

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

15 December 1978

Pages

5707 - 5897

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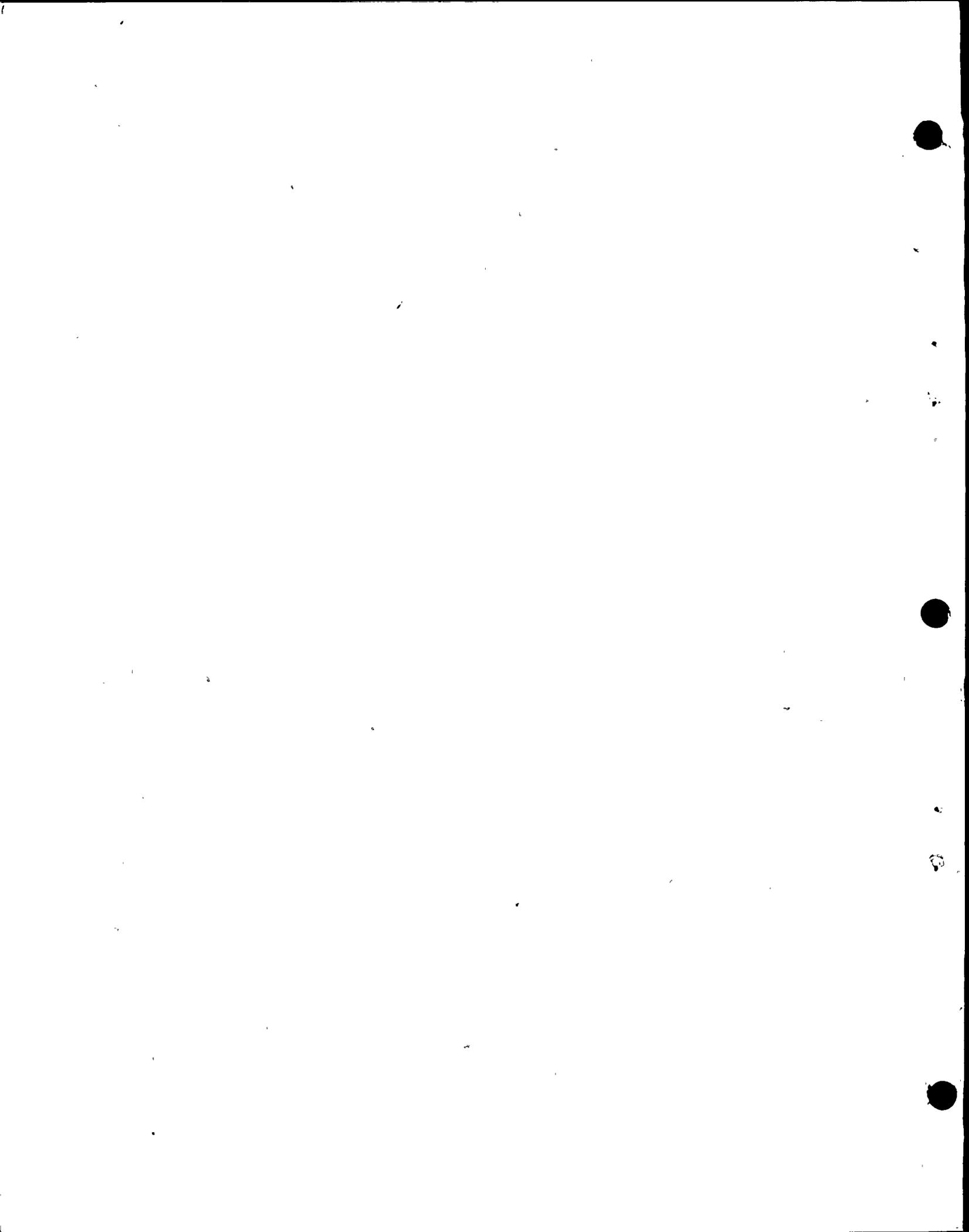
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UNITED STATES OF AMERICA

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.

Friday, December 15, 1978.

The hearing in the above-entitled matter was reconvened, pursuant to adjournment, at 8:30 a.m.

BEFORE:

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

DR. WILLIAM E. MARTIN, Member.

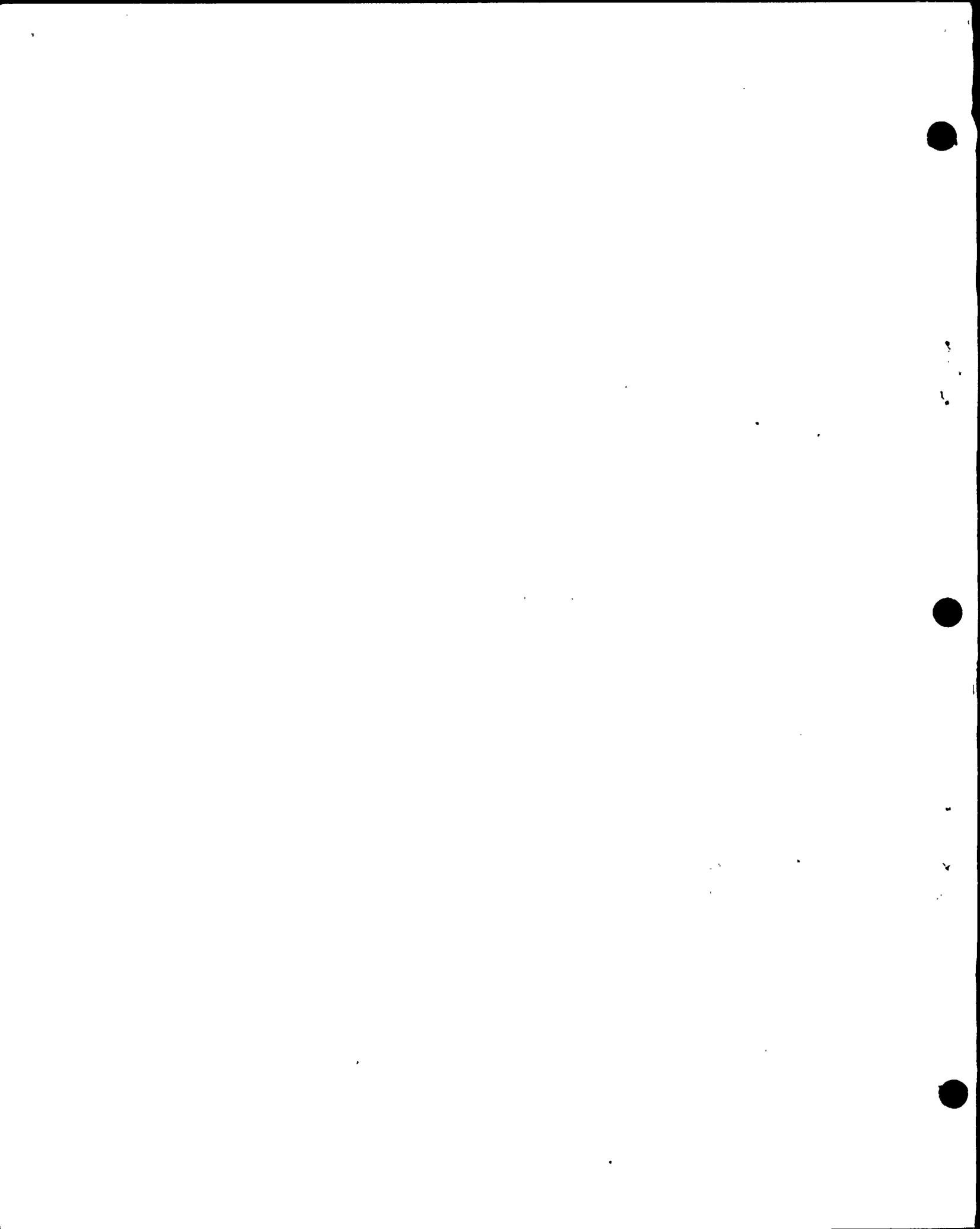
GLENN O. BRIGHT, Member.

APPEARANCES:

On behalf of the Applicant, Pacific Gas and Electric Company:

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MALCOLM H. FURBUSH, Esq. and PHILIP CRANE, Esq.,
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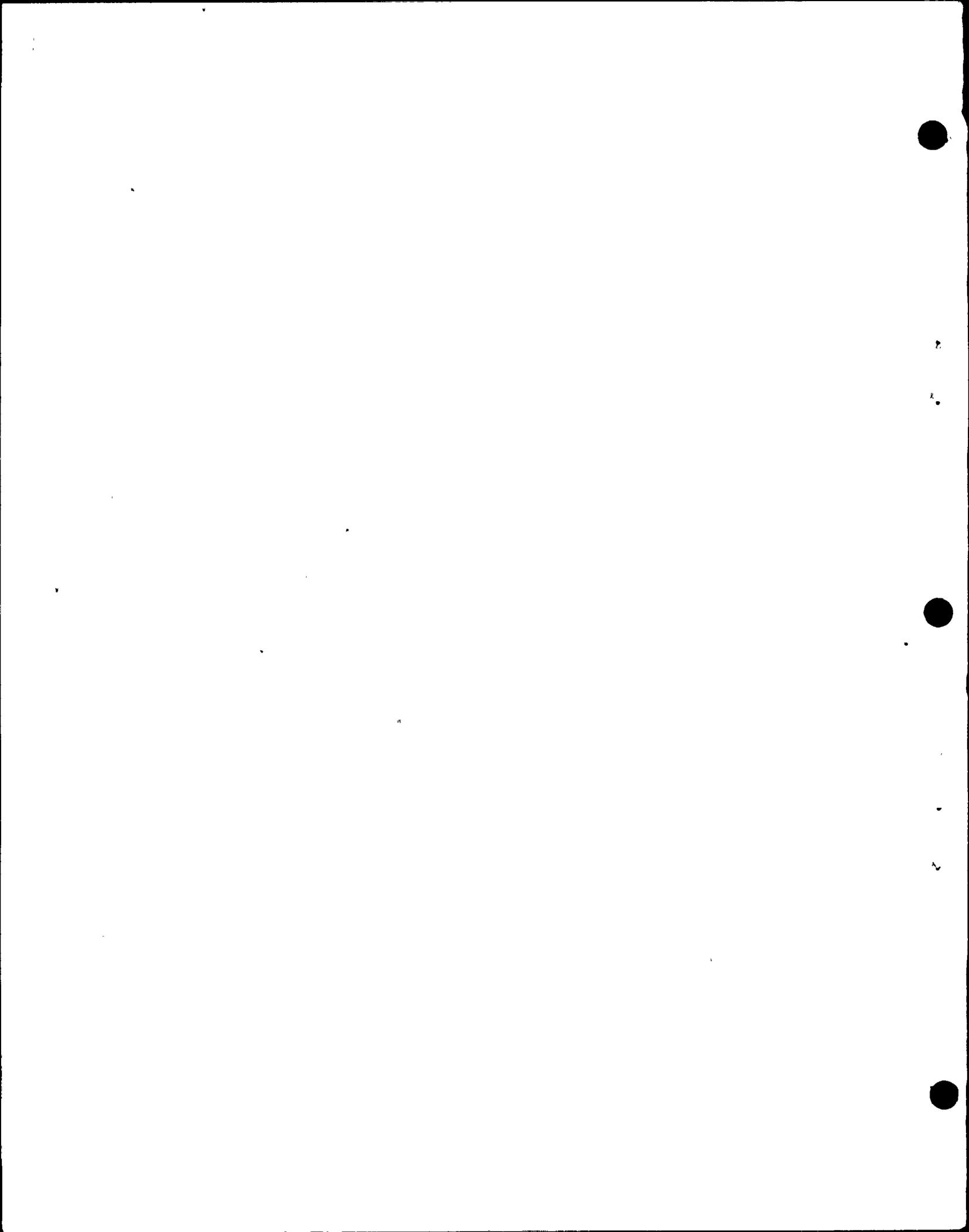
On behalf of the Joint Intervenors:

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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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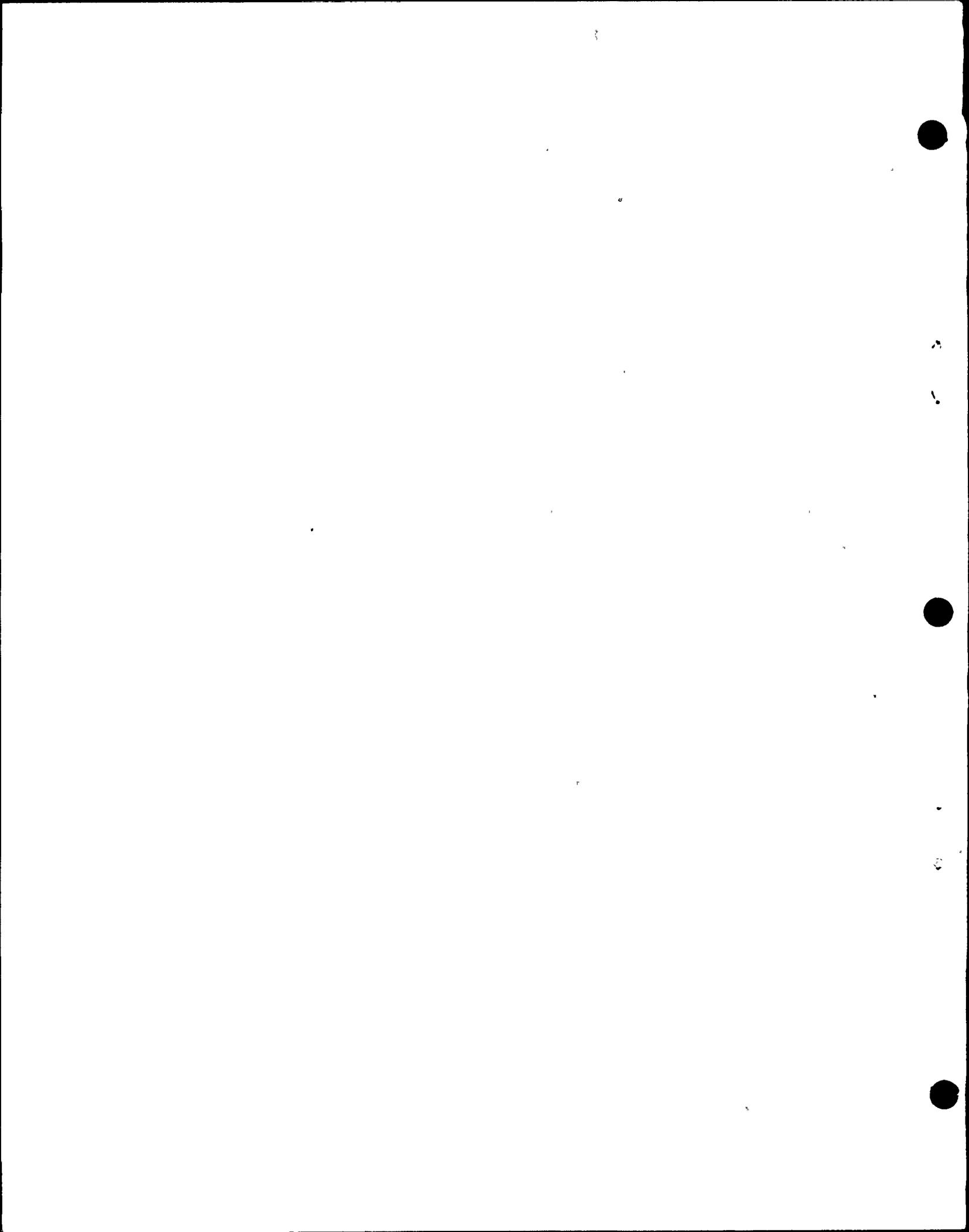
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25WitnessesDirectCross

Stewart Smith)	5744
Bruce Bolt)	
Gerald Frazier)	
Douglas H. Hamilton)		
(Continued)		

ExhibitsIden. Ev.

Int.44	Pages from 2.5(e) of FSAR	5741
Int.45	USGS Bulletin 672	5855
Int.46	"Estimation of Ground Motion Parameters" USGS Survey Open File Report 509,1978	5855
Int.47	Paper, Hanks and Johnson	5889



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MRS. BOWERS: We'd like to begin.

Now I realize, in going back to a matter that occurred yesterday afternoon, that fur and feathers may fly all over again, but I do feel I need to go back.

If you'll look in the transcript at page 5676, Mr. Fleischaker is cross-examining Dr. Smith, and if you look down to line 21:

"Assume there is substantial uncertainty with respect to the fault slip."

And then Witness Smith responds.

Then Mr. Fleischaker:

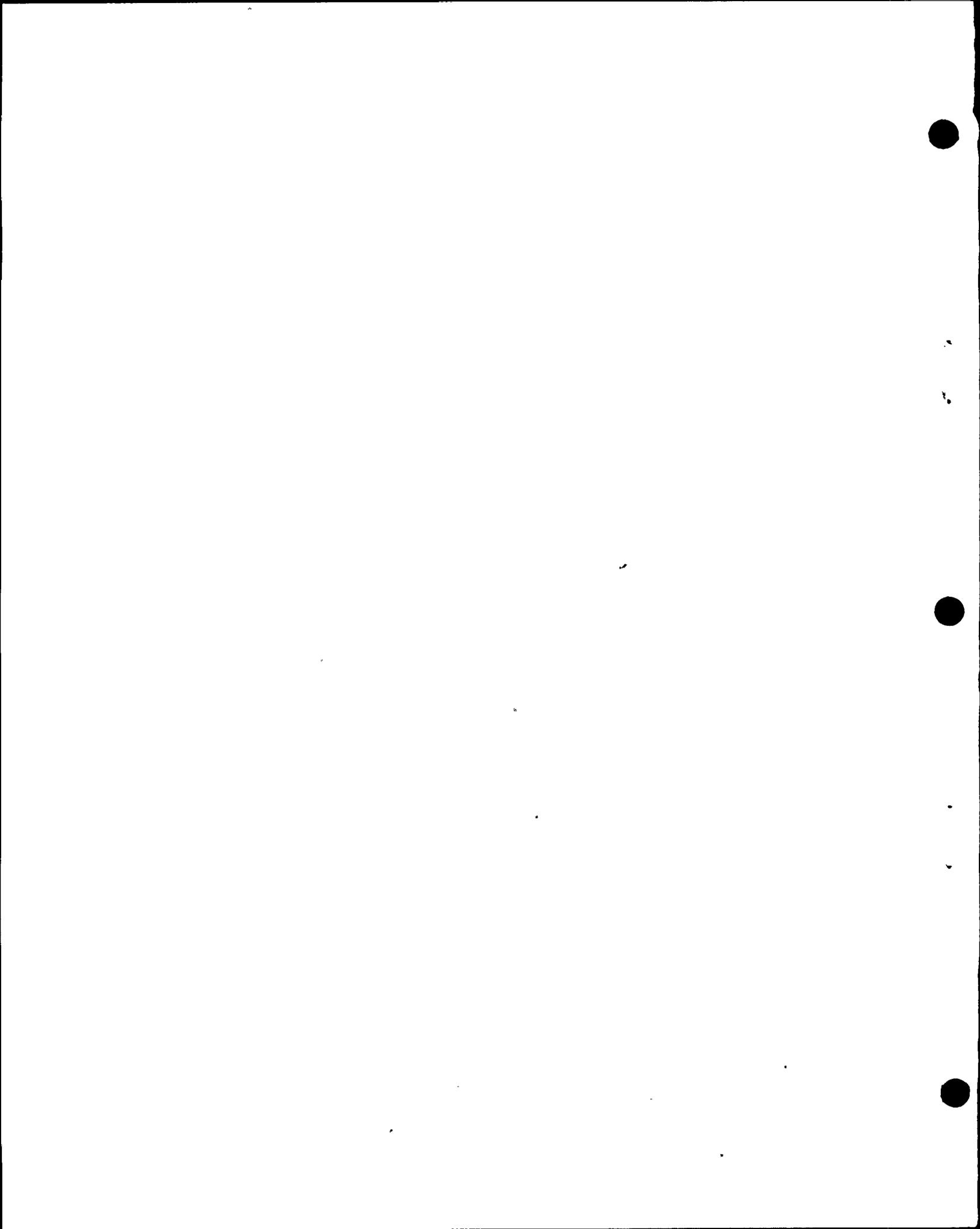
"I don't think that answered my question. Just assume, however, for the purpose of this question that there is substantial uncertainty in establishing the slip. Is fault length a useful tool?"

Well, I focused on the front end of that rather than "Is fault length a useful tool?" and felt that we had a vague, unsharp question.

Then Mr. Norton objected:

"It assumes facts not in evidence."

Well, after considerable discussion, we granted -- we sustained Mr. Norton's objection. But I want to make it clear his objection was based on the wrong reason.



eb2

1 Our thinking was that we were dealing with a
2 question of substantial uncertainty in establishing the slip
3 without focusing in on the fact that the second time it was
4 asked there was added "Is fault length a useful tool?"

5 Now we had a discussion the day before about
6 hypothetical questions and hypothetical questions in an
7 administrative hearing, must they be based on the evidence
8 that has already been admitted? And the Board agreed with the
9 Staff that in administrative hearings you don't have that
0 strict rule of evidence.

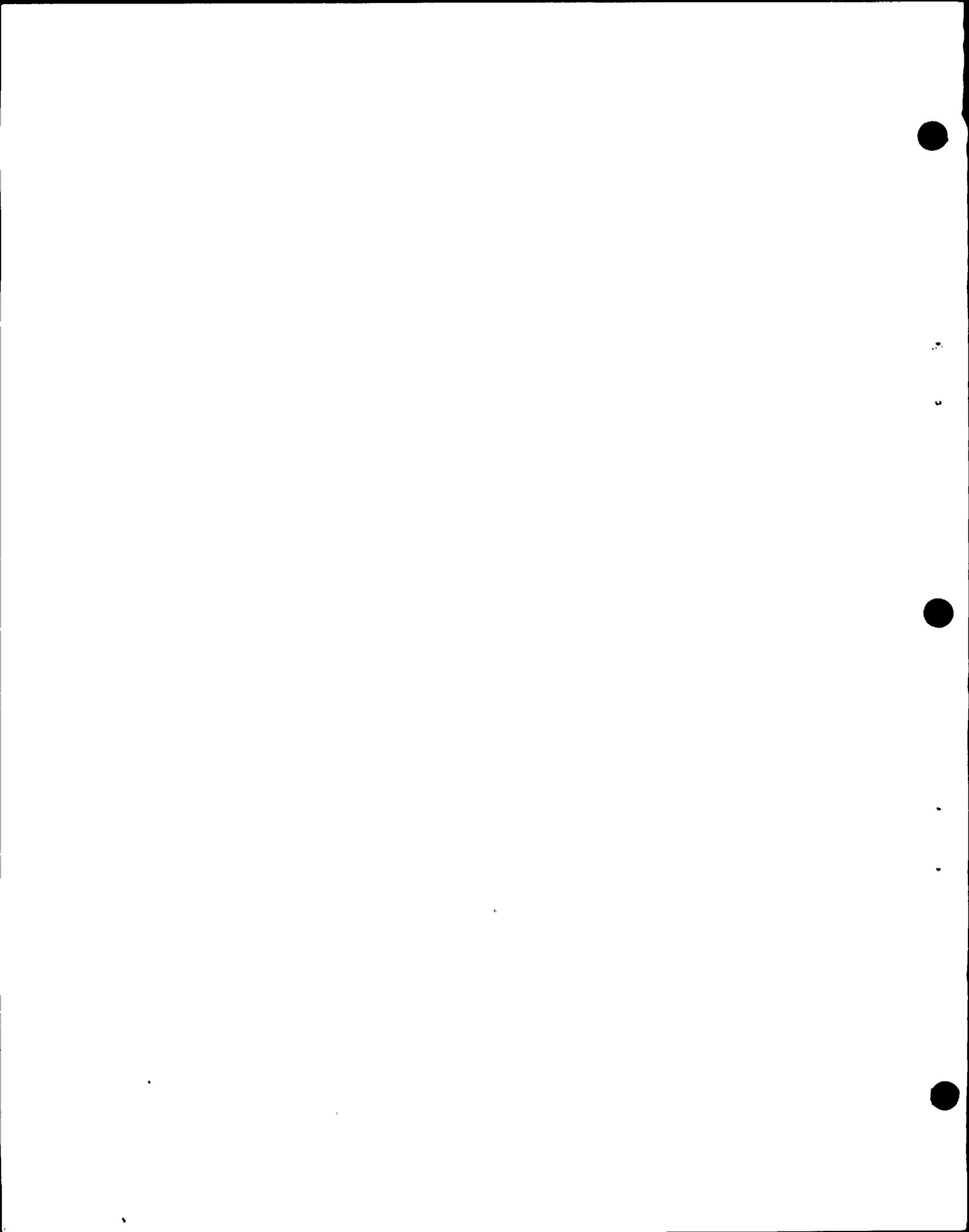
1 So I just wanted to make clear that you under-
2 stood the position of the Board. If that had been the problem
3 that the matter was not in evidence we would not have con-
4 sidered that a good reason, and so we really were focusing
5 on trying to recall language that we see now is slightly
6 different from what we heard.

7 To get to another problem --

8 MR. FLEISCHAKER: Excuse me. I'm lost at this
9 point in the Board's discussion.

10 MRS. BOWERS: Well, go to 5676 of yesterday's
11 transcript, down to line 21. That's where you start your
12 question, "...substantial uncertainty with respect to the
13 fault slip."

14 Then the transcript of course shows a period
15 there. And Dr. Smith responded to that.



eb3

1 And then you say, on line 3 of 5677:

2 "I don't think that answered my ques-
3 tion. Just assume, however, for purposes of this
4 question, there is substantial uncertainty in
5 establishing the slip."

6 Then here you go on to say:

7 "Is fault length a useful tool?"

