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NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF:

PACIFIC GAS & ELECTRIC COMPANY

(Diablo Canyon Units 1 and 2)

Docket Nos. 50-275
50-323

Place -

Date - Avila Beach, California

6 December 1978

Pages 4250 - 4485

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the matter of:

PACIFIC GAS & ELECTRIC COMPANY (Diablo Canyon Units 1 and 2)

Docket Nos. 50-275
50-323

Cavalier Room,
San Luis Bay Inn,
Avila Beach, California.

Wednesday, December 6, 1978.

The hearing in the above-entitled matter was reconvened, pursuant to adjournment, at 9:00 a.m.

BEFORE:

ELIZABETH BOWERS, Esq., Chairman, Atomic Safety and Licensing Board.

DR. WILLIAM E. MARTIN, Member.

GLENN O. BRIGHT, Member.

APPEARANCES:

On behalf of Applicant, Pacific Gas & Electric Company:

BRUCE NORTON, Esq., 3216 No. Third Street, Phoenix, Arizona 85012.

MALCOLM H. FURBUSH, Esq. and PHILIP CRANE, Esq., Legal Department, Pacific Gas & Electric Company, 77 Beale Street, San Francisco, California 94106.

wb

On behalf of the Joint Intervenors:

DAVID S. FLEISCHAKER, Esq., Suite 602, 1025 15th Street, N.W., Washington, D. C.

STEPHEN KRISTOVICH, Esq., Center for Law in the Public Interest, 10203 Santa Monica Boulevard, Los Angeles, California 90067.

On behalf of the Regulatory Staff:

JAMES R. TOURTELLOTTE, Esq., MARC STAENBERG, Esq. and EDWARD KETCHEN, Esq., Office of Executive Legal Director, U. S. Nuclear Regulatory Commission, Washington, D. C. 20555.

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C O N T E N T S

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P R O C E E D I N G S

MRS. BOWERS: We'd like to begin if the parties are ready.

Now the thought expressed yesterday morning in the bench conference was if time permitted, the parties would respond if they so desired to limited appearance statements, toward the close of business yesterday. Well, those of you who were here know there was no time for response. We heard limited appearance statements right up until five o'clock.

So now we have several things to discuss this morning, but do you want to start with that, Mr. Norton?

MR. NORTON: Thank you, Mrs. Bowers.

We will very briefly respond to the limited appearances. As I understand, there were 146 limited appearances represented in these two transcripts of the proceedings yesterday and the day before. We have read them in fairly good detail. It is obviously impossible to address each and every point raised by many of the people, but I think basically the categories of statements that we would like to respond to very briefly are those that deal with the waste matter, and those that deal with the Hosgri Fault.

As respects the waste, that's not the proper subject of course of this hearing, but it was addressed by a number of people who were concerned about the handling of waste in the future.

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Rather than get into a technical discussion of that, that has been considered by this Board and it is to be considered by this Board in its decision as to the handling of the waste matter. It is not something that this Board or this Applicant are unaware of.

As respects the Hosgri Fault, I'm afraid there was a great deal of misconception expressed by many of the people making limited appearances. Perhaps that misconception was intentional, perhaps it wasn't. But many people felt that the plant was -- quote -- "on the Hosgri FAult."

It is not on the fault. The plant is not built on any active fault of any kind. There is no question but what the Hosgri Fault is approximately five kilometers from the plant, and one says, "Well, what's five kilometers? It doesn't make any difference."

Well, it makes a significant difference, and I would only wish, as I look out in the room today and see basically people who are witnesses for Pacific Gas and Electric and a few newspaper reporters, and I see none of the people, with the exception-- I see one lady who just raised her hand who is a limited appearance person.

Unfortunately, none of the people are here today to hear the evidence which is going to take at least three weeks, and yet they have their minds made up that indeed the facility will not withstand earthquakes on the Hosgri Fault.

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We think it is indeed unfortunate that they can't remain to hear the testimony and have an open mind and reach a decision based on the testimony.

But again, as we said in our opening statement, I think the evidence will overwhelmingly show that the Diablo Canyon facility can withstand anything the Hosgri Fault could possibly offer.

Finally, there were some questions about insurance and I think I'll pass that question to the NRC attorney who is intimately more familiar with the question of insurance than I am.

That concludes our response to the limited appearances.

MRS. BOWERS: Thank you.

Do the Intervenors want to respond?

MR. FLEISCHAKER: Thank you, Mrs. Bowers.

Just a few words. I'm not going to respond specifically to anything that was said by the people who made limited appearances but, rather, make this observation:

It seems to me that one of the fundamental problems that we face is involving the individual citizen in the decision-makings on matters that fundamentally affect his life, like the construction of nuclear power plants, and these are matters that involve highly complex, technical questions and the average guy doesn't really have the technical

background, the education, that permits him to participate directly in analyzing the evidence and submitting an analysis for the Board's consideration.

But the decisions that are made on those technical matters affect all of us in a very fundamental way, and all of us, I think this society recognizes, have a right to participate in those decisions. We haven't yet got a very good handle on how to involve those people in the decision-making. One of the ways we do it is through limited appearances.

It seems to me that what's happening in the limited appearances is that the people aren't getting up and giving you an assessment of the credibility of the Applicant's or the Intervenor's or the Staff's case. Rather, what they're saying to you is we're concerned and we'd like you to hear our concern.

This Board, when it sits in judgment on these questions, will apply two things. It will apply its analytical ability and it will also-- It will speak from its head and it will speak from its heart, because the decision of how safe is safe enough is not only an analytical decision, it's a decision that requires the Board to bring its whole background of values. And what those people are talking to, they're talking to your heart.

And I hope-- I was moved for the short time that

I was able to be here. I hope and I think that the Board understands that and will listen to the concern that is being expressed by the people who appeared in limited appearances and will weigh that concern in making the decision.

Thank you.

MRS. BOWERS: Thank you.

Mr. Tourtellotte?

MR. TOURTELLOTTE: Mrs. Bowers, it is rather difficult to know how to answer the numerous limited appearances that were made. There are a couple of approaches that could be taken. I think one is you can be very stiff and very bureaucratic and point out a few items where there were rather gross errors made, and there is an approach of trying to really meet the suggestions of those who appeared yesterday on at least a subject-by-subject basis.

Frankly, I've given it a great deal of thought and as I was driving in today I was discussing it with the other members of my staff, and I frankly didn't make up my mind until I sat down here and started looking through my notes, and I've decided that I'd like to address it more on the level of those people who appeared here yesterday and the day before, rather than on a stiffer, more formalistic basis.

I have to say that I was impressed by the limited appearances with the sincerity of some of the people who

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appeared, such as Sister Marnie Young. There are different human emotions that were evoked there, like the reverence of Orloff Miller, and the humor of Charles Baron who, incidentally I think probably did a tongue-in-cheek routine on nuclear power which I've never seen the likes of before, and it was very interesting.

Ross Richards was poetic. Jimmie Jones, who was pro-nuclear, was rhetorical, and John Halloway was pragmatic. And then there's Arthur Armstrong who-- As you pointed out, Mrs. Bowers, we've been in this a number of years and we see these people appearing at numerous hearings, and I think I always get an interesting response out of listening to Arthur Armstrong because he's always talking about the human feelings that are involved here.

That's sort of what Mr. Fleischaker was talking about a few moments ago.

And there were a lot of human feelings during the course of these limited appearances. There was a lot of mind-reading going on, it seemed to me, which is not really warranted by anybody. There's a lot of anger; there's a lot of frustration, expressions of helplessness and expectations. And also on the part of the people who are in favor of this plant, there was a lot of hope and a lot of anticipation of relief for problems that they see.

Larry Levine, who was opposed to the plant, made

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an interesting statement. He said it's important to see each other as human beings, and I think that's true, too.

I asked myself as I listened to these people, well, what is it that makes the difference between those people and me? Why is it that they see this thing one way and I see this thing another way?

And what I really boiled it all down to is it's a matter of choice. They made one choice and I made another choice.

The choice of course is controlled by the weight that we assign to the advantages and the disadvantages of everything that we do or we choose not to do.

It's funny how that little particular bit of philosophy was sort of epitomized by Ruth Barrett, who talked about Christopher Columbus and the advantages and disadvantages of his voyage to this country, and how, had he undergone a similar type of review, perhaps America would still not be found.

It was also pointed out by a young lady whose name was Leana, who talked about the gross national product, and talked about how gross national product brought about pollution. What she did not talk about were the advantages of having a good gross national product, and she only chose to talk about the disadvantages.

It was also amusing to see that the Board was

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accosted by one complainer, one protestor, Ross Richards, for not having eye contact, and then was accosted by another for having stared at them.

There are advantages and disadvantages to everything. If you don't look at somebody then you're not paying attention; if you do look at them then you're staring.

The concerns that were expressed there were concerns over waste, the fault, accidents, the children and grandchildren of these people, and the general quality of life. I tried to ask myself, well, what's the difference between their view and my view? I guess their view and my view differ because on waste, I choose to believe that we have a viable answer. That's a choice.

On the fault, very specifically related to this plant, I chose to believe that our technical review is a responsible review and is accurate and reflects that this plant can operate in a safe manner. That's a choice.

On accidents, I guess I choose to believe that we can continue to have a good safety record in nuclear power. And I am bolstered by the fact that no deaths have occurred in commercial reactors in over 400 years of commercial operation. That's a choice.

On alternatives, I choose to believe that Congress was correct in making nuclear power a part of the total energy answer. That's a choice.

And on health effects, I choose to believe that the extremely low releases do not adversely affect the public health. And I guess I'm bolstered in that by years of study of the subject and such incidental matters as the fact that a change in altitude from San Luis Obispo to Denver, Colorado, subjects one to greater radiation than if you were to sit in the stream of the effluent that comes from a nuclear plant for an entire year. That's a choice.

The matter of the concern about children and grandchildren and the quality of life, I'm impressed by the fact that it seems that those who were complaining held me and those who work for the government in some sort of special regard, that we are not concerned about our children or grandchildren, nor are we concerned about the quality of life. That is not true.

I believe, and I choose to believe that the quality of life for my children and grandchildren will have more advantages than disadvantages, not just from the standpoint of having the good things in life but as well, from the standpoint of having the basic necessities of life.

There was a great deal of talk yesterday and the day before about returning to the simple life, and I think no one can sit and listen to that without a little bit of discomfort. I know when I drive my car around the Beltway and I get caught on the Cabin John Bridge and I can't move

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and I feel helpless and I wonder whether I'm doing the right thing and whether or not it would be better if I just quit and go out to the woods and live the so-called simple life, well, I grew up living the simple life and where we had coal oil for heat and for light, and wood for heat, and the simple life isn't always what it's cracked up to be.

I saw a lot of people who suffered from disease and who died because the simple life was so simple in those days that we didn't have a lot of the advantages that we have because of the technological advances today.

The question is how simple do you want your life to be?

There is concern about nuclear power and its effects upon humanity, but you can turn that around and ask, well, what about the effects of the wheel? Do we want to give up the wheel as well? I don't know. The wheel has caused a lot of deaths, but I'm not sure that I'm ready to give up the wheel, much less the automobile. Perhaps I can give up moon rockets. I'm not sure that I'm ready to give up computers, and I'm certainly not ready to give up the wheel.

Another important point, it seems to me, is that along the lines of advantages and disadvantages, is that we have to consider that technological advances in our society are necessary not just to maintain a luxurious life style but they are also necessary to maintain the necessities of

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life.

Back in the late 1700s and the early 1800s, there was an English economist who established a theory that basically said that population tends to increase faster than food supplies with, inevitably, disastrous results. It was called the Malthusian theory. And in fact he predicted that the world would starve to death by the time that we're living in right now.

The reason that his theory was foiled was because of technological advances, the technological advances in farming and farm techniques and food processing and food storage.

Now I don't know exactly where the world is going, but I'm certain that most of those people who expressed concern over the past two days would also agree that there is a problem with population and there is a world problem with food supply. And if we do not keep some kind of a technological equilibrium, we indeed face a potential disaster in that respect.

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The fear that was expressed was, we don't know what's going to happen with nuclear power.

Well, the fact is, we don't know what's going to happen tomorrow with anything, and we don't know what's going to happen tomorrow without nuclear power.

David Crockett said that the decision -- although he was also speaking against nuclear power, he did say that the decision must be based upon evidence, facts, statistics and common sense.

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And that's exactly what we intend to do in this case, we intend to present evidence, facts, statistics and, in a certain respect, common sense, the subjective judgment of experts in the field to establish that this plant can operate in a safe manner.

I wanted to touch on a couple of other items. One, more specifically in this case, there were a lot of statements that were made yesterday -- and Mr. Norton alluded to some of them -- that the plant was being built on a fault. More than what Mr. Norton said, I think there are a number of points that should be made about that.

First of all, this plant is not being built on this Hosgri Fault. It is being built a considerable distance away from that fault.

The second point to be made here is that it has never been clearly established that the 1927 earthquake

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of a 7.2 magnitude was really on the Hosgri Fault. What actually happened was that the USGS, in surveying the information, came up with triangulations from instruments on the 1927 earthquake and located that earthquake in various potential spots. And then, after locating it in the various spots, put a dot in the center of the most densely marked areas and drew a circle around it, which they call the circle of error. The Hosgri Fault fell within the circle of error.

They then postulated, for conservative purposes, that the fault could have occurred on the Hosgri Fault -- I'm sorry, that the earthquake could have occurred on the Hosgri Fault.

And not only that, but they assigned it a magnitude which was also a conservative magnitude of a 7.5. And I think this is important, because what we are doing here is, we are injecting into this whole review system conservatism.

For those who are listening who don't really understand what conservatism means, basically I think that ma maybe a good analogy is, if you were told you are going to have to run a race that would be a mile and that your life would depend upon your being able to run a mile, what you do is you go out and run two miles every day so that in the event that you're called upon to run more than a mile and they change the rules on you at the last minute, then you can

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really run more than one mile. That is a conservative approach. That is, that you are doing more that you have to do to insure that when you're called upon that you can at least perform to the level that you're required to perform to.

There is another small question that Mr. Norton suggested that I might answer and that is the insurance. There was a statement yesterday -- a few statements -- that private industry would not touch nuclear power and that private insurance companies have nothing to do with it and that's why the Price-Anderson Act exists.

In fact, private companies do participate in insuring nuclear power plants. And the representations relative to the Price-Anderson Act are inaccurate.

One other question that came up, both during the course of the proceedings and it seems the question was asked to me in-between times and I think we should address it here is, why are we having an operating licensing proceeding at this late date? Why do you let the plant be built and then have an operating licensing proceeding?

Well, I think to understand this you need to understand how the entire concept of development of nuclear power in this country came about.

Prior to 1954, the government controlled and operated all nuclear power in the United States. Principally, the nuclear power was developed for military purposes. And it

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was decided just prior to 1954 to have atoms for peace, to develop atomic energy for peaceful purposes. And that is why, in 1954, the Atomic Energy Act was passed by Congress.

In so passing the bill, what they decided to do -- they had an option actually that they could have exercised at that time. The option was, shall the government build all of these plants, as they were going to build a rocket to the moon, or shall they leave this matter to free enterprise.

Well, it was decided by Congress to leave it to free enterprise. But that doesn't tell the whole story.

What happened then was they said, we'll establish the Atomic Energy Commission, and the Atomic Energy Commission will see over what the free enterprise system does, and they must be able to assure that these plants are built so that there's a reasonable assurance of the public health and safety.

Well, when the Atomic Energy was commissioned -- was established and they were confronted with the problem, What are we going to do, are we going to dictate how plants are built or are we going to let free enterprise tell us how they're going to build them, and then we're going to -- and then review them to determine whether the plant is safe or unsafe or whether some aspect of the plant is safe or unsafe.

Well, at that time, the AEC decided to allow private enterprise to come up with all the suggestions, that is

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we weren't going to tell them -- the government was not going to tell them how to build their plants, because this was an evolving technology.

So private enterprise undertook to start building nuclear plants some time after 1954, and they did it under the review of the Atomic Energy Commission.

The Atomic Energy Commission was also confronted with a number of infinitesimal questions about how they're going to implement their regulations.

And it would seem, then, that because this was an evolving technology, that perhaps we could pass upon the construction phase of the plant prior to the time that we got down to the details about how the plant was going to operate.

That is, that we would be able to review the plant site, where it was to be located; whether or not the foundations are--14-foot thick with steel rebars were sufficient; whether other certain limited information could be approved prior to the final details.

They had the option of either deciding at that point whether they would do it in phases or whether they would just license the entire operation in one fell swoop.

Well, they decided they could do it in phases, that they could license the construction permit phase and then, because of the advance in technology, it would be five

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or six or seven years later before the plant would be completed, it would give the industry the opportunity to keep up with the technological changes and, at the same time, it would allow us in our regulatory scheme to keep up with technological changes and not only approve what industry suggests might be a better plant than they knew about five years ago when they were planning it, but also allow in our regulatory mandate allow the Atomic Energy Commission to require more than they would have required five years earlier to assure the public health and safety.

And it is precisely this kind of a theory which is handed down to us today, it seems, and that's why we're here to decide today, after the plant is built and after all of the details are attended to, whether or not this plant can operate in a safe manner.

MRS. BOWERS: Mr. Tourtellotte, there was one other point that perhaps you could respond to. Several people said why is seismic coming at the last, rather than the first?

MR. TOURTELLOTTE: Yes.

Well, again, I think it has to do with the overall philosophy about handling each part of the hearing as we are capable of dealing with discrete subject matters.

For instance, we'll start out in the overall licensing process. We have two phases to the process, one

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is the approval of the construction permit, the second is the approval or disapproval of the operating license.

In the construction permit phase of the hearings, we have two matters that we are particularly concerned with: one is the environmental concerns, and the second is the safety concern.

The question arises as to what can we deal with at the earliest possible date. And it usually turns out, not always, but it usually turns out that we can deal with the environmental questions before we can resolve the safety questions in the construction permit stage. So we have environmental hearings, and then usually a year or so later, we have safety hearings because then the safety matters are resolved.

A time period lapses between the construction permit being granted and an operating license being requested.

And we go through the same process. The process of determining whether, from an environmental standpoint, this plant can be operated in a safe manner -- in a manner that is environmentally acceptable, or from a safety standpoint, whether the plant can be operated in a safe manner.

We've already gone through all of the stages of the construction permit proceeding, environmental and safety, we've gone through the environmental phases of the operating license proceeding, and we have gone through part

agb8 of the safety matters.

The reason we are deciding the seismic matter at this late date is principally because of the decision by USGS in 1975 to assign a 7.5 magnitude earthquake to the Hosgri Fault.

At the time that that was done, the Staff saw that it was necessary to re-evaluate the plant design for the larger magnitude earthquake. And that evaluation has taken virtually the past nearly three years to complete.

Had they been able -- had PG&E been able to complete the seismic re-evaluation of their plant two years ago, I'm certain that they would have been happy to be in here and have had their hearing on the seismic matters two years ago and have it done with.

But the re-evaluation required looking into everything, including the structure itself; the pipes and mechanical devices in the structure; the electrical devices in the structure; and there are literally tens of thousands of items that had to be analyzed before they could even present the matters to the Staff.

Now after they presented those matters to the Staff, the Staff reviewed them and the Staff asked hundreds and hundreds of questions which, one would think the question would elecit an answer, but oftentimes the question simply led to an answer which led to more questions.

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And it's all part of the exhaustive analysis that has taken place for Diablo Canyon. And I think, as I pointed out in my opening statement, this is a plant which has been reviewed more than any other plant certainly in the United States and, I believe, probably more than any other plant in the world.

But basically, and finally, to get down to the very essence of answering your question then, the reason that the seismic hearings have not been held prior to this time is that the seismic re-evaluation has been going on since 1975.

And it is only at this time and within the very recent months, in time to prepare for this hearing, that we have had all of the information that is necessary so that the Staff could say that there is reasonable assurance that this plant can operate in a safe manner, given the seismicity of the Hosgri Fault as conservatively assigned by the USGS.

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MRS. BOWERS: I should ask the other parties: Does anyone want rebuttal time?

MR. NORTON: No, Mrs. Bowers.

MRS. BOWERS: Mr. Fleischaker?

MR. FLEISCHAKER: No, ma'am. I've learned when Jim starts up you don't tangle with him.

MRS. BOWERS: Well, one other matter that we put you on notice that we wanted to discuss this morning is the recent Commission position on the subpoena of ACRS consultants.

Mr. Fleischaker, earlier you asked this Board -- well, you didn't submit proposed subpoenas, but you put us on notice that you considered it important to your case to consider the subpoena of two ACRS consultants. So now do you want to proceed?

Now yesterday we ascertained that you do all have copies of the Commission document which actually was issued at the close of business last Wednesday. So do you want to proceed?

MR. FLEISCHAKER: Thank you, Mrs. Bowers.

I have a statement which outlines the background and presents our arguments. Essentially we will request the issuance of a subpoena for Dr. Trifunac and Dr. Luco.

The issue before the Licensing Board is whether to grant Joint Intervenors request to subpoena two experts

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who consulted to the Advisory Committee on Reactor Safeguards in that Committee's review of the reanalysis of the Diablo Canyon seismic design. These two experts are Dr. Trifunac, an associate professor of civil engineering at the University of Southern California, and Dr. Enrique Luco, associate professor of applied mechanics, University of California, San Diego.

The Joint Intervenors requested that the subpoenas be issued for Dr. Trifunac and Dr. Luco on September 1st, 1978. Both the Nuclear Regulatory Commission Staff and Pacific Gas and Electric opposed the Joint Intervenors' request.

Both the Staff and the Applicant argued that the general immunities from subpoenas granted to members of the Advisory Committee on Reactor Safeguards covered consultants to the Committee as well. The Applicant argued as follows:

> "The Commission in other proceedings has expressly considered and rejected requests by parties to proceedings that ACRS members be required to testify in licensing proceedings. Consultants to the ACRS are quite obviously agents of the Committee itself. They are retained by the Committee to assist in their deliberations. To allow Intervenors to

subpoena consultants would for all practical purposes be no different than calling the Committee members themselves.

"There is express authority that such a procedure is impermissible in these proceedings."

The Staff argued in much the same vein. The Staff argued as follows:

"Clearly there is a prohibition against subpoenaing ACRS members. This position has been supported in the federal court, notably in the Aeschliman decision. And there the Board held that the unique role of the ACRS as an independent part of the administrative procedures was sufficiently analogous to that of an administrative decisionmaker to bring into play the rule that the mental process of such a collaborative instrumentality of justice are not ordinarily subject to probing, citing U.S. v. Morgan, 313 U.S. 409 422, 1941.

"Certainly if it is improper to examine the mental processes of ACRS members, it is even more inappropriate to examine ACRS consultants since they are presumably less involved with the total synthesis of the ultimate ACRS decision."

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In addition, the Staff argued that in any case the Joint Intervenors had failed to satisfy the tests set out in 10 CFR Section 2.720H, the regulation that controls the issuance of subpoenas to "NRC personnel".

This regulation requires a showing of exceptional circumstances before issuance of subpoenas. That is, in this case, a showing that Drs. Trifunac and Luco had direct personal knowledge of a material fact not known to witnesses made available by the Executive Director for Operations.

On October 10, the Board issue an order deferring ruling on this question, noting that the Commission was in the process of establishing a general policy on the amenability of ACRS consultants to licensing board subpoenas.

On October 20, the Commission asked the parties to this proceeding and one other, as well as the OELD, the Office of Executive Legal Director, to submit comments on the general policy question that it was considering. The ACRS advised the Commission of its position on the matter in a joint session with the Commission on November 3. The ACRS took the position that its consultants should be extended the same immunity from subpoena as the members.

PG&E agreed with the ACRS. The Office of Executive Legal Director, representing the Staff, took the position that ACRS consultants should be subpoenaed only where they have unique possession of material facts.

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The Joint Intervenors argued that ACRS consultants should be subpoenaed when their view would materially assist in the full development of a record, and in the alternative if the exceptional circumstances were to apply it should not be limited to unique possession of material facts as urged by the Office of Executive Legal Director.

On November 29 the Commission issued a document entitled "Interpretive Commission Statement on Amenability to Subpoena of Consultants to the Advisory Committee on Reactor Safeguards" under 10 CFR 2.720. In that statement the NRC first rejected the ACRS and PG&E position that ACRS consultants be granted the same immunity from subpoena granted to members of the ACRS. And second, rejected the OELD position that exceptional circumstances be limited to unique possession of material facts. Third, accepted the Intervenor argument for a broader reading of the exceptional circumstances test.

Essentially the Commission recognized that the test must balance two legitimate and possible conflicting considerations. On the one hand the Committee recognized that ACRS consultants represented an important source of scientific opinion useful to licensing boards in resolving technical issues. On the other hand, the Commission recognized that making consultants amenable to subpoena might impair the ACRS's ability to obtain qualified consultants who do not

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want to expose themselves to the hassle of appearances before licensing boards.

The Commission found that the balance is struck by providing the ACRS "the limited protection of the exceptional circumstances test". The Commission then provided the following guidelines in its interpretive statement -- excuse me, this interpretative statement actually was written by the Office of General Counsel.

By the terms of the rule:

"Exceptional circumstances are not limited to situations in which the particular individual has unique knowledge of facts. Furthermore, the mere fact that a particular person may have been an ACRS consultant in a particular case does not mean that exceptional circumstances must be shown as a predicate for a subpoena to that person in another case. That limitation applies only in cases where we has served as a consultant."

Finally:

"Parties may not seek to probe the reasoning process underlying the collegio-ACRS report through the device of a subpoena to a consultant."

The thing I want to focus on here in part is that in rejecting the OELD argument that the test should be restricted to unique possession of material facts, the

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Commission appears to have accepted the point brought out by the Joint Intervenors. I think the transcript from the NRC's last meeting demonstrates that point.

Let me read from page 30 of the transcript of the meeting of November 17, 1978.

(Pause.)

Again, this is the transcript of the Commission's meeting dated November 17, 1978; I'm at page 30 of the transcript, at the end of line six. This is Chairman Hendrie speaking:

"Mr. Fleischaker points out that should the Commission adopt the exceptional circumstances standard for consultants, ACRS consultants that is, put them in the same category as the other approach, it should make clear that it is not implying that personal knowledge of material facts not known to other witnesses provision is the sole basis because I think he makes the perfectly sound point that experts -- and I'll just quote him. I'll just quote from him, in fact:

"Since experts are often working with the same data base, this narrow reading would preclude the issuance of a subpoena in many instances where an ACRS consultant has an opinion on an important issue"

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substantially different from experts of the Staff and the Applicant."I feel that's a worthwhile point."

The request for the subpoenaes for Drs. Trifunac and Luco satisfies the exceptional circumstances test, first as the ACRS itself recognized in the letter of July 14, the assumptions critical to the Staff analysis, the use of effective accelerations and tau effect which have the effect of reducing the earthquake input on a plant, are based primarily on the judgment and experience of its consultant, Dr. Nathan Newmark, rather than on extensive observations and analysis.

The use of these assumptions is exceptional. They have not previously been applied in the design of nuclear power plants. That is almost a direct quote from page two of the July 14 letter from the ACRS, down at the bottom of the page.

Both Drs. Trifunac and Luco had submitted comments disagreeing with the use of these reduction factors, arguing in essence that they distort the design analysis. And let me quote from some of the papers that they've written.

First with respect to the tau effect:

In his comments entitled "Comments on Seismic Design Levels for Diablo Canyon Site in California", dated April, 1978, Dr. Trifunac states as follows -- excuse me, I

mpb9

have copies of these which I was going to submit for the record. I can provide them to the Board now before I continue.

MRS. BOWERS: Fine.

MR. FLEISCHAKER: Okay. Just one moment.

(Pause.)

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MR. NORTON: Mrs. Bowers, might we ask what documents are being put into the record? Are they being put in as an offer of proof? Are they being put in as evidence? And what is the purpose of this?

MR. FLEISCHAKER: These documents are not being put in as evidence. They're being put in as exhibits to accompany the legal argument, and I would like to have them marked as exhibits for the limited purpose of accompanying legal arguments. They are not being offered as substantive evidence relating to the contentions themselves but, rather, relating to the legal question before the Board, whether subpoenas should issue for the consultants.

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MR. NORTON: Well, I guess my question is are these all of the submittals by Dr. Luco and Dr. Trifunac, or are they a hand-picked few? What are we receiving? That's what I'm not sure of.

MR. FLEISCHAKER: They are those that I have that I selected and what you are receiving. You will see.

MR. NORTON: But they are not all of the submittals of Luco and Trifunac to the ACRS?

MR. FLEISCHAKER: I think they are all that I have. There are a couple that I don't have, I think, which haven't been docketed. But if the Applicant is aware of others, and if you want to submit them in support of your argument, I think you're free to do so.

eb2

MR. NORTON: No, I'm just trying to find out what you're submitting, Mr. Fleischaker.

MR. FLEISCHAKER: You'll see them when I hand them to you.

(Pause.)

I'm sorry to take the time. I thought we had it organized but I don't have it as well organized as I should like.

(Distributing documents.)

MR. NORTON: Excuse me. Are these different papers than accompanied the original motion for subpoena which I thought included everything that they had submitted? I think we're doing something redundant, is really why I'm asking. Are these something different?

MR. FLEISCHAKER: No. My recollection is what was submitted with the original motion were curriculum vitae and the April, 1978, comments. This packet includes the April, 1978, comments and other comments that have been submitted.

MRS. BOWERS: I think it would be appropriate to take a 15-minute recess so we have an opportunity to read these. Have you distributed them to everybody?

MR. FLEISCHAKER: There's more to come.

MR. NORTON: Mrs. Bowers, we've seen them all, and I'm sure the Staff has, and we don't need the opportunity to

eb3

read them unless if the Board wants to read them before a decision is made, I have a feeling it is going to take a lot more than 15 minutes.

MRS. BOWERS: We do not intend at the close of argument this morning to give you our decision. We may be able to give you our decision after the luncheon break or maybe tomorrow. We need an opportunity to carefully review these papers.

MR. NORTON: I didn't realize this was going to be an exhibit to the evidence. I thought it was going to be an attachment to his legal argument which has a distinct difference on an appeal. I thought it was not an exhibit. I thought it was just an attachment to the legal argument.

MR. FLEISCHAKER: I think all we have is a difference in the name you want to hang on it. I was going to mark it as an exhibit. I don't intend to introduce it into evidence to go to the substantive issues. But however we want to agree upon how these should be designated for purposes of the record is fine with me.

MRS. BOWERS: I think calling them attachments A through whatever it amounts to would be better.

MR. FLEISCHAKER: Okay. Let me then designate these. Attachment A would be the curriculum vitae for Dr. Mihail Trifunac.

Attachment B would be the curriculum vitae for

eb4

Dr. Luco.

Attachment C would be --

MRS. BOWERS: Now some of these already have attachment letters or numbers on them, so we want to make sure that's not confusing.

MR.FLEISCHAKER: The curriculum vitae for Dr. Luco has Attachment H on the top. That's because this curriculum vitae was attached to the original motion that was filed. That should have been whited out for purposes of xeroxing.

MR. NORTON: Excuse me. I really don't understand why we're putting these in the transcript which is going to be voluminous enough. If the Board has copies of them as part of this oral argument, I don't understand why they're going in the transcript as attachments or exhibits or anything else, if they're just part of a legal argument and the Board has copies of them.

MR. FLEISCHAKER: For purposes of appeal it would be useful to have them in the transcript so that if this issue needs to be briefed on appeal, reference can be made to the specific documents themselves.

MRS. BOWERS: He's just identifying them.

You don't intend to furnish 30 copies to have them physically inserted in the transcript, do you?

MR. NORTON: I think that's exactly what he intends Mrs.Bowers, and that's what I'm trying to prevent. We're

eb5

putting in, I don't know how many, 100, 150 pages of extra transcript, and Mr. Fleischaker only has two copies of some of the documents, let alone the 35 or 40 that he needs.

MR. FLEISCHAKER: My only concern is that however we want to facilitate this, that we have the opportunity, if we need to brief this on appeal, to refer to these documents and their contents for purposes of appealing this specific issue, the question of issuance of a subpoena.

MRS. BOWERS: Well, if you fully identify them in the transcript, doesn't that preserve their identity?

MR. FLEISCHAKER: Okay. That's all that's necessary.

Attachment C then would be-- It includes a cover letter dated September 22, 1978, from Dr. Luco to John McKinley, comments that he submitted, and a cover letter from Dr. Luco to Mr. McKinley dated June 5, 1978, and comments that he submitted to the ACRS dated May 30, 1978.

Attachment D --

MR. TOURTELLOTTE: Excuse me. Was that all one attachment?

MR. FLEISCHAKER: Yes.

Attachment D includes or is comments on seismic design levels for Diablo Canyon site in California by Dr. Trifunac dated April 1978.

Attachment E includes the letter from Dr. Trifunac

eb6

to Mr. McKinley dated February 28, 1978, his report entitled "Comments on the SAM V Procedure for Estimating Peak EArthquake Accelerations," and all attachments to that report.

Attachment F includes a cover letter from Dr. McKinley to Dr. Siess dated June 12, 1978; a letter from Dr. Trifunac to Mr. McKinley dated June 3, 1978 enclosing Dr. Trifunac's calculations for peak ground accelerations at the Diablo Canyon site in California. Those attachments are entitled Table 1, Table 2, Table 3, and then two graphs.

MRS. BOWERS: Mr. Fleischaker, what did you identify as D?

MR. FLEISCHAKER: Those were Dr. Trifunac's comments dated April, 1978.

MRS. BOWERS: You see my problem. You have just the two copies of those.

MR. FLEISCHAKER: That's correct.

MRS. BOWERS: Okay.

(Pause.)

MR. FLEISCHAKER: Thank you. I apologize to the Board for this delay.

MR. TOURTELLOTTE: What is this thing here? It's attachment what?

MR. FLEISCHAKER: That's Attachment E.

MRS. BOWERS: I mentioned that we might be able to state our position after the luncheon break, or perhaps

eb7

tomorrow morning. It may be next Monday by the time we get through all the documentation.

MR. FLEISCHAKER: Let me run through this again as we have it here.

Attachment A is the resume of Dr. Trifunac.

Attachment B is the resume of Dr. Luco.

Attachment C is the September 22nd letter to Mr. McKinley, including Dr. Luco's -- including certain comments by Dr. Luco, and then a June 5th letter from Dr. Luco to Mr. McKinley, including Dr. Luco's May 30th comments.

Attachment D is Dr. Trifunac's comments dated April, 1978.

Attachment E includes a letter from Dr. Trifunac to Mr. McKinley dated February, '78, including his comments on the SAM V procedures and also attachments thereto.

And Attachment F includes a letter from Mr. McKinley to Dr. Siess and Dr. Trifunac's letter to Mr. McKinley, and several tables and graphs attached to the transmittal letter from Dr. Trifunac to Mr. McKinley.

MRS. BOWERS: Mr. Fleischaker, before you begin again, were you making a point when you stated that the Commission position document was prepared by the Office of the General Counsel, and then you read from a transcript of a Commission meeting on this question of ACRS consultants as to what Chairman Hendrie had said? Were you trying to

make a point that the document issued did not reflect his thinking? I'm not sure.

MR. FLEISCHAKER: No, Ma'am. I think that the document issued reflected his thinking. I have referred to it as the Commission's document and I was just being more precise in identifying that it had been drafted by the Office of General Counsel to the Commission. That's all.

MRS. BOWERS: And quoting him from the meeting, was the purpose to bring in additional criteria?

MR. FLEISCHAKER: The purpose in quoting the transcript was to support our argument that the Commission essentially has recognized the validity of our argument that the test, "exceptional circumstances," should not be limited to the unique possession of a material fact.

MRS. BOWERS: Well, do you think the Commission document says something else?

MR. FLEISCHAKER: No. I was simply offering additional support for that argument.

MRS. BOWERS: Fine.

MR. FLEISCHAKER: Frosting on the cake.

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Okay. Let me start again with the argument that these circumstances are exceptional circumstances which merit the subpoenaing of Drs. Trifunac and Luco.

First, as the ACRS recognized in its letter of July 14, the assumptions are critical to the Staff's analysis. That is, the use of effective accelerations and tau effect and which have the effect of reducing the earthquakes input to the plant are based primarily on the judgment and experience of its consultant, Dr. Nathan Newmark, rather than on extensive observations and analysis.

The use of these assumptions is exceptional, they have not previously been applied in the design of nuclear power plants. Dr. Luco and Dr. Trifunac have submitted comments disagreeing with the use of these reduction factors, arguing in essence that they distort the design analysis. . . .

With respect to the tau effect, Dr. Trifunac, in his April, 1978, comment states as follows on Page Two:

"Scattering and defractionoof high-frequency waves from the foundations of different plant structures has been proposed as a vehicle to justify reduction of high-frequency spectro amplitudes (tau effect).

"The manner in which this reduction has been effected requires unrealistic assumptions,

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for example, that the foundation is rigid. The manner in which this assumption is introduced into analysis is often one-sided and considers mainly only those consequences of the physical phenomena which lead to reduction of spectral amplitudes.

"Other consequences of this phenomena, for example, torsional and rocking excitation the foundation which may amplify the structural re ponse have been so far either overlocked or treated inadequately.

"This has been achieved by utilization of dynamic models for analysis which are so defined that only an incomplete physics of the problem; i.e., seismic excitation and the structural response, can be considered."

Later on, on Page Three of his comments, under 4.230 the designation small-letter "c," Dr. Trifunac comments further on the tau effect:

"Hypocentral rather than distance closest to the fault have been used to evaluate peak and effective peak acceleration. This assumption implies certain angle of approach of seismic wave energy. These angles of approach should then be consistent with

the extent to which tau effect is allowed to influence the spectral amplitueds.

"Little or no attention seems to have boen given to mutual consistency of these assumptions, and in some cases, inconsistent assumptions have been utilized.

"For example --

MR. NORTON: Excuse me, are we reading from the documents that were just handed to the Board for the Board to read? Is that what's happening and, if so, I object. I mean, the Board is perfectly capable of reading the documents. You know, this argument can take three weeks if we proceed to read all the papers and we would like to get on with the argument and then on to the hearing.

MRS. BOWERS: I believe Mr. Fleischaker was highlighting certain areas that he considers particularly relevant.

Are you going to continue with many areas?

MR. FLEISCHAKER: I'm going to discuss basically three areas: tau effect, effective acceleration and damping.

The Board has an enormous amount of material before it. I don't intend to go through it piece-by-piece, but rather, as you indicated, the purpose here is simply to highlight those areas, specific areas of disagreement between the Staff and Applicant's analysis and the opinions of

agb4

Drs. Trifunac and Luco. And that's the purpose.

What I am doing now is highlighting the areas in their papers where I think their comments indicate a clean-cut disagreement on the methods used.

Continuing on Page Three, Dr. Trifunac indicates:

"Little or no attention seems to have been given to mutual consistencies of these assumptions and, in some cases, inconsistent assumptions have been utilized.

"For example, the hypocenter will increase the distance at which peak acceleration is evaluated, thus, reducing the estimated peak acceleration amplitudes.

"This would, however, also imply that waves arrive toward the foundation almost vertically. In consideration of tau effect, however, horizontal dimensions of foundations appear to have been used implying horizontal incident waves."

With respect to effective acceleration in his April, 1978, comments, Dr. Trifunac states as follows:

"The term 'effective peak acceleration' has been introduced suggesting that the structure will see something smaller than actual peak accelerations.

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"Though such approach may be useful for earthquake-resistant design of ordinary structures by means of the response spectrum technique, the term 'effective peak acceleration' has not been defined in a way that would enable the derivation of consistent results by several different experts in the field.

"Since the procedures for scaling Reg. Guide 160 spectra are based on maximum laboratory acceleration, as defined in Appendix A, this departure from routine design practices makes it difficult to evaluate the number and the nature of the consequences which would result from such an approach."

With respect to the tau effect, Dr. Luco states as follows. I'm going to quote from parts of Dr. Luco's comments dated May 30, 1978, beginning on Page Three, Number Three, on the effective scattering of waves from rigid foundations.

"The high-frequency components of the free field motion have been reduced by the so-called 'tau filtering procedure' to account by the scattering of waves by the supposedly rigid foundation.

"This correction amounts to a reduction

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of the Newmark free field design spectrum by 20 to 30 percent for frequencies higher than two cps, cycles per second. Slightly lower reductions have been used in the Blume spectrum.

"The correction for foundation scattering effects is based on assumption of a rigid foundation and horizontally propagating SH waves.

"Although the assumption of a rigid foundation may be reasonable, it must be recognized that deviations from the assumption lead to localized higher stresses in the lower portions of the different structures."

"The assumption of horizontally incident SH waves is highly questionable, considering that the epicentral distance is comparable with the focal depth. Under these conditions, the possibility of nearly vertically incident waves may not be ruled out. For vertically incident waves, the scattering by the foundation is practically nonexistent, given the shallow embedment.

"Assuming for the sake of the argument that the seismic excitations at the sites corresponds to horizontally incident SH waves, I

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find that the reductions proposed by Newmark and Blume are too high when compared with analytical solutions. For horizontally incident SH waves, the reduction of the translational components of motion is coupled with the existence of a marked torsion input to the structure. For details, refer to the attached papers.

"The Applicant has included accidental eccentricities of five to seven percent to represent these torsional effects."

Then, continuing over to Page Five:

"From the point of view of the analysis of the structural response, it does not seem adequate to introduce the torsional input through the use of accidental eccentricities. Such procedure, which leads to the coupling of the torsional and translational response; is essentially symmetric structure, distorts the response of the natural frequencies of the system.

"The effects of the torsional input may be significant for the turbine building in which the possibility of portions of the structure undergoing inelastic deformation may increase with eccentricity."

Finally:

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"If it is shown that the seismic excitation of the site corresponds mainly to horizontally incident waves, the reductions of the translational and torsional response should be evaluated on the basis of the more exact methods presently available to include an exaggerated reduction of the translational motion without incorporating the full torsional effects is improper."

With respect to effective acceleration, Dr. Luco states as follows:

"A judgmental factor has been used to reduce the 1.15 peak acceleration recommended in USGS Circular 672 to a value of 0.75g. This ill-defined factor has been used in the past to account for discrepancies on the level of damage observed as compared with the predictions of ordinary seismic analysis which do not account for the effects of soil-structure interaction -- are based on nominal values for damping and strength, assumed linear behavior and do not include energy dissipation in partitions and other non-structural elements. This 'catch-all' reduction factor has no place in the design of carefully analyzed structures, such as those in nuclear power plants."

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Finally, let me move to damping.

The Staff has permitted the use of damping values equal to seven percent. While this is permitted in the regulations, Reg. Guide 1.61, it is exceptional in nuclear power plant design. Most facilities utilize damping values in the range of four to five percent. Increasing the damping values reduces predicted plant response. And according to Dr. Trifunac in the case of Diablo Canyon, may underestimate the plant's response to a given level of strong ground motion.

Let me read again shortly from the Trifunac comments of April, 1978. On page 3 of the April, 1978, comments:

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"The large damping equal to seven percent has been adopted for dynamic response calculations. Though the apparent damping for the complete soil-structure system subjected to earthquake excitations may be larger than seven percent, inadequate basis has been presented to justify seven percent damping in structural systems only. Selection of too large structural damping coupled with only two dimensional or simple three dimensional analysis of soil-structure interaction can lead to unreliable response estimates."

Those are a brief outline of some of the important

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comments that have been made by Drs. Trifunac and Luco. Included in that package is Dr. Trifunac's criticism of the SAM V model used to predict peak accelerations given magnitude, distance, site foundation characteristics, the SAM V is Dr. Blume's model.

Also included is Dr. Trifunac's probabilistic estimates of the time -- of the probability for exceedance of the spectral response during the life of the plant.

I should also point out that included in Dr. Trifunac's comments are suggestions as to how the plant should be analyzed. Those same kinds of suggestions were submitted in earlier comments dated November and October of 1976, and essentially the same suggestions were made by Dr. Luco. And as I think about it, I probably ought to submit those as attachments for the Board too, and I will do so this afternoon. I have a copy of them here.

Moving from the point that Dr. Trifunac and Dr. Luco have specified -- have indicated identified specific areas with disagreement with the Staff and Applicant analysis, all of which are critical to designation of the design of the facility, all of which are critical to the Staff and Applicant reanalysis, let me move on to other factors which I think support the conclusion that this is exceptional circumstances.

The Trifunac and Luco comments pertain to engineering questions that are directly related to the plant

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safety.

Third, as the ACRS acknowledged in its letter of July 14 -- let me get that letter, please.

(Pause.)

At page 3 of the July 14 letter, 1978, the ACRS in its top paragraph stated as follows:

"It is evident from the foregoing that the design basis and criteria utilized in the seismic reevaluation of Diablo Canyon Station for the postulated Hosgri event are in certain cases less conservative than those that would be used for an original design."

Even though the ACRS determines that the plant has "an adequate margin of safety" it finds also that the plant has a design which is less conservative than for a plant that would be built today.

Finally, the pool of experts who have the experience necessary to adequately address the engineering issues raised in this reanalysis is small. This experience relates to two specialized fields: earthquake engineering and the design of nuclear power plants, and within that field there are very few who have the experience and the knowledge and the expertise to address the questions of expected building response in the near field to a causitive fault assuming the occurrence of a 7.5 magnitude event.

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Therefore the Intervenors' access or opportunity, ability to draw upon experts is extremely limited.

So basically for those reasons we believe that the Trifunac -- that this case constitutes one of exceptional circumstances.

First of all, the issues under consideration are critical to plant safety. Secondly, Drs. Trifunac and Luco have specifically criticised the Staff and Applicant's analysis, parts of those analyses that are critical to their conclusions regarding the safety of this facility.

Thirdly, the ACRS has recognized that those assumptions that are used, that many of those assumptions are unique in power plant design, and that this facility does not have a design, is not designed to the level -- as high a level as a plant that would be designed today.

And finally, the pool of experts available for such analysis and for such comment is extremely limited.

MRS. BOWERS: We'll have a ten minute recess.

(Recess.)

MRS. BOWERS: Mr. Fleischaker, do you want to continue, or have you concluded?

MR. FLEISCHAKER: Thank you, Mrs. Bowers, I had concluded.

MRS. BOWERS: The Staff?

The Joint Intervenors were the movants on this

mpb5

thing.

Mr. Norton?

MR. NORTON: We have a couple of questions of Mr. Fleischaker before we respond to the argument.

Normally one would get a written brief on this sort of thing, and I listened very carefully to his argument and a couple of the questions I had were answered, a couple I had were not.

The first one is:

Is Mr. Fleischaker proposing that if called Drs. Luco and Trifunac would simply sponsor all of their submittals to ACRS, all of their reports, some of which Mr. Fleischaker has already given to the Board and the rest of which he tells me he intends to give to the Board this afternoon after he's had an opportunity to make copies?

Is it for the purpose of new testimony, things that we don't know anything about, analyses that we are unaware of? Or is it simply to sponsor their comments to the ACRS? Because if it is for something new, something different, certainly that would affect our position.

MRS. BOWERS: Do you want to respond to that, please?

MR. FLEISCHAKER: We would be calling them primarily to sponsor the comments, reports that have been previously submitted to the ACRS.

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MR. NORTON: Okay.

It's my understanding they have done thorough analyses and a thorough review of Blume and Newmark's work, and that they have fully set forth their opinions in those reports.

But I wondered if -- I know that Mr. Fleischaker has been in close contact, he and Mr. Hubbard have been in close contact with Drs. Luco and Trifunac, and I wondered if perhaps they prepared additional testimony or something like that.

My second question is --

MRS. BOWERS: Mr. Fleischaker was shaking his head, which doesn't show up in the transcript.

MR. NORTON: Perhaps he could say yes or no.

MR. FLEISCHAKER: Should I go under oath?

I have not prepared with Drs. Trifunac or Luco any additional testimony.

MR. NORTON: Okay.

In addition to that, the next question we have is:

We have never, as far as I know, other than in incidental conversation between, for example, Dr. Blume or Dr. Smith or Dr. Cornell or something like that in an ACRS subcommittee meeting when they stand out in the hallway or something, we've never engaged in conversations with Trifunac

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and Luco as have Intervenors. Intervenors have in some small sense, I think, used Drs. Luco and Trifunac as consultants. And I don't say that's bad; I don't say that's wrong. But for Intervenors to then -- quote -- subpoena them -- end quote -- and treat them as subpoenaed witnesses and feel that they have the right to ask leading questions to cross-examine the people who are in effect their own witnesses I think is a great miscarriage of justice because it is not the way the American judicial system is set up.

So I would like to know if they are going to be treated by Intervenors as Intervenors would treat their own witnesses, such as Dr. Silver and Dr. Graham and Mr. Hubbard and Dr. Brune. I think that is important again for us to posture our response.

MR. FLEISCHAKER: Well, I think there's a clear distinction between the position that Drs. Trifunac and Luco have and the position that any witness we might sponsor has. Dr. Trifunac and Dr. Luco are consultants to the ACRS and we must pass this exceptional circumstance test before we -- before the Licensing Board will issue a subpoena.

So I believe that they are in a different posture from a witness that the Intervenors might sponsor. And so I don't believe that the rules applicable to the form of questioning that might apply in the case when an Intervenor is directing its own witness should apply in this case. Drs. Luco

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and Trifunac are not our consultants. They are consultants to the Advisory Committee on Reactor Safeguards. They are not -- well, okay.

MR. NORTON: I'm not sure that answers my question, Mrs. Bowers, because the concern we have is that the purpose or the technique of cross-examination -- you are allowed to cross-examine when a witness is hostile even if you call him as your own witness if it suddenly becomes apparent to the judicial body trying the case that the witness is hostile, then cross-examination is allowed.

Very clearly Mr. Fleischaker has taken great pains to read at length the positions as presented to the ACRS of Drs. Luco and Trifunac. Very clearly they are not hostile to Mr. Fleischaker's position. And, as I have seen walking down the hall Mr. Fleischaker and Dr. Luco, sitting in Dr. Luco's office and taking notes and drinking coffee, I don't think they're going to be hostile witnesses.

And, again, in private conversations I've had with Mr. Fleischaker, he gives me the impression he's going to put these people on the stand and lead them as if they were hostile witnesses. And I don't think it is proper, and we very strongly object to that. And that's why we're trying to get an answer, and I'm not sure Mr. Fleischaker did answer that question.

MR. FLEISCHAKER: I think I answered the question.

mpb9

The issue goes to the form of the questioning period, as I understand it, what form will the questions have to take. And if I understand it, the Applicant's position is that the ACRS consultants are like consultants to the Intervenor. That's not the case.

We do not have the special relationship with these individuals that we might have with our own witnesses, first.

Second, it's often the case in administrative proceedings that you aren't limited to the strict rules regarding the form of questioning that you might be in a criminal trial or in a civil proceeding in the federal district courts.

It is true that Drs. Trifunac and Luco are not hostile witnesses to the Intervenors. But on the other hand, they are not our consultants. So I think that fact and the fact that the administrative procedure recognizes that some looseness, some flexibility has to be applied when you're considering things like the form of the questioning leads to the conclusion that the Intervenors should not be locked into a form of questioning which is limited in the narrowest sense to direct presentation as you would find in a federal district court.

I think it would be perfectly appropriate for us to ask leading questions and for us to engage in formal.

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cross-examinations with respect to Drs. Trifunac and Luco if they're brought to the proceeding.

MRS. BOWERS: Well you've just stated that you would not consider them hostile witnesses. So are you saying that you would be bound by what they would have to say?

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MR. FLEISCHAKER: I think we ought to have the opportunity to question them.

MR. NORTON: Mrs. Bowers, I have one last question.

I take it then, from what Mr. Fleischaker has said this morning, that it's the purpose of Intervenors to have these witnesses appear here to express the same views that they expressed before the Advisory Committee on Reactor Safeguards, both in their written submittals before the ACRS-- I think there were three or four submittals apiece, if I'm not mistaken, over the past several years.

I take it that I am correct that that is the purpose.

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MR. FLEISCHAKER: Would you repeat your question?

MR. NORTON: I gather from what you said, Mr. Fleischaker, that it is your purpose or your intent by calling these witnesses to have them express to this Board those opinions that they expressed in their many written submittals to the ACRS Subcommittee and Full Committee over the past several years concerning the Hosgri analysis of Diablo Canyon; and indeed that's the justification for calling them; that there is nothing additional to that.

MR. FLEISCHAKER: I guess I don't have any problem with your formulation. I'm just trying to figure out where you're going.

MR. NORTON: Well, you're going to find out right

eb2

now.

MR. FLEISCHAKER: Okay. Good.

MR. NORTON: In that case we would suggest to the Board, and we would stipulate to entering into the record as evidence, every single document submitted by Drs. Trifunac and Luco before the ACRS, every word, every analysis, every attachment, their qualifications. We would stipulate that indeed they are qualified by their qualifications which Mr. Fleischaker has put in the record today.

We see absolutely no need to take up two days of hearing time for them to come and simply read that which has already been presented in full, and would be considered as evidence in this hearing.

Absent that, we don't see any showing of exceptional circumstances whatsoever. What Mr. Fleischaker has postulated is three things:

One, they have a different opinion. I don't read the opinion of the Commission, the letter memorandum of the Commission, as saying that is the test for exceptional circumstances. If they had said that what they would have said is ACRS consultants who have a different opinion from that of the Applicant and/or Staff may be subpoenaed, period. That's the first showing.

The second showing is that it's related to safety. Well, of course it's related to safety. The Advisory

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Committee on Reactor Safeguards is a safety function. All ACRS consultants are related to safety. They're not environmental consultants; they're safety consultants. So that certainly isn't what the term "exceptional circumstances" means, that if it is a difference of opinion and it's related to safety, they may be called.

The third thing Mr. Fleischaker states is the pool of experts is small. Well, that's very interesting that Mr. Fleischaker makes that statement.

One of the Vice Presidents of Engineering of Pacific Gas and Electric came up to me at the break, and this is something I didn't know. I was going to comment that that was a statement of Counsel; there is no record in the evidence to indicate that the pool is small.

In any event, the engineer came up to me and told me that's totally untrue. The pool is very, very large of people who do this kind of work and who are available as consultants.

I don't know personally, but there is nothing in the record and nothing before this Board to indicate whether it is small, other than Mr. Fleischaker's statement, and you now have my statement, based on hearsay, as I assume Mr. Fleischaker's is, that the pool is not small.

So there's been no showing whatsoever of exceptional circumstances. I can't imagine how that meets the

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test of -- quote -- "exceptional circumstances."

But I think the whole problem can be avoided by simply including -- and we're willing to so stipulate, that everything that they have ever submitted be put into the record as evidence and considered by this Board. They're not going to say anything new if they come here. They may say it in different ways but they're not going to say anything new. They've worked with this problem for several years.

Nor is Dr. Blume going to say anything new than what he said over the last several years, and I assume Dr. Newmark isn't going to say anything new than what he said over the last several years.

And we have no objection to having that information submitted to the Board for its due consideration.

MRS. BOWERS: Perhaps there hasn't been full communication here, but would it be, in your opinion, Mr. Norton, based on perhaps consultation-- Is the pool small if you consider seismologists who have personal knowledge of Diablo Canyon?

MR. NORTON: No. And that wasn't what Mr. Fleischaker was referring to. Mr. Fleischaker and I have had private conversations about this, and he's talking about seismologists who would be willing to get involved and look at the evidence and arrive at decisions.

Obviously the pool is small of people who have

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worked on Diablo Canyon or any specific facility. I think that's correct. But basically what we're talking about here is a matter of analysis.

If you read carefully Drs. Luco's and Trifunac's reports, they're not talking about Diablo Canyon *per se*. What they're mostly talking about is the method of analysis. Dr. Luco's primary concern is that we're using values for damping, et cetera, et cetera, et cetera, that we shouldn't. And Dr. Trifunac is slightly different than Dr. Luco. But again, it's an analysis; it's an approach difference of opinion. There is not any difference of opinion otherwise.

As a matter of fact, Dr. Trifunac-- I guess he does have some specific knowledge about the Hosgri-Diablo situation because he believes the magnitude 7.5 is way too high for the Hosgri. He believes it should be no more than a 6.5, as do we.

But I really think it's a procedural analysis difference of opinion, not a site specific. And in fact, I think Dr. Trifunac's primary concern was that this method of analysis would be used elsewhere if used here, and he felt that, you know, it ought to be fine-tuned a little more before it was used elsewhere.

And I think the ACRS staff said that Well, this is not to be used elsewhere; this is to be used only at Diablo.

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MRS. BOWERS: We haven't had a chance to read the documents.

MR. NORTON: It's all in Dr. Trifunac's documents. I'm paraphrasing of course what I think Dr. Trifunac has said. he said a heck of a lot more than that. As you have in front of you, there are a number of pages but it's all there. Everything he said is there. And there are also transcripts from the ACRS where Dr. Trifunac spoke, and we have absolutely no objection to those being in the record. We have copies and would happily furnish the Board with copies of those, the exchanges between the scientists at the ACRS Subcommittee meeting, both ours, the Staff's, and the consultants for ACRS.

And we have no objection and in fact would invite the Board's attention to those discussions.

MRS. BOWERS: Mr. Fleischaker, before we leave you to go on to the Staff, Mr. Norton has suggested a stipulation. Are you prepared to respond?

MR. FLEISCHAKER: I think that that's a totally unsatisfactory way to proceed. The reason it's a totally unsatisfactory way to proceed is because it doesn't permit anyone to — because the whole purpose of these proceedings is to clarify, to examine carefully what those writers meant when they wrote those papers.

Mr. Norton has one interpretation of what

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Dr. Trifunac intended when he wrote those comments in April, 1978. I have a very different, and the Board may have a different one. The Staff may have a different view altogether.

It is only by questioning Dr. Trifunac about the statements in the papers themselves that we can know what it is that he meant. To put the papers into the-- Just to submit them into the record I think leaves us with a skeleton without any real flesh on its bones. We have to have those experts here in order to permit questioning by the various parties on the different points of view in order to clarify and to build a complete record as to what it is that Drs. Trifunac and Luco meant in their various comments.

I'm not going to get into the specific points of disagreement that I have with Mr. Norton, but as to the representations that he made about Dr. Trifunac's testimony and the meaning of that testimony, I have a very different interpretation with respect to each of the specific points he made.

As far as-- Is that all you wanted me to limit my comments to, without responding to other arguments that he made?

MRS. BOWERS: Yes. We'll come back and give you a chance.

MR. FLEISCHAKER: All right.

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MRS. BOWERS: Mr. Tourtellotte?

MR. TOURTELLOTTE: I'm not certain exactly where we are, but it seems to me that the case is this, that Mr. Fleischaker has made a motion to subpoena Drs. Trifunac and Luco on the basis that there is some outstanding extraordinary circumstance consistent with the memorandum put out by the Office of General Counsel on November 29, 1978, and that there is some kind of a counteroffer by the Applicant to simply stipulate all of these materials that are written into the record without having to reach the question of whether there are or are not exceptional circumstances.

And I understand that the only reason for having Drs. Trifunac and Luco here is that Mr. Fleischaker believes that it would be beneficial to inquire of them as to exactly what their basis for their thoughts were, and how they worked this into their over-all participation in the ACRS.

It seems to me there are a couple of things. One is that basically I don't really have much trouble with stipulating those materials into the record, assuming that it is made clear on the record that the Staff is not conceding that any extraordinary circumstances are shown at all, that we are simply doing this as a method of aiding the record.

It also seems to me that in light of the questions asked by Mr. Norton and answered by Mr. Fleischaker, the only question that remains as to whether or not those

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materials might be inserted into the record in lieu of their being present, is the question of whether or not Mr. Fleischaker or the Board should question Drs. Trifunac and Luco.

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There are two points to make with respect to this memorandum by the Office of General Counsel. One is that I don't believe the points made by Mr. Fleischaker, the four points, in any way show exceptional circumstances. I personally do not know what "exceptional circumstances" are, and perhaps as one Justice said in the Supreme Court, "I don't know exactly what it is but I will know one if I see one. I do know that I haven't seen one yet."

The fact that the issues are critical to safety, I don't want to sound redundant but I guess I agree that the issues are critical to safety is no different than it's going to be in every case where we have a safety hearing, and if the issues are not critical to safety in the safety hearing, then obviously it's going to be irrelevant and we don't need their testimony at all.

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That Trifunac and Luco are critical of the Staff position is of no particular consequence to me, we've known that all along. They were critical of the ACRS consideration of the matter, and the ACRS chose to, at least, apparently, reject the views of Trifunac and Luco and in their overall consideration, arrived at a determination that the plant could be operated in a safe manner.

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The ACRS recognition of the uniqueness of the methodology that's used in this plant is also not an extraordinary circumstance. I think I indicated in my opening statement that we're proceeding in this case under Appendix A to Part 100, where it states very clearly that if the Applicant has another approach rather than the approach that is suggested by our regulations, then they may suggest that and we will review it. And obviously, if they come up with something that is new or different, there may be unique methodologies. But the fact that a methodology is unique does not make it any less valid.

The fact that the pool of experts is small is -- I don't really know what pool of experts Mr. Fleischaker is talking about. I don't really know whether it is small or not. And, frankly, in order to answer that kind of a question, I think I would have to do considerable digging myself or, to put the shoe on the right foot, I think Mr. Fleischaker owes us an explanation of what thepool is and how many people

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are in that pool and how he tried to attract or tried to hire the people from the pool and why he can't hire anybody from that pool.

Finally, the second part that I have to address relative to the statement of the General Counsel, is that if the purpose, the only purpose of asking Trifunac and Luco here is to inquire into their minds as to what their own reasoning processes were, it seems to me that that is inconsistent with the final statement that's made in the General Counsel's memorandum which we're supposed to treat as governing in this proceeding. And that is, and I'm quoting here from Page Three:

> "Finally, parties may not seek to probe the reasoning process underlying the collegial ACRS report through the device of a subpoena to a consultant."

It seems to me that, if indeed that is the reason why Mr. Fleischaker is asking Drs. Trifunac and Luco be presented, then that runs squarely in opposition to the memorandum that is supposed to be governing our proceeding. And if it is something else, then I don't understand his position.

Consequently, I think I would have to argue that the motion, at least, for a subpoena in the present state of circumstances that are shown by the Intervenors' counsel

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that that request for a subpoena be denied because there aren't exceptional circumstances and because the only reason for bringing these witnesses appears to be that of probing the reasoning process underlying the ACRS report.

And as far as the suggested alternative of stipulating those papers in, I think that's a matter which, if we're going to stipulate, everybody is going to have to agree to it or we won't have them in at all.

MRS. BOWERS: Mr. Tourtellotte, in looking at the Commission's memorandum on Page Two, the beginning of the first full paragraph, starts out by saying:

> "Upon considration, the Commission believes that the exceptional circumstances test of Section 2.720(h) is properly applicable to consultants to the ACRS in cases in which they have served as consultants."

Then you get down, in the last full sentence on that page, by the terms of the rule,

> "...exceptional circumstances are not limited to situations in which the particular individual has unique knowledge of facts."

Now, going back up for a minute to 720(h), the example given in (h) to small (i):

> "The presiding officer may, upon a showing of exceptional circumstances, such as a

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case in which a particular named NRC employee has direct personal knowledge of a material fact not known to the witnesses made available by..." -- otherwise made available.

I guess my question, and I will go to the other parties too, if I followed your position, Mr. Fleischaker, I don't believe I heard you say that these two people are the only ones that have knowledge of material facts that others do not have. Is that correct?

MR. FLEISCHAKER: That's correct.

I do not base the argument on the fact that -- I do not argue that Drs. Trifunac and Luco have unique possession of material facts.

MRS. BOWERS: So you would be falling under the sentence near the bottom of Page Two that:

"....exceptional circumstances are not limited to situation in which the particular individual has unique knowledge of facts."

MR. FLEISCHAKER: That's correct.

MRS. BOWERS: Well, back for a moment to Mr. Tourtellotte:

In considering the situation, does the Staff have a position as to whether the -- as to how the last full sentence on Page Two affects the regulation?

We realize that an example was given here that

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would clearly establish in the regulation exceptional circumstances. But if you get away from that, then what, in the Staff's opinion, would be necessary to establish exceptional circumstances?

MR. TOURTELLOTTE: Well, to begin with, I guess before I could say whether or not Drs. Trifunac and Luco have possession of a material fact that is not known to the witnesses that we're going to present, I think Mr. Fleischaker owes us an explanation of what that material fact is or those material facts are that he expects Drs. Trifunac and Luco to present which the Staff is not in possession -- does not possess the knowledge of.

MRS. BOWERS: He just said that's not his position. He's not claiming that they have material facts that others do not have.

MR. TOURTELLOTTE: Well, with all due respect to General Counsel's Office, I don't know what that last sentence means at all.

I think it means, what it says is it's leaving the door open to the fact that there may be other situations where exceptional circumstances may exist, and it's not necessarily associated with unique knowledge of facts.

But I don't know what those exceptional circumstances are. And I think, again, as I pointed out, I can only say that maybe if someone came up with an exceptional

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circumstance, I could agree that it was one. But I don't see that any of the arguments that are made by Mr. Fleischaker present that kind of a forceful presentation.

MR. NORTON: Excuse me, Mrs. Bowers, could we comment on the same question?

MRS. BOWERS: Yes.

MR. NORTON: I don't see the last sentence of that opinion differing or changing in any way the regulation.

MRS. BOWERS: The last sentence on Page Two?

MR. NORTON: Yes. It says:

"The presiding officer may, upon a showing of exceptional circumstances, such as a case in which a particular named NRC employee has direct personal knowledge of a material fact not know to the witnesses made available...."

That's just an example of an exceptional circumstance. Evidently the lawyer who wrote that memorandum, all he was trying to do was to say that's not the only thing. Of course, that's not any help, because the regulation says that's not the only thing, so I don't think it adds anything and the regulation isn't in any way changed by it.

But perhaps to look at -- Mr. Tourtellotte hit upon as good a definition as any that you know what one is when you see one.

I think in this case the clearest way to show

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that you don't have an exceptional circumstance is to simply counter Mr. Fleischaker's motion to subpoena Drs. Trifunac and Luco because they differ with the opinions of one of the parties, we'll ask that the Board subpoe a Dr. Page, Dr. Thompson, Dr. Pickel, Dr. White, Dr. Wilson, Dr. Scavuzzo, who are all consultants to the ACRS who all differ with the Intervenors' position in a safety related matter.

If that's exceptional circumstances, then I guess they should all nine members be called. The only difference is one has a different opinion than another, and that cannot be the basis for exceptional circumstances.

MRS. BOWERS: Mr. Bright has a question.

MR. BRIGHT: I'm just curious, how many consultants does ACRS have on this particular case?

MR. NORTON: On this particular case, I believe they had nine. One of them, I believe, passed away, as have several people on this project for the past 13 years, through longevity, have passed away. And I forget who it was. I guess it was Dr. Wilson. So a lot of the people I suggested subpoenaing we obviously can't subpoena.

And I don't have all the names, there is one name I do not have. But there were, I believe, a total of nine consultants, one of whom has passed away so there are now only eight.

Dr. Pickel, I remember, did a special study on

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snubbers at Diablo Canyon. Dr. Page was involved in the geology and seismology aspect of it.

And Mr. Fleischaker hasn't shown anything different for Drs. Luco and Trifunac expect they disagree with us, but all the others disagree with Mr. Fleischaker, so they are just as exceptional circumstances.

MR. BRIGHT: Well I really was just interested in knowing whether ACRS was dependent upon these two gentlemen, or --

MR. NORTON: Oh no, they had nine consultants.

MR. BRIGHT: Thank you.

MR. NORTON: The ACRS itself, of course, had people in that field or in related fields and in those fields that they were considering, of course.

MRS. BOWERS: Mr. Fleischaker.

MR. FLEISCHAKER: A couple of comments.

First of all, Dr. Bright, to answer your question, they may have had nine, ten or eleven consultants, I don't know, but the number of consultants that they had on the question of engineering design, the derivation of the response spectra, was substantially more limited.

They had a number of experts on the question of geology, a number on seismology and then they had a smaller group on engineering design. And I believe that the number of consultants that they had on that issue was perhaps four:

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Dr. Pickel, Dr. White --.

MR. NORTON: I don't disagree, they weren't all nine consultants on the same issue, I don't disagree with that.

MR. FLEISCHAKER: Okay.

Now let me see if I can respond to some of the arguments that have been made here.

First of all, I think the Applicant mischaracterizes our argument when they say that we think exceptional circumstances exist when there's a difference of opinion only. That sort of foreshortens the argument and distorts it.

The argument here is that there's different opinions on engineering assumptions that are unique to nuclear power plant design.

As indicated in the ACRS letter, there are differences of opinions on engineering assumptions, each of which has the effect of reducing the earthquake input. There are difference of opinions on assumptions for which there is -- excuse me; which are without extensive observations and analysis. All of that appears in the ACRS letter of July 14. This isn't simply a matter of a difference of opinion.

Secondly, I think it's significant that we're talking about a difference of opinion on matters critical to safety, not tangientially related to safety.

This is a safety hearing, but that doesn't mean that everything we discuss in this hearing or in any safety

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hearing is as centrally related to the question of plant safety as the seismic design of that facility. We're talking about the very core -- and I mean that word literally -- we're talking about the core of the plant, we're not talking about perimeter fences, we're not talking about transmission lines specifically. We're talking about the design of the facility to withstand the shaking.

Let me move on to some of the Staff arguments.

Mr. Tourtellotte points out that even if Drs. Trifunac and Luco had their figures different from the Staff and Applicant, the ACRS went on and found that there was an adequate margin of safety. That's not legally sufficient.

If the ACRS sign-off is all we need, let's close up shop and go home, we can brief this thing. But the ACRS doesn't have the duty to make the definitive finding of safety. What the ACRS found is that there was an adequate margin of safety, but nowhere in that letter will you find that the ACRS found that the Commission's regulations had been met.

