well, insofar as we know virtually all earthquakes occur on faults so I assume that the Bakersfield aftershock did also.

Q But you don't know specifically what the fault was or the nature of the fault?

A I don't recall at the moment specifically. There are some faults mapped in that area, particularly from subsurface oil well data, and as I recall there was some reason for saying that that particular aftershock might have been on one of these faults, but as you well know, it is very dangerous to very arbitrarily assing epicenters to faults.

Q On the basis of your knowledge of aftershocks, do you think it is possible that a magnitude 7 earthquake on the Newport-Inglewood-Rose-Canyon fault zone could have aftershocks in the magnitude of, say, 5 to 7?

A Well, certainly it is very common for aftershocks in major earthquakes to have magnitudes that are up to, let's say, one magnitude unit smaller than the main shock.

Generally speaking the larger aftershocks tend to occur closer to the main fault than do the smaller aftershocks. I think this is exemplified, for example, by the 1968 data from the Braga Mountain earthquake, but certainly it is, in my opinion, possible that aftershocks of a

magnitude 7 earthquake could occur some distance away from the main cause of the fault and we have seen this time and time again.

Generally speaking, of course, they are of such magnitudes that they cause considerably less ground shaking than did the main shock itself, although the Bakersfield situation is an exception to this.

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Q Could these aftershocks on Newport Inglewood fault, could they be as much as eight kilometers away from the epicenter on the Newport Inglewood fault?

A I assume that is possible, yes.

MR. WHARTON: Mr. Chairman, I have marked this as Intervenors' Number 14 and I don't believe that we have been trying to put too many documents into evidence. This is a document that Dr. Allen has testified to and put it together in its entirety because on previous occasions I have been requested to put documents together in their entirey. I would submit that the document, pages 790 and 791, and the top of 792, along with figure 12 of this particular document be admitted into evidence.

JUDGE KELLEY: Pages 791 --

MR. WHARTON: 790, starting with implications for seismic --

JUDGE KELLEY: Allright.

MR. WHARTON: 791 --

JUDGE KELLEY: The top of 792 and the figure?

MR. WHARTON: 792 and the figure, yes.

MR. PIGOTT: I am going -- I think I am going to have to object to a portion of this particular document going in. I think if we are going to get it, we have to get this one in its full context. We do have the author in this case. I don't think that it is appropriate to have just a portion

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of the document.

MR. WHARTON: Well, if you want the whole document, I will move for the whole document.

JUDGE KELLEY: You would have no objection to including the whole document?

MR. PIGOTT: Not to putting the whole document in, no.

JUDGE KELLEY: All right.

MR. WHARTON: That is fine.

JUDGE KELLEY: This is as evidence of what it discusses --

MR. PIGOTT: Whatever it says.

MR. CHANDLER: Staff has no objection.

JUDGE KELLEY: So ordered.

(Whereupon, the document previously marked for identification as Intervenors' Exhibit Number 14 was received in evidence.)

MR. WHARTON: For the record, I have just distributed to the Board and to the parties and to the Court Reporter, two copies, and I will supplement one more copy to the Court Reporter of an article entitled Earthquakes, Faulting and Nuclear Reactors by Clarence Allen, and I would mark that as Intervenors' Number 15 for identification.

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(Whereupon, the document referred to was marked for identification as Intervenors' Exhibit Number 15.)

BY MR. WHARTON:

Q Dr. Allen, would you take a minute to look over that article?

A Yes.

Q Did you write this article?

A Yes, I did.

Q Did you write it in its entirety?

A Insofar as I know, yes.

Q The article as submitted to you is not complete in that I am going to be referring to page 13 of that article, 13 and 14 of that article, and I might note the copy I have does not -- has a -- you cannot read the number 13 at the bottom of the page, but it is identified by a picture of what appear to be rolling hills.

A That is a fault.

Q Do you have a copy of the full article yourself, Doctor?

A Yes, I have a reprint of the article.

Q Okay. Would you compare your reprint to page 13 and 14 as submitted?

A Insofar --

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MR. WHARTON: Correction. The article is complete.

JUDGE KELLEY: It is?

MR. WHARTON: I thought it was parts. It is a complete article.

JUDGE KELLEY: All right.

MR. WHARTON: Do you need something, Dr. Allen?

WITNESS ALLEN: Oh, I was looking for something you put out that quoted from this. Oh, here, I guess it is in -- yes, okay.

BY MR. WHARTON:

Q What is that you are referring to?

A Well, this is in the -- I don't know what you call these things. The Intervenors' answers to interrogations propounded by the Southern California Edison.

Q Okay. Fine.

A You quoted from this -- or purported to quote from this document.

Q Okay, referring to page number 13, there at the first paragraph you state, and I take it this is your writing here --

A As far as I know, yes.

Q In the case of nuclear reactors, the specification of the maximum credible earthquake for which public safety must be assured demands extreme conservatism for two

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principle reasons. One, the consequence of some types of serious failure in a nuclear facility must be guarded against, even if their likelihood is exceedingly remote, and two, the historic record of earthquake occurrences is so short that it cannot encompass the entire spectrum of possible events. Almost every large earthquake that has occurred in California has proved to be surprising in terms of what would have been expected by geologists, seismologists and engineers at the time. The recent unexpected events associated with the relatively small 1966 Parkfield Cholame earthquake emphasized once again how little we know about what constitutes an average or likely earthquake. For this reason the present state of knowledge demands an unusually conservative approach to the specification of seismic citing and design criteria for structures such as nuclear reactors and dams that are critical to public safety.

Do you still -- when was this particular article written?

A This was written in 1967, as I recall.

Q Do you still agree with the statements made there?

A Basically, yes. I should point out that you -- in your document you quoted this, as you have now, with a couple of errors I can point out. But also, you sort of stopped short of the final sentence of the paragraph, --

Q Yes.

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A -- which says perhaps we can become less conservative as we learn more from research studies and from experiences during major earthquakes in the future, and I think that is an important concluding sentence for that paragraph, but I still stand by what I said. Yes, I think we must continue to be conservative, and as far as I know, there is not great disagreement on that matter.

Q Okay, since this article was written, have we learned more from research studies and from experience during major earthquakes to allow us to become less conservative?

A I think so, yes.

Q Is there any way you could quantify the amount of conservatism that we could reduce since this article was written?

A That is hard to say, but as we will presumably talk about later, one of the reasons I wrote this article was because we had just completed or were just in the process of completing the Bolsa Island meetings, and one of the things as you well -- as you all well know, is that we suggested a magnitude eight earthquake. I would no longer suggest that earthquake, and I think this is the result of knowledge we have gained and experience we have had in the meantime, particularly looking at the localities at which magnitude eight earthquakes occur around the world, so in a sense yes, I think we have benefited from observations, from our

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research, and to some degree we can be less conservative than we were 15 years ago. That doesn't mean we still should not be conservative, and I still stand by the statements made here. We must indeed be exceedingly conservative.

Q Very good. You did bring up the Bolsa Island Report and that was the next area I was going to get into.

A Before we leave this --

Q Yes.

A -- may I point out a couple --

Q Sure.

A -- corrections in the -- since it is a matter of court record apparently, on page 28 of this document --

Q Is this the answers to the interragatory?

A Yes.

Q I don't know that we -- if it is something that you want to do -- I don't know that it is necessary for the record --

JUDGE KELLEY: It is not necessary for the record.

WITNESS ALLEN: Okay. There were a couple of words left out that -- at least one word that did tend to change the meaning in that.

JUDGE KELLEY: The reason is they aren't in evidence. They are there to help the parties prepare.

WITNESS ALLEN: And I felt rather strongly that

that final sentence should not have been omitted from the paragraph because it did tend to put things in somewhat of context.

MR. WHARTON: Well, we have straightened that out now since we talked about it.

WITNESS ALLEN: Okay.

BY MR. WHARTON:

Q Getting into the Bolsa Island Report, and you indicated as an example of less conservatism that you may not agree with the magnitude eight that was originally in the Bolsa Island Report, so I think we probably should be talking about that, since it is a report that concerns the Newport Inglewood fault zone.

I have just distributed to the Board and to the parties copies of the geological seismological factors pertaining to the proposed construction of a nuclear power desalting plant in Bolsa Island, California, report to Stuart L. Udall, Secretary of the Interior, October, 1967.

It was pointed out by Mr. Pigott, there are some notations on the first page that, for purposes of the reuse of this article are to be ignored. I would mark this as Exhibit -- Intervenors' Exhibit -- I believe it is 16.

(Whereupon, the document referred to was marked for identification as Intervenors' Exhibit Number 16.)

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MR. VOGLER: Mr. Wharton?

MR. WHARTON: Yes.

MR. VOGLER: I didn't hear your explanation of the --

MR. WHARTON: Of the --

MR. VOGLER: I didn't have it in my hand.

MR. WHARTON: The relation of the --

MR. VOGLER: What is the writing on it?

MR. WHARTON: The writing is a -- on the top page is a note for someone which copies to -- which part of the report to copy.

MR. VOGLER: What about the one in the middle?

MR. WHARTON: Okay, the one that says note page 18, I don't know what context that came in there. That is to be ignored and treated as if it is not there.

BY MR. WHARTON:

Q Dr. Allen, turning to page 1 of the Bolsa Island Report, I note that your name is second on the list of people as they refer to as membership. Is that correct?

A Yes, I assume it is second because of alphabetical listing. Yes.

ghp 1

Q Did you participate in writing this particular report?

A Yes.

Q Turning specifically to page 18 of this report --

JUDGE KELLEY: Could we get a little more background on this first?

MR. WHARTON: Yes.

JUDGE KELLEY: For example, it is a report on Seismic Hazard for a Nuclear Power Plant. What does the Atomic Energy Commission have to do with that issue? Why was the Secretary of Interior interested in the matter?

MR. WHARTON: I don't know all the background on this and I am sure there are people in the room who know more about it than I do.

JUDGE KELLEY: Okay.

WITNESS ALLEN: There was a proposal to build particularly a desalting plant and then for some reason a procedure was set up by appointing this committee with Harry Sieh as chairman, to advise the Department of Interior on it.

How the AC was involved, I just don't know.

JUDGE KELLEY: Maybe they never got to the point of filing an application for a reactor. I am just curious. If we are going to have this in the record and talk about it, let's just have its standing and parentage a little clearer than it now is. It would be helpful.

Does the Staff have any intelligence on this?

MR. VOGLER: Not at the moment.

JUDGE KELLEY: Go ahead. Perhaps at some later point we can fill it out.

MR. VOGLER: Excuse me, do you want us to try and find out?

JUDGE KELLEY: Would you look into the background a little bit? Was there ever an application by anybody to build a reactor? Did the AEC ever review this site or seismic, those sorts of things?

MR. VOGLER: Fine. We will look around our group. I believe we might have some people who know the history of this particular one. I might ask, if this is going to be proposed as an exhibit which seems to be the case, if we could have the kind of background as to whether or not this witness is an appropriate sponsor for it.

BY MR. WHARTON:

Q Dr. Allen, you stated that you participated in writing this report?

A Yes, and before I am accused of plagarism, I should perhaps point out that I apparently specifically wrote at least the first draft on parts of this report because I see that some of the language here is almost exactly the same as the language in this document we were just talking about, although a couple of the words -- exceedingly was modified to

very, apparently on the advice of my more sobor colleagues -- but I do recall that I was heavily engaged in this particular part of the report, yes.

Q Did you review the final report before it was published?

A Yes, again the entire panel reviewed it, although I emphasize that the panel consisted of people with different expertise in different areas, and we all reviewed the report although some of us were much more concerned with some parts than others.

There was a particular problem here that had to do with the fact that this was to be on an artificial island built offshore so there was a considerable problem on soil stability and that is really not my field of expertise. That was one reason Dr. Seih was chairman of that particular group because that was the particular problem on that particular proposed facility.

Q In the area on seismological consideration, starting with page 18, is that the area of seismological consideration that you wrote the draft?

A Yes. I at least apparently wrote part of the draft. I wouldn't say I wrote the whole draft.

Q Starting on page 18, second paragraph, if you could review that whole second paragraph, do you recall whether that is a statement -- whether that particular paragraph -- was

written by you?

A I think it was and it is word-for-word the same as the paragraph in this volume except for the use of the word very instead of exceedingly, and modifying the word remote.

Q Okay, so I take it that you have read that paragraph before and you say you basically agree with that and would you say that you basically agree with this paragraph at the present time?

A Yes.

Q Going down to the next paragraph, it states, in view of the mandatory conservatism, we suggest that the maximum earthquake for which public safety might be assured should be a magnitude 8 on the Newport-Inglewood fault or in one of the parallel offshore breaks.

In addition a magnitude 8.5 earthquake must be assumed in the more distant San Andreas fault or one of its major branches.

Would you still agree with the entirety of that statement?

A No, I would not and I note that it was followed by the sentence, although we consider the probability of a magnitude 8 shock in the Newport-Inglewood plant to be exceedingly low in the life of the plant, the present state of knowledge does not allow us to rule out the credibility of such an event.

What I am stating is that I think that the state of knowledge has, indeed, changed.

In saying that, incidentally, I helped write this. I fully agreed with it when it was written, but as I have told you on several occasions, or Glen Barlow in the past several months, the fact that I no longer agree with that number is not a matter of news to you, I think.

Q Have you published any retractions or disagreements on this report in writing, or distributed them to anyone else?

MR. PIGOTT: I object on relevancy, Mr. Chairman. If the gentleman says it is no longer his opinion, it is no longer his opinion.

JUDGE KELLEY: Sustained.

BY MR. WHARTON:

Q Would you agree that at the present time a 7.5 earthquake on the Newport-Inglewood --

MR. PIGOTT. Objection as to no foundation laid for this witness having made any kind of a study that would allow him to come to a current precise assessment of the maximum magnitude on this particular event.

MR. WHARTON: Mr. Chairman, I was going on the basis that he made this before. I can simply go into foundation. He has stated that he has reassessed Newport-Inglewood and in his reassessing it I think we have the foundation for his knowledge.

JUDGE KELLEY: The reassessment I understood to be general advances of seismology and not subsequent studies of that area.

Let me ask you, Doctor, since that time have you done any site-specific, if you will, studies of the geology and seismology in that fault zone?

WITNESS ALLEN: Well, I think in two contexts the answer is yes. It was subsequent to this, of course, that I was a consultant to the ACRS and certainly at that time we considered at least the Newport-Inglewood fault zone, or what at that time they thought to be it further south.

I think at the time this report was written there was not great concern about how far south the fault extended and indeed our stipulation of the earthquake here had to do with the segment of the fault opposite Bolsa Island, not what somebody might visualize the total length of the fault to be.

I would also say that the Newport-Inglewood fault is a major fault of Southern California and it is going to continue to be of interest to us in terms of seismicity, in terms of trying to understand the tectonics of the State.

No, I have not done site specific work, I guess, in the Newport-Inglewood fault but certainly something like other faults in Southern California, I have been continually concerned about it.

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JUDGE KELLEY: When you say Newport-Inglewood, in this proceeding, as you may know, we have some terms of art. Are you familiar with the so-called OZD?

WITNESS ALLEN. Certainly at the time we wrote this report, no. I think we assumed that the Newport-Inglewood fault ended opposite Newport Beach, so that is the context that I speak of here.

JUDGE KELLEY: The part in this report was --

WITNESS ALLEN: That segment.

JUDGE KELLEY: Now when you consulted to the ACRS later on, did that involve -- to the Commission, did that involve any different length fault?

WITNESS ALLEN: As I recall, and this was some time ago, at that time the Newport-Inglewood, that name, was extended farther south. There was some debate at that time as to exactly how continuous it was, or in particular how it might connect into the Rose Canyon fault.

But certainly, as I recall, the name we were using at that time was the Newport-Inglewood fault zone and not these various initials that are now being used.

JUDGE KELLEY: Did I understand you correctly earlier -- maybe I shouldn't put words into your mouth -- I thought when you said that you wouldn't say 8 today, you weren't referring so much to the particular geology of that area as you were to general advances in your science. Was I

wrong about that?

WITNESS ALLEN: We may get into this problem of why I have modified my position but it has to do with the nature of that fault zone in the area of Bolsa Island and I would just as soon talk about that area more than the area offshore from San Onofre since I am not cognizant of all the recent work that has been done offshore.

JUDGE KELLEY: I think I did misunderstand you. Thank you. Go ahead.

BY MR. WHARTON:

Q You stated, I believe, on the basis of new knowledge of less requirements of conservatism, that you would reduce the magnitude shock which you had predicted in the Bolsa Island report.

I would ask you now, if you were to be writing this report today and using the same level of conservatism, what would you suggest the maximum earthquake for which public safety must be assured would be?

MR. PIGOTT: I really must object. I heard the Board's questioning of Dr. Allen, but I really think that in a case such as this requiring a precision such as this that the foundation for this particular kind of an assessment has not been made.

JUDGE KELLEY: Perhaps you could ask the witness a little more about his work in that area.

BY MR. WHARTON:

Q Dr. Allen, what kind of research did you do in writing the Bolsa Island report to recommend a magnitude of 8 on the Newport-Inglewood fault at that time?

A Our justification for that number is not very adequate. On the following page, on page 19, I think it states that we were particularly concerned with fact that the magnitude 7.1 Imperial Valley earthquake in 1940 and the magnitude 7.75 Kern County earthquake in 1952 occurred on relatively short faults.