8 Well, we heard the first question which didn't
9 have that addition, and then when it was repeated with that
0 addition we focused on the front part of it rather than the
1 second short sentence there. And then that's when Mr. Norton
2 objected:

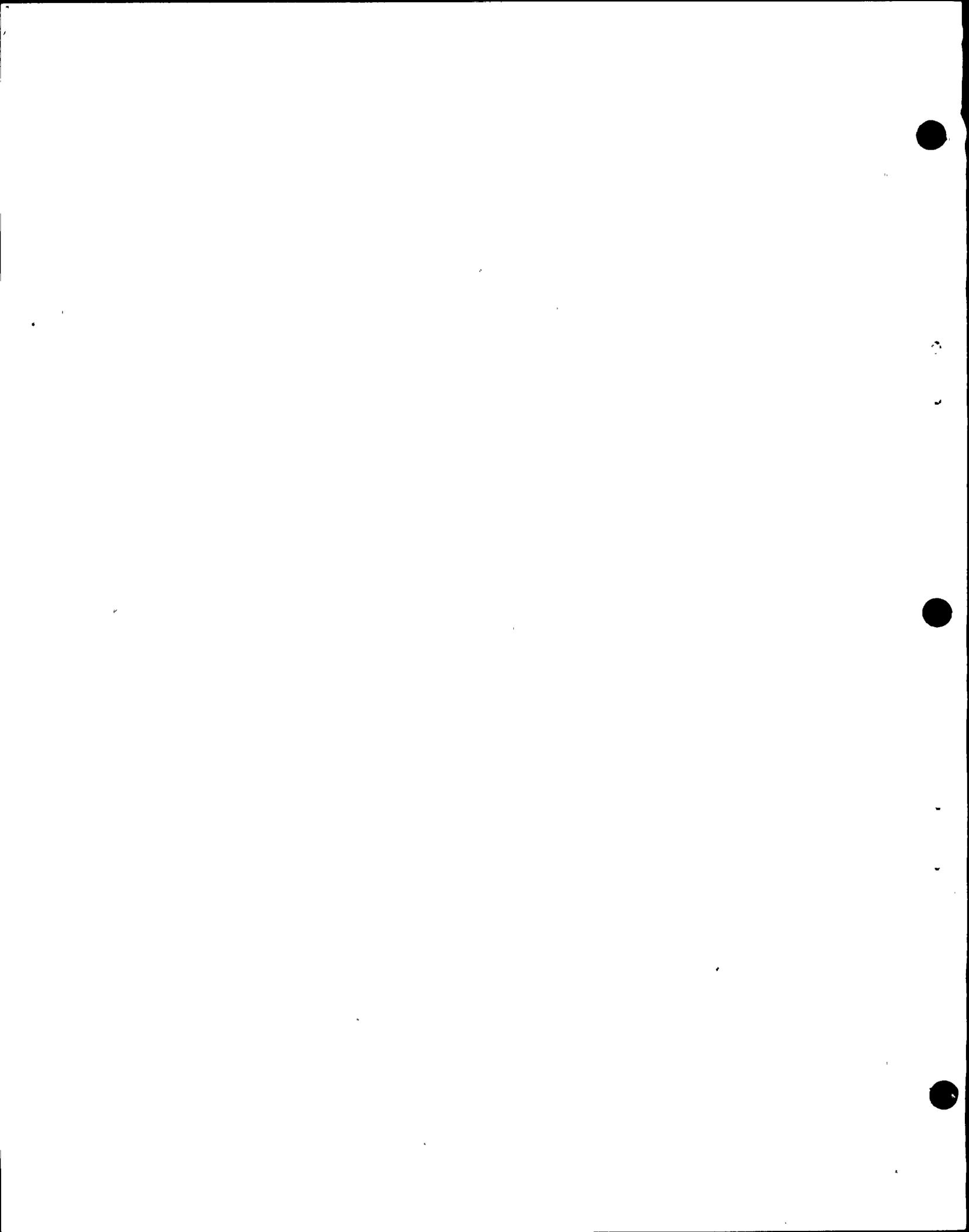
3 "It assumes facts not in evidence."

4 Now we know that a hypothetical is perfectly
5 proper when it's based on reasonableness. Now our problem,
6 in a very technical hearing like this:

7 When do you have that reasonableness if you don't
8 have testimony supporting a certain position or fact?

9 Later of course there was what amounted to a
0 motion for reconsideration, and after we heard more, and it
1 was really to the question of length, then we asked the wit-
2 ness to respond to Mr. Fleischaker's question.

3 I just felt we needed to clear up the position
4 that we didn't want a preliminary ruling to stand as if a
5 hypothetical is not proper unless it is based on evidence in



1 the record.

2 We think, in administrative hearings, if there's
3 a reasonable basis for it, if we feel, even though it hasn't
4 come into the record that there's a reasonable basis, then
5 we think the hypothetical is proper.

6 Well, I'll give each one of you one minute to
7 respond.

8 Do you want to comment, Mr. Norton?

9 MR. NORTON: I just have trouble understanding
10 how one determines reasonableness if he doesn't use the test
11 of the facts in evidence. I think that's what bothers me.

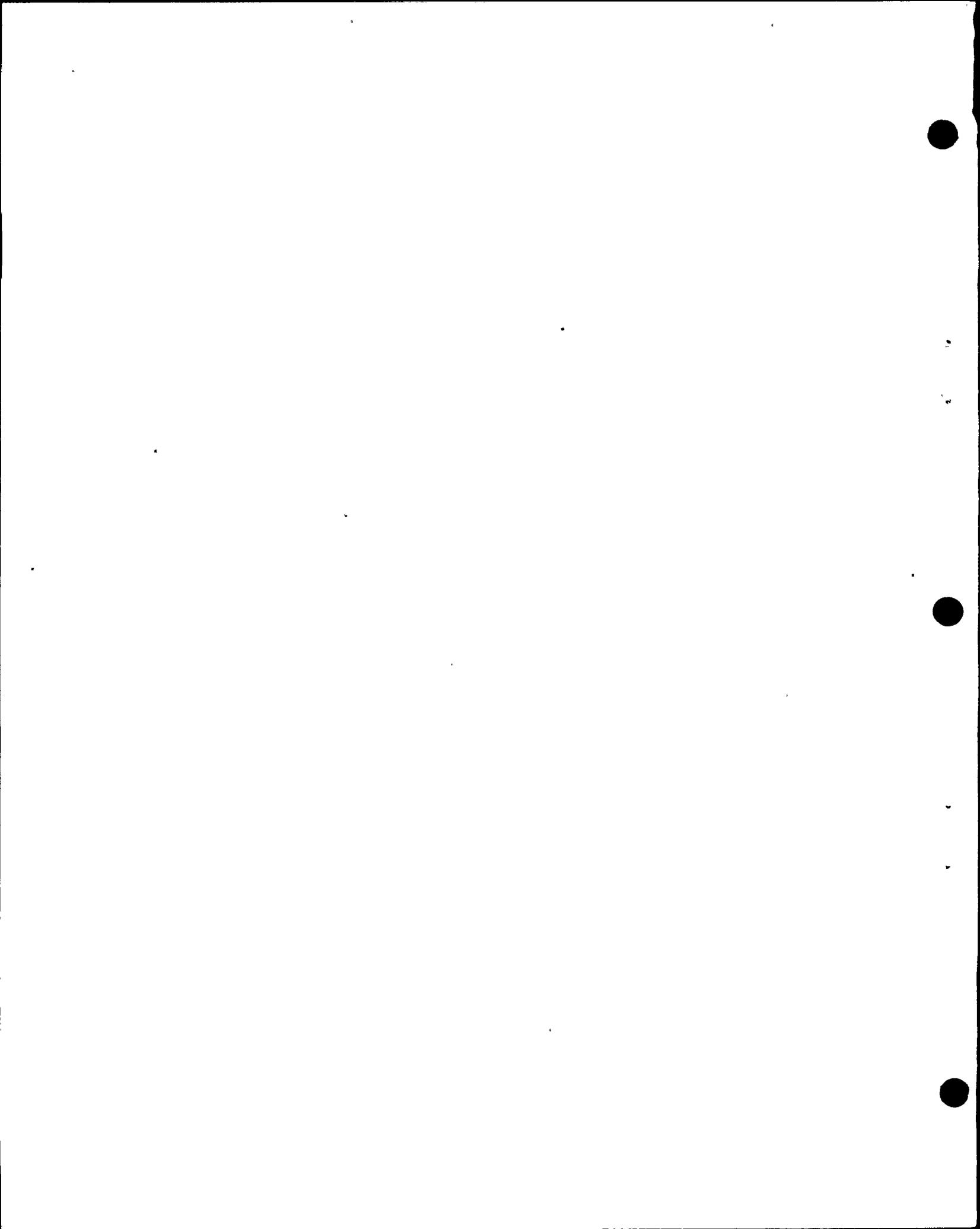
12 MRS. BOWERS: Well, as Dr. Martin says, the
13 witnesses will be helpful to us in that area.

14 MR. NORTON: In that case we'd have to stop and
15 voir dire the witness to see if he thinks there's enough
16 facts in evidence to make that hypothetical a reasonable
17 hypothetical, and I don't know where that goes. That could go
18 off into Never-Never Land.

19 I understand your ruling and I'm perfectly willing
20 to abide by it. I just think the more proper test is that
21 the question assumes facts in evidence; that's all.

22 MRS. BOWERS: Well, it's easier when you're
23 dealing with more general subject matter to recognize the
24 reasonableness.

25 DR. MARTIN: I think in this case it might be



eb5 1 useful to take a couple of minutes to review a little bit more
2 of the transcript, in other words at some point earlier than
3 5676 because it seems to me in this case that the witness'
4 response indicated that he didn't believe that was a reason-
5 able assumption, unless I'm completely mistaken in my reading
6 of it.

7 And I believe we have expert testimony because
8 we don't -- we rely on experts. All right, and in this case
9 it is up to them to comment on the reasonableness of a
0 hypothetical question.

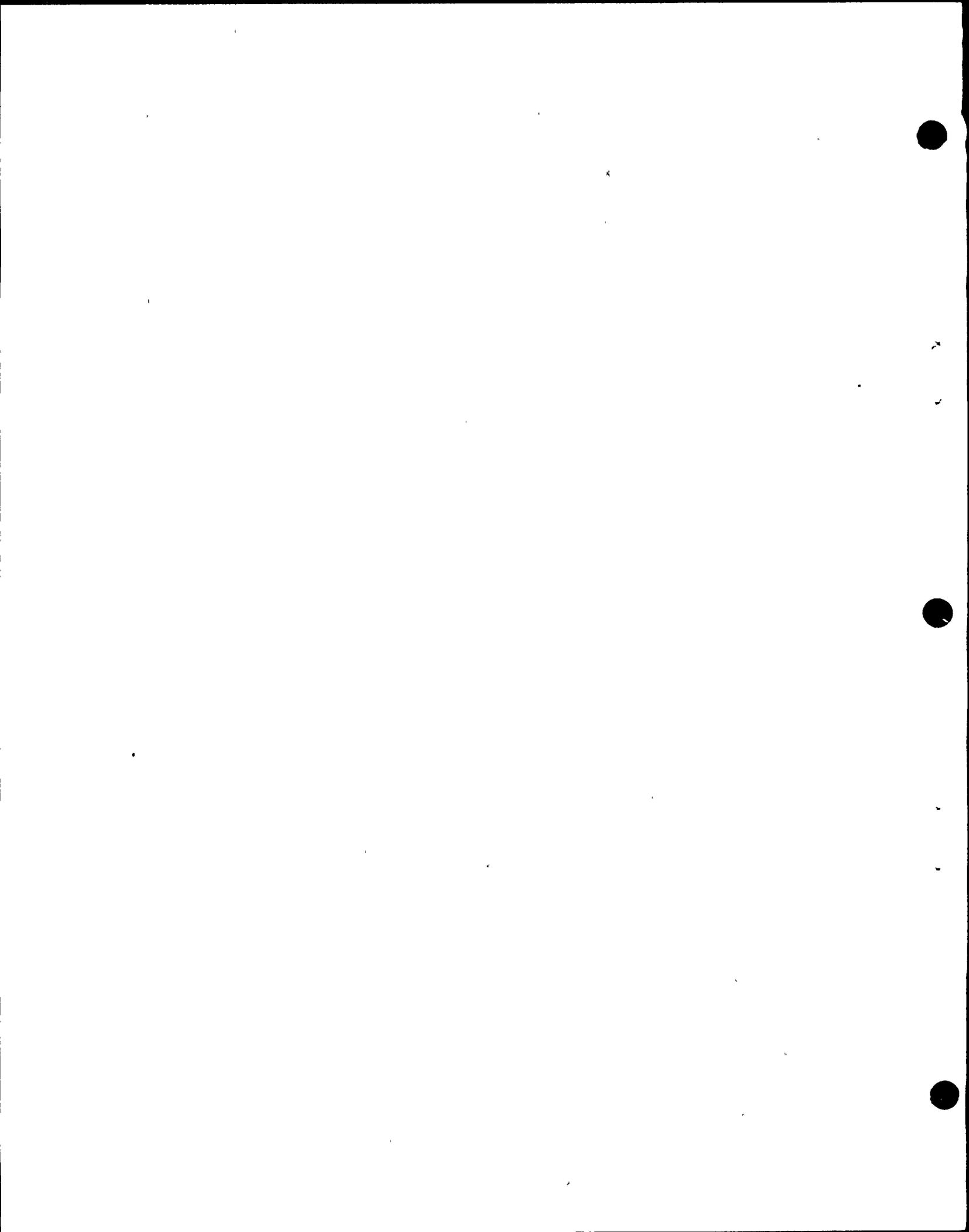
1 MR. NORTON: Dr. Martin, the only problem I have
2 with that-- Well, I have a technical legal problem with that,
3 but that's neither here nor there.

4 But in substance the problem I have with that is
5 that when you get a hostile witness up there and he doesn't
6 want to answer your question he just says Well, that's an
7 unreasonable hypothetical. And then where do we go? You
8 know you can't leave it up to a witness as to whether or not
9 he thinks a question is reasonable. The Board has to determine
0 that.

1 DR. MARTIN: Are you calling your witness hostile?

2 MR. NORTON: No, I'm calling somebody else's
3 witness hostile perhaps.

4 DR. MARTIN: Well, hostility hasn't entered into
5 it then, so it's a different problem, don't you think?



eb6

1 MR. NORTON: No, I respectfully disagree. I
2 think you cannot leave it up to a witness as to whether he
3 thinks the hypothetical is reasonable.

4 DR. MARTIN: Really, we're trying to find out
5 what the witnesses believe, or what their opinions are. And
6 it becomes very difficult if you set down a contraining set
7 of ground rules.

8 My feeling is that's why the rules of evidence
9 are relaxed in the case of expert witnesses, and that we are
10 really more interested in what the witnesses have to say than
11 in what the lawyers have to say about the witnesses' comment.

12 MR. NORTON: I couldn't agree more. On that
13 portion of it I totally agree.

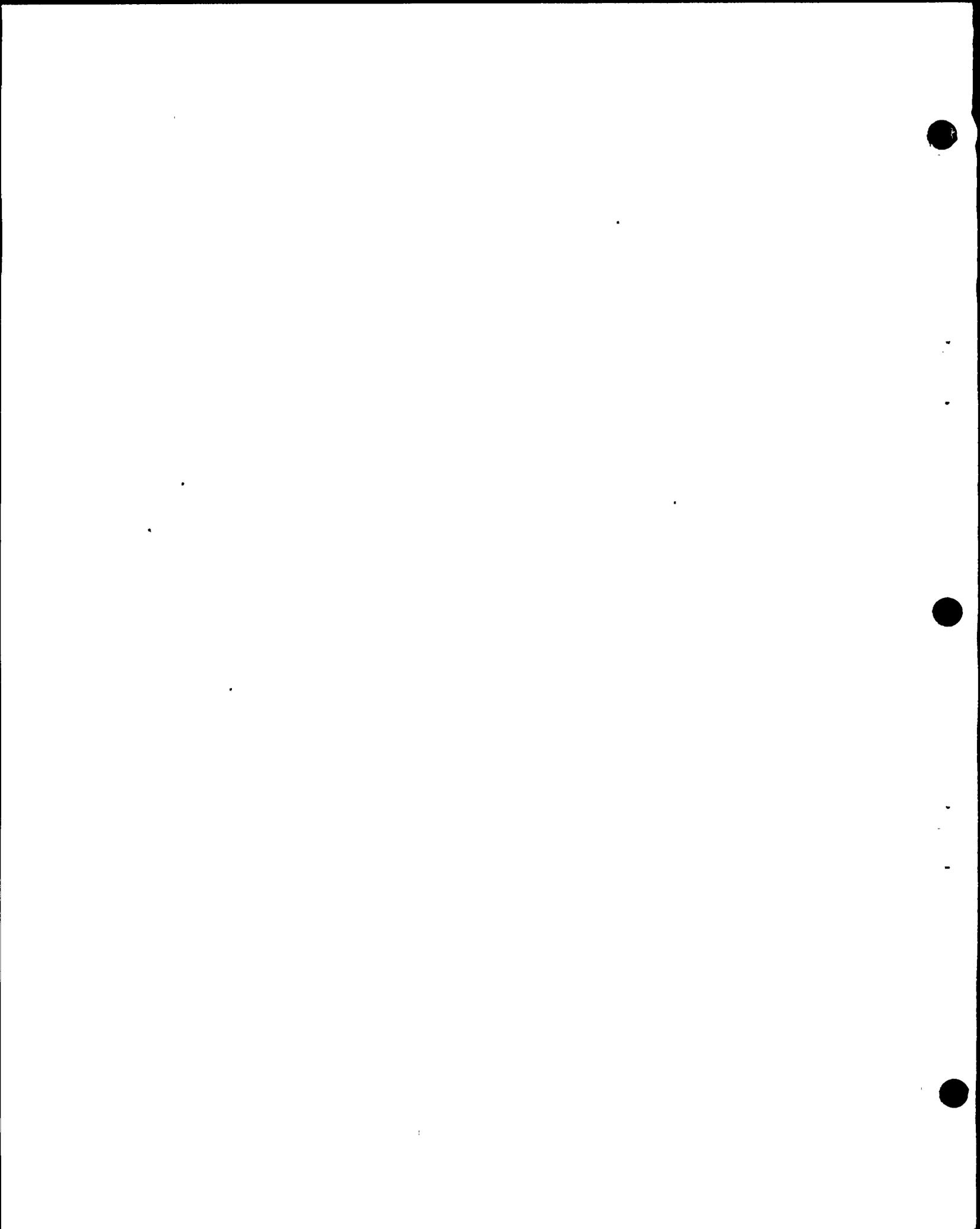
14 MRS. BOWERS: Well, Mr. Norton, some day you may
15 be sitting here and I may be sitting sitting there and there
16 will be a different ruling.

17 (Laughter.)

18 Mr. Fleischaker?

19 MR. FLEISCHAKER: I think the Board's ruling was
20 correct. It is with some hesitation that I say that I have
21 to in part agree with Mr. Norton that the sole test of the
22 reasonableness of the facts upon which the hypothetical is
23 based cannot be the testimony of the witnesses because then
24 he can just throw out any hypothetical you put to him.

25 I think that his view is one factor to be



eb7

1 considered in determining the reasonableness, and I think the
2 Board's assessment of the record to date and the information
3 contained in submitted testimony is another factor to be
4 considered.

5 One of the problems is the timing that we have
6 here, that unless we make all these people subject to recall,
7 we cannot test their position against the reasonableness of
8 facts which are submitted through the testimony of our wit-
9 nesses. So I believe that that is-- You know, because of
0 the timing problem, it is one of the principal reasons for
1 loosening up the rules of evidence so that you aren't strictly
2 limited to facts in evidence.

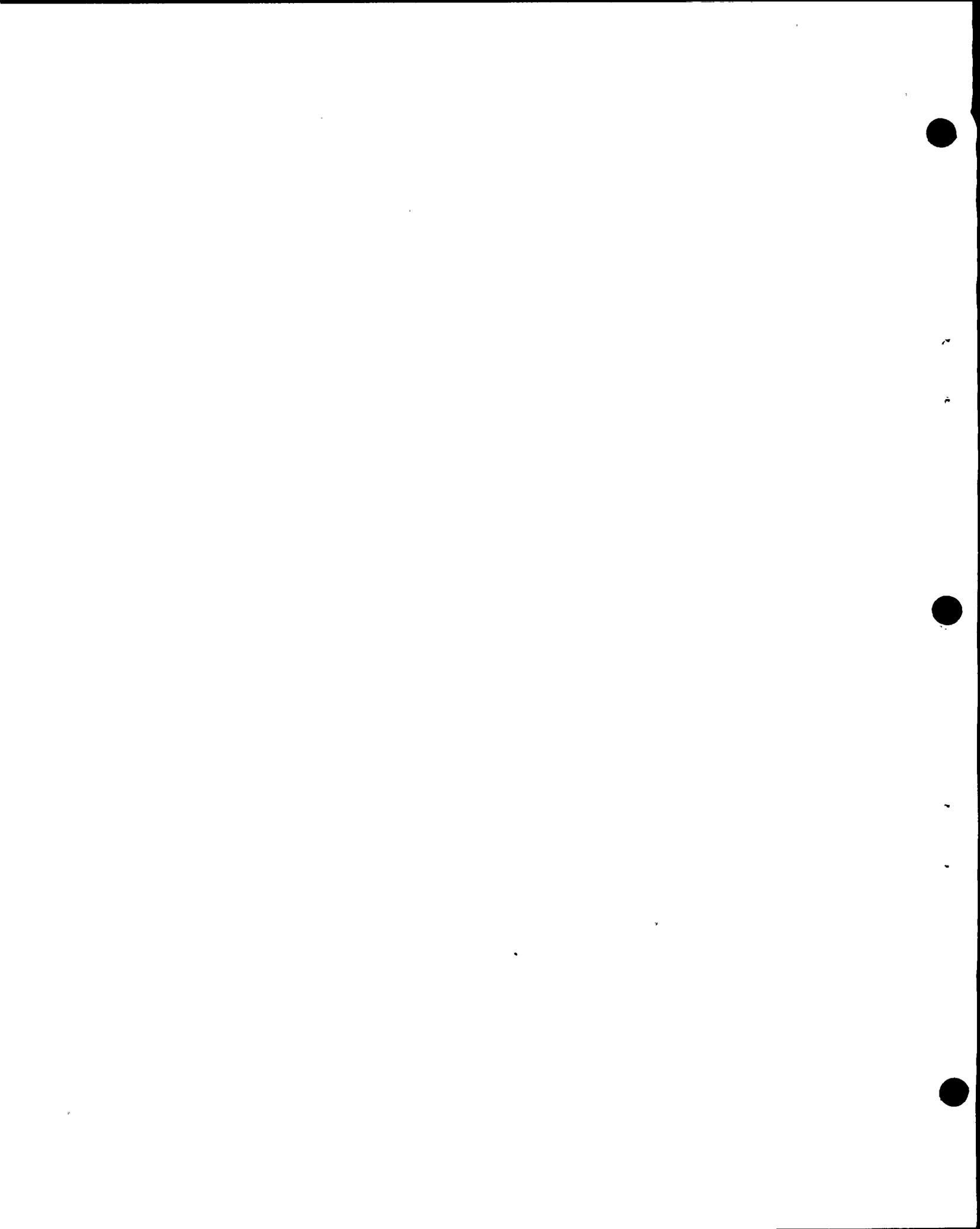
3 Rather, there are a number of things that are
4 considered by which you judge the reasonableness of the facts
5 upon which the hypothetical is predicated: This witness'
6 view, the submitted testimony, the information elicited in
7 cross-examination. That's my view.

8 MRS. BOWERS: Mr. Tourtellotte?

9 MR. TOURTELLOTTE: I take it we're commenting on
10 this for future purposes since this ruling has already been
11 made and the witness has already answered the question?

12 MRS. BOWERS: That's right. I wanted to clear
13 up the record. In granting Mr. Norton's objection it's just
14 as if we had adopted his position on the preliminary ruling.

15 MR. TOURTELLOTTE: On the preliminary ruling, but



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then you reversed yourself ultimately.

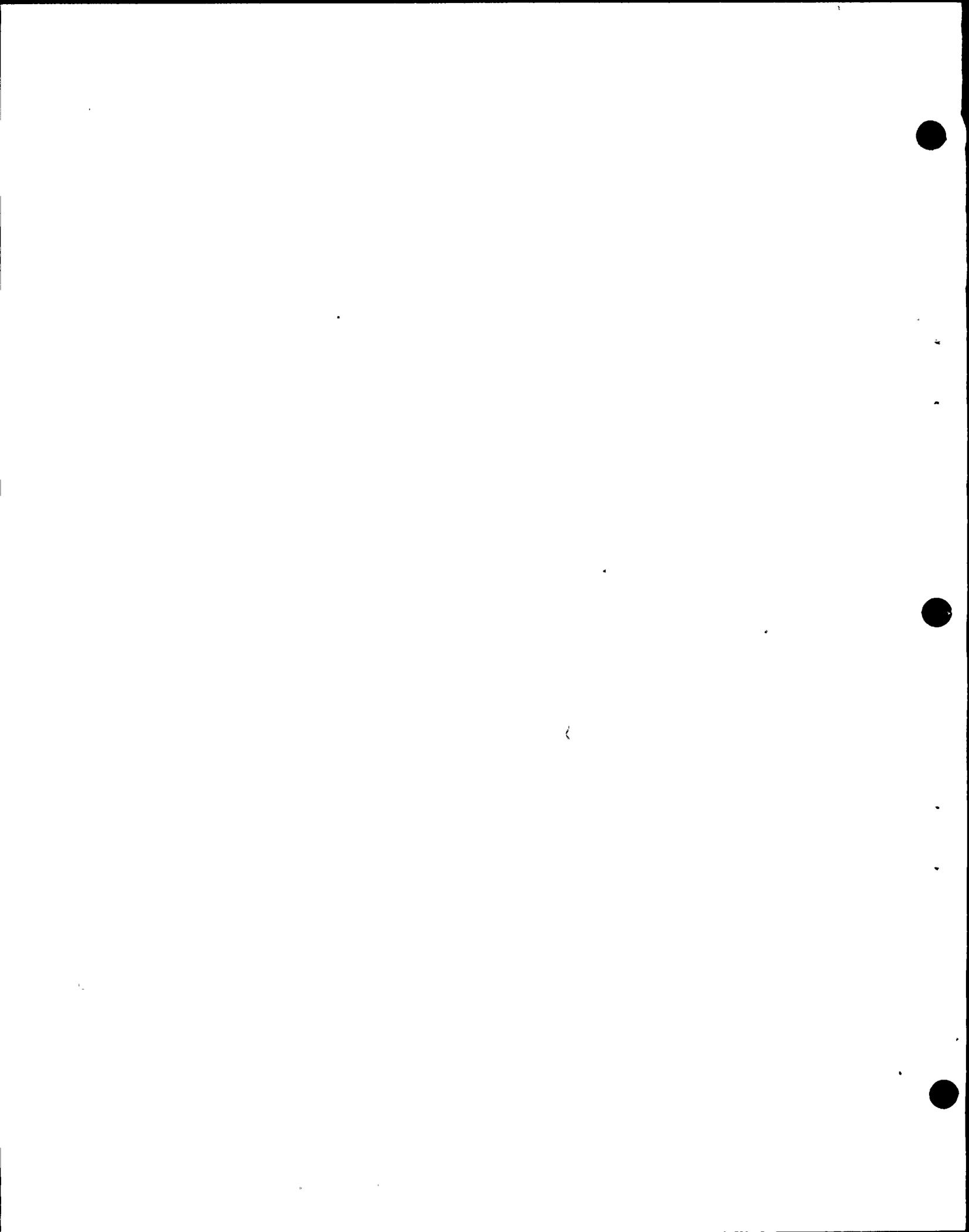
MRS. BOWERS: That's right. We heard more. We then were able to focus in that length was the purpose of the question rather than just a vague question on uncertainty.