The Commission, not the ACRS, decides what is safe, and the Commission's definition of safety is contained in Appendix A, so it's important that this Board measure the evidence that is submitted at this proceeding against the Commission's definition of safety, because it is the Commission that has the mandate from the Congress to define how safe is safe enough, not the ACRS.

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So whether the ACRS signs off on this or not is legally irrelevant. It's the Commission's.... I think it was Vermont Yankee when the Appeal Board pointed out the Staff can come in and say it's safe enough, the ACRS can come in and say it's safe enough, but the law is: what is safe enough is defined by the regulations. And the Board has to determine that the Applicant's analysis and the Staff's analysis meets regulations.

So the fact that the ACRS position is the sign-off I think is legally irrelevant and should not alone bar this Board -- bar the issuance of the subpoenas. Because Drs. Trifunac and Luco have some very important information, I think, to present to the record.

There was a question as to the efforts we had made on how large the pool of people is. Ithink that's a subsidiary point: I don't think it's fundamental to the issue here. But I'll tell you about it.

We've been to a lot of people to try to get some experts on this issue. I talked to Dr. Trifunac on a number of occasions and asked him if he could provide me with the names of people who could assist us in this presentation. Nobody.

I talked to Dr. Luco and asked him whether he could provide me with names of people. And Dr. Luco has, I think, three graduate students: one works for General Atomics,

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one works for Mr. Frazier, Dr. Frazier, who is the applicant's expert, and the other one I don't think had the time.

So the fact is we were trying to get to people who had both the training and would be close enough to the problem so they could understand the particular problems involved with Diablo Canyon and get experts. We weren't able to do that.

Those are the efforts we made.

We also went up to Stanford and looked for people up there to see if we could get some people up there to help us. And we can't find people who are available to assist us in this problem.

That's in response to Mr. Tourtellotte's inquiry.

Finally, it should be clear from every filing that we've made that we are not calling Drs. Trifunac and Luco to this proceeding to probe the collegial decision-making of the ACRS; rather, we call them for a different reason, and that reason is to probe their expert opinion on the adequacy of the Staff and Applicant analysis.

MRS. BOWERS: Since we haven't had an opportunity to read what you've handed us this morning, would their testimony in any way duplicate the testimony of your other witnesses?

MR. FLEISCHAKER: Not at all. Not at all. Our other witnesses are-- There may be some small overlap in the testimony of Dr. Brune and Dr. Trifunac insofar as they are

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both talking about the kinds of peak accelerations one can expect to see in the near field of a large event; that is, instrumental peak accelerations.

But when you get to all the other engineering questions, the questions of effective accelerations, the question of soil-structure interaction, the question of tau effect, the question of damping, the question of the non-linear or the linear response of the facility, only Trifunac and Luco can talk about those issues. Those are engineering design issues. And neither Dr. Silver, Dr. Graham nor Dr. Brune or Clarence Hall -- should he get back in time -- none of those people can talk about those issues.

MR. TOURTELLOTTE: Mrs. Bowers, I think it is my turn.

MRS. BOWERS: Yes. But I think we're going to have to stop taking turns at some point.

MR. TOURTELLOTTE: This is one of the difficulties, of course, of trying to deal with an oral motion. It seems to me in ordinary circumstances Mr. Fleischaker would have filed a piece of paper with us and we'd have several days to consider it. And we're trying to consider and give the Board our views as they come up and as we get an exchange here.

Of course Mr. Fleischaker parsed the difference between the ACRS and their use of the term "adequate margin of safety" and the one tht I used, "reasonable assurance of

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public health and safety." But that's really not important. The fact is that the ACRS found that the plant was going to be safe.

And it seems to me there are a couple of things we should be considering here. One is -- and it's associated with what Mr. Norton says, but it's not exactly the same thing. He's saying, Well if the intervenors want to subpoena Drs. Trifunac and Luco then we're entitled to subpoena the rest of the ACRS and let them state why they overruled the findings and the beliefs of Drs. Trifunac and Luco.

There is something that is more important than that, it seems to me. --or as important as that. That is, that if -- the whole business of extraordinary circumstances and subpoenaing ACRS consultants is affected by the fact that you can reasonably foresee that if Dr. Trifunac and Dr. Luco are subpoenaed in this case to present additional material -- and it isn't clear what additional material they're going to present that they haven't presented to the ACRS. You can only ask yourself a couple of questions:

One is: If there is additional material for them to present here, why didn't they present it to the ACRS? And if they didn't present it to the ACRS, why is it suddenly important to us here?

The second thing that you can foresee is that you're going to wind up, whether you like it or not -- and

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regardless of what this order says. you're going to wind up in order to maintain your responsibilities for ensuring due process of law is met, you're going to wind up probing the mental processes of the ACRS. Because there's a simple fact here: Trifunac and Luco are consultants to the ACRS, and by reason of being consultants to the ACRS their titles carry a certain amount of prestige. The best way for any trial lawyer to meet that kind of a challenge is to simply subpoena the other people who are concerned who have equal type of status, and that's the ACRS.

And when you ask the ACRS to come in here and tell why they overruled Trifunac and Luco, then you're going to be into the business of probing the mental processes of the ACRS. And that's precisely what this order says that they can't do.

It's a reasonably foreseeable thing. And it's a dilemma, it's a real dilemma to know what to do.

But in the final analysis it seems to me that when you consider that back when we started discussing this matter Mr. Fleischaker answered Mr. Norton's question that he knows of no other information that these ACRS members are going to present, other than that information that they gave to us in all of these many pleadings and filings, if they indeed are not going to present any other information, why is it even necessary that they be here?

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I mean, two days, or one day, or whatever time it is, to have them to sit here and sponsor this information in, when the applicant, and I guess the staff, are willing to stipulate that material in. What other information is it?

Now if indeed there is other information which they are going to present to us, then I would say to you that Mr. Fleischaker has the responsibility to tell us here and now what that other information is. Because maybe that's the kind of information that we need to decide whether there are exceptional circumstances.

But it seems to me you can't have it both ways: you can't say that they're not going to present any new information but it is still necessary for them to be here, or you can say that they may present new information: let's have a fishing expedition to see what the ACRS consultants think, and they may come up with something new, and it may be important, and it may present exceptional circumstances, when, in fact, nobody knows.

It seems to me that we have the right to know what Trifunac and Luco are going to say before they come in here. And if this is all they're going to say, and everybody is willing to stipulate it in, they don't have to be here.

MRS. BOWERS: Well we'll call for a response from Mr. Fleischaker and then we'd like to go on to other matters.

One thought that crossed my mind, and you may or

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may not have information on this: Assume for a moment that it is determined they will be subpoenaed. Are they in the country? Are they available?

MR. FLEISCHAKER: Yes. As of about a week ago they were.

MRS. BOWERS: Do you want an opportunity to respond to Mr. Tourtellotte's last position?

MR. FLEISCHAKER: I think Mr. Tourtellotte's argument misses the point, it's wide of the mark.

The issue isn't whether Drs. Trifunac and Luco have new information to subject, the question is whether they should submit their opinions to the body that is legally required to make the decision, to make the definitive finding of safety. That's the legal question. And so the whole question of new information is irrelevant to that determination.

That's all.

MRS. BOWERS: Well we will take under consideration the arguments of all parties, and we will-- We want to have today's transcript available to us, also, in considering this matter.

So we now should go on to other things.

One thing that occurred to me in discussing this: we got out an order some time ago and asked the staff to consider whether the record in this case would meet the criteria in River Bend and North Anna on generic safety issues.

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And, of course, we didn't expect a response. We just wanted to flag it, that this was a matter that we would be interested in considering. And I forgot to mention that yesterday morning when I was running down a laundry list of various things that we expected to cover.

Let me check and see. We also, of course, mentioned the environmental impact of the fuel cycle, Table S-3. What do you desire now? That we go to some of these other matters?

And we also have to consider the proposed schedule that Mr. Fleischaker submitted, which we frankly haven't had time to thoroughly consider. Or shall we now commence with the applicant's direct case?

MR. FLEISCHAKER: I think, Mrs. Bowers, we have a couple of housekeeping matters that we ought to address. And I would propose that we try to get questions of scheduling and some other questions that we have, and would request Board rulings on, out of the way before we proceed to the presentation of the applicant's case.

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MR. NORTON: We have, I assume, the same housekeeping chores. Scheduling is one of them.

We also received Mr. Fleischaker's proposed schedule and the basic feeling is that it's worthless at this point to guess whether you're going to put Witness X on the stand in the middle of January or not. I think we have to proceed as rapidly as we can proceed. And we would ask that, in light of Mr. Fleischaker's proposed schedule-- He wants to go home I guess on the 20th of December and not work the 21st and 22nd, and come back on the 9th of January, using the 8th for travel, Monday, and he doesn't want to work any

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Saturdays. We think that this is yet another further delaying tactic, and we very, very strongly urge this Board to work on Saturday sessions if it is at all possible.

People have colds and so on. If it's the case that people should be in bed, then they should be in bed and we wouldn't work on Saturday, but if it is at all possible, we would like to finish this hearing in December. We think that reasonably we can make a good effort at it. We don't know whether it can be finished in December or not, but we certainly don't want to come back for three weeks in January as Mr. Fleischaker is proposing.

MR. FLEISCHAKER: Let me address that.

This proposed schedule isn't meant to-- Well, this proposed schedule, I didn't intend by this to try to

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slot everybody into an exact time, but to try to figure out approximately how long this proceeding was going to last, and so I sat down with my consultants and we tried to allocate some reasonable time for cross-examination of each of the witnesses here, and then I submitted it to both the Applicant and the Staff to see whether I could get any feedback from them, and we talked about it and agreed not to agree.

But essentially the point that's brought out by this schedule is that I think it is very unlikely that we're going to end this proceeding before Christmas, and two issues I would raise, and I would like to address them both.

The first one is about Saturday sessions. We have very strong feelings about Saturday sessions. The bottom line is that we're not prepared to accept the Applicant's proposal that we work on Saturday for several good reasons:

First, we don't view this as a trial by endurance but Saturday sessions would turn the proceeding into exactly that. It seems to me that the purpose of these proceedings is to examine, in a thoughtful and a careful way, several highly complex, technical issues. The record that is going to be compiled in this proceeding is going to be the basis for the Commission's decision, not the ACRS decision, not the SER, not the FSAR, but the record that we compile in this proceeding.

And a schedule which exhausts lawyers, witnesses,

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and the members of the Board doesn't make a good record. I've had substantial experience, particularly in seismic proceedings, where we went for seven or eight weeks before the Appeal Board in the seismic show-cause of Consolidated Edison, and after so long you can take so much and that's it; you're full up. You reach a tolerance level.

I think five days a week, eight hours a day, is enough.

There's a second reason, however, and I consider it equally as important. My associates and I have other professional obligations and while the convenience of the litigants cannot be dispositive of the question of scheduling, the Appeal Board has recognized that it's entitled to recognition, and I will cite the Board to ALAB-296 and to ALAB-249.

The Appeal Board in ALAB-249 ordered hearings reopened because the Licensing Board insisted on adhering to the schedule when Intervenor Attorney could not attend the proceeding because he had to prepare briefs in a related matter in the U. S. Court of Appeals.

I face a similar situation here. I have two cases pending in the Federal District Court. I have a status call scheduled for December 18th on which I have written a memorandum requesting to be moved, and I don't know whether it has been moved or not yet. This is pending before the

eb4

Federal District Court, Judge Oberdorfer.

In any case, I represented to Judge Oberdorfer that I would have an amended complaint filed within the next two weeks. Saturdays have been set aside to work on that amended complaint.

In addition, Saturdays have been set aside to address other matters that come into my office during the week while I'm out here in California.

It was never indicated in any prehearing conference or in the Board's orders that we would work on Saturday. Both Mr. Hubbard and I have made our schedules so that we could set apart that day to work on other matters.

MRS. BOWERS: I think the Board is the one who first mentioned the possibility of having Saturday hearings in one of our orders.

We did not grant the Applicant's request that we start two days last week, Thursday and Friday of last week, but said in our order December and, if it was necessary, we would consider sessions on Saturday.

MR. FLEISCHAKER: Okay, then I stand corrected. I don't recall that. I accept your recollection of the Board's order.

But in any case, still, for the two reasons I've cited,-- Well, let me go on.

The third reason is that those two days I don't

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think are going to make a significant difference. As you can tell, we are going into -- I believe we are going to go into January in any case, so the two days that we might save by having Saturday sessions isn't going to get these hearings over with by December 25th.

So for the reason that first of all that I think working six days a week is too much, secondly because the commitments of the professionals in this is due some consideration, we are arguing very strongly against Saturday sessions.

MRS. BOWERS: The Staff?

MR. TOURTELLOTTE: Well, to back off from the schedule a minute and back to the item you were talking about, we do have an intention of presenting information on the generic items and on S-3 in this case, and I suppose it will come after all of the presentation on the contested issues.

As far as scheduling goes, I do think it is important that we try and resolve as much as we can resolve about schedule today.

The Staff is here and we were cognizant of the Board's order indicating that we would have Saturday sessions or perhaps have Saturday sessions. And we're prepared to proceed on that basis.

If there is some doubt about whether we should or should not proceed on a Saturday basis, I think it is mostly

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a matter that is up to the Applicant. I could not help but sit here though-- And I guess you hear arguments of counsel, and I guess it seems like lawyers are always making arguments that they have to be some other place. I recall back when I first went into private practice with another attorney, and I told the Judge that I couldn't be there on a certain day and he said, "You are practicing with another lawyer, aren't you?"

And I said, "Yes, I am."

And he said, "And he is your colleague, isn't he?"

And I said, "Yes, he is."

And he said, "Are you telling me that he can't be here on that day either?"

And I said, "No, I can't tell you that."

And he said, "In that case, you're request is denied."

And that's a very empty feeling when you get that sort of thing.

I would point out that Mr. Fleischaker does have co-counsel on this case and, while I understand his predicament because I think almost every lawyer has been in that similar predicament, it does seem that perhaps whatever we agree upon, perhaps his co-counsel could take over for him on those days when he has to be gone.

But the Staff has no real position one way or the

eb7

other on Saturday sessions. If it serves to expedite the proceeding, it seems to me that we have the responsibility to resolve the issues before us as quickly as we can. And on the other hand, if it serves no real purpose, then we don't mind having an ordinary week-end, just like other folks do.

MRS. BOWERS: Like people.

MR. TOURTELLOTTE: Like real people.

MR. NORTON: Excuse me, Mrs. Bowers. There were several other things I meant to mention that I don't understand about Mr. Fleischaker's proposed schedule.

For example, he has Mr. Trifunac and Mr. Luco listed for two days, right plumb in the middle, totally out of order. You know, the schedule. I just don't understand here. Two days down for Trifunac and Luco. He quits on Wednesday, the 20th. I hate to use this as a working document. In other words, it doesn't really have-- It doesn't have some of our witnesses in there at all. They're just cut out.

I would rather work from a blank calendar and have the Board work up its own schedule rather than Mr. Fleischaker's schedule which doesn't even include all the days of the hearing.

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MR. FLEISCHAKER: Mrs. Bowers, that's fine with us. I submitted this simply as a working document to counsel and I didn't get much of a response by yesterday.

I can answer the specific questions. It is the most broad kind of a guesstimate as to how long the proceedings were going to run as to why I put Trifunac and Luco in there and had to do with our Saturday discussions in which you said, They are your witnesses, you put them in in your case. So I said well I'll follow Bruce's advice and put Trifunac and Luco in in our case.

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There's one other substantive issue, I think, that is raised by this that I would like to raise to the Board and it is this:

I have -- as the Board has designated in its order, the order of proceeding case-by-case with the exception of one set of issues, and that set of issues are basically the components, the electrical and the mechanical equipment. The reason that those were put at the end -- the reason we would argue they should be put at the end is as follows:

After the submission of testimony, the Applicant submitted four amendments to the FSAR. Those four amendments consisted of 600; over 680 pages, most of which were amendments relating to the Hosgri re-evaluation of structures, systems and components. Mr. Hubbard has the responsibility for reviewing that.

agb2

Those were listed in the -- two of the amendments were listed in the daily session sheet here for the Nuclear Regulatory Commission as -- this went in on November 14, we probably received it two or three days later. The second two amendments went in on November 22, we probably received those two or three days after that.

So essentially, after we filed our testimony and as we were trying to get ready for cross-examination, we were engaging in depositions, getting ready for trial all the various tasks that that requires, 680 pages of amendments relating to the structures and systems and components, Hosgri re-evaluation landed on my consultant's desk.

He has yet to have the time to review those documents. He is assisting me every day in this proceeding in efforts to prepare cross-examination. I don't think he's going to have an adequate opportunity to assess those documents so that he can address them either on cross-examination or prepare me for cross-examination of the Applicant and the Staff witnesses.

Now this is only one part of the case. I'm not suggesting that he change in any respect the geology, the seismology and the engineering -- and by engineering, I mean, the derivation of the design response spectra -- but only that part of the testimony that deals with structures, systems and components.

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Another point to be made along that line is that there was a meeting on November 8 in Champaign, Illinois between the NRC Staff and the Applicant with Dr. Nathan Newmark in which they discussed, among other things, the structural analysis of the intake structure.

The results of that meeting are reported at Pages 3-8 and 3-14 of Supplement Eight to the SER. All the supplement says is that:

> "...we resolved these questions as a result of the November 8 meeting."

No meeting notes were issued as is usually the case, so we have yet to see a document that serves as the basis for the resolution of those issues.

And those are issues that are related, again -- fall within that capsule, that small capsule of issues that we would move out to the end of the hearing in order to give Mr. Hubbard an opportunity to consider those issues, so that he can respond on cross-examination and to provide me with the input I need for cross-examination.

So the bottom line is that there are really only two issues I see growing out of this guesstimate. Number one is the Saturday sessions and number two is the moving out of the structures, systems and components. And that's all that was intended, really. Those are the only two issues that I see that are now --

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MR. NORTON: May I respond to the question of the submissions?

MRS. BOWERS: Yes.

MR. NORTON: Mr. Fleischaker has got to be a little more careful with his figures. He just said over 680 pages of the four amendments. The four amendments he's talking about are Amendments 70, 71, 72 and 73. There are exactly 553 pages. It's only a 19 percent error by Mr. Fleischaker, but I would suggest that he, you know, in arguing before the Board, be a little more exact.

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Now I can break that down -- and when I say it is exactly, it is exactly within a few pages, it certainly is not over 680.

The breakdown is as follows: approximately 200, I think it is 199 to be exact, do not deal with any items in contention here today, dropping this down to 353 pages and in these proceedings.

Pages which were prior submittals which were sent to Mr. Hubbard: 260 pages, so that drops the 553 down to 94 pages.

The information of the 260 pages was all submitted to NRC in the months preceding November via letters in informal submittals, all of which were passed on to Mr. Hubbard and Mr. Hubbard has seen them all.

Now, of the 94 pages, a lot of that is just

agb5

changes to prior submittals, and I will hold up a few examples. For example, there's just a couple of lines on Page 7-10 that were changed. I'll show you Page 7.6 where it was a significant amount that was changed.

But it isn't new material, it's not over 680 pages, and Mr. Williamson, who prepared this data for me in a short period of time this morning, would be happy to sit down with Mr. Hubbard and show him any changes and it would only take moments. It's not a whole big new thing, as Mr. Fleischaker would lead the Board to believe.

Now perhaps Mr. Hubbard -- because there were 553 pages or approximately, give or take a couple -- said, Oh, gee, I don't have time to review all this. What he doesn't know because he hasn't done that is that he already has seen most of it and it is not new and a great part of it doesn't deal with these hearings at all. And, as I said before, Mr. Williamson would be happy to sit down with Mr. Hubbard to expedite the matter with him.

Finally, as to the matter discussed in Champaign-Urbana, Mr. Hubbard's affidavit of his qualifications and his deposition testimony -- which I, unfortunately, don't have here with me, I didn't realize it would be in question at the moment -- shows that he has absolutely -- he admits in his deposition -- absolutely no expertise on the matter discussed with Dr. Newmark in Champaign-Urbana and has no intent to

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offer any testimony about that subject whatsoever. So I don't see any reason to delay because of that.

Again, Intervenors are groping for reasons to delay this hearing process.

MR. FLEISCHAKER: I would like to respond to that.

It wasn't us that took four years to finish the re-analysis and we didn't put the fault out there. We're ready to go to hearing, Bruce. But what we don't want is for you to drop--according to the daily session sheet, if I may back up, we didn't count the pages.

MR. NORTON: We did.

MR. FLEISCHAKER: Good, I'm glad you had the manpower.

Rather, we took a look at the United States Nuclear Regulatory Commission PDR daily assessment sheet, and right here it says: "Number of Pages: 400 pages." Right here it says: "Number of Pages: 286 pages." -- according to the official documents from the NRC. I understated that, but it doesn't matter. That's where we got our figures.

The point is that we haven't had the opportunity to look at those documents at all. And they were dropped on us after we had filed our testimony.

It seems -- we're not requesting a delay, we're requesting a reorganization of the matter of proceeding, so

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that we will have an opportunity to examine those documents in our own right.

It's not delay we're requesting. I would like to get this over with too.

MR. NORTON: Mrs. Bowers, might I suggest that Mr. Williamson and Mr. Hubbard get together because there really is not a problem. There's nothing new. It's not new things, these are changes to sentences of old submittals, informal submittals, of prior informal submittals. It's not what Mr. Fleischaker seems to think it is.

And I'm sure if Mr. Hubbard and Mr. Williamson spent a couple of minutes together, that could be resolved.

What Mr. Fleischaker is doing, in case the Board hasn't noticed, his prior argument that he didn't want to go Applicant-Intervenor-Staff, he wanted to go issue-issue-issue, and that's what this little ploy results in that he has already denied, it results in going issue-by-issue-by-issue as opposed to party-by-party-by-party.

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MRS. BOWERS: Mr. Tourtellotte.

MR. TOURTELLOTTE: Well, it seems to me that there are a couple of points to be made about the amendment. I'm not really sure why we're talking about this, whether it has to do with the schedule, or whether it has to do with the presentation of the case, the right to discovery, or whatever it is.

But at any rate the amendments, it seems to me that the Applicant has proffered a good alternative here, that indeed there were only 94 pages of new material and that material can be gone over rather quickly, or even if it takes a couple of evenings. Certainly I think an effort should be made to do exactly that on the part of the Applicant and the Intervenor.

Another thing occurred to me about this, that, you know, there will be submittals made by the Applicant, additional submittals that will be made because it's just the nature of the way the plant operates and the way the system operates, that there will be additional submittals. There will be additional submittals after -- if an operating license is granted, after the plant begins to operate.

So the real question is not if there are submittals, the question is is there any new information available here which was not previously available to the Intervenor that bears upon the presentation of his case.

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It seems to me then that we should be able to proceed, especially in light of the suggested compromise by the Applicant, and if there is any new material and if, during the course of the proceedings we happen to bypass that area of inquiry where new material does happen to come up, then the Intervenor is certainly afforded the procedural opportunity to request that the case be reopened on those matters, and that witnesses be recalled on those matters, so that a full inquiry can be made.

So it seems to me that what I'm saying is we have a mechanism here where we can go ahead and proceed in the manner that we agreed to or was mandated by the Board. We can go ahead and proceed on a party-by-party basis, and Mr. Fleischaker still has the opportunity to look into these items by reason of reopening the issue.

MR. FLEISCHAKER: Mrs. Bowers, may I respond briefly?

MRS. BOWERS: Briefly, and then we want to take our luncheon break.

MR. FLEISCHAKER: The Director of Reactor Regulation has an interesting phrase, and I heard it mentioned once. He said there is no reason why the Intervenors have to eat the scheduling slip. And it seems to me that is sort of what's happening here.

We certainly aren't responsible for the submission,

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the timing of the submission of this information. I don't think the issue is whether it contains new information or not. We don't know whether it does or not.

I think the issue is whether we should be given some reasonable time to examine it. I'm not suggesting a delay in the proceeding, nor are we suggesting a significant overhaul in the case-by-case way of proceeding. There's all the geology, all the seismology, and all of the engineering that will go case-by-case.

We're simply suggesting that in order to give us some additional time to examine that, we move components to the end of the proceeding and if at that time-- That's the cutoff date, and we're prepared to go as soon as we finish with the geology, seismology, and the engineering stuff. That will provide us with thetime necessary to examine this new information.

MRS. BOWERS: Well, our order said if it is determined-- I could read the exact language. I have it here, but I won't bother.

If it is determined necessary, then we would consider, you know, the possibility of Saturday sessions. And of course our thinking was to get started on the evidentiary hearing to see how it goes and by the end of the first week and by the end of the second week, we would have a better feel as to whether we needed one or two Saturdays

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in order to proceed and complete.

So anyway that was our thinking, not to make a predetermination, yes Saturdays or no Saturdays, but to play it by ear as the proceeding went along.

We'd like to take the luncheon break. Can you try to be back at one o'clock? We'll consider these things during the luncheon break.

(Whereupon, at 12:00 noon, the hearing in the above-entitled matter was recessed to reconvene at 1:00 p.m. the same day.)

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AFTERNOON SESSION

(1:00 p.m.)

MRS. BOWERS: May I have your attention, please?

While this equipment is being set up we can proceed, I think, with some other matters. We would like to begin, please.

During the luncheon break the Board considered several matters. And one was the business of the schedule and of the difference of opinion on the possibility of having Saturday sessions.

Our position is just exactly what it was before lunch. Our whole idea was to get started, to see how it's going, and then see if it's necessary to have Saturday sessions.

So after one more announcement, we would like the Applicant to proceed immediately with the direct case.

The second thing:

We considered the position of the Intervenors and response on the idea of pulling out the structural systems and components issue because of amendments that have been issued to the FSAR. Accepting the Applicant's description that we really are talking about partial changes on 94 pages and also assuming that other matters will come first with the Applicant's case and that this would be a later issue, we see no reason to pull it out separately as an issue to

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come after the parties' cases are put in on other matters.

So we will proceed as originally planned.

And I think that the Applicant suggested that one of their people could work with Mr. Hubbard and give any additional information needed to identify changes. We noticed in the pages that were held aloft of the amendments -- and of course we're familiar with the FSAR -- there is the clear identification of what part of the page has been changed or is new.

MR. NORTON: Excuse me.

The pages for any changes are marked with a line down the side which is where the change is.

And, again, Mr. Williamson is available to sit down with Mr. Hubbard, at Mr. Hubbard's convenience, for whatever period of time is necessary to answer any questions Mr. Hubbard has about what's new language. For example, there are tables where a number has been added to the table and so on. So Mr. Williamson will be happy to sit down with Mr. Hubbard and show those specific things. And Mr. Williamson assures me that there is not anything new in any of it, that Mr. Hubbard won't have any problem with any of it.

We would be happy to do whatever is necessary to cooperate with Mr. Hubbard in that regard.

MRS. BOWERS: Well, they can talk about that outside of the hearing record.

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Mr. Fleischaker, you handed us some documents during the luncheon break. Do you want to proceed with those?

MR. FLEISCHAKER: Yes, ma'am, Mrs. Bowers.

As I indicated in the earlier argument concerning the Joint Intervenors' request to subpoena Drs. Trifunac and Luco, I would submit as attachments earlier submissions by Drs. Trifunac and Luco to the ACRS. And I have provided copies of these earlier submissions to the Board and to the Applicant, PG&E.

And let me designate those. There is a set of comments by Dr. Trifunac dated November 11, 1976 which I will designate as Appendix G.

There is a set of comments by Dr. Luco dated November 13, 1976, which I will designate as Appendix H.

And there is a set of comments designated by Dr. Luco dated October 11, 1976, which I will designate as Appendix I.

In addition, I think I provided to the Board one additional copy of Appendix D, the April, 1978, comments of Dr. Trifunac.

MRS. BOWERS: Yes, you did. Thank you.

MR. FLEISCHAKER: Mrs. Bowers, there is one more preliminary matter that I think we ought to raise at this point. And I think it's important because it has to do

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with the Applicant's method of presenting its testimony in this case.

As I understand, the Applicant intends to present a number of witnesses for whom no prefiled direct testimony, written testimony has been submitted. I don't have the names of all of those witnesses, but my recollection from Counsel's arguments at the opening statement is that the Applicant will present for cross-examination Dr. Bolt, Dr. Cornell, Dr. Frazier, Dr. Seed, and a number of other witnesses.

I think that this method of proceeding is in direct violation of 10 CFR 2.743, which provides as follows:

> "The parties shall submit direct testimony of witnesses in written form unless otherwise ordered by the presiding officer on the basis of objections presented."

That rule uses mandatory language. It says:

> "The parties shall submit direct testimony of witnesses in written form..."

It doesn't seem to me that the provision is a discretionary provision. Moreover, I did a little checking and I found an appeal board order which, while not interpreting that exact provision, nevertheless it interprets the whole point of those rules that relate to submission of testimony, ALAB-367, 1977.

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There the appeal board ruled that an exhibit altered over the objection of one of the parties could not be admitted into evidence since the objecting party did not have a reasonable opportunity to examine the exhibit. Where the Applicant proposes to present witnesses for whom direct testimony hasn't been filed, the Intervenors are in precisely the same position. We haven't had an opportunity to examine the testimony of all of those experts that the Applicant proposes to put on his panel.

And so we are going to at this point mount an objection to that manner of proceeding. The Applicant has submitted a substantial body of testimony. The authors of those testimonies are listed on the covers of those testimonies.

We're perfectly prepared to cross-examine those people. But under the circumstances and given the rules of the Commission, I don't think it's appropriate for us to be required to cross-examine witnesses for whom direct testimony, written direct testimony has not been prefiled.

MRS. BOWERS: Mr. Norton?

MR. NORTON: Well, first of all, we are not putting on any direct testimony in our case that has not been filed. I don't know where Mr. Fleischaker gets such an idea. We're not putting on one word of direct testimony that has not been filed.

We are putting on the witnesses. The witnesses will be summarizing their direct testimony, which has been the procedure in these proceedings since I've been involved in them. And frankly, I don't have any idea of what he's talking about.

MR. FLEISCHAKER: Well, what I'm talking about is in your opening statement and in various discussions and conversations that we've had you've indicated to me that the Applicant proposes as part of its panels to present various experts for whom written testimony has not been prefiled. Dr. Cornell, Dr. Seed, Dr. Frazier....

MR. NORTON: Excuse me.

Let me perhaps speed this up a little bit because I think I can perhaps address your concern.

The work that has gone into this project, as we said before, involves literally hundreds of people, if not thousands of people. For example, the first witness today is going to be Dr. Jahns, who is the chairman of the Geology Department at Stanford University, who will sponsor the written testimony that he and Doug Hamilton prepared.

The panel available for cross-examination will be Dr. Jahns, Doug Hamilton, and a man named Dick Willingham.

Specifically on Friday Mr. Fleischaker asked me to bring documents for him to cross-examine those people with them. There was no formal request for production, no subpoena,

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no nothing; and that's what this great big cart full of documents that was just brought in is. These are the sparker records, seismic reflection data that was used by those gentleman.

Now Dr. Jahns obviously didn't go out and collect all of that data. It's done by a compilation of people. And Mr. Fleischaker wants to examine on it. Dick Willingham was going to be on the panel available for cross-examination by Mr. Fleischaker, and he did a lot of that work. We're not going to ask any direct testimony of Mr. Willingham at all. His name was furnished as a witness in the answer to interrogatories. He's no newcomer, no surprise, and he's not going to offer any direct testimony. He's available for Mr. Fleischaker to cross-examine and to answer detailed questions.

I can't imagine why Mr. Fleischaker is complaining about that. I don't understand the complaint. I guess maybe he doesn't want answers to some of his questions. I don't understand.

And incidentally, their technical qualifications were supplied, and this is the same procedure we followed in the environmental hearing where we used panel, where one person writes the testimony and sponsors it and the people working for him are available to answer detailed questions that Mr. Fleischaker might have.

I'm at a loss as to what his problem is with that.

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MRS. BOWERS: Mr. Fleischaker, does that explanation settle your fears?

MR. FLEISCHAKER: Not exactly.

I understand that with respect to Mr. Hamilton, for example -- the answer is no.

I have a set of testimony here that's been offered by Dr. Jahns and Dr. Hamilton, and I'm prepared to cross-examine those gentlemen on that. If they don't have answers to questions that I ask and they need to consult with others, or if it's appropriate at that time for others to take the stand to answer those questions, then we can consider that at that time.

What I'm concerned about, however, is facing a panel of experts, many of whom I have never seen written testimony from. For example, for all I know on the engineering or seismology panel the Applicant may put up Dr. Bolt, Dr. Seed, any number of people, and I have never seen any written testimony. I have seen the written testimony of Dr. Smith and the written testimony of Dr. Blume. I've read it and we're preparing cross-examination on that.

But if I ask a question and Dr. Seed or Dr. Bolt gives me an extensive answer -- you know, I don't know where they're coming from. I haven't ever seen their testimony, their views or those positions before. That's my concern.

MR. NORTON: All right. I'll address that.

mpb9

I'm simply saying that, again, those are people that worked with Dr. Blume and Dr. Smith and were consultants on those projects. And when Mr. Fleischaker says he's never heard or seen their views before, he must not have read the ACRS transcript where they engaged in lengthy subjects with Drs. Trifunac and Luco who he very much wants this Board to hear.

And, again, these gentlemen are not offering direct testimony. They're here to assist people who are sponsoring the testimony in answering detailed questions of which they have the detailed knowledge.

No one person in a project like this can have all the answers to all the questions. Again, if Mr. Fleischaker's objective is to keep out evidence, it seems to be contrary to the argument he made this morning.

We are not going to surprise him with any new direct testimony. They are here for the Board's and Mr. Fleischaker's purpose. I'm not going to cross-examine them or direct examine them as to their qualifications to introduce them to the Board.

MRS. BOWERS: Mr. Fleischaker, how does this differ from the situation of the Staff's documents, the SER, which I assume will be sponsored by a panel.

Is that correct?

MR. TOURTELLOTTE: Yes.

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MR. FLEISCHAKER: The SER isn't testimony. My understanding is that the Staff also submits testimony, and I'll raise an objection to the USGS. I have raised an objection to the Staff and the USGS coming in and sponsoring the SER.

My view is if a witness is going to take the stand they should take the stand with prefiled written direct testimony.

Now if the witnesses that the Applicant is going to bring, all these additional people that he's going to bring wish to adopt this testimony as their prefiled written direct testimony, then that might solve that. Or if the Applicant wants to submit prefiled written direct testimony as rebuttal by some of these people, that would be all right too.

But I think that the purpose of having written prefiled testimony is to permit each of the parties to study that testimony and to get prepared and to cross-examine on the basis of it. And in this case there are a number of experts who are going to take the stand for whom no testimony has been prefiled.

MR. TOURTELLOTTE: Mrs. Bowers, may I respond?

I think it's become apparent that this whole discussion could affect the Staff's case as well as the Applicant's case. And I must say that I'm a little bit

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surprised by Mr. Fleischaker's approach to this matter.

It has been a practice in the Commission, both the NRC and its predecessor, the AEC, ever since we started these types of proceedings to have testimony introduced which is sponsored by someone, prepared by them or under their supervision, and oftentimes to present with them the people who helped prepare that testimony. And the people who are there that helped prepare the testimony are in effect also co-sponsoring the testimony, but are there simply for the benefit of answering cross-examination questions.

The way I see this is that the Applicant is going to present his testimony, has presented his testimony, and that's his case. And if his case as presented in this filed testimony does not meet the burden of proof, then the Intervenor should point that out. And it will have to fall on that account.

If it does meet the burden of proof, then it's up to the Intervenor to either counter that through cross-examination or by presenting rebuttal evidence.

But it seems to me that it's indeed strange that after lo these many years of following this procedure that we now have an attorney who's objecting to this type of procedure being used on the grounds of the regulations under which the process has been promulgated for well over 15 or 20 years. And I would simply say that there's a general rule of

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administrative law -- and don't ask me for a citation right now, but I think I can provide you one -- that when you have a practice that is used by a given agency over a period of years pursuant to regulations and those regulations are changed and the process continues, then there is a presumption that the procedure used is a valid procedure. It actually becomes part and parcel of the regulations.

Now this is the way we have operated, and I don't really see that there is any difference in this proceeding than there is in any other proceeding where we have evidence that is -- a case in chief that is presented, and then we have a co-sponsoring panel of witnesses to respond to those questions.

And I would add one other point, which is a very minute point:

The Safety Evaluation indeed is a part of the Staff's case and indeed is testimony for all intents and purposes. And I'm well aware of the objection that Mr. Fleischaker has made with respect to the USGS witnesses and we've discussed that.

But the central fact is that they are going to be there on the panel with the other people on the SER to answer any questions that he has relative to the USGS report and we're not required by these rules or by any other previous practice to file testimony for each and every person who sits

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up there on the panel and is sworn into this case. That is simply not the way that the rule has been interpreted through the years. And I would submit that if indeed Mr. Fleischaker disagrees with this that his remedy is to proceed under 2.758 to change the rule and not to at this time interpose some sort of rather meaningless objection, it seems.

MRS. BOWERS: Do you think the Supreme Court decision in Bailly that says the Commission can interpret its own regulations in applying them would apply here?

MR. TOURTELLOTTE: Well, as I mentioned a while ago, I didn't have any citation at hand, but I would use that one certainly if I were going to brief the overall problem.

There are other cases that I think hold with the general principle that if an agency has established a practice over a number of years, that it is in fact -- that practice is incorporated into its general rules of practice.

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MR. FLEISCHAKER: Mrs. Bowers, can I just respond to one point?

The rule says that:

"The parties shall submit"--

Excuse me. This is 2.743, subparagraph (b):

"The parties shall submit direct testimony of witnesses in written form..."

MR. NORTON: Excuse me.

What page are you reading from?

mpb14

MR. FLEISCHAKER: 10 CFR 2.743.

MR. NORTON: Sub-what?

MR. FLEISCHAKER: (b).

MR. NORTON: It doesn't read like my copy. I think you've got 19-something else.

(Pause.)

MRS. BOWERS: Well, I have, I know, the current copy. But as you know, Mr. Norton, by the time that volume comes out it's obsolete because of the May 26 changes. But that's why I carry this one.

MR. NORTON: But that doesn't agree with my copy at all.

MR. FLEISCHAKER: Well, I have one dated January 1, 1978.

MR. NORTON: So do I.

MR. FLEISCHAKER: 2.743, Evidence, Subparagraph B, Written Testimony.

MR. NORTON: Okay. I'm sorry. I thought you were someplace else.

MR. FLEISCHAKER: You scared me.

(Laughter.)

MRS. BOWERS: Okay. Go ahead.

MR. NORTON: Okay.

MR. FLEISCHAKER: "The parties shall submit direct testimony of witnesses in written form unless

mpb15

otherwise ordered by the presiding officer on the basis of objections presented."

I read that literally, and the reason I do is important from the Intervenors' point of view. We don't have a pool of witnesses to call upon to put behind the table to respond to questions from the Board or of various parties. Intervenors generally have two or three or four or five witnesses. In each case we prepare written direct testimony. That testimony is in the hands of the Applicant and the Staff well before the beginning of the proceeding. They have an opportunity to dissect that testimony and dissect our case, and they know where we're coming from.

Now the Board's decision is based in large part on the written testimony of the experts as well as information that may be in the SER, or whatever. But if we give this rule the loose kind of interpretation I think that the Staff apparently has applied -- the proceedings that I have been in, there has always been written direct testimony submitted.

I'm suggesting that the rule should be appropriately applied in this case because it constitutes a real disadvantage, it results in a real disadvantage to the Intervenors.

The Applicant can submit the testimony of two or three people and then put up a range of experts. And if I ask questions and one or two of those experts can respond, I'm looking at opinions that I've never seen before, and I'm

mpb16

looking at opinions that haven't been probed and the basis for the assumptions that underlie those opinions.

So I think that there is an extremely strong interest in strictly applying this regulation. And I'm going to argue for it for this proceeding, and if the Board rules otherwise, fine, we'll accept that ruling. But at the time that these witnesses take the stand I want to make an objection so that I can preserve that point.

MR. NORTON: I would want to make one brief response.

A, they are not presenting direct testimony. They are available for cross only. Now they may in rebuttal, and we obviously cannot prefile rebuttal testimony because we haven't seen their testimony.

But I also refer the Board to Appendix A of Part 2, wherein it states

> "The proceedings should be conducted as expeditiously as practicable" --

And that isn't why I'm reading it, but I wish we would.

> --"without impairing the development of a clear and adequate record. The order of presenting testimony may be freely varied in the conduct of the hearing. The Board may find it helpful to take expert testimony from witnesses on a round

mpb17

table basis after the receipt in evidence of prepared testimony."

You have received in evidence our prepared testimony. We have panels of experts to sponsor that testimony.

It has been done, as Mr. Tourtellotte says, for the past 15 years, and I just see no basis for the objection.

MRS. BOWERS: Dr. Martin has a question.

DR. MARTIN: Maybe I'm at a disadvantage because I've had no legal education. But I'm having trouble understanding how a witness can be cross-examined if he has presented no testimony.

MR. NORTON: Well, Dr. Martin, let me explain an example, and I think perhaps this very first piece of testimony we have is a good example of it.

Dr. Jahns will prepare the testimony. This is the result of field work, data collection, data analysis done in the past probably 11 years, 12 years, resulting in --

DR. MARTIN: This is being presented as Dr. Jahns testimony?

MR. NORTON: It was co-authored by Dr. Jahns and Dr. Hamilton.

The data was all collected by Dick Willingham, Doug Hamilton, and Dr. Jahns, and even some other people that worked for them. But the three of them have analyzed and

treated it. Now Dr. Jahns hasn't analyzed and treated all of it.

DR. MARTIN: You mean he's presenting testimony that is not his own?

MR. NORTON: No, that's not what I'm saying.

What I'm saying is that, as in the case with any scientific endeavor, people work for people, and maybe that sparker data, that top roll there, was done and analyzed by Mr. Willingham and simply reviewed by Dr. Jahns, but Dr. Jahns can't answer any specific questions about Well, what time of the day did you do it, when did you do it, where did you do it, that sort of thing, because Mr. Willingham did it.

DR. MARTIN: He can answer that question. He can say I didn't do it.

MR. NORTON: That's right.

DR. MARTIN: So I don't know what kind of data is done.

Now it's his testimony, isn't it?

MR. NORTON: It's his and Mr. Hamilton's.

DR. MARTIN: Well, then, he should be able to answer questions about it if it's his testimony.

MR. NORTON: He can't possibly.

DR. MARTIN: And if he doesn't have an answer, well, then it's somebody else's testimony.

MR. NORTON: No.

mpb19

The testimony leads to many questions which the witness doesn't have personal knowledge of.

DR. MARTIN: Fine. Then if he wants to consult with someone who can answer the question, then he can come back and answer it, right?

It sounds to me like this is what Mr. Fleischaker wants.

MR. NORTON: He could leave there and come down and consult with Mr. Willingham and then come back and answer the question, but it's obviously Mr. Willingham's answer, and why not have Mr. Willingham sit there and say the answer to save everyone a lot of time?

DR. MARTIN: Well, then, he's not being cross-examined.

MR. NORTON: He certainly is.

Who is? Who is not being cross-examined?

DR. MARTIN: The man who isn't a witness to begin with. He's answering for somebody else.

MR. NORTON: He may well be cross-examined, though, because Mr. Fleischaker might want to say, Well, gee, if you took that in 1972, do you still know that it's reliable or something like that. And Mr. Willingham might be able to answer that question. He may well want to ask Mr. Willingham questions about that. And the Board may well want to ask questions of the person who actually did the work, the analysis

mpb20

of equipment, and so on and so forth.

This is very often done by others. You can't have every person who tested every piece of equipment come in here and testify. You have to have the person who supervised it. But they can't answer the detailed kinds of questions that may come up.

DR. MARTIN: All right. I appreciate that. And I've been in that position myself personally.

In what way will you be harmed or prejudiced if the person who prepared written testimony is required to answer or to find answers to any questions that arise about that testimony?

MR. NORTON: Only that it would probably lengthen the hearing considerably because you don't know if the answer to that question is going to give rise to five more. So he goes out, he says, Okay, I'll call my office or I'll check with Mr. Willingham to see, or whatever, and I'll come back and I'll report to you tomorrow the answer. Well, the answer that he gives may give rise to more questions, and then he's got to go back again. Where if you have the person right here he can answer the question and terminate it right there.

And it's only for convenience of the Board and for imparting information to the Board that it's done this way. It can be done another way. It would just drag the proceedings out. It could drag them out ad infinitum.

and MADELON; [illegible]OOM [illegible]

MR. FLEISCHAKER: Mrs. Bowers?

MRS. BOWERS: Wait a minute, please.

Are you done?

DR. MARTIN: Now that the answer to my question is on the record, I'm not sure that I understand the answer. I still hold the opinion that if a man has prepared testimony and it's his testimony, then he ought to be able to answer questions about it.

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MR. NORTON: Dr. Martin, that's true at a certain level, but as you well know, when there are a great number of people who do the backup work that leads to the conclusions of the testimony, that the person who supervises that work doesn't have the detailed answers to all the questions. We are simply supplying the people who do.

We have listed them as witnesses. They have been listed as witnesses for months, and it's exactly what they are going to be testifying about. We could have just as well I guess put Mr. Willingham's name on the prepared testimony. We could have had him review it and say -- and he probably did, as a matter of fact.

DR. MARTIN: Well, are you telling me that they are here to provide information that, for some reason or other, has been left out of the prepared testimony?

MR. NORTON: No, absolutely not at all.

Mr. Fleischaker, if he is going to ask questions that the

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answers to are already in the direct testimony, might just as well not ask any questions. He is obviously going to go beyond the direct testimony.

DR. MARTIN: Well, if you can ask questions without help, other than what has been written down, I can't understand why the one who wrote it down can't answer without having a lot of consultants backing him up as witnesses.

MR. NORTON: I'm not sure I followed that. I assume he prepares his cross-examination --

DR. MARTIN: I'm trying to determine in part whose testimony we're going to hear.

MR. NORTON: You're going to hear the direct testimony of Dr. Jahns.

DR. MARTIN: But he's not going to answer any cross-examination?

MR. NORTON: He certainly is and he will answer every question he can answer. And if there are questions asked of him that he doesn't know the answer to that lead into, for example, these Sparker records, then the other person who is here will be able to answer.

DR. MARTIN: That's very convenient. I wish I had somebody to answer for me.

MR. NORTON: Dr. Martin, this is exactly what we did in the last two sessions.

DR. MARTIN: Well, I didn't like it then either,

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but I didn't say anything about it because that seemed to be they way we're doing it.

Now somebody has raised an objection to it.

MR. NORTON: Well, Dr. Martin, the problem-- if I might go a little bit further with this, because the problem that presents is this:

For example, we've taken the deposition of their witnesses. They rely on the work of others in arriving at their conclusions. Now if you're going to allow that kind of evidence in, then-- That's hearsay, and that's allowed in in these proceedings. It's frequently done, where one scientist, for example, Dr. Silver, will talk about the work of people who are not here that he relies on. That's hearsay, and probably in a trial it would not be allowed into evidence. But it is here.

Basically we're trying to avoid as much hearsay as we can and if we have the man here who actually did the work and could say, "Yes, I did it Saturday morning at nine o'clock, and by golly, that's when it was done," then we figure that's information the Board wants to know as opposed to Dr. Jahns saying, "Gee, I'm not sure when he did it. I know I saw it a month or two later."

DR. MARTIN: But I still want to know whose testimony I'm hearing.

MR. NORTON: You're hearing Dr. Jahns' testimony

eb4:

in the first instance, the first situation; no question about it. It's testimony that he and Mr. Hamilton wrote together. They worked on it together; they wrote it together; they reviewed it together. And they're both here.

And you know it's kind of silly to have two people stand up and sing in unison the summary of it, so only one person is going to do that, but they both prepared it, and they did it together.

DR. MARTIN: In that case I can't understand why they didn't all submit it.

MR. NORTON: THey did. It is submitted by two--

DR. MARTIN: Only two guys signed it. Are these other fellows capable of supporting the same testimony?

MR. NORTON: Mr. Willingham happened to be in Santa Barbara. Mr. Jahns and Mr. Hamilton are in Stanford and they go together and wrote the testimony. Mr. Willingham did a lot of the work that went into the testimony that leads to the conclusions. He did a lot of that work. He did a lot of the analyses.

DR. MARTIN: But he couldn't appear as sponsoring that as his own testimony?

MR. NORTON: Oh, I'm sure if he were asked if he agreed with that testimony he would certainly say he does, and that he contributed a lot of the data that leads to the conclusions.

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DR. MARTIN: Well, maybe what you need to do is to re-identify who the hell the witnesses are in this thing, whose testimony it is that we're taking. That's what we want to know.

MR. NORTON: That has already been done. There's no question about that. It's Dr. Jahns' and Mr. Hamilton's testimony. You know there's no question, Mr. Willingham did not write that testimony.

DR. MARTIN: But he's going to answer questions.

MR. NORTON: He may not answer any questions if Mr. Fleischaker doesn't have any.

DR. MARTIN: Well, what's he going to do up here on this panel?

MR. NORTON: Sit, and if Mr. Fleischaker has any questions that only Mr. Willingham knows the answers to, such as when certain data was collected -- and I use that as an example. Really, Dr. Jahns knows the answer to the question but I use it as an example -- then Mr. Willingham would be able to supply that answer.

Again, it is to facilitate the Board in deriving information from these people because Dr. Jahns didn't do all the work himself. It's an immense task. It covered years of time, and he just didn't do all the work himself.

And if you have a specific question, for example maybe a certain rock formation was looked at, maybe that

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was done by Mr. Willingham and not Dr. Jahns, and again I'm just using that as an example. And it is to help the Board get the facts. And when I heard Mr. Fleischaker this morning, that's what he wanted to do, but this afternoon --

DR. MARTIN: Well, the Board needs help, but they'll get the facts whether they receive help or not.

I think there's some confusion, though, about who is supplying the facts. You know, when you have testimony that is signed by one or two people, and then you have several other people appearing as witnesses to answer questions about that testimony --

MR. NORTON: Along with the people who prepared it. And Mr. Fleischaker can direct his question to any one member of the panel he wants to. He can direct every single question he's got to Dr. Jahns if he wants to. That's up to him.

DR. MARTIN: All right. And then this other fellow is just sitting there at his elbow to feed him answers if he doesn't happen to know what they are.

MR. NORTON: No, sir. The way to proceed properly I think in a case like this is he has a question for Dr. Jahns and Dr. Jahns-- You know, normally we do it a little more informally than that. But if it wanted to be done formally, we would have no objection.

If Dr. Jahns says, "Gee, I'm not sure of that, I

eb7

think Dick Willingham, you dug out that record," or whatever the answer is, and he sits there and bes quiet and Mr. Willingham doesn't say anything. If Mr. Fleischaker wants to ask Mr. Willingham, he can. But I would think if he asked the question he would want to know what the answer was, and that's the only reason to have the person there.

Normally the way it's done is Dr. Jahns in that case would say, "Gee, I don't think I know the answer to that but I'm pretty sure Dick does." And Dick Willingham would answer if he knew it.

But I don't understand the need to be so formal about it. I mean if it's the information they want, then we're here to supply it.

MRS. BOWERS: Are you done?

DR. MARTIN: Yes, I'm finished.

MRS. BOWERS: Mr. Tourtellotte?

MR. TOURTELLOTTE: I would like to address the same issue, and maybe give it a little different perspective.

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It seems to me the question you have to ask yourself is why is it that we are presenting any testimony at all, what is the purpose of testimony?

And the purpose of testimony is simply to tell a story in the logical way, so that introducing facts and methodologies which will help the Board arrive at a conclusion of whether this plant can be operated in a safe manner. And that testimony is usually prepared by a number of people.

8.090

And it is simply administratively and judicially inefficient to have each person prepare their testimony separately and file separate pieces of paper with the Board. So the practice that has evolved through the years is to file one piece of paper which is sponsored by a panel.

Now you asked the question, well, why a panel, why not just one person, this isn't the way it goes in a regular court proceeding.

Well, it isn't the way it goes in a regular court proceeding. But there's also a little rule in administrative law which says that the rules of evidence supplied to court proceedings don't necessarily apply to administrative proceedings.

The reason for that rule is that there is considerably broader latitude given in presentation of evidence to insure that the evidence is reliable and probitive because of the complexity of the evidence involved and because of the

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very nature of the instrumentalities that create this evidence for the Boards or for the courts.

Now, in this case, then, the testimony is what is important and not exactly who it is that is with that testimony. And the questions that are being asked and the cross-examination that is being made is being made of the testimony. And the people who are there to sponsor that testimony are only the instrumentalities of answering the questions directed toward that testimony.

Consequently, it doesn't make any difference whether there's one person there or two persons or three or four or five or six, because the questions are not directed toward any one of those people individually. Because, as everybody knows, in most cases, that all of them -- that one of them singularly did not perform the type of background investigation to come up with that single document, it took a sort of a collegial effort on their part.

This is really the way the thing has operated for years and years. It's not a matter of each person having to file the testimony to justify their position.

To indicate to you, too, how that process developed and the sense of it all, I would simply invite your attention to 2.743, the Evidence subpart (g).

2.743(b) is what Mr. Fleischaker was reading from, but under (g), it says that:

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"Proceedings Involving Applications:

"In any proceeding involving an application, there shall be offered into evidence by the Staff any reports submitted by the ACRS in the proceeding in compliance with Section 182(b) of the Act, any safety evaluation prepared by the Staff and any detailed statement of environmental considerations..." -- et cetera.

Well that right there is indicating that the SER will be presented by the Staff. Everybody knows that the SER was worked on by hundreds of people. Not just one, not just two, not just three, but hundreds of people. You would have to virtually fill this room with witnesses, and you would have to file separate pieces of testimony for each separate section that each one of those people worked on in order to introduce the SER. That's a very clumsy way of proceeding and, in the final analysis, it doesn't get you anywhere.

What will happen is that a few key members who guided the accumulation of information for the SER will be here to sponsor it. It will be sponsored into evidence by them as being prepared by them or under their supervision. And they will answer all the questions that they can answer.

Now, it could well be that a question will be answered that they can't answer -- will be asked that they cannot answer. And in those cases where that occurs, what

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we simply have to do is request time to find out what the answer is, but that's the way the thing is handled,

And the cross-examination is not specifically of Dennis Allison, he's the project manager and he's going to be sponsoring that in there, the cross-examination is of the document itself, and it presents all the facts that need to be presented and it presents all of the fundamental bases upon which cross-examination can be based.

So that is a rough explanation of how the process works and has worked for a number of years. And the cross-examination, it seems to me, we're talking about parameters of testimony and not the individual who is sponsoring the testimony itself.

MRS. BOWERS: I think we've spent enough time on this.

Mr. Fleischaker, in the proceedings you were in, how did you avoid not having a Staff panel sponsor the FES or the SER? Were you there only for discrete issues?

MR. FLEISCHAKER: I'm trying to think back.

Let me recall one case, first of all, the first proceeding I was thinking of was the Indian Point show-cause seismic which was tried by the Appeal Board, which was a fact-finding body at that time.

We may have had an SER, but my recollection was that all the parties submitted testimony and they were

cross-examined on the basis of their testimony. And the Staff submitted testimony as a panel, but each member of the Staff who was on that panel signed the testimony. So it was a joint statement, but the joint statement was sworn testimony of the various joint participants to the panel.

Seabrook was a long time ago, and I can't recall, frankly, what the practice was. But I do recall that the cross-examination was primarily of the testimony. And, again, my recollection was that the testimony was submitted by the Staff sitting as a panel, and that individual pieces of testimony were submitted jointly and four or five names were on that testimony and each of them swore to it.

MRS. BOWERS: Well we've had that in this situation. Now this is your first experience in appearing in Diablo in an evidentiary hearing.

MR. FLEISCHAKER: That's correct.

MRS. BOWERS: And I recall a year ago, at the non-seismic safety issue hearing, there was separate testimony prepared by a witness of the Applicant and the Staff on the possibility of an aircraft crash into the facility, and there were other separate testimonies that were discrete issues that had been raised.

But it certainly has been the practice in the 6.5 years I've been in this program to have a panel of Staff witnesses sponsor a major document.

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Now, once in a while, a question is raised where they either pull someone out of the audience and have that individual join the panel because he has the specific information, or they get in touch with the person back on the reservation. And, of course, we've also had the experience of the Applicant having that panel sponsoring a particular document.

And, if you think a situation arises in this case that is prejudicial to you, I'm sure you'll let us know, but we would like to proceed with what is a usual practice.

MR. FLEISCHAKER: Okay. I'll note my objection at the time that the panel takes the witness stand.

MR. NORTON: Excuse me, Mrs. Bowers, I would like to say one more thing that occurred to me in terms of Dr. Martin's concern.

8.210

It seems to me that to proceed the way we're proceeding is far more fair to the Intervenor than to simply hold all these people until everything is all done and then bring them in in rebuttal.

We can bring them in in rebuttal and they can get up there and testify for weeks on rebuttal, and the Intervenor is going to have no advance notice of anything they're going to say.

We're not trying to sneak something in, it's not our purpose, we're not trying to sneak something over on

agb7

the Intervenor, sneak some evidence in that wasn't there before, because all the opportunity in the world to do that is there in our rebuttal.

We are putting them there for the Board's use to gather information and for the Intervenors' use to gather information. And in terms of a surprise direct testimony, we can do all we want of that in rebuttal, so that is clearly not our purpose and I don't understand how Mr. Fleischaker is in any way prejudiced.

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MRS. BOWERS: Mr. Fleischaker has promised the Board if he feels a particular situation comes up where he feels he is prejudiced, he will bring it to out attention.

May we begin?

MR. NORTON: Very much so.

At this time we would like to call Dr. Jahns and Mr. Hamilton and Mr. Willingham to come up to the witness table.

While they're coming up, Mrs. Bowers, we have one minor thing. We have three copies of the witnesses' qualification which we would like to have marked as Exhibit 7 -- I believe it is Applicant's Exhibit 7. We thought we would put these all in at one time as an exhibit, and after our discussion, it now takes a little bit of a twist because there are a great many witnesses' qualifications in here of people who may never be called, for example. They are backup people to answer detailed questions and they may never be called and may never testify.

But in case they are called, we would like to have these in the record as an exhibit. Counsel for the Intervenors have stipulated so. However, we will present a person like Dr. Jahns and someone like that who is on a panel, we will present a resume to go in the record as though read for those witnesses. But this exhibit is everybody's professional qualifications, and we have supplied sufficient

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copies to the Court Reporter.

MRS. BOWERS: And both Intervenor and Staff have stipulated to this?

MR. NORTON: I'm not sure I talked to Mr. Tourtellotte about it. I think I did. Maybe I forgot to, but I know Mr. Fleischaker said it was all right to have Exhibit 7, which is our list of qualifications, go into evidence.

MR. FLEISCHAKER: That is correct.

MRS. BOWERS: Well, Applicant has identified the Direct Testimony of Applicant, Pacific Gas and Electric Company, for Hearings Commencing December 4, Witness Qualifications, as Applicant's Exhibit Number 7, and it will be accepted into evidence.

(Whereupon, the document referred to was marked Applicant's Exhibit 7 for identification and received in evidence.)

MR. FLEISCHAKER: Mrs. Bowers, I don't anticipate we will have any problems, but just let me bring up one point on this.

In our preparation of cross-examination we understood Mr. Bettinger was going to go first. We've prepared a lot of cross-examination for him, and only began to prepare our cross-examination for this panel. I understood from

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previous discussions with Mr. Norton that Mr. Jahns might have a substantial presentation summary of his direct testimony which might last two or three hours, one hour to three hours.

The bottom line is that we have not completed the preparation of our cross for this panel, anticipating that Mr. Bettinger would go first, and that the day would be taken up.

I understand that the Applicant has some scheduling problems. That's okay with me. But if we could proceed as far as we can into our cross today and if necessary, if the Board would permit us to adjourn a little early so we could go back and finish our preparation of our cross-examination, I would appreciate it.

MRS. BOWERS: Well, let's get started. In the first place, we don't know who these people are.

Do you want to identify them?

MR. NORTON: Yes.

Gentlemen, I think it would probably be best if you would just sit at the table, the three of you.

MRS. BOWERS: Well, we want to swear them in first.

Whereupon,

RICHARD H. JAHNS,

DOUGLAS H. HAMILTON,

and

C. RICHARD WILLINGHAM

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were called as witnesses on behalf of the Applicant and, having been first duly sworn, were examined and testified as follows:

MR. NORTON: Dr. Jahns is the gentleman sitting at the right side of the table. In the middle is Doug Hamilton. And to the left of Mr. Hamilton is Dick Willingham.

Mr. Willingham, you missed all the discussion about your being on this panel.

DIRECT EXAMINATION

BY MR. NORTON:

Q Dr. Jahns, do you have in front of you a copy of your qualifications as a witness in this matter?

A (Witness Jahns) Yes.

Q All right.

And is that a true and correct copy of your qualifications, or are there any changes you wish to make to it?

A It's a correct copy.

Q All right.

And there are no changes to be made to it?

A No.

MRS. BOWERS: Is that microphone working?

BY MR. NORTON:

Q Dr. Jahns, I would like to ask a little about yourself before we get started. I understand you are the

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Chairman of the Geology Department at Stanford University. Is that correct?

A (Witness Jahns) No, I can't claim that. I'm Dean of the School of Earth Sciences there.

Q I'm sorry, Dean of the School of Earth Sciences as opposed to Chairman of the Department. I'm sorry.

And how long have you been there, Dr. Jahns?

A 13 years.

Q All right.

And how long have you been involved in this particular project, that is, the Diablo Canyon project?

A Almost exactly 13 years.

Q All right.

And who did you work with initially in this as a co-worker?

A Initially I worked along.

Q All right.

And then did someone join you later on in your work?

A Yes. At a later time, Mr. Hamilton and some of his associates became involved in the project.

Q All right.

Would you care to very briefly describe your related work experience to the Board, as to the type of investigation you did here in this case?

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A Well, basically I'm a general geologist in terms of my professional work. I have long worked in the State of California, and particularly in the southern half. This work has included studies of the coastal region with special emphasis on the transverse ranges and the southern part of the Coast Ranges Provinces.

Q All right.

Could you describe some of the professional affiliations and memberships you hold as a geologist?

A Well, they include most of the recognized professional associations such as the Geological Society of America, the Society of Economic Geologists, the American Institute of Professional Geologists, and so on.

Q All right.

MR. NORTON: Mrs. Bowers, I think, if we might, we'll hold off after Dr. Jahns' presentation, to introduce the other two panel members.

BY MR. NORTON:

Q Dr. Jahns, at this time I understand you have submitted testimony, direct testimony, in this case. Are there any corrections of any kind that you have to make to this testimony of a typographical nature or such?

A (Witness Jahns) Yes, there are a few essentially typographical errors, but they are so obvious that I don't think it's necessary particularly to call attention to them

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in this formal way, save for one near the end.

Q All right.

Do you have a copy of that in front of you? If you do, we could make that correction at this time.

A On page 132 of the formal testimony, the last word on line 24, --

Q "Transitional"?

A -- "transitional," should read "translational."

Q All right.

A We had one more correction that might well be pertinent here.

Q All right.

A Figure 43. The title should read "....between Point Arguello and Point Sal" rather than Point Estero.

MR. BRING: Sal instead of Estero?

WITNESS JAHNS: Yes.

BY MR. NORTON:

Q Now, Dr. Jahns, I understand you have prepared a summary of your testimony today. Are you prepared to give that at this time?

A (Witness Jahns) Yes, sir. It's a summary of a peculiar type in that it is skewed toward clarification of some geologically complex methodology and means for interpretation that I think are pertinent at this point.

Q All right.

MR. NORTON: I understand, Mrs. Bowers, we have some slides to show on the scren. Now these slides are the same as the figures from the direct testimony. They are no different, and they will be identified as to which figure they are when they're discussed, but they are not anything new.

BY MR. NORTON:

Q As I understand it, Dr. Jahns, the standup microphone comes out of the holder, but I see now that somebody has would it underneath the table that the projector is on, so if we can get that squared away, I think you can go ahead.

A. (Witness Jahns) I think for the most part that the testimony that Mr. Hamilton and I have prepared is rather complete, and we made an attempt to document it to the appropriate degree of completeness as well.

What I would like to do at this time is to select certain features in order to accomplish two purposes: one, better to outline the geologic setting as it applies to the distribution and behavior of faults, some of which are highly pertinent to the site being discussed here, and the other is to answer some questions that normally arise in connection with geologic discussions, whether in print or oral.

For example, it's a very common thing for observers of such discussions to ask how can it be that presumably

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competent geologists can seemlingly differ so dramatically in some of their interpretations? And I think by means of outlining certain geologic features in California and more immediate areas relative to the site, some of this can be made a great deal clearer.

(Slide.)

First the general setting. This is a geologic map of the State of California, showing in red the igneous rocks of the Sierra Nevada, and also in red some igneous rocks south of Monterey Bay. The site would be in this part of the coastline, well north of the major bend from an east-west trend to a north-northwest trend of the coastline itself.

Traversing a good part of the coastal part of California is the master break, as it is known among many geologists, the San Andreas FAult, and I can trace it here on the map. It's essentially a series of breaks in extreme southern California, making a general bend at the latitude of Los Angeles but actually east of Los Angeles, extending west-northwest, and then making another bend to which I will refer a little later that geologists refer to as the Big Bend, and from the Big Bend extending with a remarkably straight trace in the northwesterly direction into the Bay area, the San Francisco Bay area, and then in effect playing tag with the coastline before going offshore about at this latitude.

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The fault evidently makes a series of bends farther north in the suboceanic area and picks back on shore at Shelter Cove in Mendocino County, and then it goes offshore again for the last time.

The San Andreas FAult is a long way from the site, but I think it is useful to consider it for just a few minutes and develop a kind of a feel for it because, in effect, it's our baseline for considering other faults that are of more immediate concern at the site.

Why do geologists call it the master break? Because for many millions of years it has been the principal plate boundary, that is, a major boundary between two continental-dimension plates of the earth's crust. One extending to the east all the way to the Mid-Atlantic Ridge is generally referred to as the American Plate, and the other, extending west, including a little bit of the continental United States and a good deal of the Pacific Basin, is known as the Pacific Plate.

Basically those two plates have been drifting horizontally past each other, the one to the east in a relatively southeasterly direction , the one to the west in a relatively northwesterly direction, at rates that have varied through time. And this is a good point to introduce something that I think it's well to keep in mind during subsequent discussions, particularly discussions of faults, and

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that is the question not only of what has happened along a given fault but when, in terms of geologic time.

And most significant in any kinds of engineering context is what has happened in this part of the world during the last four and a half to five million years? Because that's recent enough to be significant. It encompasses a long enough period of geologic time to establish a baseline.

And finally, all the evidence available to us suggests that the general pattern of behavior along the San Andreas Fault and other faults has been relatively consistent during that past four and a half to five million years.

Most geologists look on this period as the time since the original opening of the Gulf of California which began to open then and which has been opening ever since, and is doing so today.

So the San Andreas then is a very active fault. It's the master break and in general, I think it fair to say that all geologists who have been involved in work in the coastal area look on it as a first-order feature.

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Pointing to another first-order feature in the views of most geologists, we can see this great curving break south of the Sierra Nevada bounding the Mojave Desert region in the north, the Garlock Fault.

It has an opposite sense of movement relative to the San Andreas in that the ground to the north is moving to the left, or westward, relative to the ground to the south.

So the San Andreas has been characterized by predominant right-hand slip, the Garlock by predominant left-hand slip. The Garlock is like the San Andreas: big and active, although there has been no historic event in the way of an earthquake along it.

Now let's consider for a moment the faults lying in a coastal direction from the San Andreas in the overall latitude of the site, Monterey Bay, on down to Point Conception, here, the typical coast range faults normally regarded by geologists as part of the San Andreas system.

Like the San Andreas, they trend northwest. LIke the San Andreas most of them have been characterized during this past 4.5 to 5 million years by right-hand lateral slip, a dominance of horizontal movement, with some notable exceptions.

A good many of them have been characterised by major amounts of dip-slip, that is, slip approaching pretty much directions straight up or down, the dip of an inclined

agb2

fault plane. Many of these faults have gentle to moderate dips, in contrast to the San Andreas which, for all practical purposes, we can regard as vertical.

So this, then, is the general framework with which we have to deal.

To a critical geologist examining the scientific products of his colleagues, the first question that comes up in connection with anything involving an analysis of fault behavior over time is when, when are you talking about?

To illustrate what I mean here: Consider for a moment, the San Andreas. I come back to that because we happen to know a great deal about it, with a great deal more still to be known.

The San Andreas is an old fault, probably born on the order of 100 million years ago, although that hasn't been demonstrated firmly, but a fault that has not behaved uniformly throughout that total period of time. There have been long pauses of possibly tens of millions of years, in one case, in which there has been relatively little activity along it.

But certainly during the last 25 million years or so, it has been very active. And the matching up of correlatable units on opposite sides of the fault today gives us a handle on the accumulated slip along the fault which, in this part of the fault in Southern California south of the

agb3

big band, has apparently amounted to something on the order of 300 kilometers in the last 25 million years.

Now, one of the enigmas about this fault -- and this turns out to be pertinent to some of the geologic studies that have been applied recently in the context of Diablo Canyon, there is evidence relative to this enigma.

There's evidence of something on the order of 500 to 550 kilometers of slip during the same period, or along the period, perhaps, of geologic time. And this has prompted a good many geologists to play a sort of "button, button, who's got the button" game in Southern California looking for some other fault, an ancestral San Andreas, for example, that might account for that other 200 or 250 kilometers of movement.