In particular we were concerned that the 1952 earthquake occurred on a fault of not very great length and it still, as a matter of fact, I think is well short of the average for faults -- for earthquakes -- of that magnitude.

I think the primary reason that we came up with a magnitude 8 shock is because of our comparisons with the White Wolf fault where we had what appeared to be a very surprising event -- a surprisingly large event -- on a relatively short fault and this tended to create a concern for Newport-Inglewood fault which is even greater length, of course, an on which the White Wolf fault occurred, apparently.

Subsequent to that time, many of us have spent a lot of time looking at areas around the world where magnitude 8 earthquakes have occurred, large earthquakes, trying to see what kind of geologic characteristics are typical of those

areas.

In particular I think it has become recognized since this time, more than it was in 1967, that there are some major differences between strike slip areas and areas of vertical faulting.

Here was a case where we were comparing an admittedly strike slip fault -- the Newport-Inglewood fault -- with the White Wolf fault which at least as a very large vertical component to it.

I think one of the things we have learned is that the mechanical characteristics of strike slip faults are indeed somewhat different from those of vertical faulting.

So I think it is primarily on the basis of looking -- and I have done this myself and other people have written many articles on this -- on the kind of areas where many large earthquakes have occurred.

For example, I spent some time after this looking at the North Anatolian fault in Turkey where we had a magnitude 8 earthquake in 1939, looking more carefully at the areas of the 1906 and 1857 earthquakes.

I have spent some time since then looking at the Bocono fault in Venezuela which apparently caused a major earthquake with strike slip displacement in 1812. I spent some time in New Zealand looking at some of the major faults there that have caused large earthquakes of strike slip nature.

On that basis it seems to me that an earthquake as large as magnitude 8 does not appear to be an event of any reasonable likelihood on this part of the Newport-Inglewood fault.

It seems to me the nature, the branching nature, the fact that we fail to see continuous -- evidence for continuous recent displacement at the surface -- that these are simply not characteristics of the kinds of strike slip faults that have generated truly large earthquakes.

Therefore, I am inclined now to come down somewhat from that number magnitude 8, and this is on the basis of looking at lots of these areas and reading the studies that have been done by others, say on the Montago fault in Guatamala, which was a strike slip earthquake of not even magnitude 8, but approaching it, or the Lituya Bay earthquake in 1958 in Alaska on a strike slip fault.

These faults, it seems to me, have a simplicity and a continuity of them, not to speak of length, that in general I do not see on at least this segment of the Newport-Inglewood fault.

Q On the basis of this, what would you redice your estimate to?

A I think it would be in the magnitude 7 to 7.5 range. I say range because I have not been assigned the task of coming up with a specific number. I have often criticized

the Geological Survey for always giving magnitudes in a range that are a half-a-unit apart.

In this particular case, though, I would say it is in the 7 to 7.5 range, rather than magnitude 8. That seems to be the maximum event that I think is at all reasonably likely on the segment of the fault opposite Bolsa Island.

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Q If you weren't looking at the segment of the fault, but if the Newport-Inglewood fault zone was part of a throughgoing fault zone 240 kilometers long, would that raise your estimate, as you presently state it, between seven and seven point five?

A Oh, certainly if the Newport-Inglewood fault were a single well-defined fault zone that extended without all sorts of branches and whatnot all the way from Santa Monica to somewhere in the middle of Baja California, as is typical of the San Andreas fault or the north Anatolian fault, or the fault at Lituya Bay, or some of the faults in New Zealand, then indeed I would be willing to consider not only an eight, an eight and a half on that event -- on that fault.

I do not see that, and at least on the basis of the diagrams I have seen, I am not impressed with the continuity of a single well-defined fault zone throughout this entire area, such as we seem to see on these other faults that have generated truly great strike-slip earthquakes.

Now, I must point out that I have not examined in great detail the offshore data from San Onofre. A great deal of this has been done since the time of the ACRS study, but what maps I have seen, such as those in the testimony of -- what is the one that shows the fault map offshore?

JUDGE KELLEY: Greene and Kennedy?

WITNESS ALLEN: No, Legg. Legg's, there is a map

in here, and sort of a zerox of a zerox of a zerox, but what I see in there does not lead me associate that fault zone with the same kinds of features on which these truly great earthquakes have occurred, and I have spent a lot of time walking along the north Anatolian fault in Turkey. I walked over most of the length that broke in 1938, and I have -- on some of the other, particularly along the San Andreas and on the New Zealand faults, I have tried to look at these very carefully, and many people, some in this room, have tried to do similar exercises on other areas in the world.

To me, the Newport-Inglewood fault as we see it in the area of Bolsa Island and northward across the Los Angeles Basin simply does not look as impressive as do these other features in terms of the capability of producing a truly large earthquake, in terms of continuity or recency of displacement.

Q Okay, one more thing, is in page 19 of the report, they state, "In particular, the two largest earthquakes in the region in the past 30 years, of magnitude 7.1 and seven and three-fourths, both occurred because of displacement on faults that had not previously been recognized as likely sources of major shocks."

A That is true. Prior to the time of the 1940 earthquake, insofar as I am aware, that fault had not -- the Imperial fault, which broke at that time, had not been

recognized by geologists as an active fault, or perhaps even as a fault.

Likewise, the White Wolf fault, that broke at the time of the 1952 earthquake, the fault had been recognized. Indeed, it had been pointed out by Andy Lawson almost a hundred years ago, but I don't think it had been particularly considered by geologists as a feature that was high on their list of faults most likely to generate a large earthquake.

Times have change a great deal, and I think we are in a much better position now to recognize those faults that are most likely to produce major earthquakes, and this has certainly been one of the major accomplishments of geological investigations in Southern California and elsewhere in the world over the past ten or 15 years, the trenching of faults, the mapping of these faults, we have been surprised.

Even the San Fernando earthquake, I think we have to admit, occurred on a fault that most of us had not recognized as one that would be high on our list of major earthquake-producing faults yet it had been recognized, not widely publicized, but the major portion of it had been recognized as a fault that broke Quaternary strate. Certainly it could have been and should have been and in part was recognized.

So, I guess my statement is that every single major earthquake you have had in Southern California and for

the most part throughout the world, has occurred on a fault that either had been or could have been or at least should have been recognized by modern techniques as a seismogenic fault prior to the time of that event.

I don't know of a single major earthquake anywhere in the world that has not occurred on a fault that was pre-existing, and has not occurred on a fault that had an earlier history of Quaternary displacement. (sic)

There has been some debate on the Inangahua earthquake in New Zealand, some debate on the Meckering earthquake in Australia, but my impression is that even those earthquakes now, people are willing to say that there are reasons that geologists should have recognized them prior tothe time of those events as major active faults with a high degree of activity.

Q Okay, one more question, and it is fairly general. Would an earthquake magnitude M_S 3, located on -- locating the epicenter on a fault, would that necessarily mean that there has been movement on that fault? More or less a definitional question.

A Well, if we have an earthquake of magnitude 3, let us say M_L, and that earthquake indeed was centered on the fault plane, not just a map view, but on the fault plane, then I think insofar as all earthquakes, virtually all earthquakes are caused by shearing, and assuming that focal -- that

surface of shearing was in the same direction as the fault, I think yes, we would have to say that fault has slipped.

MR. WHARTON: I have no further questions of Dr. Allen. I thank you very, very much.

JUDGE KELLEY: Thank you, Dr. Allen.

Let us just consider here for a moment. Mr. Pigott, have you thought about how you would like to proceed, I mean, with regard to Dr. Allen?

MR. WHARTON: Oh, Mr. Chairman, I forgot one thing. Let me go back just a second.

JUDGE KELLEY: Do you have further questions?

MR. WHARTON: No. I believe I identified the Bolsa Island report and I would like to move that the Bolsa Island report be accepted into evidence.

JUDGE KELLEY: Any objection from the parties?

MR. PIGOTT: I think I will -- yes, I object to the introduction of this document. I don't think that Dr. Allen, despite his familiarity of having been on the committee that put it together, is an appropriate sponsor for the document itself, nor do I believe that he purports to sponsor the document, and all its statements, as probative evidence.

MR. WHARTON: Mr. Chairman, if we could narrow it to seismological considerations --

JUDGE KELLEY: Let me ask, Mr. Pigott, what do you

think we are lacking in Dr. Allen as a sponsor? Who should sponsor such a document?

MR. PIGOTT: If anyone were to sponsor it, I would say it would have to be someone designated by the -- either by the committee itself or whoever received it. Now, we do have that he is familiar with it, and he has testified to portions of it, and that will stay in the record, but to put the whole document in for the truth of every word and line contained therein, I don't believe that Dr. Allen has attempted to sponsor it in that capacity, or use it in that capacity, and I think that that is what Mr.Wharton is offering at this time.

JUDGE KELLEY: Well, the seismological considerations beginning on page 18, that we talked about, some of that, doctor, could you refresh my memory on the extent of your authorship of this document? You wrote the seismological sections, correct? Substantially?

WITNESS ALLEN: Not in entirety. For example, on the bottom of page 19, where we go into the nature of the ground motion, that has the ring of Harry Seed to it, as I read it. I can't believe that I wrote that, but the section that was quoted in the middle of page 18, and perhaps the rest of that paragraph, and the rest of that page and the following page, I may well have written that, yes; the first draft of it.

JUDGE KELLEY: Well, Mr. Wharton, again, I haven't had a chance to read this, I am just flipping through, but subsidence problems have got nothing to do with our case.

MR. WHARTON: I agree.

I would move it just be the seismological considerations part. Dr. Allen has testified that he has written a large portion of this and that he has reviewed all of that. I believe that is sufficient for identification, and for the parts relied on in testimony, certainly we go into detail about it considerably. The testimony explains the document.

WITNESS ALLEN: I say, I thought I wrote the first draft, parts of it. Not necessarily a large part of it, because most of the seismological considerations, actually, two and a half pages of that has to do with the design ground motion

JUDGE KELLEY: And as to that part, is ground motion, that kind of thing, particularly within your field?

WITNESS ALLEN: No. No.

JUDGE KELLEY: It is not.

MR. PIGOTT: Then I would also submit we have an incomplete sponsorship of the total seismic criteria. There is a criteria in there of 0.5 Gs being the design basis for the site. We are getting bits and pieces, and --

MR. WHARTON: Mr. Chairman, I maybe shouldn't

bring this up, but I might remind Mr. Pigott that we have 160 pages of anonymous documents, namely the FSR (sic), in evidence here. I am talking here about four pages. If we are talking about hearsay and sponsorship.

MR. PIGOTT: We are talking about context and misconstruction.

JUDGE KELLEY: Well, I am just talking about truth and justice, and is it -- wouldn't it be feasible to split out the ground motion portion from -- where exactly does that --

MR. WHARTON: That starts here, the last paragraph on page 19, and I would be -- for purposes of putting it into evidence, page 18 through the end of the first full paragraph on page 19.

MR. PIGOTT: If I might be heard, that is a part of the problem. The overall -- there was an overall recommendation, which was that, I believe if you study the full document, is that you assume -- or assign the H, but then there is the acceleration value assigned in connection with it. They are -- they are together, in effect, as the seismic design basis for this particular project, and we are getting -- we have one person's --

JUDGE KELLEY: Well, is the seismic design basis for this particular project of any interest to us whatever? I thought that you were pursuing this, because this is

evidence that somebody once thought there might be an eight on that fault zone.

MR. WHARTON: That is correct. It goes into the considerations --

JUDGE KELLEY: You are not getting into what the Bolsa Island project should have been designed to, I would assume.

MR. PIGOTT: If you are trying to compare a seismic design, apparently on a segment or a portion of the Newport-Inglewood, that you should be discussing the full -- or discussing not just one little part of what has been designated, i.e., the magnitude value, but there is also the ground motion value.

We have spent so much time talking about 0.67, I am sure Mr. Wharton realizes that that cannot be divorced from the maximum magnitude. Here, he selects -- here he chooses to bring in someone to talk about having written the first draft, and having knowledge of a portion of it, and just sort of leaving us with half of the story, and --

JUDGE KELLEY: Any comment from the Staff on this?

MR. VOGLER: I have been talking with the gentlemen from my staff, and I didn't hear all of Mr. Pigott's remarks that have just concluded. I understand that you are offering, Mr. Wharton, for the first page and a half?

MR. WHARTON: Yes, that is correct.

MR. VOGLER: And not the last page and a half, or whatever comprises the rest of this chapter?

MR. WHARTON: That is what was objected to by Mr. Pigott. Now, he appears to be saying we should have it in. I am not sure --

MR. PIGOTT: I am saying that we shouldn't have any of it in.

JUDGE KELLEY: All right, we have, as I understand it, a motion, as modified, but a motion from Mr. Wharton, to put in pages 18 and the first half of page 19 of this document.

MR. VOGLER: The Staff doesn't object to that.

JUDGE KELLEY: The Staff does not object?

MR. VOGLER: As limited.

JUDGE KELLEY: It doesn't seem to me, Mr. Pigott, I listened to your argument, but I don't believe that would distort the record, and I am going to grant that motion. So that is admitted in evidence.

(Intervenor's Exhibit No. 16 was thereupon received into evidence.)

MR. WHARTON: I have nothing further for this witness. Thank you very much.

JUDGE KELLEY: Why don't we take a coffee break here, and maybe in the course of that, we can discuss witnesses

and cross-examination a little bit.

(Brief recess)

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JUDGE KELLEY: We are back on the record.

The direct examination of Dr. Allen was completed. He will return tomorrow morning for cross examination, and we will go now to the next witness, Dr. Boore, right?

MR. WHARTON: Our next -- Intervenors' next witness is Dr. David M. Boore, and I will point out that Dr. Boore is a subpoenaed witness. He is not appearing voluntarily.

JUDGE KELLEY: Whenever you are ready.

MR. WHARTON: Okay.

Thereupon

DAVID M. BOORE

having been first duly sworn, was called as a witness herein and was examined and testified as follows.

DIRECT EXAMINATION

BY MR. WHARTON:

Q Would you please state your full name for the record please?

A David Meredith Boore.

Q Dr. Boore, would you please state your educational background and your experience, job experience background?

A I have Bachelor's in geophysics from Stanford University in 1964, a Master's from Stanford in geophysics in 1965, a Ph.D. from the Department of Earth and Planetary Sciences at MIT in 1970. I worked for the Geological

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Survey for two years, '70-'72. I was an assistant professor at Stanford from '72 to I can't remember -- '78 perhaps, and I have been at the Geological Survey since.

Q Do you have any particular specialty area in the area of seismology or geophysics?

A I would say strong motion seismology.

Q Referring first to -- for the record, I have handed out to the parties and to the Board copies of what is called Letters to the Editor, Bulletin of the Seismological Society of America, Volume 70, Number 6, pages 2295 through 2297, December, 1980, entitled Peak Acceleration From Strong Motion Records, a Post Script by David M. Boore. Intervenors would like this marked as Intervenors' Exhibit, I believe it is 17?

(Whereupon, the document referred to was marked for identification as Intervenors' Exhibit Number 17.)

Q Dr. Boore, have you had an opportunity to review the paper that I gave you?

A Yes, I have.

Q Does the paper consisting of three pages with the title Peak Acceleration From Strong Motion Records, a Post Script, appear to be complete?

A I don't understand.

kw-3

Q Is this --

A This is the --

Q -- paper that I --

A -- way it appeared in the Bulletin, if that is what you mean.

Q Fine. Now, do you claim authorship of this particular document?

A Yes, I do.

Q In the process of writing this document, did you perform studies or -- perform studies on the directivity in the Livermore earthquake?

A Yes, we considered that.

Q Okay, and your paper on page 2295, the second paragraph, even with smaller prediction intervals, however, a large uncertainty still exists in the prediction of peak acceleration. One factor contributing to the scatter is suggested by the data from the Livermore Valley earthquake. We plotted the ratio of peak accelerations from both events recorded at the same site without regard to structure size and corrected for distance against a mean azimuth from the closest points in the rupture surface to the recording site. And then you refer to figure two.

Using the same sites should limit a variation due to site effects. Results show a strong dependence on azimuth and are most easily interpreted as the result of

kw-4

directivity.

Can you further explain the determination that it was the result of directivity that you state here? Maybe I can rephrase the expression -- rephrase the question.

What method did you use to analyze the directivity?

A We simply plotted the ratio.

Q And by plotting the ratio did you come up with a directivity factor?

A We came up with an azimuthal variation, which might indicate directivity. We also plotted some theoretical curves, but those were not intended to actually be a definitive study of the -- to try to explain the observations.

Q Now at the present time would you endorse and stand behind the contents of what is referred to as Peak Acceleration From Strong Motion Records, a Post Script by David Boore and Ron L. Porcella in its entirety?

A When I reviewed this, I was looking primarily at the directivity part, but I would, yes. I would endorse it.

MR. WHARTON: Okay, Mr. Chairman, I would move that this Exhibit 16 be admitted into evidence.

MR. PIGOTT: No objection.

MR. VOGLER: Staff has no objection.

JUDGE KELLEY: So ordered.

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(Whereupon, the document previously marked for identification as Intervenors' Exhibit Number 17 was received in evidence.)