MR. TOURTELLOTTE: Well, preliminarily let me say that I think a good many people misunderstand the rules of evidence themselves. I think oftentimes the people believe that the rules of evidence are devised as some medieval tool used by lawyers to frustrate and obfuscate the hearing, and that's not what evidentiary rules are all about.

Evidentiary rules have evolved in the legal system over the period of several hundreds of years and perhaps even thousands of years, back to Roman times and perhaps before in our legal system. And the reason they do evolve is because -- or the reason they have evolved is because the system itself wants to make sure that the evidence that gets into the record, into the basic factual situation to be considered is reliable and probative.

Now understanding that for a moment, and if we turn our attention to the hypothetical question problem, the real question is can you ask a hypothetical not based on facts in evidence and come up with reliable and probative results?

The answer is No, you can't, because it doesn't have any relevancy or materiality to the proceedings. And consequently, I believe, in the very technical, evidentiary



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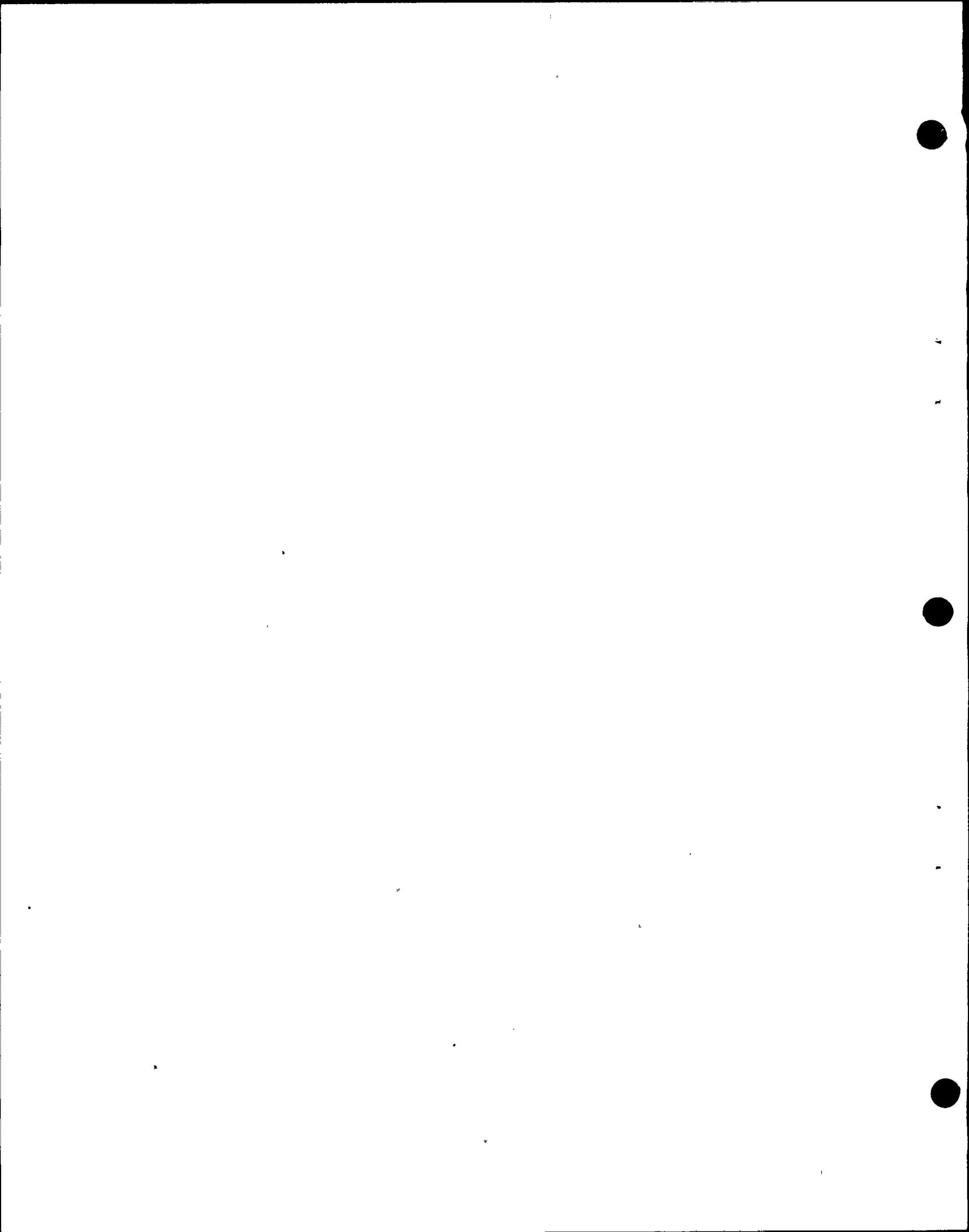
1 sense, there were no facts in evidence for the basic assump-
2 tion that was made, given the way the question was stated.

3 I think as a pure evidentiary matter, then
4 probably the ultimate ruling was wrong, but it's not fatal
5 necessarily to this proceeding. And I say that because of
6 the way the question was stated. It was stated in two parts,
7 and the witness was asked to make an assumption about some-
8 thing which really either was not in evidence or if it was in
9 evidence, proper reference was not made to it.

0 Now with that preliminary discussion, however,
1 I would also point out that we are in administrative proceed-
2 ings and the rules of evidence are relaxed. This is true.
3 But I think it is also important to understand that the rules
4 of evidence aren't relaxed in administrative proceedings in a
5 sort of open-door way.

6 The rules of evidence are relaxed only to give
7 the amount of flexibility necessary to insure that reliable
8 and probative evidence gets into the record which, for some
9 very particular technical reason, might not otherwise get in
20 there.

1 And also one of the purposes of the development
2 of the rules of evidence was to protect juries, and it is
3 assumed in administrative proceedings that the expertise
4 necessary to shift out that which is relevant and irrelevant
25 and that which is reliable and probative from that which is



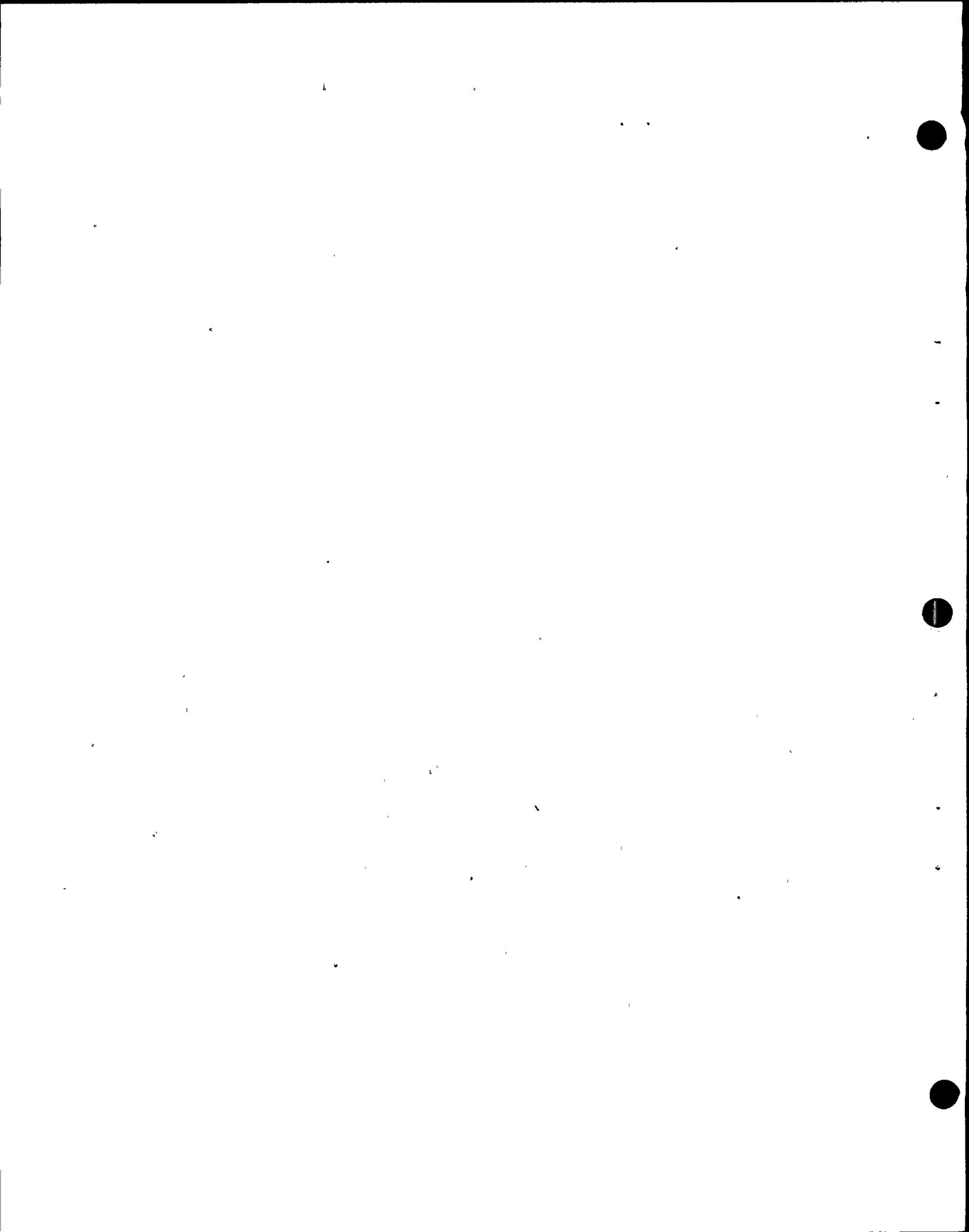
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1 not is possessed by the tryer of fact and therefore, if
2 evidence of that nature happens to come up during the course
3 of the proceeding, then they will just simply ignore it.

4 I tend to agree in some respects with
5 Mr. Fleischaker, that we have a time situation here where it
6 might require looking into the questions and determining
7 whether or not the question hypothetically stated bears a
8 reasonable relationship to the testimony that has already been
9 filed, and therefore is a proper foundation for a hypothetical
0 question.

1 However, I think so that we're all on notice if
2 we're going to proceed in this manner, so that we're all on
3 notice, I think that the attorney who is asking that hypo-
4 thetical has the responsibility to the record and to the
5 other parties to give us an indication of what part of his
6 testimony, if it is his testimony, or somebody else's testi-
7 mony that he is relying upon for the basis of his hypothetical
8 question, if indeed there is some basis in his testimony and
9 that testimony has already been stipulated into the record.

10 MRS. BOWERS: On that point: For instance,
11 Mr. Fleischaker we understand will have Dr. Graham here. Now
12 his testimony hasn't been stipulated into the record, and
13 yet we'd like to hear your response on statements of Dr. Graham
14 in his testimony that Mr. Fleischaker might want to use now
15 with these witnesses.



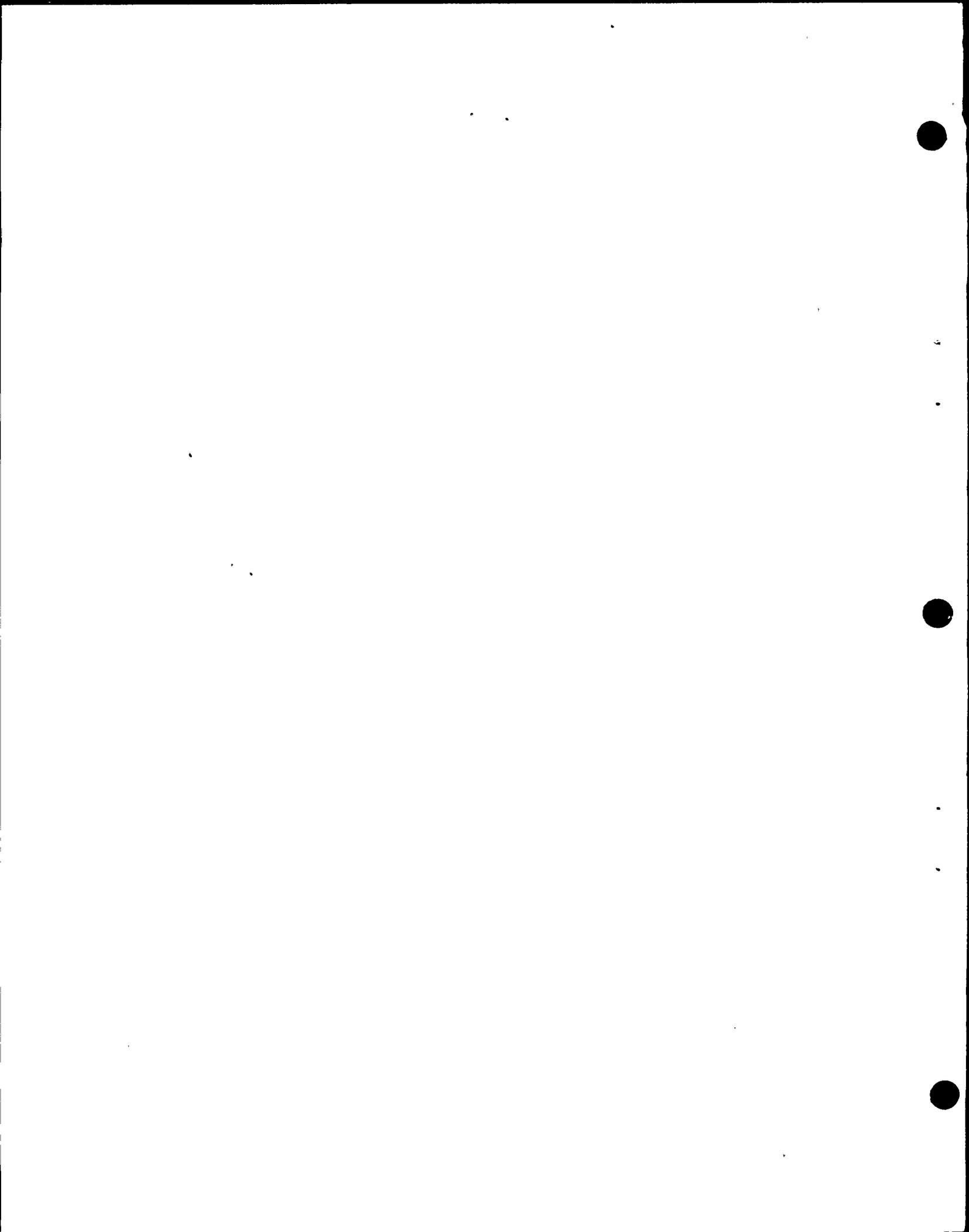
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MR. TOURTELLOTT: It's a tough question, and the time factor is in there. But the problem that you are confronted with is what if we spend three days listening to hypothetical questions, based upon Dr. Graham's appearance, and for some reason -- and I'm not implying for a moment that Mr. Fleischaker is not going to present him, or that Dr. Graham is not going to show up, but if for some reason Dr. Graham never shows up or if Dr. Graham shows up and then it turns out that half of the questions which are based upon, presumably, what Dr. Graham will say Dr. Graham himself turns out not agreeing with, then we have a whole bunch of hypothetical questions in the record which are not really relevant to the proceedings and are not reliable and probative, and we have to sift those out from the ones which are reliable and probative.

It's a very messy process. There is some danger there and there is a risk to be run, and I'm not sure that it's worth it.

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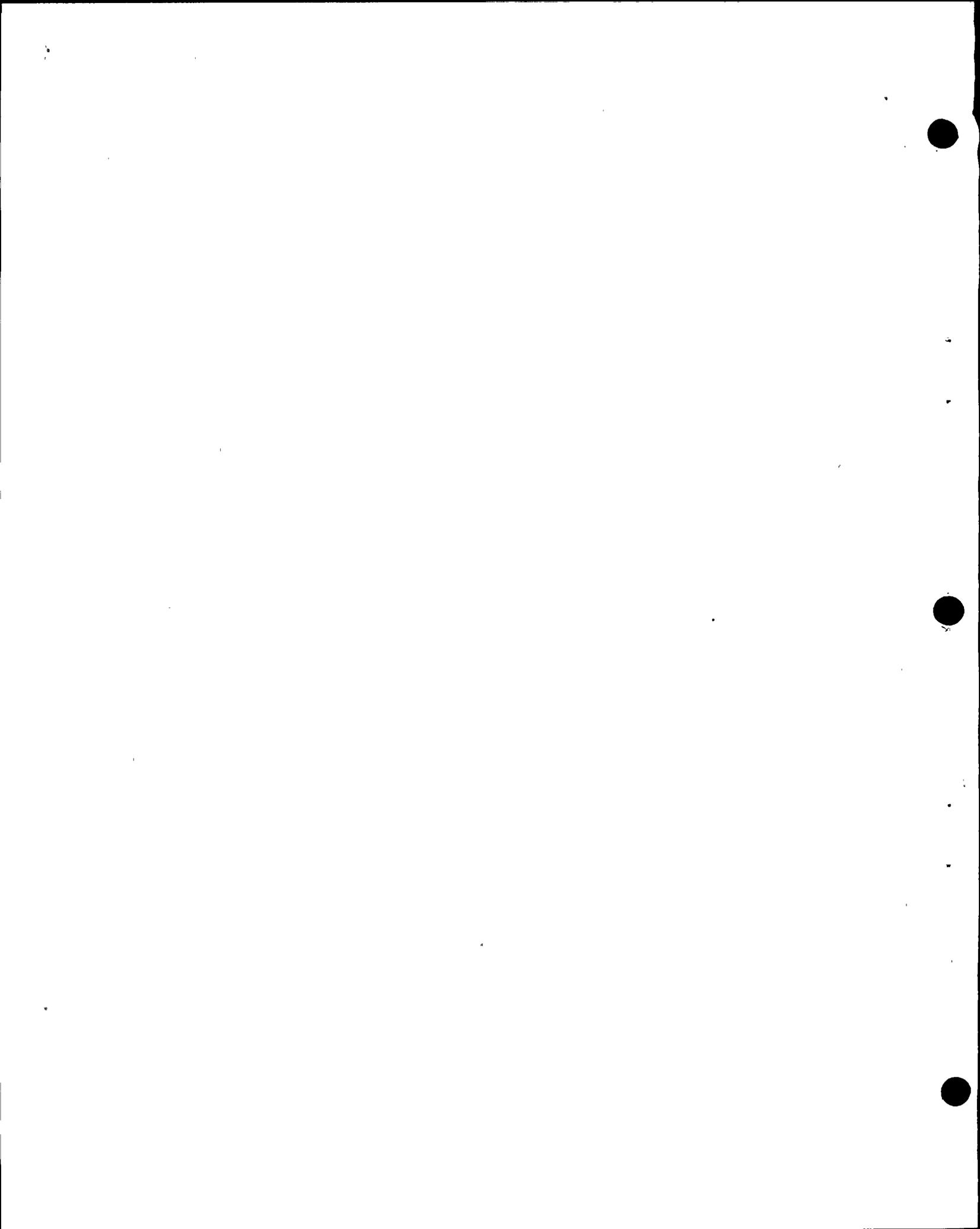
MRS. BOWERS: Mr. Tourtellotte, we have a couple of Science articles that have been marked for identification. I don't believe they've been offered in evidence. But what is your position when you have a prestigious scientific publication like that document and people have taken positions who -- we've heard testimony from witnesses that they enjoy a very fine reputation in their scientific community.

MR. TOURTELLOTTE: Well I think in the case of an article -- and I am relatively certain that a check of Wignore again would indicate, and also Davis on administrative law, would indicate that an expert can give his opinion of another expert's opinion if, indeed, that has any bearing or any relevancy to the story that he is telling.

So that I believe that a hypothetical, if a proper foundation is laid, that the expert witness who is testifying has knowledge of this article and if he has read the article and has taken it into consideration, even if he has discarded it, then he can be questioned about his opinion on that article vis-a-vis his own opinion.

But it has to be in the article, and I really believe it should be a matter that is in evidence. If it is worth asking a question about, I think those articles ought to be placed into evidence.

And then you have the process of asking questions about hypotheticals of opinions that are clearly expressed



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and are clearly in the record, and then we don't have the problem.

Now I would grant you, too, that in the administrative proceeding if, again, we perceive that at least some of these people -- Graham and Dickinson, is that what we're talking about?

MRS. BOWERS: And Hall.

MR. TOURTELLOTT: Graham is going to be here, so I think we might reasonably look into that. I don't know about Clarence Hall.

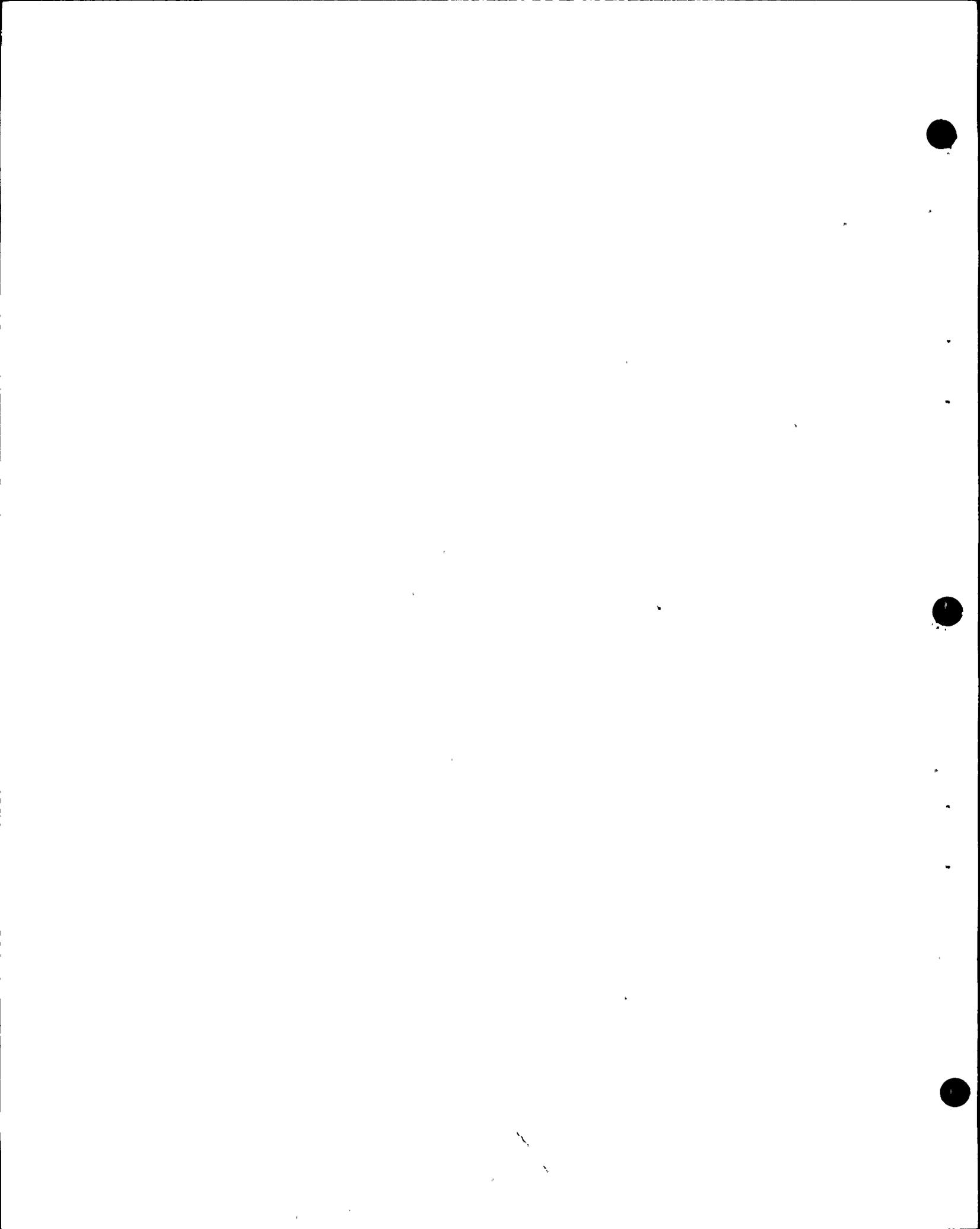
I have some difficulty with the Clarence Hall thing because Clarence Hall may never get here, and Clarence Hall may have something entirely different to say about the article than he wrote some time ago. And that degree of uncertainty also makes those hypotheticals very, very vulnerable.