Now a very ingenious explanation for this enigma might be this kind of alternative: a fault farther west from the present San Andreas, included in the latitude of Montery Bay and the Diablo site that joins up with the San Andreas.

And you can recognize immediately I'm talking about, as a candidate, the Hosgri and associated breaks.

It could be, as we will see directly in another slide, geometrically possible to combine movements on that fault with the present San Andreas to account for a greater amount of movement along the San Andreas north of the junction

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of the two faults.

So that is the rationale that lies behind the presentation by Graham and Dickenson, for example, which has figured very heavily in much of the testimony. And some of my

And some of my comments are frankly addressed not toward any conclusions about this, but toward factors, an understanding of which will contribute to an understanding of the strengths and the frailties and possible significance of such an hypothesis.

Okay, let's move to the next slide.

(Slide.)

Just to give a feel for what a first-order currently active fault looks like, here's a view of part of the San Andreas on the Kerezo plain about in the latitude of Bakersfield.

We see here this very clearly defined continuous trough, each of which represents the locus of relatively recent episodes of movement along that fault, with the most recent locus over here toward the left. West is, in general, toward the left in this view.

What this tells us is something about what a master break or any major break that is geologically active can be expected to look like. There is a topographic continuity here, a very definite kind of flavor of the physical features associated with it.

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In this case, there has been movement as recent as historic time. There was actually 30 feet of horizontal offset along this part of the fault in 1857.

Next slide, please.

(Slide.)

Here is a map showing some of the major faults, just to give us a bit of geographic perspective. Here's the San Andreas, the big band on it, the long straight stretch extending northwest from it. The site area is over here on the coast, north of the latitude of the big band.

The general region of the transverse ranges extending generally east-west across this part of the map, and including the east-west part of the coastline on which Santa Barbera is situated. And the northern boundary of the transverse ranges lies upcoast from Point Conception.

The Diablo Canyon site is in the southeasterly part, the coastal southerly part of the coast range provinces, which is this belt extending northward from the transverse ranges.

The San Andreas, it is of special interest to note cuts across both provinces. It slices acutely across the coast ranges, nicks the big band at about the northern end of the transverse ranges and then cuts across the transverse ranges. It is the only fault that does so. It's the only fault that has been able to do so from all the evidence that's

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available to us.

Now, if I may take about five minutes to develop a series of points.

Most of the reporting data that appear in brief form in the written testimony, I believe one can understand a little better how it is that different parts of a given major active fault and different parts of provinces with such faults can be expected and do deliver large earthquakes of different magnitudes.

First, it's well known today, not only from the historic record but from several other kinds of geologic evidence, that different parts of the San Andreas should be considered capable of generating maximum earthquakes at different levels.

For example, the reach of the fault extending from the San Bernardino area, about in here, westerly to the Big Bend and a little bit northwest from that bend, has a style all its own, it's a style of seismic quiescense for long periods of time during which strain, representing the effects of this southeastward drift north of the fault, accumulates to higher and higher levels.

Evidently the geometry of the Big Bend is such that movement, ready movement, is forestalled. So strain builds up, nothing much happens in the way of earthquakes, until suddenly there's a big bang and a great earthquake occurs.

agb7

1857 was a good example.

Quite in contrast to that, parts of the fault farther north, extending northwest to the general San Francisco Bay region and parts of the fault extending southeastward from the San Bernardino area, are much more active and are characterised by moderate-to-major earthquakes but not by great ones.

And it would seem that in these straighter regions of the fault, there is less frictional resistance to fault-slip to be overcome, with the result that seismicity is characterized through time by more closely spaced events of smaller magnitude.

Now, why is that important?

It's important because the same kind of feature probably extends westward, along the general northern boundary of the Transverse ranges and southern boundary of the Coast ranges. And that makes it highly applicable to the situation at Diablo Canyon, which is not far north of that boundary.

In most geological analyses, until very recently, it has been agreed that the behavior of the San Andreas Fault during this past five million years that I keep emphasizing has been characterized by this shear that I've described that can be easily related to the horizontal slip along the fault and by a concomitant north-south crustal shortening.

And it's this shortening that characterizes the

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geologically recent structures in the Transverse Ranges. These are compressional structures, including both folds and thrust faults.

What has been neglected until very recently, because the data simply haven't been available, is another factor that for purposes of simplicity whether or not this is exactly the mechanism can be considered as a kind of westerly or a west-southwesterly push from the Mojave Desert region and Great Basin up in this area. That push is shown on this map by these doubly-shafted arrows.

Now I hope I won't be misunderstood, especially by other geologists who might be present, because my following remarks are merely my way of description in order to make clearer what is happening in this area. And it is said, hence, without genetic prejudice, so to speak.

We know that the Sierra Nevada, in this general area of the palm of my hand, has a deep root. It's a feature, a major feature that we can liken to an iceberg in the sense that more of it extends downward than extends upward.

It's a part of the earth's crust that is relative less dense than the material on which it is floating, the underlying mantle. So there it sits fairly high because its vertical dimension is relatively great.

In the areas east of the Sierra, quite in contrast, the continental crust is characterized by exceptional

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thinness and by very high heat flow. It's an area of extension, east-west extension in which the crust is being, in effect, attenuated and thinned.

It is as if something underneath slowing flowing in the mantle were moving in the direction of these arrows and were shoving against the root of the Sierra, pushing that big block in a west to west-southwest direction.

And it is further as if the various ranges and valleys in the Great Basin east of the Sierra were the expressions of a dragging along of that part of the crust and a thinning out of that part of the crust.

Now here it's important to ask when has this occurred, for how long, and can't we match it up in geometry and in time? And if it doesn't stand the two tests of space and time, then something is wrong with the analysis.

Sure enough, it can be matched up, this general thing I've been describing, with the beginning of the appearance of the Big Bend in the San Andreas.

The Big Bend began to form roughly five million years ago. Prior to that, the San Andreas had a straight sweep on down toward the southeast, the San Gabriel Fault traversing the San Gabriel Range, was a part of it. This is why so much of the San Gabriel Fault extends through the Transverse Range province, not long ago geologically it was part of the San Andreas. But as this shoving developed a

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kink in the San Andreas, it became very difficult for movement along it, accumulating in a horizontal sense, to make a double curve.

And about 4.5 million years ago, this segment of the San Andreas from the Fort Tejon area in the Big Bend country on down to the San Bernardino area was developed, apparently largely as a brand-new feature. That's a very young part of the fault.

So it cut the corner, essentially isolated the San Gabriel which has been moribund ever sense.

This is the kind of thing that becomes very significant as background for present-day engineering geology considerations, because to know what one of these faults has been doing lately is very important.

But beyond that, it's well to consider here what has been happening in the area at constant latitude westerly from the Big Bend. And we see repeats of the same geometric pattern, a characteristic switch in trend from the southeasterly trend of the coast range breaks to a more easterly trend. In some places, the junctions with east-west transverse range features represent rupturing of one break by another. In other places, it's a smooth transition.

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This is the kind of background for considering what happens offshore where we don't have the advantages of continuous exposure and have to rely on geophysical traverse or other source of less direct information. Here again the pattern seems to be consistent in pattern, if not in trend, in that offshore area. And this in turn is directly applicable to the problem of what happens southward to the Hosgri Fault.

Next slide, please.

(Slide.)

Now, this little almost cartoon indicates something of the enigma to which I referred earlier. We see here an area of unusual rocks at Eagle Rest Peak. These are enough unusual so that we're prompted almost immediately to ask is there something on the other side of the fault that we could match up, because if we could find something corresponding to the very unusualness of the rock it would make it highly probable that its counterpart on the other side of the fault is indeed a counterpart. And this has been found in a not wholly direct sense way up in the Gualala Basin just south of Point Arena on the south coast where fragments derived evidently from this source now present in sedimentary rock, ancient gravels and so forth, are present on the opposite side of the fault.

This is one of the lines of evidence -- I shall

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try not to burden you with others -- for concluding that there has been something on the order of 500 to 550 kilometers of movement along the San Andreas Fault over a period of a good many million years.

Now the point here in this cartoon is to indicate the role, the possible role of the San Gregorio-Hosgri Fault system, as I prefer to call it because that's a less prejudicial term, the possible role of that system in explaining the difference between the 550 kilometers farther north and the 300 kilometers that appears to be the maximum displacement along the southern part of the San Andreas.

We can perhaps visualize it most clearly by assuming that at some time we can forget the San Andreas in here and just consider all the movement as having occurred along the San Gregorio and the northern part of the San Andreas, north of the junction. And we can see then with a right-hand sense of slip how further displacement of this green patch could occur relative to its source down here in the present big bend area.

This is the basic notion behind the Grants-Dickinson paper in Science Magazine, and frankly it was their principal reason for publishing it, because it's an exciting possible explanation for something that has bothered geologists for a long time.

Now one of the problems with it -- a purely

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geometric one --- is that this limits the amount of addition we can make to this offset, to the distance between the junction and this green patch up here. And one can see why this has to be so.

So this addition is at the maximum about 70 kilometers and won't do the trick for explaining the full 250 kilometers. So that it's only fair to report that several geologists today are continuing their search for an ancestral San Andreas down in this southern California area in order better to account for this enigmatic situation.

Next slide, please.

(Slide.)

Now I'd like to turn to and close with another general problem.

On the previous slide we saw some dots and patches in color on opposite sides of the fault. To reach any kind of conclusion quite apart from the immediate context of Diablo Canyon about the offset on these faults we must ask ourselves what do those dots really mean.

Here's an example of the point I'm making. A common correlation across the San Andreas Fault has involved the granitic rocks of the Sierra Nevada, and specifically the present southwest corner here in the big bend area of those rocks on the east side of the fault with similar rocks on the west side of the fault in the general area, mostly offshore,

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north of San Francisco Bay.

This is the so-called Farallon plate. That includes the Farallon Islands and a little bit of the coastline north of the Golden Gate.

But the question here is how precisely can we regard that correlation? If those dots on the previous slide were really dots, geologically, if they represented rocks that never did extend any farther on the scale of the maps than the dots themselves, we might have a pretty precise correlation.

But here obviously we don't have dots. We have a spread of rocks within each of which we can distinguish something that is unique, and that can be correlated across the fault.

On the other hand, we have a couple of dots that probably represent the best fits for correlating across the San Andreas, and this is a series of very unusual volcanic rocks in the Neenack area in the transverse ranges on one side of the fault and in Pinnacle National Monument on the other side of the fault not too far from Salinas. Those rocks are so unusual that the probability is very high that at one time these two occurrences represented a single occurrence that happened to lie astride the subsequent trace of the San Andreas Fault, and hence have been progressively separated through time.

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This is a very choice kind of evidence that a geologist is always seeking but very very rarely finds. And I think this should be kept in mind in all analyses that are more directly applicable to the case that we're talking about in these hearings.

Next slide, please.

(Slide.)

Getting to what we're talking about in these hearings, here is a fairly detailed map of the plant site on the coast here with a general distribution of onshore and offshore geology, showing the axes of folds, the different ages of rocks shown by different colors, the details of which is probably not much to the point to go into here. But this provides a general background in a geographic sense for the distribution of the geologic units including the trace of the Hosgri Fault zone in the offshore area. And it's intended to convey some notion of the continuity of these various rock types.

Next slide, please.

(Slide.)

Here we see a broader view of the coast, and we get back to this final point that I've been discussing, the distribution and uniqueness of units on opposite sides of the fault.

The units covered in orange here represent

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volcanic rocks of not too great geologic age. This is the Obispo formation. And here is the trace of the Hosgri Fault zone offshore.

Now, what we would like to find and what has been suggested has been found would be one or more occurrences of rocks that first we can feel confident were once connected before the Hosgri Fault was born, and, second, rocks for parts of which we could specifically correlate across the fold.

Now in this case we can see that by looking at the present distribution of these rocks we can't really get much of a feel for accumulated right-hand slip or any other kind of displacement along the Hosgri Fault zone because we do have one control point on the seaward side or the oceanic side of the fault zone in the form of a Standard Oil Company well, the Oceana Well. And that well penetrated a thick section of these same rocks.

So so far as the distribution of that particular formation is concerned, there is no need to specify a major slip along the Hosgri Fault.

Next slide, please.

(Slide.)

Now here is an example that represents an extreme case, but one that is very often neglected in these geologic analyses by both geologists and nongeologists alike,

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and it's one very pertinent in some of the publications that have been quoted in the testimony regarding this hearing.

Here we see the distribution of a very wide spread unit in coastal California, the Miocene Monterey formation, more than ten million years old.

Let's imagine for a moment -- this is a kind of simple tool, analogy, but it's a non-trivial one -- let's imagine for a moment that we have an infinitely-extending sheet of cheese, a progenitor of Swiss cheese, and let's assume that that cheese is transected by a break, and that through time we have differential movement in a horizontal sense, and that further through time this cheese begins to develop holes and becomes a Swiss cheese.

Well, if we stop that process at any intermediate stage and look at what is on either side we can imagine the problem of correlating across a fault. How certain can we be that a piece of a hole on one side really corresponds to a piece of hole on the other side, as opposed to one forming at one time and one at another. We can't be sure.

Now, if the process continues to the point where there are far more holes or far more volume of holes than there is residual cheese we are looking at something very closely akin to what a geologist faces up to.

All I'm pointing out here is that everything in our knowledge of almost a century of examination across active

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faults in the western United States indicates that we're dealing with a very difficult problem of analysis. And this sort of closes the traverse relative to my initial question:

How is it that presumably competent geologists can seem to disagree?

Well, it is simply a matter of this: that the problem is basically complex. It doesn't mean it's insoluble, but it does mean that a suggested conclusion about amount of slip, if not very carefully cast and very carefully outlined in terms of its constraints, can be quite different from someone else's conclusion, even though based on the same data.

If there are differences of view concerning the data and the interpretation, and there are significant differences of view in interpretation on features on opposite sides of the Hosgri, the problem is compounded.

This is the kind of thing that some of us have attempted to look at very critically.

I would simply close this oral testimony by indicating that almost any geologist, including several of those reaching contrasting views in connection with matters that are significant relative to this case, would cheerfully admit that in order to be fairly certain about these interpretations all of the available evidence, whether in a promotional sense or in a constraining sense, must be accounted for by that explanation. And if there is one line of solid

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evidence that cannot be accounted for, then the chances are pretty good that the geologist, rather than nature, has made the mistake. And this again is the kind of thing that several of us have attempted to be very critical about in examining the sum total of available evidence.

MRS. BOWERS: We'd like to take a brief recess.

MR. NORTON: Okay. Thank you.

(Brief recess.)

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MRS. BOWERS: Would you like to proceed, Mr. Norton?

MR. NORTON: Yes.

During the break we discovered that one of the slides that was shown was not in the prepared testimony. It was the slide that Dr. Jahns referred to as the cartoon from Gualala Basin to Eagle Rest Peak. Because it was not in the prepared testimony I suspect that if Mr. Fleischaker wanted to have it stricken he could do so now. And I could argue about that.

If not, I could simply have it maked as Applicant's Exhibit 8. We have other slides in there that generally show the same thing. I think Dr. Jahns had a world of slides to draw from, and he thought this one was in the testimony and it wasn't.

MRS. BOWERS: Mr. Fleischaker?

MR. FLEISCHAKER: I have no objection. I might have some questions about it, but I don't have any objection.

MR. NORTON: Then we would ask that it be marked as Exhibit 8 for the record.

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

BY MR.NORTON:

Q Now, Dr. Jahns, you've given a background summary

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for your testimony here orally today. You did not, however, in that oral presentation invite the attention of the Board to the conclusions that you may have drawn about the Hosgri FAult.

Let me first ask you if you have drawn conclusions from your work regarding the Hosgri FAult.

A (Witness Jahns) Yes, we have.

Q All right.

Could you tell us, Dr. Jahns, what conclusions you have drawn?

A First, the Hosgri Fault, in terms of the criteria that most geologists would use in defining a fault, is about 145 kilometers long. It legitimately could be regarded as part of a San Gregoria-Hosgri-San Simeon perhaps fault system, to be consonant with the normal terminology in geology, rather than a part of a Hosgri-San Gregorio Fault or FAult Zone.

This leads to a second conclusion, that the Hosgri and the San Simeon Faults are not connected, certainly not at any present levels of exposure on the sea floor.

We further have concluded that the Hosgri dies out in both directions by various mechanisms involving in general a splaying or a transition into fold structures. The details of the dying out at the southerly end are very difficult to determine and doubtless are complex because that area lies in the crucial part of the transition zone

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between the caost ranges and the transverse ranges of the provinces.

So far as displacement is concerned, it is our judgment that there are several kinds of constraints that make it difficult, if not impossible, to apply the interesting Grant-Dickinson model to cumulative offset along the San Gregoria-Hosgri trend.

More a propos in terms of more recent movements, we regard the Hosgri in the strict sense as a capable fault along which there have been relatively minor movements in Late Pleistocene and Post-Pleistocene or Holocene time.

Finally we regard, in terms of the tectonic framework as outlined in some detail in my oral testimony, it to be such that the Hosgri line directly north of the transition zone between transverse ranges and coast ranges structure along which major, and possibly great earthquakes can occur.

In other words, we draw a contrast, on the basis of tectonic setting, in earthquake capabilities between those two regions.

Q Dr. Jahns, you've used a few terms that I would like to ask you to define for the Board's benefit if possible. Perhaps they may understand some or all of them.

You distinguished between "fault," "fault zone," and "fault system." You've used those three terms. Can you distinguish those terms at this point in time?

A Yes, I can have a try at it, I'll put it that way, because there's a great deal of overlap among geologists in use of the terms "fault" and "fault zone."

In the strictest possible sense, a fault is a single break, knife-edge in sharpness, along which there has been differential movement. There are very few such breaks, certainly almost none among those that represent large displacements. So that it's only normal to characterize most of the kinds of faults we talk about in situations like this really as fault zones, because they represent branching and joining breaks commonly occupying zones, feet, ten's of feet, hundred's of feet, or even large fractions of a mile wide.

Nonetheless, in common usage one finds in the published record a flip-flop back and forth between the term "fault zone" and "fault."

Fortunately there has been no such smearing of usage between the terms "fault zone" and "fault system." I say fortunately because the term "fault system" is very useful. It is generally applied to a series of faults, ordinary large ones that would seem, in terms of their past geologic behavior, to represent a stress-strain system that makes them, genetically and behaviorally, closely related.

And perhaps I can best convey this notion by means of some examples.

South of the transverse ranges the San Andreas

Fault Zone, because it is a fault zone, splays but it doesn't splay in any minor way. It spays into other major faults, most notably into what is called the San Andreas in those southerly latitudes in a strict sense, and what is called the San Jacinto.

The San Jacinto and adjacent parts of the San Andreas are normally regarded as units in the San Andreas system.

So that's the kind of distinction that's involved.

Q Dr. Jahns, will you then describe once again what the Hosgri-- Will you now define the Hosgri in terms of fault, fault zone, and fault system, if you could?

A I would call the Hosgri a fault or a fault zone. I would also feel comfortable in referring to it as part of a fault system.

Q All right.

And part of what fault system?

A It would be a well-defined unit in what we might call a Hosgri-San Simeon-San Gregorio fault system.

Q Okay.

And that would be along the coastal range of California, part of that system?

A Yes.

Q Now that is not to say, however, that they are in any way connected. Is that correct?

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A That's right. And I would go a step farther and point out that this nomenclature specifically reflects a fundamental difference between the Hosgri as part of that system and the San Andreas. We regard the Hosgri as a second-order feature or possibly a big third-order feature. And the system it represents had no more than a second-order feature during, let's say, the past five million years.

Q All right.

Now you did I believe in your oral summary refer to the San Andreas and the other fault that you said where the Big Bend occurred in 1857, I believe, were first-order faults or fault systems, and now you have just described the Hosgri as a second-order or possibly a high third-order fault and as part of the second-order fault system.

Could you tell the Board what you mean by first order and second order and third order, what that terminology means?

A First order, almost by definition, would be the biggest and the most profound, the most influential, the most significant of all the fault features, and certainly on this continent, the San Andreas fills that bill. And one might include as first-order features certain other parts of the San Andreas system, most notably in the geologic present the San Jacinto Fault in southern California. That's probably California's most active major fault today.

eb7

But in over-all terms, those are first-order features by almost any standard of comparison: length, behavior, and accumulated offset during relatively recent geologic time. And again we can make that the past five million years for purposes of comparison.

By any other parameters we might normally apply to faults, the Hosgri isn't even nearly in the class of a San Andreas, and for this reason it is not first order but is second order or lesser. And there is some ambiguity there because we don't know, frankly, as much about the Hosgri as we'd like to know, even though we do know a great deal about it. It's not as much as we know, for example, about the San Andreas.

Q But I take it then that you do know enough about it to state, with a reasonable degree of geological certainty, the conclusions you've stated here today?

A Yes, indeed.

MR. FLEISCHAKER: Objection. I have an objection to that question. The objection to that question is that it's ambiguous. The phrase, "reasonable degree of geologic certainty," hasn't been defined.

MR. NORTON: I'm sorry, what doesn't Mr. Fleischaker understand, "reasonable," "geologic," or "certainty"?

MR. FLEISCHAKER: I understand if you ask Dr. Jahns whether he is reasonably certain about something,

eb8

but I guess from your formulation that you're trying to posit some sort of test that has legal significance. It seems to me that the question is improper.

If the question to Dr. Jahns is "Is he reasonably certain?" I have no objection to that question. If the question is something about "Can you determine whether to a reasonable degree of geologic certainty," I object. It's ambiguous.

MR. NORTON: Well, Mrs. Bowers, I don't think the term is ambiguous. Dr. Jahns answered the question and I assume he knows what it meant. If he didn't understand my question I would assume he would tell me so. I don't understand the nature of the objection. To me, "a reasonable degree of geologic certainty" is not ambiguous. I don't know how to respond to the objection because those words are just common words in the English language.

MR. FLEISCHAKER: Well, let me see if I can explain a little bit more. We've been round and round on this in the depositions, and during the course ofthe depositions I objected to Mr. Norton utilizing that as any kind of test, and indeed, in one deposition he asked one of my witnesses that question, and he said, "I'm not quite sure what you mean. I can respond personally whether I have reasonable certainty."

In explaining that test, Mr. Norton often made

eb9

references to the tests that are used in medical malpractice cases. As the Board may well be aware, the formulation of those tests results from Court formulation which has developed over time, and the formulation has a special legal significance.

What I'm trying to avoid is getting into the record some sort of test, "reasonable degree of geologic certainty," which is essentially meaningless. It has no history of common law development. It has no history of administrative law development. The question is whether Dr. Jahns himself is reasonably certain. That question is an appropriate question. The other question is ambiguous and confusing, so I'm objecting on that basis, and would suggest that we avoid placing that kind of confusion in the record.

MRS. BOWERS: I thought Dr. Jahns was giving his personal opinion.

MR. NORTON: Mrs. Bowers, --

MR. FLEISCHAKER: I'm sure that's the case. It's the formulation of the question that I'm concerned about because it has come up before repeatedly in depositions, and I objected to it then and I'm going to object to it now so that we can avoid this confusion.

MRS. BOWERS: Well, let's ask Dr. Jahns what you meant by your answer.

MR. NORTON: May I interrupt a minute, Mrs. Bowers?

eb10

For one thing, there's a slight misstatement of the fact again by Mr. Fleischaker. It was discussed in depositions. However, in the first deposition of Dr. Silver it wasn't discussed and Dr. Silver had no problem understanding the question. There were no objections made and Dr. Silver -- And I can read, and I can read Mr. Fleischaker. There were no objections made. Dr. Silver understood. He answered the question.

It was only after several days when Mr. Fleischaker had several days to think about the next deposition that he suddenly decided to objection about that question, and his witness had no problem understanding it, until the next deposition with a different witness, and then suddenly there was a problem.

It's a very common question that is asked of expert witnesses in proceedings all the time, if they can state within a reasonable degree of,whatever field they are in, certainty.

Mr. Fleiscahker objects to it very strongly because of the answers of his witnesses to those questions, but to use that as a basis for objecting to those questions of my witness, to say that it's ambiguous. I just-- Those are just common English language words. And if Dr. Jahns can say he doesn't understand it, then the objection is well-taken.

eb11

MR. FLEISCHAKER: The point is that through the course of the deposition, a substantial disagreement developed concerning the use of that as some sort of legal test.

MR. NORTON: Not in Dr. Silver's.

MR. FLEISCHAKER: Dr. Silver and I discussed that after it was over, and I also discussed it-- I think if you'll read the whole deposition-- I don't recall, we may well have discussed it on the record. The point is it arose in all subsequent depositions.

The question as to whether or not the witness is reasonably certain is a fair question. It can be asked of this witness, any witness. I have no problems with that. The problem is in the formulation of a question so as to posit some sort of test that appears to have some legal significance. The test, "reasonable degree of geologic certainty," to what community, to whom? That test has never been defined, either in courts, in the geologic scientific literature, so I'm arguing that that essentially is a meaningless test, and it's an ambiguous question.

The question properly phrased should be "Dr. Jahns, are you reasonably certain?"

3d

MR. TOURTELLOTTE: Mrs. Bowers?

MRS. BOWERS: Mr. Tourtellotte.

MR. TOURTELLOTTE: Because of another aspect in this case I had occasion to read up on expertise and expert witnesses and expert testimony, and I have to say that there are any number of cases where "reasonable degree of blank certainty" has been used, and I think it is fairly clear from the cases involved that this is not only a reasonable question to ask but is a question which practically has to be asked of an expert in order to put any validity into the conclusions that are reached there.

With all due respect, I really believe that Mr. Fleischaker is objecting to it at this time-- He did not object to it at the time I wrote the deposition. And I think really he's objecting to it because Dr. Silver gave some very damaging answers to that question as posed in that manner, and it is likely to come up during Dr. Silver's testimony when he appears here. So there is really more at stake than whether or not this question can be asked of this person.

It has to do with the underlying questions that are to be asked throughout the course of this proceeding, and the question will be coming up again and again to establish whether indeed there is a reasonable basis for the opinions of the various experts that are to testify.

wbl

I see no real distinction between asking Dr.Jahns as a geologist "Do you have a reasonable degree of certainty in your opinion?" whatever that opinion is, and asking him the question "Do you have a reasonable degree of geologic certainty that the conclusion you reached is adequate?"

I don't think we need the interpretation of courts, because it has been asked over and over and over again with respect to various areas of expertise, not just the medical field but other fields as well.

MR. FLEISCHAKER: I'd like to respond to that, because I think Mr. Tourtellotte's comment injects a lot of confusion into the record.

First of all, putting aside the question as to whether or not Dr. Silver's answers were damaging or not; we'll let the Board judge as to that; the point is that if those same questions are asked to Dr. Silver and they are asked, "Do you have a reasonable degree of certainty?" I wouldn't have a problem with that. What I have a problem with is the appearance that there is some test that has been developed either in the geologic community or through common law and positing this as some test against which one measures one's opinion. That isn't the case here.

The kinds of cases that Mr. Tourtellotte is talking about concern tests that have been developed through the common law, through court interpretations, and are accepted by

wb2

lawyers and accepted by courts. In fact when instructions are given to a jury the test is defined specifically through a jury instruction. In this case that doesn't exist. We have a vague term "Do you find to a reasonable degree of geologic certainty?" --whatever that means; whatever that means to this body; whatever that means to that witness; whatever that means to Mr. Norton, to myself or to Mr. Tourtellotte. It's ambiguous.

The question: Does the witness? --are you reasonable certain? It's the form of the question. And what I'm asking for is a clear, straightforward question.

MR. TOURTELLOTTE: Mrs. Bowers, I think that there is a test that can be applied, and the test really amounts to this: As a scientist with a particular expertise, is there sufficient data in existence, and in his possession, which he has been able to interpret consistent with his science so that he can form a responsible -- so that the average person of similar experience and background could form a sound opinion? And that's what that all is about.

I believe that that is consistent with the general law that you would find if search into the cases on this general subject matter.

MR. NORTON: Excuse me, Mrs. Bowers, I would just like to make one last comment.

I don't think the term is ambiguous to me, I don't

wb3

think it's ambiguous to the witness. If it was he would say so. And it certainly doesn't appear to be ambiguous to Mr. Tourtellotte.

If it's ambiguous to Mr. Fleischaker, I don't know what to do about that. If it is ambiguous to the Board then I guess we have to pursue it further. But if it is as clear to the Board as it is to everyone other than Mr. Fleischaker than I just don't see why we're wasting all this time on it.

MRS. BOWERS: I think we've heard your position. We'll take a minute or two to confer.

(The Board conferring)

MRS. BOWERS: Dr. Martin has some questions of Dr. Jahns.

MR. NORTON: Regarding this question?

MRS. BOWERS: Yes.

DR. MARTIN: I think it's all right for me to disregard the legal implications of this. I'm speaking as one scientist to another.

Do you regard your conclusions as certain; that there is no question, no doubt in your mind that these are the only conclusions that could be drawn or that will ever be drawn about the questions that have been raised?

WITNESS JAHNS: There can be no guarantee of that, because we don't have enough data, we don't have complete exposure. There must remain, under the circumstances, a faint

wb4

possibility of a significantly different kind of interpretation. But I would rate that probability as extremely low, something on the order of the probability of a brand new fault appearing in a block of previously unbroken ground.

DR. MARTIN: All right. So you would be able to characterize the kind of evidence that might be produced by further study which would require you to change your conclusions?

WITNESS JAHNS: Yes, that's a possibility.

DR. MARTIN: And on the basis of your experience and general knowledge you can, at least to some degree, quantify the probability of such evidence arising?

WITNESS JAHNS: Yes, indeed. That's the basis for my assessment of probability associated with that possibility.

DR. MARTIN: All right. So your certainty is provisional; is that correct? I mean it is based upon your assessment of the currently available information?

WITNESS JAHNS: I think that's fair. It is semi-certainty.

DR. MARTIN: I guess what I'm really wondering, Dean Jahns, is whether it is reasonable to ask a scientist if he is certain and that his certainty is of such a degree that nothing would ever change his mind about it.

WITNESS JAHNS: In this response I'm not attempting

wb5

to be facetious. But that would depend on two different kinds of things. It would depend on how able and objective the individual happened to be, and it would also depend on the completeness of the data set.

DR. MARTIN: Well I think the second part was what I was really driving at, that there's always the possibility of an ugly fact appearing on the horizon to upset some beautiful theory or conclusion which, based on incomplete evidence or data, are there to be changed as a consequence of the information.

But you can state your degree of certainty based on what's currently known. And I believe you've done that.

I'm not trying to ask leading questions; I'm simply expressing my own opinion and asking whether we would agree in principle.

WITNESS JAHNS: I believe so.

Very few things in geology are locked up completely tight, simply because a complete, a truly complete set of data rarely is available. And the result then is, one takes the data and considers the constraints they impose and the directions they lead. And this is the principal reason why an experienced geologist looks for as wide a variety of data as possible, and attempts to examine many contrasting courses of reasoning to see if they all lead to the same place or if, at the least, they are all compatible with a given conclusion.

wb6

DR. MARTIN: All right.

Your little cartoon leaves, well, a residual of -- I have forgotten the numbers now, but perhaps 100 Km left as an enigma that hasn't been accounted for. Was that correct?

WITNESS JAHNS: Yes. If one accepts that particular explanation the enigma is considerably reduced.

DR. MARTIN: Following that line of reasoning you accounted for a certain fraction of the displacement, and some remains unaccounted-for.

WITNESS JAHNS: Quite so.

DR. MARTIN: All right.

Well I believe my questions and your answers establish that certainty is based on the convergence of evidence, and it's based on what is presently known, and that there is some possibility, which you can quantify subjectively at least, as to the likelihood of new evidence turning up that would change your conclusions.

WITNESS JAHNS: Yes.

DR. MARTIN: Thank you.

MR. NORTON: Mrs. Bowers, if I might take just a moment to address Dr. Martin's line of questioning: That is precisely why we used the term "reasonable degree" of awhatever the field is "certainty," as opposed to "Are you certain."

It seems to me that what the witness obviously has to do, and what Dr. Jahns had obviously done in his mind,

wb7

after hearing his answers to your questions, is, you know, something else is possible. And that's why we didn't ask him if he was certain, but how reasonable is that possibility. And I think he gave that as a very, very low probability, and that's why he can state it within a reasonable degree. And I think it was a very good illustration, that that's precisely what it means.

We can't ask questions in the scientific field "Are you absolutely certain?" It would seem to me we'd get very few positive answers, I assume, from a person who is being honest and using all the data. It would be almost just mutually exclusive to answer it Yes, totally 100 percent certain in every case. I mean, it just doesn't exist in these fields. And that's why we used the term "reasonable degree of certainty."

DR. MARTIN: Is that then your definition of what you mean by this terminology?

MR. NORTON: Yes, that's what "reasonable degree" means. It's much easier in the medical field, much more common in the medical field.

By way of example: A doctor who treats a patient from the time after an accident, it's now two years later, you're at trial. The question before the court and the jury is whether or not the injuries are related to the accident. And the question that the doctor must be able to answer is Yes, he can

wb8

state within a reasonable degree of medical probability that they are. If he can't say that, then they haven't met their burden of proof. And hebases that on all the evidence.

That's not to say that the lady couldn't have fallen off a chair a year after the accident and incurred that injury. But based on the data he has in front of him he can state with a reasonable degree that that's how the injury occurred.

You have to have some sort of a vehicle like that. Because, as you so aptly pointed out, Dr. Martin, there is no 100 percent certainty in fields like this. It's just impossible.

DR. MARTIN: I just want it clear on the record that there are general principles that would contribute to a definition of what this terminology means, but it has no precise definition.

We didn't get precise definitions of "fault zone" versus "fault system," but there's an understanding of what's meant by the two usages.

Okay.

MRS. BOWERS: Well, Mr. Fleischaker, your objection is overruled.

End 3E

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BY MR. NORTON:

Q Dr. Jahns, I made some notes of your conclusions and I didn't get this one very full.

You were discussing the capability of the Hosgri, you were talking about -- you mentioned late-Pleistocene and I think you said Holocene and I wasn't keeping up with you very well.

Again, for the benefit of myself and the Board, could you translate those to years, could you restate that conclusion -- if you recall the one I'm referring to -- and state it in terms of time, in terms of years, numbers?

A (Witness Jahns) All right. I'll transpose it.

There is enough evidence of late-Pleistocene and post-Pleistocene or Holocene movement along some reaches of the Hosgri Fault to lead to the conclusion that it is prudent to consider it as capable in the sense of future earthquakes.

Q Okay.

Now, what time frame has that movement taken place in? You used the term late-Pleistocene, post-Pleistocene and so on. Give us some numbers. Are we talking about five years ago or 10 hundred million eyears ago, what are we talking about in terms of numbers?

A All right. We'd better make it clear we're talking about Pleistocene rather than Pliocene. It's unfortunate

agb2

these two terms are so similar.

Q Pleistocene --

A -- but there is a significant age difference.

Late-Pleistocene in the usage of most geologists refers to about the last 500,000 years.

Q All right.

And how much movement -- or do you have an opinion as to how much movement has occurred along the Hosgri Fault in that time period, in the last 500,000 years?

A I have an opinion rather than a judgment, because the data are fairly well dispersed. And my opinion is that the amount of movement accumulated during the past 500,000 years is very small. It's movement measured in feet, rather than tens of feet or hundreds of feet.

Q All right.

And what do you base that opinion on?

A This is based principally on the off-shore records of geophysical traverses.

Q All right.

Would those be some of the records we see to Mr. Willingham's left?

A Yes, I'm afraid so.

Q All right.

Dr. Jahns, do you have a sense of movement on the Hosgri Fault, or the Hosgri Fault Zone, if you will, in

agb3

any other period of time, any longer period of time, say, in the last 22 million years or some other period, whatever period of time you wish to choose, but something longer, of course, than the 500,000 years?

A Yes. This returns us to some of the remarks I made earlier, the oral testimony.

If one looks at the entire possible history of the Hosgri, the available evidence permits but does not necessarily indicate or demand the possibility of major strike-slip movement. This is a possibility.

And much of what is embodied in the Graham-Dickenson article published in Science Magazine might be applied to such an early element of Hosgri history. And by early, I mean earlier than tens of millions of years ago.

Q You mean longer ago than --

A Longer ago than that.

Q And that would be a minimum of 20 million years ago?

A Something between 15 and 20, I would think. One would have to go well back into Miocene time, and that means probably 15 million or more years ago.

Q All right.

And what's the basis for this opinion, Dr. Jahns?

A The basis of this is the progressive removal as one moves back in time, in effect, of constraints on

agb4

movement.

In other words, if one moves back in time and peels away from the record successively older geologic units that it's possible to interpret a situation for, let's say, early-Miocene time in which the distribution of those units that we could see then would permit some large-scale displacements on the fault.

Q All right.

I take it then, Doctor, you're saying that in the last 500,000 years, we could have had no more than feet of movement. But that in a time period up to 15 or 20 million years ago, you could have had considerable movement along the fault.

What is the implication of that for this Board, for this hearing? That's just a couple of rates of movement in a couple of periods of time so far. What is the broad implication of that, if any?

A Well the chief implication would be if one were to accept a pre-middle-Miocene accumulated large-scale slip, that the Hosgri, as we know it, has had at least two chapters of highly contrasting history, in terms of its behavior.

And that's hardly a surprise, or would be hardly a surprise in view of what we know of the history of other faults, particularly some of the big ones that are on land and hence available for more detailed geological study.

agb5

The San Andreas is an excellent case in point, because its behavior during the last five million years has been, in many respects, markedly in contrast with the behavior before that time, both in terms of some of the courses that its followed geographically and in terms of its slip rates.

Q All right.

Does it lead you to any opinions as to the -- and perhaps I'm using the wrong word -- capability of the fault today, that being the Hosgri Fault, in terms of significant movement in today?

A Yes, it does.

The evidence as I have seen it and interpreted it strongly suggests to me first,the judgment that the Hosgri is capable is a highly conservative one, and second, that the geologically recent or young behavior of the Hosgri, coupled with its general position in the tectonic framework, is such that I would not attach to that fault a high capability for generating a large earthquake.

Q All right.

And would you define "large earthquake" in terms of something like magnitude that has some meaning?

A May I go in the side door on that one and put it this way: That to translate my previous statement, I would regard a magnitude 7.5 earthquake on the Hosgri Fault in the future, I would regard that judgment as an extremely

agb6

conservative one.

Q All right.

So then a 7.5 magnitude is a large earthquake?

A Yes, and according to some people's classification, a great one.

Q All right.

Would a 6.5 to a 7 be a large earthquake?

A Yes.

MR. NORTON: Mrs. Bowers, at this time, we'd like to have Dr. Jahns' and Mr. Hamilton's testimony placed in the record as though read.

But perhaps we ought to do Mr. Hamilton's professional qualifications first, and then as soon as they are in, then put it in as though read.

With the Board's permission, I'll ask Mr. Hamilton a couple of questions about his qualifications.

MRS. BOWERS: Fine.

BY MR. NORTON:

Q Mr. Hamilton, do you have a copy of your qualifications that have been submitted to the Board and the parties in this matter?

A (Witness Hamilton) Yes, I do.

Q All right. Is it a correct copy of your qualifications?

A I think I should mention that one sentence appears

agb7

to have been ommitted on Line 20 of the first page. I worked as an engineering geologist from 1961 through '69. And the following sentence reading:

"Geologic research regarding faulting and landslides in the central Andes of Chile." -- took place only in 1969, not for a period of eight years.

Q All right.

A It is otherwise correct.

Q Mr. Hamilton, before we ask that your professional qualifications be placed in the record immediately preceding the testimony, could you briefly describe to the Board first your related work experience in this field and, second, very briefly, the contribution you made to this effort? I'm not only talking about the written testimony as much as I am the work that led up to it.

A Yes, I can describe that briefly.

First, I worked as an engineering geologist since 1961, following my graduation from Stanford with a Batchelor's in 1956, and preceding getting the Master's from there in 1962.

During the period 1961 to about 1970, most of my work had to do with location of dams. And during the course of those studies, I examined both the local foundation conditions and also the regional faulting conditions that might lead to earthquakes affecting the required design of

agb8

dams, or the stability of existing dams.

This was done mostly in southern and central California. Also, however, I did work on dam projects in the Chilean Andes, as mentioned in this experience summary.

Since 1971, my work has chiefly been related to making geological studies for the safety evaluation for power plant sites. And the areas that these studies encompassed have extended from essentially the transverse ranges of Point Conception north to the Oregon border.

I worked on several different specific sites in that area during that time. The first one was a site near Point Arena, I worked a site near Collinsville on the Sacramento River, at sites in the Pigeon Point area on the Davenport coast north of Santa Cruz, at the Moss Landing site, and in particular, in the Diablo Canyon site.

I've been working on Diablo Canyon intermittently since about 1972, according to my present recollection, at least. And during that time I have performed a variety of kinds of work and investigations relating to the site, ranging from detailed mapping in the site foundation excavations through mapping along the sea cliffs north and south of the site, through looking at the regional fault and tectonic pattern and through working in particular with Mr. Willingham here in working out the offshore geology on both the distribution of rock units and faults that exist in the area under

agb9

the ocean adjacent to the coastline from more or less, oh, let's say, Humboldt Bay south to the transverse ranges, but concentrating particularly in the area from approximately San Simeon down to perhaps Point Arguelo.

MR. NORTON: At this time, Mrs. Bowers, we would then ask that the qualifications of Mr. Hamilton be placed in the record as though read, and that the testimony -- Excuse me.

BY MR. NORTON:

Q Mr. Hamilton, you don't have any more changes, to the testimony, I take it, that was sponsored by Mr. Jahns that you and he wrote?

A (Witness Hamilton) That's correct.

Q Okay.

MR. NORTON: We would ask now that those be placed in the record as though read, Mrs. Bowers.

MRS. BOWERS: I'm not sure I follow all of that. I was thinking about, perhaps, the initial part of it. The witnesses' qualifications was identified as Applicant's Exhibit Seven and it's in, so --

MR. NORTON: That's correct, Mrs. Bowers. And at the time we did that, perhaps I didn't make myself clear. That exhibit has the professional qualifications of everyone that we've listed as a witnesses in it. Many of those people may not be called, they are backup people on technical

agb10

things.

We would think that the reader of the record, should this matter ever be read later, would want to read the qualifications of the person whose testimony it is at that time rather than having to go to some volume five, ten volumes away and finding it and digging it out and reading it to know who it was that wrote this testimony.

So we are putting that exhibit in. And we do appreciate that in some small respects it's a duplication, that the qualifications, a couple of pages or so -- of Mr. Hamilton, for example -- will appear twice in the record. But that will just be attached as an exhibit.

MRS. BOWERS: Well, did I jump the gun in admitting Exhibit Seven into evidence without you formally offering it?

MR. NORTON: No, I believe we had all stipulated to it going in and you did admit it, yes.

MRS. BOWERS: All right.

MR. NORTON: Then do we have your permission to have them placed in the record as though read?

MRS. BOWERS: Yes.

(The documents follow:)

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket Nos. 50-275
	)	50-323
PACIFIC GAS AND ELECTRIC COMPANY	)	
	)	Applicants Ex. No. 7
(Diablo Canyon Nuclear Power Plant, Units No. 1 and 2)	)	December 1978

PROFESSIONAL QUALIFICATIONS
OF WITNESSES FOR
PACIFIC GAS AND ELECTRIC COMPANY

Name: Richard H. Jahns

Title or Position: Consultant (Prof. of Geology and Dean, School of Earth Sciences, Stanford University)

Degrees: B.S. California Institute of Technology, 1935; M.S. Northwestern University, 1937; Ph.D. 1943. All degrees in Geology.

Professional Experience: Experience in petrology, mineralogy, and economic, engineering, glacial, and structural geology during past 42 years of work with U.S. Geological Survey and at Caltech, Penn State, and Stanford. Much of this experience was in California, including several parts of the coastal region. Publications comprise several monographs and more than 100 scientific papers. Edited and contributed

to "Geology of Southern California," published in 1954 as Bulletin 170 of California Division of Mines.

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	)	December 1978

PROFESSIONAL QUALIFICATIONS
OF WITNESSES FOR
PACIFIC GAS AND ELECTRIC COMPANY

Name: Douglas H. Hamilton

Title or Position: Engineering geologist; Vice President and Principal Geologist, Earth Sciences Associates, Inc.

Degrees: 1956 B.S., Stanford University;
1962 M.S., Stanford University.

Professional Experience: 1956 Geologist, Utah Construction Company; 1957-60 Air Intelligence Office, U.S. Navy; 1960 Geologist, Phillips Petroleum Corporation; 1961-69 Geologic research regarding faulting and landslides in the Central Andes of Chile; 1969-78 Engineering Geologist, Earth Sciences Associates, Inc. Geologist for engineering projects, especially siting studies and geologic hazard assessments for power plants along the California coast. Work has included a siting study for the California coastal

region between Point Conception and the Oregon border, and local and regional studies for sites at Diablo Canyon, Moss Landing, Davenport, Collinsville, Point Arena, and Humboldt Bay.

cont'd

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MR. NORTON: Now I'm going to have the qualifications of Mr. Willingham placed in the record and then I'll be done.

BY MR. NORTON:

Q Mr. Willingham, do you have a copy of your qualification in front of you?

A (Witness Willingham) Yes, I do.

Q Do you have any corrections to be made to those?

A Only one minor one.

Line 15, it states "1968: M.S.," it should be "M.A."

Q And Mr. Willingham, Mr. Hamilton briefly described some of your activities in connection with this project. Would you care to add to that along with a little bit of your background, and I'm not interested in any detailed thing but just what area did you work in, so that Mr. Fleischaker will know what questions to direct to you.

A All right.

First, with regard to background, I have been employed since 1966 in various professional endeavors as an applied geophysicist, including a good deal of petroleum exploration work and engineering geophysics involving both seismic and gravity and magnetic studies.

My participation in the Diablo Canyon project has been primarily in the interpretation and discussion with

agb 2

Mr. Hamilton in development of the tectonic framework of the offshore regions, as well as interpretation of gravity data and magnetic data associated with the project. In short, I've been involved as the primary consultant in the geophysical aspects, the applied geophysical aspects.

Q All right.

And Mr. Willingham, Mr. Fleischaker had asked me to bring -- and I wasn't clear what he -- I didn't remember what he asked me on Saturday do have you and Mr. Hamilton bring -- but as I understand it, it's basically the offshore data records.

And were you able to bring -- could you tell us what portion you were able to bring of those records?

A All right.

In response to your request of this morning to try to get them together, we hastily arranged to have what records we could immediately lay our hands on deliveered, and I would guess that we have roughly 80 to 90 percent of all those used. And from what I understand Mr. Fleischaker was interested in, I believe we have all the ones he specifically mentioned.

Q The specific ones he was interested in.

Now are you telling us that those three or four boxes full of records and so on, that's approximately 80 to 95 percent of the offshore records used in the analysis of the

agb3

Hosgri in this matter?

A Yes.

Q All right.

MR. NORTON: That's all I have on direct.

MR. FLEISCHAKER: In order to preserve my legal position, I'm going to request that all of Mr. Willingham's testimony be struck from the record. I asked him no questions, he did not prefile direct testimony and, for that reason, I think that his testimony is a violation of the Commission's rules of procedure and I'm going to request the Board to strike his testimony.

MR. NORTON: Mrs. Bowers, I have no objection really to it being stricken. I was simply -- I was hoping I was assisting Mr. Fleischaker, who had asked me to bring these records so that Mr. Willingham could identify for Mr. Fleischaker's benefit what records he had brought.

I don't care if it's struck or not. It was for Mr. Fleischaker's benefit, not for the record.

MR. FLEISCHAKER: Well I appreciate that. However, it would have been possible to tell me that at the break or at any other time.

I have a legal objection and I've made that objection now. And I think that in order to preserve that position, I have to at this time request that Mr. Willingham's testimony be stricken from the record.

agb4

MR. NORTON: Excuse me, does that include his qualifications, Mr. Fleischaker, which you've had in your hands for months, which you've already stipulated into evidence?

MR. FLEISCHAKER: I understand that. The qualifications, I don't think are troublesome to me. Put them in the record, that's fine with me, it's the testimony.

MR. NORTON: I assume he's referring to the response to my questions about the records that were brought, that's the only testimony he gave. He answered yes, that's about 80 to 90 percent of them, I believe.

MRS. BOWERS: Was that what you were referring to, Mr. Fleischaker?

MR. FLEISCHAKER: Any statements on the record made by Mr. Willingham is what I'm referring to.

MR. TOURTELLOTTE: Mrs. Bowers, I'm not certain what's going on here, but it seems to me that what Mr. Fleischaker is saying is that he's going to object to any participation by Mr. Willingham by reason of the same objection that he made earlier on in the proceeding, which the Board has already ruled on.

And if that's the case, then I think it is fairly easy for the Board to continue to rule. And if he is attempting to preserve that, then I think it will be helpful if we all knew that so we could proceed in a more expeditious way.

agb5

MR. NORTON: Look, I would just as soon have that testimony withdrawn. If Mr. Fleischaker wants to consider that direct testimony, fine, on rebuttal we'll give Mr. Fleischaker a lot of direct testimony from Mr. Willingham and I guess we don't have to use the two or three little questions at this time. We're just wasting time. I withdraw it.

MR. FLEISCHAKER: I just want to preserve my legal position so that at some point down the way I don't find myself facing the argument, well, you let all this in, you didn't raise any objection at that time.

I have a continuing objection to testimony by people who have not filed prefiled written direct testimony. And if we can reach some agreement now that that is a standing objection, and if the Board wants to overrule that standing objection then that might be procedurally the neatest way to do it. If the Board wants to sustain that objection, fine.

MRS. BOWERS: Well I thought we ruled on it earlier when we were discussing it. But if you feel you have to bring it up every time, then there will be a continuing ruling that the objection is overruled.

MR. FLEISCHAKER: Okay, that's fine with me, just so there's a clear understanding in the record that I have a continuing objection to testimony for witnesses who

agb6

have not prefiled written direct.

MR. TOURTELLOTTE: In all respect, and just hopefully to conclude this forever or at least in the short run, the rules in 1.743(d), I believe, provide for the fact that once an objection is made and the ruling is made that the exception is preserved thereafter for the record. So that it seems to be that an objection has been properly made once, it's been made again, and the exceptions are there... I don't really see any need for the matter to be coming up over and over again as a formality.

MRS. BOWERS: We'll let's proceed.

end#f

WRB/mpbl
4a cl

MR. NORTON: We are done with direct.

MRS. BOWERS: Mr. Fleischaker?

CROSS-EXAMINATION

BY MR. FLEISCHAKER:

Q Dr. Jahns, I just have a few preliminary questions to try to identify or correlate some of the figures that were on the map with the figures that are in the testimony themselves.

We were able to locate most of them, but there were a couple that we were not.

This, I think, was -- do you have a figure number for this one here? This was the cartoon of the San Andreas Fault with the San Gregorio coming down. Do you know whether this was Figure 4, 5, or 6?

MR. NORTON: Mr. Fleischaker, we just admitted that into evidence as Exhibit 8.

MR. FLEISCHAKER: I understand that, Mr. Norton. But I have a question --

MR. NORTON: Because it isn't in his testimony.

MR. FLEISCHAKER: I understand that. I have questions about -- let me see if I can clarify this so you can stop.

BY MR. FLEISCHAKER:

We were unable to locate Figures 4, 5, and 6, which were shown on the screen in your testimony, and it was

mpb2

unclear to me, Dr. Jahns, which this was. And if you could identify this cartoon as Figure 4, 5, or 6, then we can go to the other two, and perhaps you can help us locate those in your testimony.

A (Witness Jahns) The cartoon doesn't appear as such in the written testimony.

Q I'm sorry.

Is this slide 4, 5, or 6? Do you know what number this was given?

The problem I'm having is we were unable to locate three of the slides --

A I understand.

Q -- as figures in the testimony, and the slides we were unable to locate were slide four, slide five, and slide six. And I was wondering if you could assist me in that.

A I understand.

You're numbering the slides in the order in which they were presented, is that correct?

Q That's correct.

A I understand.

I'm afraid I can't call that out from memory because they weren't numbered that way. I'd have to compare them with the illustrations in the testimony.

(Slide.)

mpb3

Now if we can hold that on there I think I can find it. That's Figure 6 of the written testimony.

(Slide.)

And that's Figure 20 of the written testimony.

(Slide.)

That's Figure 29 in the written testimony.

MRS. BOWERS: Mr. Fleischaker, while we have this interruption:

You talked in terms of having this volume one of the testimony physically inserted in the transcript as if read, is that correct?

MR. NORTON: It was just the testimony of Dr. Jahns, yes.

MRS. BOWERS: So you haven't done anything with this yet?

(Indicating.)

Is that correct?

MR. NORTON: It's been passed on to Mr. Bloom, 20 copies of it, to be physically inserted in the record, yes.

MRS. BOWERS: I don't think that I ever accepted it.

MR. NORTON: I think you did, but I'm not sure. I'm not positive either, but I assume you are now doing so.

MRS. BOWERS: It will be physically inserted into the transcript as if read.

mpb4

MR. NORTON: Thank you.

MR. FLEISCHAKER: Let me see if I understand the exchange.

This is just Dr. Jahns' and Dr. Hamilton's testimony?

MR. NORTON: That's correct.

MR. TOURTELLOTTE: Excuse me.

I'm not certain, but I don't ever recall it being offered up for evidence or anybody being asked if they had any objections as to whether it was introduced in the record or not. And I certainly know that I haven't been asked at all if I have any objections, not that I have any, but I would like to be asked.

(Laughter.)

MRS. BOWERS: Well, it sort of got caught in the middle of another sentence somehow, and let me check with Mr. Fleischaker.

Do you have any objection to the testimony which has been identified of Hamilton, Jahns -- and what's the third one?

MR. NORTON: Just Dr. Jahns and Douglas Hamilton.

MRS. BOWERS: Do you have any objection to it being physically inserted in the transcript as if read?

MR. FLEISCHAKER: No, ma'am, I have no objection to that subject, with later motions to strike if appropriate.

mpb5

MRS. BOWERS: Mr. Tourtellotte?

MR. TOURTELLOTTE: No objection.

MRS. BOWERS: Well, I knew the ball got dropped in this thing somehow.

So, anyway, what you have identified as the testimony of the two witnesses, Hamilton and Jahns, will be physically inserted in the transcript as if read.

MR. NORTON: I hope it doesn't get in there twice.

(The Testimony of Douglas Hamilton and Dr. Jahns follows:)

TESTIMONY OF
DOUGLAS H. HAMILTON
AND
RICHARD H. JAHNS
ON BEHALF OF
PACIFIC GAS AND ELECTRIC COMPANY
DECEMBER 4, 1978
DOCKET NOS. 50-275, 50-323

GEOLOGIC AND SEISMOLOGIC SETTING OF THE DIABLO CANYON POWER PLANT

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- B. Regional geology
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D. Geology of the Hosgri zone north of Cambria; relationship to the San Simeon fault

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G. Evidence relating to late Pleistocene and Holocene displacements

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I

OVERVIEW OF GEOLOGY AND SEISMOLOGY

A. Introduction To The Coastal Region Of Central California; Location Of The Diablo Canyon Site.

The Diablo Canyon site is located along the southwest-facing coast of the mountainous peninsula that lies between San Luis Obispo Bay and Estero Bay, in south-central California (Figure 1). More specifically, it occupies part of a narrow coastal terrace that fringes the seaward margin of the San Luis Range, which forms the backbone of this peninsula. The terrace at the site is underlain by sedimentary rocks, chiefly sandstone and siltstone, of the middle Miocene Obispo Formation (approximately 16 million years old). Prior to project construction, these rocks of the terrace bench were overlain by an unfaulted sequence of sand, clavey sand, gravel, and rubble, all of Pleistocene age.

The San Luis Range lies within the Southern Coast Ranges structural province of California. This extensive province, with characteristic geologic features and a northwest-southeast structural grain, can be taken to include both the Coast Range mountains west of the San Andreas fault, and the adjacent offshore region extending southwestward to the edge of the continental slope. The Southern Coast Ranges province extends northward to Monterey Bay and southward to a zone of structural transition into the bordering

western part of the Transverse Ranges structural and geomorphic province (Figures 2, 3).

Most of the major fault and fold features that define the structural grain of the Southern Coast Ranges are aligned northwest-southwest, essentially parallel with the nearest reach of the San Andreas fault. Toward the southerly end of the province, this grain bends markedly to an east-southeasterly orientation in a zone of transition with the east-west aligned Western Transverse Ranges farther south. The San Luis Range lies north of the transition zone, but is in a part of the Coast Ranges province where some faults and folds trend northwest and others trend west-northwest.

The coast line of the Southern Coast Ranges province corresponds approximately to a structural zone of flexuring, referred to here as the Coastal Boundary zone, that forms a broad border between the generally uplifted onshore region and the downwarped offshore region. The southerly part of this zone includes the Hosgri fault, which is the nearest capable fault to the Diablo Canyon site.

During the approximately 200 years of historic record, the interior of the Southern Coast Ranges province has exhibited a moderate level of seismic activity, with scattered earthquakes ranging up to a maximum of magnitude 6. In geologic terms the period of historical record is brief, but evidence that late Quaternary surface displacements along major faults in the province have been minor or non-

existent indicates that this pattern of small to moderate earthquakes has characterized most of the province during the past 100,000 years or more. This contrasts sharply with the geologic and historic evidence of recurrent major or great earthquakes along the San Andreas fault.

B. Regional Geology

1. Regional Features

a. The San Andreas Fault

i. General Features

The principal structural feature in California is the San Andreas fault. This is a great break of regional extent that forms a near-vertical boundary between the coastal margin of the State and the main continental mass of North America. As such, it is a first-order fault -- a "master feature" both in terms of regional structure and in terms of global plate tectonics.

The San Andreas fault is a continuous, through-going break that extends over a distance of about 1200 km (800 miles), from points offshore from Cape Mendocino on the north of the Gulf of California to the south (Figures 2, 3, 4). Throughout its length, the San Andreas is characterized by right-lateral strike-slip relative motion -- that is, displacement along it is predominantly horizontal, and the ground on the west side moves northward relative to that on the east side. Contemporary geodetic data show that this northward movement of the ground west of the San Andreas

fault is occurring fairly steadily, thus building up strain across the fault. Along most of the length of the fault the strain accumulates over intervals of time, ranging from tens of years to several centuries, before reaching a level that exceeds the strength of the material in the fault zone. The fault-zone material then fails by shearing, and the crustal blocks on opposite sides of the fault move right-laterally relative to each other. In the northerly and south-central reaches of the San Andreas, such displacement episodes occur infrequently, at intervals of many decades to a few centuries, but with displacements of 10 to 30 feet and accompanying earthquakes of very large magnitude -- in the 7 to 8-plus range. In the reaches opposite the Monterey Bay region and south of the Transverse Ranges, episodes of slip are more frequent and the accumulating strain is released more evenly and in smaller increments. Earthquakes in these regions of the San Andreas fault occur at intervals of years to tens of years, and over a wide range of magnitudes, up to about 7.5. These relatively high rates of slip give rise to distinctive fault-line topography along the trace of the San Andreas, as shown in Figure 5.

Most of the central part of the San Andreas fault has long followed the same trace it now occupies. For more than twenty million years, the only major change involving the abandoning of one course for a new one is in the area where the fault crosses the east-west structural grain of

the Transverse Ranges. There, beginning about 5 million years ago, it formed a great bend and deflected toward the east-southwest, leaving an inactive former trace known as the San Gabriel fault.

Major branches splay from the San Andreas fault in two general areas, one near the San Francisco Bay region in central California, and the other near the San Bernardino Valley in southern California. Part of the cumulative offset and part of the contemporary strain relief along the San Andreas fault system is accommodated on these faults, although the major displacements are confined to the main trace. The principal branch faults in central California are the Calaveras and Hayward faults, east of San Francisco Bay, and the San Gregorio fault along the coast west of the Bay.

Matching and restoration of distinctive rock units and other geologic features that once were continuous but are now located at widely separated points across the San Andreas fault shows that the cumulative slip along this break over the past 22 million years amounts to about 300 km (190 miles). Older rock units in northern California appear to have been displaced by even greater amounts, and the total right slip since the time of formation of one of the offset units (about 100 million years ago) is about 550 km (330 miles). Reconstruction of the environment of deposition of a sedimentary formation located along the west

side of the San Andreas fault near Point Arena, in northern California, has led to the view that this formation accumulated in a fault-controlled trough along the line of the present San Andreas. An age on the order of 100 million years for this part of the San Andreas system is thus suggested.

ii. The San Andreas Fault As A Plate Boundary

Studies based on the relatively recent concepts of global plate tectonics have shown that for many millions of years the boundary between the oceanic crustal plate of the eastern Pacific Ocean and the continental crustal plate of North America was characterized by relative underthrusting of the North American plate by the Pacific plate. Relative motion at the plate boundary was therefore represented mainly by large-scale thrust faulting at depth, such as that occurring along some other plate boundaries of the world at the present time. Underthrusting of the west coast of South America by the adjacent oceanic plate is a contemporary example. About 29 million years ago in California, however, the progressively changing geometry of the plate boundaries reached a configuration such that the underthrusting boundary movement ceased and was replaced by strike-slip (horizontal sliding) movement between the plates. By approximately 22 million years ago the horizontal shearing

between the Pacific and North American plates had become concentrated on the San Andreas fault (Figure 4). This is shown by the evidence of distinctive volcanic and other rock units that were originally deposited across the fault and then offset to locations that are now distant from each other but still close to the trace of the fault (Figure 6).

It is possible that the strike-slip plate-boundary shearing developed preferentially along a preexisting major fault, as there is evidence of an earlier period of large-scale offset along the San Andreas fault north of the Transverse Ranges (Figure 6). But no evidence of a corresponding earlier period of fault offset along the San Andreas south of the Transverse Ranges has yet been well identified. This has been cited in support of some arguments to the effect that offset along the other faults along the coastline in northern California may account for much of the apparent "excess" of offset on the San Andreas north of the Transverse Ranges.

Whatever the history of movement along either the San Andreas fault or some ancient precursor prior to 22 million years ago, the evidence is clear that the San Andreas has been the dominant locus of shear resulting from differential movement between the Pacific and North American crustal plates during the past 22 million years. It is the only geologic feature that can be traced without interruption from northern to southern California, the only

great structure that shows consistent geologic and geodetic evidence of continuing strain accumulation throughout its length, and the only regional fault the ends of which are marked by divergent plate boundary features (the spreading ridges centers in the Gulf of California on the south; the Mendocino triple junction on the north) that can generate and accommodate the large amounts of offset recorded along its central reach (Figure 5).

Evidence that the San Andreas fault is a master break representing the boundary between the Pacific and North American crustal plates does not mean that no other deformation is associated with the right lateral shear concentrated along the San Andreas. Indeed, it is generally agreed that much of the deformation resulting from regional north-south compression in both the Coast Ranges and in the Transverse Ranges is an element of the San Andreas stress-strain system. Deformation in these regions, which includes both folding and several styles of faulting, is nonetheless subsidiary, in terms of cumulative fault slip and crustal shortening, to the deformation concentrated along the San Andreas. In the vicinity of the Transverse Ranges and the "big bend" reach of the San Andreas fault, the deformation is apparently influenced and accentuated by an interfering stress-strain system associated with east-west extension in the plate north of the Garlock fault and east of the San Andreas fault. This has given rise to the existence of a

special domain of east-west oriented left-lateral shear and related elements of deformation that are unique to the boundary region between the Transverse Ranges and Coast Ranges provinces. This is discussed further in the following section on structural provinces, and is illustrated on Figure 8.

iii. Summary History Of Offset Along The San Andreas Fault Since Mesozoic Time

The major elements of geologic evidence for the history of offset along the San Andreas fault are shown on the accompanying map, Figure 6. Probably the least equivocal evidence for large offset is the correlation of the Pinnacles volcanics, on the west side of the fault in central California, with the Neenach volcanics, on its east side near the Transverse Ranges. These petrologically distinctive rocks, which have been shown by radiometric dating to be of the same age, probably were of limited original areal extent. They are now located about 300 km (190 miles) apart, thus demonstrating that that much slip has occurred along the San Andreas in the last 23.5 million years. Sedimentary rocks of about the same age in southern California are displaced across the fault by about the same distance.

In both northern and southern California, several other correlated pairs of rock units of successively younger ages have been shown to be offset by progressively smaller

amounts. The rate of slip has not been uniform through geologic time, however, but rather is characterized by a long episode of little or no movement, between 24 and 60 million years ago, and then by relatively rapid movement during the last 12 million years. Most critical, for considerations of present seismicity, is the slip behavior of the San Andreas and other faults during the past 5 million years or so. This most recent period of geologic time has been characterized by rather uniform (and rapid) plate-boundary movements and rather uniform plate geometry. Most of the movement between the Pacific and North American plates has been concentrated by slip directly along the San Andreas during this time. It has, in consequence, been the main locus of strain release and earthquake generation during latest Tertiary and Quaternary time (Figure 7).

The earlier history of the San Andreas fault is less clear. Two sets of geologic features are recognized that seem to have been displaced, from south-central to northern California, over distances on the order of 500-550 km (300+ miles). One of these features is the southwest margin of the Sierra Nevada batholith of granitic rocks, which appears to be displaced from points near Bakersfield to a position somewhere north of Bodega Head, a distance of about 500 km. The other feature is a sedimentary formation, between Fort Ross and Point Arena, that contains rocks of unusual petrologic character.

Materials in these rocks are thought to have been eroded from a bedrock source now located at Eagle Rest Peak, some 550 km to the south.

The evidence for 500 to 500 km of total slip along the northerly part of the San Andreas fault since early Tertiary time, however, contrasts with evidence in southern California that distinctive Mesozoic or older crystalline basement rocks are not displaced any more than overlying sedimentary rocks of late Miocene (5 to 13 million years) age. While theories abound, no satisfactory resolution of this apparent contradiction has yet been suggested and documented.

b. <u>Structural Provinces</u>

i. <u>Regional Tectonic Pattern</u>

The regional pattern of faults in the part of California extending westward from the Death Valley trend to the continental margin between the latitudes of Monterey Bay and Los Angeles is shown in Figure 8. The dominant element of this pattern is the San Andreas fault, a continental-scale break that is a transform suture between the North American crustal plate on the northeast and the Pacific crustal plate on the southwest. Extending northeastward from the San Andreas in the "Big Bend" area is the Garlock fault, a major discontinuity between the Sierra Nevada and Basin and Range provinces on the north and the Mojave Desert province on the south. The Big Pine fault and its westward projection mark

a transitional boundary in that part of the region southwest of the San Andreas, between the Coast Ranges province on the north and the Transverse Ranges province on the south.

Faults with northwesterly trend, similar to that of the San Andreas, are dominant in the Coast Ranges and Mojave Desert provinces. Most are steeply dipping features, but numerous low-angle thrust faults are known in the southern-most part of the Coast Ranges. The principal faults in the Basin and Range province trend north to north-northwest, and in general more northerly than the San Andreas fault and the faults in the Mojave Desert. The Transverse Ranges province, in contrast, is characterized by faults with east-west trend. Many of them are thrusts with low to moderate dips.

The pattern of major faults is complex, and its totally complete history of development remains to be deciphered. Nonetheless, much is now known about this history, and certainly enough to reveal the principal aspects of regional tectonic behavior through middle and late Cenozoic time. Three important generalizations can be noted here for the past 25 million years of regional history:

1. Fault behavior in the region evidently has been associated with sea floor tectonics in the adjacent East Pacific domain, but in ways not yet completely understood.

2. Transverse Ranges structure has played an important role during much of the reference period, at times

an active one and at times a more passive one, but the San Andreas fault has been a dominating influence, expecially during later parts of the period.

3. Tectonic evolution in the region has not been uniform through time.

The last generalization is of special importance in the context of evaluating present and future fault behavior. Many of the faults shown in Figure 1 have moved in different senses at different times, and most of them, including the San Andreas, have not moved at grossly uniform rates throughout their respective histories. For example, many faults in the ground away from the San Andreas, including several that formerly represented major zones of dislocation (e.g., parts of the Sur-Nacimiento, Rinconada, and San Simeon faults in the Southern Coast Ranges), are now, in effect, relic or "fossil" parts of an older structural system. Thus translation of total slip into an appraisal of present capability for any of them can be misleading or seriously in error unless the pertinent variations in time-history are factored into the analysis.

For present purposes, it is appropriate to focus upon fault behavior through the most recent 4-1/2 million years of geologic time. This is a period during which the Gulf of California has been opening under fairly uniform conditions of seafloor spreading along the East Pacific rise, the San Andreas fault has been extremely active, and

present elements of regional tectonic behavior have been established. It corresponds to late Pliocene + Pleistocene + Holocene time. In later parts of this discussion, the focus is more specifically directed to tectonic behavior in the Southern Coast Ranges and Western Transverse Ranges provinces during late Quaternary time, i.e., during latest Pleistocene + Holocene time.

Some 4 or 5 million years ago, the San Andreas fault, with dominant rightslip, appears to have abandoned a straight trend that included the present San Gabriel fault (Figure 1), and to have adopted its present more easterly trend through the Transverse Ranges between the "Big Bend" area and San Bernardino. The continued movements along this master break, together with thrusting and folding along east-west trends in the Transverse Ranges, are regarded by most investigators as expressions of regional north-south or north-northwest-south-southeast crustal shortening. This strain system, represented diagrammatically by the pair of large arrows in Figure 8, simply and satisfactorily describes the know right-slip along the San Andreas fault and nearly all of the known north-south compression by thrusting and folding. It is less satisfactory in explaining the origin of the major bend in the present San Andreas trend and the known left-slip along the Garlock, White Wolf, and other faults with northeasterly trend. Considered alone, it is quite incompatible with known left-slip along west-to

northwest-trending faults, most important among which are the Santa Ynez fault and the numerous major breaks extending along the Mission Hills - San Cayetano - Santa Susana - Sierra Madre - Cucamonga trend between the Santa Barbara and San Bernardino areas.