MR. WHARTON: Okay, I just passed out to the Witness and parties and to the Board three copies, and I still have to submit three copies to the Reporter, a -- copies of an abstract from the Bulletin of the Seismological Society of America, Volume 68, Number 2, page 283 to 300, April, 1978, abstract entitled The Influence of Rupture Incoherence on Seismic Directivity by David M. Boore and William D. **Joyner.**

BY MR. WHARTON:

Q Are you the author of this document?

A Yes, I am.

Q Referring to -- in the part entitled abstract -- about three fourths of the way down the page you state, "these models show directivity effects as strong or stronger than the corresponding smooth motion, providing that the average rupture velocity was the same." Did you --

JUDGE HAND: Mr. Wharton?

MR. WHARTON: Yes?

JUDGE HAND: You either misread it or you are reading something that I don't have. It says smooth rupture in the second line of that quote.

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MR. WHARTON: What did I say?

JUDGE HAND: You said motion.

MR. WHARTON: I stand corrected. Thank you. I will read it again.

BY MR. WHARTON:

Q These models show directivity effects as strong or strong than the corresponding smooth rupture providing that the average rupture velocity was the same. Could you explain the way in which you arrived at this particular conclusion or statement?

A You want me to describe the model?

Q Yes, if you would.

A In this case the model is a very straightforward model of a rupture which was made up of a series of segments and on each segment -- well, there was a progression of slip, or of the rupture from one end to the other of, say, an overall fault. We broke it up into a series of segments. On each segment the amount of dislocation or slip was uniform, and the velocity of rupture was uniform on each segment, but adjacent segments could have different slips and different rupture velocities and we studied what the effect would be and the waves radiated from the kind of a model, and we found that if you had simply variable slip in a uniformed rupture velocity, in other words the propagation of loss here is the same on every segment, that you would get a --

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that the radiation -- either looked at it as a -- well, we looked at it in this frequency domain, primarily -- that the spectra would be -- the azimuth variation in the spectra would be similar to that obtained if you had just a smooth rupture.

And if you had variable rupture velocity, and constant slip, the spectra in the directions of rupture could be ctually larger, or there is a bigger difference between the azimuths ahead of the rupture and behind the rupture for that model.

Q Does the directivity observed in the Livermore earthquake indicate a factor of up to ten increased ground accelerations in the direction of rupture?

A Not necessarily. The -- if you refer to the figure, you can see that the ratio --

Q Which figure?

A Figure number -- in the first document, figure number two --

MR. VOGLER: We are a little bit confused over here as to where we are.

WITNESS BOORE: Okay, it is in the short, three-paged document.

MR. VOGLER: The original?

WITNESS BOORE: The original document.

MR. WHARTON: Exhibit 16 -- 17. I think we

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are on 17 now.

MR. VOGLER: Thank you.

WITNESS BOORE: The variation in the ratio over Azimuth is a factor of ten.

BY MR. WHARTON:

Q And would you explain that just a little bit?

MR. PIGOTT: Would you let him complete his answer.

JUDGE KELLEY: Go ahead.

WITNESS BOORE: What we plotted is the ratio at one side of the peak accelerations from two different earthquakes. Okay, that is on the ordinate. On the abcissa is the average Azimuth from the earthquake to the station. And what you see -- it depends on whether you want to think this is a cloud of points or not, but it seems to show a trend, so that as you go from an Azimuth of about 280 degrees, you have, say, a ratio of 0.4, and then as you go to an Azimuth of about 180 degrees, the ratio is about 4.0. It is a factor of ten change in that ratio as you changed the Azimuth, the average Azimuth from the earthquake to the stations.

That is the observation. The question that you asked was whether that means the peak accelerations themselves changed by that much. The data are available, and I don't rec[illegible] -- I don't think they showed that much change. This kind of a factor of ten increase is -- if you had two

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events and they were propagating in different directions, then the actual variation of acceleration in each event can be on the order of the square root of ten.

BY MR. WHARTON:

Q Could you explain how the directivity effects would vary with variation in rupture velocity?

A You mean from the theoretical model that we had?

Q Yes.

A Well, even for the smooth rupture, generally as the rupture velocity approaches the velocity of propagation of the waves, the sheer velocity, since we are considering sheer waves here, and if you are in a forward Azimuth generally the energy or the motion is coming in at a shorter time window and it has correspondingly a larger amplitude.

Q One of the documents that you are an author of is Open File Report 81-365 which I will be handing out shortly, but could you describe your participation in other USGS studies prior to the 1981 publication of the USGS Open File Report 81-365?

A You mean all of my --

MR. PIGOTT: I am going to have to object on relevancy. The question does not seem at all related to anything that we are considering in this proceeding.

MR. WHARTON: Mr. Chairman --

JUDGE KELLEY: What is your purpose?

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MR. WHARTON: My understanding -- there were other studies on acceleration and distance that led up to 81-365. Now 81-365 is, I believe, superseded the previous one, but I think it would get some help with some background on the kind of studies that led up to the document that we are going to be discussing.

JUDGE KELLEY: Well, that narrows it somewhat.

WITNESS BOORE: Do you want me just to recite the papers that we have published?

BY MR. WHARTON:

Q Yes, if you would, recite the papers that you published and what the purpose of the papers that you published prior to 81-365 were.

JUDGE KELLEY: But in the same subject area.

BY MR. WHARTON:

Q In the same subject area, yes --

A Well, it really -- well, the estimation of ground motions -- that is the subject area, and it started with US Geological Survey Circular 672, which was published on the order of 1972 or '73, I suppose, dealing with the Trans-Alaskan pipeline. And then after that we had a Circular, US Geological Survey Circular 795, and following that we published a paper in the Bulletin of the Seismological Society of America which was essentially Circular 795 with some very slight revisions. And then the -- what was it? 81-365,

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which is an Open File Report. It came out -- I don't know the publication date on that -- this year, and at the same time we submitted a paper to the Bulletin of the Seismological Society of America, which is exactly the same thing as 365. We came out with an open file report as a way of ensuring a uniform, unbiased distribution of our papers so they wouldn't have to just rely on pre-prints floating around.

Since then we have received criticisms from the reviewer at the Bulletin and we have revised the paper which is represented by 365 and we have submitted our revision to the Bulletin of the Seismological Society of America.

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Q Let me follow this up. Is there a revision to the open file report 81-365? I will show you the one we have.

A No, this is not the revision. The is the open file report and there is a revision. It was completed last week.

Q Has the revision been distributed yet?

A It has been sent back to the editor or the BULLETIN. It has been sent to our superiors in Washington. We have sent copies to, I think, to Leon Reiter at the NRC, and I am not sure of the rest of the distribution. Dr. Joyner handled that.

MR. PIGOTT: May I ask one question? Does the witness have a copy of that revision?

WITNESS BOORE: Yes, I do.

MR. PIGOTT: Can we see the copy of it?

BY MR. WHARTON:

Q Can you get the copy out?

A Sure.

(Witness obtains document.)

Q Does the revision change any of your results or finding in 81-365?

A Yes, it does, but we don't believe to any significant extent. The equations that we have in 365 have been altered slightly and the effect is -- well, I could go into the details of how it effects it, but for example, in a magnitude 7 earthquake, the mean acceleration has been reduced by about

ghp 2

two percent and the mean-plus-one standard deviation by about four percent.

JUDGE KELLEY: Does the revision that you refer to supercede 365?

WITNESS BOORE: Yes, we consider that it supercedes. 365 is obsolete in our opinion.

JUDGE KELLEY: Is it also an open file, or will it be?

WITNESS BOORE: No, we chose not to make it an open file since it has been accepted for publication and it will appear in the BULLETIN of the Seismologic Society.

JUDGE KELLEY: And right now it has been submitted for publication?

WITNESS BOORE: Yes, and it has probably been accepted. Well, it was accepted subject to revision and we have made the revisions so it will probably appear -- I can't be sure -- probably January or February.

JUDGE KELLEY: This may make the question academic for our purposes, but tell me just what an open file for the U.S.G.S. is, what that means?

WITNESS BOORE: I am not sure I can tell you exactly but it is a fairly informal way of distributing research -- usually data, actually. It is not subject to the same stringent review procedure that a, say, professional paper is subject to, but it does get distributed to various libraries throughout

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the country and it is from a formal distribution list, so it is better than just an author sitting there saying, who should I send this to.

JUDGE KELLEY: But it is essentially the work of particular people and doesn't have the U.S.G.S. stamp on it?

WITNESS BOORE: That is a good question. It certainly looks official from the cover but there is a caveat down there that says, this report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.

JUDGE KELLEY: I think this question came up earlier about 365 and now 365 has been superceded. Maybe we don't have to worry about it. Okay, go ahead.

MR. WHARTON: Mr. Chairman, this is new information to me as far as the revisions. One of the things we were looking at was submitting 81-365 into evidence. It appears now that it has been revised.

I think it is appropriate the author of the article is here, that we have a copy of the article into evidence, but unfortunately I don't have a copy of it. I am inquiring how we can handle this situation short of having Dr. Boore have to come back down and reidentify and introduce.

MR. PIGOTT: The copy is right there.

MR. WHARTON: Okay, that is one.

WITNESS BOORE: I brought two.

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MR. WHARTON: One way of handling this, I suppose, would be --

MR. PIGOTT: Applicants will make copies of it.

MR. WHARTON: If we could have Applicant make copies and stipluate that the revision, when the copies are supplied of the revision, be submitted into evidence in the matter.

MR. PIGOTT: We get one thing at a time. We will make copies. We haven't even seen it yet, let along stipulated it into evidence.

JUDGE KELLEY: Why don't you ask questions on it. I gather you haven't read the revision?

MR. WHARTON: No.

JUDGE KELLEY: If the changes are not that great, perhaps the things of interest to you won't be changed.

MR. WHARTON: I don't know.

JUDGE KELLEY: Was it your intent basically to question on 365?

MR. WHARTON: Yes, it was. The basis of the questions was not at too much depth on 365 since it is the kind of document that does speak for itself, and then have it identified and discuss the implications of it and introduce it into evidence.

Now that we have the revision, and Mr. Pigott is smiling at the revision --

MR. PIGOTT: No, I am smiling at the document speaks for itself because none of them have so far.

JUDGE KELLEY: Why don't you go ahead.

BY MR. WHARTON:

Q Would you review again the substantive changes in the revision of 81-365 at 81-365?

A The equation that we have come up with is different than we had at 365 and there is also some more material in the revision related to questions of magnitude dependent versus independent shapes, some technical questions that come into it, but as far as the actual prediction equations for peak accelerations, that has been altered slightly.

Q It has been altered slightly you say?

A Yes.

Q Would you review again, what that is?

A I can tell you exactly how it has been altered and I can tell you, if you take the ratio of a peak acceleration given by the new version relative to that in the old version, that ratio is given by an equation -- let me find it here, I did it some time ago -- so this is the peak acceleration in the new version divided by the peak acceleration in the old version is 10 to the following power: 0.21 minus 0.031 times the magnitude. That is the substance of the change in the equation.

Q I wish I could say that meant a lot to me, but it

doesn't.

A What it comes down to, you can make a little table. If you have a magnitude 6, the ratio is 1.06. In other words, we are predicting larger motions by six percent than in the previous version.

Magnitude 6.5 earthquake, there would be 1.02, magnitude 7 it is 0.98 so it is a two percent reduction, and magnitude 7.5, it is 0.95. So that gives you, I think, a feeling for how it has changed.

Also one thing I haven't mentioned here is that the standard deviation went from 10 to the 0.27 to 10 to the 0.26, which turns out to be about a two percent change.

Let me correct that. That is not the standard deviation. Standard deviation in the log of the acceleration went from 0.27 to 0.26 and that turns out to be a factor if you go back to get out of the log space of about two percent so it has decreased the standard deviation.

Q Did you put further study into your 81-365 in order to publish this revision?

A This revision represents further study, yes, of 365.

Q Would it be fair to say that you have further confidence in the revision of 81-365?

A Right. We have further confidence basically in the results of 81-365 as a result of this revision.

Q So then you would state that the acceleration model presented in the 81-365 revision is presently valid?

A From the tests that we have done, yes.

Q In the revision of 81-365, do you have any comparisons of your model as opposed to other models as found in page 46 of the previous 81-365?

MR. PIGOTT: I would ask for a clarification. Is this correction or supplement to 365, did it completely redo 365 or is it in the nature of an addendum?

WITNESS BOORE: No, it is not an addendum. It is completely redone. It is a revision. If you think of 365 as a draft, then this is a revised draft.

Your question still stands?

BY MR. WHARTON:

Q Yes.

A Yes, we do have a similar comparison and it is Figure 13 in the new version.

Q Is the comparison in Figure 13 any different than the comparison in Figure 7 on page 46 of your previous report?

A Yes, it should be. Since we have decreased our values by two percent -- well, in fact, for the magnitude 7.5 earthquake it was more than that -- the values are closer to the Campbell curves that we have for magnitude 7.5 and just eyeballing it, it looks like they are closer for the magnitude 5.5 as well, and 6.5.

Q Are they still higher, then, give higher peak acceleration?

A They are higher -- let me think now -- for which magnitude?

Q 6.5.

A It is the same shape that is in Figure 7, so if they are higher in one distance range in the 365 report, it is higher also in the same distance range in the revision.

Q Do you feel that the results of your revised 81-365 and the model you proposed is more appropriate than those of Campbell as listed in your figures?

MR. PIGOTT: For what purpose?

MR. WHARTON: For predicting peak accelerations from magnitude --

MR. PIGOTT: From any particular distance?

MR. WHARTON: I would say generally offset at any particular distance.

WITNESS BOORE: I would say they are as appropriate.

BY MR. WHARTON:

Q I am sorry?

A I would say they are as appropriate. I wouldn't say they are more.

Q Would you say they are as appropriate or more appropriate for 10 kilometers or less?

A Yes.

Q Would you agree that all current models for acceleration versus distance such as your modeling study suffer from a lack of data in the near field for earthquakes magnitude 7 or larger?

A Yes.

MR. WHARTON: I believe on the issue of 81-365 revision, as far as questioning, that I have questioned as far as I really care to. I would like to introduce that particular document into evidence since it is the latest and it is what we will be relying on.

We don't have it. Mr. Pigott says he can copy it. If we could possibly do it when he is subject to cross examination -- Mr. Pigott will have a copy for purposes of review for cross examination, if we could do it that way.

MR. PIGOTT: I won't stipulate its going into evidence but I will stipulate that we can take it up for questioning tomorrow.

JUDGE KELLEY: That is what I was saying.

MR. WHARTON: That is what I was saying.

MR. VOGLER: The Staff is concerned. I have a gentleman here who is extremely disturbed that we cannot follow the questioning. No one else can either. I appreciate the point. It seems a little bit obtuse here when we are being asked to stipulate something into evidence and we don't have it.

JUDGE KELLEY: No, you are not being asked to

stipulate, as I understand it. Mr. Wharton's proposal was that he will raise the point tomorrow after counsel and the Board have a chance to look this document over. I am sorry you didn't have a chance to look it over this afternoon.

MR. VOGLER: I understand, and the transcript. In order to follow the questions that are going, we should also have a copy of the transcript, I take it.

JUDGE KELLEY: You will have it first thing in the morning and since the questioning wasn't very long, you can go over it.

MR. PIGOTT: Does this complete the direct?

MR. WHARTON: No.

MR. PIGOTT: Mr. Boore should be advised that cross examination may not be able to be completed tomorrow, very likely.

MR. WHARTON: I have only got five more minutes, if that is the criteria.

MR. PIGOTT: One question in this area, I think as everybody appreciates, can cause a great deal of effort that has to be done to investigate its effect and whether further pursuit has to follow so if there is further direct tomorrow, I am just saying that it may be a problem.

JUDGE KELLEY: Maybe I am not following things here. I thought you were through with direct; isn't that so?

MR. WHARTON: I am essentially finished with direct

except for questions that I am going to be asking. I have like three more questions that I am asking right now, but I was finished with direct on 81-365.

JUDGE KELLEY: Right.

MR. WHARTON: Now I have the understanding of the revision. Now from what I have heard about the revision, I am satisfied that it is equivalent and we can submit it into evidence that way.

I would, again, like to have an opportunity to review it to see if there is anything major. I don't anticipate any long line of direct on the revision, but rather to be submitting the revision.

JUDGE KELLEY: We did have this nice clear arrangement which is a little clouded by carrying direct over into tomorrow, but I understand your point. You were not expecting this revision and you have to have a chance to look at it. So we will see where that takes us.

MR. WHARTON: I don't think anybody anticipated this.

JUDGE KELLEY: Do you have a few more questions now for Dr. Boore?

MR. WHARTON: Yes.

kw-17

Q Dr. Boore, do you -- are you able to calculate a formula or ratio for extrapolating from peak to ground acceleration values estimated for a magnitude 6.5 earthquake to estimate peak to ground acceleration for magnitude 7 or magnitude 7.5? Is that something you are able to do?

A The equations that we have in our revision would do that for you.

Q So the equations themselves -- you would just plug in the numbers --

A That is right.

Q -- and you could use the equation and you could come up with the figures, is that correct?

A That is right.

Q Fine. Moving back to the Livermore earthquake data briefly, would you interpret -- or do you interpret the results from the Livermore earthquake to indicate that directivity can significantly affect the high frequencies important in high peak ground accelerations?