MRS. BOWERS: I was recalling Dr. Jahns' professional opinion of Dr. Hall. And of course, he was very complimentary in the scientific community.

MR. NORTON: Excuse me, Mrs. Bowers. Can I respond to that small portion of the question?

MRS. BOWERS: Yes.

MR. NORTON: I'm very bothered by the ruling that because something appears in a magazine like Science or Bulletin of -- well, there are all kinds of references that have been referred to are and that someone has --



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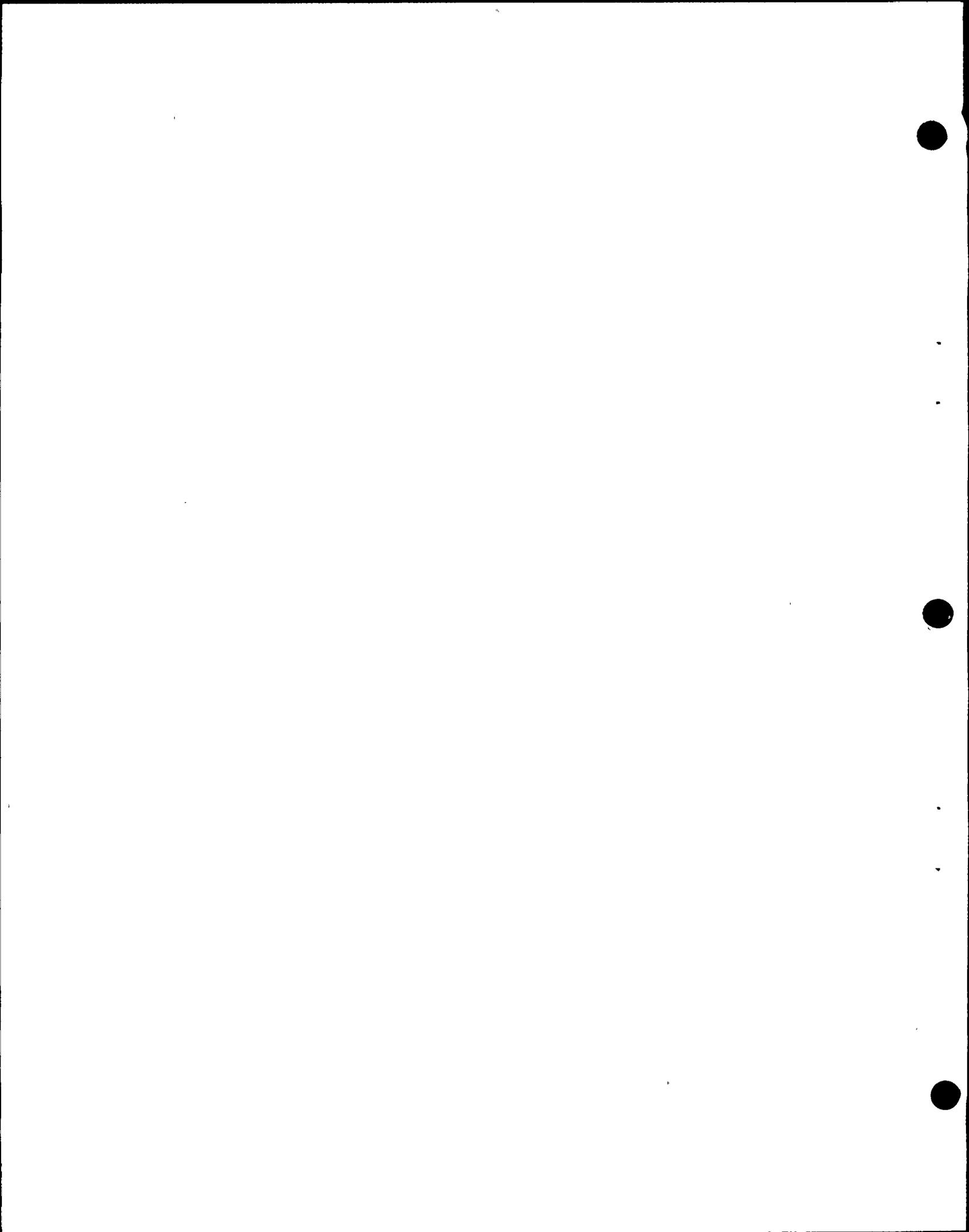
Dr. Jahns kind of reminded me of a eulogy when he spoke of Dr. Hall in light of what was going on with his article.

But because someone has a good reputation doesn't mean that every piece of work he does is correct or every opinion he holds is correct. I consider Mr. Tourtellotte and Mr. Fleischaker and hopefully myself all have fine reputations and we clearly disagree and one of us is clearly wrong or clearly right in some situations. We're never all right or all wrong.

And just because an article appears in a magazine and the person who wrote it has a good reputation doesn't make the facts of that article evidence. And there is absolutely no basis to place anything like that in evidence without someone to sponsor it and lay a foundation for it. And I just strongly disagree with any notion that because something is published someplace it goes into evidence.

Now there are exceptions to that. If you're talking about U.S. Census data and stuff like that it's a government publication, the facts stated therein can be presumed to be accurate and correct and that can be accepted into evidence.

But the Graham and Dickinson and Hall articles, they aren't that kind of information. A USGS or a geodetic map, for example, that's fine, that can go into evidence. That's just facts, there are no conclusions drawn. There's



no opinions involved.

But when you start putting in articles that propose theories and draw conclusions from those proposed theories without a foundation, I think that's a travesty on the rules of evidence, I really do, I don't care of it's administrative proceedings or town hall meetings, I just think that's very dangerous.

MR. FLEISCHAKER: Okay, I'd like to respond to that.

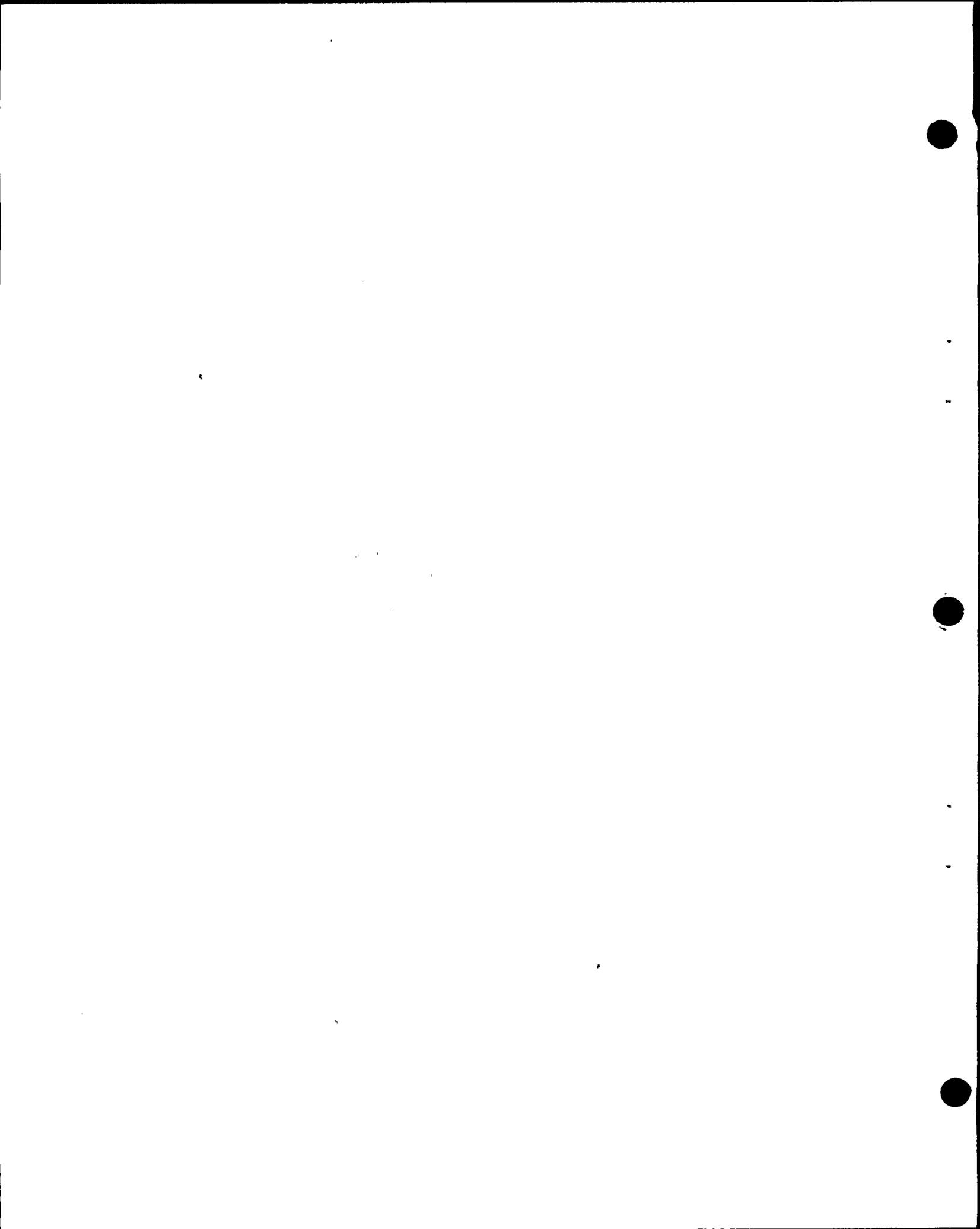
We've got a whole lot of articles that were put into evidence as a result of Mr. Norton's suggestion and willingness to stipulate -- a stack of documents that big that were written by Drs. Trifunac and Luco (indicating). They're not going to be here for you to cross-examine, Mr. Norton, that is unless you want them here.

So I would just note that inconsistency in counsel's argument.

But let me go on to the substance.

I don't think that the test for determining whether a fact or a hypothetical can be based on a particular fact is whether it is in evidence. And I think that that's -- you know, that's where the argument here seems to break down.

I believe that in an administrative proceeding there is no rule that the fact be in evidence for a number



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of reasons we discussed. But I think the real question is, for the Board's determination -- for example, Mr. Tourtellotte pointed out that it may turn out that some of the hypotheticals that are asked early in the proceeding, that the facts aren't clearly established or there is some uncertainty.

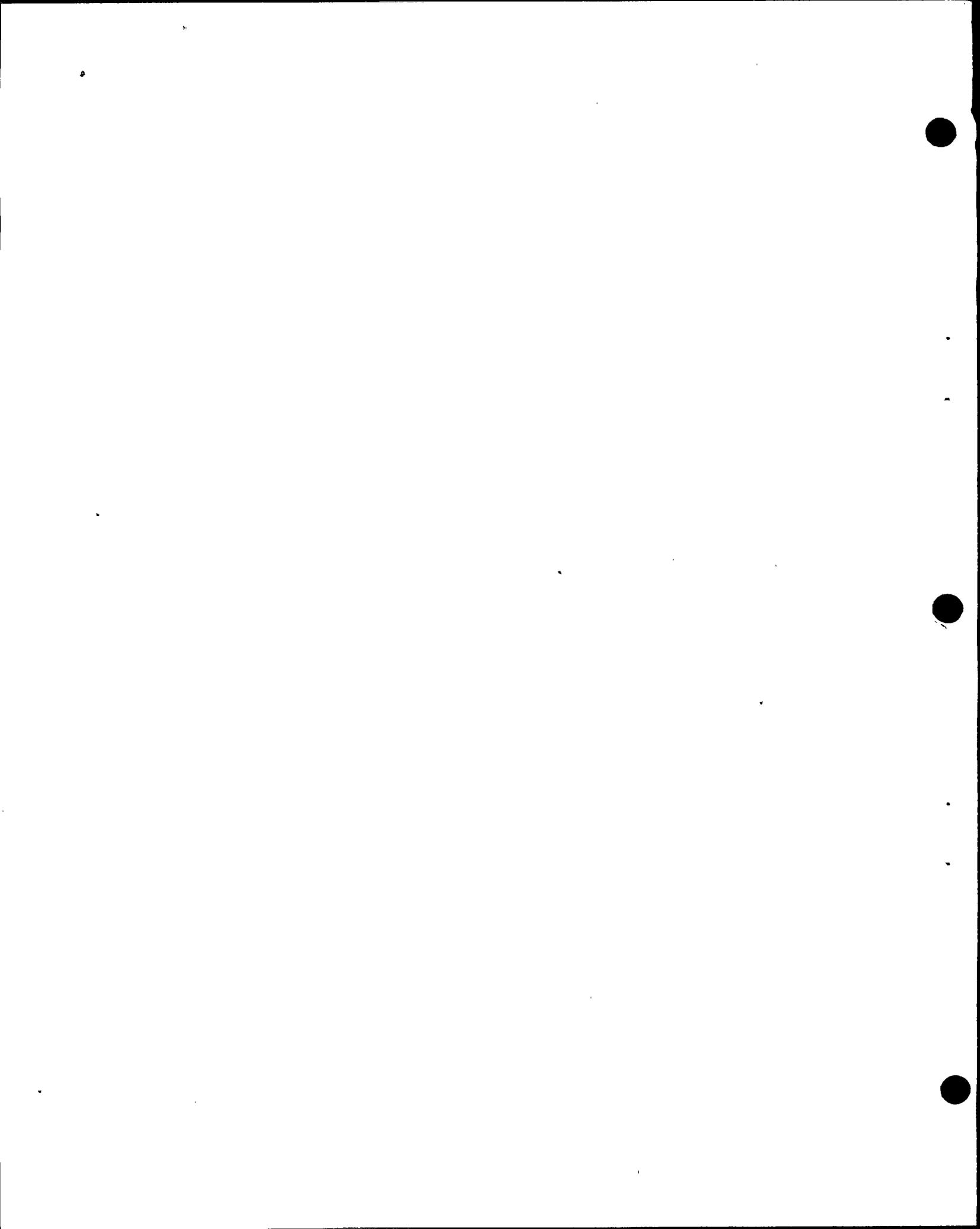
Well what that goes to, I think, is the weight of the conclusions that one draws to the hypotheticals, and that is left to the Board's discretion.

You do run a risk in an administrative proceeding that hypotheticals asked early on, based on facts that are not in evidence, may turn out to have not much weight. But that's the risk that the rules of administrative procedure assumes, that the question of weight is left to the Board. And their conclusions on that matter are determined at the end of the proceeding.

MRS. BOWERS: Let me go back to a point that I raised two or three days ago when something similar came up.

In the two weeks of evidentiary hearing on environmental issues -- and I know you weren't with us then, Mr. Fleischaker -- but the Joint Intervenors had scads of articles in magazines and there were some that were not permitted because it was sort of not in the scientific world or not peer review and that sort of thing.

Dr. Martin, as I mentioned the other day, compared one of them to National Geographic which he enjoys



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reading but doesn't consider a scientific, necessarily a scientific document.

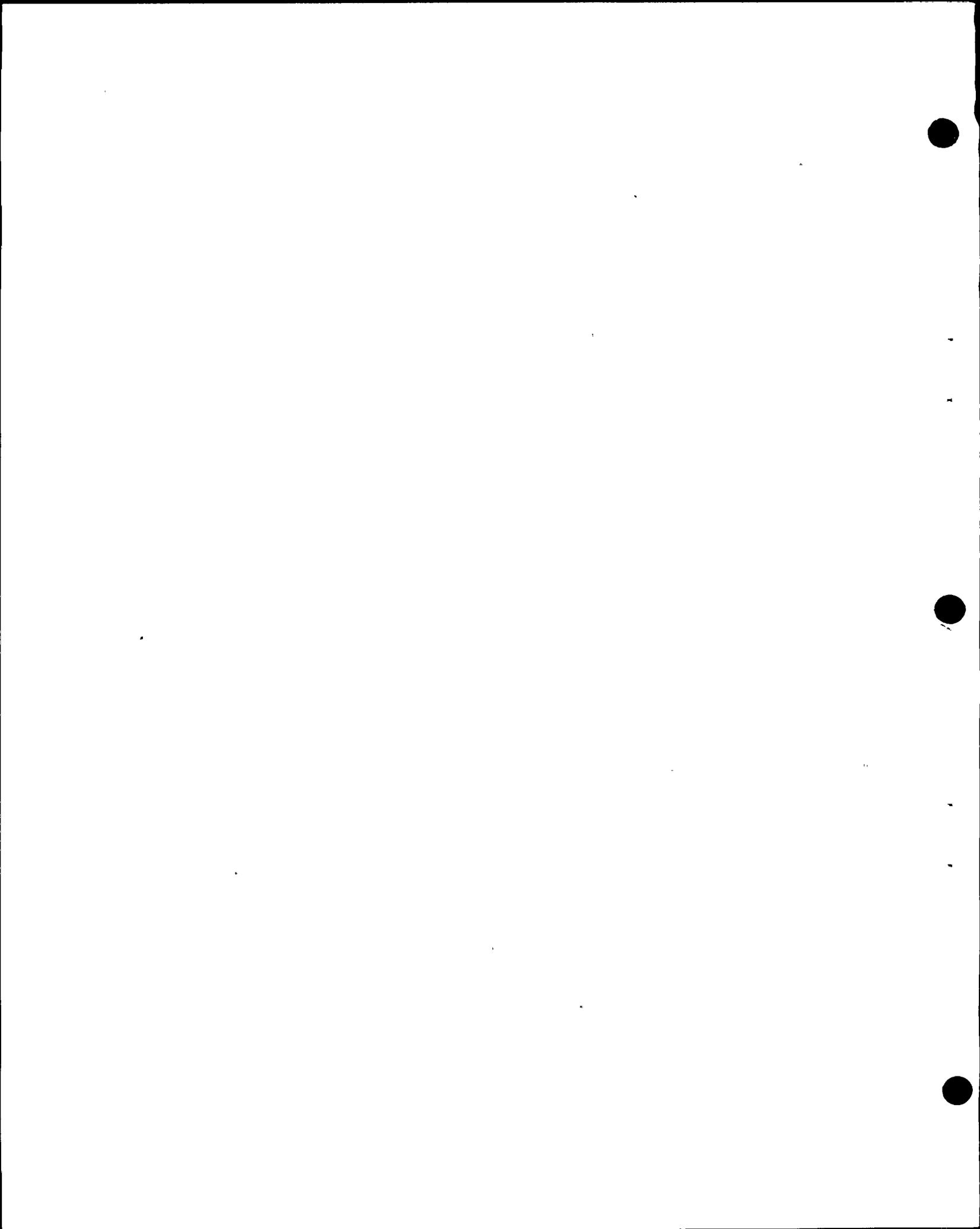
But, anyway, in that hearing -- and you were there, Mr. Norton, and Mr. Tourtelotte -- the Intervenor's counsel would show to either a Staff or Applicant witness--will identify an article: "Are you familiar with it?" "Yes, I even have a copy of it here in my briefcase."

So then questions would be asked: "Do you agree with Dr. Expert in his article when he says such-and-such-and-such-and-such?" And of course, the witness would respond.

Now, how does that situation differ from what we have here, when we have the articles from Science?

MR. NORTON: Mrs. Bowers, I have absolutely no problem with questions being asked on articles, in other words, asking someone: "Have you read it?" "Yes, I have." "Do you agree with the conclusions?"

I think it's perfectly proper, it's done in all kind of legal proceedings. That's different than placing the article in evidence to be considered by the Board or the jury or whatever the case may be as evidence of an expert that the conclusion stated in that article is evidence. It's not, there's no foundation and no opportunity to cross-examine and that's what I object to, not the use of the article for cross-examine purposes. I have no objection to that.



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MR. FLEISCHAKER: I don't think that was in answer to your question. I think you were analogizing the asking of a hypothetical question based on facts that might appear in an article with the situation where you test a witness' opinion based on the article.

MR. NORTON: My answer to that is, if the document is not in evidence then you can't base a hypothetical on it.

Now if you have a witness sponsor that article and get it into evidence where there's a foundation and proper cross-examination and that article comes into evidence, then you can ask all the hypotheticals in the world you want based on the facts in that article.

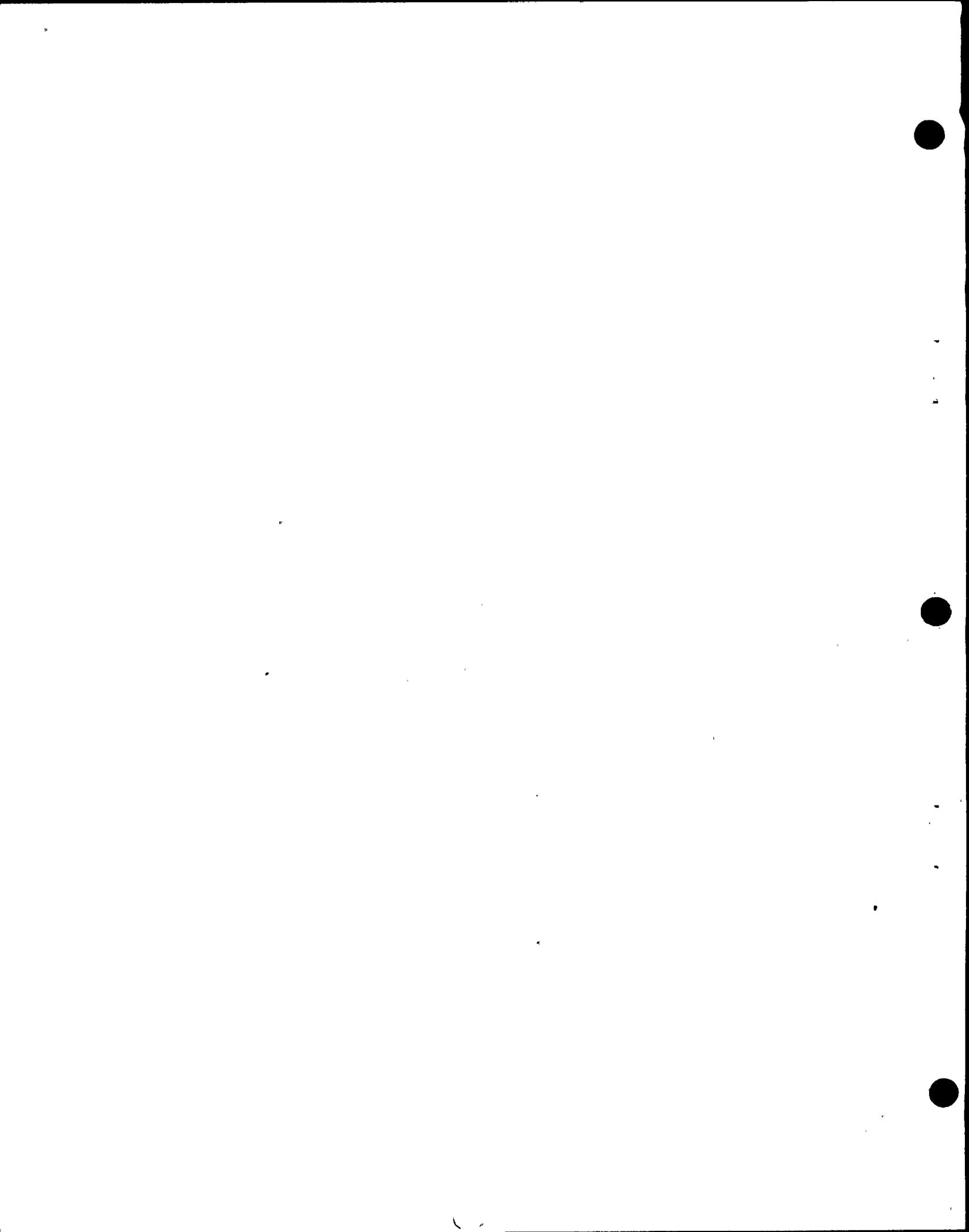
But to ask hypotheticals just because someone has read an article and then start basing all kind of hypotheticals based on that article is not proper in my opinion.

And you know, I've lost this battle, I don't know why we're really re-arguing it, but I just don't think it's proper.

MR. TOURTELLOTTE: Let me make a couple of points.

One is Mr. Fleischaker said that he didn't think there was any rule in administrative law that required that the matters be in evidence before a hypothetical is asked. And I would simply invite his attention to ALAB-334 which says that:

"Hypothetical questions may be



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propounded to a witness. Such questions are proper and become a part of the record, however, only to the extent that they include facts which are supported by the evidence or which the evidence tends to prove."