In his analysis of the White Wolf fault relative to the regional tectonic pattern, Benioff (1955) outlined the inadequacy of a simple stress system in which the San Andreas and Garlock faults are viewed as conjugate fractures reflecting north-south compression or a simple shearing couple. He pointed out that the major bend in the San Andreas fault "together with the left strike-slip displacements on the Garlock fault indicate that in addition to the regional movements parallel to the San Andreas fault there is a regional movement parallel to the Garlock fault. These two movements are eventually incompatible and it appears that the White Wolf fault is an expression of this incompatibility." More specifically, he suggested regional "movement of the mass north of the Garlock fault in a westerly direction relative to the southern mass."

To describe the known relationships more completely, it is necessary to consider the ground lying north of the Garlock fault. This ground, often neglected in analyses of the San Andreas stress-strain system, has been characterized by east-west extension during the reference period of late Pliocene + Quaternary time. Its principal faults, such as

those of the Sierra Nevada, Panamint, and Death Valley zones, are inclined at moderate to moderately high angles and have behaved mainly as normal dip-slip breaks, in contrast to the near-vertical right-slip faults with northwest trend in the Mojave Desert to the south. Moreover, the indicated crustal extension may well be cumulative in a westerly direction toward the San Andreas fault, as suggested diagrammatically by the smaller arrows in Figure 8.

Whether described as a west-southwestward shove or as a very broad counter-clockwise rotation against the San Andreas fault and the Coast Ranges structure farther west, this relative movement of the crust north of the Garlock fault bespeaks the existence of stresses in addition to those that would account simply for north-south regional crustal shortening. Such stresses imposed from an easterly direction would explain development and progressive accentuation of the major bend in the San Andreas fault, as well as bends farther west between typical west-trending Transverse Ranges faults and typical northwest-trending Coast Ranges faults (Figure 8). They also would explain the widespread evidences of left-flip components along many west-to northwest-trending faults in the region.

In summary, the regional tectonic pattern for late Pliocene + Quaternary time emphasizes the importance of the San Andreas and Garlock faults, the San Andreas as a master

break and plate boundary, and the Garlock as a boundary element for a domain of westward crustal impingement. Such impingement, acting in concert with the regional strain system of nearly north-south crustal shortening, also focuses attention on the narrow east-west belt along which Coast Ranges faults bend abruptly or gradually eastward into Transverse Ranges trends. This is a belt of junction or abutment of right-slip and left-slip faults, with repeated geometric relationships similar to that between the San Andreas and Garlock faults in the "Big Bend" area (Figure 8). Despite the bending, the San Andreas fault has maintained a continuous course southeastward across the Transverse Ranges province, whereas the second- and lesser-order faults of the Coast Ranges have not done so. As lesser analogues of the bent and relatively "locked" segment of the San Andreas, the bent segments of Coast Ranges faults can be regarded as small domains of special strain accumulation along the northerly border of the Transverse Ranges province.

ii. Distribution Of Late Quaternary Deformation And Seismicity

The distribution of holocene and historic tectonism in the Southern Coast Ranges, Western Transverse Ranges, and adjacent offshore area is indicated by four principal types of evidence. These are (1) observed fault

rupture; (2) geodetic measurements showing active deformation; (3) geomorphic expression of faulting and deformation of late Quaternary deposits; and (4) associated seismic activity. The pattern indicated by such lines of evidence is shown on Figure 18.

Review of such evidence has shown that tectonic activity is predominantly concentrated along the San Andreas fault. In the mainsouthern part of the Coast Ranges province, no other faults show evidence of more than minor seismic activity during Holocene time. The same is generally true of the adjacent offshore region, where both the sea floor and the unconformity at the base of the post-Wisconsinan sea floor deposits provide useful datum surfaces for gauging Holocene deformation down to about 350 feet of depth. Unambiguous evidence of extensive post-Wisconsinan deformation in the offshore region has been identified only in the area along the coast line between Point Sal and Point Arguello, which lies in the belt of transition between structural trends of the Coast Ranges and those of the Western Transverse Ranges. Obvious fault scarps also are present in the Santa Lucia Bank area, but there they are below the depth of Wisconsinan low-stand subaerial erosion, and hence may well be older than late Quaternary.

In contrast to the apparently low level of late Quaternary tectonism in the Southern Coast Ranges, the

Western Transverse Ranges (and Santa Barbara channel) and the adjacent belt of transition show fairly widespread evidence of tectonism during this time. Rupture has occurred during historic time along the Big Pine and San Fernando faults. Contemporary creep is reported on the Mesa fault through Santa Barbara, and breaks of Holocene alluvium are known along several fault traces. Study of repeated leveling traverses (Willott, 1972) has suggested that vertical deformation is currently taking place, chiefly through differential movement along faults, in the Transverse Ranges and transition zone. Recent study of the marine terraces along the coastline west of Ventura by Lajoie and others has shown that the 40,000 year old terrace has been uplifted by as much as 250 meters along the Ventura Avenue anticline, and offset by faulting. The Holocene terrace in the same area has been uplifted several meters above the present sea level.

At least three damaging shocks (1925 Santa Barbara, 1971 San Fernando, 1978 Santa Barbara) have originated along Western Transverse Ranges faults during this century. Further, the 1927 Lompoc earthquake has been shown to have originated in the zone of structural merging and transition along the northerly border of the Western Transverse Ranges. As in the Southern Coast Ranges, numerous smaller earthquakes also occur throughout the Western Transverse Ranges region. Notable concentrations of

seismic activity have been identified in the eastern Santa Barbara channel, the Purisima and Casmalia Hills, and the offshore area between Point Conception and Point Argeullo.

(1) The Southern Coast Ranges And Offshore Basins Tectonic Province

The Southern Coast Ranges tectonic province is characterized by faults with northwesterly trends and typically right-lateral or high-angle senses of movement. The larger faults, which may be regarded as second-order features relative to the San Andreas, are 50 to 100 miles long, and some of them form parts of even larger structural trends. Cumulative displacement along the fault typically amounts to thousands of feet of vertical slip and thousands of feet to a few miles of lateral slip, and most of these breaks have a complex history of movements. Features of fault-line morphology are common along their general traces, and late Quaternary surface movement can be inferred along some local segments. Most of the larger faults have records of historic seismicity, with a range from small shocks up to earthquakes of about 6.0 magnitude, but expressions of Holocene surface displacements are characteristically lacking. Unambiguous examples of second-order faults within the Southern Coast Ranges tectonic province include the Nacimiento, Rinconada, Santa Lucia Bank, and possibly the

San Simeon. The Hosgri fault has dimensions that equal those of some second-order faults; however, no record of its behavior during early and middle Pleistocene time remains owing to successive episodes of marine planation of the rocks within which it is developed. Consequently, it has not been possible to determine whether it should be regarded as a second-order or a large third-order fault.

Relatively large basin-margin faults, other relatively large faults that appear to be isolated within the tectonic framework of the Coast Ranges, and the principal branches of second-order faults can be regarded as third-order faults. Such faults typically are tens of miles long and some of them, like some of the second-order faults, form parts of longer structural trends. They show displacements of hundreds to a few thousands of feet, ordinarily dominated by vertical slip. Features of erosional fault-line topography are present locally, but expressions of late Quaternary surface faulting are rare or absent. Many faults of this order have records of minor historic seismicity, and several of them could have been the sources of shocks in the intermediate, locally damaging range. Clear examples of third-order faults within the Southern Coast Ranges include the Edna and West Huasna faults.

Faults of the Southern Coast Ranges typically bend toward the east as traced southeastward, and some develop

into reverse or thrust faults as they enter the transition region along the northerly border of the Western Transverse Ranges province.

(2) The Western Transverse <u>Ranges Tectonic Province</u>

The Western Transverse Ranges tectonic province is characterized by faults with east-west trends and, typically, reverse or left-oblique senses of movement. The major faults in this province are 50 to 90 miles long, and they exhibit geologic and geomorphic evidence of movement during late Quaternary time. The historic level of geologic and seismic activity associated with the Transverse Ranges system clearly exceeds that in the Coast Ranges. Surface movements and large earthquakes have occurred on several different faults diversely located within the Transverse Ranges, whereas in the Southern Coast Ranges such effects have occurred only along the bordering San Andreas fault during historic time and perhaps even during Holocene time.

Because of the differing structural style and level of activity in the two tectonic provinces, it is not possible directly to compare orders of faults in the Coast Ranges with orders of those in the Transverse Ranges. From the historic and the late Quaternary geologic records and from consideration of the mechanics of faulting, especially the relatively higher stress across a fault plane during

reverse slippage, it is evident that the seismic potential is significantly greater for active reverse faults in the Transverse Ranges and transition regions than it is for "capable," but not necessarily active, Coast Ranges strike-slip and normal faults of comparable or even substantially greater dimensions. This is graphically shown in maps recently prepared by the California Division of Mines and Geology (Greensfelder, 1972; Jennings, 1973), which show eight or nine "seismically capable" faults in the Western Transverse Ranges, but only three in the Central Coast Ranges.

(3) <u>The Zone Of Transition And Merging Between The Southern Coast Ranges And The Western Transverse Ranges</u>

The zone of structural transition and merging between the Southern Coast Ranges and the Western Transverse Ranges forms a 20-mile wide band across the south end of the Coast Ranges province (Figure 8). In its easterly part, the south boundary of this zone corresponds to the Big Pine fault, which clearly separates Coast Ranges structures from Transverse Range structures. The westerly part of this south boundary corresponds generally to a line through areas where most faults of east-west Transverse Ranges trend begin to bend toward the northwest. The boundary line itself gradually bends toward the southwest, intersecting the coast line just south of Point Arguello.

The north boundary of the transition zone can be taken as the line connecting areas where Coast Ranges faults begin to bend eastward. Defined in this way, the line extends 110 miles westward from the north end of the "Big Bend" of the San Andreas fault to the outer part of the Santa Lucia Bank fault system.

The tectonic style observed in this transition zone evidently results from two competing regional stress-strain systems, and it reflects the merging and intersection of northwest trends characterized by right lateral movements with east-west trends characterized by left lateral movements. These effects are especially pronounced in the westerly part of the transition zone, where there is no clear-cut boundary structure like the Big Pine fault farther east. The second and probably more fundamental tectonic effect derives from the westward shift of ground north of the Garlock and Big Pine faults, relative to the Western Transverse Ranges, as described earlier. This shift appears to have been the primary cause of the "Big Bend" distortion of the San Andreas, and probably also has sheared off the south end of major Coast Ranges faults, such as the Rinconada and South Nacimiento, along the Big Pine fault. Farther west within the transition zone, Coast Ranges and offshore basin faults bend eastward, change to compressional styles of movement, and die out within the transition zone.

A notable feature of the tectonic style within the transition zone is the existence of reverse or thrust movements along northwest to nearly north-trending faults, some of them parts of longer fault sets that extend northward beyond the transition zone. Relatively short, isolated faults also show substantial reverse movement, especially in the central part of the area of bending, merging, and intersection that lies offshore from Purisima Point. The reverse faults noted by Dibblee (1972) as associated with the southerly part of his proposed Rinconada fault system also are confined mainly to the ground included within the transition zone.

Because the transition zone is a region of "tectonic fight," where competing lateral movements within and between the Coast Ranges and Western Transverse Ranges must be accommodated through bending, vertical offsets, and other adjustments, it is characterized by local accumulations of strain in substantial amounts. This strain is relieved through folding and faulting with accompanying seismic activity. Because of the locally enhanced compressive stress regime, however, faults of all scales (including the San Andreas) tend to remain locked until high strain levels are reached, and then to generate correspondingly large earthquakes when they do yield. The Fort Tejon earthquake of 1857, the damaging Los Alamos shocks of 1902 and 1915, the large Lompoc earthquake of

1927, and the 1969 earthquake swarm in the Santa Lucia Bank system are examples of this feature of transition zone tectonics.

2. Stratigraphy - Character and Distribution Of Rock Units

a. Basement Rocks And Pre-Cenozoic Rocks

i. General Features

The pre-Tertiary bedrock sequence of the Southern Coast Ranges includes four major rock assemblages. The distribution and structural interrelationships of the units that contain these four rock assemblages provide essential clues to the early geologic history of this region.

The four assemblages are divided generally into a continental crust basement, the Salinian basement complex of granitic and crystalline metamorphic rocks; derivative sedimentary rocks known as the Great Valley assemblage; oceanic crust, represented by ophiolite assemblage rocks; and derivative sedimentary and volcanic rocks, represented by the Franciscan assemblage. The general character and distribution of these units are briefly noted below. Their regional distribution is shown on Figure 9.

ii. The Salinian Basement Complex – Granitic And Crystalline Metamorphic Rocks, And Great Valley Sequence Sedimentary Rocks

The ground between the San Andreas fault and a series of faults referred to collectively as the Sur-Nacimiento fault zone is underlain by a complex of crystalline igneous and metamorphic rocks, known as the Salinian basement complex. This complex includes two general rock types -- crystalline metamorphic rocks formed by recrystallization of sedimentary rocks, and granitic rocks formed by crystallization from melts, or magmas, that were intruded into the metamorphic rock series. This complex of rocks forms a typical continental crust. It is generally believed to represent an original southerly extension of the Sierra Nevada batholith, which was partially underthrust by oceanic rocks and then displaced to its present location by northward movement along the San Andreas fault.

A sequence of clastic sedimentary rocks known as the Great Valley sequence and apparently derived largely from erosion of the crystalline complex during late Mesozoic time, is now present overlying both the Salinian basement rocks and Franciscan and ophiolite rocks.

iii. Franciscan Assemblage And Ophiolite

Southwest of the Sur-Nacimiento fault zone, the basement of the Southern Coast Ranges is a highly deformed complex of sedimentary and volcanic rocks known as the Franciscan assemblage (or Formation). These rocks are thought to have been deposited in an offshore trench that existed during the time of underthrusting, or subduction, of the Pacific plate under the North American plate during late Jurassic and Cretacous time.

Characteristic rock types of the Franciscan assemblage include graywacke sandstone (sandstone consisting largely of grains of basic volcanic rocks), greenstones (metamorphosed volcanic rocks), shale, and chert.

Included within the Franciscan basement terrane are isolated fault-bounded masses of a distinctive assemblage of rocks, known as ophiolites, that are thought to be remnants of ocean-floor crust formed about 160 million years ago. These rocks exist in several areas in the Southern Coast Ranges (Figure 10). The presence of like-appearing ophiolite assemblages at Point Sal and near San Simeon has been cited as evidence that these rocks must have been separated by large-scale strike-slip faulting. Such a mechanism, however, is not required to account for the existence of these assemblages at widely separated locations. Little is known of their early structural

history, but their relatively widespread, though scattered, distribution in the Coast Ranges shows that they have not been uniquely positioned by strike-slip faulting.

b. <u>Cenozoic Sedimentary And Volcanic Rocks</u>

i. <u>General Features</u>

The Southern Coast Ranges, including offshore basins, constitute a region that intermittently has been the site for accumulation of clastic sedimentary rocks through Cenozoic time. Because of the several episodes of deformation, uplift, and erosion that have affected this area, especially the onshore Coast Ranges part, these rocks are now preserved mainly in structural depressions such as the Pismo-San Luis syncline, the Huasna syncline, and the onshore Santa Maria Basin. The offshore basins have undergone less uplift and consequently less erosion, especially since Middle Miocene time about 15 million years ago, so that the sedimentary accumulations are more widely preserved in them.

Most of these rocks were deposited over wide regions, although they were wedged out over local topographically high areas on the flanks of structurally controlled sub-basins. Consequently, the characteristic formations of from 22 million years ago (Miocene) through 3 million years ago (Pliocene) age occur over areas of many square miles. Differences in thickness and lithology are fairly gradual within most of these formations, although

some basin fillings are notable for substantial changes over short distances.

Besides the widely distributed sedimentary formations, some rock units were deposited or emplaced within relatively limited areas. The two chief examples of such units in the Southern Coast Ranges are the coarse clastic units that were laid down in close proximity to lithologically distinctive source terranes; these are represented by parts of the Oligocene Sespe Formation and the Lospe Formation of presumed equivalent age, and by the volcanic-derived rocks of the Obispo Formation of early middle Miocene age. The distribution of such units was controlled by proximity to local source areas; some, notably several of the coarse sedimentary breccias assigned to the Lospe Formation, apparently are local fan deposits derived from nearby high-standing masses of ophiolite rocks. Such areally restricted rock units would provide useful markers for evaluating offset along faults separating them from respectively recognizable source terranes. Occurrences in close proximity of both the source and the derivative rock, on the other hand, cannot by itself have significance regarding possible offset from other more or less similar rocks.

ii. Widespread Sedimentary Units

A succession of clastic sedimentary rock units or formations of mid-Tertiary and younger age is present in the Southern Coast Ranges and offshore basins region. Typically these units were originally deposited under marine conditions over areas of thousands of square miles, with only relatively minor changes of lithologic character and fossil content throughout much of their extent. Such changes commonly are related to variations in water depth and proximity to sediment sources, and are referred to as "facies changes." In the case of formations with original widespread distribution, apparent differences between rocks of the same formation exposed at nearby locations may be suggestive, though usually not demonstrative, of fault movement since the time of deposition. Nor do similarities between rocks exposed at even widely separated locations constitute direct evidence for an originally closer proximity. Sedimentary rocks of originally wide distribution rarely provide strong evidence either for or against post-depositional separation of originally contiguous units.

The principal middle through late Tertiary rock units of originally widespread distribution in the Southern Coast Ranges and offshore basins are noted as follows, beginning with the oldest.

Vaqueros And Rincon Formations. The Vaqueros and Rincon Formations, of Oligocene and early Miocene age, respectively, are the oldest Tertiary Formations of original widespread extent that are now preserved in the Southern Coast Ranges region. The Vaqueros strata typically rest on a surface eroded over Franciscan-assemblage basement rocks, and they are generally overlain conformably by strata of the Rincon Formation. The Vaqueros is chiefly marine sandstone with some conglomerate, whereas the Rincon is predominantly shale and mudstone. These rocks occur in scattered areas of the Coast Ranges and Western Transverse Ranges, at the base of a succession of Tertiary formations. In some areas, notably in the onshore Santa Maria Basin, the Vaqueros and Rincon are missing, either through non-deposition or because of removal by erosion prior to deposition of the younger Tertiary section.

Monterey Formation. The middle to late Miocene Monterey Formation and its stratigraphic equivalents probably constitute the most widely distributed Tertiary rock unit in California. In the Southern Coast Ranges, rocks of the Monterey Formation are prominent in all remaining Tertiary sections, either as the basal Tertiary unit or as a unit overlying Rincon, Obispo, or Point Sal rocks. In the offshore Santa Maria basin the Monterey forms a seismically distinctive unit that can be traced throughout the basin (Figure 11).

The Monterey Formation is often divided into lower, middle, and upper members, which are differentiated on the basis of lithology and microfauna-defined age. The lower member is rich in silty, phosphatic, and porcelaneous mudstone, with thin interbeds of limestone and with relatively minor amounts of chert, and interbeds of sandstone and sedimentary breccia. The middle member is characterized by abundant chert, with porcelaneous shale and minor limestone. The chert is commonly thin bedded, but it also occurs locally as lenses and pods up to several feet thick. A notable sequence of chert beds of 6 inches to about 10 feet thick is exposed along the coast south of Point Sal and the Lions Head fault, and similarly massive chert is encountered in oil well borings in that area. Shale and porcelaneous shale, which locally grade into diatomaceous shale, are the dominant lithologies in the upper member.

The Monterey Formation is overlain by a sequence of shale, claystone, and sandstone beds that have been assigned different names in different parts of the region. These beds range from late Miocene (about 12 million years) to late Pliocene or early Pleistocene in age. The formation names that have been assigned in the Santa Maria area are the Sisquoc, Foxen, and Careaga Formations, and in the region from Arroyo Grande north, the Pismo Formation. Like the underlying Monterey Formation, the lower part of this sequence of strata was deposited over an area of thousands

of square miles, and it can be followed in continuous seismic reflection profiles throughout the offshore Santa Maria basin (Figure 12). Lithologically similar rocks crop out at uplifted points along the coast as far north as Point Sur.

iii. Areally Restricted Units

Tertiary rock units in the Southern Coast Ranges that were deposited or emplaced over relatively limited areas include the shallow igneous intrusive rocks of the Morro Rock-Islay Hill complex, the Cambrua Felsite, the several local accumulations of conglomerate and sedimentary breccia referred to as the Lospe Formation, and the volcanic-related rocks of the Obispo Formation. Other locally occurring intrusive volcanic rocks and intrusive breccias have not been assigned separate names; some have been described with the sedimentary formations into which they were emplaced. The intrusive breccias and tuffs present in the Lospe Formation near Point Sal are notable examples.

The Morro Rock-Islay Hill complex is a series of shallowly emplaced igneous rock masses, which crop out as a line of prominent hills along the southwest side of Los Osros-San Luis Obispo Valley. Hollister Peak, Islay Hill, and Morro Rock are all made up of the resistant dacitic volcanic rock of this complex. This rock has been radiometrically dated in the range of 22-26 million years.

The Cambria Felsite exists in scattered outcrops in the hills east of Cambria, and possibly in a few small

patches in Los Osos Valley. It is thought to have been formed as an ash fall associated with an eruption of part of the Morro Rock-Islay Hill complex volcanics. Clasts of Cambria Felsite are present in the conglomerate of the overlying Lospe/Sespe Formation, thereby showing that this unit was at least in part derived from erosion of local source rocks.

Rocks assigned to the Lospe Formation are located near Point Piedras Blancas, in the hills east of Cambria, and in a mostly buried wedge extending east-southeast from an area of outcrop near Point Sal (Figure 13). These rocks have a common stratigraphic position below all other surviving Tertiary rocks except the Cambria Felsite in the Cambria area, and their composition and texture indicate derivation from the local bedrock. Thus, the Lospe near Point Piedras Blancas and part of it near Point Sal is apparently composed entirely of material shed from the distinctive ophiolite bedrock in the corresponding areas. The coarse, bouldery texture and the mostly poorly defined to chaotic bedding in both occurrences indicate a local debris flow or talus mode of deposition of the rocks. At another outcrop near Point Sal the Lospe consists of a basal interbedded sandstone and conglomerate, composed of mixed ophiolite and Franciscan debris, which grades up into a thick section of massive sandstone. The sandstone is overlain in turn by massive claystone. The Lospe near

Cambria consists of conglomerate made up of varying fractions of Franciscan and Cambria Felsite debris, sandstone, and claystone.

The Obispo and Tranquillon Formations represent a lithologically distinctive sequence of volcanic and volcanic-sedimentary rocks that exist in local areas around the Santa Maria Valley, including locations near Point Arguello, northeast of Purisima Point, and in the San Luis-Pismo and Huasna synclines (Figure 14). Tuff, tuffaceous sandstone, intrusive tuff breccia, and basalt are included in various parts of these formations. The Obispo-Tranquillon is of early Miocene age and has been radiometrically dated at 16 million years. It transgressively overlies Franciscan, Vaqueros and Rincon Formations, and it underlies and locally grades into Point Sal or lower Monterey Formation. It underlies the Monterey and may overlie Lospe Formation or Franciscan or ophilite rock in the section penetrated by the offshore Oceano Well.

iv. Comparison Of The Stratigraphic Section In The Offshore Oceano Well With On-Land Stratigraphic Sections East Of The Hosgri Fault

The stratigraphic section that exists at various onshore points from the San Luis Range southward to the Santa Barbara channel varies both in thickness and in character. Certain areally widespread units, especially the Middle Miocene Monterey Formation and the overlying Pismo-Sisquoc-Foxen

section, are present throughout this region, although they each vary in thickness and, to some extent, in facies. The lower Miocene Obispo-Tranquillon Formation is present at or near the base of the Tertiary section in specific areas, particularly in the San Luis-Pismo syncline, the Huasna syncline, south of Point Sal, and near Point Arguello.

The Lospe Formation, of presumed Oligocene age, is present in the trough of the onshore Santa Maria Basin in a wedge that extends east-southeastward from Point Sal (Figure 13). From Point Arguello northward, the Oligocene and younger Tertiary section rests on Franciscan or, near Point Sal, ophiolite basement rock. In the main western Santa Ynez Mountains and the Santa Barbara channel, a distinctive section of early Tertiary and Cretaceous sedimentary rocks more than 10,000 feet thick underlies the Oligocene and younger rocks (Figure 15).

The fact that the onshore geologic column, which lies east of the Hosgri fault trend, exhibits a systematically varying thickness of widespread rock units, and also locally contains units of limited areal extent, allows some assessment of the possibility of offset relative to the onshore basin of a section encountered in the offshore Oceano Well, located opposite the Santa Maria Valley west of the Hosgri fault. Comparison of the Oceano Well section with onshore sections shows that the Monterey-Sisquoc-Foxen column in the upper part of the well agrees in thickness with the thickness of these

units in the onshore columns located generally opposite the Hosgri fault, but that the Monterey is only about half as thick in the well section as in the western Santa Ynez Mountains column, located 50 km to the south (Figure 15). The Monterey in the well overlies a section of tuff and basalt that corresponds to the Obispo-Tranquillon on shore. The lowermost part of the Oceano Well may, from the available date, have been in either Obispo or Lospe, and the well may have bottomed in either Franciscan or ophiolite basement. Either of these possible combinations corresponds to sections that exist across the Hosgri fault in the subsurface near Point Sal or Casmalia, but not to the western Santa Ynez Mountains or Santa Barbara channel sections, where the thick lower Tertiary-Cretaceous section exists. The conclusion from this comparison of stratigraphic sections at points across the Hosgri fault is that right (or left) fault slip of more than a maximum of about 20 km is precluded, and essentially no lateral slip is required. This precludes a possibility of Neogene right slip on the order of 80 to 100 km, such as has been postulated by Hall (1976).

3. Faults

a. Major Faults Of The Southern Coast Ranges And Offshore Basins

The principal faults of the Southern Coast Ranges and offshore basins tectonic province, shown on Figure 16, are here briefly described as they are located from west to

east, starting with the Santa Lucia Bank fault near the westerly boundary of the province. The San Andreas fault, described earlier, forms the east boundary of the province. The Hosgri fault is also discussed in greater detail in Section III of this testimony.

i. <u>Santa Lucia Bank Fault System</u>

<u>Santa Lucia Bank Fault</u>. This fault lies along the east flank of the Santa Lucia Bank, between 40 and 50 km west of the California coastline. The fault is well defined and linear over a distance of about 80 km, but it loses definition northward. It turns toward the east near its southerly end. It clearly exhibits evidence of substantial vertical offset, including an east-facing scarp up to 150 meters high, and it probably has a cumulative horizontal displacement of several kilometers since early Miocene time. Lack of continuity through Miocene strata that lie across its trend to the north and south probably imposes a 5 to 10 km limit for lateral slip along it during the past 20 million years. Shocks of the 1969 earthquake swarm near the southerly end of the Santa Lucia Bank fault zone, with magnitudes up to 5.8 and with focal mechanisms indicating a component of right slip, suggest that some Holocene slip probably is represented along the fault zone.

West of the Santa Lucia Bank fault, between latitudes 34°30' and 35° North, several subparallel faults

are characterized by apparent surface scarps. The longest of these faults trends along the upper continental slope for a distance of as much as 45 miles, and generally exhibits a west-facing scarp. Other faults are present in a zone, about 30 miles long, that lies between the 45-mile fault and the Santa Lucia Bank fault. These faults range from 5 to 15 or more miles in length, and have both east- and west-facing scarps. All parts of the Santa Lucia Bank fault system are submerged at depths of more than 1200 feet, and hence they may be relatively old compared to sea floor topographic features that exist at depths of less than about 400 feet.

Hosgri Fault. The Hosgri fault forms the southerly part of the east boundary of the offshore Santa Maria Basin. It lies offshore from the coast at distances ranging from 4 to 20 km, and it extends over a total distance of about 145 km (90 miles), from near Purisma Point on the south to near Cape San Martin on the north. The Hosgri is part of the larger Coastal Boundary zone of flexures and faults that lies between the uplift of the Southern Coast Ranges and the structural depression of the offshore basins.

The central, main reach of the Hosgri fault strikes about N25W and extends over a distance of about 50 miles between Point Sal and Cambria. Most of this reach consists of only one or two major strands, although it is somewhat wider and more complex where it impinges on the Pt. San Luis structural high between San Luis Obispo Bay and Estero Bay.

Northward from the latitude of Cambria, the Hosgri merges into a zone of isolated breaks and folds. It also splays and dies out in a series of several breaks south of Point Sal.

Cumulative vertical displacement along the Hosgri fault, as recorded by seismic reflection profiles, is between 1 and 2 km, east up, in the last 15 million years. Right-lateral displacement, inferred chiefly from indirect evidence, may amount to as much as about 10 km near the central part of the Hosgri. Lateral displacement decreases toward the ends of the fault, in general to 1 or 2 km, i.e., to amounts that can be accommodated or transferred to other nearby faults through folding and local reverse faulting.

The Hosgri fault has no gross topographic expression in the present sea-floor topography, and detailed investigation by high resolution profiling shows that the late Pleistocene sea floor over most of the trace of the Hosgri was smooth and unbroken. There is no clear evidence as to whether some sea-floor displacements are present in the area where the Hosgri extends along and across submerged terraces in the reach between San Luis Obispo Bay and Estero Bay. A possible sea-floor offset, between 1 and 2 meters high, and less than 2,000 feet in maximum length, is present along one fault strand north of Point Buchon. From San Luis Obispo Bay southward, available evidence indicates that both the sea floor and the underlying wave-cut surface beneath several

tens of feet of post-Wisconsinan surficial deposits are unbroken over the Hosgri fault.

San Simeon Fault. The San Simeon fault extends from an end point near Point Estero northward about to the latitude of Lopez Point, and is approximately 100 km (60 miles) long. Available evidence does not clearly define a northerly end point for this fault, which may splay partly into the offshore Pfeiffer Point fault to the west and partly into the Serra Hill fault farther north.

The San Simeon fault can be divided into southerly, on-land, and northerly segments for convenience of reference. The southerly segment is mapped mainly on the basis of three lines of indirect evidence. The most obvious but least definitive of these is the existence of a straight reach of coastline between Cambria and Point Estero, which aligns with a southerly projection of the onshore segment of the fault. From San Simeon Bay southward for about 8 km (5 miles), the well-stratified rocks of the Monterey Formation, which lie along the west side of the fault and butt against Franciscan basement rock on the east side, can be traced in seismic reflection records. Thus a continuation of the fault is indicated for at least that distance. Finally, the aeromagnetic map of residual magnetic intensity of the coastal region shows a southerly shoreline continuation of the magnetic trough that exists over the onshore part of the San Simeon fault.

The onshore segment of the San Simeon fault extends 20 km (12 miles) from San Simeon Bay northward to Ragged Point. This segment includes an older major trace along which Franciscan rocks are juxtaposed against ophiolite basement rocks, Mesozoic sedimentary rocks, and rocks of the Tertiary Lospe and Monterey Formations, and an apparently younger trace that lies within the Franciscan section. The older fault trace bends westward along a somewhat irregular trend, and corresponds at Ragged Point to a zone of shearing several hundred feet wide. Linear elements of fabric within the shear zone plunge steeply, indicating high-angle oblique movement along this fault strand. The fault apparently does not break the overlying terrace deposits.

The younger trace, named the Arroyo Laguna fault by Hall (1976), comprises several apparently discontinuous en-echelon segment that are defined by side hill rifts and right-laterally deviated canyon crossings. The trace, which extends northward from Arroyo de la Cruz to an intersection with the coastline 1 km north of Ragged Point, is a nearly straight-line projection of the well-defined southerly reach of the on-land segment of the San Simeon fault. If the right-deviated canyon crossings indeed represent actual strike-slip faulting, rather than fault-line erosion features, late Quaternary right-slip of some 500 meters is indicated along the Arroyo de la Cruz trace. The most

recent displacements along this fault, however, were vertical, as shown by the orientation of well-defined grooving and slickensiding in its sea-cliff outcrop.

Evidence relating to possible late Quaternary displacements of faults in the San Simeon area has been sought through detailed mapping by Earth Sciences Associates (Appendix 2.5E to Diablo FSAR, 1975) and by Hall (1976). A more recent investigation by Envicom, Inc. for the Hearst Corporation (Envicom, Inc., 1977) involved trenching at selected localities. The Earth Sciences investigation showed that a branch fault, subsequently named the Arroyo del Oso fault by Hall, has displaced the lower part of the lowest emergent marine terrace by about 3 m (1 foot) in a reverse sense. The same fault also has displaced a higher, older terrace. This investigation further showed that partially cemented dune sand of late Pleistocene or early Holocene age has not been offset along the main trace of the San Simeon fault at San Simeon Bay. The Envicom trenching revealed evidence that the San Simeon fault does not displace land surfaces graded to terrace surfaces, or near surface terrace deposits, that exist at elevations ranging from 80 feet to more than 400 fee above present sea level. However, older terrace deposits underlying, and truncated by, the lowest terrace surface were found to be deformed and faulted. This accords with the impression, gained from photogeologic and surface mapping, that the onshore segment

of the San Simeon fault has been active during the last several million years but has not undergone surface rupture during the last 10,000 to 100,000 years.

The northerly segment of the San Simeon fault is known from a few seismic reflection line crossings, as well as from gravity and magnetic data. Along this segment a section of Tertiary strata more than 3,000 meters thick is juxtaposed against Franciscan rocks. The indicated vertical separation is on the order of 5,000 meters along the reach centered opposite Cape San Martin. This represents the thickness of the Tertiary section against the Franciscan rocks, plus the height of the uplifted Franciscan rock east of the fault. Much of the trace of the northerly segment of the San Simeon fault coincides with a steep topographic break. Bedded deposits having the form of an on-land talus accumulation are banked against this slope in places, but evaluation of whether latest Pleistocene or younger surface displacement has occurred along this segment is difficult because of the steepness of the submerged terrain, and because it lies at greater depth than was exposed to subaerial erosion during the Wisconsinan low-stand of sea level. The geologic and topographic relationships suggest, however, that a significant amount of Quaternary vertical displacement may be represented along the northerly San Simeon scarp.

<u>Suey - West Huasna Fault</u>. The Suey and West Huasna faults have been studied by Hall and Corbato (1967)

and by Hall and Prior (1975). Hall and Corbato state (p. 576), "Evidence that most strongly suggests lateral movement along the West Huasna fault is provided by different thicknesses and facies relationships between units of equivalent age on opposite sides of the fault." They make no estimate of the total movement represented, but the distribution of units across the fault suggests about 5 km of right slip since Miocene time, an estimate confirmed by Hall (1977). There is no known evidence of Holocene movement along the West Huasna fault.

Rinconada Fault. The Rinconada fault, as considered here, is the zone of faults that was studied and redefined by Dibblee (1972, 1975). This zone extends northwesterly from a point of truncation by the Big Pine fault in the Transverse Ranges to the vicinity of Arroyo Seco Canyon in the Santa Lucia Range. It comprises principal breaks that have been mapped separately as the Espinosa, San Marcos, and Rinconada faults, along with the southerly part of the Nacimiento fault.

By correlating formations, facies relationships, source terranes, and other features of specific ages that exist at different localities on opposite sides of the Rinconada fault, Dibblee developed a history of increasing cumulative offset along this zone through Cenozoic time. The indicated offset for post-early Miocene time (about the last 20 million years) ranges between limits of 23 and

56 km. A value of 30 km is adopted for this testimony. It should be noted, however, that the amount of cumulative lateral slip along the Rinconada fault decreases toward its end points. Vedder and Brown (1968), for example, showed that there is little difference in the Miocene section on opposite sides of the "Nacimiento segment" of this fault in the San Rafael Mountains.

Regarding the possibility of Holocene or late Pleistocene movement along the Rinconada fault, Dibblee (1975) stated (p. 52), "The Paso Robles Formation, the youngest geologic unit definitely truncated by the faults, is probably not younger than several hundred thousand or possibly a million years old. Except possibly at a few places, there are no surface indications that either fault has moved since deposition of the older alluvium, which is estimated to be about 50,000 to 500,000 years old." Envicom (1974) concluded (p. 2.35), ". . .the most recent movement on the Rinconada fault near Santa Margarita is herein considered pre-Holocene (i.e., at least 10,000 years ago), but possibly late Pleistocene. . ." These conclusions suggest that no movement has occurred along the Rinconada fault during the past 10,000 years; however, the fault is not known to have been explored by trenching, and it is possible that a few meters of Holocene offset actually could be present but not yet detected.

ii. <u>Sur-Nacimiento Fault Zone</u>

The Sur-Nacimiento fault zone has been regarded as the system of faults that extends from the vicinity of Point Sur, near the northwest end of the Santa Lucia Range, to the Big Pine fault in the western Transverse Ranges and that separates the granitic-metamorphic basement rocks of the Salinian Block from the Franciscan basement rocks of the Coastal Block. Page (1970) has made an extensive study of this zone. In an excellent overview statement, he described and discussed the Sur-Nacimiento zone as follows:

> "The structural zone . . . is an arbitrarily delimited, elongate belt of faults of various kinds and ages, extending southeast from the Sur fault zone which is included:
>
> "The Sur fault zone is conspicuously exposed at intervals for 67 km along or near the coast south of Monterey Bay. It visibly separates the pre-Campanian granitic and regionally metamorphosed Sur series rocks of the Salinian block on the northeast from the Upper Jurassic (?) to mid-Cretaceous Franciscan rocks on the southwest. It dips northeast for the most part, and has generally been considered to be a

steep thrust fault, but its original character is not well established.

"The Sur fault meets the Nacimiento fault, which extends southeast from the point of intersection . . .The Nacimiento fault perpetuates the general trend of the Sur fault and continues to form the surficial boundary of the Franciscan rocks, but the basement rocks of the Salinian block are nowhere exposed in the immediate vicinity, being covered by Upper Cretaceous and Tertiary formations. The Salinian basement rocks may or may not be bounded by this fault at depth.

"Although the Nacimiento fault for the most part dips steeply northeast, along its course, low angle faults and klippen have now been recognized . . . .Allochthonous sheets of Cretaceous Great Valley-type clastic sedimentary rocks tectonically overlie the Franciscan assemblage. Windows of Franciscan rocks, bounded on one or both sides by high-angle faults, are found along the zone from the latitude of Lake

Nacimiento to the latitude of San Luis Obispo.

"It is fruitless to argue about which one of the faults south of the latitude of Lake Nacimiento should be called the Nacimiento fault sensu stricto, and the writer prefers not to apply this name to any particular fault except near the Nacimiento River, which is presumed to be the type area. However, the term "Sur-Nacimiento fault zone" is meant to include the southeastward prolongation of the belt of faulting.

"Near Santa Margarita, the Rinconada fault merges with the Sur-Nacimiento fault zone, and for at least a short distance, it is the virtual boundary between the granitic and regionally metamorphosed basement rocks of the Salinian block and the Franciscan rocks of the southwest block.

"Southeast of the latitude of San Luis Obispo, neither the Salinian basement nor the Franciscan rocks are exposed along the fault zone, unless one includes the large window of Franciscan that is

crossed by the Cuyama River several kilometers west of the principal fault trace. For approximately 96 km, the Sur-Nacimiento fault zone is represented by a generally northeastward-dipping fault which, for the most part, separates Upper Cretaceous clastic sedimentary rocks on the southwest from Paleocene and Eocene clastic sedimentary rocks on the northeast. . . .

"In the Transverse Ranges, the Sur-Nacimiento fault zone appears to be cut off, with a 16 km left-hand separation, by the Big Pine fault, beyond which is may be represented by the Pine Mountain fault (Vedder and Brown, 1968).

"It is unlikely that the Nacimiento fault proper has displaced the ground surface in Late Quaternary time, as there are no indicative offsets of streams, ridges, terrace deposits, or other topographic features. The Great Valley-type rocks on the northeast side must have been down-dropped against the older Franciscan rocks on the southwest, yet they commonly stand higher in the

> topography. This implies relative quiescence of the fault in Late Quaternary time, allowing differential erosion to take place. In a few localities, the northeast side is the low side, and this inconsistency favors the same conclusion. In addition to the foregoing circumstances, the fault is offset by minor cross-faults in a manner suggesting that little, if any, Late Quaternary near-surface movement had occurred along the main fracture."

Richter (1969) noted that some historic seismicity, particularly the 1952 Bryson earthquake, appears to have originated along the Nacimiento fault. This view is supported by recent work of S.W. Smith (1974), which indicated that the Bryson shock and the epicenters of several smaller, more recent earthquakes were located along or near the trace of the Nacimiento.

<u>La Panza And San Juan Faults</u>. The La Panza and San Juan faults are located between the Rinconada and San Andreas faults. These breaks have been interpreted as predominantly dip-slip features that have been inactive since middle or early Pleistocene time (Envicom, 1974). Hill (1954), however, suggested that right-lateral movement along the San Juan fault since Miocene time could have amounted to several kilometers. Although the available

information about possible lateral slip along these faults is poorly defined and contradictory, a value of 3 km for aggregate lateral slip along the La Panza and San Juan faults during the last 20 million years seems reasonable. Slip during the past 10,000 years apparently has been negligible.

b. Major Faults Of The Western Transverse Ranges

The Western Transverse Ranges and Santa Barbara Channel region are characterized by generally east-west structural alignment, and by left-oblique reverse faults, thrust faults, and folds. Many of the faults in this structural province are of major dimensions, and only a few of the most important ones are noted here.

Along the northerly margin of the Western Transverse Ranges, the Big Pine and the Santa Ynez faults are the largest individual breaks. Each is a major left-oblique reverse fault, with rift topography and left-deviated cross canyons along its trace. The Big Pine fault is believed to have ruptured in Lockwood Valley during a strong earthquake in 1852. No historic ground ruptures or large earthquakes have been attributed to the Santa Ynez fault, but it has experienced surface displacement at least as recently as late Pleistocene time, as shown by exploratory trenching across the trace of its south branch in Alegria Canyon.

The axial part of the Western Transverse Ranges is occupied by the structural depression of the Santa Clara River Valley and the Santa Barbara channel. Large, recently active left-oblique reverse and thrust faults extend along the margins of this onshore-offshore depression. The rate of late Quaternary deformation along the north margin of the Santa Clara River Valley, as expressed by folding, uplift, and fault slip, is relatively high.

The southerly margin of the Western Transverse Ranges is defined by north-dipping thrust faults of the Malibu Coast and Sierra Madre fault zones. These faults also are highly active, as indicated by thrusting of Mesozoic and Tertiary rocks over late Quaternary alluvial deposits along them.

Earthquakes and episodes of surface faulting have occurred within the past few decades along the San Fernando fault, the Malibu Coast fault, and faults in the Santa Barbara channel.

C. Cumulative Holocene And Neogene Right Slip Along Faults Of The Southern Coast Ranges

The cumulative amount of right slip that has been reported, or can reasonably be estimated, along those faults that extend across a band transverse to the structural grain of the Southern Coast Ranges at the general latitude of Diablo Canyon is shown in the following table:

Cumulative Right Slip During The Last 10,000 Years And The Last 20,000,000 Years Along Principal Faults In The Southern Coast Ranges

Fault Name	Slip During The Last 10,000 Years (Meters)	Slip During The Last 20,000,000 Years (Kilometers)
Santa Lucia Bank	2*	10*
Hosgri (also applies to San Simeon	2*	10
West Huasna - Suey	1*	5
Rinconada (also applies to Nacimiento)	6*	30
La Panza	-	1
San Juan	-	2
San Andreas	400	280

*Indicated amount of slip has not been reported, but is here considered possible, within the resolution of available exploration data.

For the purpose of graphic comparison, the total Neogene right slip of the San Andreas fault, the faults west of the San Andreas, and the Hosgri fault are all shown on the cumulative lateral slip vs. time plot on Figure 17. These data show that Holocene right slip considered possible for faults west of the San Andreas amounts to about 2.5 percent of that on the San Andreas itself. Holocene slip considered possible for the Hosgri fault amounts to about 0.5 percent of that on the San Andreas.

The relative amount of Neogene right slip considered possible for faults west of the San Andreas, and for the Hosgri in particular, is substantially higher, being about 20 percent and 4 percent, respectively, of the total Neogene slip along the San Andreas. This reflects the relatively high level of activity of second- and third-order faults in the Southern Coast Ranges during late Tertiary time.

C. <u>Seismicity</u>

1. <u>Historical Seismicity Of The Coastal Region</u>

The seismicity of the coastal region of central California is known from scattered historical records extending back about 200 years, and from Instrumental records dating from 1900. Relatively detailed records of earthquake locations and magnitudes became available only following installation of the California Institute of Technology and University of California (Berkeley) seismograph arrays in 1932.

A plot of the epicenters of all instrumentally recorded earthquakes in the coastal and offshore region is shown on Figure 18. The pattern of seismic activity seen on this plot is generally representative of the pattern that has obtained through the approximately 200 years of historic record, with a few significant exceptions. These include the occurrence of the great earthquake of 1857 on the San Andreas fault and the large earthquake of 1852 on the Big Pine fault, both of which involved substantial surface

rupture of the causative fault, within the area covered by Figure 18.

The highest levels of seismic activity in the Coastal Region shown on Figure 18 during the period of historical record have been concentrated along the San Andreas fault and in the area including the Western Transverse Ranges, the Santa Barbara channel, and the transition zone along the northerly margin of the Transverse Ranges. West of the San Andreas and north of the Transverse Ranges and transition zone, the largest instrumentally recorded shock is the M 6.0 1952 Bryson earthquake. The identification of the source structure for the M 7.3 1927 Lompoc earthquake is controversial, but is here considered, on the basis of geological evidence, to probably be the offshore Lompoc fault, which breaks the sea floor west of Purisima Point in the transition zone. Numerous smaller shocks have been recorded in the Southern Coast Ranges region, generally along the trends of the larger faults. Thus virtually all of the second- and third-order faults in the coastal region appear to have some level of associated seismicity. The major zones of earthquake-related release of strain energy, however, are primarily directly along the San Andreas fault, and secondarily within the region of the Western Transverse Ranges.

2. Seismologic Characteristics Of The Coastal Region Of Central California

The generation of earthquakes in the crust of the coastal region of central California occurs in response to strain accumulation associated with adjustments within the San Andreas plate-boundary stress-strain system. The thickness of the crust, and the pattern of deformation relative to the regional north-south compression that is associated with this system apparently limits the hypocentral depth of earthquakes in this region to about 12-15 km. Geologic data consisting of observations of fault displacement patterns and seismologic studies consisting of precise locations of earthquake hypocenters and analysis of the orientation and relative sense of seismogenic fault slip, yield complementary determinations showing that right lateral strike-slip fault offsets and earthquake focal mechanisms are dominant along the San Andreas, while right oblique to nearly pure dip-slip fault offsets and earthquake focal mechanisms are characteristic of the continental margin west of the San Andreas. In the Western Transverse Ranges, fault offsets and earthquake focal mechanisms typically range from left oblique to pure thrust dip slip. In both areas, instrumentally well located earthquakes are generally clearly associated with geologically recognizable faults or with areas where high rates of crustal deformation, reflected by local elevation changes, are occurring.

The period of historical record of earthquakes in the coastal region of central California is relatively brief - about 200 years - but the geologic evidence of late Quaternary fault behavior in the region provides a sort of "fossil record" of larger earthquakes over a period ranging from about 10,000 to 17,000 years offshore to as much as 100,000 years or more on land. The geologic evidence appears to indicate that the levels of seismic activity in the Southern Coast Ranges represented by the historical record have in fact been reasonably representative of the seismicity throughout late Quaternary time. This assessment is based on the observation that the cumulative slip along the largest faults in the region west of the San Andreas and north of the Transverse Ranges and transition zone appears to not exceed a maximum of a few meters during the last 10,000 (up to 100,000+) years, and the largest earthquake of record is about M 6.0 (the 1952 Bryson earthquake). Recurrent earthquakes much in excess of this size -- say around M 6.5 or larger -- during a comparable time span should have resulted in greater amounts of recent fault slip than have been reported for the region.

This observed low level of fault slip and earthquake activity in the Southern Coast Ranges region may be attributable to the concentration of fault slip and associated earthquake activity strain release directly along the San Andreas fault. The amount of right slip recorded along the San

Andreas, together with right slip on faults lying east of the Sierra Nevada Range, during the last 200 years of historical record, in fact essentially equals the total current rate of relative movement along the plate boundary. This supports the historical and geologic evidence that the rate of movement along faults in the Southern Coast Ranges west of the San Andreas is very low, with correspondingly moderate seismicity in that region.

The rate of crustal deformation and the level of historical seismicity in the Western Transverse Ranges, and in the transition zone between the Southern Coast Ranges and the Western Transverse Ranges, on the other hand, is much higher, as noted previously in this testimony. This may be attributable to the different orientation of the pattern of geologic structure in this area relative to the regional north-south compression. The tendency toward active east-west left lateral shear in the area may also result in part from the effect of westward extension of the crust located west of the San Andreas and north of the Garlock faults, described earlier.

II

SITE GEOLOGY

A. <u>Geologic Setting</u>

The Diablo Canyon Power Plant Site is located on the coast along the south-western side of the San Luis Range (Figure 1). This peninsula-forming range is underlain by

sedimentary, igneous, and tectonically emplaced ultrabasic rocks of Mesozoic age, by sedimentary, pyroclastic, and hypabyssal intrusive rocks of Tertiary age, and by a variety of surficial deposits of Quaternary age. The lithology and distribution of these rocks were studied by Headlee (1965), and more recently the range has been mapped in detail by Hall (1973). The geology of the San Luis Range is shown on Figures 19 and 20.

1. Basement Rocks

A complex assemblage of rocks typical of the Coast Ranges basement terrane west of the Nacimiento fault zone is exposed along the south and northeast sides of the San Luis Range. As described by Headlee (1965), this assemblage includes quartzose and greywacke sandstone, shale, radiolarian chert, intrusive serpentinite and diabase, and pillow basalt. Some of these rocks have been dated as Upper Cretaceous (more than 70 million years old) from contained microfossils, and Headlee suggested that they may represent dislocated parts of the Great Valley sequence. There is contrasting evidence, however, that at least the pillow basalt and associated cherty rocks may be more characteristic of the Franciscan terrane. Further, a potassium-argon age of 156 million years, equivalent to Upper Jurassic, has been determined for a core of similar rocks obtained from the bottom of the Montodoro Well No. 1 near Point Buchon.

2. Tertiary Rocks

Five formational units, ranging in age from about 20 to 6 million years, are represented in the Tertiary section of the San Luis Range. The lower part of this section comprises rocks of the Vaqueros, Rincon, and Obispo Formations, which range in age from lower Miocene through middle Miocene. These strata crop out in the vicinity of Hazard Canyon, at the northwest end of the range, and in a broad band along the south coastal margin of the range. In both areas the Vaqueros rests directly on Mesozoic basement rocks. The core of the western San Luis Range is underlain by the Middle and Upper Miocene Monterey Formation, which constitutes the bulk of the Tertiary section. The Upper Miocene to Lower Pliocene Pismo Formation crops out in a discontinuous band along the southwest flank and across the west end of the range, resting with some discordance on the Monterey section and elsewhere directly on older Tertiary or basement rocks.

The coastal area in the vicinity of Diablo Canyon is underlain by silty and sandy strata that have been variously correlated with the Obispo, Point Sal, and Monterey Formations. Whatever the exact stratigraphic relationships of these rocks might prove to be, it is clear that they lie above the main body of tuffaceous sedimentary rocks of the Obispo Formation and below the main part of the Monterey Formation. The existence of intrusive bodies of

both tuff breccia and diabase in this part of the section indicates either that local volcanic activity continued beyond the time of deposition of the Obispo Formation, or that the section represents a predominantly sedimentary facies of the upper part of the Obispo Formation. In either case, the strata underlying the power plant site range downward through the Obispo Formation and presumably include, below levels of present exposure, a few hundred feet of the Rincon and Vaqueros Formations resting upon a basement terrane of Mesozoic rocks.

The Vaqueros Formation consists of resistant, massive, coarse-grained calcareous sandstone, and the overlying Rincon Formation consists of dark gray to chocolate brown calcareous shale and mudstone. The much thicker Obispo Formation (or Obispo Tuff) comprises alternating massive to thick-bedded, medium- to fine- grained vitric-lithic tuffs and tuff breccias (in part intrusive), finely laminated black and brown marine siltstone and shale, and medium-grained light tan marine sandstone. It grades upward into medium- to fine-grained siltstone and silty sandstone that in turn grades upward into siliceous shale characteristic of the Monterey Formation. The Monterey Formation itself is composed predominantly of porcelaneous and finely laminated siliceous and cherty shales. The overlying Pismo Formation consists of massive, medium- to fine-grained arkosic sandstone

with subordinate amounts of siltstone, sandy shale, mudstone, hard siliceous shale, and chert.

3. Quaternary Deposits

Deposits of Pleistocene and Holocene age are widespread on the coastal terrace benches along the southwest margin of the San Luis Range, and they are present in areas farther onshore as local alluvial and stream-terrace deposits, landslide debris, and various colluvial accumulations. The coastal terrace deposits include discontinuous thin basal sections of marine silt, sand, gravel, and rubble, some of which are highly fossiliferous, and generally much thicker overlying sections of talus, alluvial-fan debris, and other deposits of landward origin. All of the marine deposits and most of the overlying nonmarine accumulations are of Pleistocene age, but some of the uppermost talus and alluvial deposits are Holocene. Most of the alluvial and colluvial materials consists of silty clayey sand with irregularly distributed fragments and blocks that represent locally exposed bedrock types. The landslide deposits include chaotic mixtures of rock fragments and finer-grained matrix debris, as well as some large masses of nearly intact to thoroughly disrupted bedrock.

4. Structural Features

The geologic structure of the San Luis Range - Estero Bay area and the adjacent offshore area is characterized by a complex system of folds and faults (Figure 19).

These areas lie near the zone of transition between the west-trending Transverse Ranges structural province and the northwest-trending Coast Ranges province. Major structural features within them are the long, narrow downfold of the San Luis - Pismo syncline and the flanking antiformal structural highs of Los Osos Valley on the northeast and Point San Luis and the adjacent offshore area on the southwest. This set of folds trends obliquely into a north-northwest aligned zone of basement upwarping, folding, and high-angle normal faulting that lies a few miles off the coast. The main onshore folds can be recognized offshore, by seismic relection and gravity techniques, in the structure of the buried, downfaulted Miocene section that lies beyond (west of) this zone.

Lesser but nonetheless important structural features in these areas include smaller zones of faulting. The Edna and San Miguelito fault zones disrupt parts of the northeast and southwest flanks of the San Luis - Pismo syncline. A southward extension of the San Simeon fault can be inferred from linearity of the coastline between Cambria Point Estero, and from the gravity gradient in that area; this fault may extend into, and die out within, the rock section beneath the northern part of Estero Bay. An aligned series of plugs and lensoid masses of Tertiary volcanic rocks, which intrude the Franciscan Formation along the axis of the Los Osos Valley antiform, extends from the outer part of Estero Bay

southeastward for a distance of 22 miles (Figure 19). These distinctive bodies and their consistent alignment provide a useful reference for assessing the possibility of northwest-trending lateral-slip faulting within Estero Bay. It shows that such faulting has not extended across the trend either from the inferred offshore south extension of the San Simeon fault or from faults in the ground east of the San Simeon trend.

The main synclinal fold system of the San Luis Range, the San Luis - Pismo syncline, trends about N 60 W and forms a structural unit more than 15 miles in length. The system comprises several parallel anticlines and synclines across its maximum onshore width of about 5 miles. Individual folds typically range in length from hundreds of feet to as much as 10,000 feet, and in plunge range from zero to more than 30 degrees. Some of them have flank dips as steep as 90 degrees. Various kinds of smaller folds exist locally, most notably flexures and drag folds associated with tuff intrusions and with zones of shear deformation.

Near Estero Bay, the major fold extends to a depth of more than 6,000 feet. Farther south, in the central part of the San Luis Range, it is more than 11,000 feet deep. Parts of its northeast flank are disrupted by faults associated with the Edna fault zone. Local breaks along the central part of the southwest flank have been referred to as the San Miguelito fault zone.

As shown by extensive marine geophysical surveying, the stratigraphy and the west-northwest-trending structure that characterizes the onshore region from Point Sal to areas north of Point Estero extend into the adjacent offshore area as far as the north-northwest-trending structural zone that forms a boundary of the main offshore Santa Maria Basin. Owing to the irregular outline of the coast, the width of the offshore shelf east of this boundary zone ranges from 2-1/2 miles to as much as 12 miles. The shelf area is narrowest opposite the reach of coast between Point Sal and Point Buchon, and widest in Estero Bay and in areas south of San Luis Bay.

The major geologic features that underlie the near-shore shelf include, from south to north, the Casmalia Hills anticline, the broad Santa Maria Valley downwarp, the anticlinal structural high off Point San Luis, the San Luis - Pismo syncline, and the Los Osos Valley antiform. These features are defined by the outcrop pattern and structure of the lower Pliocene, Miocene, and basement-complex rocks. Upper Pliocene strata that form the upper one to two thousand feet of section in the adjacent offshore Santa Maria Basin are partly buttressed and partly faulted against the rocks that underlie the near-shore shelf, and they unconformably overlap the boundary zone and parts of the shelf in several areas.

B. General Features Of The Site

1. Physiographic Features And Associated Superficial Deposits

The power plant site lies immediately southeast of the mouth of Diablo Canyon, a major westward-draining feature of the San Luis Range, and about a mile southeast of Lion Rock, a prominent offshore element of the highly irregular coastline (Figures 21, 22). It occupies an extensive topographic terrace about 1,000 feet in average width. In its pre-grading, natural state, the gently undulating surface of this terrace sloped gradually southwestward to an abrupt termination along a cliff fronting the ocean; it rose with progressively increasing slope in a landward, or northeasterly, direction to merge with the much steeper front of a foothill ridge of the San Luis Range. The surface ranged in altitude from 65 to 80 feet along the coastline to a maximum of nearly 300 feet along the base of the hillslope to the northeast, but nowhere was its local relief greater than 10 feet. Its only major interruption was the steep-walled canyon of lower Diablo Creek, a gash about 75 feet in average depth. The ridge that flanks the terrace on the northeast has been deeply scored by Diablo Creek, but farther upstream the canyon broadens out as a large, irregular bowl-like feature.

Like many other parts of the California coast, the Diablo Canyon area is characterized by several wave-cut

benches of Pleistocene age. These surfaces of irregular but generally low relief were developed across bedrock by marine erosion, and they are ancient analogues of the benches now being cut approximately at sea level along the present coast. They were formed during periods when sea level was higher, relative to the adjacent land, than it is now. Each of the ancient benches is thinly and discontinuously mantled with marine sand, gravel, and rubble similar to the beach and offshore deposits that are accumulating along the present coastline. Along its landward margin each bears thicker and more localized coarse deposits similar to the modern talus along the base of the present sea cliff.

Both the ancient wave-cut benches and their overlying marine and shoreline deposits have been buried beneath silty to gravelly detritus derived from landward sources after the benches were in effect abandoned by the ocean. This nonmarine cover is essentially an apron of coalescing fan deposits, other alluvial debris, and colluvial accumulations that are the thickest adjacent to the mouths of major canyons and along the bases of steep hillslopes.

Where they have been deeply trenched by subsequent erosion, as along Diablo Canyon, these deposits can be seen to have buried some of the benches so deeply that their individual identities are not reflected by the modern (pre-grading) rather smooth terrace topography. Thus the surface of the main terrace is defined mainly by nonmarine

deposits that conceal both the older benches of marine erosion and some of the abruptly rising ground that separates them (Figures 23, 24).

The observed and inferred relationships among the terrace surfaces and the wave-cut benches buried beneath them can be summarized as follows:

Wave-Cut Bench		Terrace Surface	
Altitude (Feet)	Location	Altitude (Feet)	Location
170-175	Small remnants on sides of Diablo Canyon	Mainly 170-190	Sides of Diablo Canyon and upper parts of main terrace; in places separated from lower parts of terrace by low scarps
145-155	Very small remnants on sides of Diablo Canyon	Mainly 150-170	
120-130	Subparallel benches elongate in a northwest-southeast direction but with considerable aggregate width; wholly beneath main terrace surface	Mainly 70-160	Most of main terrace, a widespread surface on a composite section of nonmarine deposits; no well-defined scarps
65-80			
30-45	Small remnants above modern sea cliff	50-100	Small remnants above modern sea cliff
Approx. 0	Small to moderately large areas along present coastline		No depositional terrace

Within the site area the wave-cut benches increase progressively in age with increasing elevation above present sea level, hence their order in the above list is one of decreasing age. By far the most extensive of these benches

slopes gently seaward from a shoreline angle that lies at an elevation of approximately 100 feet above present sea level.

2. Bedrock Units

The entire site area is underlain by a complex sequence of stratified marine sedimentary rocks and tuffaceous volcanic rocks, all of Tertiary (Miocene) age. Diabasic intrusive rocks are locally exposed high on the walls of Diablo Canyon at the edge of the area. Both the sedimentary and volcanic rocks have been folded and otherwise disturbed over a considerable range of scales.

a. Obispo Formation (Obispo Tuff)

Rocks of the Obispo Formation, the oldest bedrock units exposed in the site area, crop out extensively in its coastward parts and form nearly all of the offshore prominences and shoals. They are dense to highly porous, and thinly layered to almost massive. They range in color from white to buff in fresh exposures, and from yellowish to reddish brown on weathered surfaces. Most outcrop surfaces have a characteristic "punky" to crusty appearance, but the rocks in general are tough, cohesive, and relatively resistant to erosion.

The Obispo consists mainly of fine-grained vitric tuff, with locally prominent crystal tuffs. Other observed rock types include pumiceous tuffs, pumice-pellet tuff breccias, perlitic vitreous tuffs, tuffaceous siltstones and mudstones, and fine-grained tuff breccias with fragments of

glass and various sedimentary rocks. No massive flow rocks have been recognized anywhere in the exposed volcanic section. Most of the tuffaceous rocks, and especially the more vitreous ones, have been locally to pervasively altered. Products of silicification, zeolitization, and pyritization are readily recognizable in many exposures, where the rocks generally are traversed by numerous thin, irregular veinlets and layers of cherty to opaline material. Veinlets and thin, pod-like concentrations of gypsum also are widespread. Where pyrite is present, the rocks weather yellowish to brownish and are marked by gossan-like crusts.

The various contrasting rock types are simply interlayered in only a few places. Much more typical are abutting, intertonguing, and irregularly interpenetrating relationships over a wide range of scales. Septa and inclusions of shale and sandstone are abundant, and a few of them are large enough to be shown separately on the geologic map (Figure 23). Highly irregular inclusions, a few inches to several feet in maximum dimension, are so densely packed together in some places that they form breccias with volcanic matrices.

The Obispo Formation is underlain by mudstones of early Miocene (pre-Monterey) age, on which it rests with a highly irregular contact that appears to be in part intrusive. This contact lies offshore in the vicinity of the power plant site, but it is exposed along the seacoast

to the southeast. In a gross way, the Obispo underlies the basal part of the Monterey Formation, but many of its contacts with these sedimentary strata are plainly intrusive. Moveover, individual sills and dikes of slightly to thoroughly altered tuffaceous rocks appear here and there in the Monterey section, not uncommonly at stratigraphic levels well above its base. The observed physical relationships, together with the local occurrence of microfossils within the principal masses of volcanic rocks, indicate that much of the Obispo Formation in this area probably was emplaced at shallow depths beneath the Miocene sea floor during accumulation of sedimentary strata. The volcanic rocks do not appear to represent a single, well-defined eruptive event, nor are they likely to have been derived from a single source conduit.

b. Monterey Formation

Stratified marine rocks variously correlated with the Monterey Formation, Point Sal Formation, and Obispo Tuff underlie most of the site area, including all of that portion intended for power plant structures. They are almost continuously exposed along the crescentic sea cliff that borders Diablo Cove, and elsewhere they appear in much more localized outcrops. For convenience they are here assigned to the Monterey Formation in order to delineate them clearly from the adjacent more tuffaceous rocks so typical of the Obispo Formation.

The observed rock types, listed in general order of decreasing abundance, are silty and tuffaceous sandstone, siliceous shale, shaly siltstone and mudstone, diatomaceous shale, sandy to highly tuffaceous shale, calcareous shale and impure limestone, bituminous shale, fine- to coarse-grained sandstone, impure vitric tuff, silicified limestone and shale, and tuff-pellet sandstone. Dark-colored and relatively fine-grained strata are most abundant in the lowest part of the section, as exposed along the east side of Diablo Cove, whereas lighter-colored sandstones and siliceous shales are dominant at stratigraphically higher levels farther north. In detail, however the different rock types are interbedded in various combinations, and intervals of uniform lithology rarely are thicker than 30 feet.

The sandstones are mainly fine to medium grained, and most are distinctly tuffaceous. Some of these rocks contain small but megascopically visible fragments of pumice, perlitic glass, and tuff, and a few beds grade along strike into submarine tuff breccia. The sandstones are thinly to very thickly layered; individual beds 6 inches to 4 feet thick are fairly common, and a few appear to be as thick as 15 feet. Some of them are hard and very resistant to erosion, and they typically form subdued but nearly continuous elongate projections on major hillslopes.

The siliceous shales are light colored platy rocks that are moderately hard to extremely hard according to

their silica content, but they tend to break readily along bedding and fracture surfaces. The bituminous rocks and the siltstones and mudstones are darker colored, softer, and grossly more compact. Some of them are very thinly bedded or laminated; others appear almost massive or form matrices for irregularly ellipsoidal masses of somewhat sandier material. The tuffaceous rocks are softer, and the diatomaceous ones are soft to the degree of punkiness; both kinds of rocks are easily eroded, but are markedly cohesive and tend to retain their gross positions on even the steepest of slopes.

Stains of iron oxides are widespread on exposures of nearly all the Monterey rocks, and are especially well developed on some of the finest-grained shales that contain disseminated pyrite. All but the hardest and most thick-bedded rocks are considerably broken to depths of as much as 6 feet in the zone of weathering on slopes other than the present sea cliff, and the broken fragments have been separated and displaced by surface creep to somewhat lesser depths.

c. Diabasic Intrusive Rocks

Small, irregular bodies of diabasic rocks are poorly exposed high on the walls of Diablo Canyon at and beyond the northeasterly edge of the site area. Contact relationships are readily determined at only a few places where these rocks evidently are intrusive into the Monterey

Formation. They consist chiefly of calcic plagioclase and augite, with some olivine, opaque minerals, and zeolitic alteration products, and in most places they are considerably weathered.

3. Quaternary Deposits

Coastal Terrace Deposits

The coastal wave-cut benches of Pleistocene age, as described earlier, are almost continuously blanketed by terrace deposits of several contrasting types and modes of origin. The oldest of these deposits are relatively thin and patchy in their occurrence, and were laid down along and adjacent to ancient beaches during Pleistocene time. They are covered by considerably thicker and more extensive nonmarine accumulations of detrital materials derived from various landward sources.

The marine deposits consist of silt, sand, gravel, and cobbly to bouldery rubble. They are approximately 2 feet in average thickness over the entire terrace area and reach a maximum observed thickness of about 8 feet. They rest directly upon bedrock, some of which is marked by numerous holes attributable to the action of boring marine mollusks, and they commonly contain large rounded cobbles and boulders of Monterey and Obispo rocks that have been similarly bored. Lenses and pockets of highly fossiliferous sand and gravel are present locally. All the marine sediments are poorly to very well sorted and loose to-

moderately well consolidated. They have been naturally compacted, and the degree of compaction is consistently greater than that observed in any of the associated surficial deposits of other types.

Near the inner margins of individual wave-cut benches the marine deposits merge landward into coarser and less well-sorted debris that evidently accumulated along the bases of ancient sea cliffs or other shoreline slopes. This debris is locally as much as 12 feet thick; it forms broad but very short aprons, now buried beneath younger deposits, that are ancient analogues of the talus accumulations along the inner margin of the present beach in Diablo Cove. One of these aprons is well exposed high on the northerly wall of Diablo Canyon.

A younger, thicker, and much more continuous nonmarine cover is present over most of the coastal terrace area. It consistently overlies the marine deposits noted above, and where these are absent it rests directly upon bedrock. It is composed in part of alluvial detritus contributed during Pleistocene time from Diablo Canyon and several smaller drainage courses, and it thickens markedly as traced sourceward toward these canyons. The detritus is chiefly fine- to moderately coarse-grained gravel and rubble characterized by tabular fragments of Monterey rocks in a rather abundant silty to clayey matrix. Most of it is

thinly and regularly stratified, but the distinctness of this layering varies greatly from place to place.

Slump, creep, and slope-wash deposits, derived from adjacent hillsides by relatively slow downhill movement over long periods of time, also form major parts of the nonmarine terrace cover. All are loose and uncompacted. They comprise fragments of Monterey rocks in dark-colored clayey matrices, and their internal structure is essentially chaotic. In some places they are crudely interlayered with the alluvial-fan deposits, and elsewhere they overlie these bedded sediments. On parts of the main terrace area not reached by any of the alluvial fans, a cover of slump, creep, and slope-wash deposits, a few inches to nearly 10 feet thick, rests directly upon either marine terrace deposits or bedrock.

b. <u>Stream-Terrace Deposits</u>

Several narrow, irregular benches along the walls of Diablo Canyon are veneered by a few inches to 6 feet of silty gravels that are somewhat coarser but otherwise similar to the alluvial-fan deposits already described. These stream-terrace deposits originally occupied the bottom of the canyon at a time when the lower course of Diablo Creek had been cut downward through the sedimentary cover of the main terrace and well into the underlying bedrock. Subsequent deepening of the canyon has left remnants of the deposits as cappings on scattered small terraces.

c. Landslide Deposits

The walls of Diablo Canyon also are marked by tongue- and bench-like accumulations of loose, rubbly landslide debris that consists mainly of highly broken and jumbled masses of Monterey rocks with abundant silty and soily matrix materials. These landslide bodies represent localized failure on naturally oversteepened slopes, generally confined to fractured bedrock in and immediately beneath the zone of weathering. Individual bodies within the site area are small, with probable maximum thickness no greater than 20 feet. All of them lie outside the area of power plant construction.