A That is my best interpretation of that particular data set, is that it does show directivity.

Q And it can significantly affect the high frequencies, that is significantly --

A It has affected the peak accelerations in that --

Q Fine.

A -- particular earthquake.

kw-2

Q So directivity does cause an increase in peak ground acceleration?

A It seemed to have done that in that particular earthquake.

MR. WHARTON: I have no further direct at this time. I would reserve only for portions of the revised 81-365 and I expect it to be very brief.

JUDGE KELLEY: Let me ask Mr. Pigott. I wasn't sure that that was clear. In our caution that we may not be able to get through tomorrow on cross, were you referring to Mr. Wharton's desire to be able to ask direct questions tomorrow, or were you just talking about what you had heard so far today and how long that would take you?

MR. PIGOTT: Both, and especially the changes. I -- they are -- well, my impression is usually these changes are rather sophisticated and subtle, and they don't jump out at you. So, it may be that it will take some investigation to complete the cross examination. I would --

JUDGE KELLEY: I gather you were --

MR. PIGOTT: As well as --

JUDGE KELLEY: -- anticipating --

MR. PIGOTT: As well as whatever Mr. Wharton may bring out in the morning.

JUDGE KELLEY: I gather you were anticipating a cross on 365?

kw-3

MR. PIGOTT: Yes. But based on the new results and the way the changes have come about, I would ask that I be allowed a couple of minutes in the nature of a -- maybe it is a partial cross examination or a Voir Dire to elicit a little bit further information with respect to the change.

JUDGE KELLEY: This would be to shed some more light on it this afternoon?

MR. PIGOTT: Yes.

JUDGE KELLEY: Well, that sounds sensible.

MR. WHARTON: Mr. Chairman, can we go off the record just one second? There is just a very small procedural thing I want to discuss.

JUDGE KELLEY: All right. Off the record.

(Discussion off the record.)

JUDGE KELLEY: Okay, back on the record. Go ahead, Mr. Pigott.

CROSS EXAMINATION

BY MR. PIGOTT:

Q Dr. Boore, I understand -- from what I understand, you revised 365 as a result of comments from the editors of the -- what is it, BSSA or -- what do they call it?

A Bulletin of the Seismological Society of America.

Q Is that correct?

A Yes.

Q Okay. Those were reviewer's comments?

kw-4

A It was a reviewer comment, yes.

Q Okay.

A And also, you have to understand, 365 we consider to be a preliminary publication, and it is subject to revision as research goes on.

Q I understand. Who are your reviewers on that document?

A Beats me. I don't know. That is -- you know, it is anonymous reviewing process.

Q So you do not know who these persons were who reviewed that document?

A For the Bulletin, no I do not know.

Q Right. Do you know if there was more than one?

A We got comments from one only.

Q You got comments from one reviewer?

A One reviewer.

Q What were the comments you got

A I don't know. I can't recall and I didn't bring them with me.

Q What comment did you respond to? What was the nature of the comment that caused you to make the modification?

A I just can't remember. It wasn't -- what you have to understand -- we weren't responding just to one thing. We presented this paper at the SSA meeting in

kw-5

Berkeley. We received comments from that, you know, from people, and we don't later rest a paper at this stage. We get it into review process and we continue working on it.

Q Okay, so --

A So it wasn't that we were responding to any one comment of the reviewer.

Q I am trying to get it clear this whole situation of how it gets to the stage it is in now.

A Right.

Q I had the impression that you had received a comment from the Bulletin and that subject to complying with the comment, apparently, or responding to the comment, that it would then be suitable for publication.

A That is correct.

Q Okay. So was there a condition on publication that you make some kind of change?

A They all are suggested changes that you have to make. Then it is up to the editors to decide whether you have sufficiently -- that your revision complies -- you know, with the changes to the extent that he wants. And -- am I answering your question?

Q Yeah, I think we are getting there. In the absence of taking these suggestions, would 365 have been published?

A That is up to the editor. I really couldn't say.

kw-6

Q Had he indicated, or she indicated?

A It is he. That is interesting. I don't remember the word. You know, if it was a form letter saying your paper will be published subject to these revisions, or we suggest you look at these revisions. I don't recall what his words were.

Q Did you get a letter from the editor?

A Yes. Right. I just don't have that here. I didn't bring my files relating to that.

Q You got other comments on this paper, is that correct?

A Yes.

Q How many?

A How many other comments? Well, we received written comments from -- let's see -- approximately four people. I would have to sit down and actually write them out.

Q Are they -- are any --

A Those were informal -- I mean in the sense that they were not comments from the editor.

Q Right. Were they in writing?

A Yes.

Q Do you have them in a file?

A You mean here?

Q No, just anywhere, first of all.

kw-7

A We have them in a file, yes.

Q I have a feeling the answer to my next question is that they are in Menlo Park? Or close to that. Where are they?

A Some of them -- well, certainly they are in Menlo Park.

Q You don't have any of them here in San Diego?

A I might. I am not sure. I would have to -- I have a whole bunch of stuff here. I just threw everything into a briefcase.

Q I wonder if you could check to see if you do have those comments.

A Is that appropriate?

Q Yes, I think so.

MR. WHARTON: Mr. Chairman, I -- I forgot one thing. I had identified Intervenors' Number 17, the article by David Boore, Influence of Rupture Incoherence on Seismic Directivity -- he identified it and said it was his, and the basis for his conclusions on directivity, and I would move that it be introduced and accepted into evidence.

JUDGE KELLEY: Counsel? Is that the three pager?

MR. WHARTON: No, this is the longer one.

MR. VOGLER: Well, that is 18 then, isn't it?

JUDGE KELLEY: You are talking 18, Mr. Wharton. And is 18 the revision of 365?

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MR. WHARTON: No, we have not submitted anything of 365.

MR. PIGOTT: Can we go off the record and go through the papers --

JUDGE KELLEY: And you are offering the entire article?

MR. WHARTON: Yes.

MR. PIGOTT: Can we go off the --

MR. VOGLER: What are you offering, Mr. Wharton, Number 18?

MR. WHARTON: Yes. I believe it would be 18, and it is Influence of Rupture Incoherence on Seismic Directivity, article by David Boore and William Joyner.

JUDGE KELLEY: There is a request that we go off the record, is that right?

MR. PIGOTT: Yes.

JUDGE KELLEY: Okay, then let's go off.

(Discussion off the record.)

JUDGE KELLEY: Back on the record.

WITNESS BOORE: Okay, to answer your question, the only thing I have --

JUDGE KELLEY: I am sorry, wait a minute.

WITNESS BOORE: Sorry?

JUDGE KELLEY: We are right smack in the middle of something. Can we just finish up something we were

kw-9

talking about?

Does the staff have any objection to Intervenor Carstens' Number 18?

MR. VOGLER: None.

MR. PIGOTT: Nor do Applicants.

JUDGE KELLEY: So ordered.

(Whereupon, the document previously marked for identification as Intervenors' Exhibit Number 18 was received in evidence.)

MR. VOGLER: We have a brief question to Mr. Boore in regards to something that was just said, if I can --

MR. PIGOTT: Okay, go ahead. I still have something --

MR. VOGLER: Did you indicate, Mr. Boore, that you sent Dr. Rider a copy of the revision? Of 81365?

WITNESS BOORE: That is what I understand from my coauthor. I --

MR. VOGLER: Did you send it --

WITNESS BOORE: -- didn't send it to him myself.

MR. VOGLER: Did you send it to him here in San Diego?

WITNESS BOORE: No, I think to his o ice.

kw-10

MR. VOGLER: In Washington?

WITNESS BOORE: I believe so, yes.

MR. VOGLER: Do you have any idea when?

WITNESS BOORE: It would have been toward the end of last week.

MR. VOGLER: Thank you.

BY MR. PIGOTT:

Q Dr. Boore, did you check your files that --

A Yeah.

Q -- you brought with you to find out if you have any of the comments?

A Yes, I did. All I have was something sent to me by Mr. Wharton, which is the testimony of Dr. Stewart Smith given, I presume, last week.

Q Okay, we have that. Is there anything --

A I don't have anything else here related to that.

Q Is it possible to have those transmitted? Would it be possible to obtain those overnight?

A I don't know how.

Q Federal -- either Federal Express or an Express Mail? Is your coauthor --

A If he is there.

Q -- in a position to send them? Oh, okay.

A Certainly he could send them.

Q Secondly, did you make any changes in the data?

kw-11

A No, we didn't add any data. The reason --

Q Did you change any?

A Well, the reason that the equations are different is that we have chosen to give zero weight to a few earthquakes. So, in other words, in effect, the data has been reduced. It hasn't been added to.

MR. PIGOTT: Okay, that was in the nature of trying to get a little bit more information. Could we perhaps ask the Witness to contact his office and see if they could be Express Mailed to --

Actually, if we could find that your coauthor is there, I am sure we could arrange to have them picked up and delivered to us here tomorrow morning, if that would be acceptable to the Witness.

WITNESS BOORE: I don't have any choice. No, it is fine with me.

MR. PIGOTT: If it was burdensome, you would have a choice, yes.

JUDGE KELLEY: It is, just to interject to say that we would do that as a proper request --

WITNESS BOORE: Okay, fine. So, let's see, do you want every piece of written criticism that we received on the paper, is that correct?

MR. PIGOTT: I am afraid so, yes. Other than that, I think I would await tomorrow morning for the

kw-12

cross examination.

JUDGE KELLEY: All right, then, at this point, that finishes today's direct, except we would appreciate your making the call and seeing if that is doable, and --

WITNESS BOORE: Yes.

JUDGE KELLEY: -- we can take a break here, I guess, of 15 minutes. Let's now -- are you going to have Mr. Simons here after the break?

MR. WHARTON: Mr. Simons is here now.

JUDGE KELLEY: Oh, he is here now?

MR. WHARTON: Yes.

JUDGE KELLEY: And so we can go along this offer of proof type procedure that we discussed yesterday to make some use of the remainder of the afternoon? Okay.

Let's see, Mr. Boore, you will be here tomorrow morning?

WITNESS BOORE: Yes.

JUDGE KELLEY: Okay. We had planned to have Dr. Allen -- wanted to come on first and we agreed to that, but sometime after that -- you can have mid-morning I guess.

WITNESS BORE: That is fine. I have to leave by five -- or four o'clock.

JUDGE KELLEY: I am sure we will quit by then. Thank you. Off the record.

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JUDGE KELLEY: Back on the record.

All right, the main remaining item of business today, this afternoon, is to have the presentation of direct and cross of Dr. Simons, subject to the discussion of the motion to strike, and the ruling on that at a later date, which was made yesterday, and is in yesterday's transcript.

I think we pretty well covered what we were going to do, and can just go ahead.

MR. WHARTON: Okay. I call Richard S. Simons.

MR. PIGOTT: I am sorry, I -- I think our procedural -- while Mr. Simons is coming up, I thought our procedural arrangement was off the record. Perhaps it might be recited for the record.

JUDGE KELLEY: If it was off -- I guess that is right. That is right, you did suggest off the record, I think we had it off the record, so I will have a go at it and Counsel can add or correct, but we have had a motion from -- your motion, I believe, was on the record.

MR. PIGOTT: The motion is on the record, that is correct.

JUDGE KELLEY: And the argument thereon.

MR. VOGLER: Both parties were on the record.

JUDGE KELLEY: Okay. That was done yesterday, and then following that we had an off-the-record discussion about how to proceed, and it was decided that in view of the

availability of witnesses and our desire to make the best use of our time, that we go ahead and hear Mr. Simons' evidence and have cross-examination with the understanding that the ruling to be made might result in that being stricken. It is really being put forward today as an offer of proof, subject to the ruling which is expected over the break, or to be made immediately following the break.

Does that state it accurately? Any additions or corrections?

MR. PIGOTT: That is Applicants' impression.

MR. VOGLER: That is correct. That is Staff's understanding.

MR. WHARTON: That is correct with Intervenors.

JUDGE KELLEY: Fine.

MR. PIGOTT: And Mr. Beoletto will be handling this portion of the examination for the Applicant.

JUDGE KELLEY: Very good.

Whereupon,

RICHARD S. SIMONS

was called to the witness stand and, having been first duly sworn by the Chairman, was examined and testified as follows:

DIRECT EXAMINATION

BY MR. WHARTON:

Q Would you please state your name for the record, please?

3g

A Richard S. Simons.

Q Mr. Simons, I -- do you have before you a copy of the written testimony of Richard S. Simons, consisting of five pages of text, two figures labelled as figure 1 and figure 2, and attachments, one as Appendix A consisting of four pages, a list of references, and a biographical sketch of Richard S. Simons, and Richard S. Simons' list of publications, is that complete before you?

A I think I have got all of that, yes.

Q Turning to your biographical sketch, is there anything that you could add to this particular biographical sketch to show your qualifications to testify as to the subject matter? Or that you would like to highlight in that?

A Well, I guess I could say that with respect to this particular subject matter, this particular type of research or plot, is something that I have done frequently in my years at Scripps. It is -- a large part of my research has consisted of precisely this, going into the Caltech Catalogue of epicenters, and making a plot of whatever region we are interested in, say part of Baja, California, try to see how those epicenters relate or don't relate to the faults as mapped, and going down that, perhaps trying to -- well, certainly trying to relocate some earthquakes and see if we can get better accuracy on them, or place them in some other place that is tectonically more significant.

So, this -- what you see here today is just a continuation or an extension of a type of study that has been going on for a long time.

Q Very well. Do you have any additions or corrections to make to your testimony as submitted?

A In the way of an addition, on figure 1, I have taken the liberty of placing in a few more of the faults that exist in that area, just for the sake of completeness, and for the sake of analogy with a couple of other seismicity patterns that I had hoped to present later, so that is a change there; another possible change which I have not been able to make, for reasons -- are in figure 2, it turns out that --

JUDGE KELLEY: As we go along, excuse me -- these aren't marked, or mine aren't, anyway.

MR. WHARTON: No, I was just going to interrupt.

BY MR. WHARTON:

Q Dr. Simons, on figure 1 --

MR. BEOLETTO: Excuse me, Mr. Wharton, is it Dr. Simons, or --

MR. WHARTON: I am sorry, Mr. Simons. Excuse me.

BY MR. WHARTON:

Q Figure 1, as listed in the testimony filed --

A Yes.

Q -- now, do you want to substitute a new map which

has been distributed to the parties, which shows the Cristianitos fault and other faults in the area, is that correct?

A That is correct.

Q Okay, now that would be labeled as figure 1A, would that be an appropriate figure for that?

A As far as I am concerned, it would be.

MR. WHARTON: May the record reflect that the witness proposes to substitute a map showing the same area as figure 1 in the submitted testimony, with the only change being the addition of certain faults in the area, and this would be listed as figure A, and substituted instead of figure 1.

MR. VOGLER: Do you want us -- Excuse me, do you want us to strike the original figure one, and take it out?

MR. WHARTON: Yes. We would strike the original figure one, and put in what I am labeling, and which we can label as figure 1A.

MR. VOGLER: Okay.

MR. BEOLETTO: Mr. Chairman --

JUDGE KELLEY: Do you want to go over all three, or take one at a time if there are objections?

MR. BEOLETTO: Prefer to take one at a time.

JUDGE KELLEY: All right.

MR. BEOLETTO: The reason for that is, the

Applicants were provided a copy of the revised figure one at the break, and we recognize that there are more fault traces appearing, but we don't think that will alter the nature of our cross-examination, and so we are willing to accept this as a change.

MR. VOGLER: The Staff is the same. I take it, Mr. Wharton, that the -- the symbols that are on the map, forget the faults, are all the same.

MR. WHARTON: That is correct, and we may want to double-check with Richard Simons, Mr. Simons.

BY MR. WHARTON:

Q Is there any change in this map other than the addition of faults?

A Only the addition.

MR. VOGLER: Then we don't.

JUDGE KELLEY: All right, this is being substituted, you are saying?

MR. WHARTON: Yes. We are striking figure one as originally submitted, and adding -- we are calling now figure 1A, which shows the same map, the same data as the previous figure 1, but adds faults to the map.

JUDGE KELLEY: All right.

JUDGE HAND: It looks -- it looks to me as if this is at a different scale, and I overlaid them and discovered yes, it has been shrunken a bit, and a couple of

things do slip in on the right-hand margin that aren't on the margin of the original figure 1.

BY MR. WHARTON:

Q Mr. Simons, would you want to comment on that?

A That is the inevitable result of Xerox technology, I guess, and -- the real original of this diagram goes a little bit beyond the borders to left and right of what was initially submitted, so I guess the second time it was zeroxed, it wasn't positioned exactly the same way. It sort of affects the very periphery of the seismicity pattern.

I don't think it has any particular bearing on the conclusions that come out of this.

JUDGE HAND: Fine. That is all right.

JUDGE KELLEY: Go ahead.

BY MR. WHARTON:

Q Okay, do you have any corrections that you want to have made in the text of the presentation?

A Let me address figure 2. Well, the answer to your question is no.

Q You want to address figure 2?

A I would like to do that, yes, just for sake of accuracy. There are many circles on this figure, and it is hard to look at it, and it was also hard to prepare. It turns out that one of the circles, up about the middle of the graph, it is a 1977 event, and it is a quality C event, and

the circle that has been drawn around it is a -- one that is appropriate to a B quality event. That circle should be somewhat larger than it is.