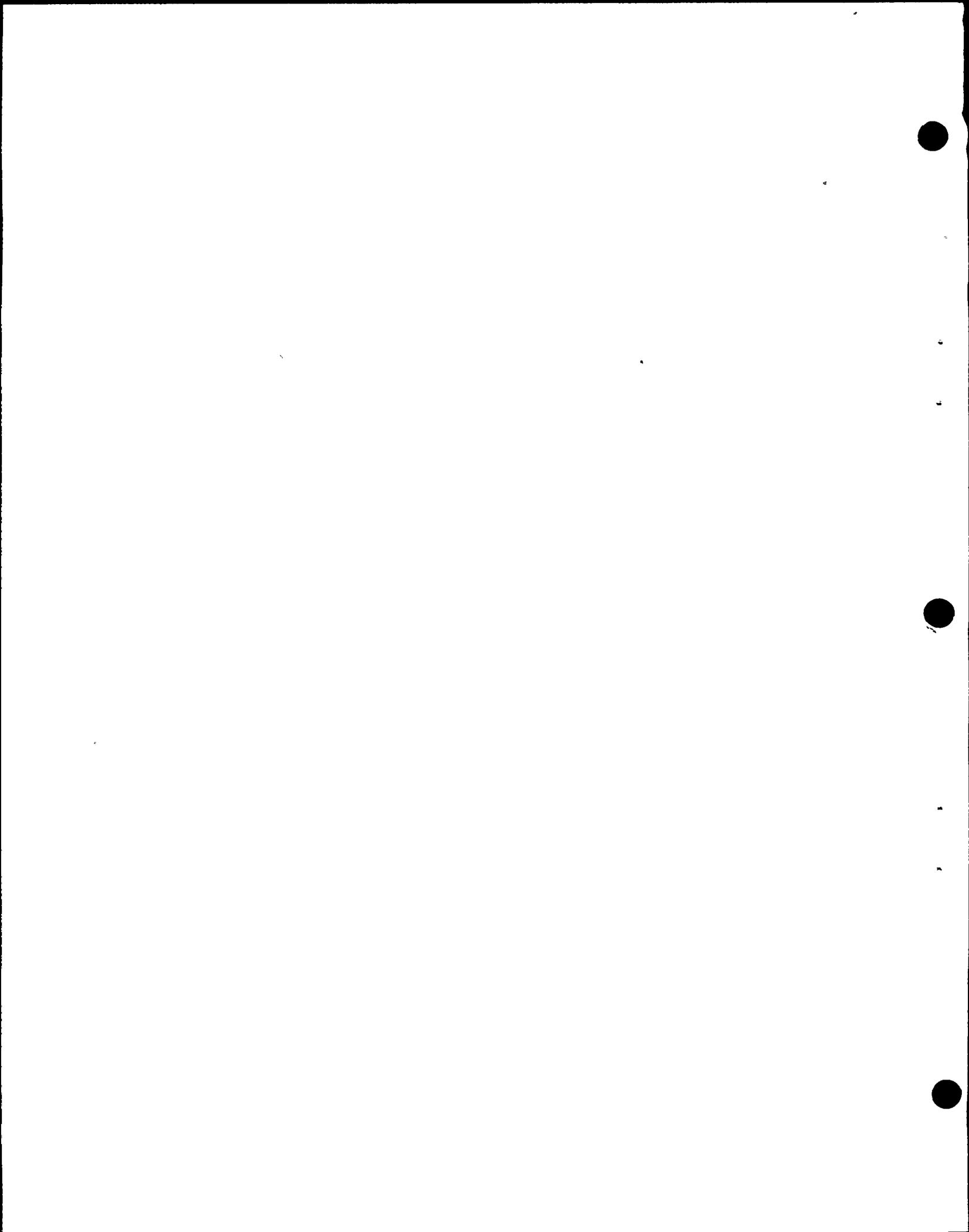
Now I think that's a fairly straightforward statement in an administrative tribunal which, therefore, is a rule that the facts have to be in evidence.

Let me say that there are -- well, there are a couple of things I want to say.

One comment I want to make is that oftentimes people really use the business about this is an administrative proceeding and we don't have to abide by the rules of evidence as a cop-out for allowing people to do virtually anything.

And what can result and frequently does result is a breakdown in the judicial nature of the proceeding from an efficiency standpoint. In other words, a breakdown of judicial efficiency. And also, it results in building a record which has no real meaning and no real -- it's not a matter of whether it has any weight or not, it doesn't have any weight at all if there are no facts in evidence.

Then one final point is that virtually everything that Mr. Fleischaker wants to do by asking the hypothetical he could accomplish if he does it the right way.



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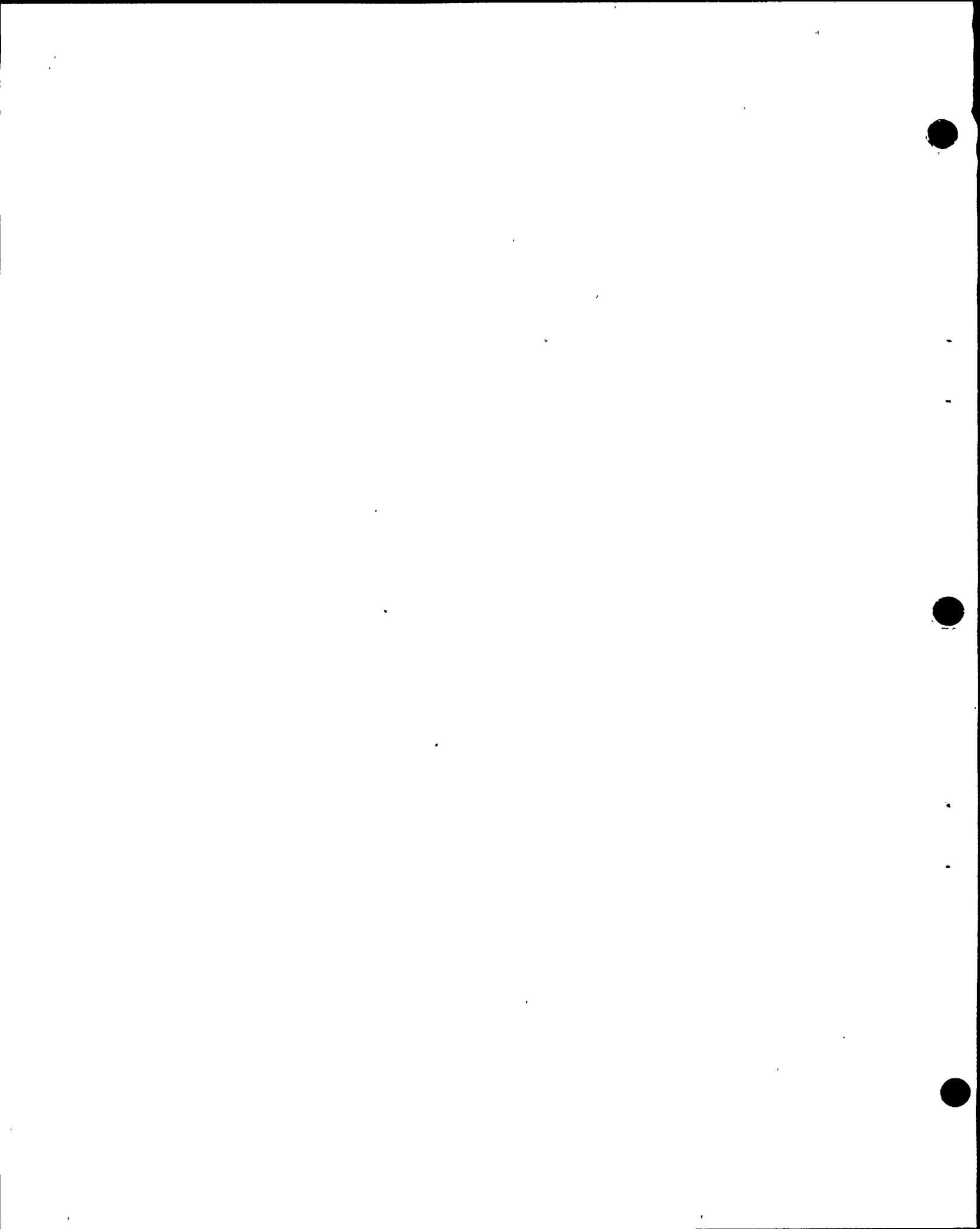
There is a way -- the question we were talking about yesterday, which I still maintain was improper because the basic foundation upon which the question was based is improper because it's not a fact in evidence, it's a representation of counsel. I can see sitting right here how he could ask exactly the same question and get exactly the same result in a proper way without running afoul of this rule of evidence.

When I was in private practice, I was with -- at the time, I thought he was a very old attorney, right now it doesn't seem like he's so old.

(Laughter.)

But he had a vast amount of experience. And he said, you know, the rules of evidence are important and sometimes they give you a hard time, but if you stop and think about anything long enough, there is a way that you could accomplish the same task and stay within the rules. And that's what you really have to do in trial work. You just have to stop and think about it and you can stay within the rules and keep the integrity of the record.

Now I know that may sound to some people like, well, if that's the case, then these are foolish evidentiary rules. But that's not really the case at all. It is a matter of placing direction and emphasis on your questions and not putting your questions in the context that they run



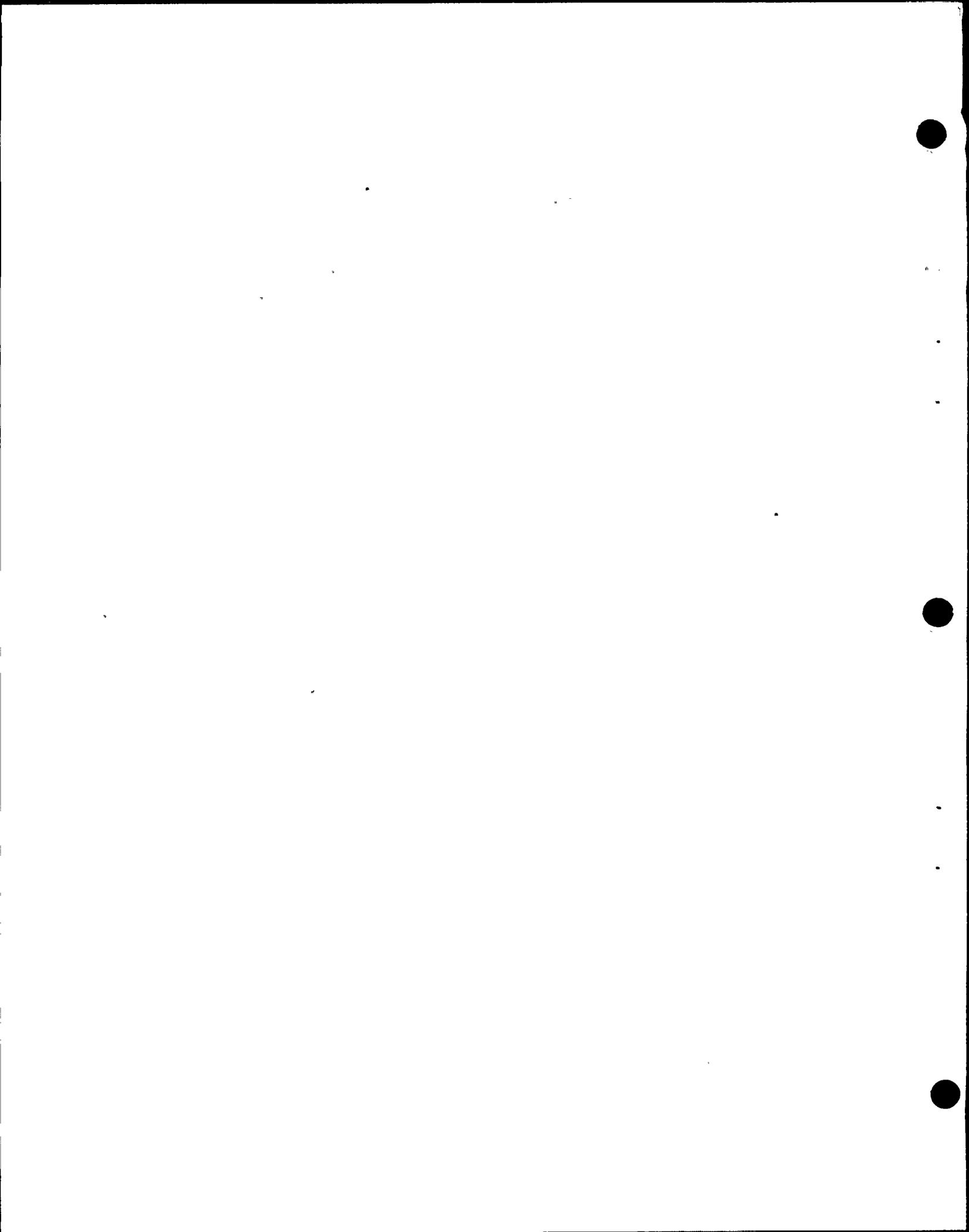
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afoul of the rules. And when you place your questions in that context, at the same time, the record is going to be reliable and probitive.

I don't think I really disagree with much of anything -- I don't think Mr. Norton and I are disagreeing about anything, because you can ask questions about articles, it can be done in a particular way. But you can't rely upon the truth of the matter asserted in those articles.

That's basically what it's all about. You have to rely upon this expert's opinion of how whatever opinion is registered in that article will affect their ultimate result and that's all you can do. But you can do it that way and you can accomplish almost the same task.

If you want to reverse the role, I can take almost any good question and make it into a bad one, evidentially.

So I would simply say that, for the purposes of both (A), insuring the reliability and relevancy of the evidence that we adduce in proceedings and, (b), for the protection of the judicial efficiency of the entire proceedings, that we stay fairly close to this rule of evidence and not jump on the bandwagon with everybody else that this is an administrative proceeding and we can do anything we want.



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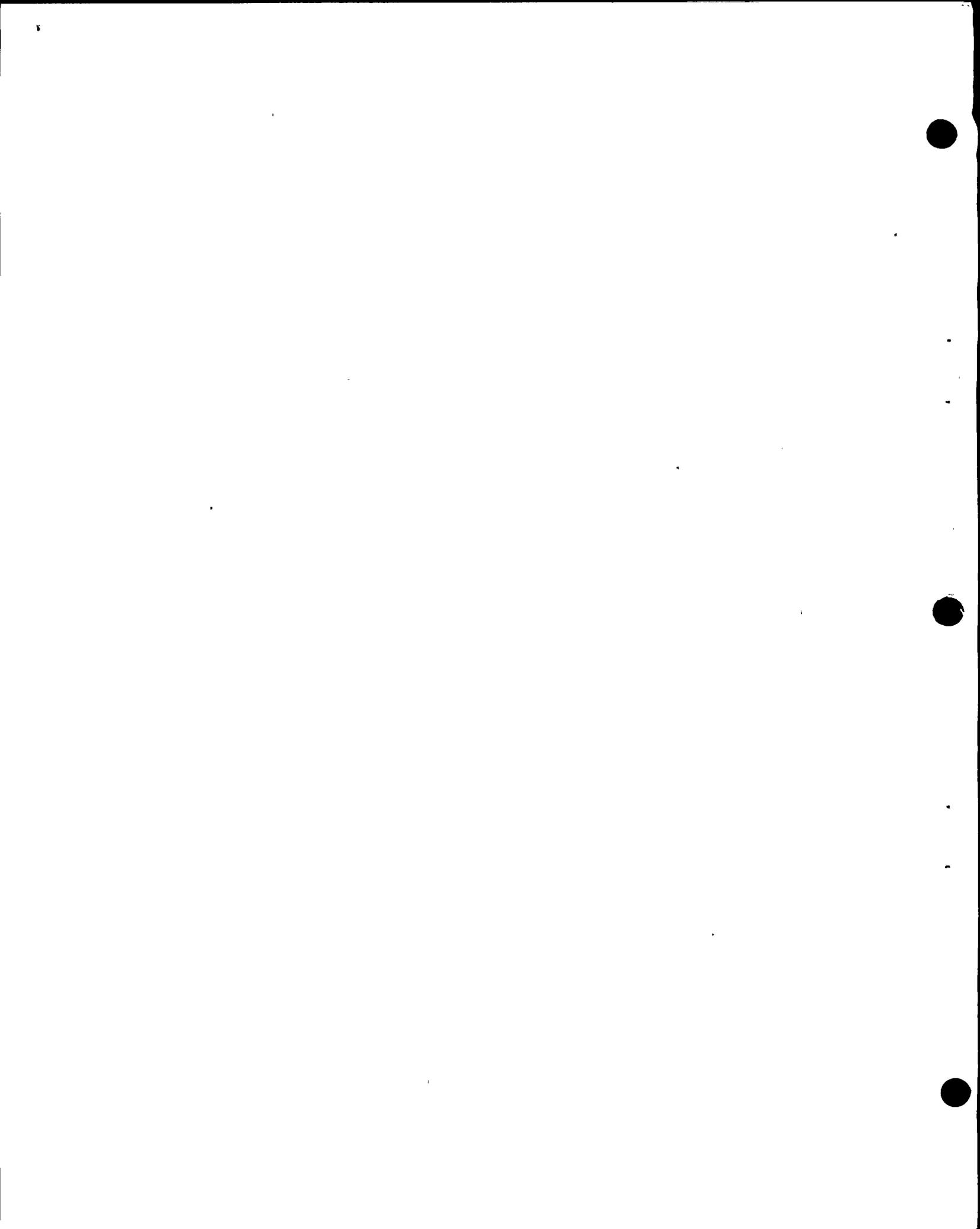
MRS. BOWERS: I spent a little over a year as a Hearing Examiner in Social Security cases, and 99 percent, 99.9 percent were disability. And I had an evidentiary record where physicians came to different conclusions as to the physical state or the mental state of the claimant, and I had expert witnesses, a medical advisor and a rehabilitation expert who was a Ph. D. psychologist with special work in vocational rehabilitation.

And it was a breeze to ask hypotheticals because, you know, I hadn't yet come to a conclusion but assuming the person can't stand more than ten minutes, can't lift more than five pounds, and this sort of thing, then what is your opinion as to his ability to work, and if so, at what kind of jobs?

But this situation doesn't lend itself to that easy role.

MR. NORTON: And, Mrs. Bowers, the distinction there also is that-- I happened to practice before that in Phoenix a number of times, and the difference there is that that goes up through an administrative process and that's really, you know, the kind of second or third step you're describing. And then it goes to Washington.

But then, if the claimant loses, he starts in the United States District Court, trial de novo all over again.



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That isn't the case here.

This is the so-called Federal District Court trial de novo and the only thing that comes after this is an appeal, no new trial, no other forum in which to put in evidence. This is it. And I think we have to be extremely careful that,-- You know, the thing I envision with this article business is the way we try nuclear cases in the future. We call all of our consultants to go out and publish a lot of articles. "Just keep publishing, fellows, because when we get to hearing we're going to have a weight contest and we're going to have articles that weigh more more than the other side."

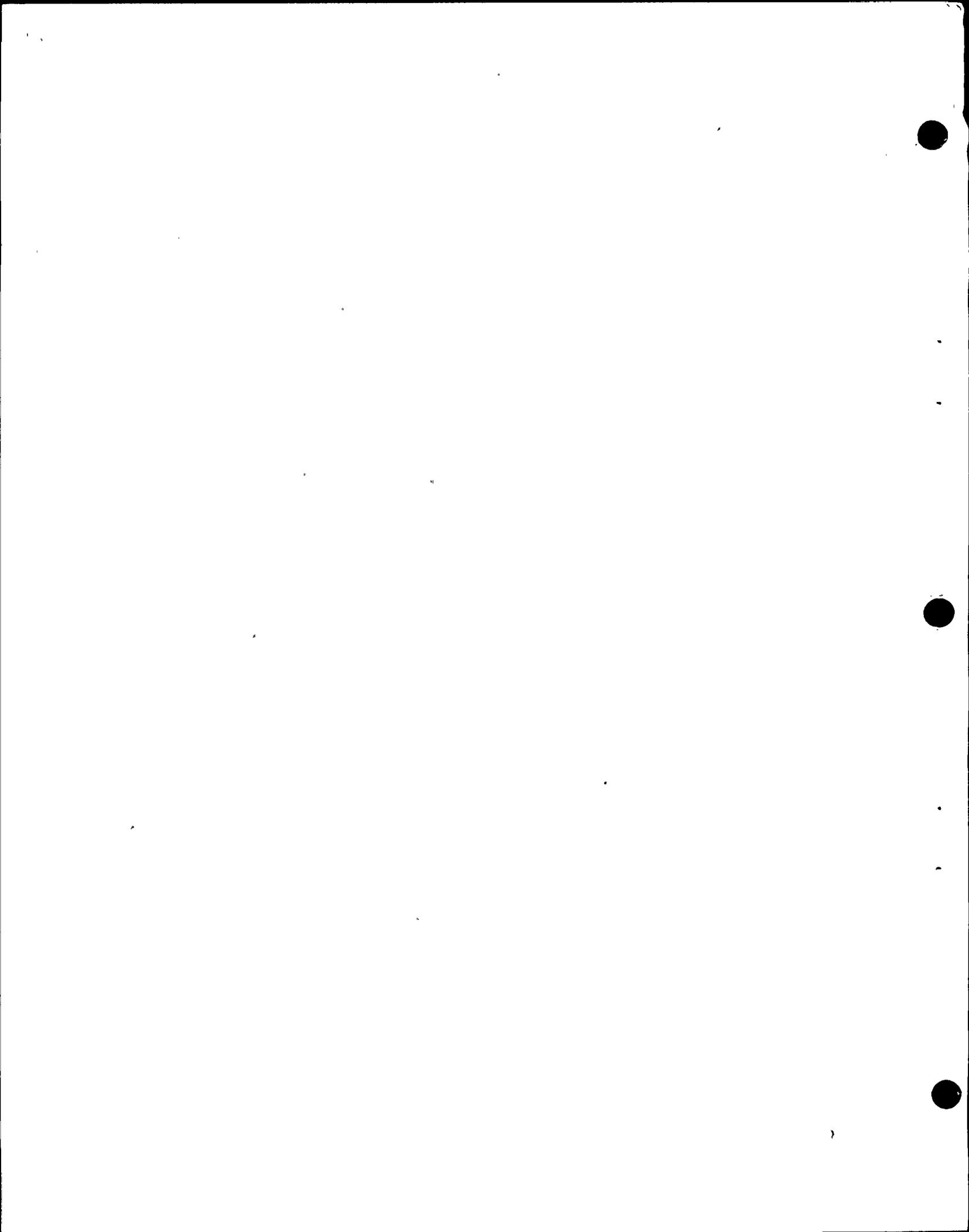
That's not the way you try cases. You go to the facts.

It's not a paper weight contest; it's a factual evidentiary hearing, and I think we've got to stick with the facts of the witnesses who are here, and not place into evidence articles that no one has a basis to lay a foundation for.

And I think the most important thing that Mr. Tourtellotte said is that you cannot rely on opinion in articles when the author is not here to be cross-examined.

MRS. BOWERS: He also said he thought both articles ought to be in evidence.

MR. NORTON: I think he's dead wrong.



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MR. FLEISCHAKER: Can I focus on one--

MR. TOURTELLOTTE: Which articles?

MRS. BOWERS: The two Science articles.

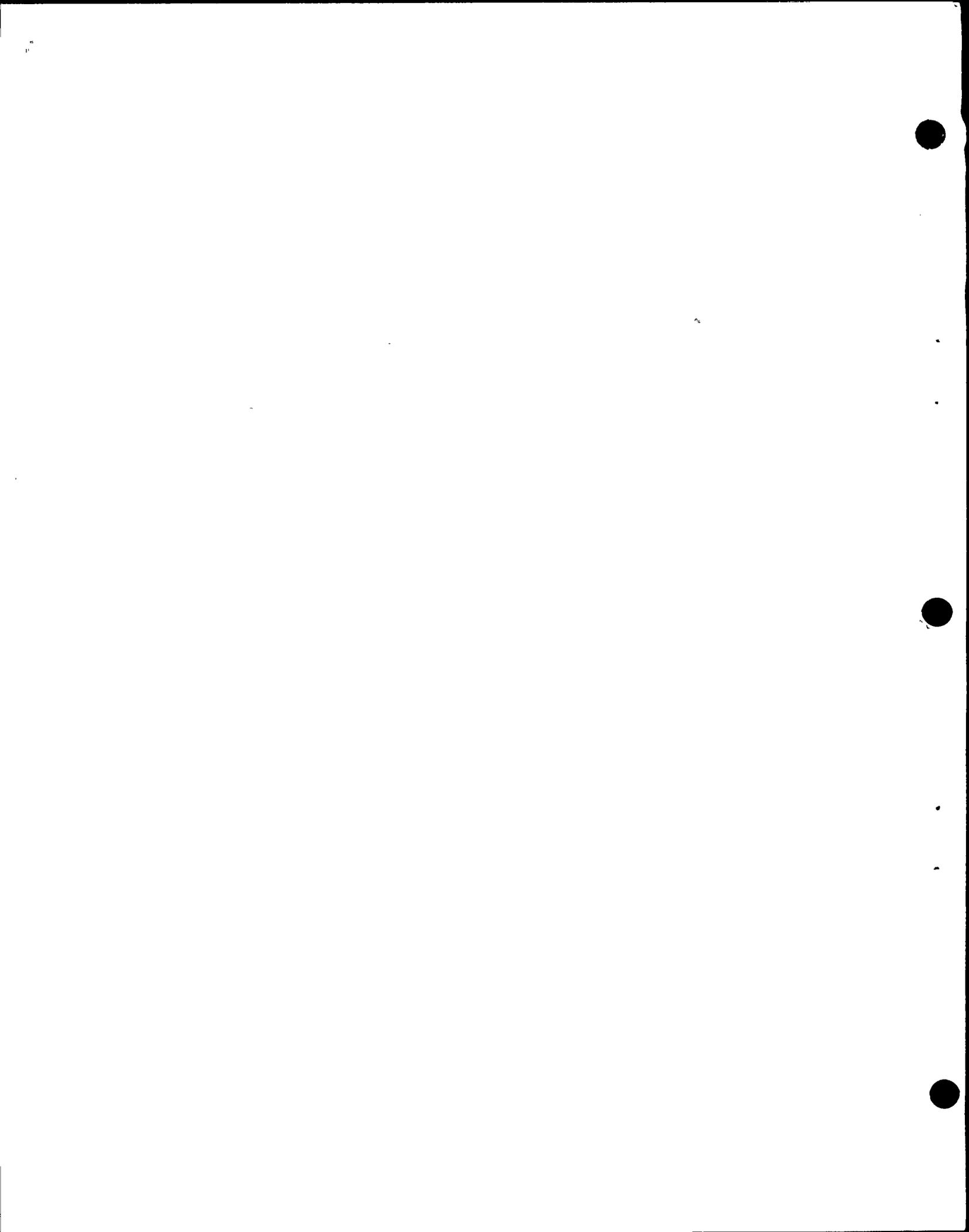
MR. TOURTELLOTTE: I don't mean that they ought to be in evidence right now. I said I think they ought to be in evidence before they're used to base hypotheticals on.

MRS. BOWERS: Oh, I misunderstood.

MR. TOURTELLOTTE: And I don't think that-- If Clarence Hall isn't going to be here I don't think his should be in evidence at all in the first place.

Here's another problem. I alluded to this briefly before, but one of the problems of testing somebody's opinion about an article that someone else wrote, particularly if they wrote it a year or two ago, is that -- and this is particularly true in an area like geology and seismology where it's a developing sort of science and there is new information that is developed on a regular basis, that is, more and more knowledge is being gained.