Landslide deposits along the sea cliff are associated with small scale failure that represents slippage along bedding and fracture surfaces in siliceous Monterey rocks. Several episodes of sliding are attested by thin, elongate masses of highly broken ground separated from one another by well defined zones of dislocation. Some of these masses are still capped by terrace deposits. The composite accumulations of debris are not more than 35 feet in maximum thickness, and the ground failure does not appear to have resulted in major recession of the cliff. Landsliding along the sea cliff evidently has not been a major process within the site area.

Large landslides, some of them involving substantial thicknesses of bedrock, are present on both sides of Diablo

Canyon not far northeast of the power plant area. These occurrences need not be considered in connection with the plant site, but they have been regarded as significant factors in establishing a satisfactory grading design for the switchyard and other up-canyon installations.

d. Slump, Creep, and Slope-Wash Deposits

As noted earlier, slump, creep, and slope-wash deposits form parts of the nonmarine sedimentary blanket on the main coastal terrace. They also have been considerably concentrated along well defined swales on major slopes, where they are readily distinguished from other surficial deposits.

Angular fragments of Monterey rocks are sparsely to very abundantly scattered through the colluvial deposits, whose most characteristic feature is a fine grained matrix that is dark colored, moderately rich in clay minerals, and extremely soft when wet. Internal layering is rarely observable and nowhere is sharply expressed. The debris seems to have been rather thoroughly intermixed during its slow migration down hillslopes in response to gravity. That it was derived mainly from broken materials in the zone of weathering is showwn by several exposures in which it grades downward through soily debris into highly disturbed and partly weathered bedrock, and thence into progressively fresher and less broken bedrock.

e. Talus And Beach Deposits

Much of the present coastline in the vicinity of the site is marked by bare rock, but Diablo Cove and a few other large indentations are fringed by narrow, discontinuous beaches and irregular concentrations of seacliff talus. The total volume of these coarse grained deposits is small, and they are of interest mainly as modern analogues of Pleistocene deposits at higher levels beneath the main terrace surface.

The beach deposits consists chiefly of well rounded cobbles. They form thin veneers over bedrock, and in Diablo Cove they grade seaward into patches of coarse pebbly sand. The floors of both Diablo Cove and South Cove probably are irregular in detail and are featured by rather hard, fresh bedrock that is discontinuously overlain by irregular thin bodies of sand and gravel. The presumed remnant of the gash cut in the cove area by Diablo Creek during Wisconsin time probably is filled with sand and gravel.

4. Geologic Structure

The rocks underlying the Diablo Canyon site have been subjected to intrusive volcanic activity and to later compressional deformation that has given rise to folding, jointing and fracturing, minor faulting, and local brecciation. The site is situated in a section of moderately to steeply north-dipping strata, about 300 feet south of an east-west trending synclinal fold axis (Figure 23). The rocks are jointed throughout, and they contain local zones of closely

spaced high-angle fractures (Figure 27). In addition to these features, cross-cutting bodies of tuff and tuff breccia, and cemented "crackle breccia" could be considered as tectonic structures.

Exact ages of the various tectonic structures at the site are not known. It has been clearly demonstrated, however, that all of them are truncated by and therefore antedate the principal marine erosion surface that underlies the coastal terrace bench. This terrace can be correlated with coastal terraces to the north and south that have been dated as 80,000 to 120,000 years old. The tectonic structures probably are related to the Pliocene-lower Pleistocene episode of Coast Ranges deformation, which occurred more than a million years ago.

a. Folds

The bedrock units within the entire site area form part of the southerly flank of a very large syncline that is a major feature of the San Luis Range. The northerly dipping sequence of strata is marked by several smaller folds with subparallel trends and flank-to-flank dimensions measured in hundreds of feet. One of these, a syncline with gentle to moderate westerly plunge, is the largest flexure recognized in the vicinity of the site. Its axis lies a short distance north of the site and about 450 feet northeast of the mouth of Diablo Canyon (Figures 23, 24). East of the canyon, this fold appears to be rather open and simple in

form, but farther west, it probably is complicated by several large wrinkles and may well lose its identity as a single feature. Some of this complexity is clearly revealed along the northerly margin of Diablo Cove, where the beds exposed in the sea cliff have been closely folded along east to northeast trends. Here a tight syncline (Figure 23) and several smaller folds can be recognized, and steep to near-vertical dips are dominant in several parts of the section.

The southerly flank of the main syncline within the site area steepens markedly as traced southward away from the fold axis. Most of this steepening is concentrated within an across-strike distance of about 300 feet as revealed by the strata exposed in the sea cliff southeastward from the mouth of Diablo Canyon; farther southward the beds of sandstone and finer grained rocks dip rather uniformly at angles of 70 degrees or more. A slight overturning through the vertical characterizes the several hundred feet of section exposed immediately north of the Obispo rocks that underlie South Point and the north shore of South Cove (Figure 23). Thus the main syncline, though simple in gross form, is distinctly asymmetric. The steepness of its southerly flank may well have resulted from buttressing, during the folding, by the relatively massive and competent unit of tuffaceous rocks that adjoins the Monterey strata at this general level of exposure.

Smaller folds, corrugations, and highly irregular convolutions are widespread among the Monterey rocks, especially the finest grained and most shaly types. Some of these flexures trend east to southeast and appear to be drag features systematically related to the larger scale folding in the area. Most, however, reflect no consistent form or trend, range in scale from inches to only a few feet, and evidently are confined to relatively soft rocks that are flanked by sections of harder and more massive strata. They constitute crudely tabular zones of contortion within which individual rock layers can be traced for short distances but rarely are continuous throughout the deformed ground. Some of this contortion appears to have derived from slumping and sliding of unconsolidated sediments on the Miocene sea floor during acculation of the Monterey section. Most of it, in contrast, plainly occurred at much later times, presumably after conversion of the sediments to sedimentary rocks, and it can be most readily attributed to highly localized deformation during the ancient folding of a section that comprises rocks with contrasting degrees of structural competence.

b. Faults

Numerous faults with total displacements ranging from a few inches to several feet cut the exposed Monterey rocks. Most of these occur within, or along the margins of, the zones of contortion noted above. They are sharp, tight breaks with highly diverse attitudes, and they typically are

marked by 1/16 inch or less of gouge or microbreccia. Nearly all of them are curving or otherwise somewhat irregular surfaces, and many can be seen to terminate abruptly or to die out gradually within masses of tightly folded rocks. These small faults appear to have been developed as end products of localized intense deformation caused by folding of the bedrock section. Their unsystematic attitudes, small displacements, and limited effects upon the host rocks identify them as secondary features, i.e., as results rather than causes of the localized folding and convolution with which they are associated.

Three distinctly larger and more continuous faults also were recognized within the mapped area. They are well exposed on the sea cliff that fringes Diablo Cove (see Figure 23), and each lies within a zone of moderately to severely contorted, fine grained Monterey strata. Each is actually a zone, 6 inches to several feet wide, within which two or more subparallel tight breaks are marked by slickensides, 1/4 inch or less of gouge, and local stringers of gypsum. None of these breaks appears to be systematically related to individual folds within the adjoining rocks. None of them extends upward into the overlying blanket of Quaternary terrace deposits.

One of these faults, exposed on the north side of the cove, trends north-northwest essentially parallel to the flanking Monterey beds, but it dips more steeply than these

beds. Another, exposed on the east side of the cove, trends east-southeast and is essentially vertical; thus, it is essentially parallel to the structure of the host Monterey section. Neither of these faults projects toward the ground involved in power plant construction. The third fault, which appears on the sea cliff at the mouth of Diablo Canyon, trends northeast and projects toward ground in the northernmost part of the power plant site. It dips northward somewhat more steeply than the adjacent strata.

Total displacement is not known for any of these three faults on the basis of natural exposures, but it could amount to as much as tens of feet. That these breaks are not major features, however, is strongly suggested by their sharpness, by the thinness of gouge along individual surfaces of slippage, and by the essential lack of correlation between the highly irregular geometry of deformation in the enclosing strata and any directions of movement along the slip surfaces.

The possibility that these surfaces are late-stage expressions of much larger scale faulting at this general locality was tested by careful examination of the deformed rocks that they transect. On megascopic scales the rocks appear to have been deformed much more by flexing than by rupture and slippage, as evidenced by local continuity of numerous thin beds that denies the existence of pervasive faulting within much of the ground in question. That the finer grained rocks are not themselves fault gouge was

confirmed by examination of numerous samples under the microscope.

Sedimentary layering, recognized in 27 of 34 samples that were studied, was observed to be grossly continuous even though dislocated here and there by tiny fractures. Moreover, nearly all the samples were found to contain shards of volcanic glass and/or the tests of foraminifera; some of these delicate components showed effects of microfracturing and a few had been offset a millimeter or less along tiny shear surfaces, but none appeared to have been smeared out or partially obliterated by intense shearing or grinding. Thus the three larger faults in the area evidently were superimposed upon ground that already had been deformed primarily by small scale and locally very intense folding rather than by pervasive grinding and milling.

It is not known whether these faults were late-stage results of major folding in the region or were products of independent tectonic activity. In either case, they are relatively ancient features, as they are capped without break by the Quaternary terrace deposits exposed along the upper part of the sea cliff. They probably are not large scale elements of regional structure, as examination of the nearest areas of exposed bedrock along their respective landward projections revealed no evidence of substantial offsets among recognizable stratigraphic units. Seaward projection of one or more of these faults might be taken to

explain a possible large offset of the Obispo Formation as this unit is exposed on North Point and South Point. The notion of such an offset, however, would rest upon the assumption that the two outcropping masses are displaced parts of an originally continuous body, for which there is no real evidence. Indeed, the two tuff masses are bounded on their northerly sides by lithologically different parts of the Monterey Formation, hence clearly were originally emplaced at different stratigraphic levels and are not directly correlative.

c. Masses Of Brecciated Rocks

Highly irregular masses of coarsely brecciated rocks, a few feet to many tens of feet in maximum dimension, are present in some of the relatively siliceous parts of the Monterey section that adjoin the principal bodies of Obispo rocks. The fracturing and dislocation is not genetically related to any recognizable faults, but instead seems to have been associated with emplacement of the volcanic rocks; it evidently was accompanied or soon followed by extensive silicification. Many adjacent fragments in the breccias are closely juxtaposed and have matching opposed surfaces, so that they plainly represent no more than coarse crackling of the brittle rocks. Other fragments, though angular or subangular, are not readily matched with adjacent fragments and hence may represent significant translation within the entire rock masses.

The ratio of matrix materials to coarse fragments is very low in most of the breccias, and nowhere was observed to exceed about 1:3. The matrices generally comprise smaller angular fragments of the same Monterey rocks that are elsewhere dominant in the breccias, and they characteristically are set in a siliceous cement. Tuffaceous matrices, with or without Monterey fragments, also are widespread and commonly show the effects of pervasive silification. All the exposed breccias are firmly cemented, and they rank among the hardest and most resistant units in the entire bedrock section.

A few 3 to 18 inch beds of sandstone have been pulled apart to form separate tabular masses along specific stratigraphic horizons in higher parts of the Monterey sequence. Such individual tablets, which are boudins rather than ordinary breccia fragments, are especially well exposed in the sea cliff at the northern corner of Diablo Cove. They are flanked by much finer grained strata that converge around their ends and continue essentially unbroken beyond them. This boudinage, or separation and stringing out of sandstone beds that lie within intervals of much softer and more shaly rocks, has resulted from compression during folding of the Monterey section. Its distribution is stratigraphically controlled and is not systematically related to recognizable faults in the area.

c. Mapping And Exploration Of The Site

The geologic relationships at the Diablo Canyon Units 1 and 2 power plant site have been studied in terms of both local and regional stratigraphy and structure, with an emphasis on relationships that could aid in dating the youngest tectonic activity in the area. Geologic conditions that could affect the design, construction, and performance of various components of the plant installation also were identified and evaluated. The investigations were carried out in three main phases, which spanned the time between initial site selection and completion of foundation construction.

Feasibility Investigations. Work directed toward determining the pertinent general geologic conditions at the plant site comprised detailed mapping of available exposures, limited hand trenching in areas with critical relationships, and petrographic study of the principal rock types. The results of this feasibility program were presented in a report that also included recommendations for determining suitability of the site in terms of geologic conditions. Information from this early phase of studies is included in the preceding four sections and is illustrated by Figures 23 and 24.

Suitability Investigations. The second phase of investigations was directed toward testing and confirming the favorable judgments concerning site feasibility. Inasmuch

as the principal remaining uncertainties involved structural features in the local bedrock, additional effort was made to expose and map these features and their relationships. This was accomplished through excavation of large trenches on a grid pattern that extended throughout the plant area (shown on Figure 25), followed by photographing the trench walls and logging the exposed geologic features. Large scale photographs were used as a mapping base, and the recorded data were then transferred to controlled vertical sections at a scale of 1 inch = 20 feet.

During these suitability investigations, special attention was given to the contact between bedrock and overlying terrace deposits in the plant site area. It was determined that none of the discontinuities present in the bedrock section displaces either the erosional surface developed across the bedrock or the terrace deposits that rest upon this surface. An example of the recording of the pertinent data is illustrated by Figure 26.

Construction Geology Investigation. Geologic work done during the course of construction at the plant site spanned an interval of five years, which encompassed the period of large scale excavation. It included detailed mapping of all significant excavations, as well as special studies in some areas of rock bolting and other work involving rock reinforcement and temporary instrumentation. The mapping covered essentially all parts of the area to be

occupied by structures for Units 1 and 2, including the excavations for the circulating water intake and outlet, the Turbine Generator Building, the Auxiliary Building, and the Containment Structures. The results of this mapping are described farther on and are illustrated by Figure 27.

<u>Exploratory Trenching Program</u>. Four exploratory trenches were cut beneath the main terrace surface at the Unit 1 power plant site, as shown on Figure 23. Trench A, about 1,080 feet long, extended in a north-northwesterly direction and thus was roughly parallel to the nearby margin of Diablo Cove. Trench B, 380 feet long, was parallel to Trench A and lay about 150 feet east of the northerly one-third of the longer trench. Trenches C and D, respectively 450 and 490 feet long, were nearly parallel to each other, 130 to 150 feet apart, and lay essentially normal to Trenches A and B. The two pairs of trenches crossed each other to form a # pattern that would have been symmetrical were it not for the long southerly extension of Trench A. They covered the area intended for Unit 1 power plant construction, and the intersection of Trenches B and C coincided in position with the center of the Unit 1 nuclear reactor structure.

Eight additional trenches were cut beneath the main terrace surface south of Diablo Canyon in order to extend the scope of subsurface exploration to include all ground in the Unit 2 plant site. As in the area of the

Unit 1 plant site, the trenches formed two groups; those in each group were parallel with one another and were oriented nearly normal to those of the other group. The excavations pertinent to the Unit 2 plant site can be briefly identified as follows:

1. North-Northwest Alinement:

a. Trench EJ, 240 feet long, was a southerly extension of older Trench BE (originally designated as Trench B).

b. Trench WU, 1,300 feet long, extended southward from Trench DG (originally designated as Trench D), and its northerly part lay about 65 feet east of Trench EJ. The northernmost 485 feet of this trench was mapped in connection with the Unit 2 trenching program.

c. Trench MV, 700 feet long, lay about 190 feet east of Trench WU. The northernmost 250 feet of this trench was mapped in connection with the Unit 2 trenching program.

d. Trench AF (originally designated as Trench A) was mapped earlier in connection with the detailed study of the Unit 1 plant site. A section for this trench, which lay about 140 feet west of Trench EJ, was included with others in the report on the Unit 1 trenching program.

2. East Northeast Alinement:

a. Trench KL, about 750 feet long, lay 180 feet south of Trench DG (originally designated as Trench D)

and crossed Trenches AF, EJ, and WU.

b. Trench NO, about 730 feet long, lay 250 feet south of Trench KL and crossed Trenches AF, WU, and MV.

These trenches, or parts thereof, covered the area intended for the Unit 2 power plant construction, and the intersection of Trenches WU and KL coincided in position with the center of the Unit 2 nuclear reactor structure.

All of the trenches, throughout their aggregate length of about 4000 feet, revealed a section of surficial deposits and underlying Monterey bedrock that corresponded to the "two-ply" sequence of surficial deposits and Monterey strata exposed along the sea cliff in nearby Diablo Cove. The trenches ranged in depth from 10 feet (or less along their approach ramps) to nearly 40 feet, and all had sloping sides that gave way downward to essentially vertical walls in the bedrock encountered 3 to 22 feet above their wide floors. To facilitate detailed geologic mapping, the wall along one side of each trench was trimmed to a near-vertical slope extending upward from the trench floor to a level well above the top of bedrock. These walls subsequently were scaled back by means of hand tools in order to provide fresh, clean exposures prior to mapping of the contact between bedrock and overlying unconsolidated materials.

The geologic sections shown in Figure 26 correspond in position to the vertical portions of the mapped trench walls in the Unit 1 area. Relationships exposed at

higher levels on sloping portions of the trench walls have been projected to the vertical planes of the sections. Center lines of intersecting trenches are shown for convenience, but the planes of the geologic sections do not contain the center lines of the respective trenches.

Interface Between Bedrock And Surficial Deposits. As exposed continuously in the exploratory trenches, the contact between bedrock and overlying terrace deposits represents two wave-cut platforms and intervening slopes, all of Pleistocene age. The broadest surface of ancient marine erosion ranges in altitude from 80 to 105 feet, and its shoreward margin, at the base of an ancient sea cliff, lies uniformly within 5 feet of the 100-foot contour. A higher, older, and less extensive marine platform ranges in altitude from 130 to 145 feet, and most of it lies within the ranges of 135 to 140 feet. As noted previously, these are two of several wave-cut benches in this coastal area, each of which terminates eastward against a cliff or steep shoreline slope and westward at the upper rim of a similar but younger slope.

Available exposures indicate that the configurations of the erosional platforms are markedly similar, over a wide range of scales, to that of the platform now being cut approximately at sea level along the present coast. Grossly viewed, they slope very gently in a seaward (westerly) direction and are marked by broad, shallow channels and by

upward projections that must have appeared as low spines and "reefs" when the benches were being formed. The most prominent "reefs," which rise a few inches to about five feet above neighboring parts of the bench surfaces, are composed of hard, thick-bedded sandstone that was relatively resistant to the ancient wave erosion.

As shown in the geologic sections (Figure 26), the surfaces of the platforms are nearly planar in some places but elsewhere are highly irregular in detail. The small scale irregularities, generally three feet or less in vertical extent, include knob-, spine-, and rib-like projections and various wave-scoured pits, notches, crevices, and channels. Most of the upward projections closely correspond to relatively hard, resistant beds or parts of beds in the sandstone section. The depressions consistently mark the positions of relatively soft silty or shaly sandstone, of very soft tuffaceous rocks, or of extensively jointed rocks. The surface traces of most faults and some of the most prominent joints are in sharp depressions, some of them with overhanging walls. All these irregularities of detail have modern analogues that can be recognized on the bedrock bench now being cut along the margins of Diablo Cove.

The interface between bedrock and overlying surficial deposits provides information concerning the age of youngest fault movements within the bedrock section. This interface is nowhere offset by faults that were exposed in

the trenches, but instead has been developed irregularly across the faults after their latest movements. The consistency of this general relationship was established by highly detailed tracing and inspection of the contact as freshly exhumed by scaling of the trench walls. Gaps in exposure of the interface necessarily were developed at the intersections of trenches. At such localities, the bedrock was carefully laid bare so that all joints and faults could be recognized and traced along the trench floors to points where their relationships with the exposed interface could be determined.

Corroborative evidence concerning age of the most recent fault displacements stems from the marine deposits that overlie the bedrock bench and form a basal part of the terrace section. That those deposits rest without break across the traces of faults in the underlying bedrock was shown by the continuity of individual sedimentary beds and lenses that could be clearly recognized and traced. As in other parts of the site area, some of the faults are directly capped by individual boulders, cobbles, pebbles, shells, and fossil bones, none of which have been affected by fault movements. Thus the most recent fault displacements in the plant site area occurred prior to marine planation of the bedrock and deposition of the overlying terrace sediments.

The age of the most recent faulting in this area is therefore at least 80,000 years. More probably it is at

least 120,000 years, the age most generally assigned to these terrace deposits along other parts of the California coastline. Evidence from the higher bench in the plant site area indicates a much older age, as the unfaulted marine deposits there are considerably older than those that occupy the lower bench corresponding to the 100-foot terrace. Moreover, it can be noted that ages thus determined for most recent fault displacements are minimal rather than absolute, as the latest faulting actually could have occurred millions of years ago.

During the Unit 2 exploratory trenching program, special attention was directed to those exposed parts of the wave-cut benches where no marine deposits are present, and hence where there are no overlying reference materials nearly as old as the benches themselves. At such places the bedrock beneath each bench has been weathered to depths ranging from less than an inch to at least ten feet, a feature that evidently corresponds to a lengthy period of surface exposure from the time when the bench was abandoned by the sea to the time when it was covered beneath encroaching nonmarine deposits derived from hillslopes to the east. Stratification and other structural features are clearly recognizable in the weathered bedrock, and they obviously have exercised some degree of control over localization of the weathering. Moreover, in places where upward projections of bedrock have been gradually bent or rotationally "draped"

in response to weathering and creep, their contained fractures and surfaces of movement have been correspondingly bent. Nowhere in such a section that has been disturbed by weathering have the materials been cut by younger fractures that would represent straight upward projections of breaks in the underlying fresh rocks. Nor have such fractures been observed in any of the overlying nonmarine terrace cover.

Thus the minimum age of any fault movement in the plant site area is based upon compatible evidence from undisputed reference features of four kinds: (1) Pleistocene wave-cut benches developed on bedrock, (2) immediately overlying marine deposits that are very slightly younger, (3) zones of weathering that represent a considerable span of subsequent time, and (4) younger terrace deposits of nonmarine origin.

<u>Bedrock Geology Of The Plan Foundation Excavations</u>

Bedrock was continuously exposed in the foundation excavations for major structural components of Units 1 and 2. Outlines and invert elevations of these large openings, which ranged in depth from about 5 feet to nearly 90 feet below the original ground surface, are shown on Figure 27. The complex pattern of straight and curved walls with various positions and orientations provided an excellent three-dimensional representation of bedrock structure. These walls were photographed at large scales as construction progressed, and the photographs were used directly as a

geologic mapping base. The largest excavations also were mapped in detail on a surveyed planimetric base.

Geologic mapping of the plant excavations confirmed the conclusions based on earlier investigations at the site. The exposed section of Monterey strata was found to correspond in lithology and structure to what had been predicted from exposures at the mouth of Diablo Canyon, along the sea cliff in nearby Diablo Cove, and in the test trenches. Thus the plant foundation is underlain by a moderately to steeply north-dipping sequence of thin- to thick-bedded sandy mudstone and fine-grained sandstone. The rocks at these levels are generally fresh and competent, as they lie below the zone of intense near-surface weathering. The appearance of the thick bedded sandstone that was exposed in the excavation for the Unit 2 containment is shown in Figure 21.

Several thin interbeds of claystone were exposed in the southwestern part of the plant site in the excavations for the Unit 2 Turbine Generator Building, intake conduits, and outlet structure. These beds, which generally are less than 6 inches thick, are distinctly softer than the flanking sandstone. Some of them show evidence of internal shearing.

Layers of tuffaceous sandstone and sills, dikes, and irregular masses of tuff and tuff breccia are present in most parts of the foundation area. They tend to increase in abundance and thickness toward the south, where they are relatively near the large masses of Obispo Tuff exposed

along the coast south of the plant site. Some of the tuff bodies are comfortable with the enclosing sandstone, but others are markedly discordant. Most are clearly intrusive. Individual masses, as exposed in the excavations, range in thickness from less than an inch to about 40 feet. The tuff breccia, which is less abundant than the tuff, consists typically of small fragments of older tuff, pumice, or Monterey rocks in a matrix of fresh to highly altered volcanic glass. At the levels of exposure in the excavations, both the tuff and tuff breccia are somewhat softer than the enclosing sandstone.

The stratification of the Monterey rocks dips generally northward throughout the plant foundation area. Steepness of dips increases progressively and in places sharply from north to south, ranging from 10-15 degrees on the north side of Unit 1 to 75-80 degrees in the area of Unit 2. A local reversal in direction of dip reflects a small open fold or warp in the Unit 1 area. The axis of this fold is parallel to the overall strike of the bedding, and strata on the north limb dip southward at angles of 10 to 15 degrees. The more general steepening of dips from north to south may reflect buttressing by the large masses of Obispo Tuff south of the plant site.

The bedrock of the plant area is traversed throughout by fractures, including various planar, broadly curving, and irregular breaks. A dominant set of steeply dipping to

vertical joints trends northerly, nearly normal to the strike of bedding. Other joints are diversely oriented with strikes in various directions and dips ranging from 10 degrees to vertical. Many fractures curve abruptly, terminate against other breaks, or die out within single beds or groups of beds.

Most of the joints are widely spaced, ranging from about a foot to 10 feet apart, but within several northerly trending zones, ranging in width from 10 to 20 feet, closely spaced near-vertical fractures give the rocks a blocky or platy appearance. The fracture and joint surfaces are predominantly clean and tight, although some irregular ones are thinly coated with clay or gypsum. Others could be traced into thin zones of breccia with calcite cement.

Several small faults were mapped in the foundation excavations for Unit 1 and the outlet structure. A detailed discussion of these breaks and their relationship to faults that were mapped earlier along the sea cliff and in the exploratory trenches is included in the following section.

Relationships Of Faults And Shear Surfaces

Several subparallel breaks are recognizable on the sea cliff immediately south of Diablo Canyon, where they transect moderately thick-bedded sandstone of the kind that was exposed in the exploratory trenches to the east. These breaks are nearly concordant with the bedrock stratification, but in general they dip more steeply and trend more northerly

than the stratification. Their trend differs significantly from much of their mapped trace, as the trace of each inclined surface is markedly affected by the local steep topography. The indicated trend, which projects eastward toward ground north of the Unit 1 reactor site, has been summed from numerous individual measurements of strike on the sea cliff exposures, and it also corresponds to the trace of the main break as observed in nearly horizontal outcrop within the tidal zone west of the cliff.

The structure section shows all recognizable surfaces of faulting and shearing in the sea cliff that are continuous for distances of ten feet or more. Taken together, they represent a zone of dislocation along which rocks on the north have moved upward with respect to those on the south as indicated by the attitude and roughness sense of slickensides. The total amount of movement cannot be determined by any direct means, but it probably is not more than a few tens of feet and could well be less than ten feet. This suggested by the following observed features:

As indicated earlier, bedrock was continuously exposed along several exploratory trenches. This bedrock is traversed by numerous fractures, most of which represent no more than rupture and very small amounts of simple separation. The others additionally represent displacement of the bedrock.

That the surfaces of movement along these faults constitute no more than minor elements of the bedrock structure

was verified by detailed mapping of the large excavations for the plant structures. Detailed examination of the excavation walls indicated that the faults exposed in the sea cliff south of Diablo Canyon continue through the rock under the Unit 1 Turbine Generator Building, where they are expressed as three subparallel breaks with easterly trend and moderately steep northerly dips. Stratigraphic separation along these breaks ranges from a few inches to nearly 5 feet, and in general decrease eastward on each of them. They evidently die out in the ground immediately west of the containment excavation, and their eastward projections are represented by several joints along which no offsets have occurred. Such joints, with eastward trend and northward dip, alos are abundant in some of the ground adjacent to the faults on the south (Figure 27).

The easterly reach of the Diablo Canyon sea cliff faults apparently corresponds to the two most northerly of the north-dipping faults mapped in Trench A (Figure 23 and 26). Dying out of these breaks, as established from subsequent large excavations in the ground east of where Trench A was located, explains and verfies the absence of faults in the exposed rocks of Trenches B and C. Other minor faults and shear surfaces mapped in the trench exposures could not be identified in the more extensive exposures of fresher rocks in the Unit 1 containment and turbine generator building excavations. The few other minor faults

that were mapped in these large excavations evidently are not sufficiently continuous to have been present in the exploratory trenches.

1. All individual breaks are sharp and narrow, and the strata between them are essentially undeformed except for their gross inclination.

2. Some breaks plainly die out as traced upward along the cliff surface, and others merge with adjoining breaks. At least one well-defined break butts downward against a cross-break, which in turn butts upward against a break that branches and dies out approximately 20 feet away (see structure section for details).

3. Nearly all the breaks curve moderately to abruptly in the general direction of movement along them.

4. Most of the breaks are little more than knife-edge features along which rock is in direct contact with rock, and others are marked by thin films of gouge. Maximum thickness of gouge anywhere observed is about half an inch, and such exceptional occurrences are confined to short curving segments of the main break at the southerly margin of the zone.

5. No fault breccia is present; instead, the zone represents transection of otherwise undeformed rocks by sharply-defined breaks. No bedrock unit is cut off and juxtaposed against a unit of different lithology along any of the breaks.

6. Local prominence of the exposed breaks, and especially the main one, is due to slickensides, surface coatings of gypsum, and iron-oxide stains rather than to any features reflecting large-scale movements.

This zone of faulting cannot be regarded as a major tectonic element, nor is it the kind of feature normally associated with the generation of earthquakes. It appears instead to reflect second-order rupturing related to a marked change in dip of strata to the south, and its general sense of movement is what one would expect if the breaks were developed during folding of the Monterey section against what amounts to a broad buttress of Obispo Tuff farther south (see geologic map, Figure 23). That the fault and shear movements were ancient is positively indicated by upward truncation of the zone at the bench of marine erosion along the base of the overlying terrace deposits.

III

THE HOSGRI FAULT

A. Overview

The Hosgri fault zone is present in the area offshore from the coast of south-central California, where it extends for a distance of about 145 km (90 miles) between end points near Purisima Point on the south and near Cape San Martin on the north (Figure 29). The fault zone is part of a larger zone of flexurng and faulting, referred to here as the Coastal Boundary zone, that is a boundary feature

between the uplift of the Southern Coast Ranges and the structural depression of the adjacent offshore Santa Maria and Sur Basins.

The Hosgri fault is a basin boundary structure that has a complex history of generally east-up displacements with a large component of dip-slip. Several lines of geologic and seismologic evidence also suggest that significant amounts of lateral movement have occurred along it. The most recent movements along both the Hosgri fault and other faults of the Coastal Boundary zone have been characterized by oblique-slip displacements with dominantly dip-slip components.

The Hosgri fault is nowhere exposed on land, as are some other major elements of the Coastal Boundary zone such as the San Simeon fault and the Serra Hill fault which are exposed locally in uplifted areas near Point Piedras Blancas and Point Sur. The Hosgri fault underlies the sea floor at water depths ranging from 150 feet to 500 feet. The part of the sea floor above about 400 feet depth was exposed subaerially during the late Pleistocene Wisconsinan glacial maximum, but it has been submerged during the gradual rise of sea level to its present elevation during the past 17,000 years or so. Since erosion is minimal below the depth of active wave disturbance, the sea floor provides a generally good morphologic record of the cumulative total of any surface faulting episodes that have occurred during this

time span. Along the trace of the Hosgri, several topographic features are associated with different fault strands at scattered localities, and these could represent local surface breaks during the 17,000-year time span. The generally featureless character of the sea floor along the Hosgri fault trace, however, precludes the possibility of either large-scale or recurrent surface offsets along it during the last 10,000 to 17,000 years. In the event that such offsets had occurred during this time span, detectible rift and scarp topography, similar to that along the San Andreas fault, should be present along long reaches of the submerged Hosgri trace.

The feature now referred to as the Hosgri fault evidently was first mapped by geologists and geophysicists of the Shell Oil Company during the course of a program of exploration along the offshore margin of central and northern California for hydrocarbon potential. This work was done in the mid-1960's, and a paper that includes maps showing the faults, other structural features, and locations of offshore borings was published by Ernest G. Hoskins and John R. Griffiths of the Shell Company in 1971 (Figure 30). The zone of structural disturbance that includes the Hosgri fault also was noted in 1970 by the U.S. Geological Survey during the course of offshore geophysical profiling related to the Survey's review of the construction license application for Diablo Canyon Unit 2. This zone was not then considered

to represent a potential for a level of seismic activity beyond that for which the plant was designed.

In 1973, the USGS carried out a much more detailed and extensive geophysical survey of the offshore region between Point Sal and Cape San Martin. This, together with a reevaluation of seismicity data for the corresponding region, led the Survey to a view that the fault, now named the Hosgri after its discoverers, probably is seismically capable. The USGS further concluded that the 7.3 magnitude Lompoc or Pt. Arguello earthquake of 1927 could have originated along the southerly part of the Hosgri fault. This conclusion apparently was a principal factor in the Survey's postulation of a 7.5 magnitude earthquake on the Hosgri fault as the design earthquake for the Diablo Canyon site.

In 1975, Clarence A. Hall published an hypothesis that there has been 80 km or more of right slip on a combined San Simeon - Hosgri fault system during the past 5 to 13 million years. This hypothesis of major slip was based upon the proposed correlation of an assemblage of rocks exposed near Point Sal with an assemblage exposed near San Simeon. Hall apparently made no independent study of the actual geometry of the Hosgri and San Simeon faults, and his map, derived from the then current USGS map, does not show these faults to be joined. Neither does it show the Hosgri fault to extend south of Point Sal in a way that would permit accommodation of the postulated amount of slip.

In 1977, Steven Graham and William R. Dickinson published an hypothesis based on a series of correlations inferred by them and by Clarence Hall and Eli Silver. They suggested that about 115 km of right slip has occurred along a series of breaks extending from the San Andreas north of San Francisco through the San Gregorio fault to the Hosgri. This hypothesis assumed the existence of through-going links between the known faults, thereby providing a continuous fault of at least 400 km in length. In contrast, studies at various points along this series of faults by D.H. Hamilton and C.R. Willingham indicate that the total amount of right slip along any of these faults in the area extending southward from the Santa Cruz Mountains cannot have exceeded a maximum value of approximately 20 km. Moreover, they found that the Hosgri and San Simeon faults are not connected by a through-going link, an interpretation consonant with the map prepared earlier by Hoskins and Griffiths.

Other work, including seismologic studies by Stewart W. Smith and detailed high resolution geophysical surveys of the ocean floor in the epicentral area of the 1927 earthquake, has led to a conclusion that the earthquake did not occur on the Hosgri fault, but instead probably originated on a currently active fault associated with a large anticline located offshore from Purisima Point, southwest of the Hosgri fault. The Hosgri fault itself terminates in this area, where its trace is overlain by apparently

undisturbed sea-floor deposits of from around 10,000 to 100,000 years of age.

B. Exploration; Geophysical Manifestations

Throughout its known length, the Hosgri fault underlies the ocean floor, along which it has no consistent topographic expression. Thus exploration of this feature necessarily has been accomplished chiefly through use of various geophysical techniques. Methods that have been employed include several types of seismic or acoustic reflection profiling systems, as well as mapping of the earth's gravity and magnetic fields in the region traversed by the fault. Samples of the rocks and surficial deposits that underlie the sea floor near the fault trace have been gathered by means of dart coring techniques. One deep test well, drilled earlier at a location west of the fault, provides for comparison of the stratigraphic section there with the onshore section east of the fault at various places.

Maps showing some of the regional and local geophysical survey track lines that have yielded data applied to the Hosgri fault investigation are shown on Figures 31 and 32. The several techniques that have been applied in exploration of the Hosgri fault are described briefly as follows:

Seismic-Accoustic Reflection Techniques

Three major categories of reflection-surveying procedures have been used in the investigations along the

Hosgri fault. All involve receiving and recording energy reflected from the sea floor and from various horizons within the geologic section beneath the sea floor. The resulting data define a seismic cross section through the ground along the survey line; this section usually resembles a geologic cross section through the corresponding area. The three systems can be described as single-channel, multi-channel, and shallow high-resolution.

Single channel systems are commonly referred to as sparker or airgun, according to the source used for input energy. The reflected energy is picked up by hydrophones, then recorded by a one-channel analogue procedure that usually employs a strip-chart recorder. Energy penetration beneath the sea floor varies according to geologic conditions; it also varies with power and frequency of the energy input, higher power and lower frequency giving deeper penetration but also lower resolution. Horizontal or gently inclined layered sedimentary sections give the best energy returns; massive or complexly deformed bedrock generally gives little in the way of useful returns.

The earliest and most extensive surveys of the Hosgri fault employed single-channel sparker systems. Fault breaks tend to appear in the resulting records as disruptions or truncations within the section, as zones of disturbance indicated by confused or incoherent seismic returns, as sharp changes in apparent dip of strata, as changes in the

character of adjacent sections, or as zones where diffraction patterns originate. Figure 33 shows an example of the appearance of the Hosgri fault on a single-channel sparker record.

A more advanced type of reflection surveying involves recording the seismic returns on several channels, usually in digital form on magnetic tape. This allows use of the "common depth point" (CDP) technique of data processing, which greatly improves the accuracy and usefulness of the seismic information. Fault breaks have the same general manifestations in multichannel CDP records as in single channel records. Energy sources commonly used for multi-channel reflection surveying include sparker, air gun, expanding sleeve explosion chamber, and explosives. Most of the multichannel CDP surveying of the Hosgri fault has yielded data proprietary to oil companies and contract geophysical surveying firms, but data from two surveys have been acquired for use during the investigations relating to the Diablo Canyon site.

Shallow penetration, high-resolution survey procedures are used to investigate the details of sea floor morphology, surficial deposits, and structure in the uppermost few tens of feet of the underlying rock section. Most high resolution systems employ a single-channel analogue recording system.

Other systems for investigating details of the surface morphology include precision fathometer profiling, which is similar to the high resolution shallow penetration system except that it does not penetrate beneath the sea floor; the side-scan sonar system; and underwater photography. Both fathometer and side-scan sonar records of the sea floor over the Hosgri fault have been obtained during various surveys. Underwater photography has not been attempted because of the generally high turbidity of the water in the region of interest.

Magnetic Field Mapping

The earth's magnetic field can be mapped by plotting and contouring measurements taken along a grid of traverses. Magnetic surveys of regional extent are usually accomplished by ship- or aircraft-borne magnetometers. The resulting data, after appropriate corrections are made, can be plotted to yield a map showing local variations, or anomalies, in the earth's magnetic field. For geologic purposes this is most useful if rocks containing magnetic minerals are present at or near the surface. Faults usually are best inferred where intact blocks of ground composed of rocks with relatively high but different magnetic signatures are juxtaposed. Fault breaks in rocks of low magnetism, such as much of the basin fill section that is cut by the Hosgri fault, may not be detectable by magnetic mapping. For the areas of shallow, magnetic basement rocks near the Point Piedras Blancas and

Point Sur uplifts, in contrast, the magnetic anomaly map pattern can show both faults and unfaulted blocks of rock between faults. Figure 34 shows the magnetic map of the coastal margin and its relationship to mapped faults of the Hosgri and San Simeon zones.

<u>Gravity Field Mapping</u>

The earth's gravity field can be mapped using procedures similar to those employed in magnetic mapping. Data from scattered points or traverses of gravity-field measurements are plotted and contoured. The measurements are made from shipboard or with land-sited gravity meters. The resulting map of gravity anomalies essentially shows areas of contrasting density in the upper part of the crust. As with magnetic mapping, this data can reveal, under conditions where rocks of differing density are structurally juxtaposed, useful information about geologic structure.

C. <u>Geology Of The Main Reach, Point Sal To Cambria</u>

The main or central reach of the Hosgri fault (Figure 35) extends over a distance of about 60 miles, between the approximate latitudes of Point Sal on the south and Cambria on the north. Beyond this reach the fault extends about 10 miles farther south and about 20 miles farther north, to give a total length of about 90 miles for the entire zone.

Within the main reach, the fault zone is fairly straight and trends about N25W. North of Estero Bay, the

strike bends westward and the zone widens and evolves into separate splays and isolated breaks. Folding of the strata within and adjacent to the fault zone becomes prominent near the ends of the main reach.

The Hosgri fault, in its main reach, is a nearly vertical planar break or a narrow zone of such breaks that appears as segments within thick sections of late Tertiary sedimentary rocks opposite the Santa Maria River Valley and opposite Morro Bay. These geometrically simple segments are separated by a more complex zone, comprising at least four large breaks, where the fault cuts across the more resistant rocks of the Point San Luis structural high. The area of multiple breaks includes a graben, or down-dropped slice, between the two dominant fault strands.

Sections across the Hosgri fault to a depth of about 5000 feet show that Pliocene and older rocks are displaced downward to the west along it (Figure 36). Commonly the displacement can be seen to have been progressive through late Miocene and subsequent time. Evidence of at least local, deeply buried, pre-late Miocene reverse faulting is preserved along the reach of the zone opposite the Point San Luis high (Figures 36, 37). Within the upper two to three thousand feet of section, the fault planes of the Hosgri zone are relatively narrow, clean breaks, apparently with minimal development of gouge (crushed rock in the fault) and little severe distortion or fracturing of the

adjacent rocks. The relationships seen in cross section suggest long-term incremental displacements in a vertical sense.

Evidence of strike-slip (horizontal) movements along the Hosgri fault is less definitive than is the obvious evidence of vertical separation. The three main lines of evidence that indicate or suggest a component of strike slip movement are:

1. Focal mechanism solutions of small earthquakes on the Hosgri show a right oblique sense of fault slip.

2. The fault zone is nearly straight along its central reach, which is a characteristic of lateral-slip faults.

3. Some onshore parts of the San Simeon fault and the Sur fault zone members of the Coastal Boundary zone show geomorphic evidence of right-lateral offsets.

H. Wagner of the USGS has cited, as possible evidence of lateral slip along the Hosgri fault, observed differences in thickness of Tertiary rock sections on opposite sides of the fault, along with inferred differences in character of juxtaposed Tertiary and Quaternary units as seen in seismic reflection records (Wagner, 1974). Although some lateral slip may well have occurred, these conditions might better be attributed to successive episodes of vertical offset combined with continuing sedimentation on the down-dropped side and erosion on the up-thrown side of the fault,

and also to changes in the seismic registration of similar but differently oriented strata.

The large amount of right-lateral slip along the Hosgri fault, as proposed by C.A. Hall (Hall, 1976), apparently reflects an hypothesis that was developed independently of any direct study of the actual fault zone geometry or characteristics. The hypothesis was based on an inferred correlation of rocks exposed at Point Sal and near San Simeon, and on an inference that the two rock assemblages were originally together and subsequently separated by more than 80 km of right slip along the Hosgri fault. The hypothesis has been challenged on both stratigraphic and structural grounds, and it is here regarded as invalid. Consideration of all available evidence leads instead to a conclusion that not more than about 20 km of right-lateral slip could have occurred along the central reach of the Hosgri fault since early Miocene time (about 20 million years ago); the actual amount could be as little as a few kilometers. Vertical movement displacement along this part of the fault zone has ranged between 1 and 2 km during the same time span.

Considerations that appear to limit the amount of possible lateral slip along the Hosgri fault include the following:

1. The fault is not through-going in the sense of connecting with other faults in a way that would permit transmission of tens of kilometers of lateral offset.

Instead, it dies out longitudinally in folds and in groups of separate, isolated fault breaks.

2. The stratigraphic section penetrated by the Oceano Well, located west of the fault, is similar to the stratigraphic section of the adjacent Santa Maria - Casmalia region east of the fault. Further, it is unlike the stratigraphic section south of the Santa Ynez River, with which it should correlate if many tens of kilometers of right slip had occurred along the Hosgri fault. The similarity of sections between the Oceano Well and the onshore Santa Maria region appears to limit possible lateral slip to a maximum of about 20 km, although it actually could have been much less.

3. The existence of a wider, more complex pattern of faulting in the Hosgri zone directly opposite the Point San Luis structural high strongly suggests that lateral slip in that region has not exceeded a few kilometers, at least since Pliocene time. Otherwise, lateral movement of the seaward block would have carried the wide zone progressively northward across Estero Bay.

The sea-floor morphology along the main reach of the Hosgri fault varies chiefly in accordance with recency of uplift in local areas and with differential resistance to erosion of rocks juxtaposed across the fault. Opposite and south of San Luis Obispo Bay, the fault lies within younger Tertiary rocks and has no surface expression (Figure 38).

Where they are adjacent to the Point San Luis high, the more easterly fault strands locally coincide with submerged marine terrace steps (Figure-39). The steps in places are localized at the fault where it forms a boundary between rocks of lesser and greater resistance, which makes it difficult to determine whether some of the slip differential elevation could represent vertical fault movement. Opposite Estero Bay, the Hosgri fault locally coincides with small sea-floor ridges or steps, including one that faces landward. Some of these features are interpreted to represent possible local sea-floor offsets. The existence of an undisturbed sea-floor across the fault at other nearby points, however, precludes any possible Holocene rupture along the north-central reach of the Hosgri from exceeding a few thousand feet length.

D. Geology Of The Hosgri Zone North Of Point Estero; Relationship To The San Simeon Fault

The Hosgri fault zone can be traced for a distance of about 30 miles, 50 kilometers, north of Estero Bay. Within this northerly reach, it changes progressively northward from a narrow zone with large vertical offset to a wide zone of folds with less well-defined fault breaks, and thence to an unbroken fold structure (Figures 40, 41).

The general trend of the Hosgri zone curves gradually toward the west between Estero Bay and Point Piedras Blancas, thence back to a trend similar to that of the central reach.

The broad, convex-to-the-west broad arch described by this trend follows the southwest flank of the Point Piedras Blancas antiform or upwarp. The uplift lies between the northerly part of the Hosgri zone and the central and southerly part of the en-echelon San Simeon fault, and it has effected much of the transfer of vertical and lateral offset between these faults. From the vicinity of this uplift northward nearly to Pfeiffer Point, the San Simeon fault forms the main break of the Coastal Boundary zone.

A question of some importance in evaluating the structural relationship of the Hosgri fault to the San Simeon fault is whether a direct, through-going connection may exist between the two faults. It seems clear that the existence of such a connection would be necessary to permit transfer of a substantial amount of slip from one fault to the other, either cumulatively through geologic time or during one earthquake - fault rupture event.

Evidence bearing on this issue has been reviewed previously (FSAR Appendix 2.5.E, p. 2.5.E 38-39) and is here summarized as follows:

1. Seismic reflection lines that cross the Hosgri fault between Point Estero and San Simeon Point do not show any major branches of the Hosgri extending toward the projected southerly extension of the San Simeon fault.

2. These reflection lines show that the contact between late Tertiary rocks and acoustic basement rocks that

approximately parallels the shore line between Point Estero and San Simeon Point is not displaced as it should be if offset by major vertical or lateral faulting.

3. The Monterey cherty shale that lies along the southwest side of the San Simeon fault at San Simeon Point can be traced 4 miles to the southeast in seismic reflection records, indicating that the San Simeon fault does not veer toward the Hosgri in that reach.

4. The splay faults that branch westward from the San Simeon fault north of San Simeon Point form a distinctive structural pattern. These faults may well extend to the northernmost part of the Hosgri fault, but their orientation precludes significant transference of strain (especially right-lateral strain) between the major parts of the two faults.

5. The Hosgri fault dies out north of Point Piedras Blancas. It does not veer toward the San Simeon fault, but instead gradually dies out along a trend that is subparallel to that of the San Simeon fault.

Additional evidence regarding the possibility of a Hosgri - San Simeon fault link, not dependent on interpretation of seismic reflection profiles, is provided by the aeromagnetic map of the Point Estero - San Simeon region (Figure 42). This map of residual magnetic intensity clearly shows the San Simeon fault as a linear magnetic low, or trough, between the pronounced magnetic high associated with

the ophiolite basement rocks west of the fault and the more scattered magnetic highs of the mixed Franciscan and ultramafic terrane east of the fault. The Hosgri fault, as mapped from seismic reflection data, is associated with the gradient along the southwesterly, seaward side of the San Simeon area magnetic high. This magnetic high appears to be associated with a block of basement rocks that extends unbroken between the Hosgri and the San Simeon faults in the area that would contain any linking break that could permit through-going transfer of slip from one fault to the other. The magnetic anomaly pattern indicates that no such break exists, and reinforces the conclusion that the Hosgri and San Simeon faults are distinct, unconnected breaks.

E. Geology Of The Hosgri Zone South Of Point Sal; Relationship To The Western Transverse Ranges

From about the latitude of Point Sal southward, the Hosgri fault progressively loses definition as a separate major break and merges into a zone of complex folding that generally characterizes this region (Figure 43).

The southernmost extension of the Hosgri zone may continue for a distance of about 10 miles south of Point Sal. At its extreme southerly end it apparently dies out within a zone of tight folding that extends seaward from the vicinity of Purisima Point. This interpretation agrees closely with the original Shell Oil Company map of the Hosgri fault published by Hoskins and Griffiths, and more

generally with the map included with Appendix 2.5.E of the Diablo FSAR. An early interpretation by the USGS (e.g., Figure 2 of USGS open-file report 77-593, McColloch et al., 1977) that the Hosgri fault continued southward as far as Point Arguello evidently has been revised, and the most recently released USGS map of the fault (Map MF-910, Buchanan - Banks, et al., 1978) shows the break as ending just south of Purisima Point.

The substantial displacement across the central reach of the Hosgri fault diminishes southward, and strain in its southerly reach evidently has been accommodated by folding distributed throughout the region, as well as by local reverse faulting. Some movement probably has been taken up along the Lions Head fault, which extends onshore south of Point Sal. This fault has the same east-up sense of vertical displacement as the Hosgri farther north, whereas the southernmost break along the Hosgri trend is east-down.

The southerly end of the Hosgri is in the region where mutually interfering strain systems are present. These are the dominantly right-oblique system extending from the Coast Ranges and offshore basin to the north, and the left-oblique system extending from the Western Transverse Ranges to the east. The major structural feature that shows evidence of late Quaternary tectonic activity, indicated geologically by fold arching and fault disruption of the sea floor, is the offshore Lompoc anticline and reverse fault

system, located several miles west of the Hosgri trend. The Hosgri itself offsets rocks of Pliocene age, as it does along its central reach to the north, but it has not been found to exhibit evidence of late Quaternary (post-Wisconsinan) surface displacement.

F. Overall Structural Relationships Of The Hosgri Fault

As has been noted earlier in this testimony, the Hosgri fault forms the southerly part of the Coastal Boundary zone of features and faults that lies between the uplift of the Southern Coast Ranges and the structural depression of the offshore basins. Because of its location at the south end of the Coast Ranges it is also involved in the transition from Coast Ranges to Transverse Ranges structure. The overall structural relationships of the Hosgri can be generalized into three regions, each characterized by a particular set of relationships. These are, first, northerly region, where strain is transferred across the Piedras Blancas antiform between the Hosgri fault and the next major member of the Coastal Boundary zone to the north, the San Simeon fault. Second, the central region, where west-northwesterly trending folds and faults in the uplifted ground east of the Hosgri are detached across it from north-northwesterly folds in the downdropped basin on its west side. Lastly is the

southerly zone where the Hosgri enters and dies within the region of merging between the northwesterly, right lateral structure trends of the Southern Coast Ranges and the east-west, left-lateral structure trends of the Western Transverse Ranges. These general relationships are illustrated on Figure 44.

In the central regions of both the Hosgri and the San Simeon faults, vertical strain is accommodated chiefly by high angle dip slip displacement, so that sections of early Miocene and younger strata ranging between 1 and 3 km in thickness are buttressed against the faults. Right lateral slip is also at a maximum along the central regions of each of these faults, although it probably does not exceed about 10 km, and it may amount to only a few km. Along the central part of the Hosgri, the structural trends across the fault differ in orientation by about 30 degrees, and the folds in the ground on the east side are large, long established features that show evidence of progressive evolution since upper Miocene time. This pattern of large folds oriented oblique to the trend of the Hosgri fault may, at least in part, represent accommodation by folding of the right lateral strain along the central reach of the fault - essentially in effect of "wrinkling" the crust on one side of a set of horizontally sliding blocks.

In the northerly region of the Hosgri, the vertical strain is mainly taken up by the large complex upwarp of the

Piedras Blancas antiform. This fold, together with a series of reverse fault splays contained within it, apparently effects the transfer of both horizontal and lateral strain between the Hosgri and San Simeon faults, and the faults themselves are less developed in this region. The antiformal transfer region nonetheless appears to be a zone of relatively higher stress concentration, since it has been the source of frequent small to moderate earthquakes throughout the time of historic record.

The southerly region of the Hosgri fault lies within the transition zone between the Southern Coast Ranges and the Western Transverse Ranges structural provinces. Here the main east-up vertical strain from the central reach of the Hosgri is partly taken up along the Lions Head fault, which extends onshore south of Point Sal as a steeply dipping north-up right-oblique fault with at least 1000 meters of vertical displacement, and which dies out to the east. The remainder of the vertical strain is apparently dispersed in the series of tight folds that exist in the strata adjacent to the Hosgri fault. Right -lateral slip that extends southward from the central reach of the Hosgri fault partly transfers to the Lions Head fault, and partly is accommodated in folds and isolated faults along both sides and across the end of the southernmost break of the Hosgri zone, along the reach between Point Sal and Purisma Point.

G. Evidence Relating To Late Pleistocene And Holocene Displacements

The Hosgri fault underlies the gently seaward-sloping, near-shore margin of the continental shelf area. The nearest abrupt topographic rises lie 2.5 miles (4 km) east of the fault trace at Point Buchon and along the mountainous coastline between Point Estero and Cambria. There is no overall topographic expression of the fault, and there is little associated micro-topography such as commonly exists along traces of active late Quaternary faults on land. It can be suggested that either the latest large-scale offsets along the Hosgri fault occurred far enough back in time -- at least hundreds of thousands of years ago -- to have been obliterated by successive episodes of marine and coastal erosion, or that late Quaternary movement has been dominantly horizontal.

In considering the significance of the fine details of sea-floor morphology and of relations of faulting to surficial deposits underlying the sea floor, it is important to note that the sea floor to depths of about 400 feet was exposed to subaerial erosion during the late Pleistocene Wisconsinan low stand of sea level and was then subjected to marine planation during the succeeding rise in sea level to its present elevation. The rise, which occurred mainly between about 17,000 and 5,000 years ago, resulted in obliteration of earlier small-scale topographic evidence of

surface fault movements during the past 10,000 to 17,000 years, after submergence exceeded the depth of active wave erosion.

Surface displacements that have occurred since this resubmergence should have created detectable disturbance of the sea floor and of the late Pleistocene and Holocene deposits that locally underlie. Seismologic evidence that earthquakes in the region have right-oblique mechanisms, and geologic evidence that the Hosgri fault has a history of vertical offset, and geologic evidence that the most recent movements of faults in the San Simeon zone have been high-angle reverse or vertical strongly indicate that any recent surface movements along the Hosgri should have had significant vertical components and therefore should have created scarps and vertical offsets of contacts that would be detectible on high-resolution seismic reflection profiles. Furthermore, any recent surface faulting associated with large earthquakes should have produced topographic effects along substantial reaches of the fault trace.

The entire length of the Hosgri fault zone has been surveyed by intermediate and high-resolution systems. The density of survey coverage is greatest along the reach between Estero Bay and San Luis Obispo Bay, but good reconnaissance coverage exists for the fault zone as far as its north and south ends. The results of this exploration show that both the sea floor and the wave-cut rock surface beneath

the post-Wisconsinan surficial deposits are unbroken along any survey line south of San Luis Obispo Bay (e.g., Figures 38, 45). From San Luis Obispo Bay northward to Estero Bay, the Hosgri extends across an area of submerged marine terrace steps in the sea floor (Figure 39). These steps show the form that is characteristic of a sea cliff formed by retreat of the coastline; that is, the slope of the sea floor flattens in a wave-cut bench at the base of the step. Some of the steps are cut into unfaulted ground, thus demonstrating that they were formed independently of any faulting. At some places, however, the terrace steps are essentially coincident with well-defined fault breaks in the underlying rock section. These localities represent uncertainties as to whether some vertical fault offset may be involved in addition to the erosionally developed topographic relief. The fact that no similar topographic steps exist along the fault at points north and south of the area of submerged terraces strongly suggests that the terrace steps are wholly erosional in origin, whether or not they correspond in general position to the trace of a fault. In the absence of proof to the contrary, however, it must be considered possible that some late Pleistocene or Holocene vertical surface displacements may exist for short distances along some strands of this reach of the Hosgri zone.

Opposite Point Buchon, a high-resolution profile indicates a low land-side-down step in the sea floor over

the seaward trace of the Hosgri fault along the west side of the graben structure in that area. Because this step faces landward instead of seaward, and has the same topographic sense as the sense of offset along the underlying fault, it is considered to have significant probability of being a young fault scarp. It is between 1 and 2 meters in height, but no such feature can be detected in high-resolution profiles located at distances of 1000 feet to the north and south, across the Hosgri trace.

IV

CONCLUSIONS

1. The Diablo Canyon area is underlain by sedimentary and volcanic bedrock units of Miocene age. Within this area, the power plant site is underlain almost wholly by sedimentary strata of the Monterey Formation, which dip northward at moderate to very steep angles. More specifically, the reactor sites are underlain by thick-bedded to almost massive Monterey sandstone that is well indurated and firm.

2. The bedrock beneath the power plant site occupies the southerly flank of a major syncline that trends west to northwest. No evidence of a major fault has been recognized within the immediate vicinity of the site, and bedrock relationships in the exploratory trenches positively indicate that no such fault is present within the area of the power plant site.

3. Minor surfaces of disturbance, some of which plainly are faults, are present within the bedrock that underlies the power plant site. None of these breaks offsets the interface between bedrock and the cover of terrace deposits, and none of them extends upward into the surficial cover. Thus the latest movements along these small faults must have antedated erosion of the bedrock section in Pleistocene time, at least 80,000 to 120,000 years ago.

4. Larger faults in the region of the Diablo Canyon site, including the Hosgri fault, exhibit evidence of no more than small or negligible amounts of displacement of the ground surface during latest Pleistocene and Holocene time, indicating that the level of seismic activity in the region has been such that no large offsets have occurred, either as single events or cumulatively, along potentially seismogenic faults during a span of time ranging back at least to late Pleistocene.

5. The Hosgri fault is about 145 km in length, its end point lies within complex zones of folding and minor faulting that die out into unbroken strata. It is part of a larger system of faults and flexures that form a boundary zone between the relatively rising and subsiding blocks of the Southern Coast Ranges and the offshore Santa Maria Basin, but it is not a primary element of a transitional plate boundary system.

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GLOSSARY

Acoustic Basement - The zone that yields no coherent or useful seismic reflections, at the base of a sequence of reflecting horizons (if any are present).

Acoustic Reflection Technique - (see Seismic Reflection) The process including the receiving and recording of energy reflected from the sea floor and from various horizons beneath the sea floor.

Aeromagnetic - Referring to magnetic measurements taken from an airplane.

Allochthonous - Formed elsewhere; not formed at its present location.

Alluvial - Pertaining to or composed of alluvium (sediment transported by a stream), or deposited by a stream or running water.

Anticline - A convex upward fold, the interior of which contains the oldest rocks.

Antiform - A complex anticlinal structure in which the stratigraphy may not be defined.

Arkosic Sandstone - A sandstone which contains a large percentage of the mineral feldspar.

Augite - A pyroxene rock-forming mineral.

Basalt - A common, dark-colored volcanic rock, often formed by solidification of a lava flow.

Basement - A complex of undifferentiated rocks that underlies the oldest identifiable rocks in the area.

Batholith - A large, generally discordant mass of intrusive igneous rock (such as granite) having more than 100 km^2 of surface exposure.

Bedrock - Any solid rock exposed at the surface or covered by unconsolidated sediment.

Bench - A level or gently sloping erosion surface.

Bituminous - Referring to the content of a mixture of hydrocarbons, or loosely to a material containing much organic or carbonaceous material.

Boudin - One of a series of elongate, sausage-shaped segments occurring in a boudinage structure.

Boudinage - A structure common in deformed rocks in which an originally continuous, competent layer has been stretched and thinned at regular intervals to produce elongate bodies (boudins) parallel to the fold axis.

B.P. - Before the present.

Breccia - Course-grained, clastic (fragmented) rock composed of large, angular, rock fragments cemented together in a find-grained matrix.

Cenozoic - Geologic time from present to about 65 million years before present.

Clastic - Pertaining to fragments (clasts) composing a rock.

Colluvial - Pertaining to or composed of colluvium (sediment deposited by unconcentrated surface runoff or sheet erosion).

Conformable - Said of sedimentary layers that horizontally overlie one another without deformation, or a long period of erosion, represented between them.

Conglomerate - Sedimentary rock composed primarily of pebble- and gravel-sized material.

Continental Crust - The portion of the earth's crust that forms the continents, distinguished from oceanic crust by its lighter density and (usually) its chemical composition.

Continental Slope - Relatively steep slope usually separating the submerged edge of a continent from a deeper ocean basin.

Cretaceous - The geologic period extending from about 65 to 136 million years before present.

Cross-Fault - A fault which strikes diagonally or perpendicularly to the strike of faults in the area.

Crust - The outermost (100 km ±) layer of the earth.

Crystalline - Said of a rock consisting of crystals or fragments of crystals, formed by crystallization from a melt, or recrystallization under conditions of elevated temperature and/or pressure.

Diabase - A common igneous rock formed by intrusion into the crust of molten volcanic rock at shallow depth; "diabasic" refers to a common igneous texture.

Diatomaceous - Composed of diatoms, a microscopic single-celled marine plant made of silica.

Dike - An intrusive body which cuts across the planar structures (such as bedding) of the surrounding rocks.

Dip-Slip - Component of fault movement or slip that is parallel to the dip of the fault.

Earthquake - Brief motion or shaking in the earth caused by the sudden release of accumulated strain energy, usually through slippage of rock in the earth's crust along a fault.

En-Echelon Segments - Geologic features, such as faults, that are in an overlapping or staggered arrangement.

Eocene - Geologic time from about 38 million to 54 million years before present.

Epicenter - The point on the earth's surface directly above the focus, or hypocenter, of an earthquake.

"Facies Changes" - Minor lithologic and/or fossil changes due to local changes in the environment of deposition.

Fan Deposits - Sedimentary deposits formed at the base of a slope, usually in a fan shape.

Fault - Surface or zone of rock fracture along which there has been displacement.

Fault Creep - Slow deformation of ground along a fault due to continuous application of stress.

Fault Line - The trace of the intersection of a fault plane with the ground surface.

Fault-Line Scarp - A steep slope or cliff formed by differential erosion along a fault line.

Fault Scarp - A steep slope or cliff formed by fault movement at the ground surface.

Focal Mechanism - Process that leads to the generation of seismic waves, usually through fault slippage, during an earthquake.

Fold - A curve or bend of a planar geologic feature, usually due to deformation.

Foraminifera - Unicellular animal usually marine and microscopic in size; fossils of Foraminifera are often useful for determining the approximate geologic age of a sedimentary rock.

Formation - Primary unit for describing and mapping a succession of similar and related rock materials.

Geodetic Data - Data pertaining to the accurate surveying of the earth's surface.

Geomorphic - Of or pertaining to the form of the earth's surface features.

Geomorphic Province - Region whose form or surface features correspond to a particular pattern or range of patterns, and differ significantly from those of adjacent regions.

Graben - An elongate block which has been down-dropped along faults that bound the long sides.

Gypsum - A mineral (hydrous calcium sulfate).

High Resolution Profiling - A type of marine seismic reflection profiling that has good resolution of small-scale features, but can only penetrate to shallow depths in the material beneath the sea floor.

Holocene - Geologic time from present to about 10,000 years before present.

Hypabyssal - Pertaining to an igneous intrusion of intermediate depth in the earth's crust.

Hypocenter (focus) - That point within the earth's crust which is the center of an earthquake and the origin of its energy release.

Igneous - Descriptive term for rocks formed by crystallization from a molten state; includes both volcanic rocks and plutonic (formed at depth in the crust) rocks.

Joint - A surface of fracture or parting in a rock, without displacement.

Jurassic - The geologic period extending from about 136 to 195 million years before present.

Klippen (plural of klippe) - Isolated rock blocks separated from the underlying rocks by a low-angle fault; remnants of a formerly continuous thrust sheet.

Late Miocene - Geologic time from about 5 million to 13 million years before present.

Late Quaternary - Geologic time from present to about 200,000 years before present.

Left-Lateral - Type of motion occurring on a fault along which the side across the fault from the observer appears to have moved to the left.

Lithologic - Of or pertaining to the description of rocks, especially sedimentary clastic rocks.

Mafic - Referring to iron-magnesium minerals generally dark in color..

Magma - Molten rock, usually a large mass.

Magnitude - A measure of the strength of an earthquake or the energy released by it.

Marine Planation - Process of near-shore waves eroding the bedrock down to a planar surface, usually over a fairly long period during a time of gradually rising sea level.

Melt - Molten rock;.implies formed through the melting of once solidified rock.

Mesozoic - Geologic time from about 65 million to 225 million years before present.

Metamorphic - Descriptive term for rock formed from pre-existing rocks by mineralogical, chemical, and structural changes, essentially in the solid state, as response to changes in temperature, pressure, shearing stress, and chemical environment at depth; also, textural features associated with metamorphic processes.

Middle Miocene - Geologic time from about 13 million to 16.5 million years before present.

Mineral Assemblage - The minerals that compose a rock.

Miocene - Geologic time from about 5 million to 23 million years before present.

Modified Mercalli (MM) - Referring to a scale of earthquake intensity having 12 divisions ranging from I to XII, based on increasing felt intensity and degree of damage.

Morphology - Shape of the land (or of some geologic features).

M.Y. - Million years.

Normal Fault - A steeply dipping fault in which the rock above a dipping fault plane moves down with respect to below the fault plane rock; a fault with the opposite sense of movement of a reverse fault.

Oblique Slip - Component of fault movement or slip that is intermediate in orientation between dip slip and strike slip.

Oceanic Crust - The part of the earth's crust which typically underlies the oceans; has different composition and different geophysical properties from continental crust.

Oligocene - Geologic time from 23 million to 38 million years before present.

Olivine - A mineral usually found in igneous rocks.

Opaline - Similar to opal, an amorphous hydrous form of silicon dioxide.

Ophiolite Assemblage - A group of rock types which is characteristic of the oceanic crust.

Paleocene - Geologic time from about 54 million to 65 million years before present.

Perlitic - A texture found in volcanic glass consisting of concentric cracks.

Petrologic - Of or pertaining to the origin, occurrence, structure and history of rock, especially as reflected in the constituent minerals and fabric.

Pillow Basalt - Basalt extruded under water, having an external form characterized by rounded, "pillow" shapes.

Plagioclase - One of the feldspar rock-forming minerals.

Plate Boundary - A zone along which two crustal plates interact according to the plate tectonic model of the earth. The most common types of boundaries are: 1) spreading ridges along which new crust is formed; 2) trenches or subduction

zones along which crust is consumed; and 3) transform faults, along which crustal plates move passively by each other.

Plate Tectonics - Earth model which divides the surface or crust of the earth into a small number of large "plates" or segments of a spherical surface which "float" on a viscous underlayer or mantle. These crustal plates move relative to one another, and the geological effects that develop along the boundaries between relatively moving plates are said to be related to plate tectonics.

Pleistocene - Geologic time from about 10,000 to 2.5 million years before present.

Pliocene - Geologic time from about 2.5 million to 5 million years before present.

Plunge - The inclination of a fold or other geologic structure, measured by its angle with the horizontal.

Plutonic Rocks - Igneous rocks which solidify at considerable depth beneath the earth's surface.

Post-Wisconsinan - Geologic time extending from about 15,000 to 17,000 years, the last major low-stand of sea level coinciding with maximum extent of late Pleistocene glaciation, to the present.

Potassium-Argon Age - Radiometric age based on analysis of isotopic content and ratio of potassium and argon in a mineral.

Pumice - A very porous, glassy volcanic rock.

Pumiceous - Pumice-like.

Pyritization - The process by which an original mineral is changed into the mineral pyrite through chemical exchange and recrystallization.

Pyroclastic - Pertaining to a clastic (fragmented) rock formed by debris from explosive volcanic eruptions.

Quaternary - Geologic time from present to about 2.5 million years before present.

Radiolarian Chert - A silica-rich sedimentary rock formed primarily of radiolarians, a single-celled marine animal which has a complex siliceous skeleton.

Radiometric Dating - Determining age in years for geological materials by measuring a short-life radioactive element, e.g. carbon-14, or by measuring a long-life radioactive element plus its decay product (e.g. potassium-argon).

Reflector Horizon - In seismic reflection profiling of the ocean floor, a prominent reflecting layer.

Reverse Fault - A fault in which the rock above a dipping fault plane is uplifted relative to the rock beneath the fault plane; similar to a thrust fault but generally steeper dipping.

Richter Magnitude - Numerical scale representing earthquake energy; devised in 1935 by seismologist C. F. Richter.

Right-Lateral - Sense of motion occurring on a fault along which the ground across the fault from the observer appears to have moved to the right.

Rise - Oceanic spreading ridge or zone of crustal formation.

Sea-Floor Spreading - Theory that the oceanic crust is being added to by convective upward movement of molten material along the spreading ridges in the ocean and then moving away from the ridges as new crust.

Sedimentary - Descriptive term for rock formed of particles of other rock transported and deposited at another location; also textural features associated with sedimentary deposition.