It was impossible for me to change it in the original because of the nature of this particular diagram. It doesn't -- again, doesn't really affect the results or conclusions, so --

MR. BEOLETTO: Still, Mr. Simons, if we could, could we take the time to identify the exact circle that we are talking about?

WITNESS SIMONS: Well, we could, I could put up a viewgraph.

MR. BEOLETTO: Yeah, put up a viewgraph, that is fine.

WITNESS SIMONS: The one we are talking about is going to be this one here.

MR. BEOLETTO: Okay.

WITNESS SIMONS: It is 77C. '77 is the year. C is the quality of the location. The circle should really be of the same diameter as these other 77C circles that you see in various places. This is one example.

MR. BEOLETTO: Now wait a minute. I am confused now.

MR. VOGLER: In other words, it should be larger?

WITNESS SIMONS: It should be larger, yes.

MR. VOGLER: Is that the only change?

JUDGE KELLEY: Where would the center of that circle be? Can you show us on the map?

WITNESS SIMONS: This particular circle?

JUDGE KELLEY: Yes.

WITNESS SIMONS: The '77C?

JUDGE KELLEY: Yes.

WITNESS SIMONS: Well, it would -- as far as I can tell from my angle here, it would be right about there. It is --

JUDGE KELLEY: Oh, the 77C is written on the outer --

WITNESS SIMONS: Yes.

JUDGE KELLEY: The year and the quality is written into the outer edge --

WITNESS SIMONS: On the outer perimeter of the circle, right.

JUDGE KELLEY: I see.

WITNESS SIMONS: Yeah, you have to sort of visually infer where the center --

MR. BEOLETTO: To be sure I understand, Mr. Simons, it is not the C quality designation that is changing, but rather the diameter of the circle around the figure?

WITNESS SIMONS: That is correct.

MR. BEOLETTO: Okay. thank you.

BY MR. WHARTON:

Q Are there any other corrections in your written testimony that you would like to make at this time?

A No.

Q Are there any additions to your testimony that you would like to make at this time?

A There are two additional microseismicity maps that I had hoped to introduce for the sake of analogy. These are maps of different parts of California that have been prepared in the same way as figure 1 or figure 1A, as we are now calling it.

These are areas where -- I wanted to offer them for sake of comparison, because I think the basic pattern of events in these areas is similar to what we see in figure 1A, and yet these are in areas where things are better known tectonically, and so I thought that might provide some perspective on the possible utility or interpretation of figures 1A and 2.

MR. BEOLETTO: We are listening to a description of two additional figures that were handed out, and we are not going to listen to a description of whether or not this is an area of better tectonic quality. The Applicants are going to object to both of those figures.

MR. WHARTON: Let me interrupt. I should have interrupted Mr. Simons before.

BY MR. WHARTON:

Q Mr. Simons, would you identify the maps, please, starting with the map indicated, Simons 53 7-09-81, with a 6:58 p.m., would you identify what that area is without making any qualitative judgments about it, just indicate what the area is?

A Let me see if I -- let me get it positioned properly here.

MR. BEOLETTO: Mr. Chairman, I think we have all got copies of the figures, so -- there are two additional figures, as I understand it, and Mr. Simons wants to add to his substantive testimony, and the Applicants are going to object to their admission for a number of reasons.

One, it is late-filed direct. Number two is, looking at the viewgraph and the figures that we have in front of us, they don't seem to be plotted consistently with figure 1 which is a part of his testimony.

There is no latitude, no longitude, there is no dates, there is no --

JUDGE KELLEY: I think -- excuse me, Mr. Beoletto. It is late filed direct, indeed it is. There may be a good reason to take it, but let us let the witness tell us what that is, rather than spectulating. Could you tell us --

WITNESS SIMONS: I apologize for the lateness. I just got curious about this particular element over the

weekend, and almost in the manner of self-defense, I thought I should prepare these diagrams so that I knew whereof I spoke in these areas, and they were so interesting, I thought they might be of some value to the Board.

This is basically the seismicity and fault pattern in a part of what is identified by California Division of Mines and Geology maps as the San Bernardino quadrangle.

More importantly -- well, I will just get it up front here. This is the seismicity pattern around the area of the White Wolf fault, from 1932 to 1951. And the -- well.

MR. BEOLETTO: Is the witness saying that White Wolf has something to do with the San Bernardino quadrant?

WITNESS SIMONS: I am saying we know that the White Wolf fault, or the event on the White Wolf fault occurred, that is why something is tectonically better known about this area, and let me say about the -- the way this is presented, it really is the same sort of plot. The -- well, let us say that the limits of latitude on this plot are identical to the limits of latitude on figure 1A. The longitude goes a bit further afield.

The symbols used for the earthquakes are different. That is a thing that is easily changed in the computer, and in this case there was no reason to identify different qualities or anything like that, so they all came out the same

size.

MR. VOGLER: Could we put a number on this, so that -- as to what we are doing with it? Is it figure three?

WITNESS SIMONS: I would be happy to call it figure 3.

MR. VOGLER: Well, I -- I don't -- it is up to you or Mr. Wharton.

MR. WHARTON: Can I get back into this conversation? I haven't been able to talk since Mr. Beoletto interrupted. I am not complaining about that, but he did object, and I haven't been able to get back into it since that time.

I was going through the process of identifying these particular diagrams, and if I may just go through the process of identifying the diagrams, as properly pointed out, so we can follow what we are talking about.

BY MR. WHARTON:

Q I believe you have up on the screen right now the diagram indicated by Simons 53 6:58 p.m., and Intervenors would submit this as addition to the written testimony as figure number 3, and Mr. Simons, if you would put up the other diagram. Over so you can see the numbers.

This is Simons number 57, date 7-9-81, 7:03 p.m., we identify this and submit for the -- into the written testimony as figure number 4, and Mr. Simons, if you would,

I would just -- if you could make what they call an offer of proof, that is, would you just review figure 3 and figure 4, and briefly explain what you believe the relevance of these particular figures are -- is?

ghp 1

A I can just leave this up here while I do it, or do you need this? I can discuss them both together.

The relevance is simply by way of seeing how they compare with the seismicity pattern I am present ng in Figure 1-A as a guide to the possible interpretation or usefulness of the information in Figure 1-A.

Actually these are other parts of Claifornia and we know some other things about these other parts of California, these new sections, and so it would seem worthwhile to offer these as a perspective to know how to treat or what to make out of Figure 1-A.

Q You are offering these on how to view Figure 1-A by looking at other areas?

A That is correct, yes.

MR. WHARTON: I would submit, then, that Figure 3 and Figure 4 as identified on the record be added to the written testimony.

JUDGE KELLEY: You say these indicate seismicity of the areas depicted?

WITNESS SIMONS: Oh, yes. The little dots here are all earthquakes.

JUDGE KELLEY: All the little dots are earthquakes?

WITNESS SIMONS: Yes, and the lines are faults.

JUDGE KELLEY: And you can tell different sized earthquakes by looking at that?

ghp 2

WITNESS SIMONS: No. I know what the range of earthquake magnitude is, again as far as similar to the area that we are looking at what we call the SONG site. The range of magnitudes is the same. This particular diagram doesn't pinpoint that, though.

JUDGE KELLEY: These are Cal-Tech?

WITNESS SIMONS: Oh, yes.

JUDGE KELLEY: The catalog?

WITNESS SIMONS: They are right out of the catalog. Turn the crank on the computer, and that is what you get.

JUDGE KELLEY: That is why it says 7:03 p.m. A computer did that?

WITNESS SIMONS: That is our computer, yes. It is cheaper then.

JUDGE KELLEY: Go ahead, Mr. Beoletto.

MR. BEOLETTO: Do you have similar maps for all of Southern California?

WITNESS SIMONS: No, I don't.

MR. BEOLETTO: Could I ask how you happened to select the two areas that you brought two additional maps today which you apparently selected on the 9th of July?

WITNESS SIMONS: I was almost hoping you would, I got to thinking about this over the weekend and I for some reason anticipated somebody -- probably Mr. Pigott -- asking me if I knew of some other area in California that had a

ghp 3

seismicity pattern analogous or similar to that around the SONG site where any earthquake of any consequence might have occurred. Off the top of my head I did.

It occurred to me that I just read about that or heard about that a few years ago and I didn't really remember the source. I have told a number of public audiences about these particular events in the past --

MR. BEOLETTO: I think the narrative can stop. You just randomly selected these two areas?

WITNESS SIMONS: Not randomly at all, no.

MR. BEOLETTO: Who gave you guidance?

WITNESS SIMONS: No one.

MR. BEOLETTO: This was all done by you?

JUDGE KELLEY: Mr. Beoletto.

WITNESS SIMONS: Let me pack a little more information in this. For some time I have been telling people -- I make a lot of addresses to the public -- that the San Fernando earthquake and the Kern County earthquakes occurred in an area where there was no previous heavy record of seismicity.

Now I did not remember what the source of that was. I read it somewhere or I heard it somewhere. I actually did read it somewhere recently but it is not where I initially saw it, but it occurred to me that if I am going to go around saying things like that, I should find out whereof I speak or else -- well, I just better find out.

ghp 4

So I just took the initiative of plotting up those areas to see what I would see and that is why those particular areas were selected. There was nothing random about it. It was just that I had reason to believe that the seismicity patterns that I would see, that that would be what they were.

JUDGE KELLEY: Did you want to say something?

MR. VOGLER: There are some very fundamental questions that have been asked. In Figure 3, where is the White Wolf fault? What area of California are we discussing?

WITNESS SIMONS: I have to get Figure 3.

MR. VOGLER: Let's take Figure 4 while you have it up there. Where is that?

WITNESS SIMONS: This is the area around Los Angeles. This is the San Fernando basin here. Does that help you?

MR. VOGLER: It may help Dr. Reiter.

WITNESS SIMONS: I could read the coordinates off these maps. I have got them right here, if that would help Dr. Reiter.

MR. VOGLER: Yes.

JUDGE KELLEY: Excuse me, I understand now, I believe, well enough what is involved here to make a ruling. This is late filed direct and that isn't to say that we couldn't take it if we thought that it was extremely useful, but it is offered, as I understand it to be, to illustrate things and help us understand what it is you are presenting.

ghp 5

I think at this stage of the game, although we certainly still have much to learn, that we don't need that kind of help and the problem is that it is very hard to stay away from some very collateral issues and we are not litigating the seismicity in these other two areas.

Yet, if it is put in the case, and that is inevitably what people are going to want to do on balance -- and it is a balancing question when you are in the area of relevance -- the Board is ruling that they will not take these maps.

MR. VOGLER: Three and four, Your Honor?

JUDGE KELLEY: Three and four.

MR. WHARTON: Very well.

BY MR. WHARTON:

Q Dr. Simon, with the substitution of Figure 1-A for Figure 1, the testimony is submitted as complete; is that correct?

A That is correct.

Q And if you were called to testify in its entirety, would you testify the same as in the written testimony that you have prepared?

A Yes.

MR. WHARTON: Mr. Chairman, I would imagine that this would be the time to submit into evidence and I would make a motion to move into evidence. I understand that we are doing this as an offer of proof pending a motion to strike,

ghp 6

so I would make the offer into evidence and the ruling can be withheld until you make a ruling on the motion to strike.

JUDGE KELLEY: Yes.

BY MR. WHARTON:

Q Mr. Simons, have you prepared an overview of your testimony?

A Mentally anyway.

Q You will have to present it orally. Can you do that?

A I will try. First of all, let me say that until yesterday afternoon I wasn't even sure that there was a 1973 and all of that distinction was certainly news to me, but as pointed out, it is kind of hard to separate it from what I have got and as I go along, though, I will try to point out whatever is new here insofar as I can.

What I have done is very straightforward and very simple. In fact Mr. Wharton pretty well described it yesterday in about two sentences. For the record I will repeat those sentences and maybe make them a little bit longer.

I simply went into the catalog of earthquakes published by the Seismology Lab at Cal-Tech in Pasadena which is the record of seismicity in the State of California except, perhaps, as where amended in a few places where people have relocated some earthquakes like Dr. Beihler or myself, but basically it is the document of record.

ghp 7

I have caused to be plotted out by computer all these epicenters in an area around the SONG site and I am putting Figure 1-A up on the screen to show the results of that.

This has been overlain, I should say, on a geology map prepared by the California Division of Mines and Geology for this area. I believe the year is 1964, I think. In any case I am trusting that the basic position of the faults haven't changed too much since then.

Basically Figure 1-A is the result. Different earthquakes on the map have different symbols relating to the quality of the events. In the Cal-Tech catalog each event has a quality assigned to it which is some sort of expression of the error involved in that location and the definitions of the symbols are actually contained in the text of the written testimony.

Basically what you see on this exhibit is really that halo that Dr. Beihler was talking about. You see a scattering of events and a good selection of faults and in some cases you see some sort of correlation, possibly, between the events and the faults like up here around the Elsinore fault and in other cases one simply doesn't, like this cluster of events over here to the east.

Now what I have done subsequently is what is considered good practice in many of the empirical sciences, and

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that is to go ahead and try to put the error bars on the data. So I have caused to be drawn around each one of these epicenters a circle representing the probable horizontal error in those locations as recorded by Cal-Tech.

So let me put up, then, Figure 2, which represents that attempt at putting the error bars on the data and what we did, of course, is an unfortunately confusing maze of circles.

Now the interpretation of these error bars can vary. Fortunately since 1975 when the seismology lab went to more rigorous computer methods, we know that the error figure is a standard error and based on the residuals in the computer determination.

We can take those as being one standard error -- well, it is normally assumed it is a normal distribution as being random errors, but the ones before 1977, though, it is difficult to know exactly how to interpret them. One can make various assumptions ranging from, as a minimum -- well, the thing about prior to 1977 is that the locations were done with a combination of graphical and then early computer techniques and certainly the days of the graphical location, the error estimate, was a very qualitative thing made by the analyst at the time as to how well he thought he had done.

Later on in about 1965 things got a little bit more rigorous but it is not clear that they literally had a rigorous standard error based on solid numbers in mind. It

ghp 9

was still maybe a qualitative judgement, but you can, as I say, interpret those error bars as the minimumizer of what one would, conventionally assume one to mean when they said something was probably within some area. That is, it is more probable that it is inside the area than outside of it which means, what, at the 51 percent level it is inside, if you want to put it that way, or you can suppose that they were trying to get close to something like a standard error on normal distribution and then say, okay, well, that is maybe whatever it is, 68 percent inside.

You can take it even further and say, well, they really meant -- boy, I really believe it is inside there and you can say 90 percent level. I don't think whatever interpretation you make effects the gross result that comes out of this type of plot.

The result is that you have a vast overlap of circles and then, asked to address the question of how many of these could, within these error bars, have occurred on the Cristianitos fault, and I have counted them up and I believe the number I came up with is about 20.

They are hard to count. I had to do it over and over again, but I kept getting the same result, so it is about 20 of them as the plot now stands with those error bars.

Now of course it is maybe important to remember that most of these events are at depth somewhere, maybe

ghp 10

two kilometers, five kilometers. Anyway, they are down there at some depth.

The depth is, as Dr. Beihler indicated, very poorly controlled and that being the case, if they are down there and one doesn't know where the Cristianitos fault goes at depth, why the total number changes somehow.

The more certain you get about things, the greater number that could lie on it, particularly if you start slanting the fault to the west. It looks like there is a confluence or a fair number of events here off to the west that currently don't touch the surface trace of the fault, so the numbers would change somewhat as you pursue the fault down to wherever these events are occurring.

The numbers could also change, of course, if you were to not just stop at one standard error. If you wanted to be more certain about the possibilities and went to two standard deviations, of course, well, things just begin to add up on you and you get many more events that are so located that they intersect that area.

So, so there is nothing magic, anyway, about a single number of events in this case. I would -- well, up to this point, I think, I hope I have done nothing but present some facts, some data that is available to anybody who wants to get it, and I have avoided, I hope, any opinionating or editorializing, but I would like to take this opportunity if I can to make one -- to offer some advice about another type of information that may be can be gotten out of an Exhibit like this, which is -- I think, more certain to obtain, and also it is possibly of equal importance to the question of do these faults fall on the Cristianitos fault or not, or could they -- which I am sure is a valid thing to inquire into, but -- aside from that, it is clear that when you look at this pattern you have to realize that even though we don't know where in this contiguous area exactly these events occurred, and in many cases, probably we will never in fact know, but the fact remains we can be pretty dog-gone sure that they did occur somewhere in this area, most of them, and they of course, occurred there for a reason, and the reason is the area is a state of stress of some sort, and it is just like -- that is what causes earthquakes, of course. It is like where there is smoke there is fire. Where there are earthquakes there have got to be stresses of some sort or another, and so -- and what you see here is a pattern at depth of little areas, you know,

kw-2

tens of meters long, hundreds of meters long, responding to the stresses in the region, and of course, this presumably is what causes the halo of microseismicity that Dr. Biehler referred to all over California, because, of course, all of Southern California, anyway, is in a state of stress, for reasons related to the motion of the plate boundaries that we know of.

I believe that is all I wanted to say.

MR. WHARTON: The witness is tendered for cross.