If we use that as a basis for, say, stating hypotheticals, how do we know that, (a), that person who wrote the article could defend it if he were really here and (b), how do we know he wouldn't change his mind if he were here and (c), if he were cross-examined, he might shed some new light on his article which would demonstrate a nuance that you or I or the other witnesses do not perceive



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that indeed makes his article say something that isn't readily apparent to us?

So all these things and probably thousands of others could happen if the witness were right here, and that's why it's important to have the witness there and sponsor it into evidence before we get into the business of examining people on the basis of its importance.

MRS. BOWERS: Well, Mr. Tourtellotte, the Staff supported the idea with Drs. Trifunac and Luco that their documents come in but that exceptional circumstances had not been established to subpoena them.

MR. NORTON: May I respond to that?

The parties can stipulate to ignore any rule of evidence they want. That's what a stipulation is.

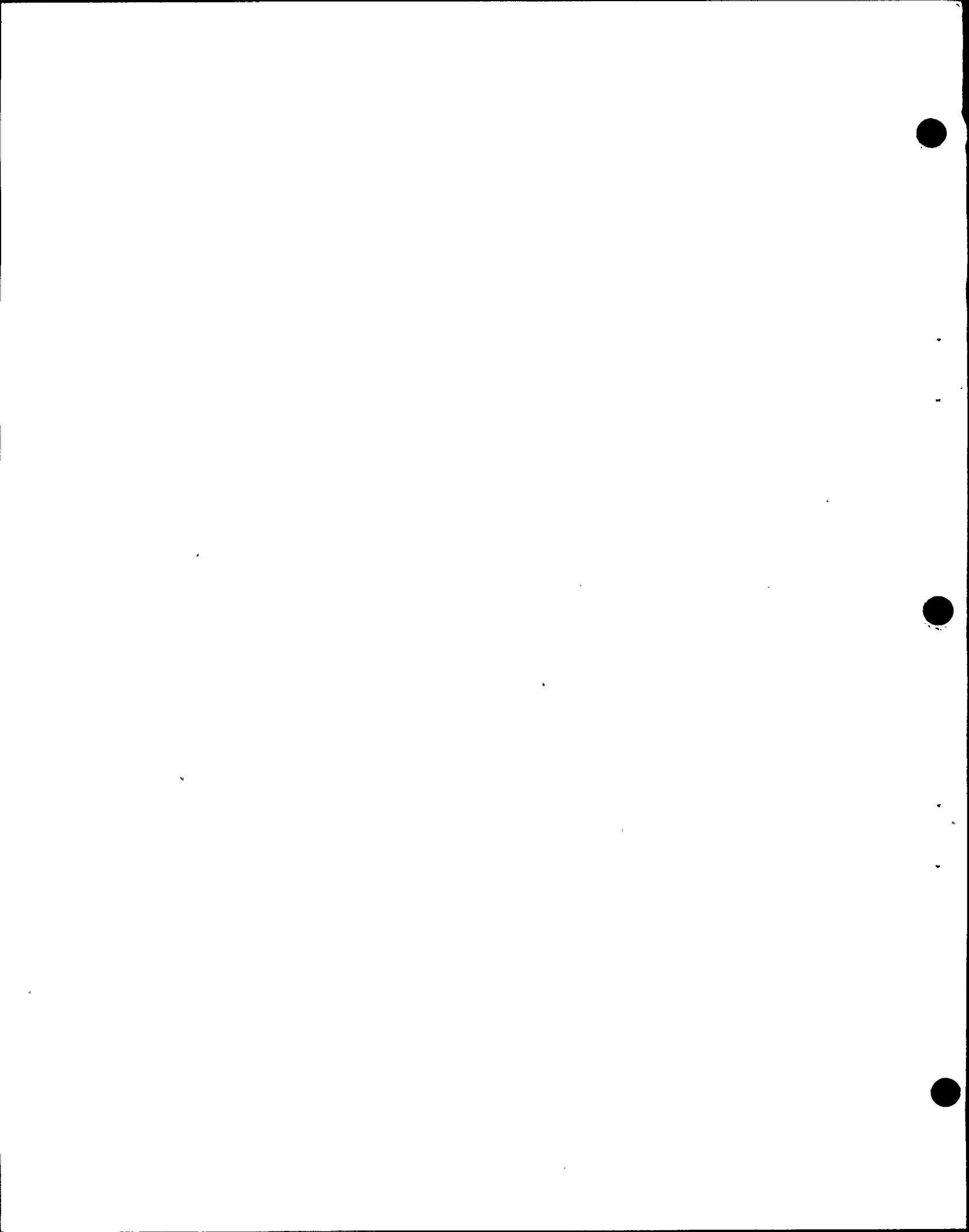
MR. FLEISCHAKER: This party didn't stipulate.

MR. NORTON: And we did stipulate that they could come in.

Now if Mr. Fleischaker is saying he doesn't want them in and he's going to keep them out, then he can do that.

MRS. BOWERS: But we don't have a stipulation unless all parties agree.

MR. NORTON: Yes, I'm willing to stipulate them in; Mr. Tourtellotte is willing to stipulate them in. The Board accepted them into evidence.



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Now I didn't realize that Mr. Fleischaker had raised an objection to the reports of Trifunac and Luco being placed into evidence. If indeed he is objecting to those documents being placed into evidence, his objection should be sustained.

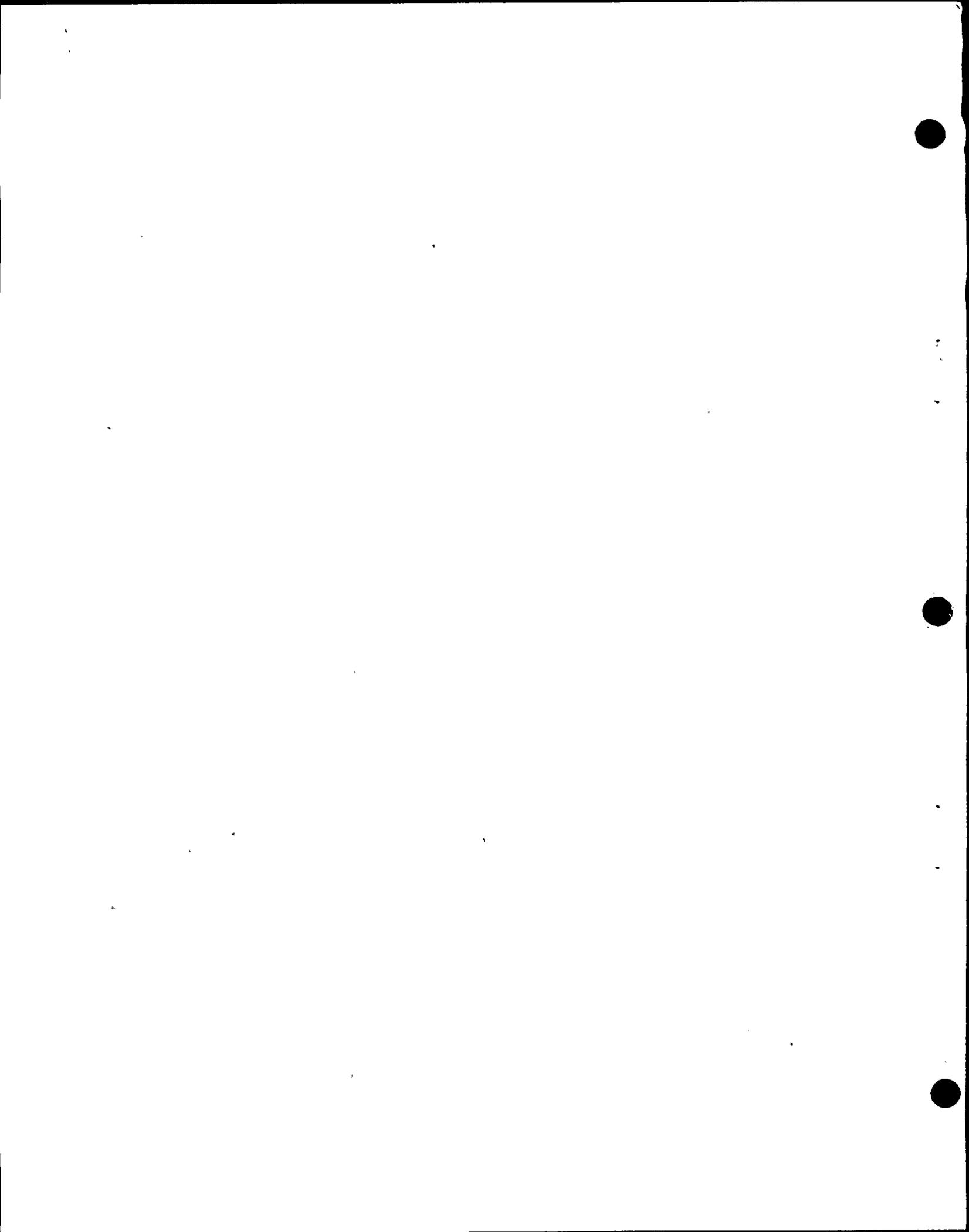
MR. FLEISCHAKER: Wait a second. We're losing sight. The question has to go to the reliability and....

I think what we need to focus on, one thing that is helpful to focus on is what is the purpose of the cross-examination and what is the harm if we proceed by way of a hypothetical question and the bases of the hypothetical question aren't strictly in evidence?

The purpose of cross-examination is to test the witnesses' viewpoints and oftentimes it is useful to utilize articles like Science Magazine to test their viewpoints. All right. Now it may be that they don't agree with the basis but if that's the case that can certainly be brought out in redirect or in cross-examination by other parties.

It may also be the case that at the end of the proceeding that the facts which are in evidence do not tend to support the basis for the hypothetical question, in which case the Board can give the answer to that hypothetical question very little weight.

But in view of the fact that it's important to test these people's opinions while they're here and that you



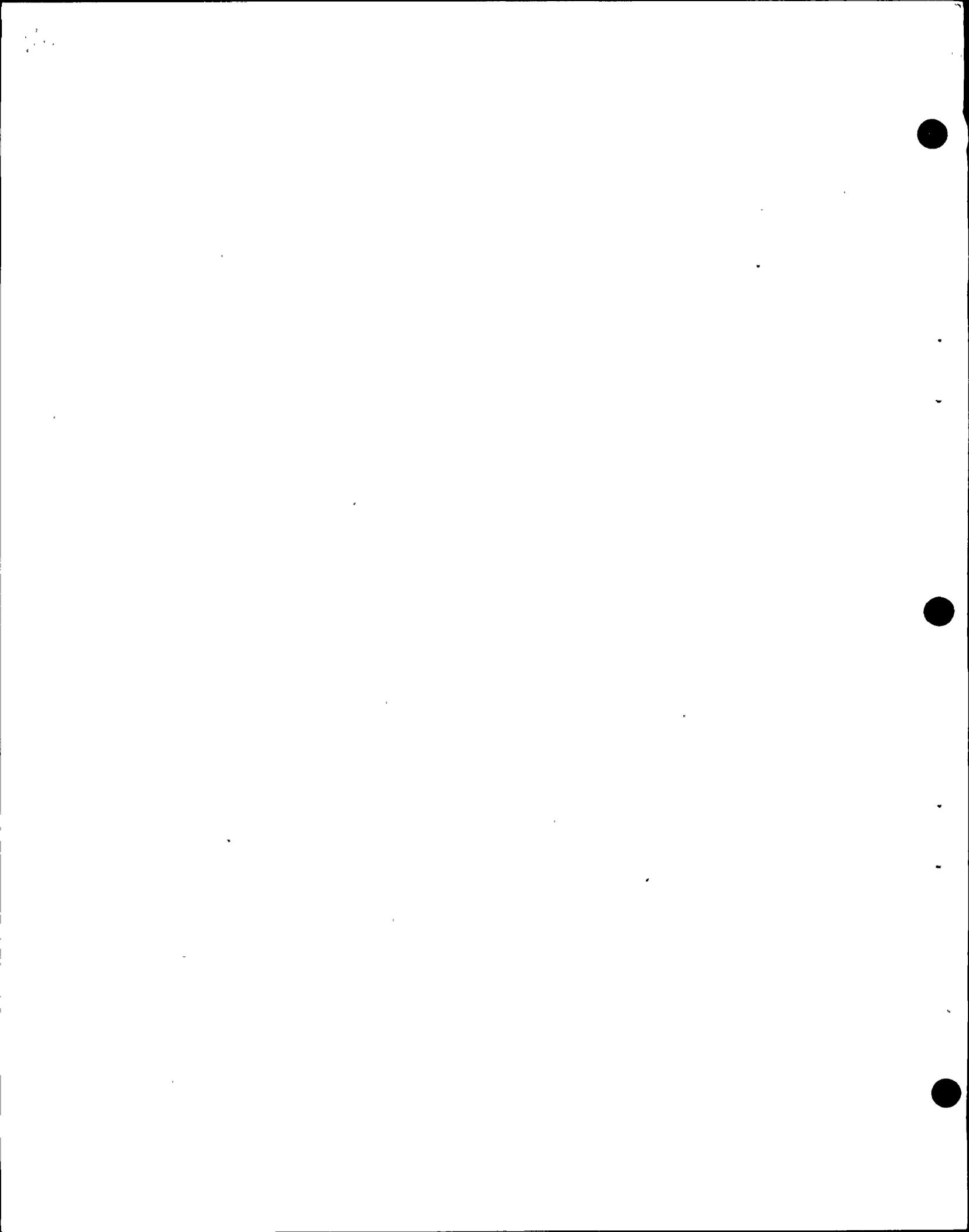
don't have a battery of witnesses in the back room that you can bring up before they take the stand to get the adequate evidence into the record, administrative proceedings recognize that -- rules applicable to administrative proceedings recognize that facts do not have to be in evidence prior to asking the hypothetical question.

Let me turn to the second point. The second point is harm. What is the harm?

The only harm that I've heard is the parade of horribles argument; that is, that too much time will be consumed in asking hypothetical questions for which there is very little basis. If that's the case, the Board certainly can cut that off. I mean there may be a point at which the basis for the hypothetical is so out of kilter with anything that the Board has observed or heard that they don't want to waste their time on it, but that's the only harm that I've heard today.

MR. FOURYELLOTT: A couple of things I want to say.

One is that everything I said about hypothetical questions is not something that I just made up. It isn't some argument that I dreamed up to support a position that I have. Those arguments are clearly stated as being the basis for the rule on asking hypotheticals in Wigmore on evidence and Chasberlayne on evidence, and Davis on



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administrative law, and virtually every treatise and every case that deals with it sets out these reasons for why you must have facts in evidence before you ask hypothetical questions.

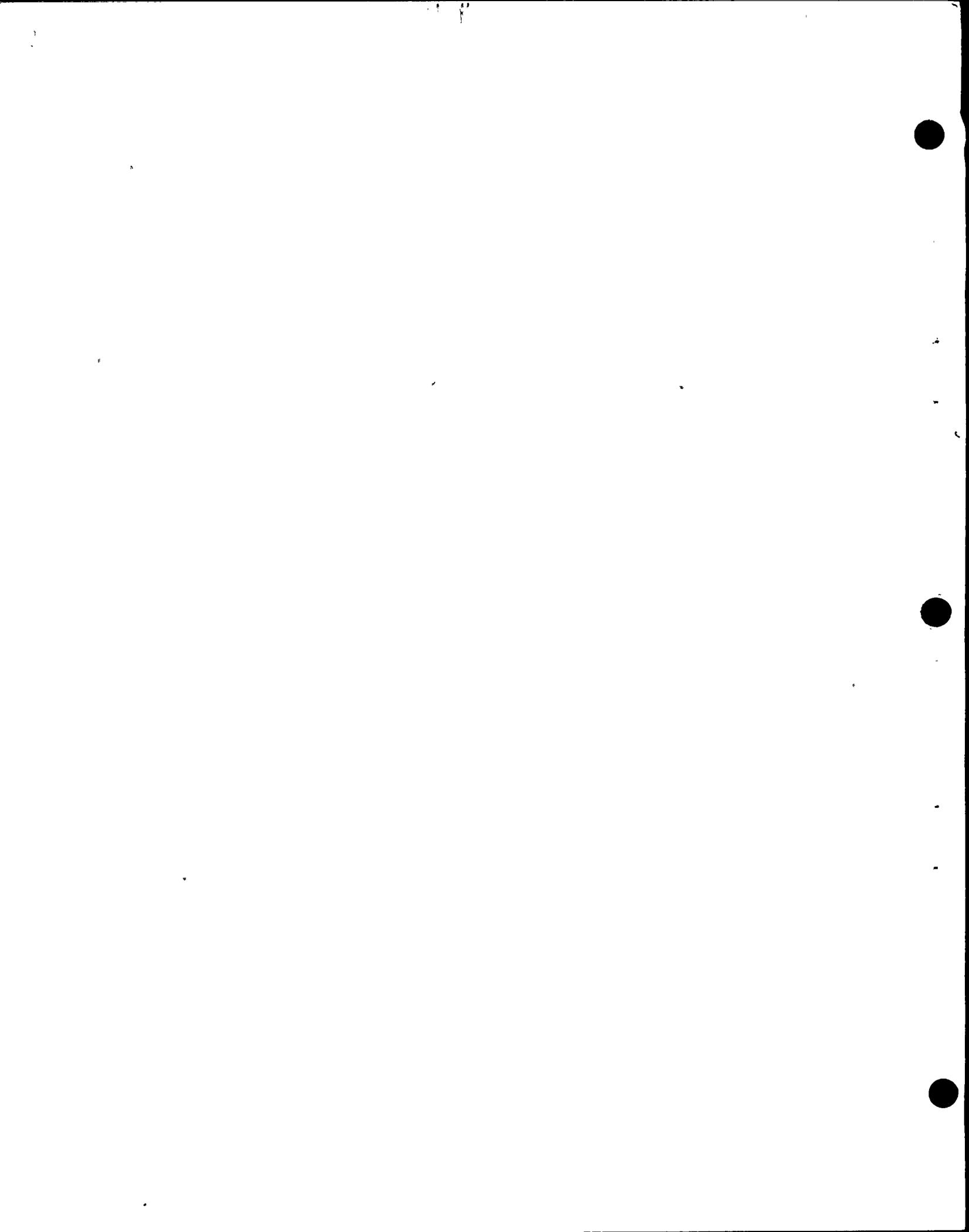
And I also was the one who argued the Diablo case which I cited a few moments ago.

Now let me turn briefly to the Trifunac and Luco thing, since that was brought up.

I really think that that argument is irrelevant to the matter that we're considering because what we had in Trifunac and Luco, the Trifunac and Luco situation, is the fact that Mr. Fleischaker wanted some documents in to evidence and he told us that he wanted those documents into evidence, and Mr. Norton was willing to agree to them to come into evidence, I was willing to agree to them coming into evidence, and Mr. Fleischaker was in agreement to them coming into evidence. And they went into evidence.

And my view of that, I don't know how you can cut it any other way, it seems to me that that is a stipulation.

What we had as a separate argument, however, was that just putting those documents into evidence wasn't enough for Mr. Fleischaker. He also wanted these people to be present. And in that particular case we have a set of rules which the Staff has an interest in seeing that they



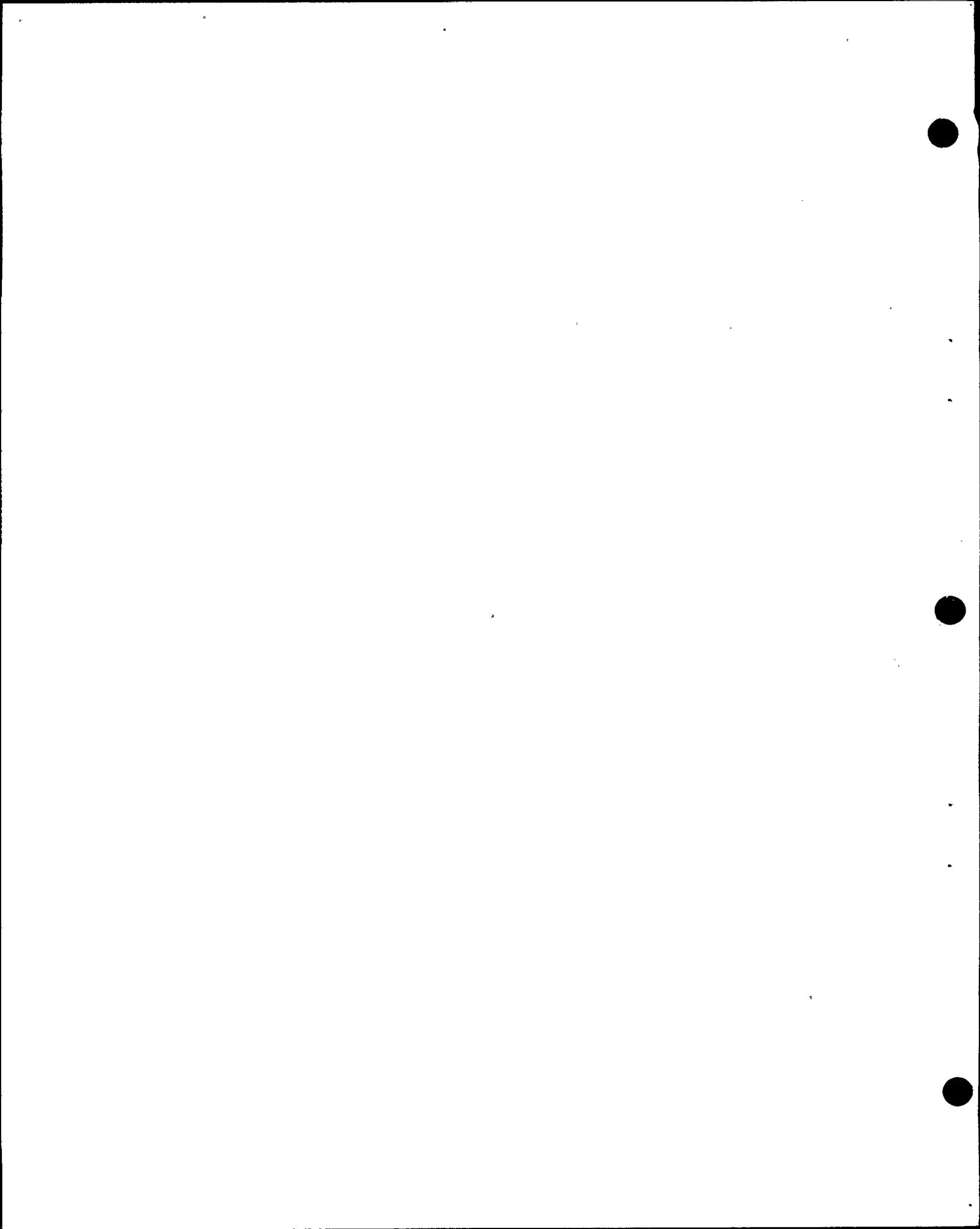
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doesn't agree with, and we think it has no probative value.

Otherwise we would be happy to see it go into the record.

So I see the situation is not really comparative at all, and I also believe that we have really said enough about hypotheticals and what should be required.

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MRS. BOWERS: Mr. Fleischaker, we want to go on.

Are you done?

MR. TOURTELLOTT: I misspoke a little while ago. I used the term, "extraordinary circumstances," it's supposed to be "exceptional circumstances."

MR. FLEISCHAKER: Are we going into Trifunac and Luco, Part Two?

MRS. BOWERS: Well the record will show what you had to say at the time that there was the discussion and the documents and so we won't do that again.

I started out by saying while we did not strictly agree that a hypothetical had to be based on facts already in evidence, we found in this situation it was very difficult to determine the reasonableness of an assumption in a hypothetical if there hadn't been testimony on it. So we'll just proceed and face each issue as it comes up.

Are you ready, Mr. Fleischaker?

MR. FLEISCHAKER: Yes, I'm ready.