Sedimentary Rocks - Rocks formed by the accumulation of particles, usually in water but also from the air, and by chemical precipitation, characteristically in layers called bedding or stratification.

Seismic Activity - Earthquakes.

Serpentine - General term used to describe a group of common rock-forming minerals, or rock composed of these minerals. The minerals are derived from alteration of pre-existing iron-magnesium-rich rocks.

Sill - An intrusive body which is emplaced generally parallel to the planar structure (such as bedding) in the surrounding rocks.

Spreading Ridge - A zone along which new crust is fairly continuously formed, according to the plate tectonics model of the earth, by the upward movement of molten

material, its solidification into crustal material, and subsequent lateral movement in opposite directions away from the zone as part of the two plates being created at, and moving away from, the spreading ridge.

Strain - Deformation of materials due to applied forces.

Strandline - The line or level at which a body of water, such as the sea, meets the land; also a former shoreline now elevated above or depressed below the present water level.

Stratigraphic - Pertaining to rock layers or strata.

Strike - The geographic orientation of an imaginary line which is the intersection of a horizontal plane with a bedding plane, fault plane, or other planar surface in question.

Strike-Slip - Component of fault movement or slip that is horizontal.

Structural - Of or pertaining to features that are the result of folding and faulting.

Structural Grain - Predominant orientation or pattern of folds and faults.

Structural Province - Region whose geologic-structural features correspond to a particular pattern or range of patterns, and which differ significantly from those of adjacent regions.

Subaerial Erosion - Erosion occurring on the land surface above sea level.

Subduction - A plate tectonic process occurring along the boundary of two converging crustal plates where one plate is thrust under and sinks beneath the margin of the other plate.

Syncline - A concave upward fold, the interior of which contains the youngest rocks.

Talus - An accumulation of fallen rock fragments forming a slope at the foot of a steeper slope.

Tectonic Pattern - Similar pattern of folding and faulting and implied history which is characteristic of a particular region during a given period of geologic time.

Terrace - Relatively flat to gently inclined surface, often long and narrow, locally present along the coast, as an uplifted (or submerged) bench developed in response to surf-zone marine erosion (wave-cut bench).

Tertiary - Geologic time from about 2.5 million to 65 million years before present.

Thrust Fault - A fault with a dip of 45° or less in which the material above the fault plane has moved upward relative to the material beneath it.

Trace - intersection of a geologic surface, such as a fault, with another surface, usually the ground surface.

Trench - (geologic term) The topographic low created during subduction. (exploration term) An elongate open excavation.

Triple Junction - Area of intersection of three plate boundaries according to the plate tectonics model of the earth. Theoretically, any combination of the three basic plate boundaries (ridges, trenches, transform faults) may intersect to form a triple junction.

Tuff - A rock formed of compacted volcanic fragments, generally smaller than 4 mm.

Ultramafic - Pertaining to igneous rocks composed chiefly of mafic (dark) minerals.

Uncomformity - A surface of erosion or non-deposition that separates younger strata from older rocks.

Underthrusting - Type of fault motion where a lower rock mass is actively moved under an upper, passive rock mass. Used especially to describe a type of plate tectonics boundary condition where one plate is being thrust under an adjacent one. The underthrusting process is referred to as subduction.

Vertical Slip - The vertical component of fault movement.

Vitric-Lithic - Textural term used to describe rocks composed of both glass and rock fragments.

Volcanic - Descriptive term for rock formed by the ejection onto the earth's surface and subsequent solidification of molten or igneous material; also describes processes associated with volcanoes.

Volcanic Rocks - Rocks formed from material erupted from a volcano, which solidified on the surface.

Zeolite - A common secondary mineral, especially in volcanic rocks.

Zeolitization - The process by which an original mineral is changed into a zeolite mineral through chemical exchange and recrystallization.

ILLUSTRATIONS

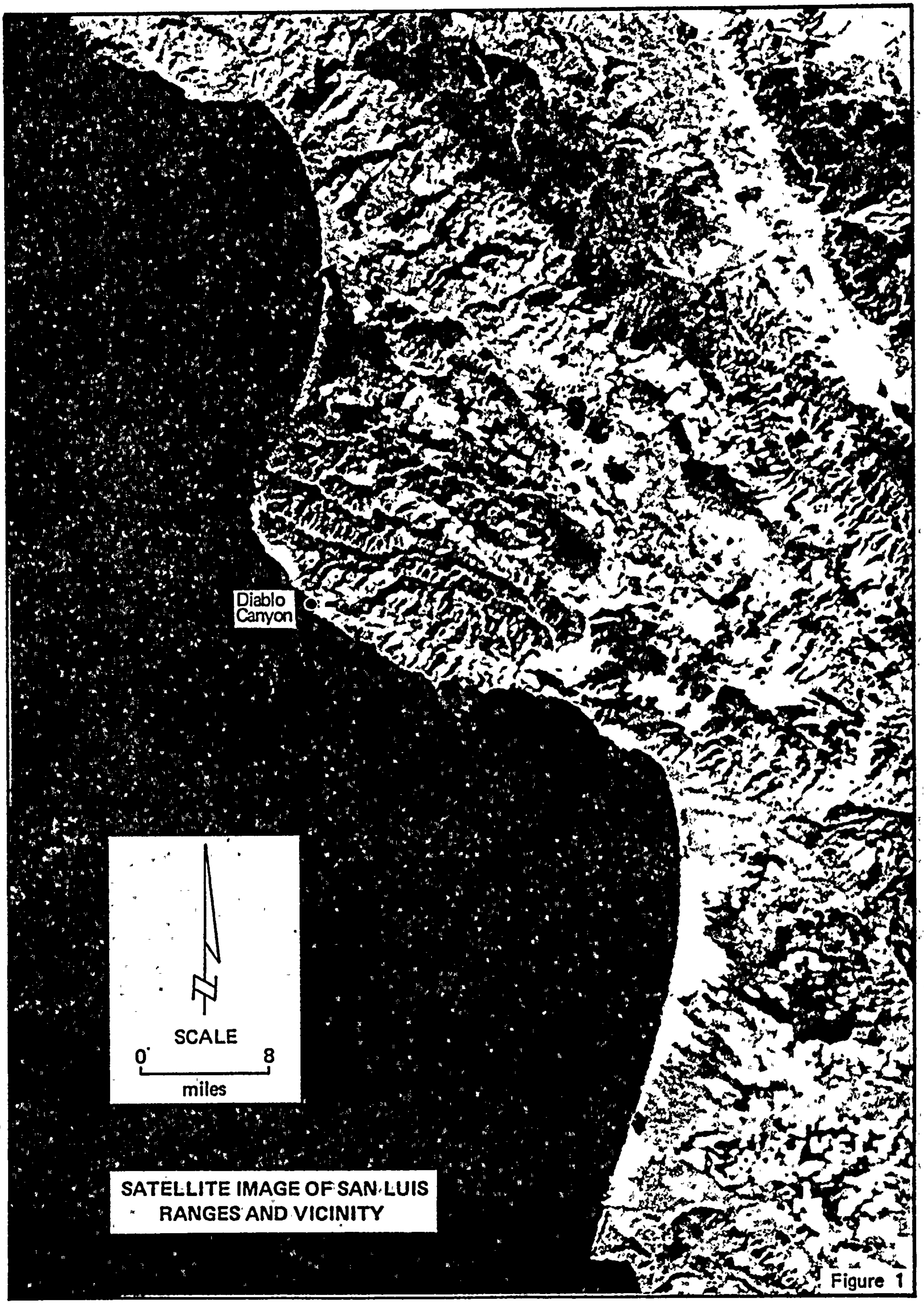
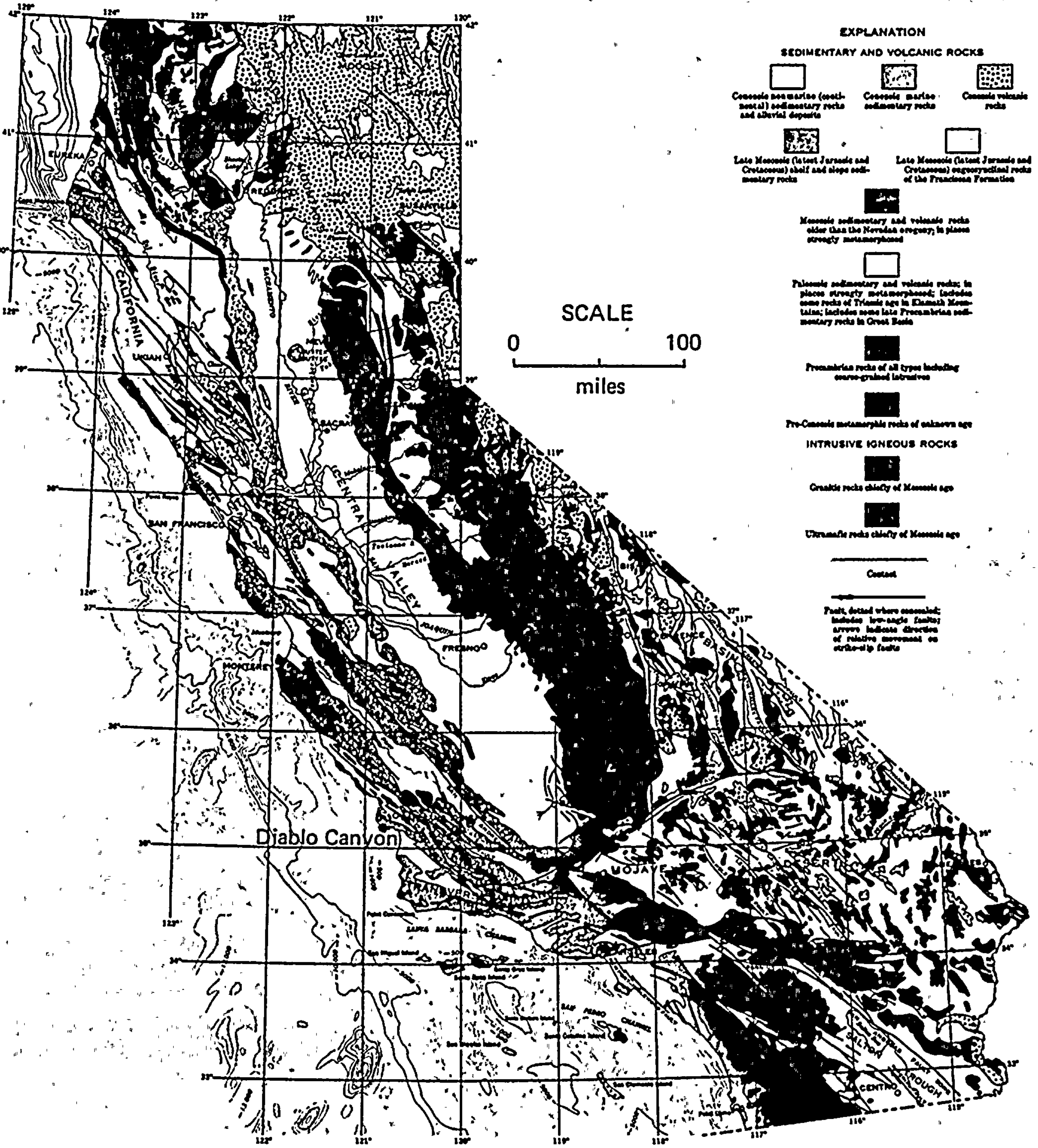
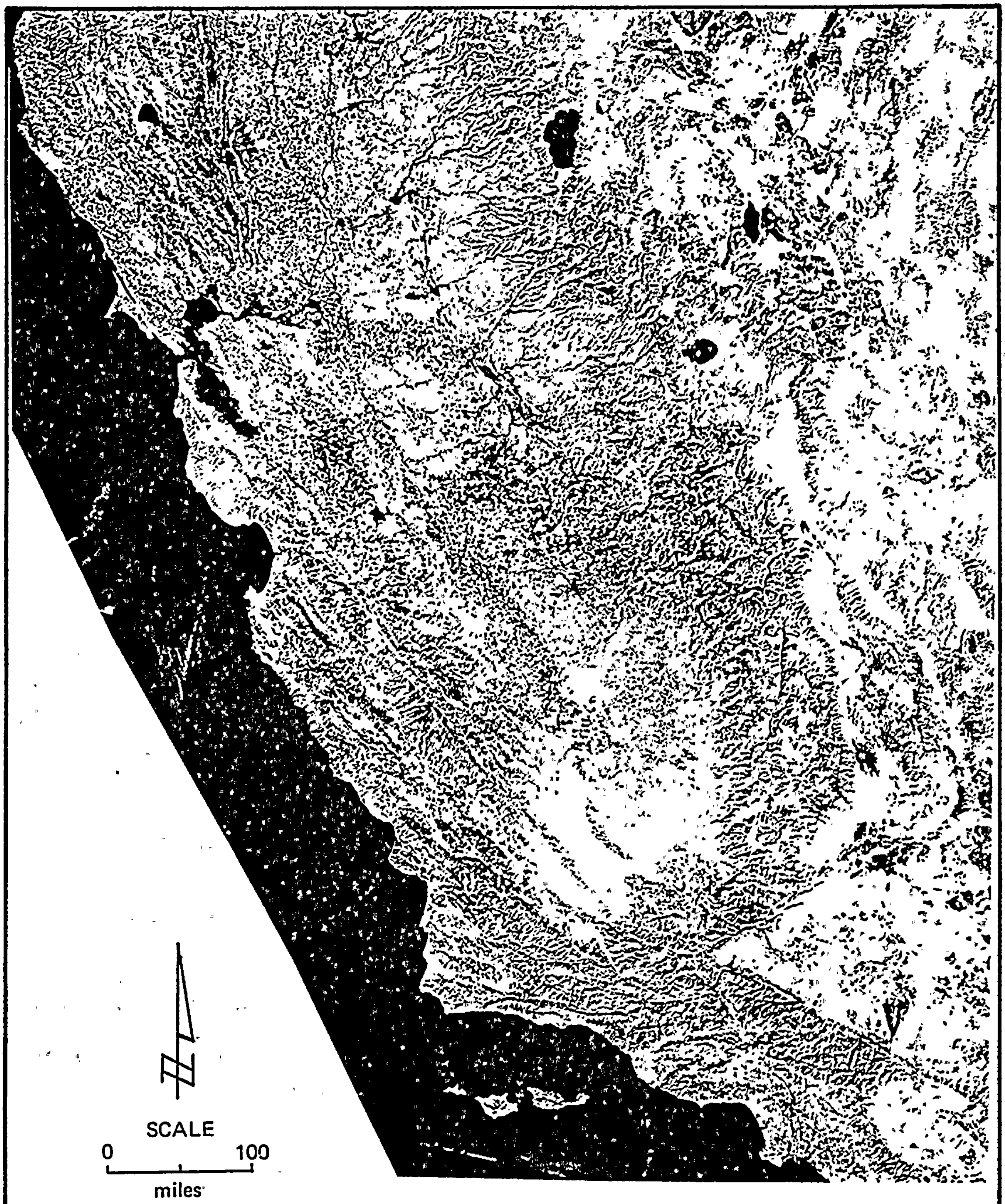

Diablo
Canyon
SCALE
0
8
miles
SATELLITE IMAGE OF SAN LUIS
RANGES AND VICINITY

Figure 1



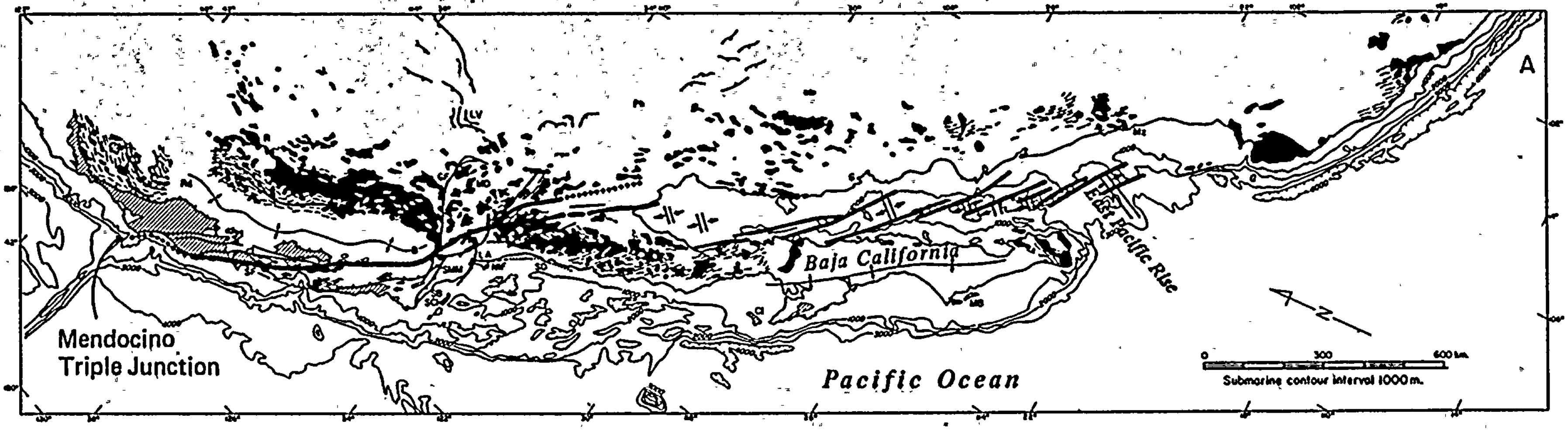
GENERALIZED GEOLOGIC MAP OF CALIFORNIA

Figure 2



SATELLITE IMAGERY — WEST COAST

Figure 3



B	Bakersfield	MZ	Mazatlan
CI	Cedros Island	N-IF	Newport-Inglewood Fault
G	Guaymas	Ph	Phoenix
GF	Garlock Fault	R	Reno
LA	Los Angeles	Rd	Redding
LV	Las Vegas	SB	Santa Barbara
M	Monterey	SCI	Santa Cruz Island
MB	Magdalena Bay	SD	San Diego
MD	Mojave Desert	SF	San Francisco

Mesozoic granitic rocks ans assorted high temperature-low pressure metamorphic rocks

Franciscan rocks; graywacke, shale, mafic volcanics ans serpentines metamorphosed to various high pressure-low temperature mineral assemblages

PLATE TECTONICS MAP: GULF OF CALIFORNIA TO CAPE MENDOCINO

Modified from Suppe, 1970.

Figure 4

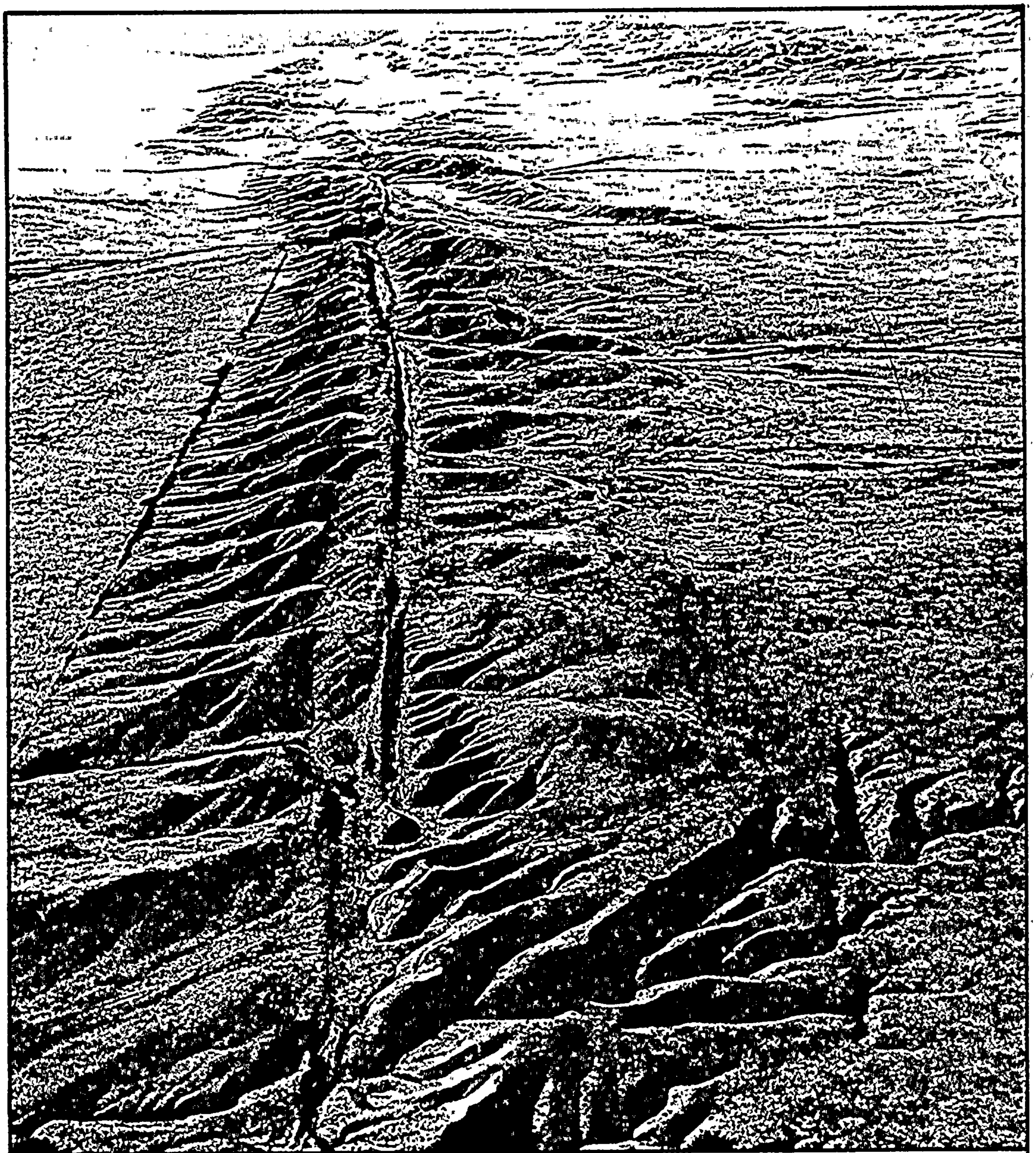
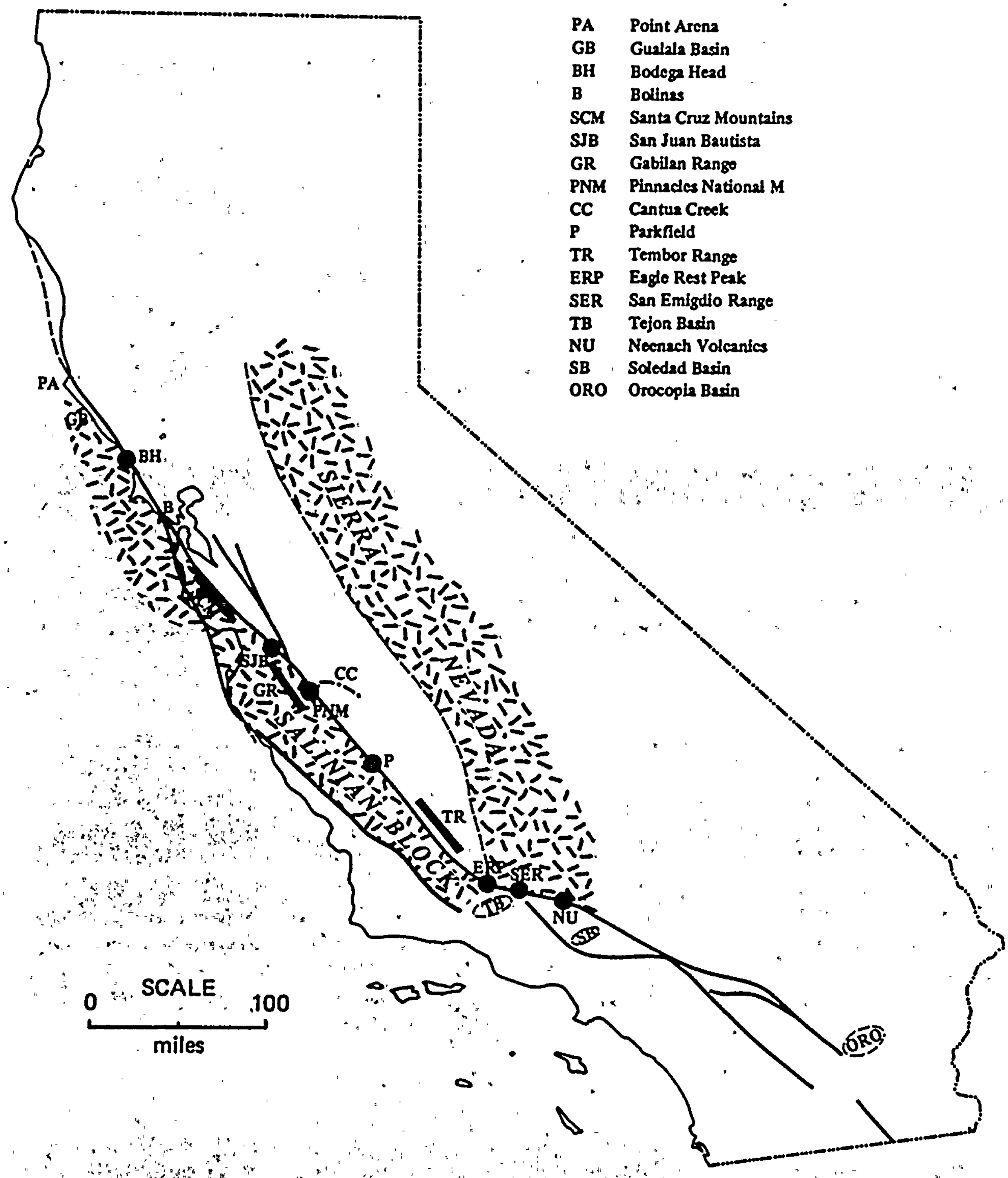


Photo by R. Wallace, USGS

OBLIQUE AERIAL PHOTOGRAPH OF SAN ANDREAS FAULT CROSSING CARRIZO PLAIN, VIEW LOOKING NORTH

Figure 5



SAN ANDREAS FAULT OFFSET POINTS

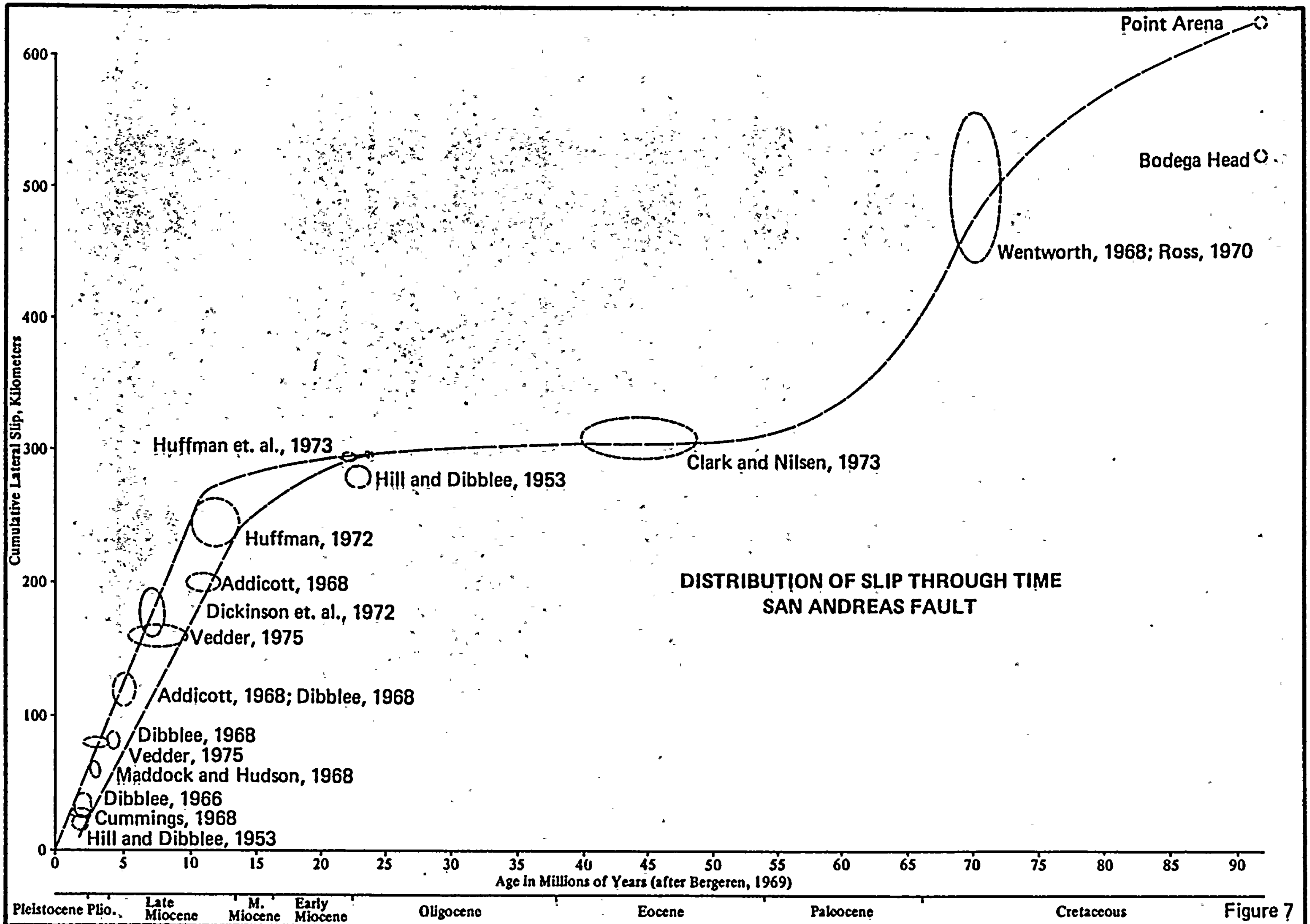
Modified from Graham, 1976.

Figure 6

TABLE FOR FIGURE 6
SAN ANDREAS FAULT OFFSET POINTS

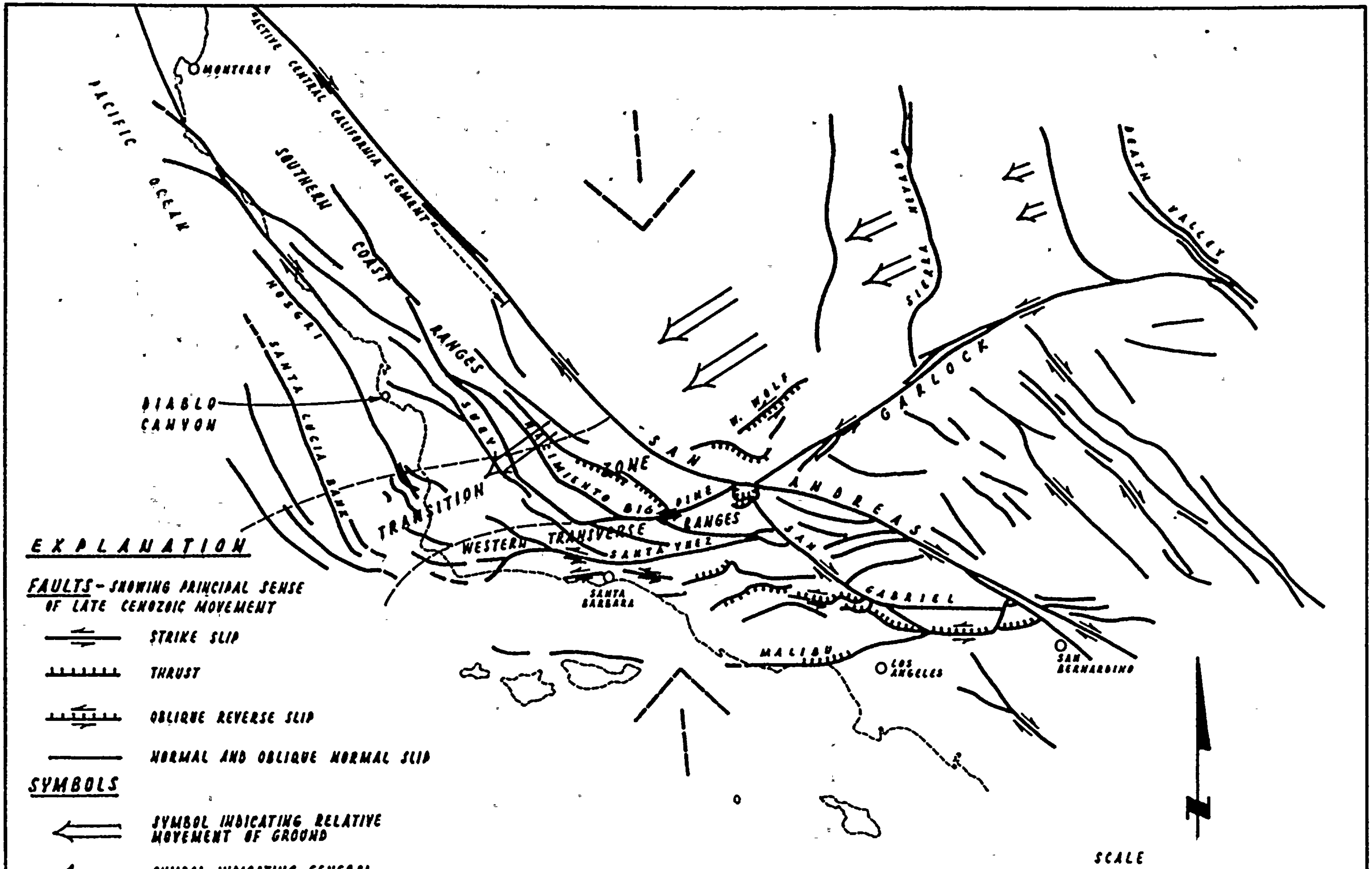
POINTS	*AGE*	*OFFSET, km.*
B-BH		*70*
P-PNM	*MIOCENE*	*80*
B-GB		*120*
TR-GR	*POST UPPER MIOCENE*	*240*
ORO-SB-TB	*POST OLIGOCENE*	*260-305*
SER-SJB	*22 m.y.*	*280-305*
NV-PNM	*23.5 m.y.*	*298-314*
TR-SCM	*POST EOCENE*	*305-330*
CC-GB	*POST EARLY EOCENE*	*322*
ERP-B	*CRETACEOUS*	*450*
ERP-GB	*CRETACEOUS*	*435-565*
ERP-BH	*92 m.y.*	*525*

PA	*POINT ARENA*
GB	*GUALALA BASIN*
BH	*BODEGA HEAD*
B	*BOLINAS*
SCM	*SANTA CRUZ MOUNTAINS*
SJB	*SAN JUAN BAUTISTA*
GR	*GABILAN RANGE*
PNM	*PINNACLES NATIONAL MONUMENT*
CC	*CANTUA CREEK*
P	*PARKFIELD*
TR	*TEMBLOR RANGE*
ERP	*EAGLE REST PEAK*
SER	*SAN EMIGDIO RANGE*
TB	*TEJON BASIN*
NU	*NEENACH VOLCANICS*
SB	*SOLEDAD BASIN*
ORO	*OROCOPIA BASIN*



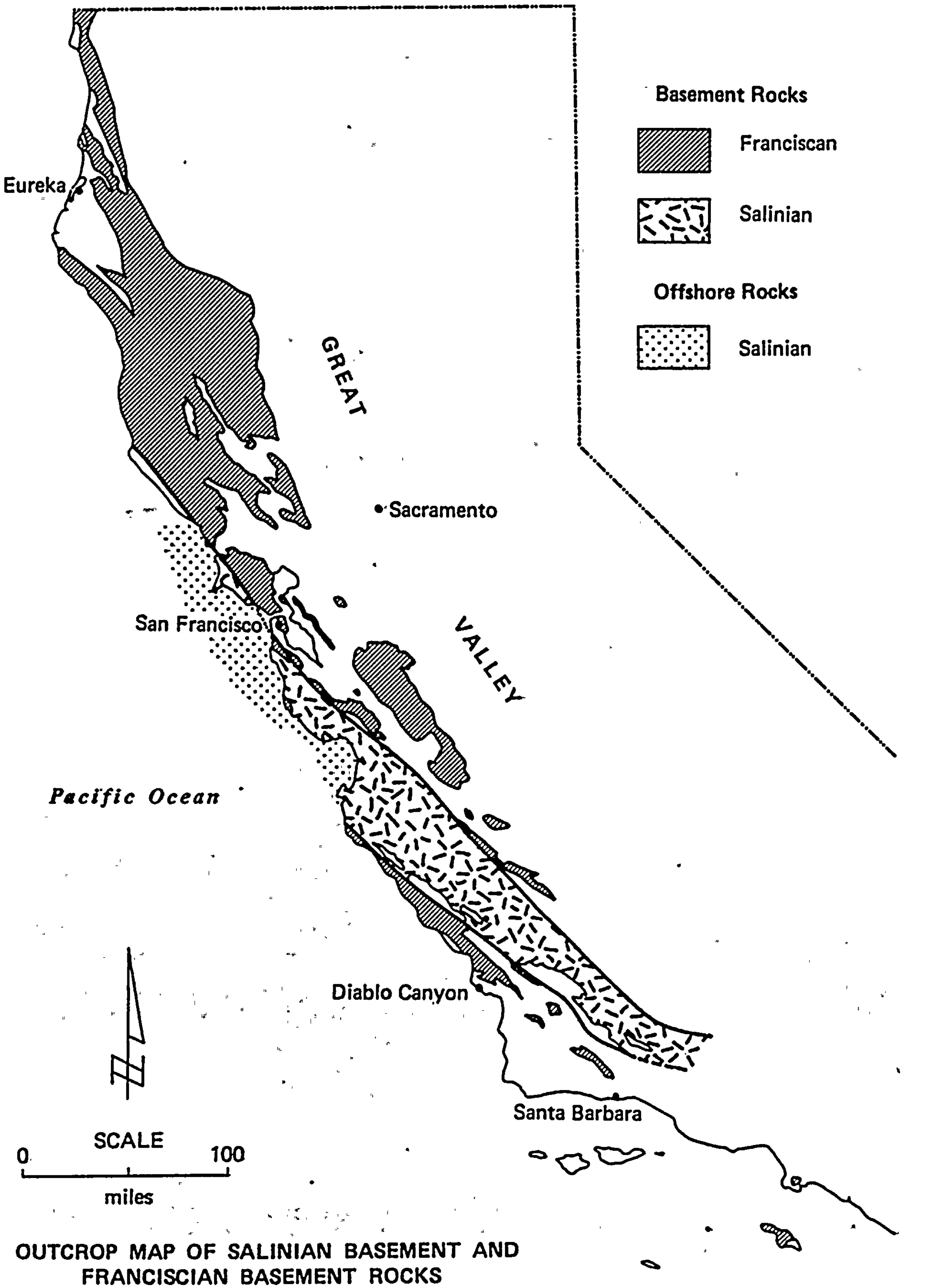
Point Arena
Bodega Head
Wentworth, 1968; Ross, 1970
Huffman et. al., 1973
Clark and Nilsen, 1973
Hill and Dibblee, 1953
Huffman, 1972
Addicott, 1968
Dickinson et. al., 1972
Vedder, 1975
Addicott, 1968; Dibblee, 1968
Dibblee, 1968
Vedder, 1975
Maddock and Hudson, 1968
Dibblee, 1966
Cummings, 1968
Hill and Dibblee, 1953
DISTRIBUTION OF SLIP THROUGH TIME
SAN ANDREAS FAULT
Cumulative Lateral Slip, Kilometers
0
100
200
300
400
500
600
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
Age in Millions of Years (after Bergeren, 1969)
Pleistocene Plio.
Late Miocene
M. Miocene
Early Miocene
Oligocene
Eocene
Paleocene
Cretaceous

Figure 7



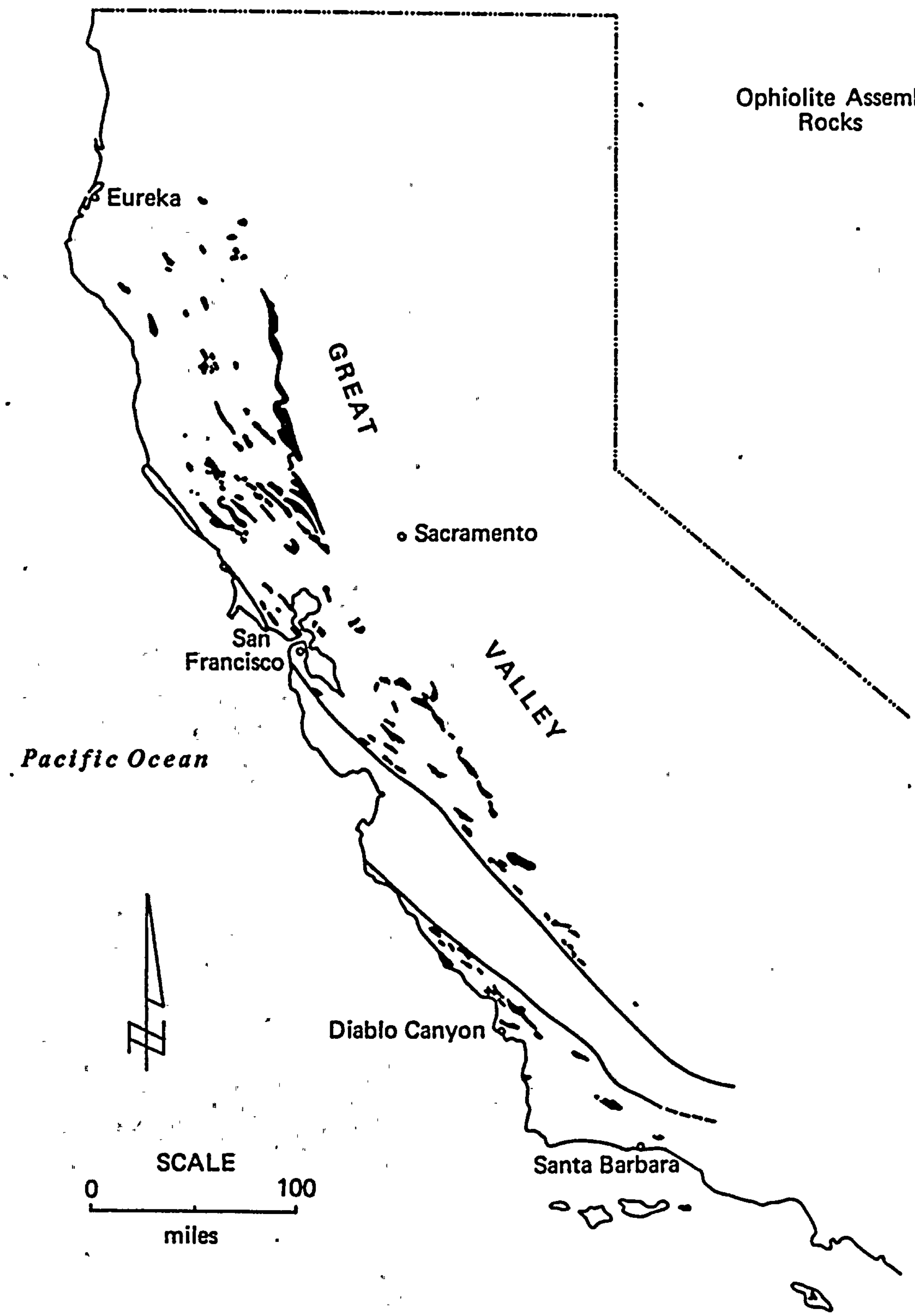
MAP OF SOUTH CENTRAL COASTAL CALIFORNIA SHOWING STRUCTURAL PROVINCES AND FAULTS

Figure 8



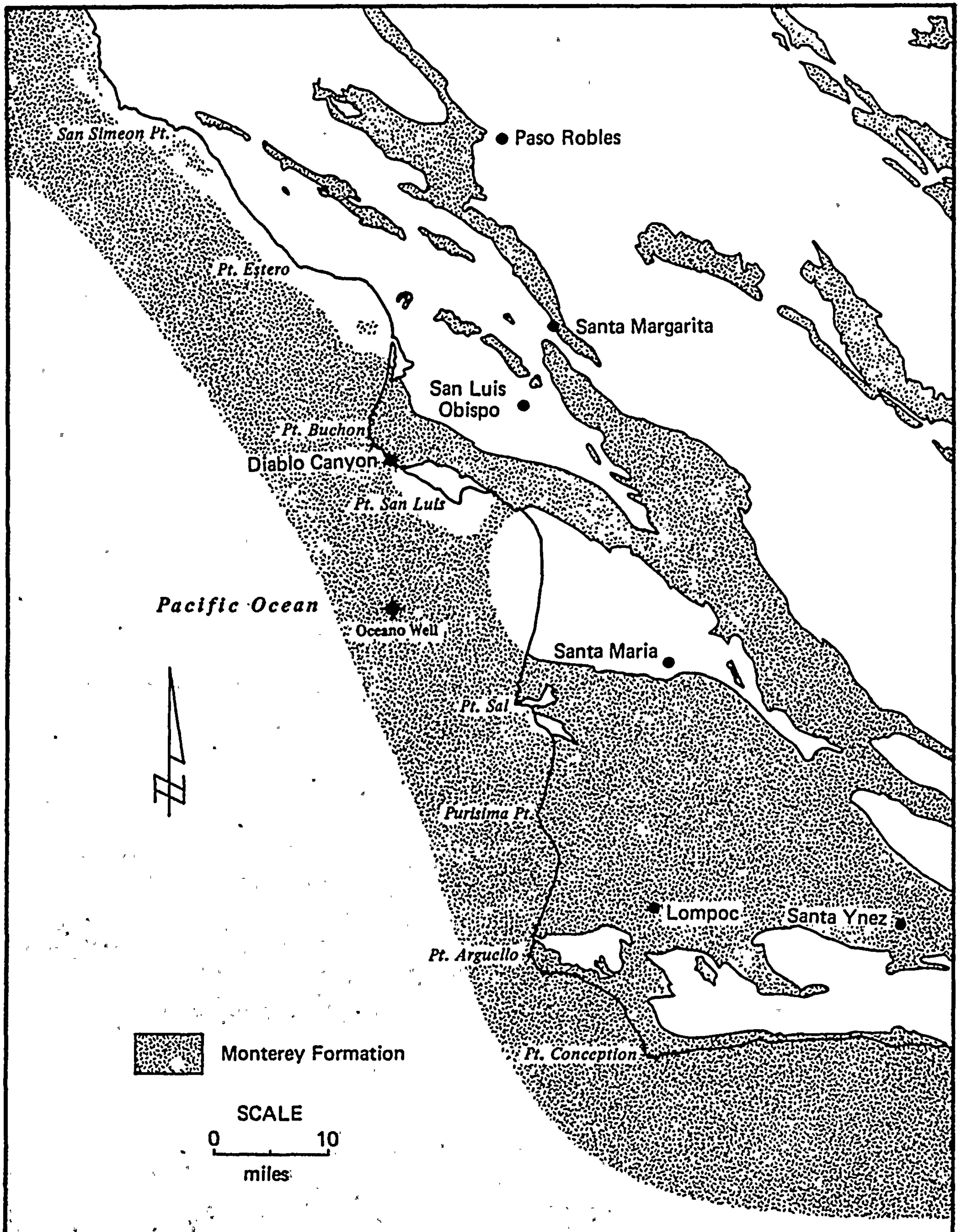
OUTCROP MAP OF SALINIAN BASEMENT AND FRANCISCAN BASEMENT ROCKS

Figure 9



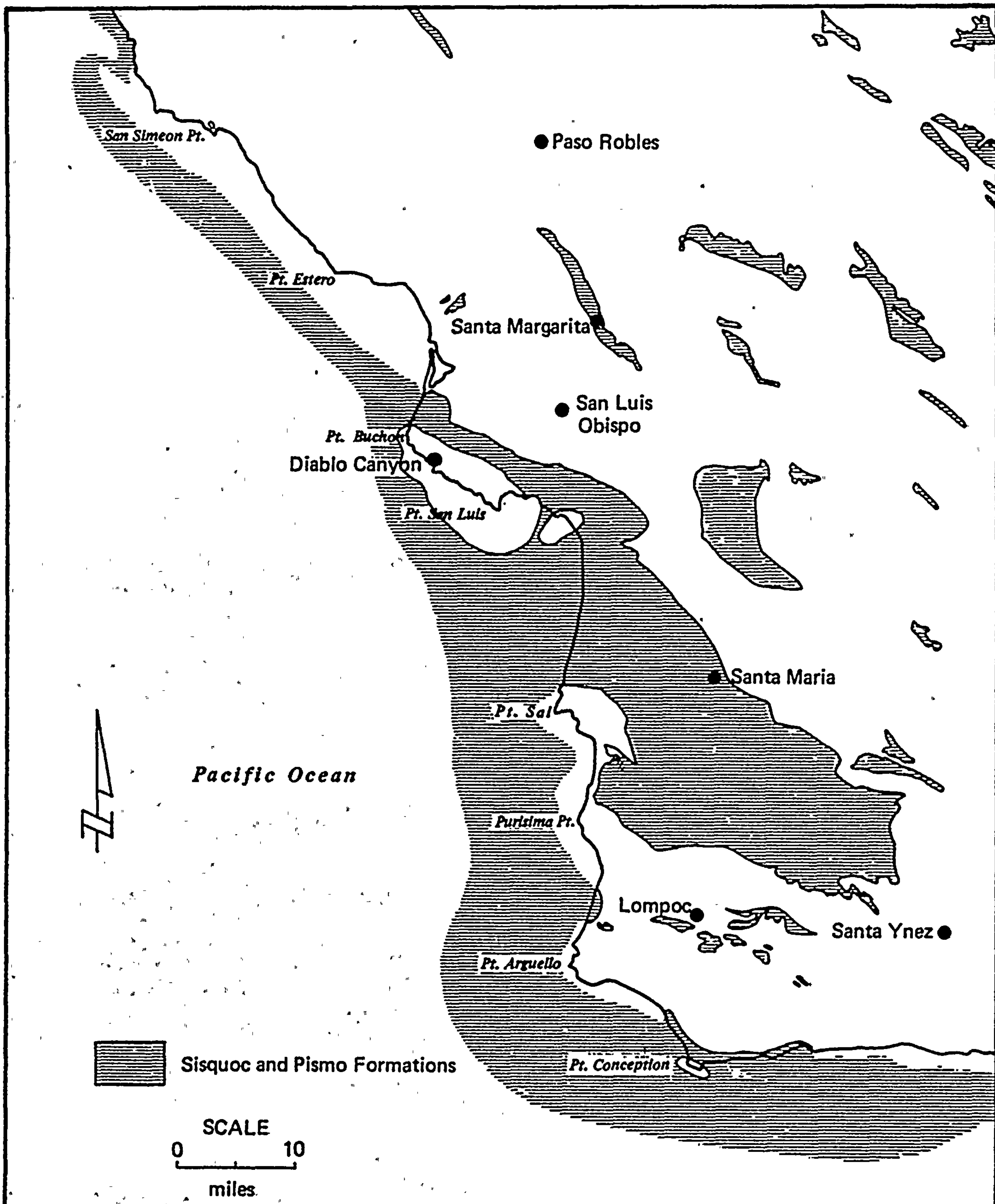
OUTCROP MAP OF OPHIOLITE ASSEMBLAGE ROCKS

Figure 10



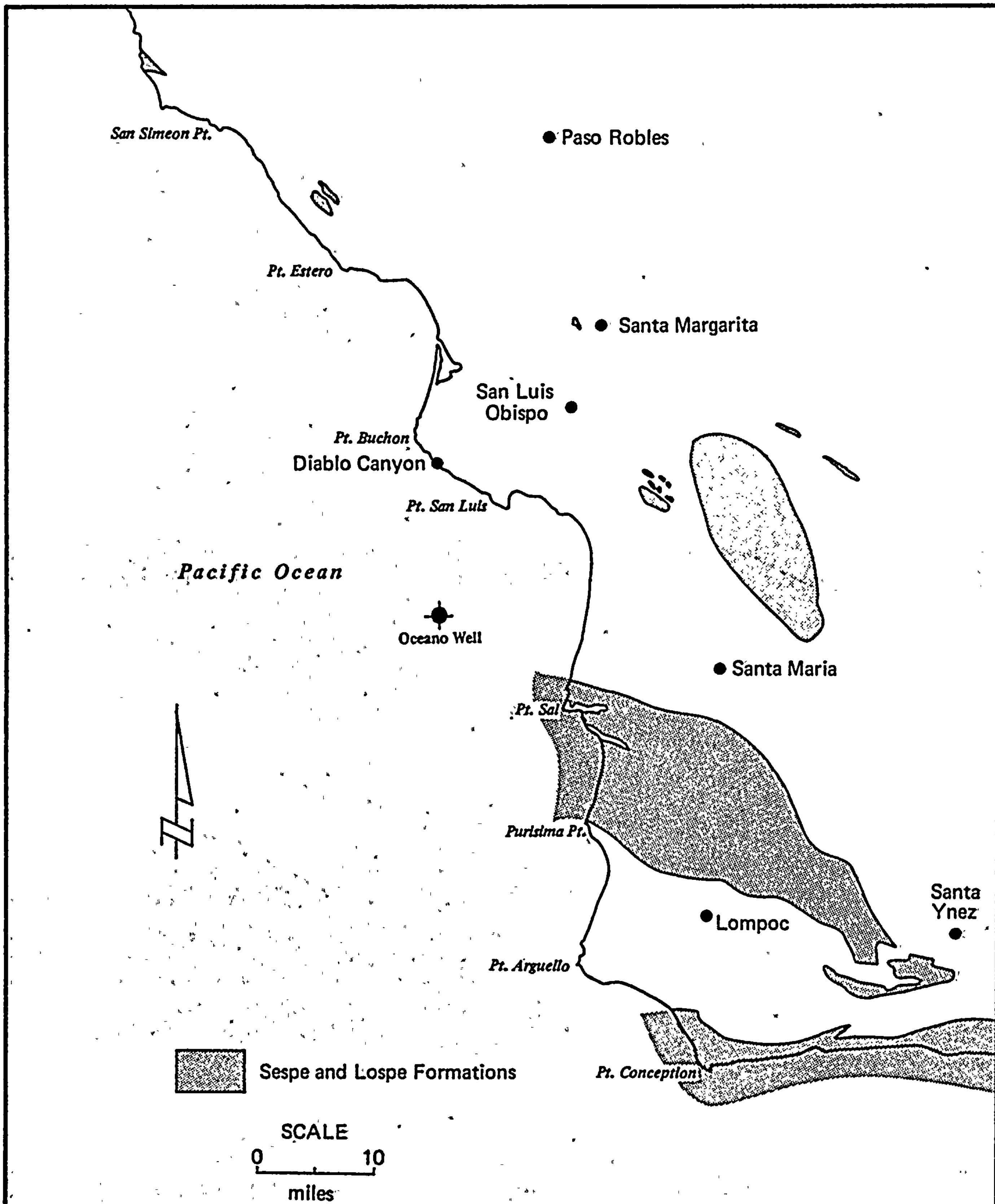
OUTCROP, SUBSURFACE AND OFFSHORE DISTRIBUTION OF MONTEREY FORMATION

Figure 11



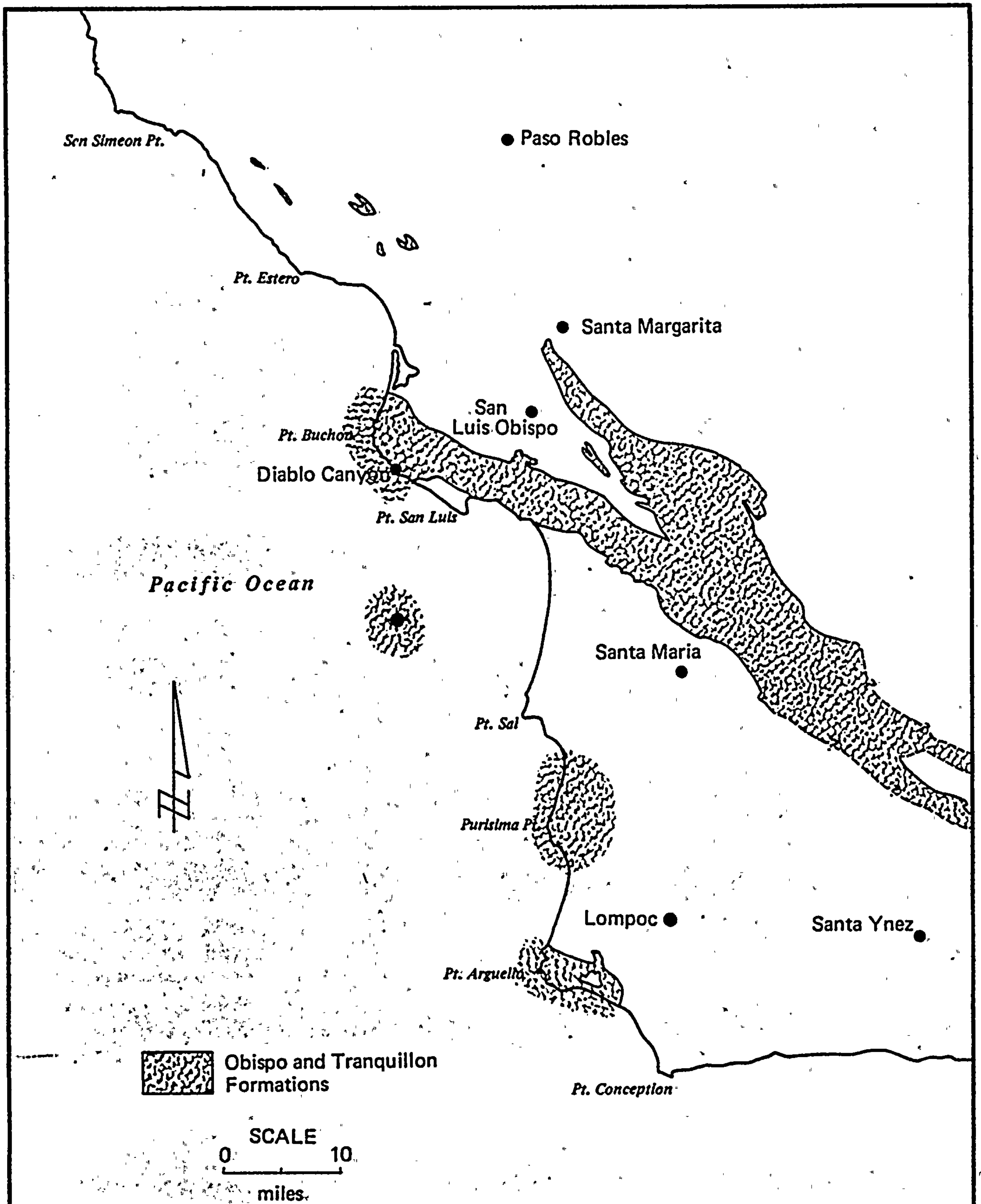
OUTCROP, SUBSURFACE AND OFFSHORE DISTRIBUTIONS
SISQUOC AND PISMO FORMATIONS

Figure 12



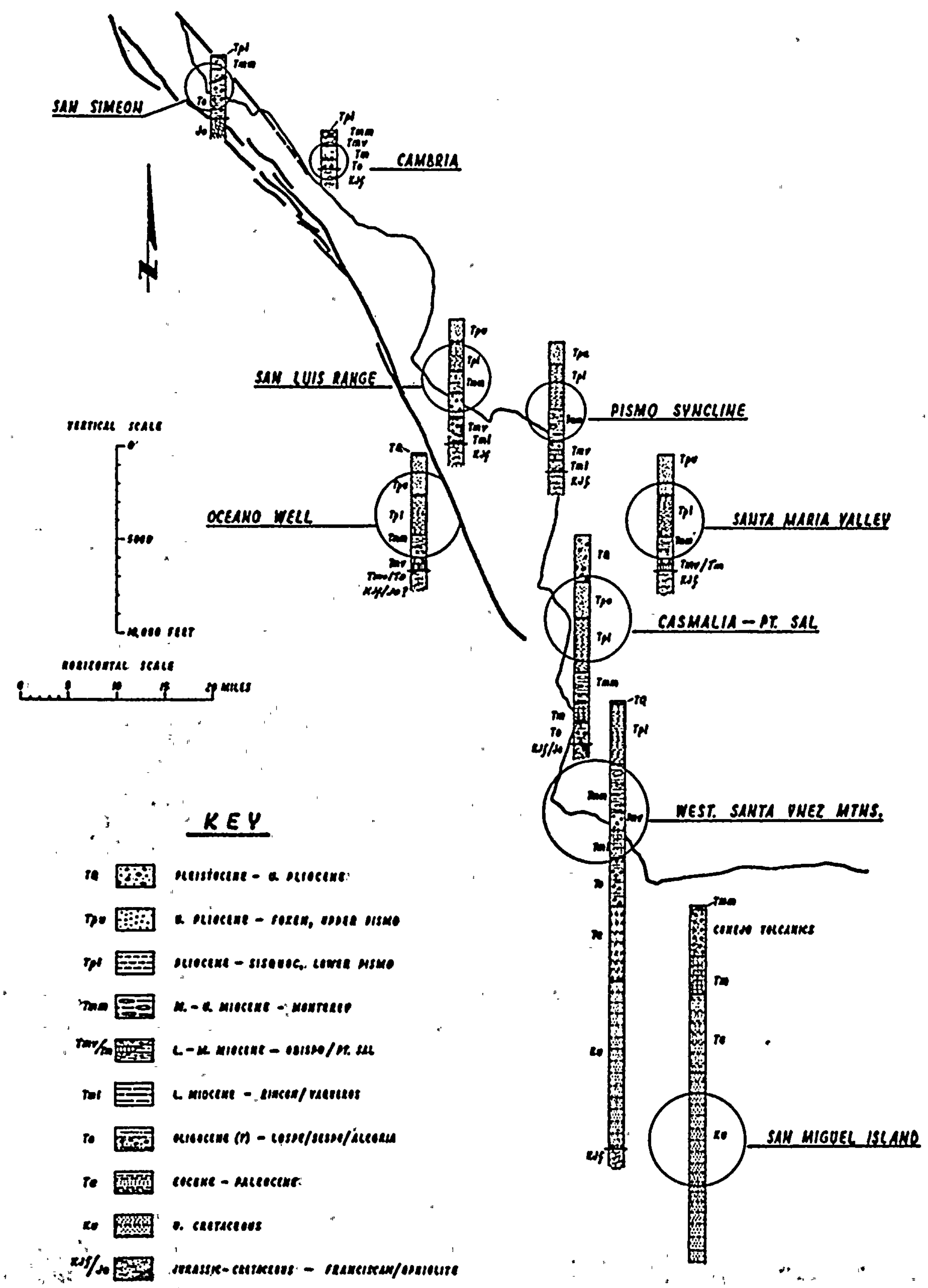
OUTCROP, SUBSURFACE AND OFFSHORE DISTRIBUTIONS OF SESPE AND LOSPE FORMATIONS

Figure 13



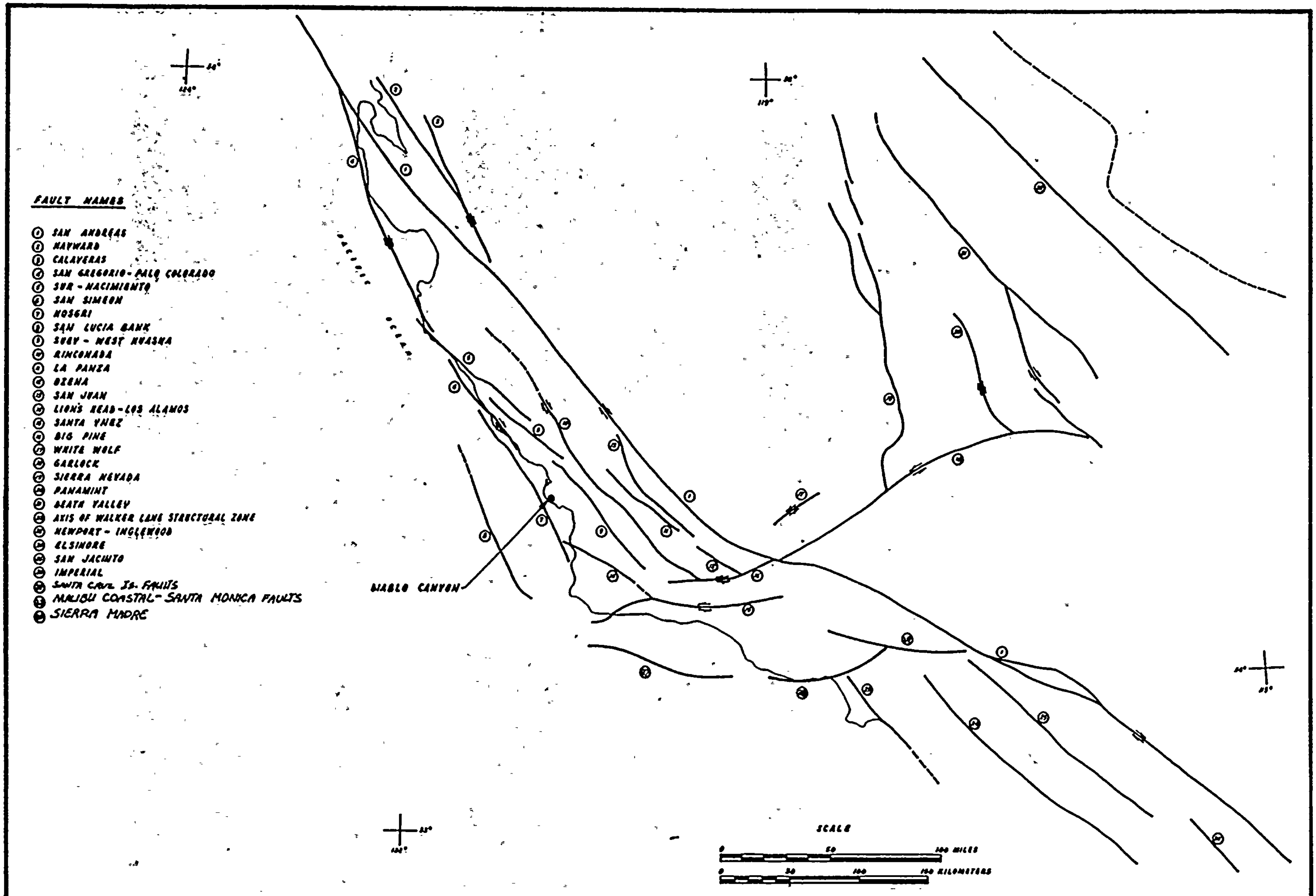
OUTCROP, SUBSURFACE AND OFFSHORE DISTRIBUTION OF OBISPO AND TRANQUILLON FORMATIONS

Figure 14



MAP OF SOUTH CENTRAL COASTAL CALIFORNIA SHOWING SPOT STRATIGRAPHIC SECTIONS

Figure 15



MAJOR FAULTS: SOUTH CENTRAL AND SOUTHERN CALIFORNIA

Figure 16

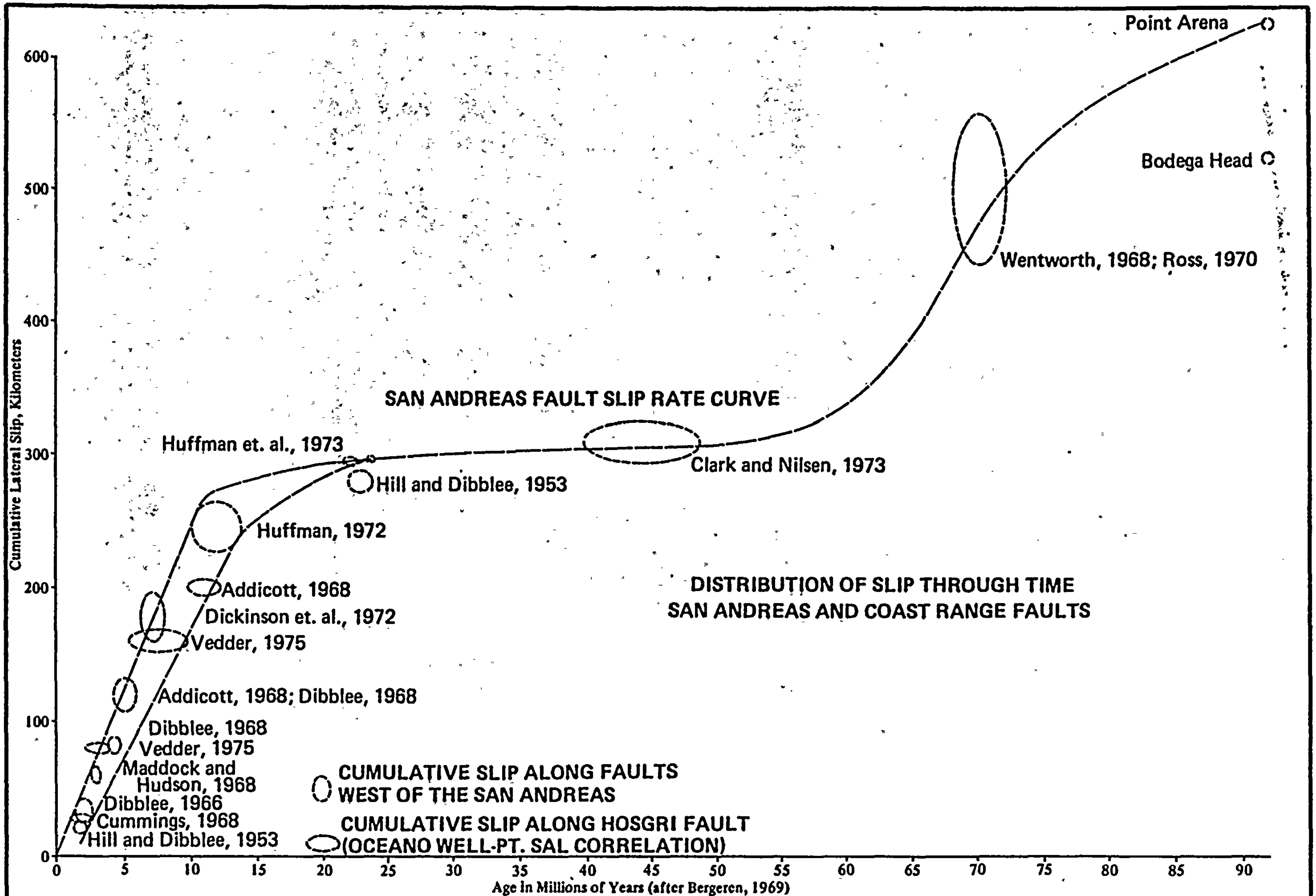
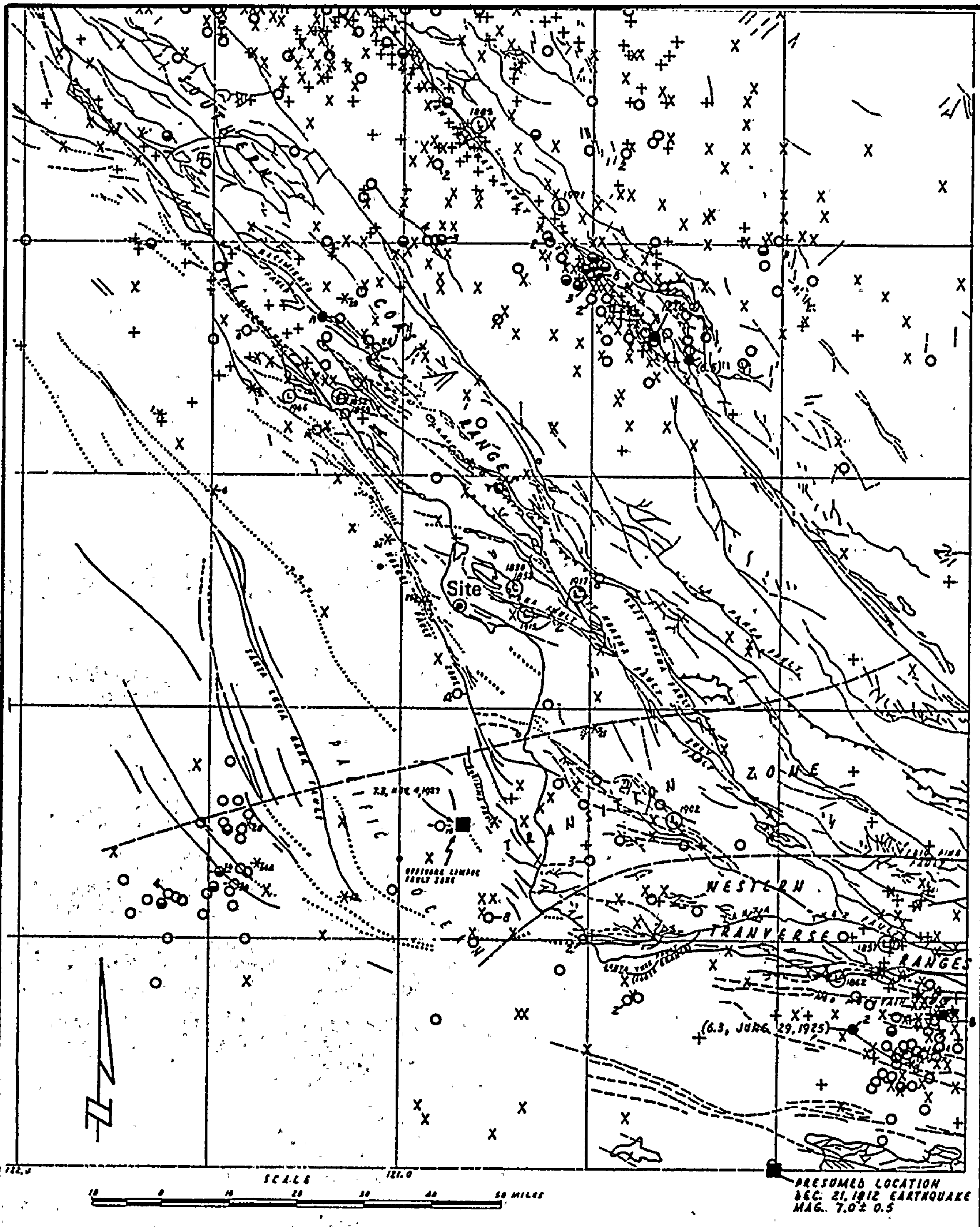

SAN ANDREAS FAULT SLIP RATE CURVE
DISTRIBUTION OF SLIP THROUGH TIME
SAN ANDREAS AND COAST RANGE FAULTS
Point Arena
Bodega Head
Wentworth, 1968; Ross, 1970
Clark and Nilsen, 1973
Huffman et. al., 1973
Hill and Dibblee, 1953
Huffman, 1972
Addicott, 1968
Dickinson et. al., 1972
Vedder, 1975
Addicott, 1968; Dibblee, 1968
Dibblee, 1968
Vedder, 1975
Maddock and Hudson, 1968
Dibblee, 1966
Cummings, 1968
Hill and Dibblee, 1953
CUMULATIVE SLIP ALONG FAULTS WEST OF THE SAN ANDREAS
CUMULATIVE SLIP ALONG HOSGRI FAULT (OCEANO WELL-PT. SAL CORRELATION)
Cumulative Lateral Slip, Kilometers
0
100
200
300
400
500
600
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
Age in Millions of Years (after Bergeren, 1969)
Pleistocene
Plio.
Late Miocene
M. Miocene
Early Miocene
Oligocene
Eocene
Paleocene
Cretaceous

Figure 17



EPICENTER MAP OF WEST-CENTRAL CALIFORNIA

Figure 18

EXPLANATION FOR FIGURE 18
EPICENTER MAP OF WEST-CENTRAL CALIFORNIA

INSTRUMENTALLY LOCATED AND LARGER HISTORICALLY REPORTED EARTHQUAKE EPICENTERS WITHIN 75 MILES OF THE DIABLO CANYON POWER PLANT SITE, 1800-1972

SYMBOL	MAGNITUDE	
■	$7.9 \geq M \geq 7.0$	MAGNITUDE AND DATE LISTED.
●	$6.9 \geq M \geq 6.0$	
⊖	$5.9 \geq M \geq 5.0$	
O	$4.9 \geq M \geq 4.0$	
X	$3.9 \geq M \geq 3.0$	
+	$2.9 \geq M \geq 2.0$	

(FIGURE O^2 INDICATES NUMBER OF EPICENTERS RECORDED AT SAME LOCATION.)