CROSS EXAMINATION

BY MR. BEOLETTO:

Q Mr. Simons, I don't recall whether or not Mr. Wharton indicated when you took the stand or not, but are you appearing here today and receiving compensation?

A I don't think that has been discussed.

Q I didn't think it had.

A I think -- what is his name, Mr. Barlow, mentioned something about lunch one time, or pay my gas.

Q You are not being paid any fee --

A No.

Q -- to participate in this proceeding?

A No.

Q But there might be some reimbursement of expenses?

A That was mentioned.

Q Okay. Have you appeared in any other regulatory

proceedings regarding nuclear power plants?

A No, I have not.

Q Have you appeared in any other regulatory proceedings?

A No.

Q Have you ever consulted with anyone or any group regarding nuclear power plants?

A No.

Q Have you done any consulting work at all?

A Not that I considered consulting. I was subpoenaed one time to appear in a law suit -- I mean as an expert witness. I am sorry. I was subpoenaed to appear as an expert witness in a law suit and just because I had offered some information of a similar nature to a lawyer, and normally, being a public university, we offer these informations and services free and don't worry about it. As it turned out, it took up so much time that I felt the state of California -- or the federal grants and contracts shouldn't necessarily pay for that, so I took the liberty of invoicing him for a little bit of time, and -- I never considered that consulting.

Q I wouldn't either.

A Thank you.

Q You are not appearing here today under subpoena though?

A No.

Q You are appearing in the nature of volunteer?

A That is correct.

Q Okay, thank you. Mr. Simons, could you generally describe your association with the Intervenors in this proceeding, known as Carstens et al?

A It is hard to describe because it is very light. Would you like a history of how I got --

Q No.

A No?

Q Just a --

A I tend to get a little bit wordy.

Q Well, let me ask you this if you don't mind my interrupting you --

A Yeah, maybe you could --

Q You seem to be struggling with that question.

A Yeah.

Q Are you a member of Friends of the Earth?

A No.

Q Are you a member of an organization known as Groups United Against Radiation Dangers?

A No.

Q Do you have a professional association with any other witnesses appearing in this proceeding?

A Yes.

Q Who might that be?

A Dr. Brune and Dr. Anderson.

Q Could you describe your relationship to Dr. Brune?

A Dr. Brune is one of the investigators or professors for whom I work. Dr. Anderson is one that I work with.

Q Is it possible that Dr. Brune asked you to participate in this proceeding?

A It is not at all possible. We never discussed it.

Q Okay. Referring to your overview that you presented just a few minutes ago, when you were discussing the circles on figure two, you indicated, I believe, I was asked to plot. I am curious, who asked you to make that --

A Mr. Barlow.

Q Mr. Barlow? Do you associate him with Friends of the Earth and Intervenors in this case?

A Well, I do now, yes.

Q Did he solicit your participation in this proceeding?

A That is correct.

Q Okay. Okay, are you a member of any organization such as Alliance for Survival or any other organization which has taken a position on nuclear power?

A No.

Q Okay. Was any of the work that is reflected in your testimony performed in your capacity as a research specialist at Scripps?

A Let's see, was any of this work --

Q Yes.

A In a capacity as -- I am not sure I understand the question.

Q When you were at work doing your job, did you do this work?

A Well, I did it at work, yes. I mean --

Q Was it a part of the --

A We can't talk about --

Q -- work you were doing for Scripps?

A No. Not that -- well, it is not that unusual.

Q I understand from your testimony that your formal education -- you have a Bachelor of Science degree in geophysics and geology from MIT, is that correct?

A That is correct.

Q Are you registered with the state of California as a professional in geology?

A No, I am not.

Q Are you registered with the state of California as a professional in geophysics?

A I am not.

Q Have you ever attempted to seek or obtain such

registration?

A No.

Q Do you know what the requirements are to obtain professional registration?

A I really don't. I never inquired into it.

Q Do you have any graduate training beyond your Bachelor's degree?

A No.

Q Could you describe generally what the responsibilities and duties are of a Research Specialist 2 at the Scripps Institution?

A Well, you know, that is kind of a catch-all category. It sort of depends on what one is really doing and what group one is associated with. In my case it involves being responsible for the collection retrieval, storage of seismic data that we collect, and it in a host of a computer -- what will I say -- programs, facilities for accessing that data, to go along with it, and so on. I am in charge of the processing software, if you will, on one hand. On the other hand I am charged with doing research and seismology, seismicity patterns in Northern Baja California, San Diego.

Q If I understand your answer, and referring to some of the terms you use, I get a feeling that you do a great deal of work with computers?

A That is correct.

Q What percentage of your work is manipulatory work on a computer?

A Oh, over the past year it has been not much -- 20 percent. In prior years it was the other way around, maybe 80 percent. It sort of depends on whether we are developing any software at the time or not and what is happening.

ghp 1

Q Is your position at Scripps a faculty position?

A I am a little bit weak on exact definitions, but I think it is. It is not tenure, or tenure track, as they say, but it is on the faculty side of things as opposed to being on the staff side of thing.

I used to be a member of staff. Now I am a member of faculty but it is not tenure track.

Q Could you explain briefly the difference, being on the faculty as opposed to being on the staff?

A I am not in administration and I only have a very narrow viewpoint only as it effects me.

Q It is not that significant. If it is a difficult question, we will move on to your testimony.

A I believe I would do a lot of woolgathering at this point trying to decipher that one for you.

Q Okay, look if you would, please, at page 1 of your testimony at what I believe is the 7th line from the opening line of your testimony where you indicate that your work has included major investigations, San Diego and northern Baja California seismicity.

I would like to focus on the word major, and if you could just distinguish for me what makes any investigation a major investigation?

A Well, in the case of, say, San Diego, it is major in the sense that it was all inclusive, in the sense that I

ghp 2

went back and attempted to thoroughly do the seismicity of everything in San Diego for all the data that was possibly available and it took me several years to do it and it stands as the only investigation to date of this kind or covering that area.

So for a number of years off and on it was a major effort.

Q I guess my next question, given that answer is, is your work reflected in your testimony a similar major study or investigation.

A Of this one, no.

Q Have you ever conducted any of what I will call field investigations in the vicinity of the San Onofre nuclear generating station?

A No, I have not.

Q How long have you been studying the seismicity in the vicinity of the Cristianitos fault?

A In total time effort, not very long ago, but in lapsed time, this goes back away to a year or so ago when Mr. Barlow came into the office and said, can you give me an epicenter map that covers the area around the San Onofre site and of course the answer was yet.

I could do it quite easily because I am equipped to do it -- I do it all the time -- so I did and gave it to him.

ghp 3

Then he disappeared for a year or so and then re-emerged -- well, this is the way it happens where I am sitting -- and then he comes back a few months ago maybe and says, you remember that map and can you update it and overlay it on a fault map, which the answer was yes again, for the same reasons. So I did that in fairly short order.

So in terms of total elapsed time we are talking about maybe a few hours total effort, so you can make whatever you want out of that.

Q In the vicinity of your study you pay particular attention to the Cristianitos fault. Are there any other faults in that area that you have included in the study?

A In Figure 1-A I have attempted to put all the faults on that are included in the California Division of Mines and Geology map.

Q As I recall on Figure 1-A it looks like the Cristianitos fault is penciled in. I am just curious. You seem to have focused on the Cristianitos and until today we didn't even realize you had identified the other faults in the area.

A Because my attention was focused on the Cristianitos. The question I was asked to address was any of these events could have occurred on the Cristianitos.

Q And you studied the work of other experts concerning seismicity at the Cristianitos fault area?

ghp 4

A Except for Dr. Beihler, no.

Q Have you studied any of the materials prepared by the Applicants in this proceeding such as the SFAR?

A I don't believe I have.

Q Have you studied the results and conclusions of the NRC Staff regarding this subject contained in the safety evaluation report?

A I am pretty sure I haven't.

Q Have or have not?

A Have not.

Q I would like you to turn to page 2 of your testimony, and the first sentence on the page. You refer to an epicenter catalog survey and I would like you to briefly describe what is involved in an epicenter catalog survey.

I realize that was somewhat covered in your overview, but if you could just concisely state that?

A These epicenters are written on a magnetic tape that can be read by computer. It is a magnetic tape catalog, and all that was involved was reading the catalog with the computer and looking at each event and deciding, is this event within the area that I wish to study and does it fit the magnitude limits that I want or depth requirements or any other constraint I want to put on it and, if it is, one keeps it and stores it on a disk file in the computer, and that is the basic survey.

ghp 5

The plot is a separate operation. The plot routine, that is the dots on the map.

Q On the fifth line on page 2 of your testimony, you refer to, the region studied extends from 33.25 to 33.75N and from 117.25 to 117.833W. You refer to that as the vicinity of the Cristianitos fault zone. Is that your definition of the Cristianitos fault zone or is that merely a convenient computer choice of coordinates or print out?

A It is my definition. I controlled what the vicinity was. The 33.25 to 33.75N, of course, was for convenience and the area of interest seemed to fall between those. The 117.25 to 117.833 W, I guess it is an odd number. I forget what it is in minutes, which we frequently do. It may have been even numbered minutes, so it could have been a number of convenience also. These numbers were just to center an area.

Q I believe Dr. Hand noted, when you were entering Figure 1-A as part of your testimony, that the area depicted in Figure 1-A seems to be more extensive than that previously depicted in Figure 1 that was replaced.

I don't recall your explanation for why that is.

A That explanation was the xerox machine, actually.

Q Let me ask you this. Maybe we can put it in with this line of questioning. All the points that appeared on the old figure are the same points that appear on the new figure 1-A and there are no new points?

ghp 6

A Correct, right.

Q The area depicted in the figure is the same?

A Oh, yes.

Q Okay, fine. You referred to the survey of the Cal-Tech catalog. Do you know how events were plotted or entered into the Cal-Tech catalog prior to the late '50's, early '60's?

A Mostly it was, as I recall looking at the work-sheets out there -- are you talking about the technique of analysis and earthquake location?

Q Yes.

A I have seen quite a few and I couldn't cite exact dates, but quite a few which seem to be based on S-minus-P times, if this is going to get technical, where you don't have absolute timing on the P waves because they had bad timing back in those days for a while.

Q Mechanically, how were they entered?

A It was graphically, if that is what you want.

Q By hand?

A Yes, by hand. That is right. You can see on the back of the analysis sheets there, you can see a bunch of hand-drawn in circles, overlapping circles, that are used and it is graphically determined where the epicenter was.

22 1g

Q The means of entering that data has become more sophisticated over the years, has it not?

A Oh, yes.

Q In making upgrades in the method employed in the method employed in entering that data, does Caltech routinely go back to the most early entries and update each according to the new procedure?

A Oh, not to my knowledge they don't. I may have misled you there, when you were talking about entry. I don't think the technique of entry or of, you know, data handling, doesn't really affect the -- it depends on the -- it is the word "entry" I am having trouble with. It doesn't relate to anything in my technical jargon.

I mean, just the mere act of entering, say, the data into the catalogue in a different way doesn't change its epicenter, its numbers. You have to recalculate -- you know, you can recalculate some epicenters if you have new data, so --

Q The Catalogue is quite heterogeneous, then, in its makeup?

A Oh, yes.

Q Older events, plotted much more crudely.

A Right.

Q But they are -- strike that.

In your work over the years, Mr. Simons, have you even found the catalogue inadequate for special studies?

2g

A Inadequate.

Q Do you understand the question?

A I think I do. I -- okay, let me try this. Are you asking whether or not the catalogue can be improved on?

Q No, no. No, no.

A No.

Q I understand your testimony to be that the nature of what you present here in the way of a study is common to the work you do routinely in your employment.

A That is correct.

Q And what I am asking basically, is in the scope of performing that work over the years, have you ever had difficulty with the Caltech Catalogue merely being inadequate for your purposes? The quality of the data, the location of epicenters and so forth.

A Well, if I understand that question, I think, you know, the answer is certainly. I have spent a lot of time improving the accuracy of it.

Q Would you agree with the general statement the Caltech Catalogue is a good reference, but not adequate for any detailed evaluations of fault activity?

A The last part there, for any investigations of fault activity.

Q Detailed evaluations is what I said in the last part.

A You know, I am close to agreeing with that. The language may be a little bit strong. It is very close to the truth. I wouldn't want to subscribe to that, just one hundred percent, because there just might be -- because especially in modern times, they are getting very, very accurate with that thing. They ought to. They have got a tremendous array of instruments out there, and in the modern data, I think there really are some detailed investigations you could do.

Q Okay. If you would refer to figure 1A, please?

A Uh-huh.

Q Again, you may have answered part of this question, perhaps most of it in your overview, but can you tell me what part of this is a computer plot, and what you have actually entered by hands or some other means?

A Yeah, the computer plot will be the -- certainly the perimeter of the plot, such as it is, north and south. Here. On the original there is other perimeters, but the lettering at the top of the plot, clearly, except for the letters. The letter "N" has been, I guess, beefed up by hand, but basically the legend of the title of the graph is done by computer, except for the scribbling off to the right that says 1932-1980.

The symbols themselves depicting the epicenters are put on by computer. The coastline and the faults are

traced by hand from the geologic map.

Q Thank you. And again, the events are actually entered with triangles, squares, circles and so forth. Could you describe, again briefly, how those are to be interpreted?

A Okay. A different symbol just indicates a different quality in the location, as explained in page 2 of the testimony, quality A is a rectangle and B is a triangle, and it looks like C is a -- holy cow. That is -- well, I think a little -- the C is -- I might double-check that. Yeah, the C is supposed to be a circle.

Q Okay.

A It is drawn in figure 2, it looks like a squashed egg. On the plot it looks like a -- it is almost a square with rounded-off edges, but that is supposed to be a circle, and diamonds are D, and stars and plusses for preliminary and experimental, and other --

Q There is a distinction, is there not, though, in the significance, if that is the right word, to be attached to these various symbols, pre and post-1961, if I read your testimony correctly at page 3?

A At the beginning of -- okay. Yes, prior to 1961, it was almost all graphical, and certainly a qualitative or maybe semi-quantitative judgment. Ways we -- are hard to find out anymore. In 1961, a Bendix Computer was used for the

first time in these locations, and they maintained the same schedule definitions, and -- but there was more numbers and more of a quantitative aspect to it. I can't -- I don't really know any more about it than that. It is --

Q Have you ever done an independent evaluation of the error bars for the quality assignments?

A Let us see. Are you talking about, say, the ones cranked out by their current program?

Q I am looking at -- I am looking at page three, and I guess my question is: Does an error of one second for a sparse array, such as existed in 1970, correspond to an accuracy of five kilometers? Have you ever done an independent determination of whether or not that correlation is correct, or have you accepted these values?

A Okay, the -- I may want to say -- say two things here. One is, the -- the errors in -- okay, further down. I am not deeply intimate with the exact algorithm used in the program to generate the numbers, first of all, but in general, the horizontal standard errors and the vertical standard errors are computed independently and are not necessarily directly related, let us say, to the RMS of the residuals, which has some other information in it. Again, I can't be more detailed than that.

In general, however, if you look at an RMS figure of half a second, and say okay, I am going to have

a PN (ph) velocity of 8 kilometers a second. You come out with a corresponding distance error of four kilometers, so -- distance error of five kilometers, is as I sit here, totally commensurate with that.

Q So you have done that kind of work?

A Yeah.

Q Okay. I would like you to look at figure one again. Now, just looking at the data apparently entered by the computer, which are the epicentral locations on this area, and I would like you to tell me if you believe that that represents a randomly distributed pattern of micro-seismic activity.

A Looking at that, I would say that is -- ah, wonderful. Randomnesses in the eye of the beholder. But no, I see patterns in this, if that is what you mean. I see a hole in the middle of it, obviously. I see a -- well, let us say a slightly higher density of events to the northeast. Other than that I don't really see much in the way of a pattern that I would want to make a story out of.

Q How do you account for the density in the area you described as the northeast?

A Well, that happens to be where the Elsinore fault zone runs.

Q Do you see any pattern of dots which exhibit an alignment with Cristianitos fault?

MR. WHARTON: Objection. Ambiguous. I -- alignment of dots to correspond with the Cristianitos fault where? You were talking about up towards the Elsinore or --

MR. BEOLETTO: He has got the Cristianitos fault mapped on the figure. All I am asking him is if -- in his mind's eye, as he looks at these points, does he see any alignment of points which corresponds to the line --

MR. WHARTON: Fine.

MR. BEOLETTO: -- that represents the Cristianitos fault the way he has entered it on the map.

JUDGE KELLEY: All right.

MR. WHARTON: Fine.

WITNESS SIMONS: I can answer?

JUDGE KELLEY: Yes.

WITNESS SIMONS: The answer is no.

BY MR. BEOLETTO:

Q Okay, figure two, please. Well -- in reference to figure two, if you would, Mr. Simons, also, at page four, line five, you say the results are graphed in figure two showing only those events reasonably close to the Cristianitos fault zone to mitigate confusion. I am wondering what criteria you used to establish reasonably close.

A I can tell you right now it wasn't rigorous.

I didn't say aha or anything, whose perimeter fall outside five kilometers from the fault I am going to suppress, but that would be approximately correct. See, well, you can understand, if I were to draw circles around all those events to the northeast, why, you couldn't see the rest of the diagram, so -- again, I can't --

Q I see.