Whereupon,

STEWART SMITH,

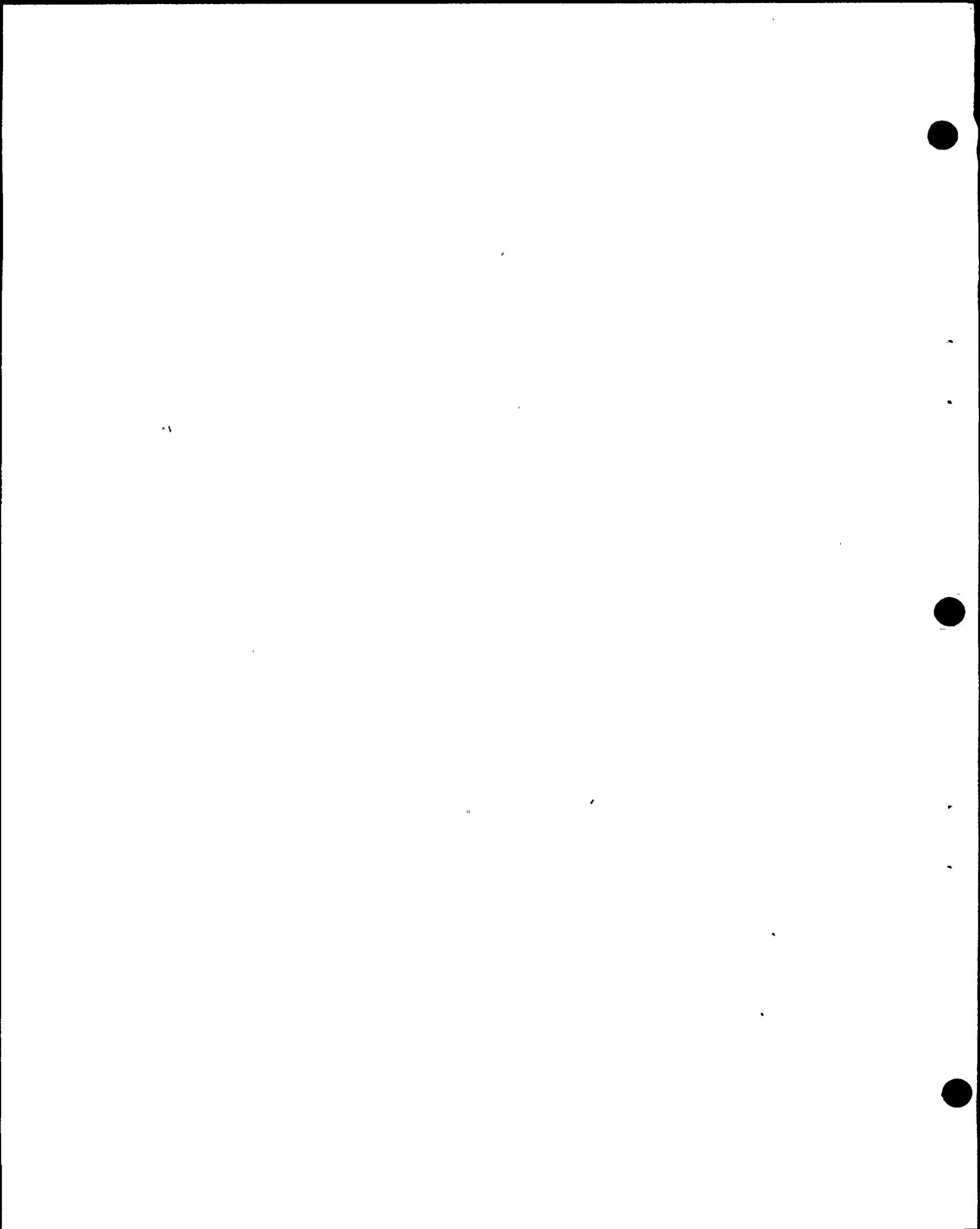
BRUCE BOLT,

GERALD FRAZIER,

AND

DOUGLAS H. HAMILTON,

were recalled as witnesses on behalf of the Applicant, and,



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having been previously duly sworn, were examined and testified further as follows:

MR. FLEISCHAKER: I would like to have marked as Joint Intervenors' Exhibit Number 44 some pages from the FSAR 2.5(e). I understand that it's in evidence but I thought that I would have these copies made available for the Board and for the parties.

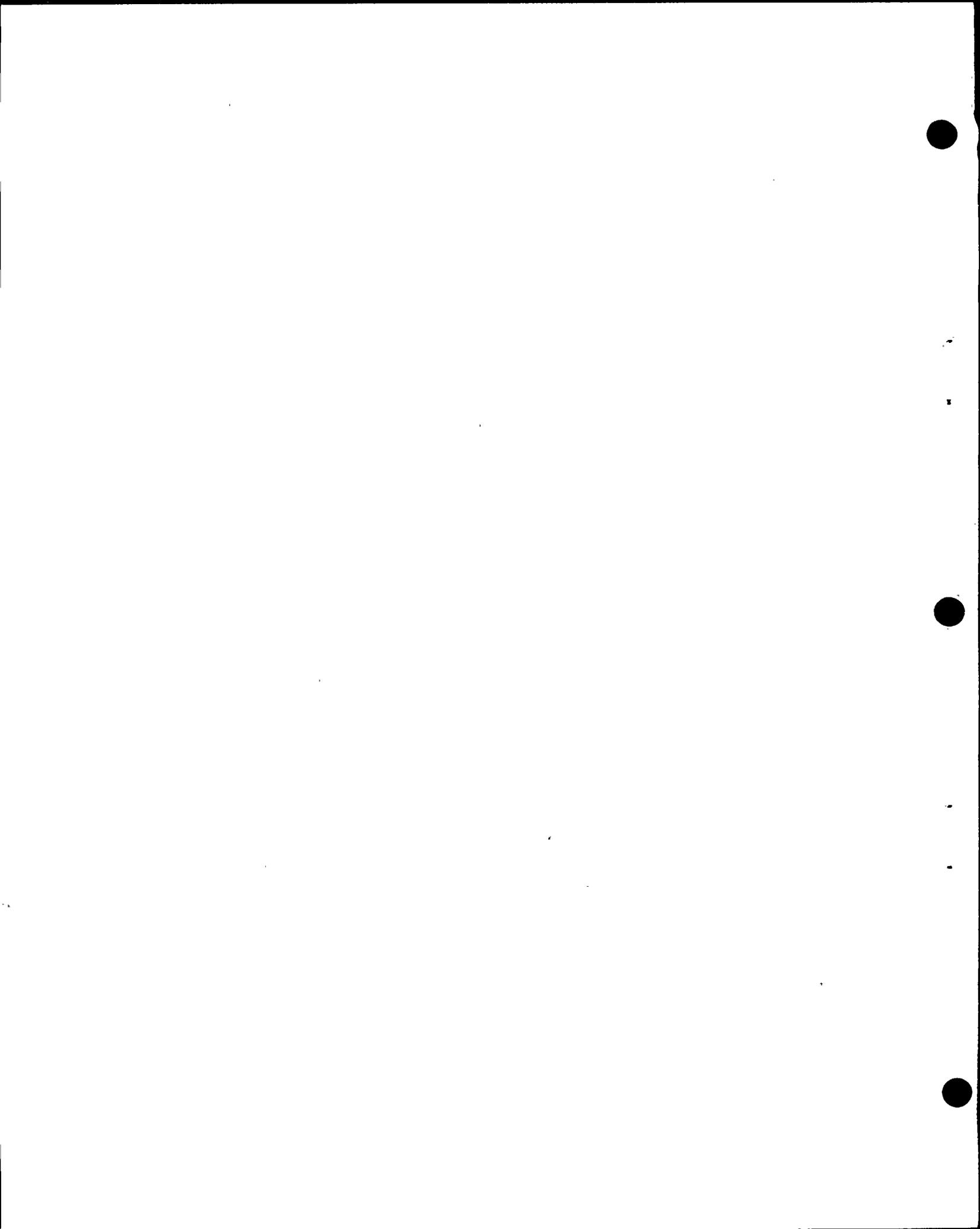
MR. NORTON: If they're already in evidence, why don't we just pass the pages around and not bother to mark them up as an exhibit and double up the volume of the file.

MR. FLEISCHAKER: I thought it would be useful to have this so people could consult it easily.

MRS. BOWERS: But they're in evidence, aren't they?

MR. NORTON: Yes.

(Whereupon, the document previously referred to as Joint Intervenors Exhibit Number 44 were marked for identification.)



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MR. NORTON: Excuse me, before this document is used, there are some notations and stuff written in. On the margin on the second page there are some calculations that, on my copy, I can read some of the numbers but not all. On the first page, there are some words written in.

Are these as copied from the FSAR or are these counsel's notes or what, may we ask?

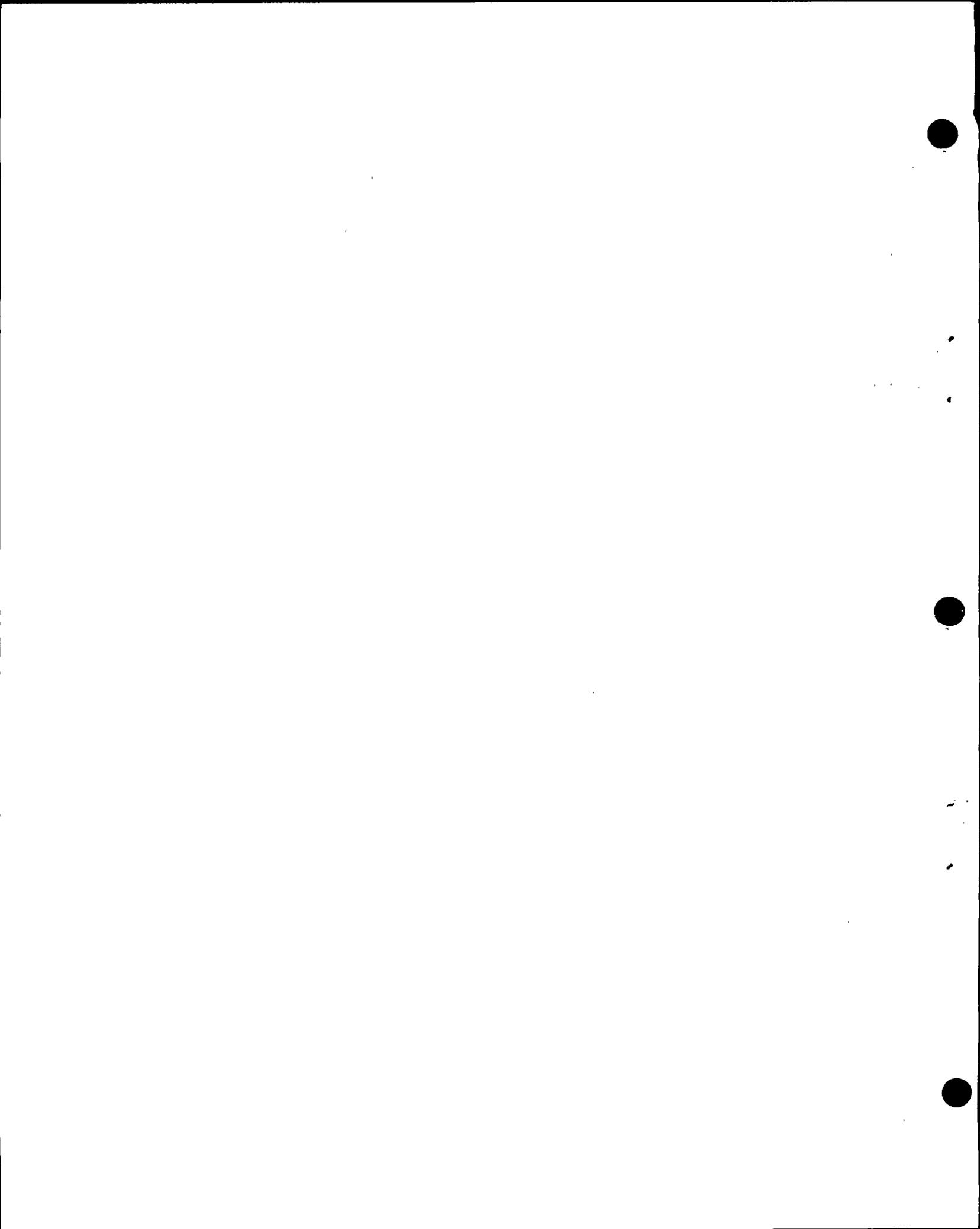
MR. FLEISCHAKER: I think accurately these are notes from the -- these are probably my notes. There are some faint pencil markings here which we tried to erase before we had it Xeroxed this morning, apparently, they didn't get entirely erased.

Do you want to have these Xeroxed over, I'll be happy to do that? Or we can just identify those things that are my markings.

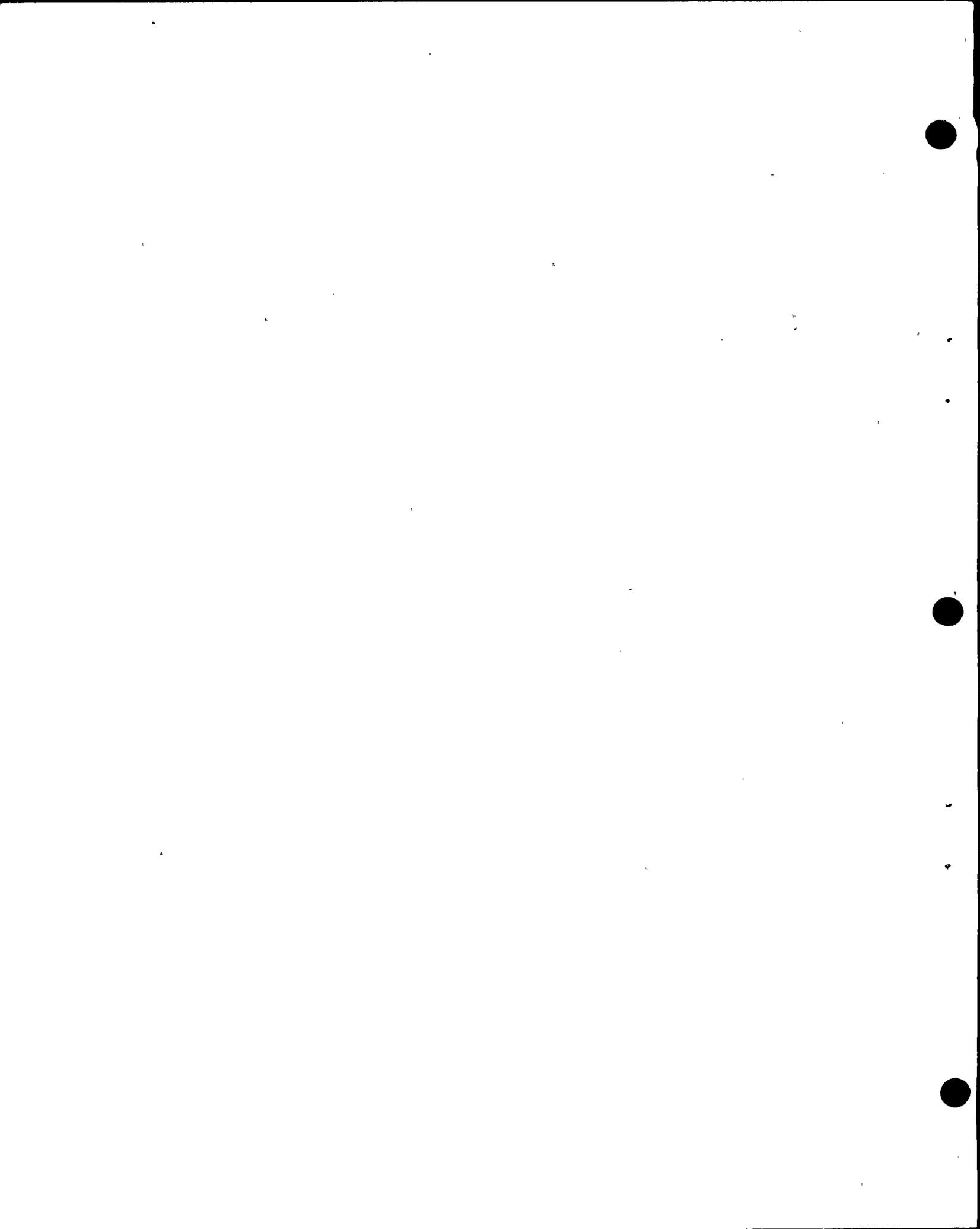
On Page 15, six lines from the bottom, there are some markings between the word, "observed" and "slip." It looks like "utot." And then above the word, "fault," there is the word, "a."

On Page 16, on the right-hand margin, there are some figures that look to be numbers which are very faint and clearly not part of the typed page. And these are counsel's calculations.

There is a question mark over on the left-hand corner, the left-hand margin of the page next to the



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second line under 3, and then there appears to be an underlining, very faint underline under total fault length. Under 4, on Page 17, there is in the first full paragraph, a faint line which forms a part-parenthesis around the lines which begin: "We believe....," and then the second line which has the hyphenated end of the word, "conservative," on it.



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I think that's it. All these look to be pencil markings, they are not part of the FSAR.

MRS. BOWERS: We'll recess for 10-minutes.

(Recess.)

MRS. BOWERS: Are you ready to resume?

CROSS-EXAMINATION (Resumed)

BY MR. FLEISCHAKER:

Q Dr. Smith, in beginning this morning, I would like to direct your attention to Page 5698 of the transcript. Do you have a copy of the transcript available to you?

A (Witness Smith) I don't have it right here at the table.

(Document handed to witness panel.)

MRS. BOWERS: Mr. Norton, you just have the one copy?

MR. NORTON: Yes.

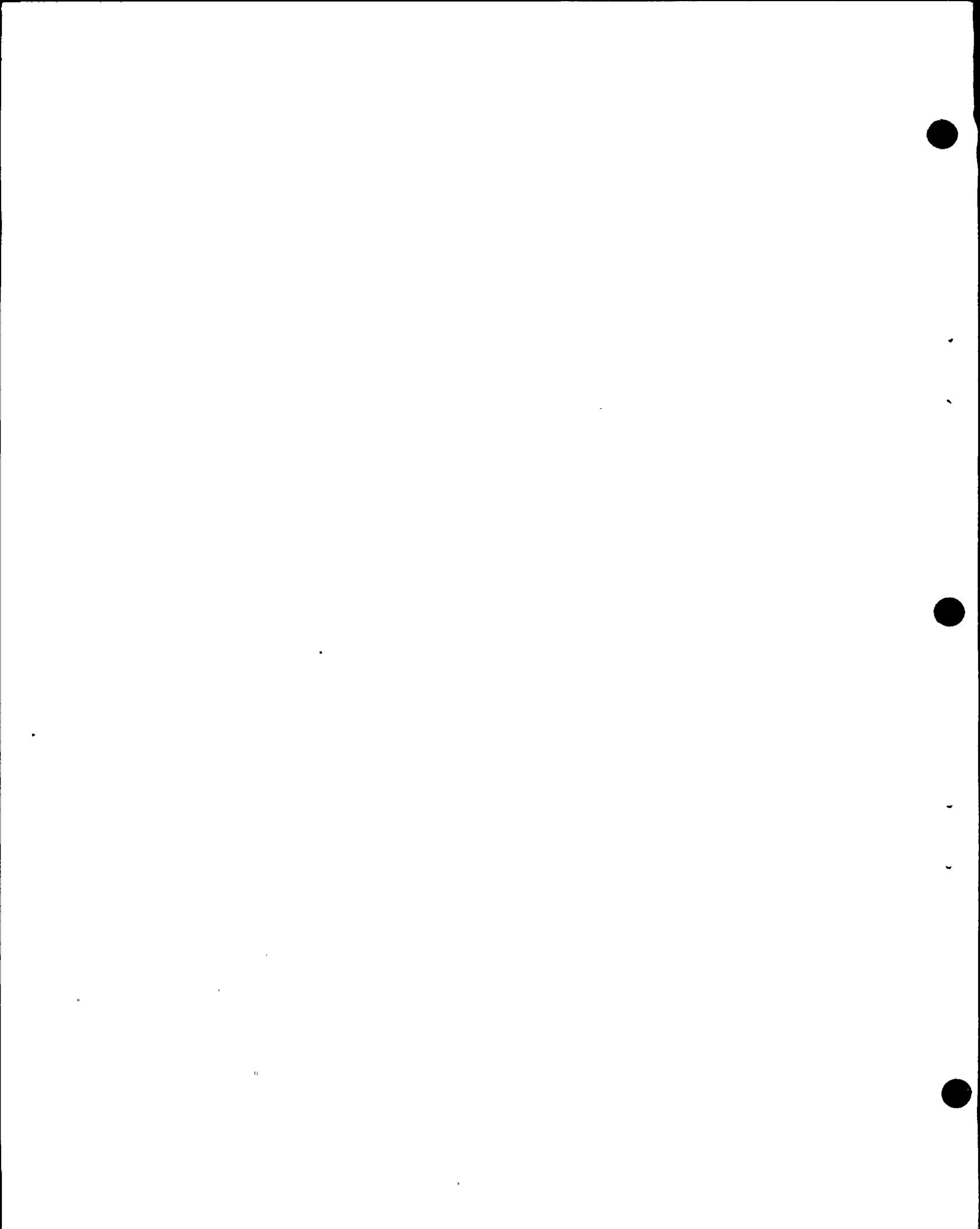
MRS. BOWERS: We can share up here.

MR. NORTON: Thank you.

WITNESS SMITH: All right. I have it.

BY MR. FLEISCHAKER:

Q To put this into context, we had just been discussing utilizing fault length as a tool for determining the maximum earthquake potential of faults. And you had listed the problems that you had with utilizing that as a tool. And I went on to ask you about what could be



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utilized and you said rate of slip.

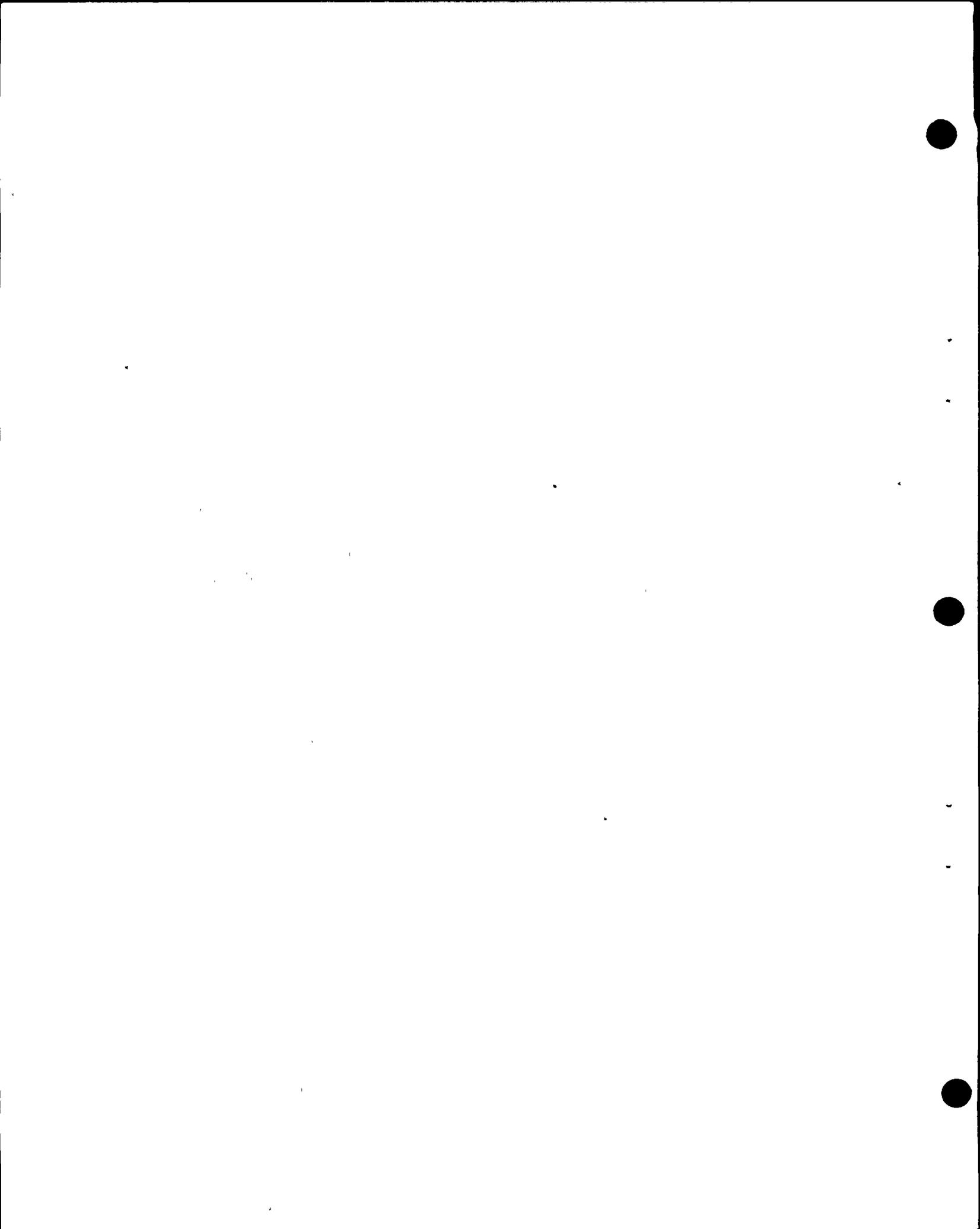
Let me direct your attention now to -- and you further indicated that you had developed a methodology for utilizing rate of slip to predict maximum earthquake potential. I'd like to follow the questions and the answers that are in the transcript from 5698 to 5699.

Starting at Line 13: "Question: How have you used those equations in developing your testimony here?"

Answer: No. Question: Why not? Answer: Well, frankly, I thought that if I presented such a procedure, then I would have to defend every single aspect of the assumptions that went into it. And considering the contentions at issue, I didn't think that was necessary. My task is to demonstrate that magnitude 7.5 earthquake is conservative and I believe I have done that. If I predict a 6.85 or something as the maximum then I would have to defend the entire process whereby I got that. I think the process has promise but I'm not prepared to use it in this hearing.

"I just heard an aside: There is a difference between research in this area and hearing-type testimony. I'm willing to publish this in the open scientific literature and get criticism on it."

Now, in response to a question put by the NRC to the Applicant regarding the maximum earthquake potential that can be expected of various ranks within the south Coast



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Ranges and the San Andreas system, did you not utilize this method to predict maximum earthquake potential, and were not the results from that submitted by the Applicant in the PSAR in response to the NRC's questions?

A (Witness Smith) Yes.

Q First of all, let me ask you, what then is the distinction in your mind between the quality of the information you submit to the NRC for its assessment and the quality of the information that you submit to this record in terms of your sworn testimony?

A I see no difference in the quality. They should reflect the state of the art as available at the time.

Q Why, then, were you prepared to use your method in response to the NRC's questions and unprepared or not prepared to use that method in submission of your testimony?