SOURCES FOR FAULT AND EARTHQUAKE EPICENTER DATA ARE AS FOLLOWS:

1. FAULT DATA FROM JENNINGS, C.W., 1972, GEOLOGIC MAP OF CALIFORNIA, SOUTH HALF. (PRELIMINARY)
2. FOR EARTHQUAKES OF ≥ 4.0 MAGNITUDE OCCURRING DURING THE TIME INTERVAL 1934 THRU JUNE 30, 1971: CALIFORNIA DIVISION OF MINES AND GEOLOGY PROVISIONAL EARTHQUAKE EPICENTER MAP, SCALE 1: 1,000,000, 1972
3. FOR EARTHQUAKES OF ≥ 2.0 MAGNITUDE OCCURRING DURING THE TIME INTERVAL 1932 THRU 1971; BUT NOT INCLUDING EARTHQUAKES GIVEN ONLY AN INTENSITY RATING: SEISMOGRAPHIC STATION BERKELEY (UNIVERSITY OF CALIFORNIA, BERKELEY).
4. FOR LARGE EARTHQUAKES OCCURRING DURING THE TIME INTERVAL 1800 THROUGH 1931, TO WHICH ESTIMATED MAGNITUDE RATINGS HAVE BEEN ASSIGNED: CALIFORNIA DIVISION OF MINES AND GEOLOGY, PROVISIONAL EARTHQUAKE EPICENTER MAP, SCALE 1:1,000,000, 1972.
5. FOR EARTHQUAKES OF ≥ 3.0 MAGNITUDE OCCURRING DURING THE TIME INTERVAL JUNE 30 THRU DEC. 31, 1972; SEISMOLOGICAL LABORATORY OF PASADENA. (CALIFORNIA INSTITUTE OF TECHNOLOGY).

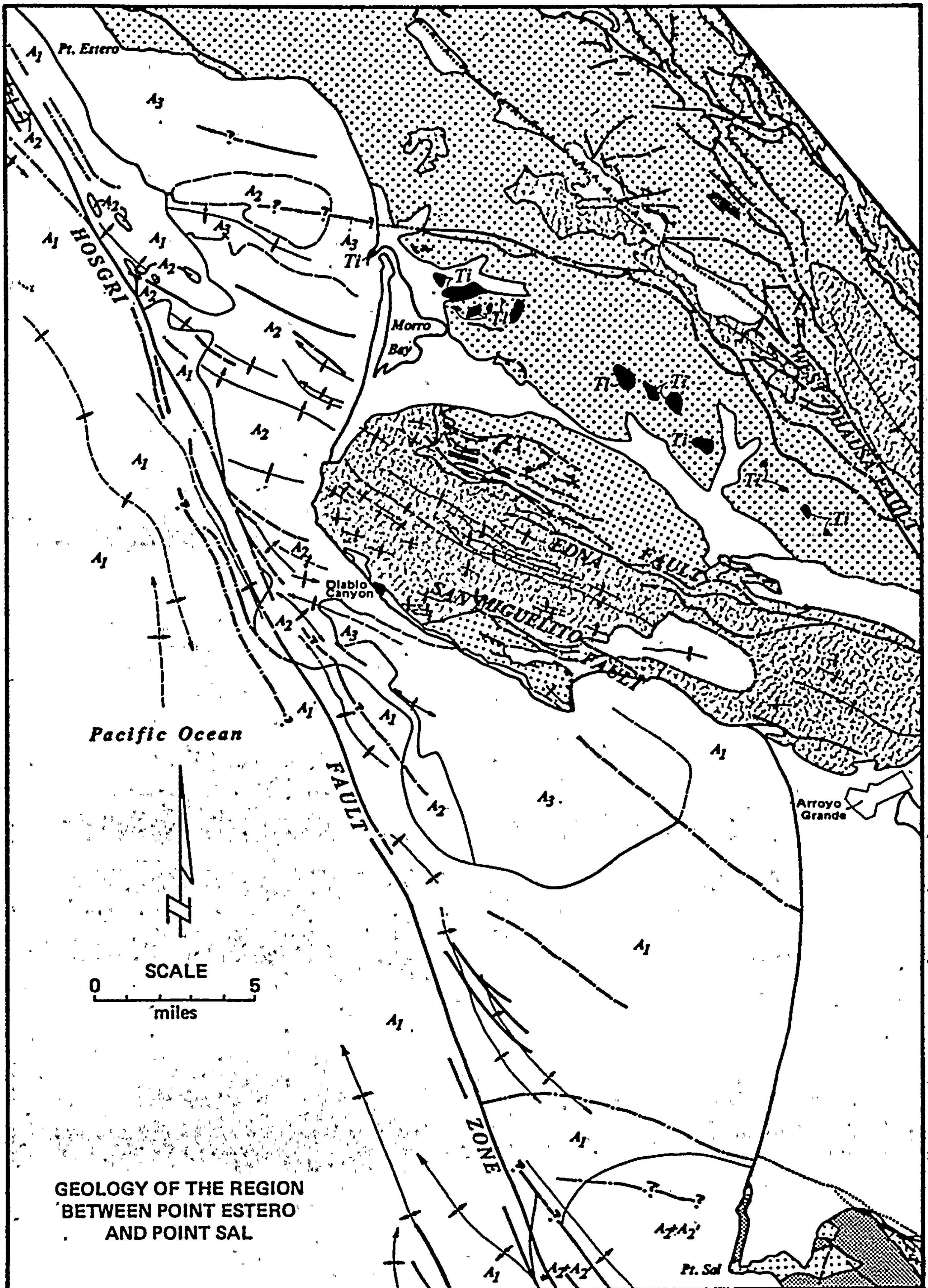
NOTES FOR REVISED FAULT AND EPICENTER DATA

A. FAULT DATA REVISED IN ACCORDANCE WITH NOTE 6, FIGURE 5 (DIABLO FSAR)

B. EPICENTERS OF 19 SELECTED EARTHQUAKES, RECOMPUTED BY S. W. SMITH (1974). EPICENTER-MAGNITUDE SYMBOL OF THESE EVENTS IS INDICATED BY HORIZONTAL DASHES ($_{8}$X-, -O$_{26}$) NUMBER SUBSCRIPT INDICATES EVENT NUMBER

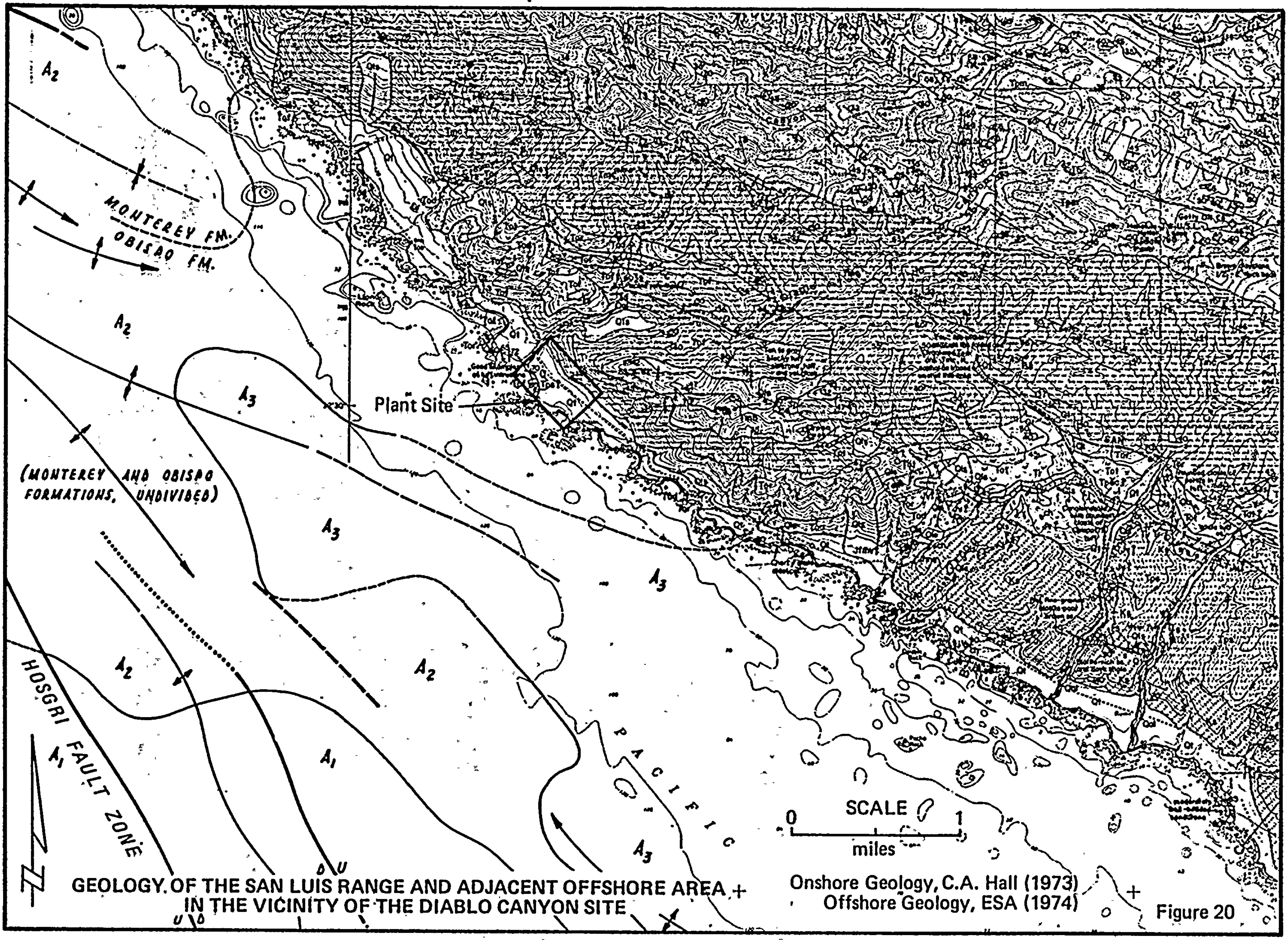
C. •-EPICENTERS (MAGNITUDE 0.4-2.0) RECORDED AND LOCATED BY WILLIAM GAWTHROP, (1973). AS DESCRIBED IN "PRELIMARY REPORT ON A SHORT TERM SEISMIC STUDY OF THE SAN LUIS OBISPO REGION IN MAY, 1973."

D. Ⓛ$_{1915}$ APPROXIMATE EPICENTER FOR HISTORICALLY REPORTED EARTHQUAKE OF ≥ MM VII INTENSITY



GEOLOGY OF THE REGION BETWEEN POINT ESTERO AND POINT SAL

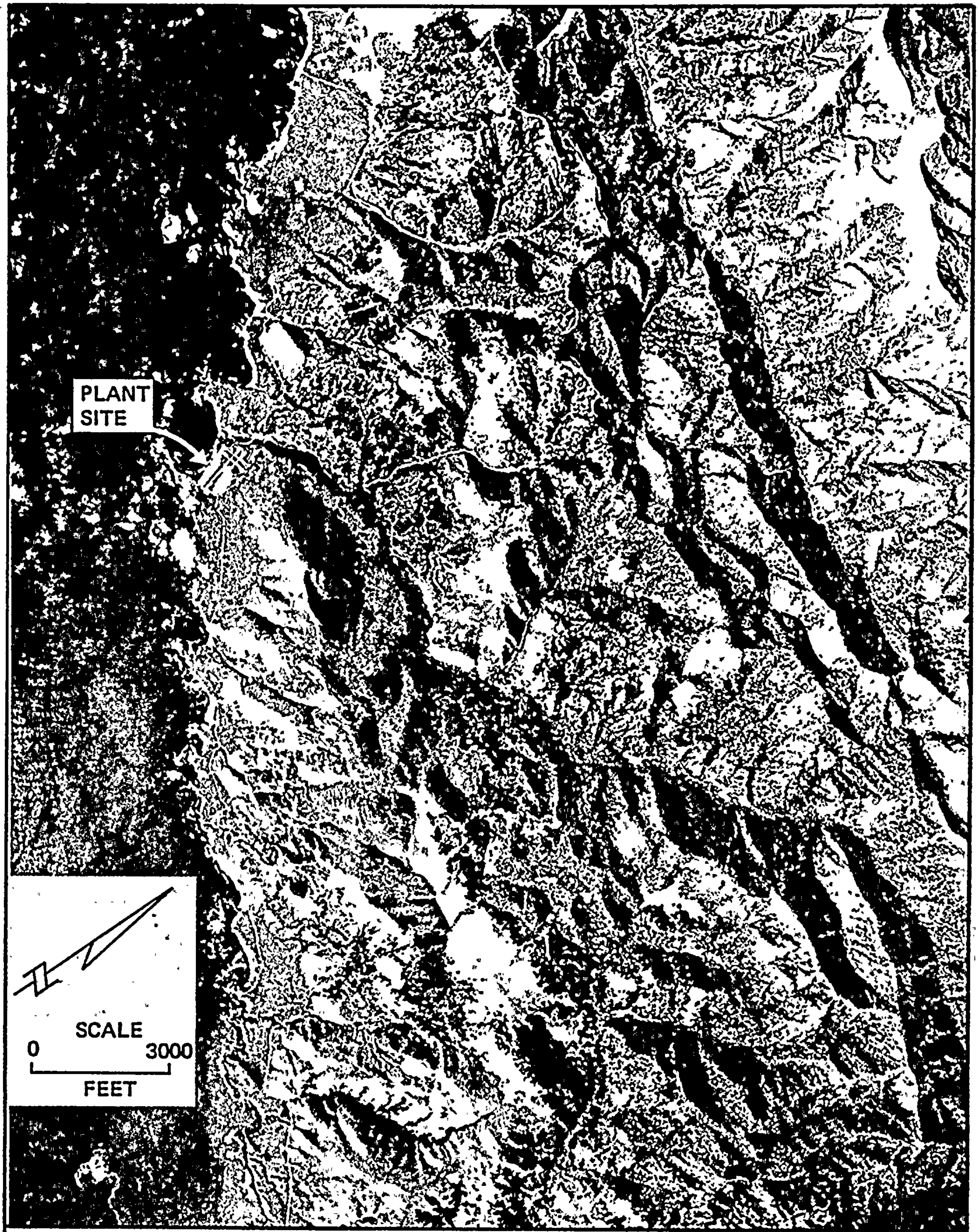
Figure 19



GEOLOGY OF THE SAN LUIS RANGE AND ADJACENT OFFSHORE AREA IN THE VICINITY OF THE DIABLO CANYON SITE

Onshore Geology, C.A. Hall (1973)
Offshore Geology, ESA (1974)

Figure 20



VERTICAL AERIAL PHOTOGRAPH OF THE SAN LUIS RANGE IN THE VICINITY OF THE DIABLO CANYON SITE

Figure 21

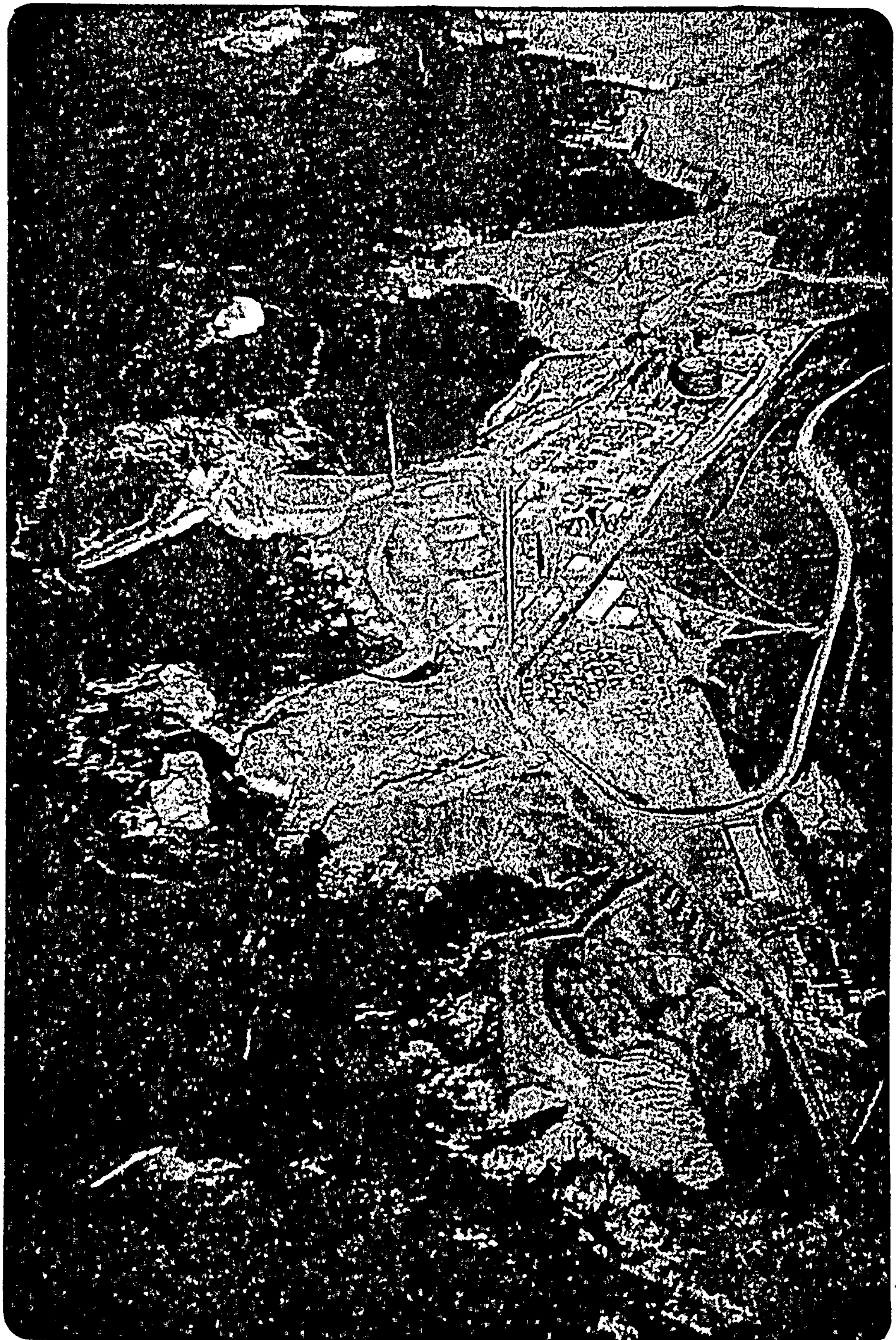
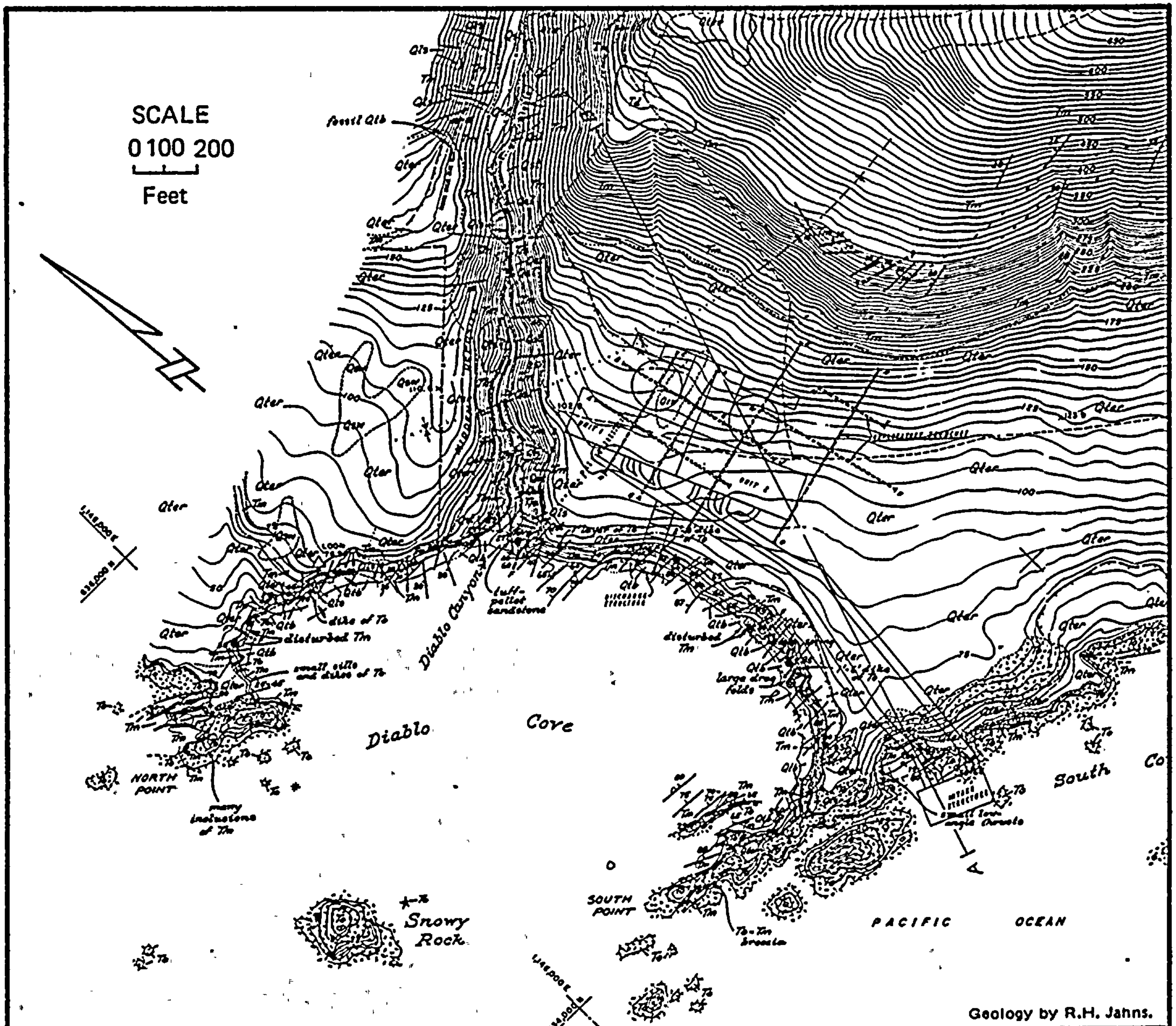


Figure 22

OBLIQUE AERIAL PHOTOGRAPH OF DIABLO CANYON SITE, LOOKING NORTHWEST



EXPLANATION

Pleistocene — Recent

- Qal — Stream-laid alluvium
- Qtb — Talus and beach deposits
- Qsw — Slump, creep, and slope-wash deposits
- Qls — Landslide deposits
- Qst — Stream-terrace deposits
- Qf — Alluvial-fan deposits
- Qft — Older fan-terrace deposits
- Qter — Deposits on marine wave-cut terraces
- Qlb — Lake-bottom (?) deposits

Miocene

- Td — Diabasic intrusive rock
- Tm — Monterey Formation
- To — Obispo tuff

Contact involving surficial deposits

Contact between bedrock units

Fault, showing dip

(dashed where approximately located, dotted where concealed by Qter.)

Strike and dip of beds

Strike and dip of overturned beds

Highly contorted beds

Axis of syncline

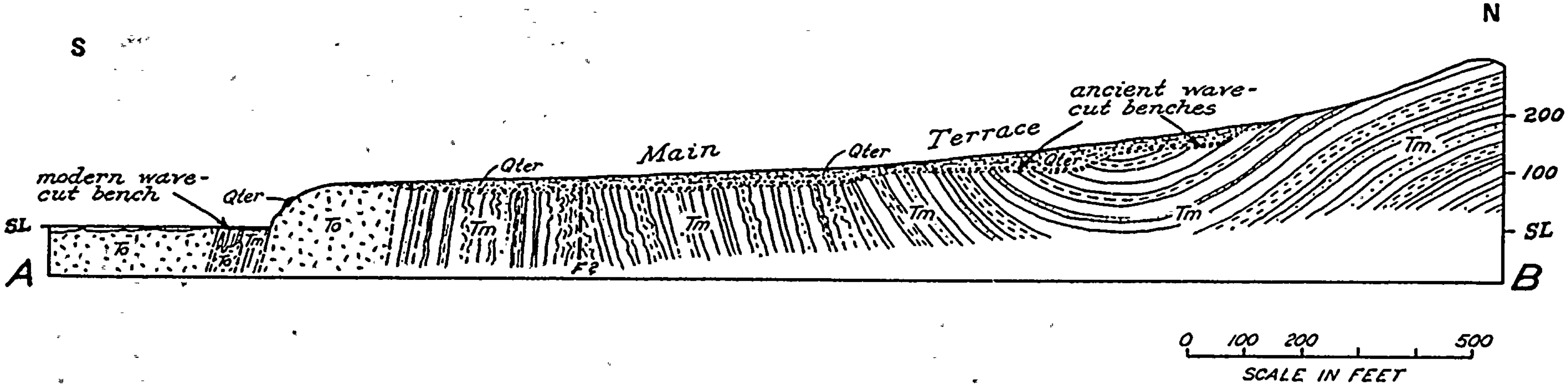
Boundary between different generations of Qter

Trend and range in dip of beds folded or warped as on a small scale

Surface trace of resistant horizon in Tm

SITE GEOLOGY MAP

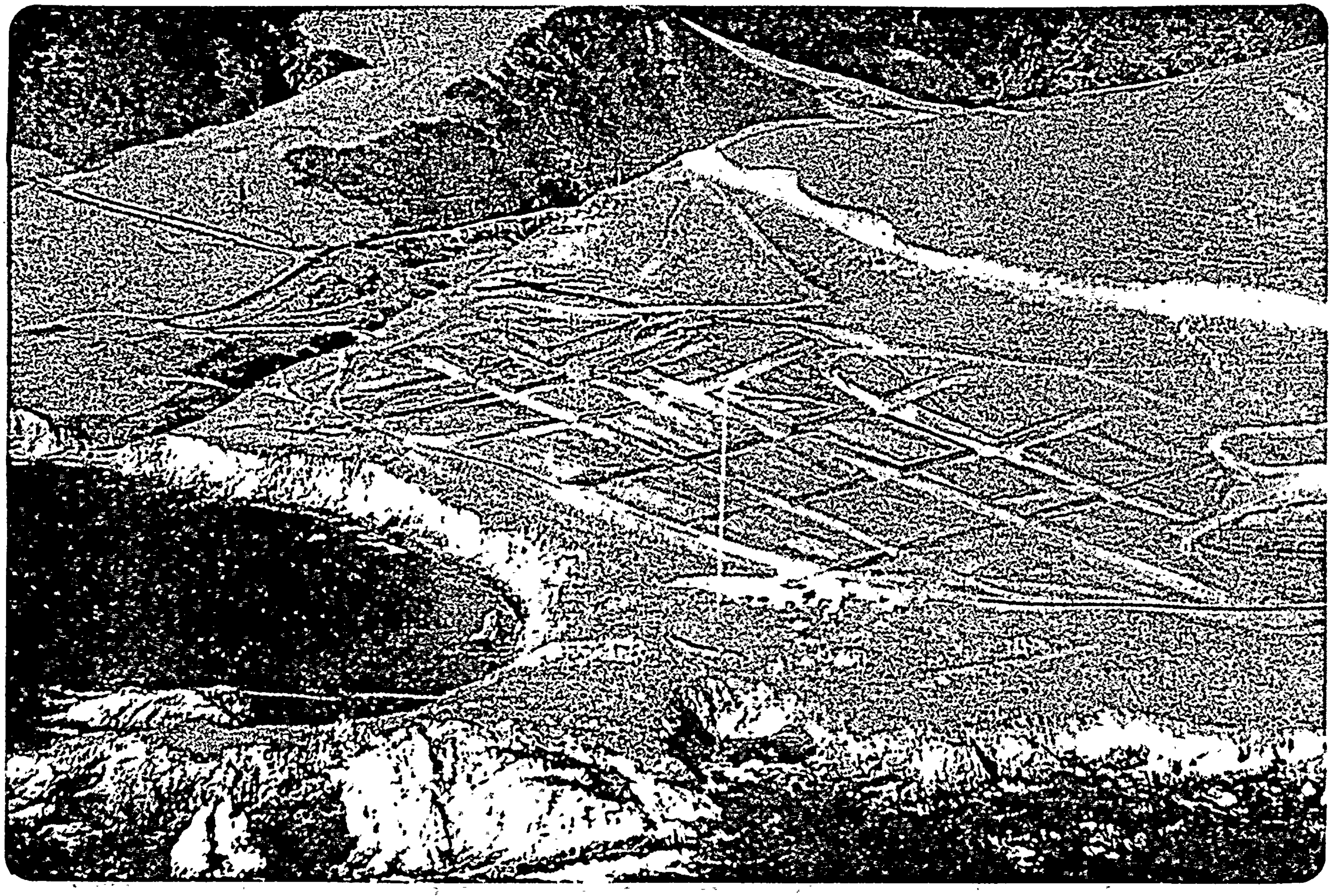
Figure 23



GEOLOGIC SECTION ALONG LINE A-B

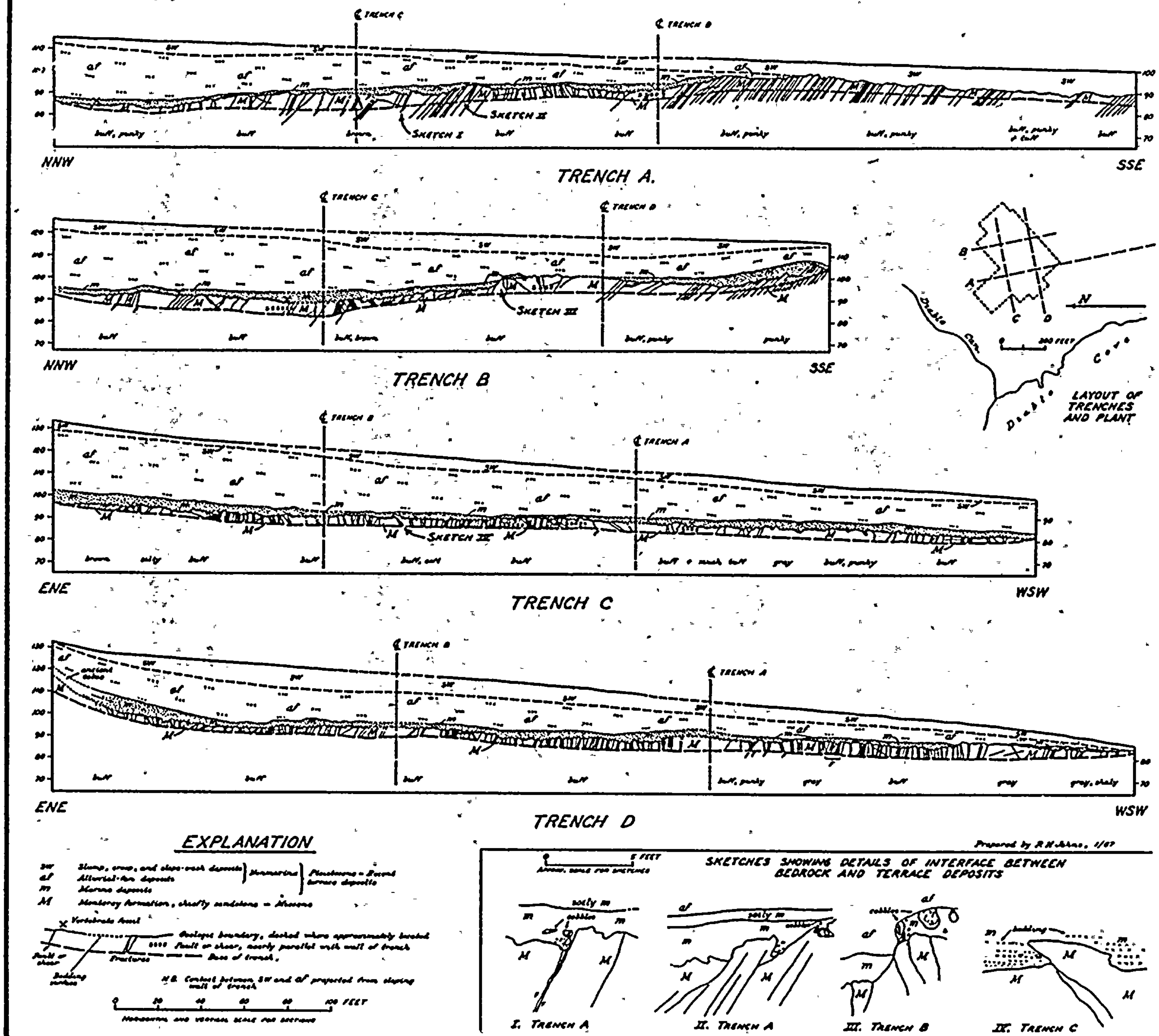
See Figure 23 for location and explanation of symbols

Figure 24



OBLIQUE AERIAL PHOTOGRAPH OF DIABLO CANYON SITE SHOWING EXPLORATORY TRENCHES

Figure 25

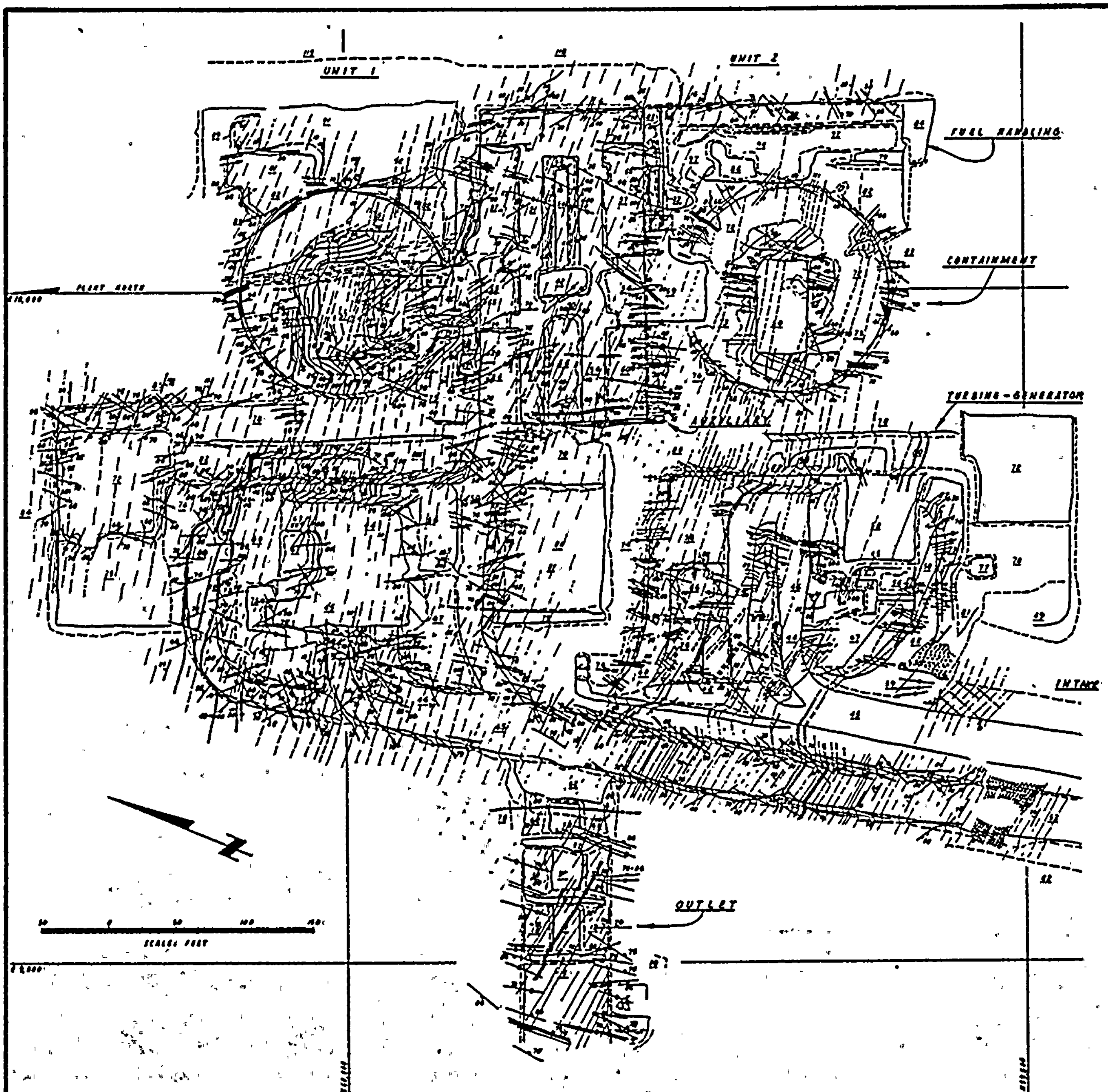


TRENCH LOGS

Figure 26

PHOTOGRAPH SHOWING MASSIVE SANDSTONE EXPOSED IN UNIT 2 CONTAINMENT CONSTRUCTION EXCAVATION

Figure 27



GEOLOGIC MAP OF UNITS 1 AND 2 CONSTRUCTION EXCAVATIONS

Figure 28

EXPLANATION FOR FIGURE 28
UNITS 1 AND 2 CONSTRUCTION EXCAVATION MAP

ROCK TYPES

Rocks of the Monterey Formation, undivided: Predominantly thin to thick bedded sandy mudstone and fine-grained sandstone.

Claystone and clayey, decomposed tuff, mainly in concordant layers.

Tuff and tuff breccia, in intrusive bodies that are at least partly discordant.

Breccia with calcite cement

SYMBOLS

Boundary between contrasting rock types; dashed where projected between mapped exposures.

Pattern of bedding traces in excavations; dashed where projected between mapped exposures.

Strike and dip of bedding

Strike of vertical bedding

Strike and dip of joint

Strike of vertical joint

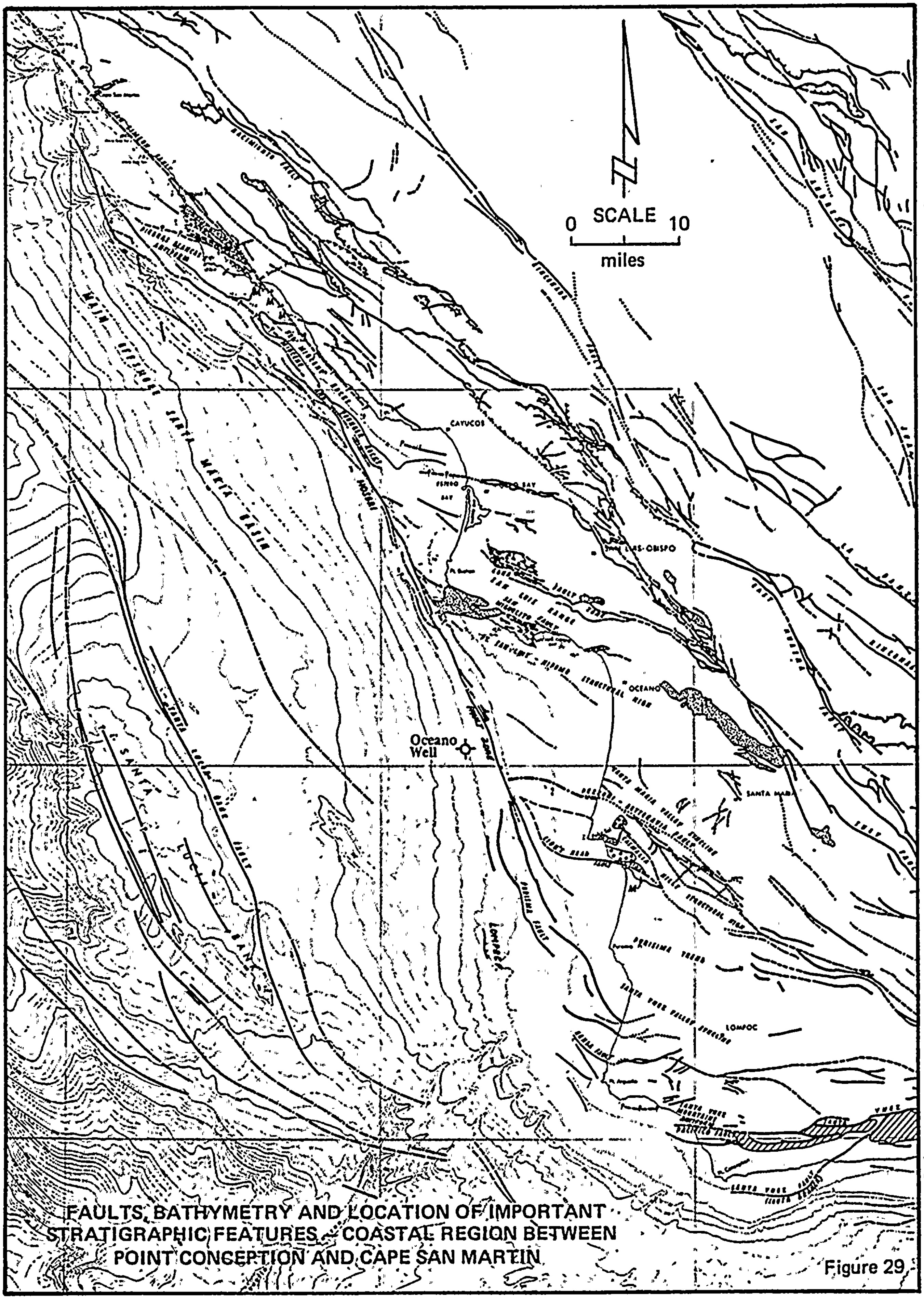
Zone of blocky fracturing

Strike and dip of fault or shear surface. Number indicates measured stratigraphic separation in feet.

Top of cut slope

Toe of cut slope

Approximate elevation of excavated surface



FAULTS, BATHYMETRY AND LOCATION OF IMPORTANT STRATIGRAPHIC FEATURES – COASTAL REGION BETWEEN POINT CONCEPTION AND CAPE SAN MARTIN

Figure 29

[illegible]

EXPLANATION FOR FIGURE 29
FAULTS, BATHYMETRY AND LOCATION OF IMPORTANT STRATIGRAPHIC FEATURES—COASTAL REGION BETWEEN POINT CONCEPTION AND CAPE SAN MARTIN

ROCK TYPES

M — *Monterey Formation*

Obispo Formation

Lospe Formation of Point Sal and breccia of Point Sierra Nevada

Eocene rocks

Ophiolite sequence rocks of Point Sal and San Simeon area

SYMBOLS

Fault, dashed where approximately located, dotted where concealed

Fault buried beneath Pliocene or older strata

Geologic contact

Hydrocarbon Potential of Northern and Central California Offshore

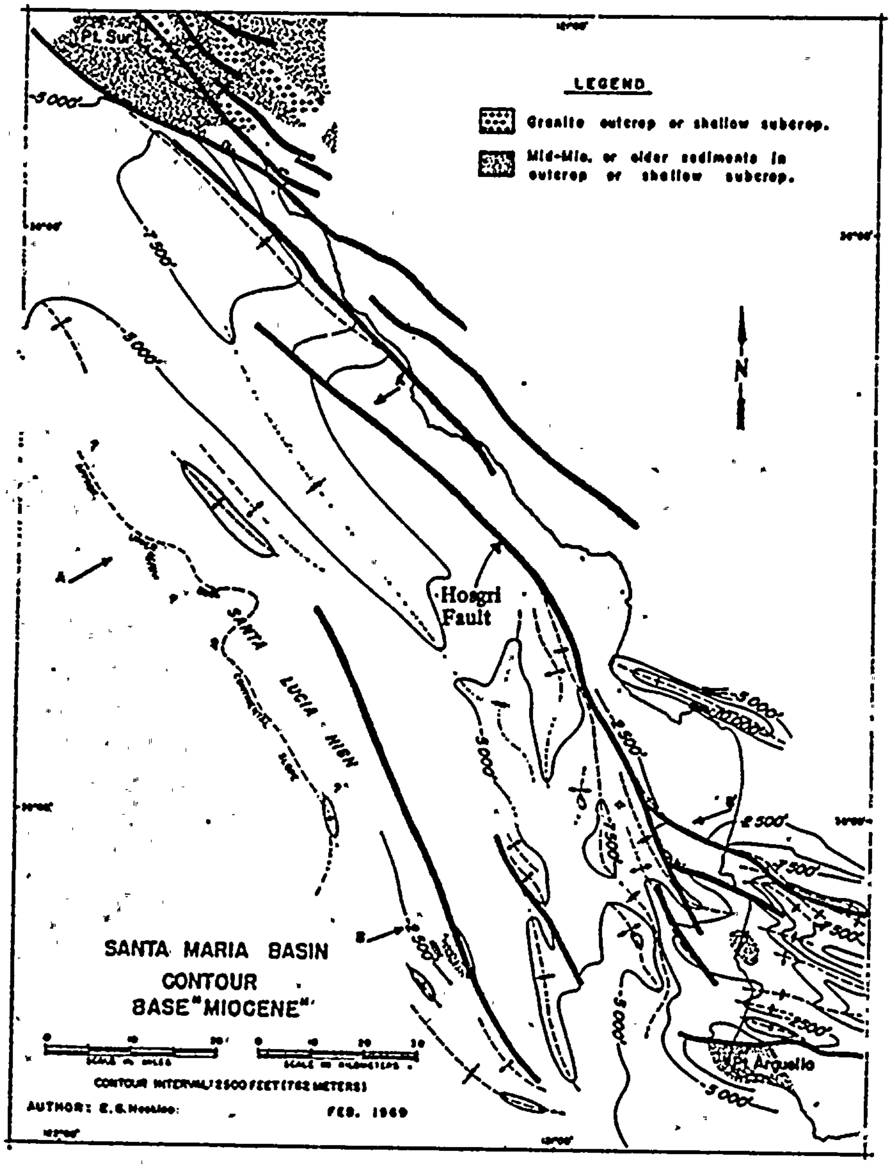
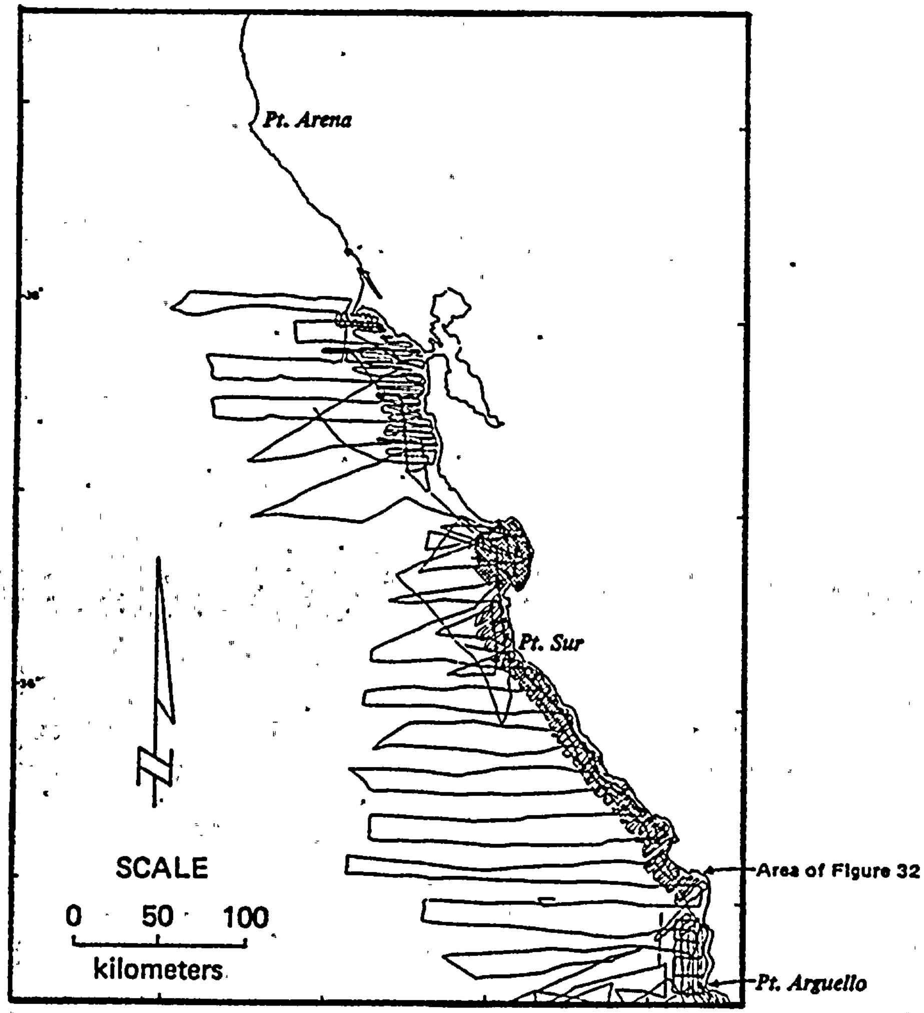


FIG. 2

Map of Santa Maria Basin, from "Hydrocarbon Potential of Northern and Central California Offshore" by E. G. Hoskins and J. R. Griffiths in AAPG Memoir 15, 1971.

Figure 30



REGIONAL TRACK CHART – CENTRAL CALIFORNIA COAST

(U.S. GEOLOGICAL SURVEY CRUISES)

Figure 31

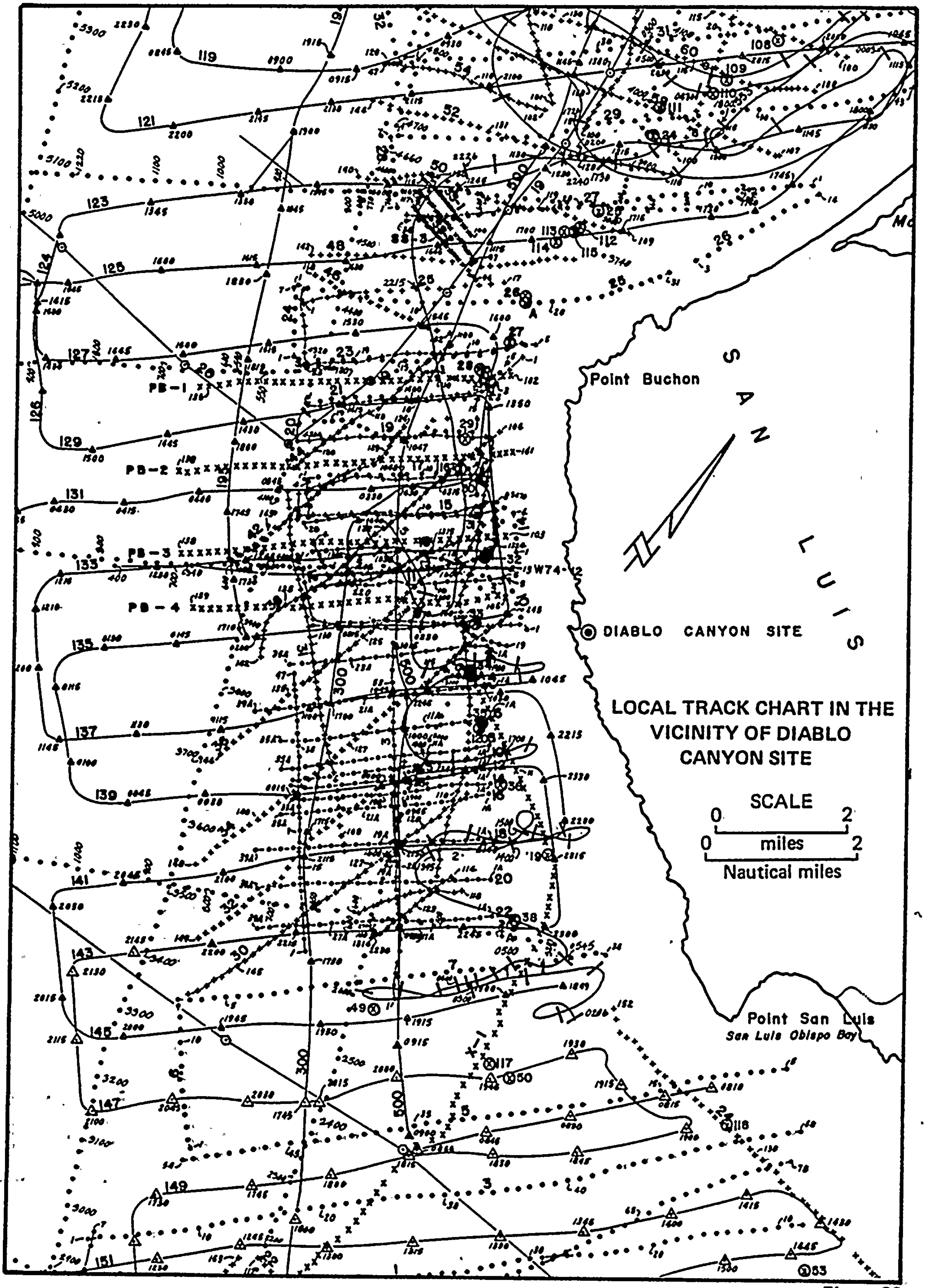
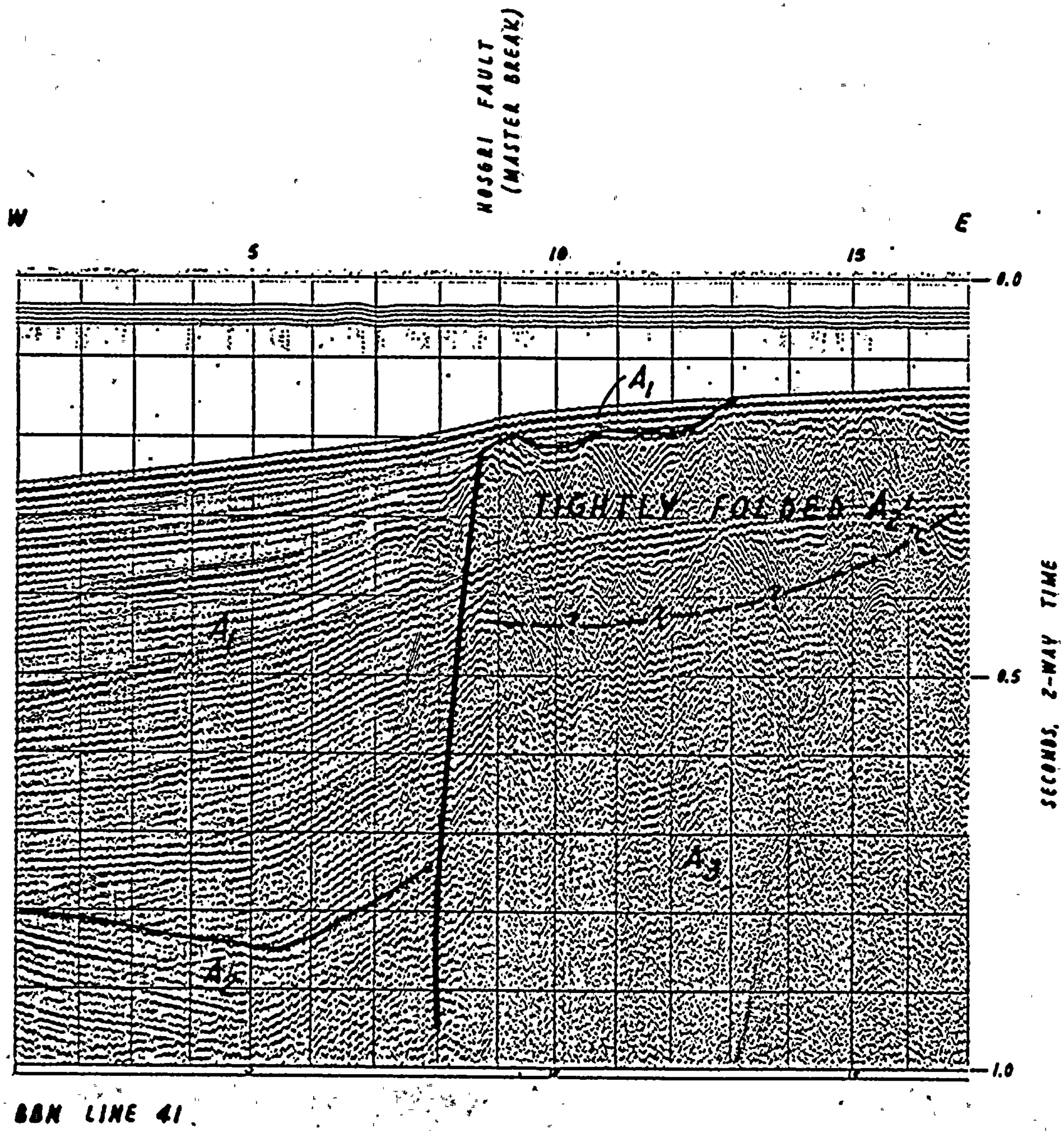

Point Buchon
SAN LUIS
DIABLO CANYON SITE
LOCAL TRACK CHART IN THE VICINITY OF DIABLO CANYON SITE
SCALE
0 miles 2
0 Nautical miles 2
Point San Luis
San Luis Obispo Bay
PB-1
PB-2
PB-3
PB-4

Figure 32

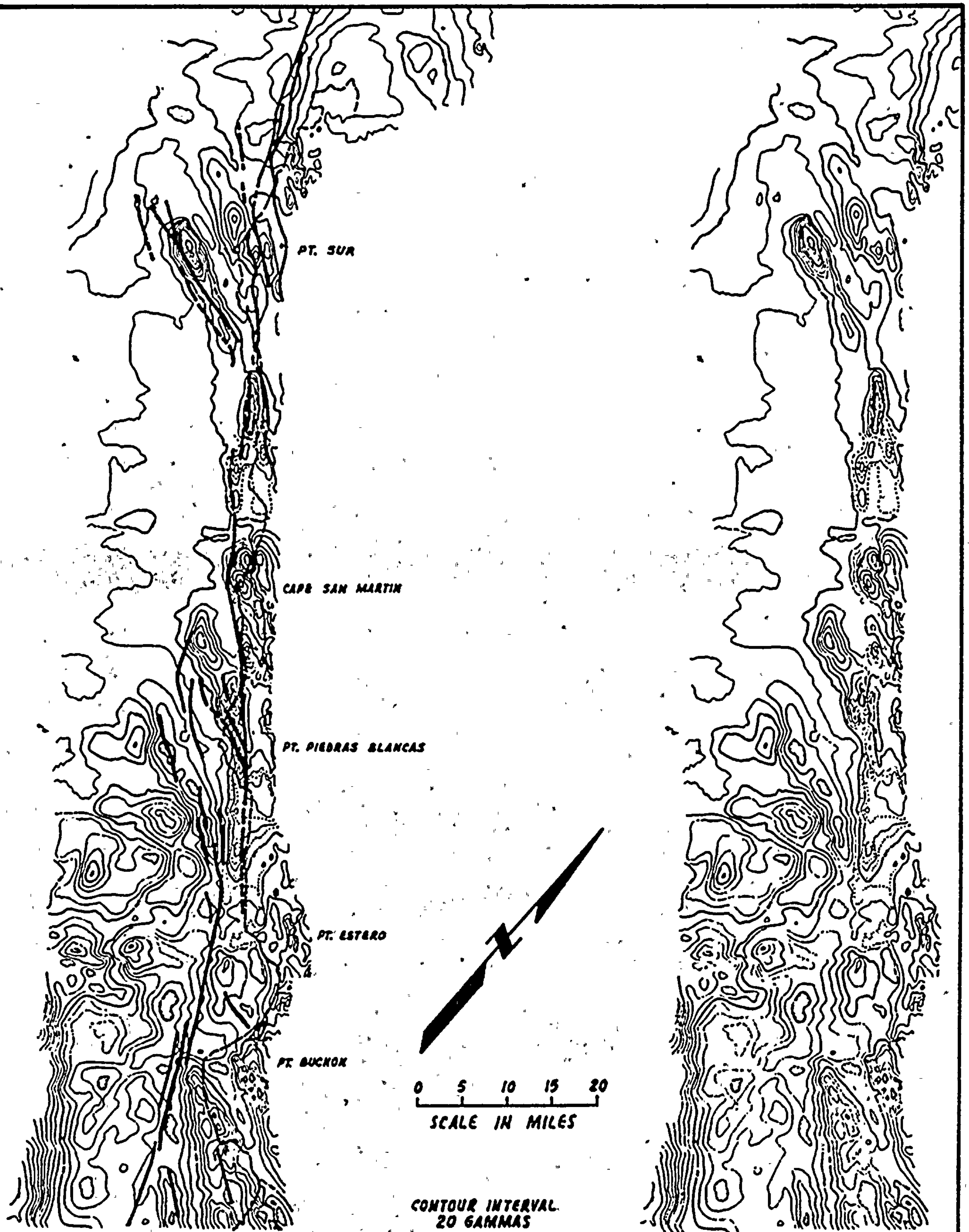


Sparker Seismic Reflection Profile, BBN Line 41

b) This profile is located ½ mile south of the Kelez Line profile (Figure 7(N)a.) It displays a higher resolution sounding of the near surface expression of the Hosgri fault. As is typical of points south of this profile, structural deformation is restricted to the immediate vicinity of the fault.