A I can't give you a rigorous quantitative criterion, but it would --

Q Do you know how many circles there are in figure two?

A As I sit here I don't. I am not sure. I may have at one time. I gather it is not in the testimony. It probably isn't --

Q I don't --

A Yeah, it isn't.

Q -- recall it being. I just was curious if you knew the number of circles. If you don't recall we will move on.

A Yeah, I would rather not count them right now.

Q Let me ask you one question with regard to both figures one and figure two. These are both epicentral plots, is that right?

A That is correct.

Q You have done no hypocentral plot?

A That is correct.

Q Okay, now, in attempting to understand what these various circles on figure two represent, I would like to look at, and picking one for convenience, the entry on the upper right hand, most upper right hand entry on figure two, I see 54C3.1. Do you see that on figure two?

A Yeah.

Q Could you tell me the -- what is conveyed by the numbers -- the letter and the last number?

A The years 1954, the quality assigned in the catalog is C. The magnitude is 3.1.

Q Okay, now does that come out of appendix A, that information?

A It certainly could be there. It is on -- I mean if you really want to know, it is on page two of Appendix A, I think, and -- about one quarter the way up the page from the bottom.

Q Okay, you find that event on page two?

A I believe I do. I see an 1954 event, 3.1, quality C, fairly far to the north, yes.

Q Okay, is Appendix A a complete listing of all of the data that appears on figure one and two?

A Oh, figure one? Yes.

Q And then there was some selection criteria that you employed to go to figure two?

A That is correct. I would only offer one qualification here. Figure 1 or 1(a) as you have it --

Q 1(a), I am sorry.

A As we have discussed it, has lost a little bit off the fringes, you know, the left and right of the diagram, so if you counted up the total number of dots you might come out a little bit short.

Q Okay, now I would like to go to figure two again, and the number that we have just been looking at, 54C3.1, moving your eye to the left to a smaller radius circle, the numbers are written nearly from the bottom to the top. It looks like 75C2.8. Do you find that?

A Oh, I do, yes.

Q Okay. Now, in Appendix A, on the third page, I am going to ask you if you would, please, take the time to run down the column -- 19 lines I believe. And I see 1975 and then a row of figures that ends with 2.8 and A. Is that the only 2.8 event that occurred in 1975?

A Insofar as I can read this copy, which I guess I can. That certainly looks like that is the case.

Q Okay. That then being the only 2.8 quality A event that occurred in 1975, corresponds to the circle that we had previously identified on figure two?

A Well, it should, yes.

Q Okay, examining the latitude and longitude given

in Appendix A, do I correctly interpret that to mean that that event should be plotted on the lower half of this figure two?

A 33.4?

Q Yes.

A No. The -- I am -- well, no, the upper -- let's see, the lower limit of this is 33.25 and the upper limit is 33.275.

Q What is the center line?

A It should be 33.5. Underline that.

Q Is it just possible that the entry is wrong on the --

A It is possible that the entry is wrong. It is possible that it was the 2. -- mind I am not looking at the latitude or anything, but that there are other 1975 events. It is just possible that there are other 1975 events. It is just possible that the magnitude was mis-written. It is really a 1.8er, it is just that -- see, I am looking at a 2.6 up here that is hard to read, that is a 33.7 about. I have a rough Xerox copy here and --

Q So do I.

A Okay. And it may be that the 2.6 may have been transcribed as a 2.8.

Q Where is the 2.6 plotted?

A Well, let's see. It is supposed to be at 33.7

and 117.4, which --

Q Can we move on?

A Yeah, I don't see a 2.6, so maybe it is the one that says 2.8.

Q Can you find --

A You said you wanted to move on?

Q Well, I want to end this though by asking you, can you find the 75C2.8 event that is plotted up on the upper portion of this curve, or at least above the center line of this curve in Appendix A?

A I can find it only if I assume that it is really the 2.6.

Q Well, have you looked on figure two to find the 2.6?

A Oh, well -- I haven't found that yet. Well, I am still not finding it. Things that it should be -- let's take a look at the coordinants of the 2.6 events, 33.7 about -- 33.679 -- 117.4 -- which what? -- should be kind of halfway up from the center to the top and -- what is that five -- probably ought to be a little bit more off to the west if I am doing the middle line on this correctly.

Let's see, and the middle line should be about .5, I guess. Oh --

ghp 1

Q When did you make this plot, Mr. Simons?

A Several months ago.

Q Did you check it for quality, for error?

A As much as I could. Let me explain what --

Q You draw some rather significant --

MR. WHARTON: Mr. Chairman, he was finishing the question.

MR. BEOLETTO: I am sorry.

WITNESS SIMONS: The circles were initially drawn on the map by my assistant I then went in and double-checked it and the end -- I had to because as I notice here, the dates and the qualities and the magnitudes so at one time I had to go in and identify and properly locate each one of these events and make sure they were in the right place so that I could label them.

BY MR. BEOLETTO:

Q Are we finding that they are in the right pla e?

MR. WHARTON: Mr. Chairman, he hasn't fi..shed his answer yet.

WITNESS SIMONS: I was just going to say that in that sense these were certainly doubled checked. If you are going to ask me if they are perfect, it is posisble that they are not.

BY MR. BEOLETTO:

Q I think we determined that they are not perfect.

ghp 2

I am wondering if you could quantify the amount of error in this figure.

A Not much.

JUDGE KELLEY: Let me be clear that the raw data and numbers back here and they are up to date for every circle and there should be an entry in the raw data; correct?

WITNESS SIMONS: That is correct.

JUDGE KELLEY: And one could confirm -- one could take --

WITNESS SIMONS: Anyone could duplicate this.

JUDGE KELLEY: That is the point I am getting to. We have explored this some and there is an indication that there is at least an error and maybe there are some errors and I think we can pass on to the next point.

MR. BEOLETTO: The point being that this was presented for the Board and the parties to rely on in interpreting this figure and I think we have established that there are some points that are correct.

WITNESS SIMONS: We have found one point that I cannot give you a satisfactory answer on; that is correct.

JUDGE KELLEY: That is right and you, in your briefs later on want to show that there are five or ten more errors, you are free to do that.

MR. BEOLETTO: I think it goes to the weight to be given to this type of plot. There is one more point here that

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I do think is worth the time to do so, and that is 75-A, 3.8 and right immediately underneath that, 3.4.

JUDGE KELLEY: You are now at Figure 2?

MR. BEOLETTO: Same figure, yes, Figure 2.

JUDGE KELLEY: Where are these that you are referring to?

MR. BEOLETTO: Slightly above the center line and slightly to the left of center. There is a rather bold, in comparison, small circle drawn 75-A through point 8 and immediately underneath another number, 3.4.

JUDGE KELLEY: And is it your point that we don't find the same information on the data sheet?

MR. BEOLETTO: Not necessarily. I think this is worth pursuing in addition to this.

BY MR. BEOLETTO:

Q Mr. Simons, can you identify that data as that data that Dr. Beihler did the relocation studies are and referred to as the two 1975 Trabuco Canyon events?

A Yes, I can, that is correct.

Q The quality identification, if I read Figure 2 correctly, is A; is that right?

A That is correct.

Q What radius is to be drawn for Quality Class A?

A For 1975 -- 1975 page 3 it says, horizontal standard error less than one kilometer, so it should be a radius of

ghp 4

one kilometer.

Q What does it appear on Figure 2?

A I am sorry, I have to say it looks like two kilometers.

Q Mr. Simons, page 5 of your testimony, if I could direct your attention there please? The first sentence in your summary: The overall picture that emerges from the above is that the Cristianitos fault is situated in an area which has experienced considerable seismic activity in the immediate past.

Can you tell me, basically, what fits your definition of considerable seismic activity?

A I think it is what I expect the Oxford English Dictionary to say, that it is capable or worthy of consideration, that is to say, not negligible.

Q Worthy of consideration, not negligible; did I understand that correctly?

A I believe you did, yes.

Q Now without getting into considerable debate about matters that occurred here earlier, have you compared the level of seismic activity that your study encompasses with the Southern California average?

A No, I have not. I did a statistical analysis of the events, but I did not go that far.

JUDGE KELLEY: Mr. Beoletto, not to turn you into

ghp 1

a witness, but is that a recognized concept, the Southern California average?

MR. BEOLETTO: I understand that it is, yes.

JUDGE KELLEY: Have we heard it in this case?

MR. BEOLETTO: One second, please, Mr. Chairman. It was included in Intervenor's Exhibit No. 14, which was admitted into evidence earlier today.

JUDGE KELLEY: It is in one of the articles?

MR. BEOLETTO: Yes, represented, as I understand it, in a figure in that document.

JUDGE KELLEY: Thank you.

BY MR. BEOLETTO:

Q To go back, I understand you have not made a comparison of your levels of seismic activity reflected in your data with that Southern California average?

A No. It is Cal-Tech's data really.

Q Let me ask you this, Mr. Simons, have you reviewed the NRC Staff safety evaluation section on seismicity which is Section 2.5.2.2?

A Not that I recall.

Q If I could have a minute, I would like to show you that section.

MR. BEOLETTO: Mr. Chair n, could I approach the witness?

JUDGE KELLEY: Yes.

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MR. WHARTON: What section again, Mr. Beoletto?

MR. BEOLETTO: It is Section 2.5.2.2 entitled, Seismicity, which appears at page 252 of the volume I have of the SER.

MR. WHARTON: Mr. Chairman, I would have one objection here. The witness has testified that he has not reviewed the SER. He is asking him to review the SER now.

MR. BEOLETTO: I am asking him to look at no more than a paragraph contained in that section, Mr. Chairman.

JUDGE KELLEY: A paragraph is okay.

MR. BEOLETTO: There is a paragraph within -- I believe it is the third full paragraph that begins, those earthquakes of magnitude 6 or larger, and Mr. Simons is reading that right now.

(Witness peruses document.)

WITNESS SIMONS: Okay, I think I have finished reading that.

BY MR. BEOLETTO:

Q The language in the very last sentence of that paragraph -- I quote -- The vicinity of the San Onofre site (within approximately 30 kilometers) appears to be one of relatively low seismicity.

My question is, Mr. Simons, do you agree with the conclusion reached by the NRC Staff, that the area is one of relatively low seismicity?

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A I have to assume something here. I don't have to assume it, but it is a question of relative to what. I am looking at the text again to see if I can find it, or do you want to tell me.

JUDGE KELLEY: Maybe the staff could tell you, if anybody.

WITNESS SIMONS: Volunteers?

BY MR. BEOLETTO:

Q I don't have a particular citation to cite you to for comparison but perhaps --

JUDGE KELLEY: Could you comment on the Staff's intent in that particular statement?

MR. REITER: I think the comparison has to do with the quiet or the 200-mile zone from the vicinity of the site. The comparison with respect to seismicity is generally within 200 miles of the site.

MR. WHARTON: Mr. Chairman, I would submit that that is a subject area that Dr. Simons has not testified to. He has testified to the immediate area of the Cristianitos fault. It would be outside the scope of direct.

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kw-1

JUDGE KELLEY: Well, but he has testified and made the conclusions about the seismicity of this area. What was the sentence that this all began with?

MR. BEOLETTO: It is in the --

JUDGE KELLEY: The overall picture that emerges. Considerable seismic activity in the immediate past -- I think it is fair cross examination to point to a statement like this and --

MR. WHARTON: Well, I was just seeking clarification. Maybe I didn't hear right. You were asking for, I believe, a definition of what was meant by the word relatively low seismicity, and my understanding was -- I got an answer back -- would you please state what you mean by relatively low seismicity. And my understanding was that I got an answer back, would you please state what you mean by relative to what area you are talking about.

MR. BEOLETTO: No, I don't believe that is exactly the question, Mr. Wharton. The Witness's testimony contains the expression considerable seismic activity. The results of the Staff evaluation contained in the safety evaluation report contains the expression relatively low seismicity, and I am just asking if he wants to offer an explanation or attempt to reconcile the apparent disparity in those two positions.

MR. WHARTON: The question is --

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JUDGE KELLEY: Let me interrupt just for the sake of -- well, let me interrupt. Doctor, didn't you then explain that you meant an area within 200 miles of the site, when you used the phrase relatively low seismicity?

DR. REITER: Yes, sir.

JUDGE KELLEY: And that means that the site -- the immediate environs of the site are relatively low in seismicity in the Staff's view, when you look at that larger area?

DR. REITER: Yes, sir.

JUDGE KELLEY: Okay, and then the Witness is being asked essentially whether he agrees with that statement or how he would reconcile the two, is that correct?

MR. BEOLETTO: That is the question.

MR. WHARTON: Mr. Chairman, the Witness said -- asked what was meant by relatively. Relative to what area.

JUDGE KELLEY: Well --

MR. WHARTON: I don't know that we -- well --

JUDGE KELLEY: Regardless of where we were two minutes ago, right now he is being asked the question I just put.

MR. WHARTON: Fine.

JUDGE KELLEY: So why don't we just ask for the answer to that?

WITNESS SIMONS: Well, I have lost track of

things here. I have to ask --

JUDGE KELLEY: Well, how about if I repeat --

WITNESS SIMONS: If you would, please.

JUDGE KELLEY: All right. Now you say at page five of your testimony that in your opinion this is an area which has experienced considerable seismic activity in the immediate past. The NRC staff in its SER has expressed the opinion that this is an area of relatively low seismicity, and by that they mean low in comparison to the 200 mile area around the site. Now, do you disagree with the Staff, or do you think that your statement and the Staff's statement can be reconciled?

WITNESS SIMONS: Well, I think that the two can definitely be reconciled. Let me just take my statement first, and again, I don't know if I can say anything different that I already have. I mean, I am using considerable here just in the sense that it is non-negligible. You know, it did happen within a subcontext that must be significant, and I have already said things about stresses causing earthquakes, and you can make some conclusions from that. So, you know, this stuff is not negligible.

Now, getting into relatively low seismicity, I can think of two ways to take that. One is to say that, well, this area that we are carving out and calling San Onofre, as compared to an average of the larger area -- and 200 miles

will take in pretty much most of Southern California -- if I interpret it that way, I come up short of knowledge, because, you know, on the average, as we have already established, I don't know how this compares with the larger Southern California area. If you want to say it is low seismicity relative to some other -- a number of other areas of California, it certainly is true that this is -- in the historical past, so far as we know, this -- the seismic history is that it is low relative to some other parts of California.

On the average, again, I don't know.

JUDGE KELLEY: Excuse me, maybe I misunderstood. Did I hear you say that you don't know what -- you are not really familiar with degrees of seismicity in the Southern California area? Or did I misunderstand what you said?

WITNESS SIMONS: Let's see. Yeah, I was saying that if the question is -- or the statement is supposed to read that as low seismicity, you know, relative to the average California seismicity, I don't know the answer to that. If the intent of it is to say that it has got relatively low seismicity as compared to a number of other areas of California -- I mean, you know, San Andreas fault and Imperial Valley -- any one of a number -- why, that is certainly true.

This is -- you know, has lower relative seismicity -- or has had in the immediate past, then a number of

other areas of California that we could pick out -- but when you talk about averaging all the events, you know, over the entire area, you know, you have pockets of seismicity, if you look at the seismicity map. You have clusters of them on the Imperial fault, clusters of them on San Jacinto, around the major faults. Well, you take any one of those clusters, you know, areas of known activity, certainly San Onofre comes out relatively low.

If you average all of California, though, well -- clearly, these areas of quiescence are pockets that are not so active and draw down the average quite a bit. And I don't know how that compares. I hope that says something.

JUDGE KELLEY: Yeah, I think I understand what you are saying. I asked earlier what Southern California average meant, and I am told it is in a scholarly article somewhere and I will look at it, but are you familiar with that concept?

WITNESS SIMONS: Not in any detail. I mean, I can -- I have never pursued the point of comparing anything to California average. I can follow the concept, but I have never read any articles on it or that used it, as a matter of fact.

BY MR. BEOLETTO:

Q You haven't done sufficient studies, then, if I understand you correctly, Mr. Simons, to know what the

Southern California average is?

A I think I know where to find it. Unfortunately I left the book in the car.

Q From recollection you don't know?

A Oh, no.

Q Mr. Simons, are you familiar with frequency versus magnitude recurrence curves?

A Well, if you are talking about MB plots or B value plots?

Q Frequency of occurrence -- numbers of earthquakes per year versus the magnitude.

A Well, then I am sorry. It is a different terminology. Same thing. But, yes, I am.

Q Okay. And I guess what I am asking -- I will ask it one more time to make sure. On that basis, have you compared the vicinity of the San -- or the Cristianitos fault as you defined it in your testimony with the Southern California average?

A No.

MR. BEOLETTO: Okay. That -- Mr. Chairman, that earlier reference was to Intervenors' Number 14, figure 10 appearing at page 781.

JUDGE KELLEY: Thank you.

BY MR. BEOLETTO:

Q Mr. Simons, given your recognition of the

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existence of the recurrence curve, can you compare the Southern California average -- could you compare the Southern California average with the work which you reference in your testimony -- the work performed by Dr. Sean Biehler, his micro-earthquake activity work in 1975?

A Somewhere in the middle of that I got lost. I must have missed the operati ; verb.

Q Well, again, I am asking --

A I didn't --

Q Your testimony references the work of Dr. Sean Biehler --

A Yes.