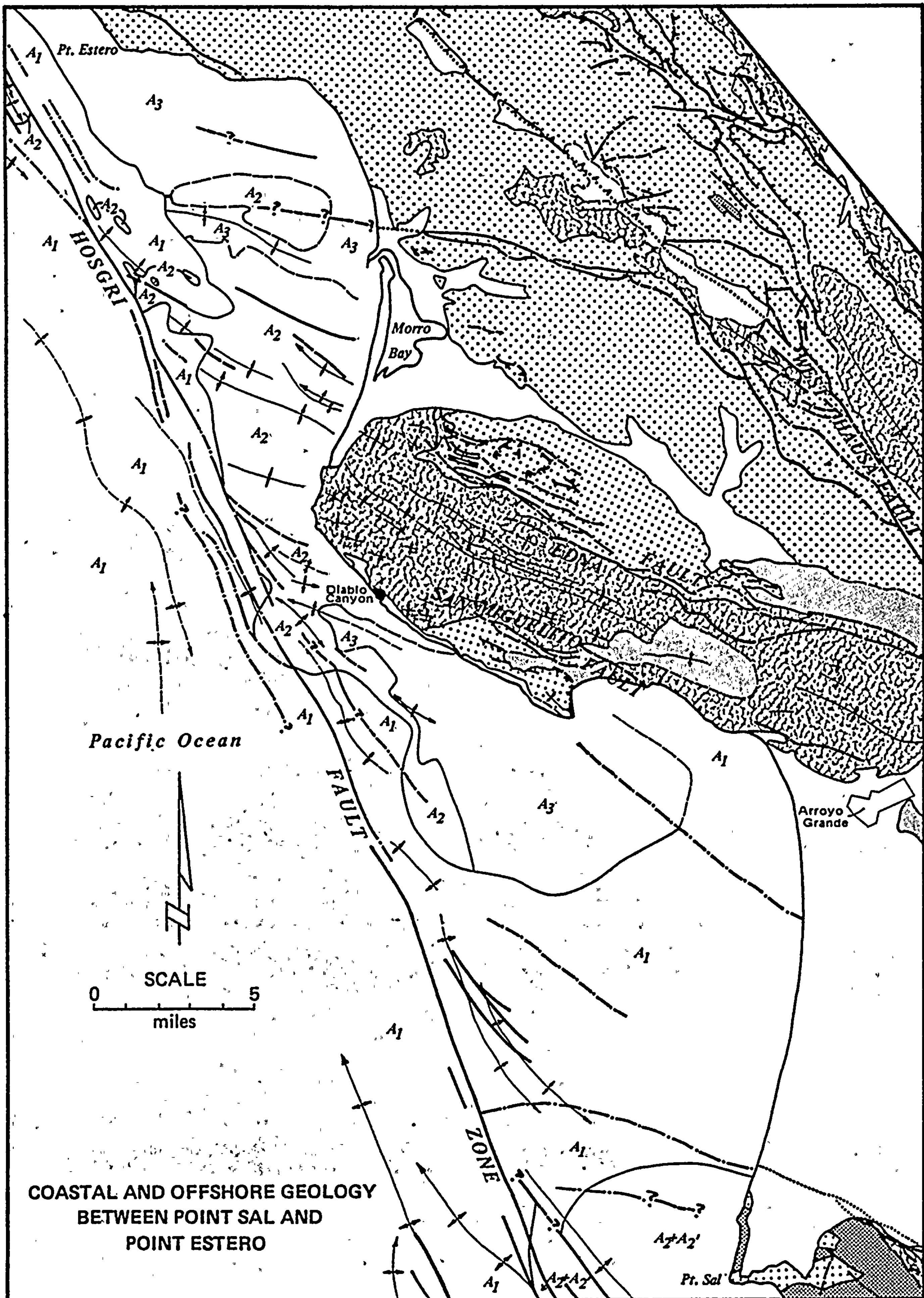
SPARKER SEISMIC REFLECTION RECORD
SHOWING THE HOSGRI FAULT

Figure 33



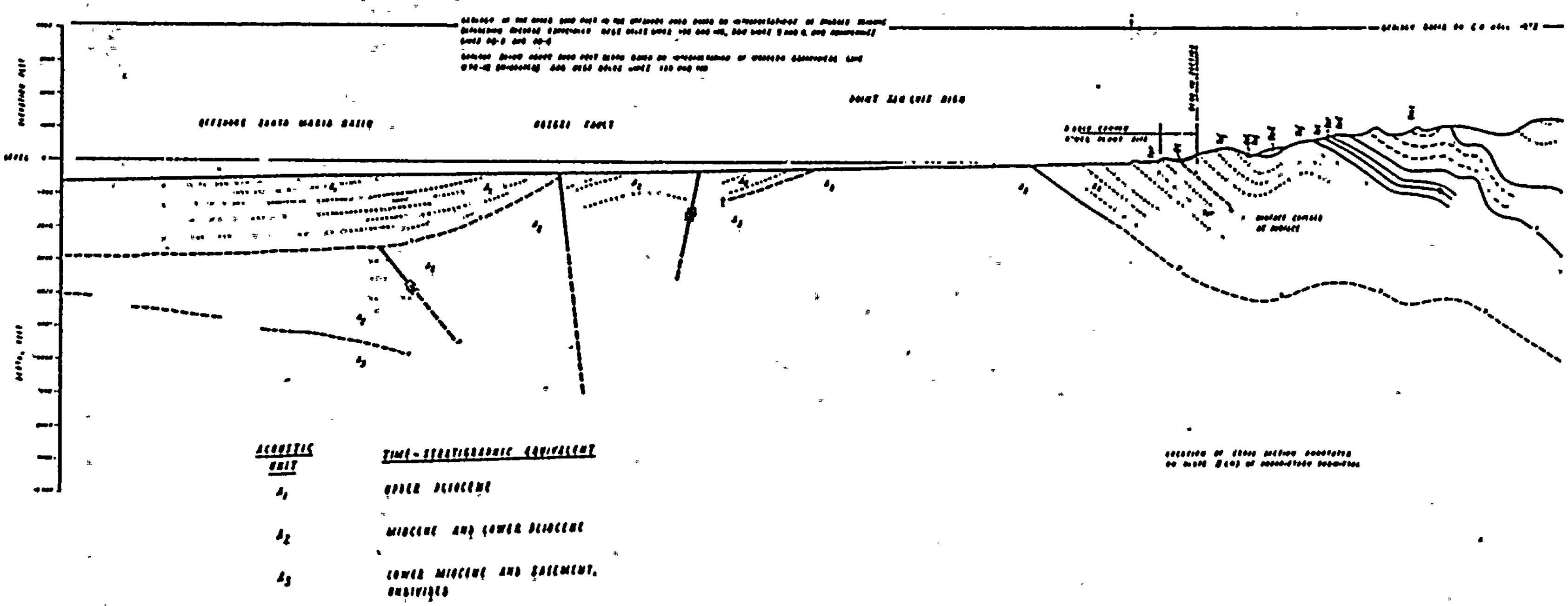
AEROMAGNETIC MAP AND PRINCIPAL COASTAL FAULTS
ALONG THE CENTRAL CALIFORNIA COAST

Figure 34



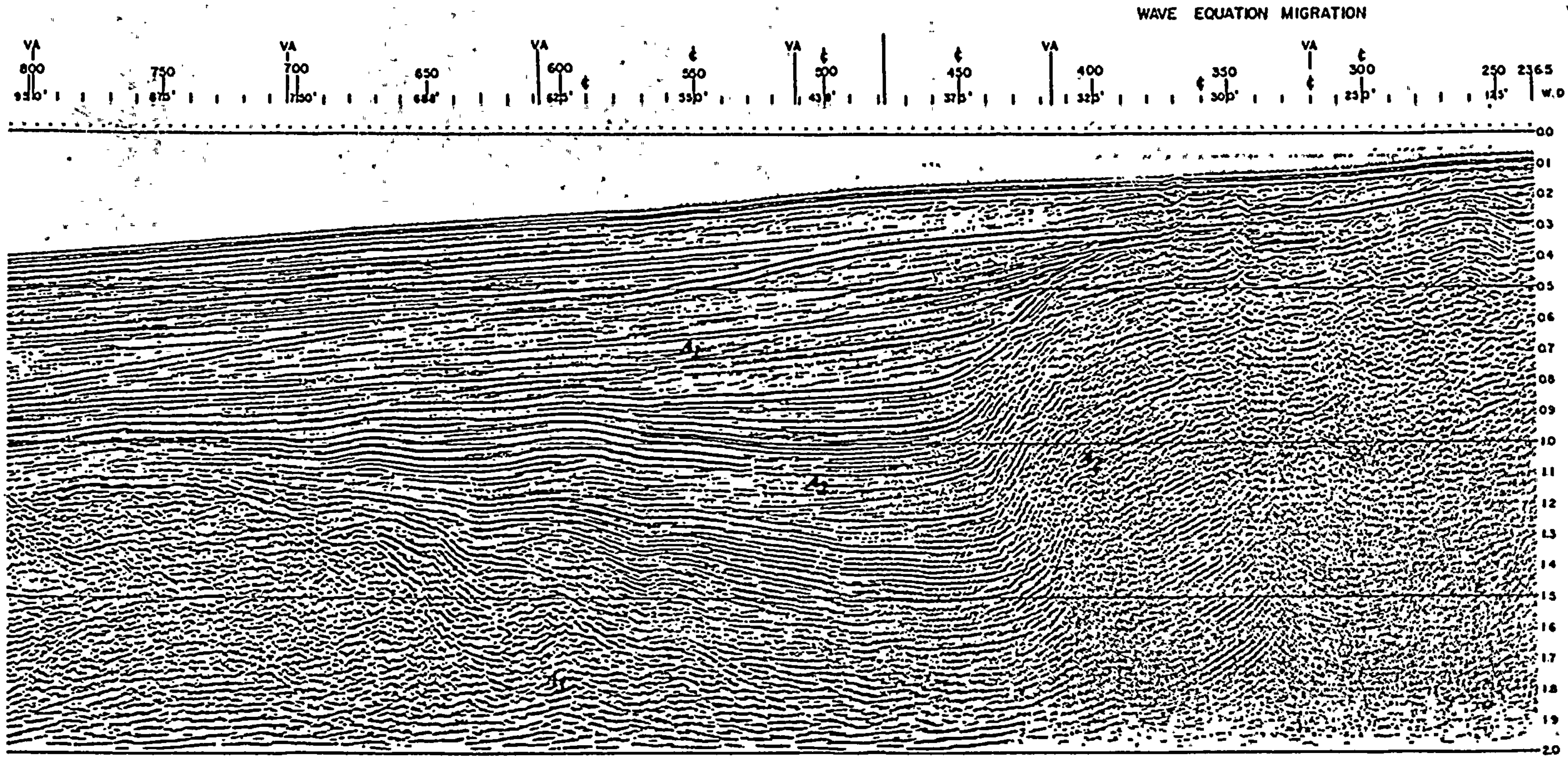
Pt. Estero
Morro Bay
HOSGRI
FAULT
ZONE
EDNA FAULT
WEST HUASNA FAULT
Diablo Canyon
Pacific Ocean
Arroyo Grande
Pt. Sal
SCALE
0
5
miles
COASTAL AND OFFSHORE GEOLOGY BETWEEN POINT SAL AND POINT ESTERO

Figure 35



GEOLOGIC CROSS SECTION OF THE HOSGRI FAULT ZONE IN THE VICINITY OF THE DIABLO CANYON SITE

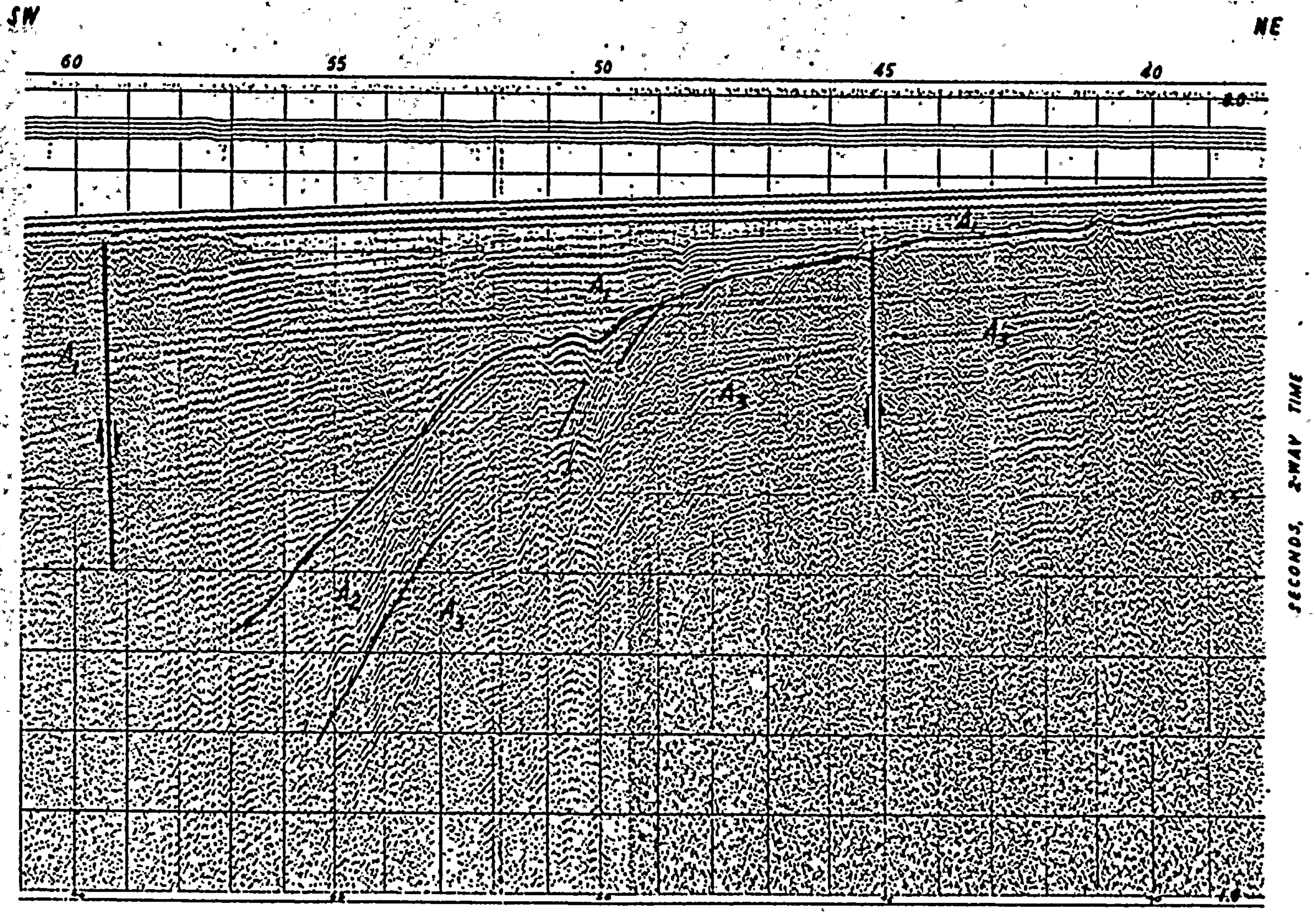
Figure 36



CDP SEISMIC REFLECTION RECORD SHOWING THE HOSGRI FAULT

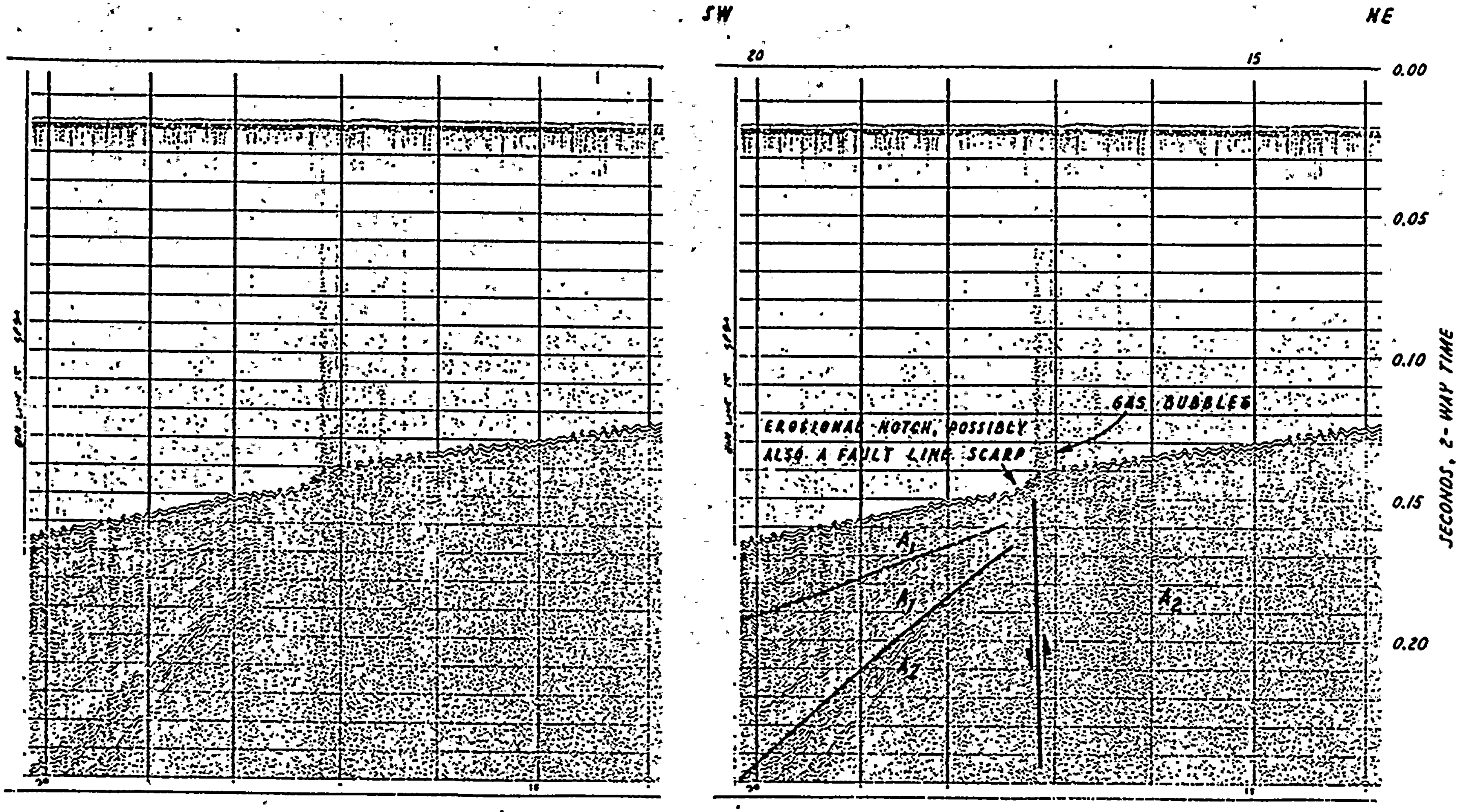
Note: The left side of the cross section shown on Figure 36 is derived from a record similar to this one.

Figure 37



SPARKER SEISMIC REFLECTION RECORD SHOWING THE HOSGRI FAULT

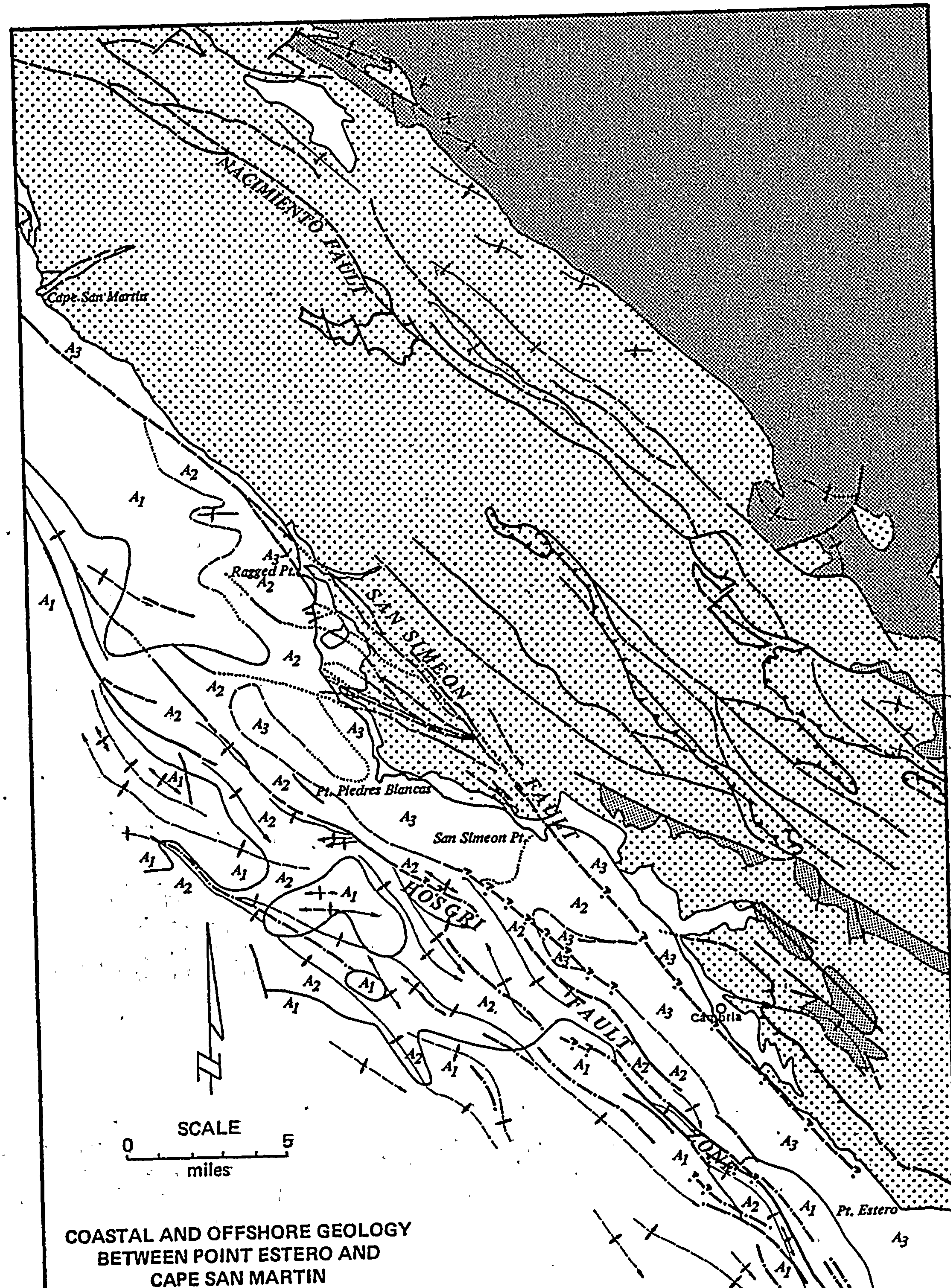
Figure 38



<u>High Resolution Acoustipulse Seismic Reflection Profile, BBN Line Ap 15</u>

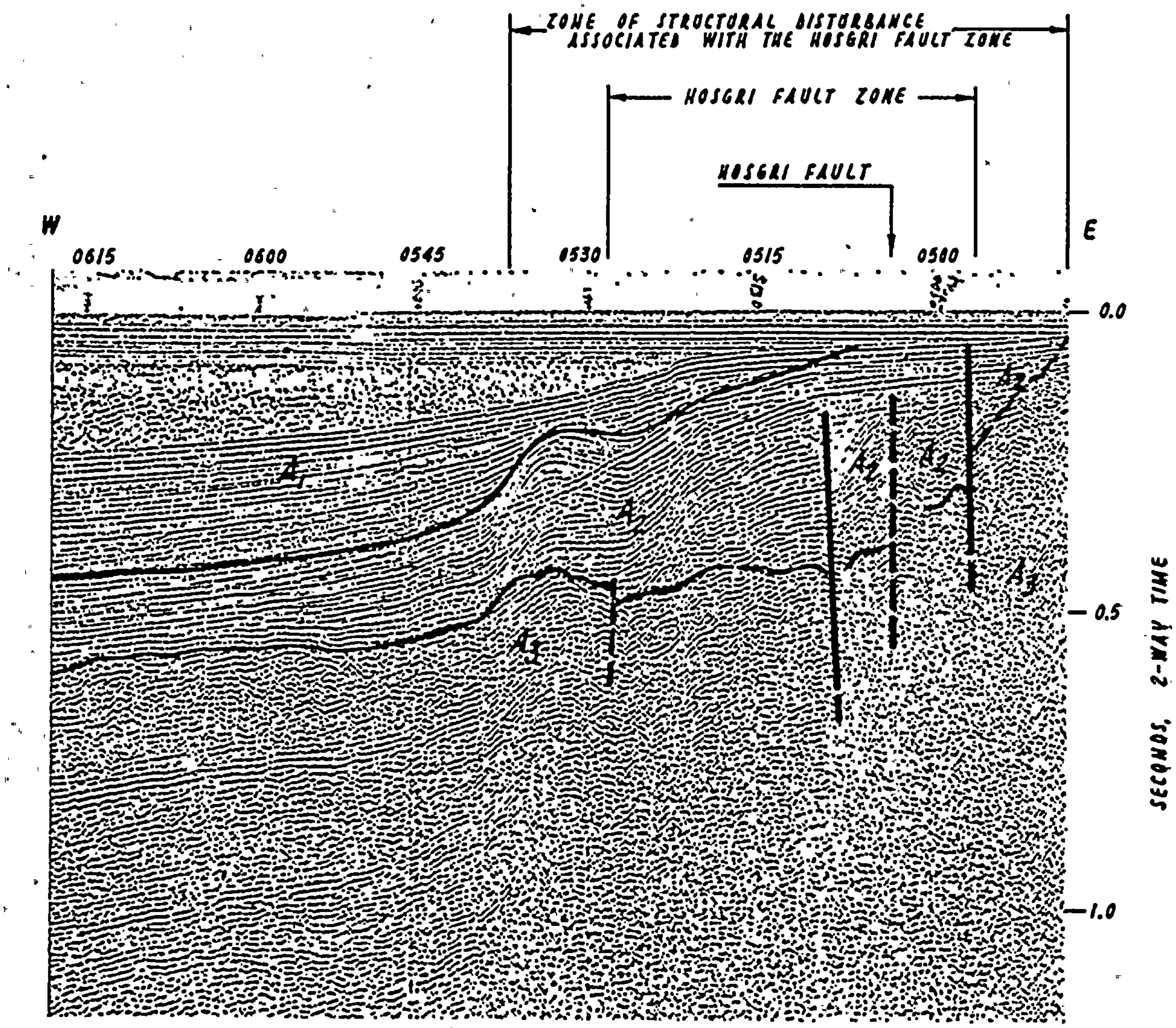
This profile shows a bench and scarp feature that is spatially coincident with a west-down fault in the underlying rock section. The notch morphology and geologic relationships of this feature suggest that it is a fault-line scarp that has been modified by strandline wave erosion. The sea floor surface steps down across the notch; however, this could express either fault offset of the sea floor or differential erosion, since the Acoustic Unit A2 rocks in the section northeast of the fault are more resistant than those of the A1 section to the southwest.

Figure 39



COASTAL AND OFFSHORE GEOLOGY BETWEEN POINT ESTERO AND CAPE SAN MARTIN

Figure 40



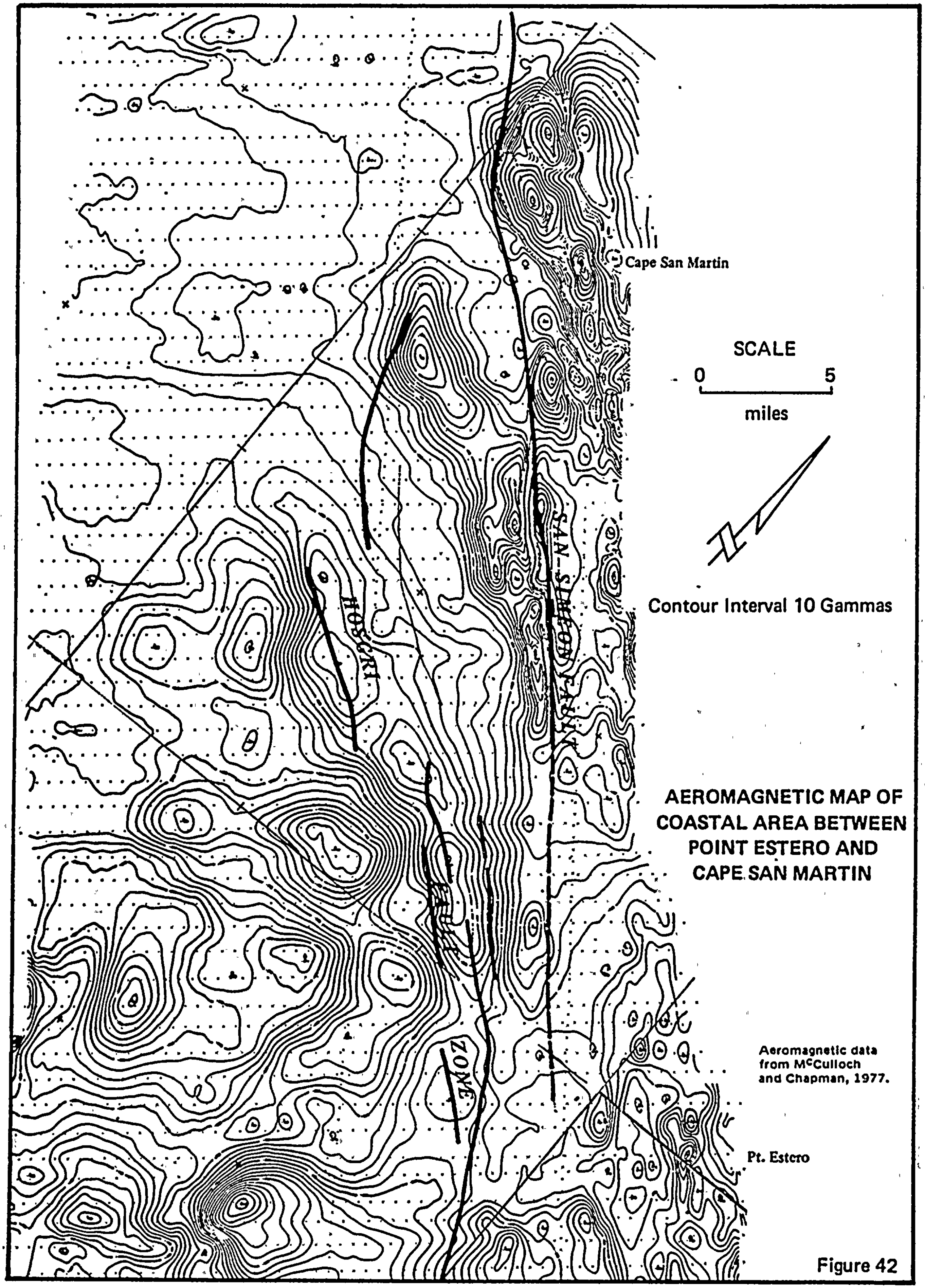
Sparker Seismic Reflection Profile, Kelez Line 87

The style of structural deformation associated with the Hosgri fault zone at the latitude of Kelez Line 87 is similar to that shown in Kelez Line 99, Figure 9(N). In this profile, however, vertical displacements across faults within the zone are smaller and the Hosgri fault master break has diminished to about the same relative size as the other breaks in the zone. The Hosgri fault cannot be identified north of this profile.

SPARKER SEISMIC REFLECTION RECORD SHOWING THE HOSGRI FAULT ZONE

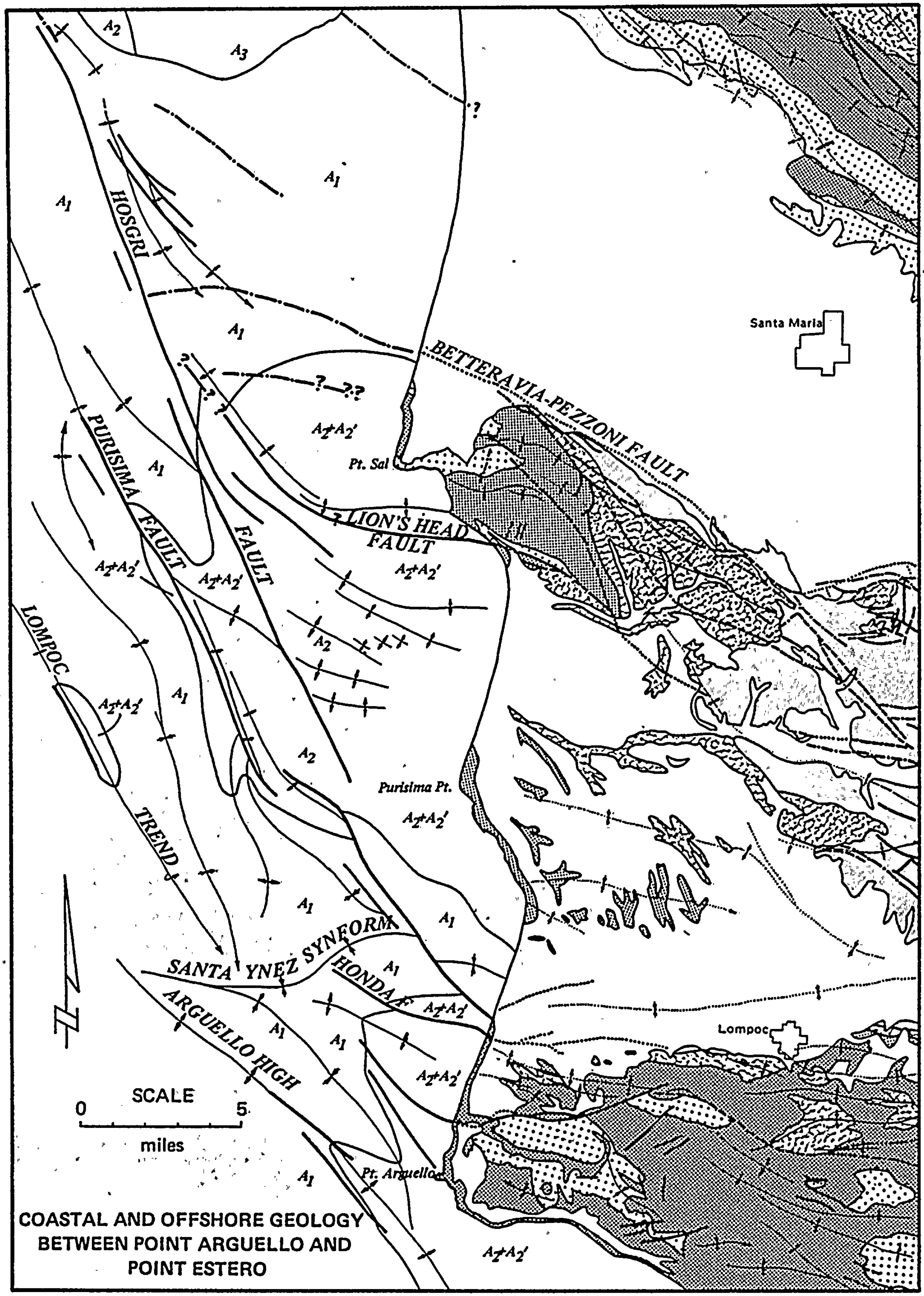
ESA 1310 JULY 1975

Figure 41



AEROMAGNETIC MAP OF COASTAL AREA BETWEEN POINT ESTERO AND CAPE SAN MARTIN

Figure 42



HOSGRI
BETTERAVIA-PEZZONI FAULT
Santa Maria
LION'S HEAD FAULT
Pt. Sal
PURISIMA FAULT
FAULT
LOMPOC TREND
Purisima Pt.
SANTA YNEZ SYNFORM
HONDA
ARGUELLO HIGH
Lompoc
Pt. Arguello
SCALE
0
5
miles
COASTAL AND OFFSHORE GEOLOGY BETWEEN POINT ARGUELLO AND POINT ESTERO

Figure 43

EXPLANATION FOR FIGURES 19, 35, 40 AND 43

OFFSHORE *ONSHORE*

GEOLOGIC UNITS

CENOZOIC

SEDIMENTARY DEPOSITS AND ROCKS

Holocene and Pleistocene nonmarine (chiefly alluvial) and marine deposits, undivided. Large land slides where mapped separately.

A_1 *Plio-Pleistocene and Pliocene nonmarine; Pliocene marine.*

A_2 *Miocene marine and nonmarine, undivided; Upper Miocene marine.*

A_2' *Middle Miocene marine; Lower Miocene marine; Oligocene marine and nonmarine, undivided; Oligocene nonmarine; Eocene marine; Paleocene marine.*

VOLCANIC ROCKS

Tertiary volcanic rocks.

Tertiary pyroclastic rocks, (including volcanic mudflow deposits).

Tertiary intrusive rocks. (Ti on Figure 19)

A_3

MESOZOIC

SEDIMENTARY AND METAMORPHIC ROCKS

Upper Cretaceous marine rocks.

Lower Cretaceous marine rocks.

Franciscan assemblage (predominantly sedimentary and meta-sedimentary rocks (including Franciscan melange).

Jurassic marine rocks (includes Knoxville Formation).

Metamorphic rocks of Pre-Tertiary Age. Undivided.

METAVOLCANIC ROCKS

Mesozoic-metavolcanic rocks (including Franciscan volcanic rocks).

PLUTONIC ROCKS

Mesozoic granitic rocks.

Mesozoic ultramafic rocks.

SYMBOLS

Geologic contact, dashed where approximate or where Quaternary deposits are involved.

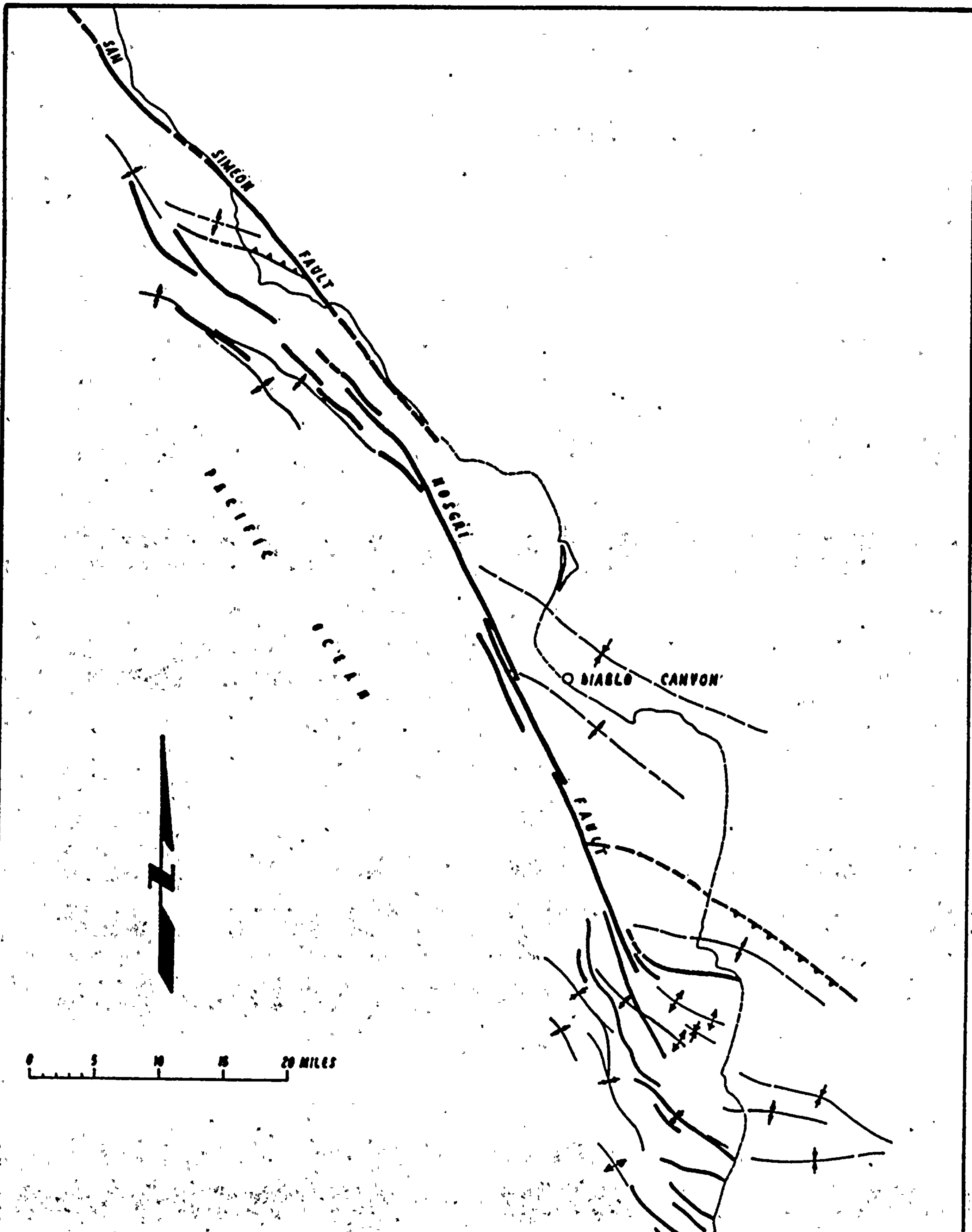
Fault, solid line where location is well defined, dashed line where approximate or inferred, dotted where concealed.

Thrust fault, barbs on up-thrown side.

Buried fault, well controlled from seismic reflection data. (Offshore and subsurface faults onshore.)

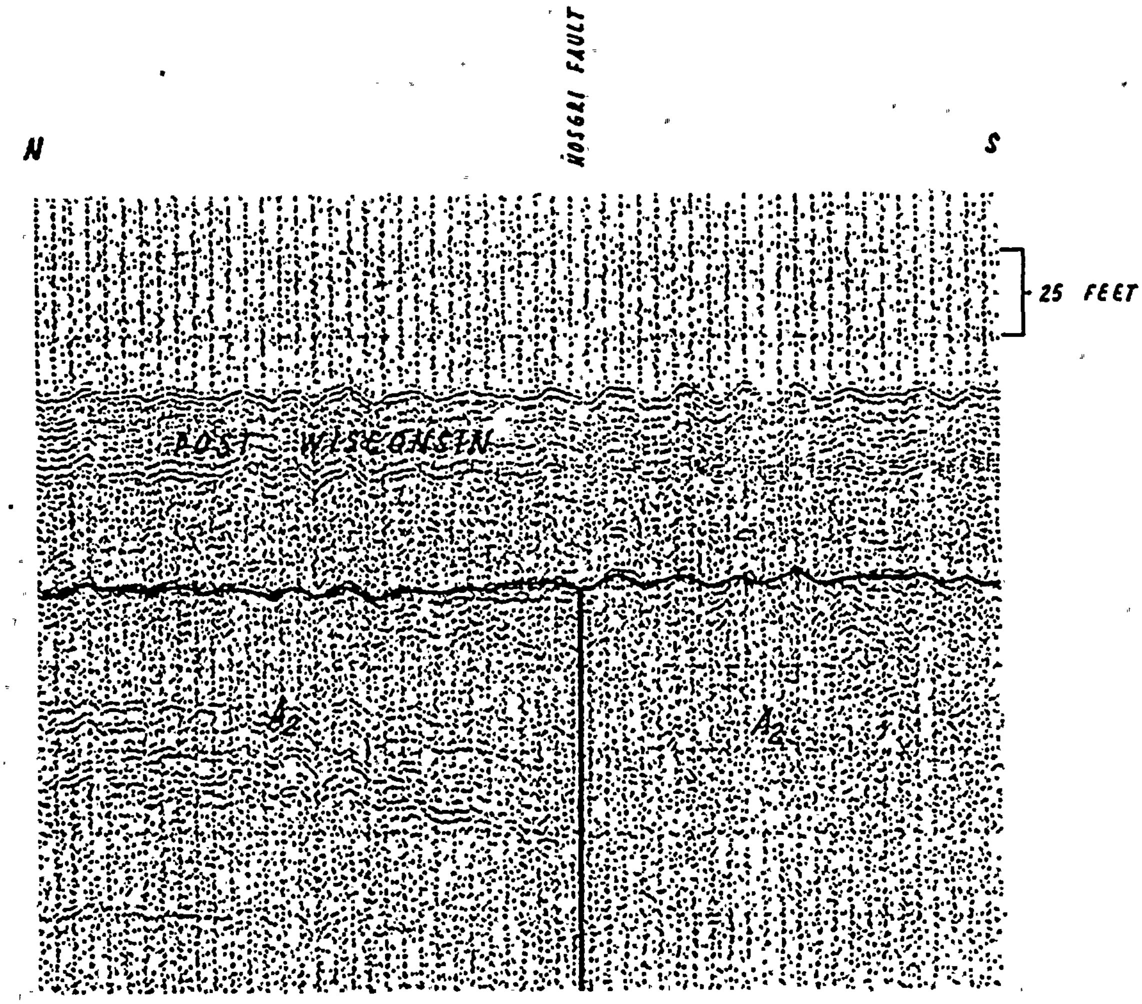
Anticlinal axis – with plunge indicated. (Solid line where location is well defined, dashed line where approximate or inferred, dotted where concealed.)

Synclinal axis – with plunge indicated. (Solid line where location is well defined, dashed line where approximate or inferred, dotted where concealed.)



HOSGRI STRAIN SYSTEM

Figure 44



High Resolution Uniboom Seismic Reflection Profile, Polaris Line 1-7

This profile shows the southernmost unambiguous evidence of the Hosgri fault. The fault is represented by the truncation of reflector horizons within the Acoustic Unit A2 rock section. The fault does not disturb the post-Wisconsin unconformity, the overlying post-Wisconsin section, or the sea floor. Undulation in the unconformity and sea floor reflector are caused by surface wave action.

HIGH RESOLUTION RECORD SHOWING THE SEA FLOOR AND NEAR SURFACE GEOLOGY OVER THE HOSGRI FAULT

ESA 1310 JULY 11, 1975

mpb1

BY MR. FLEISCHAKER:

Q Dr. Jahns, turning to this testimony which is some 130 -- it's 132 pages long with several pages of references and figures and tables, did you personally prepare any part of this testimony, and if so, can you tell me which parts of the testimony you prepared?

A (Witness Jahns) To the first part of your question, yes. And to the second part, also yes.

Q Which parts of the testimony did you author?

Perhaps we could just go to the Table of Contents on one, two, and three, and you can just designate those which you personally authored.

A Surely.

MR. NORTON: Excuse me, Mr. Fleischaker.

Do you want him to go through the entire Table of Contents and tell you whether he authored each subpart thereof or contributed to or had nothing to do with?

MR. FLEISCHAKER: Do you have an objection?

MR. NORTON: Yes. I'm not following what you're asking him to do in the Table of Contents.

BY MR. FLEISCHAKER:

Q Dr. Jahns, my question is:

Could you go through the Table of Contents and identify with respect to the various subjects that are listed there which of those you authored personally or which you

mpb2

contributed material to?

A (Witness Jahns) Yes, I could do that. It's not as simple as your question implies because in almost all of these sections Mr. Hamilton and I reviewed each other's work.

A further complication is that some of this work dates back to FSAR days. But let me have a crack at it.

Q Let me see if I can clarify.

Perhaps you can identify those parts in which you served as the principal author and those in which you served primarily as reviewer, if that's a useful distinction to make.

A All right. We can do it that way if you like.

A, I was the reviewer and made additions.

B.1.a, on the San Andreas fault, is essentially a joint effort.

The same can be said about B.1.b.

Section 2.a. is largely the work of Mr. Hamilton.

Section 2.b. is largely mine, except for this offshore section, which is largely Mr. Hamilton's.

Section 3, would be -- is more Mr. Hamilton's than mine.

Section C. is principally Mr. Hamilton's.

Section II, A. and B, are principally mine, and C, joint.

The entire section on the Hosgri Fault was

mpb3

initially prepared principally by Mr. Hamilton.

Q Okay.

Now, Dr. Jahns, with respect to that last section on the Hosgri Fault, I take it, however, that you did review that, that section there?

A Very definitely.

Q And that you have accepted the conclusions stated in that section as your own?

A Yes.

Q Could you state for the Board briefly your activities as described earlier both during the initial assessment and during the current reassessment of the geology related to the Diablo Canyon site?

A In terms of field work, I was most active during the period 1965-1970, and during that period I was occupied principally with detailed site geology mapping, the design of early on exploration trenches, and mapping of the site surrounding area to the extent of about ten square miles.

After Earth Sciences Associates became more involved, my personal role in mapping became a minor one. And although I kept in close touch with what was happening, I no longer was so heavily engaged in the field work itself.

On that score, however, I did participate in mapping of the later, and as I recall somewhat more extensive series of trenches that extended over the general area for

mpb4

Unit 2.

Since that time I have visited the site, but not for purposes of mapping. And I have been in close touch relative to reviewing offshore records, reviewing interpretations, and offering some interpretations of my own, particularly in areas of regional tectonic analysis.

Does that take care of it for you?

Q During the 1965-1970 time period you were, if I understand your testimony, involved primarily in examination of the site geology.

Where were the exploration trenches that you were involved in?

A The original exploration trenches were in the Unit 1 area.

Q Was this trenching limited to the site?

A That's correct.

Q You also indicated that you did geologic work in the site surrounding the area.

Did you do any trenching during this early period, 1965 to 1970, in the area surrounding the site?

A No trenching away from the immediate site area.

Q Before we go any further on talking about trenching, could you describe, please, this technique of trenching, what it involves and what it is we're looking for?

A Yes.

mpb5

The site is, of course, on a coastal terrace, and like other coastal terraces in California, it comprises two kinds of material, it's a two-ply sequence above present sea level. Immediately beneath the terrace surface is a section of unconsolidated materials ranging from silt to sand and gravel and rubble that we call collectively the "terrace cover". This cover rests on top of whatever bedrock is present in the area, and the surface contact between them is basically a fossil analog of the present situation at the base of the sea cliff today.

So that the surface represents typically a wave-cut bench similar to what we see today beneath the beach sediments, or exposed as bare rock on the coast, and the terrace cover represents material that we can expect some day to see a few million years or a few tens of thousands years hence above the present wave-cut bench when that section is uplifted above sea level.

So the notion of the exploratory trenches is to penetrate down in a continuous way through the terrace cover in order to expose the contact between that terrace cover and the underlying bedrock, and in order to permit the very careful inspection of that contact.

Finally, in order to determine whether that ancient boundary has been offset by faults, there are breaks in the bedrock, so it becomes very important to determine

mpb6

whether any of these small breaks penetrates upward into the terrace cover. The reason for that is that the terrace cover can be dated, and if in effect it represents an unbroken cap over the trace of breaks in the bedrock, then it provides us with the youngest possible age of the faulting, although the actual age lies somewhere within a very wide span between bedrock that is affected and that is ten-plus millions of years old, and the terrace cover that is not affected that's on the order of 100,000 to 120,000 years old.

Q This trenching technique, is this done with shovels or backhoes, or what is the actual method that we use in order to cut the earth?

I'm trying to get a physical picture of what it is we're doing to the earth to expose these, I guess strata.

A These trenches were excavated not with a backhoe because backhoe trenches are a little more difficult to work with in that they are narrow and if deep especially impose serious constraints on viewing, and viewing is the principal function of a trench. It's many times better for these purposes than drill holes because it provides a continuous view. So these trenches were excavated very wide. The width along the bottoms of the trenches was about twice the width that can be negotiated by an automobile.

One of the walls was deliberately made vertical to provide an undistorted view of this boundary I was talking

mpb7

about. The other wall was sloped back and in general was incidental.

To begin with, four trenches were developed in a tic-tac-toe pattern across the area in order to make it very certain that any fault present would be picked up among the exposures.

In Figure 25 in the testimony there is a view of the trenching alignment at a later stage, but the original trenches were essentially four in a tic-tac-toe pattern.

end 4a

4b ebl

MRS. BOWERS: Before you go ahead, Mr. Fleischaker, I'm not sure what you mean by "tic-tac-toe" arrangement.

WITNESS JAHNS: A pattern of two pairs of parallel lines crossing at 90 degrees, essentially.

MRS. BOWERS: Thank you.

c2

BY MR. FLEISCHAKER:

Q Dr. Jahns, what I would like to do with you is discuss with you this whole question of trenching, the technique of trenching, not only as applicable to the site but the technique of trenching itself. And I was wondering if you could help us understand if there are various means of accomplishing trenching, how deep the trenches are, if they are at different levels? That is, what are the different techniques that one might use if geologists have -- you know, that geologists might label Technique A as sort of a preliminary look, and Technique B as being more thorough and Technique C as being a very thorough look at trenching, if that's possible?

A (Witness Jahns) Yes, that's possible, and it is of some extra interest here because, to my knowledge, this was the first project of this kind in which trenches were extensively used as a means for exploration and certainly the first in which trenches of this dimension were used.

Ideally, what one wishes to get is complete coverage of a given area in terms of exposing any faults that

eb2

may be prsent, that, in combination with complete coverage of the boundaries with any datable geologic units whose physical relationships can be compared with those of he faults, and that of course is why a trench is very good.

So for the first element of the exploration it has become customary to put down preliminary bore holes in order to determine how thick the terrace cover is because this is one of those instances where the geology specifies the dimensions of the trench. There is no point in digging a trench on a coastal terrace unless it is carried down to a depth into the bedrock. Otherwise, the critical boundary isn't exposed.

So in this instance the trenches ranged in depth from as little as eight feet or so to something greater than 30 feet. And that was largely a function of progressively increasing thickness of the terrace cover from the sea cliff in a landward direction.

Normally, the technique of excavating a trench is whatever makes sense in terms of the material to be moved, the equipment at hand, and so forth, because it's incidental. All you want the trench for, really, is to develop an exposure, a continuous exposure. And what normally is done is to make the excavation, hustle the broken material out of the way, and then scale back the trench wall that is going to be used for the detailed mapping or logging.

eb3

Q Can I stop you? What do you mean, "scale back"?

A Actually trimming a trench wall, ordinarily with hand tools, hoes, adzes, things of that sort, and then finally the contact itself is gone over by the geologist with a paint brush or a whiskbroom or something of that sort in order to clean it up for inch-by-inch inspection and mapping.

That's normally it.

Then one might add the detail of control. Typically in the case of the Diablo exploration, the trench walls were covered with overlapping photographs, the cameramen moving 10 feet, 12 feet or so from one frame to another, shooting the picture directly on against the wall.

Q Can I stop you? Why do you do that?

A The photographs are used for the mapping itself. And when we log the trench walls we drew on the photographs all the features, the boundaries and so on, that were exposed on the trench wall.

I should interject here that prior to the photography, the trench walls were surveyed to provide control because there is distortion in the photo coverage. The control points, as I recall, in most instances were 10 feet apart, were marked with bits of colored ribbon attached with nails. Those showed up in the photographs.

So that permitted us, after the mapping was done, to tie the data that were recorded in the photographs to

eb4

an engineering control section. And it was a series of sections of that kind that appeared in the PSAR and the FSAR.

MR. TOURTELLOTTE: Mrs. Bowers, I don't know that I want to interpose an objection at this point, but my understanding is that trenching is for the purpose of deciding whether there is a fault at a given location. And I don't believe there is a contention in this proceeding that has anything to do with the fact that there is a fault at the plant site.

But I thought the contentions here and what we were going to litigate here was the effect, if any, of the Hosgri on the operation of the Diablo plant. I am really totally at a loss to see what the relevance of this line of questioning for this witness has, and it seems to me that it is just dragging out this proceedings, either for the purpose of dragging out the proceeding or for getting a free education on trenching, and I don't think that's the purpose of why we're here.

So I would just suggest to the Board that I think we ought to have some idea of what Mr. Fleischaker is after with trenching. If he is going to request that a new contention be filed, then I think we ought to know about that.

MRS. BOWERS: Mr. Fleischaker?

MR. FLEISCHAKER: Is there an objection? Do you want me to tell you where I'm going? Is that it?

ab5

MRS. BOWERS: Well, how your questions in the area you have been pursuing tie in with the Hosgri contention?

MR. FLEISCHAKER: There are several-- If you'll recall when I asked Dr. Jahns these questions I asked him about trenching, not trenching on the site. One of the things I'm going to be talking to these witnesses about in detail are the geophysical and geological tools that have been utilized to map the nature and extent of the San Gregoria-Hosgri fault zone.

The San Gregoria and the Hosgri and the San Simeon are on land. Trenching may or may not have been done, and what I want to know about is the extent. I'm talking about now trying to get some understanding into the record, some testimony about trenching, and then we can talk about whether or not trenching was done on the parts of the San Gregorio-Hosgri FAult and to what extent that trenching was adequate and to what extent it was -- you know, additional trenching could have been done.

We'll have to talk about seismic reflection data; we'll have to talk about geophysical data; and we'll have to talk about the techniques that are utilized to get that data in order to understand the uncertainty in the data.

MR. NORTON: Mrs. Bowers, I have to join in the objection although now I think it's a different objection.

I take it what Mr. Fleischaker is saying -- and

eb6

incidentally, this is the first we ever heard that the Hosgri was on land, and I'm most anxious to find where that is.

But what Mr. Fleischaker is now saying is that what he's going to do is go into all this trenching on these faults. He doesn't have a word of that in his direct testimony anyplace, and what he is now telling us is that he is going to go into all these new areas through cross-examination of our witnesses I guess.

MR. FLEISCHAKER: That's totally irrelevant. It doesn't have to be in my direct testimony. It's in their testimony. You have indicated in your testimony that you have done trenching of the San Simeon, and I want to explore the trenching techniques and then I might get to talk about the San Simeon at some later date.

But I see no reason to start flagging exactly where I'm going in my cross-examination at all times. You talk about trenching in your testimony. I am exploring that geological technique in order to understand something about it so I can understand something about the limits of the conclusions that you can draw from utilizing that technique.

MR. NORTON: Mrs. Bowers, I can only say that I strongly suspect we're going to have this kind of questioning that goes on, on, and on and on. Time will tell.

MR. TOURTELLOTTE: If I might?

MRS. BOWERS: Mr. Tourtellotte.

eb7

MR. TOURTELLOTTE: Again I see trenching as a tool that is used to determine whether or not a capable fault exists in a given place. No one maintains in this proceeding that the Hosgri is not a capable fault. No one maintains that the San Gregorio is not a capable fault. No one maintains that the San Simeon is not a capable fault. And the function of trenching then, to determine whether trenching was done at these points or not has no real basis for making a decision about the Hosgri Fault and the effects of a given magnitude of an earthquake on the Hosgri Fault to this proceeding.

MR. FLEISCHAKER: Mrs. Bowers, I have a feeling that throughout this proceeding, despite the fact that we're here to examine carefully the 130 pages of testimony that have been submitted by the Applicant, despite the fact that we just got a three-hour lecture from the Applicant, that there is going to be an effort by the Staff and the Applicant to hurry up, hurry up, and I'm going to resist it.

In another proceeding in which I participated before the Appeal Board, we found that it was necessary to examine in detail the techniques that were utilized by the seismologists in that case to locate earthquakes in order to come to any reasonable conclusions regarding the maximum earthquake potential of the Ramapo FAult.

We spent three or four days examining seismograms

eb8

on screens. The Appeal Board was prepared to -- found that it was useful to spend that time in order to reach its conclusions. It wasn't easy, and it tried everybody's temper, there's no question about it, at times.

I will try to conduct this cross-examination as expeditiously as possible. I've been on for about 30 minutes so far, and already I'm getting pushed from the left and from the right to hurry up. And, you know, I think I have the right to full cross-examination of the 130-odd pages that have been turned in here.

I might point out, not only do we have the 130 pages but we have volumes and volumes of work. The Applicant himself has at length argued that this has been the most detailed geological-seismological investigation that any plant has ever undergone, ever. It seems to me that two days, three days of cross-examination of that four-year effort isn't too much, if it takes that long, and I'm not even sure that it will.

MR. NORTON: We have no objection to his taking as long as he wants as long as the questions are relevant to the issues here. But to start going into the details of taking pictures of trenches that were done 15 years ago-- We have no objection to his asking all the questions as long as he wants.

MR. TOURTELLOTTE: I don't want to say anything

eb9

more in argument but I do really object to the characterization of my objection as trying to hurry up the Intervenor. I'm not going to hurry up this Intervenor at any time in this case. He can take all the time he wants. But I am going to insist throughout the proceedings that he stay with relevancy and reliable, probative evidence, and that's what the objection is made about.

It isn't made in any way to suggest that he should hurry up. I don't know how long it is going to take on the cross-examination.

MR. FLEISCHAKER: Let me be more specific then with regard to the area I'm going to, and I really don't like leading the witness into the area, but let me do it in this case.

The Applicant has drawn certain conclusions regarding the continuity between the Hosgri and the San Simeon based on trenching on land of San Simeon. And what I was trying to do was lay the groundwork for that technique so I could then test -- Mr. Hamilton is now writing it down -- so I could test how thorough the trenching was on San Simeon, from which he drew these conclusions.

MRS. BOWERS: Mr. Fleischaker, are you asking questions on matters in the direct testimony that were fully explained, like what trenching is and what is means?

MR. FLEISCHAKER: No. There has been testimony,

eb10

direct testimony, that indicates that certain conclusions were drawn on the basis of trenching on land. I'm trying to understand better what that technique is. That's all.

4C wbl

2.190

MR. TOURTELLOTTE: Could we have a reference as to where it is in the testimony?

MR. FLEISCHAKER: Mrs. Bowers, I don't know what that's all about, Mr. Norton conferring with his witnesses.

(Pause)

MR. FLEISCHAKER: Let me ask Mr. Hamilton. I think there might be a quicker way to get through this.

BY MR. FLEISCHAKER:

Q Mr. Hamilton, have you done any on-land trenching at San Simeon?

A (Witness Hamilton) No, I have not.

Q What kind of work have you done at San Simeon?

A We've done field mapping there, including detailed examination of the sea cliffs. But Earth Sciences nor I have not done any trenching.

Q Are you aware of any trenching?

A Yes, I am.

Q And where is that trenching? Is there trenching on San Simeon?

A Yes, several trenches were excavated across various branches of faults in the San Simeon area by another consulting firm.

Q Did you draw conclusions on the basis of any results, or have you relied on the information revealed in that

wb2

trenching?

MR. NORTON: I object to the question. It's multiple. If he's break it down into one or the other, then he can answer it properly.

MRS. BOWERS: Please divide it.

BY MR. FLEISCHAKER:

Q Have you examined any of the data that resulted from that trenching?

A (Witness Hamilton) I've seen logs prepared from the trenches. I've not seen the trenches themselves when they were open.

Q Have you relied on that data to any extent?

A I found that the data seemed to correlate with the data we had developed from our field mapping work. So it is corroborative.

MR. FLEISCHAKER: I haven't got to the exact point in the testimony, but I think that's precisely what I would have driven to maybe tomorrow at some time.

MRS. BOWERS: Pages 91 and 92 refer to trenching.

MR. TOURTELLOTTE: As a suggestion, Mr. Hamilton's responses-- I don't know whether Dr. Jahns would give the same responses or not. And I think the questions have yet to be asked to him. But if the responses of Dr. Hamilton reflect those of the entire panel then it would appear that these gentlemen have not engaged in the trenching activity as

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suggested by counsel on the San Simeon, and therefore they would be unable to testify in any respect about any trenching that went on there.

What Mr. Hamilton did say is that he read the logs. And if we want to talk about logs then we can talk about logs. But if we talk about trenching, they are the men who should have been there. Otherwise it's irrelevant to their testimony.

MR. FLEISCHAKER: It's not irrelevant.

I can inquire into the technique so I understand the technique better, and then ask Mr. Hamilton whether with respect to interpreting those logs he was aware of how thorough the technique was for the trenching. That's precisely what I was trying to do, was lay the background to understand, get something in the record about the technique so that at the time we began to discuss the trenching, and the conclusions that he drew from the trenching, I could ask him about his understanding of the detail of that trenching and the technique utilized there.

MR. NORTON: Mrs. Bowers, may I interrupt?

MR. Hamilton and Mr. Willingham have to present a paper to a professional society in San Francisco on Friday morning. And at this rate they're not going to make it. And I would ask that we please proceed with the cross-examination.

MRS. BOWERS: We do feel that the direct testimony speaks to trenching in the various areas, and we think it's

appropriate. But I think Mr. Fleischaker got an answer that--

MR. FLEISCHAKER: I can't remember what I go right now, frankly. But we have an order for transcript and we'll review it tonight and see what else we need.

Thank you.

BY MR. FLEISCHAKER:

Q Mr. Hamilton, you indicated you had been involved in investigations relating to power plants. Have you been involved in any investigations related to nuclear power plants?

A (Witness Hamilton) Yes, I have.

Q What nuclear power plants were those?

A If we include proposed nuclear power plants--

Q Please do.

A Okay. I have been involved with investigations for the existing plant at Humboldt Bay, Unit No. 3; for a proposed plant at Point Arena which was to have been called Mendocino Units 1 and 2; for a proposed plant near Collinsville near Fairfield, on the Sacramento River; for a proposed plant on the Davenport Coast north of Santa Cruz, and for the Diablo Canyon plant.

Q Did you participate at all in the review of Bodega Bay?

A I did not.

Q Dr. Jahns, have you likewise participated or assisted in the review for any other nuclear plant sites than

wb5

Diablo Canyon?

A (Witness Jahns) Yes, I have.

Q Can you identify those, please?

A. Mendocino site that Mr. Hamilton mentioned; the Collinsville site; the Davenport site; Diablo Canyon, of course, and the Corral Canyon site. Those represent the coastal or near-coastal sites.

I've also been involved with some interior sites.

Q Did you work with Mr. Hamilton on those: Mendocino, Collinsville, Davenport? Collinsville I think you both mentioned. Were you co-workers on those sites also?

A For some of them. Very much involved together at Mendocino; in some late stages at Collinsville; in some late stages at Davenport; not at all at Corral Canyon.

And I forgot to mention sites farther down the coast, San Onofre, where we were not involved together.

Q But you were involved in the San Onofre review?

A Yes.

Q Okay.

Mr. Hamilton, were you involved in the San Onofre review?

A (Witness Hamilton) No, I was not.

Q Dr. Jahns, was that for Units 1, 2 or 3 at San Onofre?

A (Witness Jahns) Units 2 and 3.

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Q Dr. Jahns, in your testimony, your oral testimony before the Board you used the word "enigma" to describe some tectonic question. Could you define that question for us, please?

A In the sense I was using it I referred to what we might call a geologic poser, a situation in which there are certain kinds of evidence that seem difficult or impossible to translate into a rational, tidy explanation. This is what I would call an enigma.

Q What was the specific enigma to which you were referring earlier in your oral statement to the Board?

A We have a master fault in the San Andreas. We have two bodies of evidence: one applying to its northern part, one to its more southerly part. These lines of evidence respectively suggest a very substantially larger cumulative slip for one part of the fault than for the other, the difference being so great that one requires a special explanation in order to apply it to a single feature like the San Andreas. This is the enigmatic part.

Q If I understood your testimony it was that some workers in the field have offered the San Gregorio-Hosgri as a continuous zone of faulting as some explanation for that enigma; is that correct?

A That's correct.

Q What part does the San Andreas -- does the

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San Gregorio-Hosgri play in the resolution of that problem according to those co-workers?

MR. NORTON: Excuse me; I would like to make an objection, and that is that I think we're going to have to be very careful. The first question used "San Gregorio-Hosgri fault zone," the second question slipped and left off "fault" or "fault zone" or "fault system" and just called it the San Gregorio-Hosgri. And I think we have to be very careful, to get a good record, with what we mean when we say "San Gregorio-Hosgri." That term hasn't been defined by anybody yet, and yet it is very easy in a question for a witness to assume he means zone or he means fault or he means system, and answer it.

I just bring that up because I think we all ought to agree on the terminology so we have a clean record in that respect.

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MR. FLEISCHAKER: I'll use the witness' terminology.

BY MR. FLEISCHAKER:

Q Dr. Jahns, in this questioning, in terms of addressing the tectonics of this region here, this San Andreas fault zone, the larger tectonic province, what tag would you utilize to describe the San Gregorio-Hosgri, what word should we use: fault zone or fault system?

A (Witness Jahns) I think I would prefer to call it a fault system.

Q Okay.

Let me reask my question:

What is your understanding of the role played by the San Gregorio-Hosgri fault system in resolving the problem that there is evidence of 600 kilometers of slip on one part of the San Andreas and 300 kilometers of slip on another part?

MR. NORTON: I object to this. It assumes facts not in evidence. There's been absolutely no testimony about 600 kilometers on one part and 300 kilometers of slip on another part.

MR. FLEISCHAKER: We can start all over again if we want.

MRS. BOWERS: The 600, was that something that tied in with the Eagle Rest Peak slide?

MR. FLEISCHAKER: I was trying to quote Dr. Jahns.

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I asked him to define the enigma. I think I understand what he's talking about. I'm certainly not trying to introduce facts into the record.

We can start all over again.

BY MR. FLEISCHAKER:

Q Dr. Jahns, would you like to describe the enigma again regarding the evidence regarding fault slip or movement on the San Andreas?

MR. NORTON: Object; asked and answered.

I'm simply objecting to the previous question because he used numbers that Dr. Jahns didn't use.

MRS. BOWERS: I was trying to find out if the 600 really was the 550 that was referred to in Eagle Rest.

MR. NORTON: It may have been.

BY MR. FLEISCHAKER:

Q Dr. Jahns, what figures would you utilize? It doesn't matter to me.

A (Witness Jahns) 300 and 550.

Q Okay.

MR. NORTON: Thank you.

BY MR. FLEISCHAKER:

Q Have some workers suggested that the San Gregorio-Hosgri fault system helps to resolve this enigma?

A (Witness Jahns) Yes.

Q Okay.

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What is the role played by the San Gregorio-Hosgri fault system?

A The role is the one basically that was indicated by the geometry on the cartoon that I projected here on the screen. First we must understand that the 300 figure, the 300 kilometer figure applies to features as old as 25 million years, and the 550 figure involves features that are more like 100 million years old. And the time factor also has to be plugged into the solution of this enigma. But the geometric notion is that with the San Gregorio-Hosgri system being active and with a sense of right-hand movement, eastside-south, then one could in effect extend farther northward the analog of the 100 million year old feature that appears on the east side of the fault far, far to the south in the Big Band area.

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So one might liken this effect to increasing the length of a telescoping ladder by extending out a sliding unit in the ladder. That's a crude analogy.

MRS. BOWERS: Mr. Fleischaker, I assume you have considerable more cross-examination of these witnesses, and we do want to stop promptly at five each day if we can.

MR. FLEISCHAKER: The answer to the first question is yes, I do.

MRS. BOWERS: Fine.

We'll recess now and begin tomorrow morning at --

MR. NORTON: May we inquire whether Mr. Fleischaker

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intends to take more than one day, because Mr. Hamilton and Mr. Willingham do have this professional paper to deliver Friday morning in San Francisco that's very important to them.

However -- you know, we would have to make some special arrangements of some kind. I don't know whether they could go up and be back early in the morning on a special flight, or what. I don't know.

But if he is going to be done with them tomorrow, then the problem disappears. That's all.

MR. FLEISCHAKER: I'll make every effort, but, you know, I don't know at this point.

As you know, Mr. Norton, it's real hard to judge how fast the cross-examination goes. But I'll make every effort to get through with them. But I can't tell you that I will be through with them. I don't think I'll have any questions for Mr. Willingham, if that will solve your problem.

MR. NORTON: Then would you like us to return all the records that you had me have Mr. Willingham bring, so that you won't ask any questions about them?

MR. FLEISCHAKER: No, I didn't say that. I thought that Mr. Hamilton might be able to assist us in examining those.

MRS. BOWERS: Well, we will be in recess now and we will reconvene at nine in the morning.

(Whereupon, at 5:00 p.m., the hearing in the above-entitled matter was adjourned, to reconvene at 9:00 a.m., the following day.)