Q And I am asking if you have compared the Southern California average with the results that Dr. Biehler has presented? Obviously you are familiar with the work of Dr. Biehler. You have got it referenced in your testimony.

A I am familiar with -- well, I certainly am, yes. The only -- it is referenced principally because, you know, I make reference to his microseismicity study. The answer to your question clearly has to be no, because I haven't done anything with average Southern California seismicity.

Q You are not familiar with the recurrence curves for the region, are you Mr. Simons?

A No, I am not. I have not studied that all for this region or the Southern California.

ghp 1

Q All we are really trying to do, since you have cited the work of Dr. Biehler in your testimony at page 5 and in the last sentence of that one paragraph section you say: It is to be assumed that this is a representative sample of data, it follows that had the array remained in place one year, a total of 27 micro-earthquakes would have been recorded close to the Cristianitos fault.

I am trying to quantify, if I could in some comparative sense, the 27 micro-earthquakes that could have occurred. Would that be a large number, a very small number or can you say?

A I must say, off the top of my head, that it sounds like a pretty hefty number for this area. Of course they are very small micro-earthquakes. Strictly speaking, how that compares with some other area in California or the California average, I can't respond to that.

Q California average is what we are talking about.

MR. WHARTON: Mr. Chairman, he has testified three times he does not know the California average; asked and answered.

BY MR. BEOLETTO:

Q I beleive you mentioned earlier you were familiar with the concept that has been described in this proceeding by Dr. Dhawn Biehler and Dr. Smith as well, the concept sometimes referred to as a halo of seismicity?

ghp 2

Could you briefly give me your understanding of that?

A It is just the frequently observed -- for lack of a better word -- phenomenon, artifact or something that when you look at micro-earthquakes over the state they do not necessarily seem to be correlated with the traces of the surface faults as shown on the geologic maps and they don't necessarily tend to cluster all around known fault zones, but rather tend to be sort of scattered and be just as likely to occur off the fault zone as on.

That is, relative to the mapped surface geology, there is a fairly strong population of micro-earthquakes that are dispersed -- scattered. They don't fall right on the fault traces like some seismologists might like.

Q In this context are you referring to micro-seismic events of magnitude 1's, 2's, in that size?

A No, I think this can go up to 2 to 4 and I think in northern Baja California we have seen them larger than that.

Q Contained within the halo of seismicity?

A Yes.

JUDGE KELLEY: Let me interrupt just a minute. I would guess from your outline that you are --

MR. BEOLETTO: Very close to being done.

JUDGE KELLEY: How much time do you think you need?

MR. VOGLER: I guess the usual, being last, it

ghp 3

depends on how much Mr. Beoletto has.

JUDGE KELLEY: You are next.

MR. VOGLER: Are you finished?

MR. BEOLETTO: I am very close.

MR. VOGLER: There is very little less, maybe 10 minutes or less.

JUDGE KELLEY: I raise it because it is 5:30 and we are starting to sag, frankly.

MR. BEOLETTO: We can finish, I am sure.

JUDGE KELLEY: I would like to finish Mr. Simons and I am sure he would like that too. Do you want two minutes?

(Brief recess.)

JUDGE KELLEY: On the record.

BY MR. BEOLETTO:

Q Mr. Simons, at page 5 of your testimony in the summary, the first paragraph, second sentence, you say, within the limits of accuracy presently assignable to these seigmic events, at least 20 earthquakes could have occurred on the Cristianitos fault. Do you know what the magnitude of the largest of those 20 events is?

A Off the top of my head I don't.

MR. WHARTON: Mr. Chairman, I think we could simply look at the map and do that.

WITNESS SIMONS: I might offer to do that, but I don't know.

ghp 4

BY MR. BEOLETTO:

Q In the interest of time, would you be in a position to agree with the representation, that is, the 3.8 event described earlier by Dr. Shawn Biehler?

A Those events are not included in the count. These 20 events are just those whose circles of error intersect the surface trace of the fault.

Q The events in your plot are not included in the events that you characterize as having possibly fallen on the Cristianitos fault?

A That is correct.

Q Is it true, Mr. Simons, that the scope of your work reported here in this testimony did not extend to the point where you could locate any events on particular fault surfaces?

A If I understand that, the answer is that it is correct. It is sort of the opposite.

Q Where faults are at depth you plotted no epicenters? You did not attempt to place any activity, any element of this study on a fault surface?

A No.

Q At page 4 of your testimony, Mr. Simons, the paragraph at the bottom, you say, with careful study the accuracy of many of these events can be improved, especially more recent ones.

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What do you have in mind when you say, careful study?

A I think probably an excellent example is probably the sort of thing that Dr. Biehler did.

Q Did you ever attempt to perform those studies for the events included in your testimony?

A No.

Q Are you familiar with the Applicant's work described in the final safety analysis report concerning relocation of events?

A You are citing something -- you mean Dr. Biehler's original report?

Q I am asking for a yes or no. Have you reviewed the final safety analysis report and, if you have, have you encountered or studied the work of the Applicants concerning relocation of events?

A Are you talking about the work -- when you are talking about the Applicants, are you talking about Dr. Biehler's work?

Q That is a part of it. I am just wondering if you have read the SFAR. If you haven't, the answer to the question is probably no.

A It is no. The reason I hesitate is that I have a lot of documents shoved at me and I read them and I don't memorize what the title of the document is.

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Q Coming in here today, were you familiar with the fact that the careful study that you refer to in your testimony and the way you described careful study, that the Applicants had done that type of work, relocating events in this area?

A For the 75 events, for instance, yes.

Q And many others?

A Such as the '77 events?

Q Yes.

A I am not aware of any others besides the '75 and '77.

MR. BEOLETTO: I don't have any other questions.

JUDGE KELLEY: Mr. Vogler?

FURTHER CROSS EXAMINATION

BY MR. VOGLER:

Q Mr. Simons, we are going to skip around a little bit because there have been an awful lot of questions asked and there is not much left to cover.

A That occurred to me.

Q Would you correct me -- this may have been covered -- on page 4 of your testimony, where you are talking about reasonably close, did you define what reasonably is? That is the last line, or in the middle of the first paragraph? You were discussing Figure 2?

A I responded earlier by --

Q You have?

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A Yes, I can repeat what I think I said. It wasn't any rigorous numerical criterion. It was a qualitative look at whether this thing was going to be so far out of the picture that we didn't want to see it and if you want to get roughly qualitative about it, it meant that if I saw that the circle came within 3.5 kilometers or so of the Cristianitos, then I didn't bother to obfuscate the diagram with it.

Q Who made the decision?

A I did.

Q But they were plotted by your assistant? I misunderstood that.

A That is correct. I identified for him --

Q Which ones you wanted?

A -- which ones I wanted plotted, yes.

Q And Figure 2 obviously, then, from what you have just said, does not contain all of the data that you have plotted on revised Figure 1-A?

A That is correct.

Q Wouldn't you say that in order to determine if a correlation of events are accurate -- desired events -- that you should review all of the data as opposed to some of the data?

My problem is with Figure 2. You haven't at all of the events on Figure 2 that are on Figure 1-A.

A That is correct. We have established that. What

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can I say? If I do that, it makes the diagram almost impossible to look at.

Q But in order to determine what you are trying to establish for Figure 2, you have selected information as opposed to all of the data that is available on Figure 1.

A I have selected information, right. In general principle, of course, I am very much in consort with the notion of looking at all the data. As a matter of fact, I did look at all the data and, to get to the question I was asked to answer, I weeded some of it out because it didn't relate to the answer.

Q It didn't relate to the question?

A It didn't relate to the answer to the question and the question following to answer was, given these epicenters and the uncertainties associated with them, how many of them could have been associated with that fault trace.

T27 1g

Q Could you put figure 2 up on the viewgraph for us again, please? Now, if you will bear with me a minute, take a pencil or a pen that you have there, and run them through the circles, in the center, so that they -- most of the circles that appear up there on the Cristianitos fault, up towards the top, would you run your -- lay your pencil on the viewgraph --

A You mean without marking it?

Q No, without marking it. Just lay it on there so that we can have a shadow?

A Pencil now --

Q Right.

A I am a little bit in doubt as to --

Q I would like you -- no -- yeah -- to disect the majority of the circles that are there. No.

A Bisect them with the --

Q Yes, with the pencil.

A Like that?

Q No, I think that that is not the way that --

A I guess I am not getting the point of this.

MR. WHARTON: Maybe we could rephrase the question. It is a little unclear, I think, obviously unclear where the witness is putting the pencil.

WITNESS SIMONS: I am way out of synch, am I, or way out of touch, okay.

T27 2g

BY MR. VOGLER:

Q I am looking at the cluster of data in the -- not in the exact center of the diagram, but in the upper slightly to the left, the grouping of circles, where most of your circles are ground, and -- right.

A About up here?

Q And I would like you to run your pencil on a -- to see the best fit here on a diagonal through all of those circles, and I think you will find that if you run your pencil, or lay your pencil through the center of those circles, you may find that the chain of events is oblique to the Cristianitos fault.

MR. WHARTON: Mr. Chairman, I believe that this is the kind of thing that can be done by Staff in any closing argument they want to do, or in any -- well, findings of fact and conclusions of law that they want to put together. They can make this argument in the --

MR. VOGLER: I am trying to say that what you could do with selected data as opposed to all of the data, and --

JUDGE KELLEY: I thought you probably wanted to ask him a question.

MR. VOGLER: Pardon me?

JUDGE KELLEY: Once you got the pen on there where you wanted it.

3g

MR. VOGLER: I would have a question, if he would put it that way.

JUDGE KELLEY: That is different. That is not just, you know, from point A to point B. It is a little bit.

MR. WHARTON: If Counsel would put the pencil on there and ask him a question rather than have Mr. Simons put the pencil.

JUDGE KELLEY: Why don't you go do that, Mr. Vogler, put the pencil where you want it, and ask him a question.

WITNESS SIMONS: Your pencil or mine?

MR. VOGLER: May I use yours?

WITNESS SIMONS: You may.

MR. VOGLER: There it is.

JUDGE KELLEY: I am glad it is you doing this and not me.

MR. CHANDLER: Mr. Vogler is an anti-trust lawyer, and not used to performing these functions.

BY MR. VOGLER:

Q Would you say that that is the approximate best fit for the circles that you have established on this figure 2?

A Yeah, I tnink if I were trying to fit something there, that would be a --

Q We are looking. We are -- the question goes to --

A -- and you are trying to --

Q -- as to what the best fit is, I am sorry.

A -- and so -- yeah, I probably couldn't do much better than that. Of course, the nice thing about error bars is, you can -- they are what they are. You can always, given a chart with error bars on it, you can put the -- you know, the line in a lot of -- I can put that line in a lot of different places, and it will still go through the errors, okay? You know, I could twist it obliquely and do all sorts of things, and still fall within the circles, but anyway, your points --

Q But the center of the circle is supposed to be the middle of the error bar, is that --

A Oh, that is correct, yeah, but you know, when you fit some data, you don't necessarily try to go through the center of the point. That is the whole point of the error bars, is that you have the latitude or the whole range to work with, so -- so the number of lines that could be fit there --

MR. VOGLER: I think that finishes the Staff's cross-examination.

JUDGE KELLEY: Thank you.

JUDGE JOHNSON: One very quick one. In your tabulation and in this figure, what scale are you using for your magnitudes, earthquakes? 3.1 is what scale? 3.8 is

what scale?

WITNESS SIMONS: Let us see. The -- you -- figure 2, and on figure 1, the -- I guess I don't understand the question. The magnitudes aren't really indicated except as the circles are --

JUDGE JOHNSON: No, sir.

WITNESS SIMONS: -- tagged for information.

JUDGE JOHNSON: You are right, we are not communicating. The computer printout that is your Appendix A -

WITNESS SIMONS: Yes.

JUDGE JOHNSON: -- lists in a column toward the right-hand side of the page, adjacent to a column that is entirely A, B, C, D, just to the left of that --

WITNESS SIMONS: Yes.

JUDGE JOHNSON: -- in generics.

WITNESS SIMONS: Yes.

JUDGE JOHNSON: How would you describe them?

WITNESS SIMONS: Well, you mean -- well, first off, they are in the magnitudes. Are you asking for the range that they cover?

JUDGE JOHNSON: No, sir. On what scale of magnitudes of earthquakes. What scale of magnitudes of earthquakes are you using for these entries?

WITNESS SIMONS: Oh. I see. I am sorry. Okay.

Hmm. I believe these are all M_L's, local magnitudes.

JUDGE JOHNSON: My apologies. I will make it two questions.

Figure 2, your computer printed what on the piece of paper from which this figure was prepared? You put the pencil notations on. You said they are your handwriting. The fault was drawn in. The coastline was drawn in. What did the computer do precisely? Did it draw each circle?

WITNESS SIMONS: I wish it had. No, the computer put the symbols representing the epicenters on the map. The circles were unfortunately drawn by hand.

JUDGE JOHNSON: And they have disappeared from what we see here? Those symbols have disappeared from what we see here?

WITNESS SIMONS: Oh, yeah. Again in the interests of legibility, the symbols were not placed at the centers of the events, because it -- well, because the -- you know, the radius of the circle was supposed to represent that.

JUDGE JOHNSON: Thank you.

JUDGE KELLEY: I gather, Mr. Simons -- did you, by the way, were you here the other day for Sean Biehler's testimony?

WITNESS SIMONS: Yes, I was.

JUDGE KELLEY: Okay. He testified about those two events in particular, and I have forgotten the exact terms,

but the concept was that it was his view that those earthquakes were on a different fault plane entirely, the Cristianitos, say, coming at this angle, and they are coming in at that angle.

The method of putting error circles on a map, I gather does not include -- the term I hear around here all the time is "parameter." Is that parameter accounted for in this circle method? The fact that they would be at a different -- on a different plane?

WITNESS SIMON: No, that is totally -- like -- independent information.

JUDGE KELLEY: But isn't it true that if you had the information relevant to that kind of a determination, a conclusion suggested by a circle might be changed?

WITNESS SIMON: Yes.

JUDGE KELLEY: I am interested, again referencing Dr. Biehler as you do on page 5, you say that if the equipment had stayed in place for a year, it would have produced about 27 microearthquakes. I am not clear how you get to that number.

WITNESS SIMON: Let me see if I can reconstruct it. It is supposed to be this sort of conventional -- what shall I say -- street wisdom here, just an extrapolation -- let us see --

JUDGE KELLEY: Three --

WITNESS SIMONS: He told me -- 45 days.

JUDGE KELLEY: Yeah.

WITNESS SIMONS: And that is what, a ninth of a year?

JUDGE KELLEY: I think maybe -- you said there were three of them in that period of time, so there are what, eight times that? Maybe you are about right. Eight and a half times. Okay, I understand.

WITNESS SIMONS: Just a -- through straightforward extrapolation.

JUDGE KELLEY: Okay. What is that -- what are we to infer from the number 27 microearthquakes close to the Cristianitos fault? I mean, is that a lot? What is the significance of that?

WITNESS SIMONS: Okay. I guess I will try to answer the way I did before. I am not sure what the significance of it is, say, relative to, here we go again, other parts of California, or the California average, so I can't tell you in that sense whether that is a lot of earthquakes or not. I said off the top of my head, it sounds like quite a few earthquakes, even though they are small, as we are talking about now in the magnitude one, one point five range, the only significance I could make out of it for sure is that they happened or would have happened, let us say, by extrapolation and as I said before, something made

them happen, some system of stresses caused them to happen.

That is the only thing I can make --

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JUDGE KELLEY: I was interested in Dr. Biehler's exhibit the other day. It struck me as quite significant that you could go out and in effect sort of take the temperature of a fault, and I asked him what one of those maps would look like with the San Andreas or some other very active fault, and he testified, as I recall, and I am paraphrasing, but words to the effect that the area would be sort of black with dots, and it would be markedly different from this depiction of a piece of the Cristianitos with sort of a dot here and a dot there, albeit over 45 days.

Again, do you have any basis for disagreeing? Does my description of Dr. Biehler's testimony roughly correspond with what you heard the other day?

WITNESS SIMONS: It sounds like a fairly accurate capitulation and I have no reason to doubt that that is absolutely right. If you can compare it to the San Andreas fault or some -- any number of well known fault zones in the area, certainly.

JUDGE KELLEY: So in terms of dots on a map, using this method, you would agree that the well known highly active areas like, say, the San Andreas, would have a great many more black dots on them than would the Cristianitos --

WITNESS SIMONS: Oh, yes.

JUDGE KELLEY: Thank you. I think subject to the possibility of redirect, that finishes --

MR. WHARTON: Yes.

JUDGE KELLEY: Mr. Simons, thank you very much. Do we have any business on or off the record?

MR. CHANDLER: Off the record.

JUDGE KELLEY: Okay, I guess we can go off the record.

(Whereupon, at 5:52 p.m., the hearing was adjourned, to reconvene at 9:00 a.m., Friday, July 17, 1981)

This is to certify that the attached proceedings before the

U.S. Nuclear Regulatory Commission

in the matter of: San Onofre Nuclear Generating Station, Units 2 and 3

Date of Proceeding: July 16, 1981

Docket Number: 50-361/362-OL

Place of Proceeding: San Diego, California

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

George Girton

Official Reporter (Typed)

Martin Kersels

George D. Girton

Official Reporter (Signature)