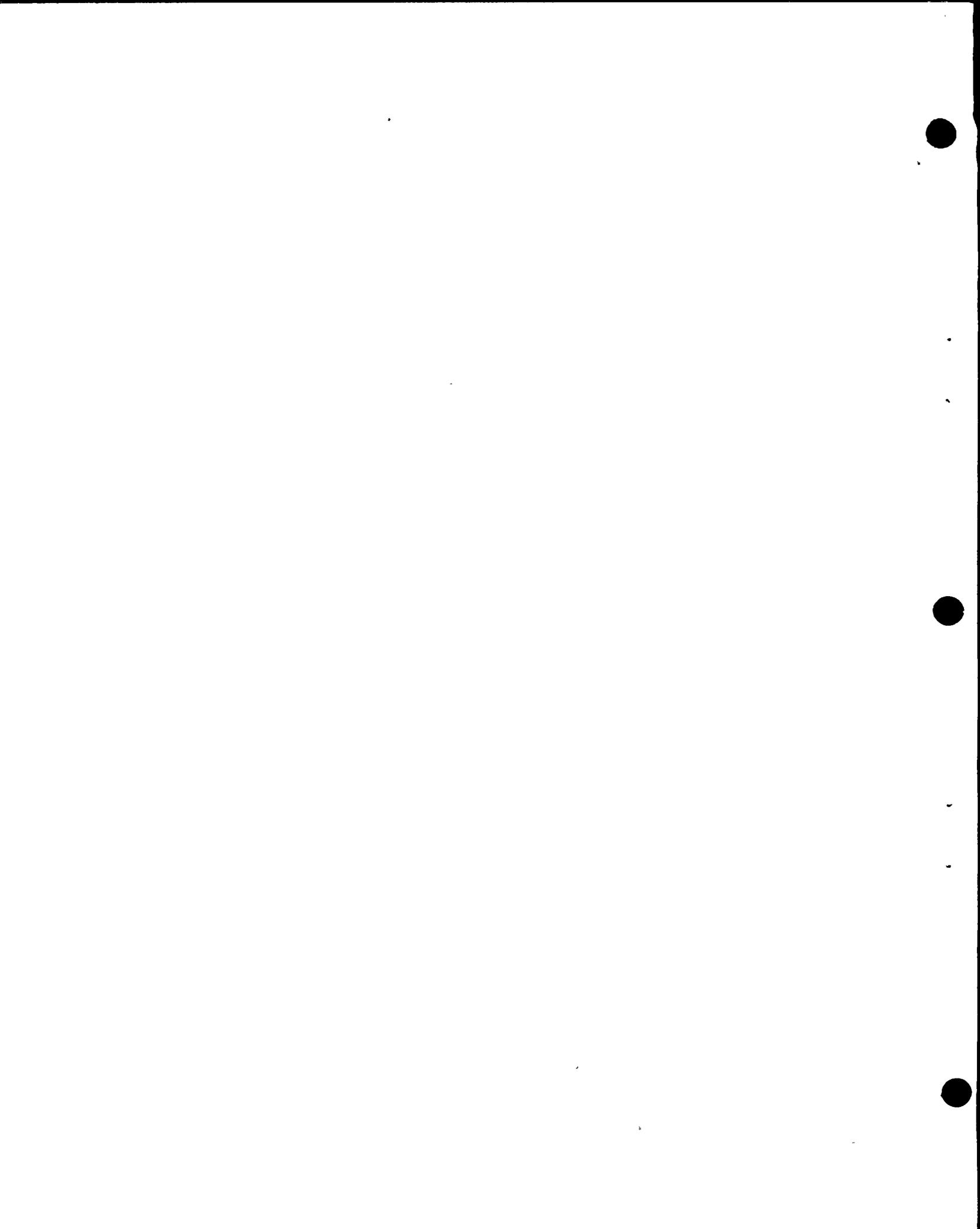
MR. NORTON: Object. That assumed facts not in evidence. The word, "prepared," is no place in these pages that have been read. I'd suggest Mr. Fleischaker re-read what he just read out loud.

MRS. BOWERS: Why don't you restate your question, Mr. Fleischaker?

MR. FLEISCHAKER: Okay.

BY MR. FLEISCHAKER:

Q Why then did you use your methods in your submissions to the NRC and not use our method in your direct



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testimony?

A (Witness Smith) I believe that I explained that yesterday on Page 5699, Line 14. I said:

"Also I think an element is missing in the paper, the rate of activity. I can only address the problem of how large an earthquake could have occurred once. And I'm not sure that that's an appropriate way to proceed. I think it is perhaps too conservative."

What I was trying to explain is that in the time since 1975, my opinion has changed. I believe I stated further on something to the effect that I now believe that the maximum earthquake for a given fault zone is likely to occur several times rather than only once.

Q What opinion has changed?

A The opinion about the assumptions that go into this type of calculation.

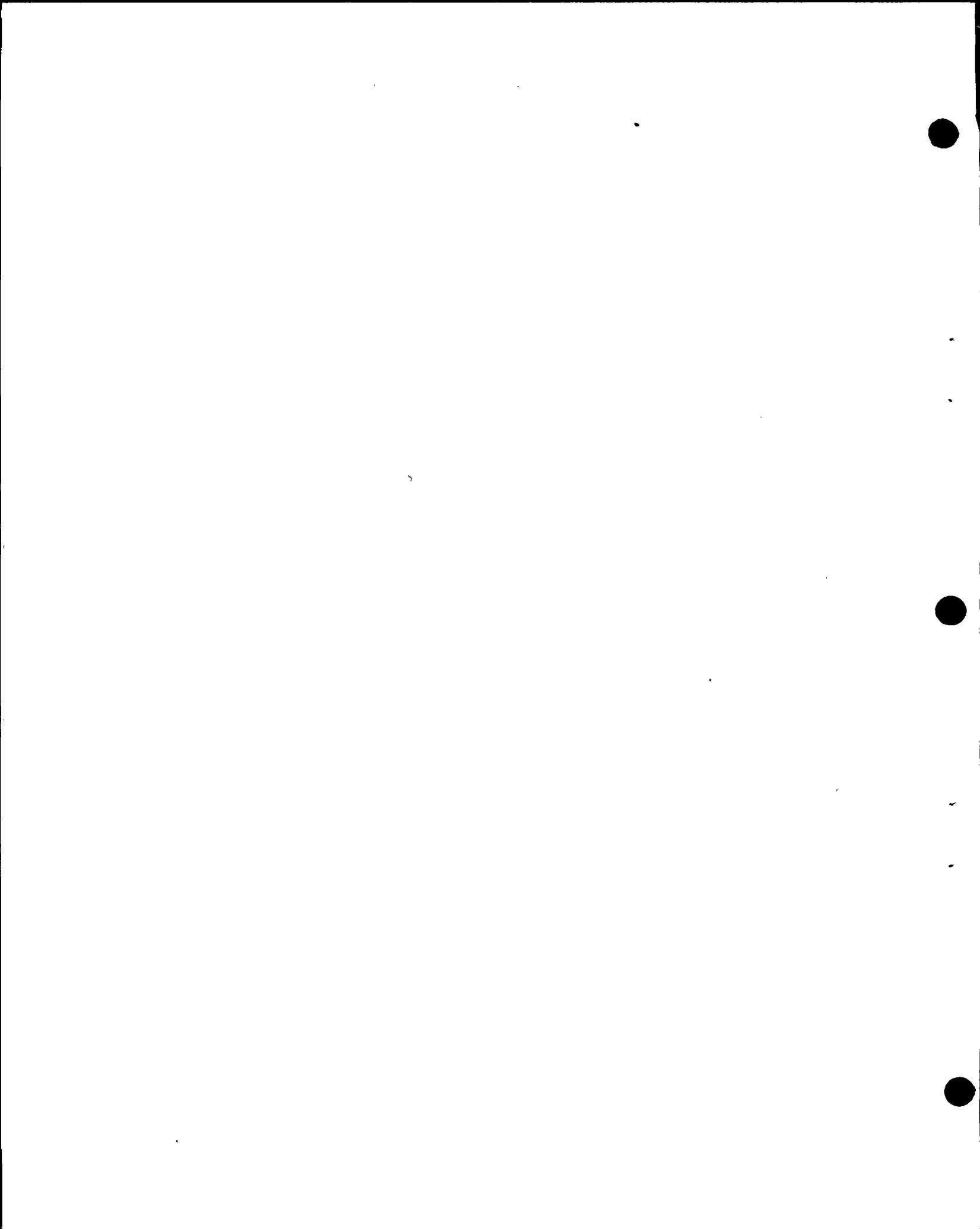
Q Well, what is that opinion?

A Which opinion?

Q That's what I'm trying to determine. What was your opinion when you wrote this paper with regard to assumptions and what is your opinion now?

A Well I think -- Let me try to explain this in the following way:

Basically, what I was attempting to do was to

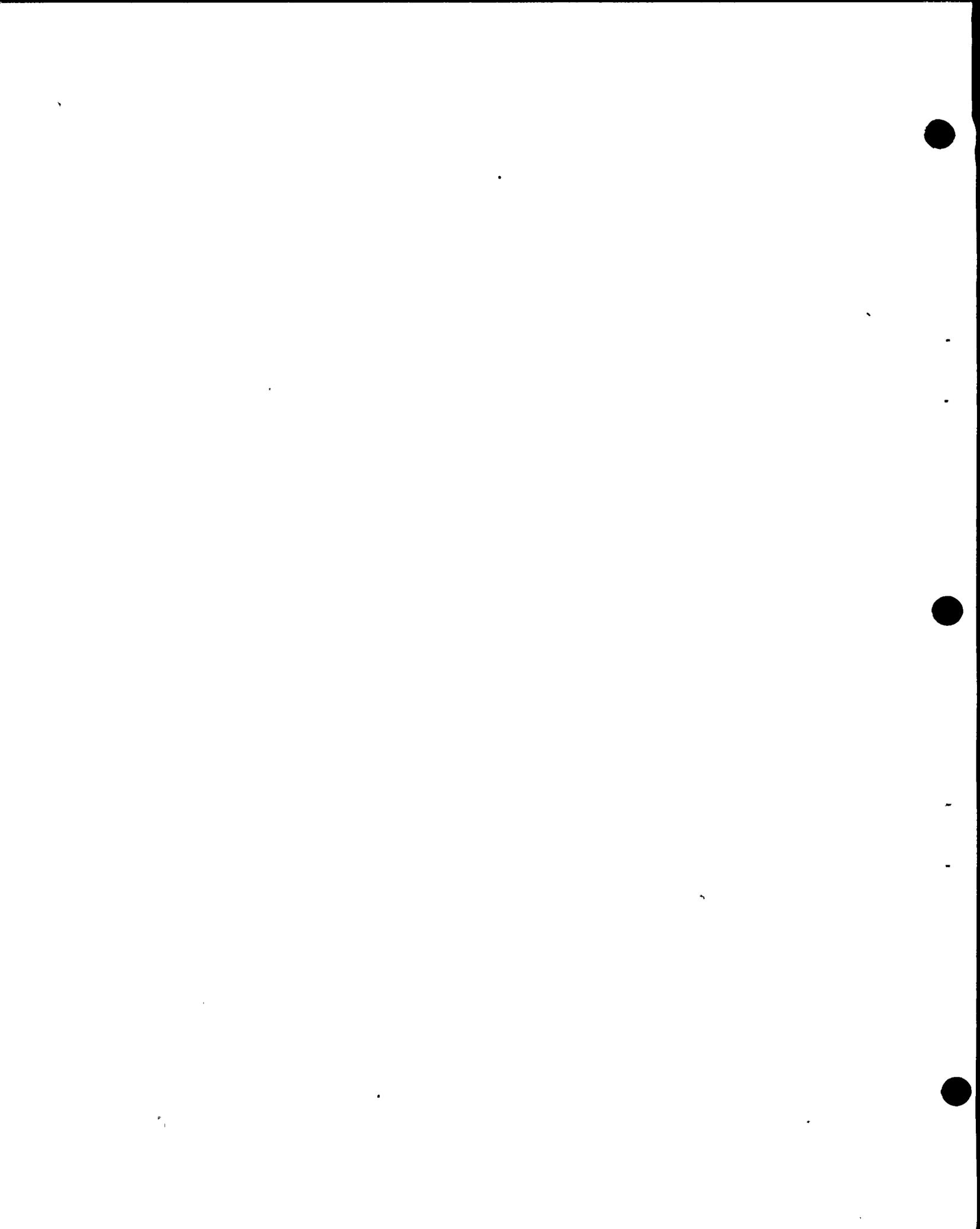


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be able to combine in a sensible way all of the available information concerning the seismicity past and future. And I think this takes us back to what I had written in 1967. Let me just read a couple of sentences:

"Historical and instrumental records of seismic activity in a region are important for the prediction of future occurrences of earthquakes in that region. Distribution and number of earthquakes versus the magnitude provides one a convenient way of summarizing the seismic activity of a region. Use of such data, however, can produce misleading results if the region considered is too small or if the data cover too short a span of time."

As a result of this, Dr. Benioff and I concentrated on using the geologic record as an indication of past earthquake activity. And I think we explained at some length as to why we thought this was a more conservative procedure than just using the relatively short seismic history that we have.

I have been critical of studies in the past that attempt to extrapolate from the occurrences of small earthquakes to predict the occurrences of large ones. So it was in this context that I was searching for a method to relate the seismic statistics and what the geologists



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can observe in the field. AT that time, no such link was available.

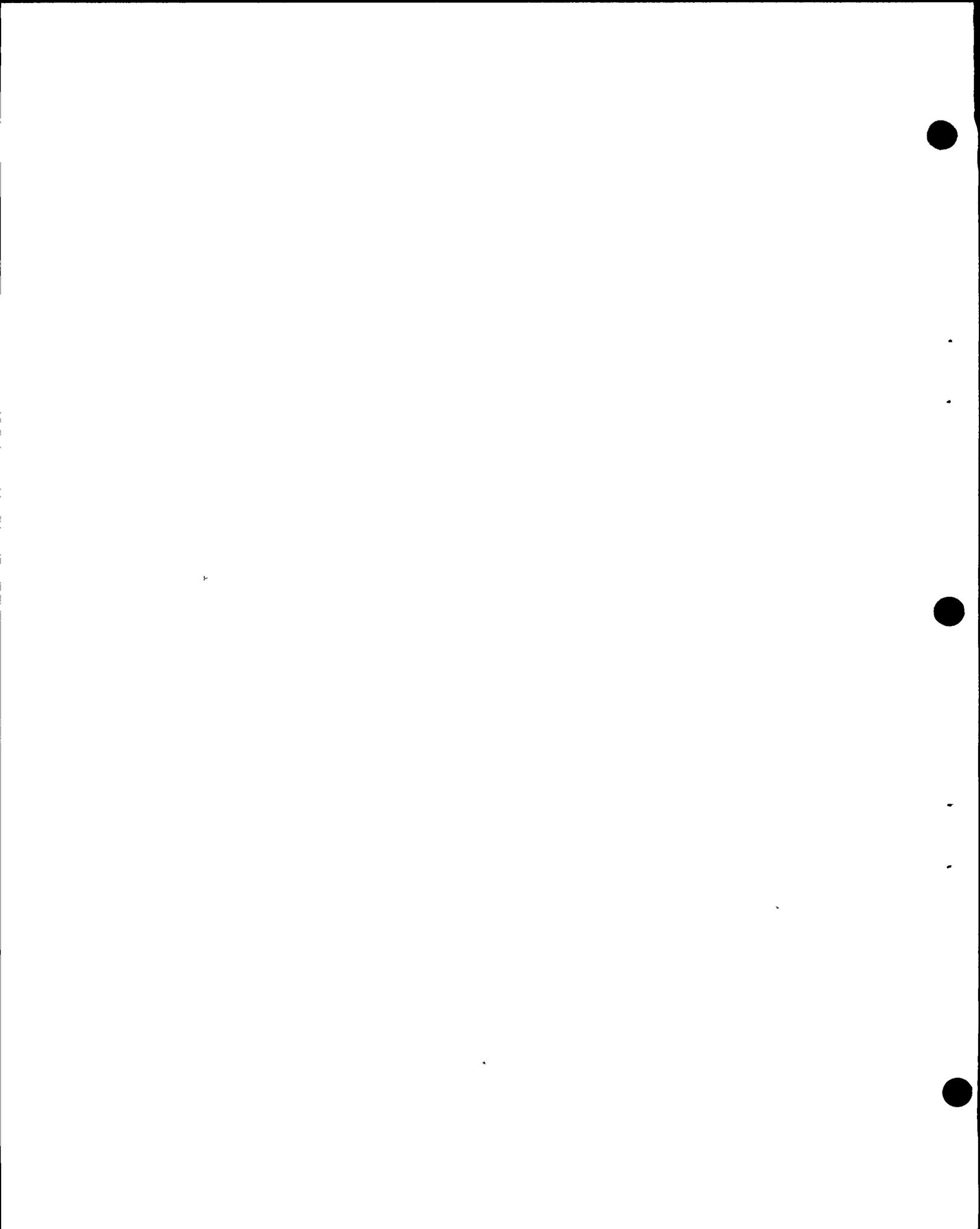
I viewed the paper that I wrote in June, 1976, which I mentioned yesterday and also the submission that you have distributed this morning from the FSAR 2.5(a)-'76, as a first step in this direction of making the link between geology and seismology. And I take some pride in trying to -- in having done this, but I don't think that it is the end of this developing process.

One of the critical assumptions that I made in this work in 1975 was basically that the maximum earthquake would occur only once during the Holocene time, the last 10,000 to 20,000 years.

And I think if you'll read my paper, you'll see that I stated that for active faults such as the San Andreas, the equation that I have developed gives a gross overestimate of the maximum magnitude.

And the reason for this is that the assumption that the maximum earthquakes occur only once breaks down. The maximum earthquakes occurred on the San Andreas Fault many, many times in the last 17,000 years.

And I think that -- this has become clear, for example, in the work that was quoted yesterday by Sieh, who essentially has extended the historic record of seismicity on the San Andreas back several thousand years.

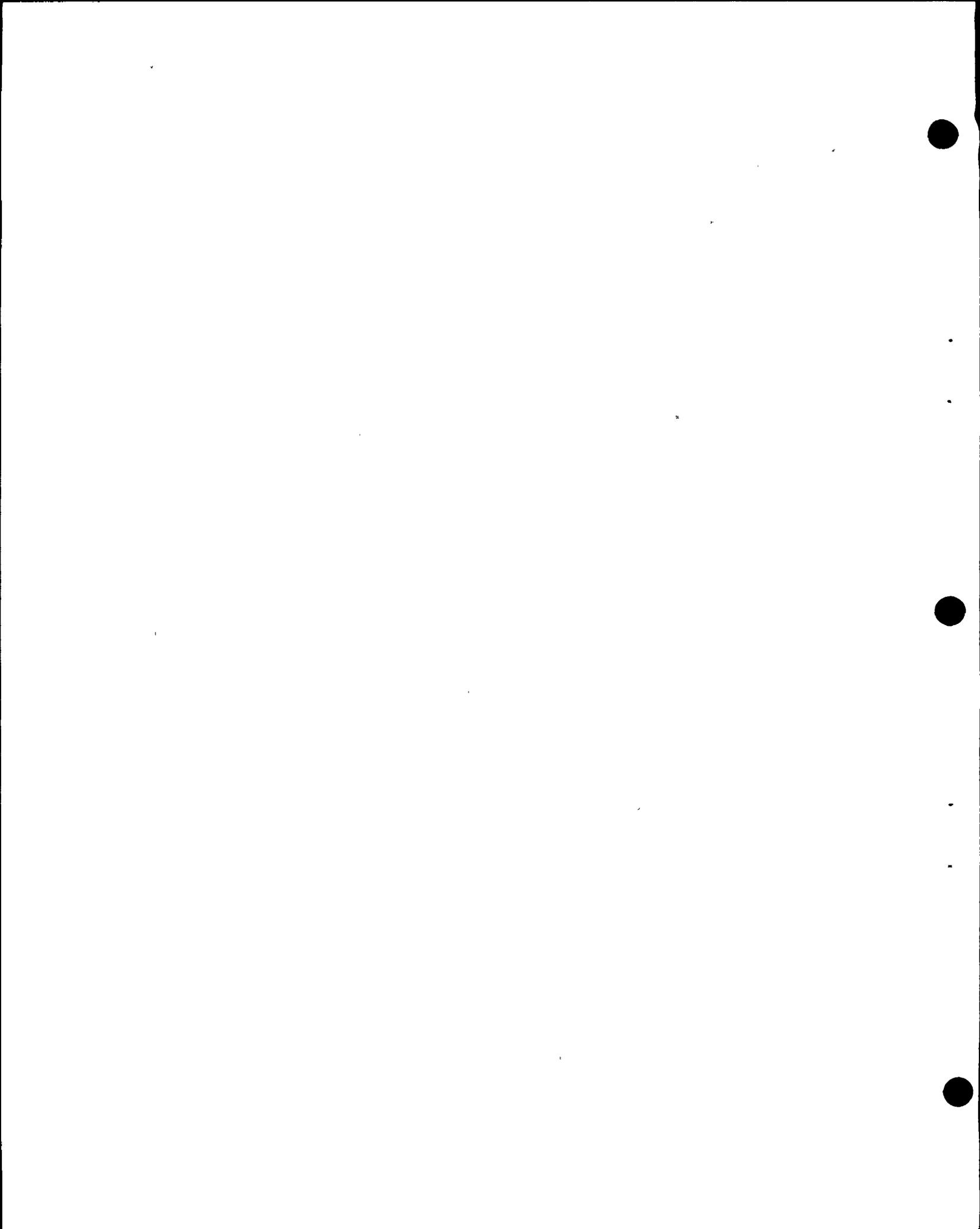


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So it is basically that assumption as to whether the maximum earthquake occur once or a multiple number of times, it was critical to getting this number.

And as I stated yesterday, I believe that procedure is too conservative. And that's why I choose not to use it at this time in 1978.

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Q But doesn't your methodology today require that same assumption?

A Which methodology?

Q Well, the one that you published in your 1976 paper?

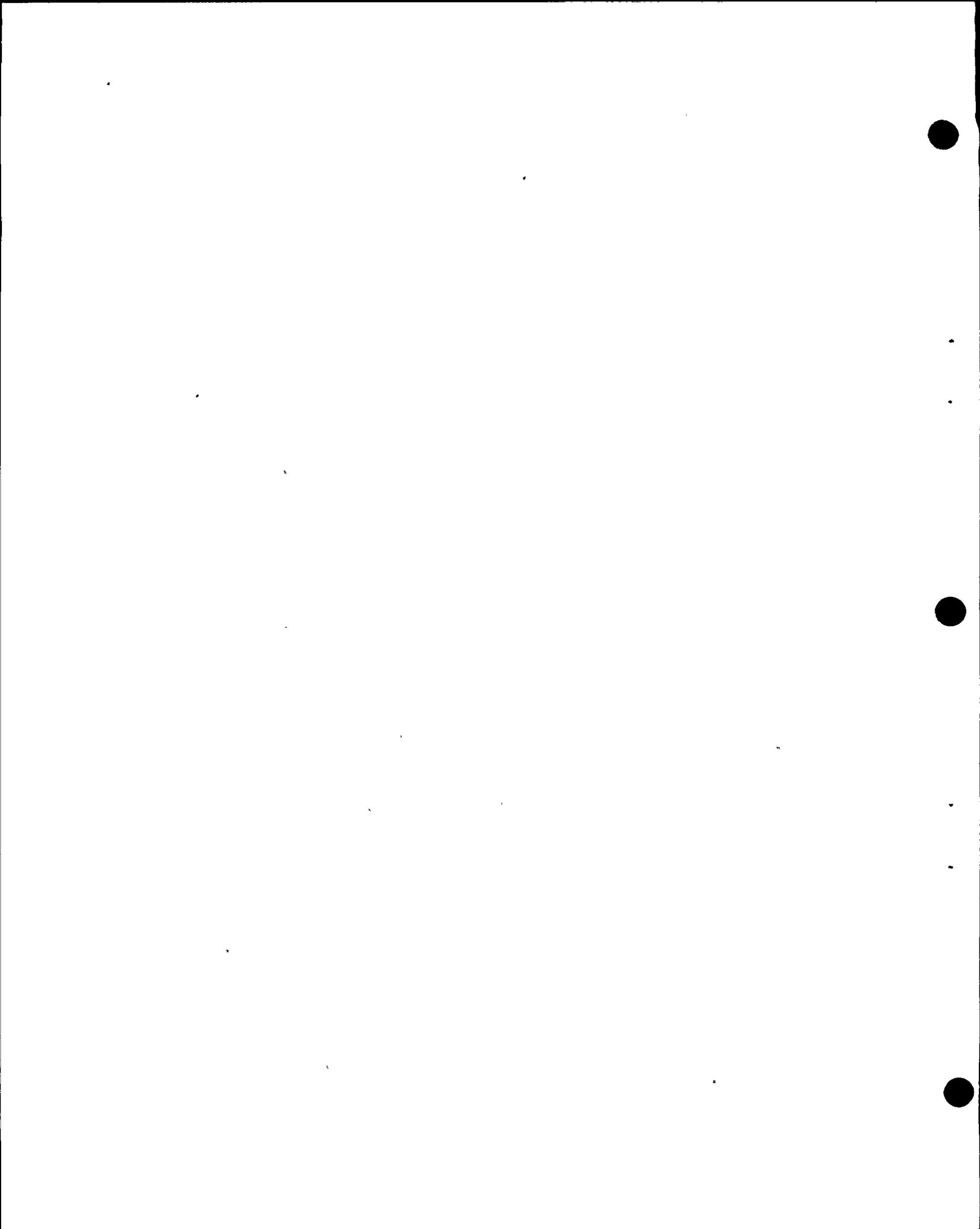
A The 1976 paper embodies that assumption, yes.

Q So that your assumptions are the same?

MR. NORTON: Excuse me, Mrs. Bowers. The testimony I've heard is he has not done it today, and Mr. Fleischaker is asking him if what he has done today is the same-- I'm confused. I thought he just testified that he had not done it. I thought Mr. Fleischaker had established very clearly that he had not done it for purposes of these hearings.

MR. FLEISCHAKER: What we're talking about is the method that is set out, the calculations that are set out in this paper and the calculations that were set out in the 1976 paper which I asked Dr. Smith if he had utilized in this proceeding and he said No. And then I asked him why not, and he said he had changed his views on the assumptions or -- his opinion on the assumptions.

And now I've asked him whether the assumptions have changed, that is, the assumptions that underlie the '74 publication and the assumptions that underlie the 1976 publication. And I think that the answer I just got was that the



assumption is the same.

MR. NORTON: Yes, the assumption in 1975 and 1976 was the same, but it has changed today and Mr. Fleischaker's question was in terms of today. That's where I got confused, "today" being 1978.

MR. FLEISCHAKER: The assumption is the same. The only question I asked him was whether the assumption was the same, in the paper and in the PSAR, is the assumption the same?

WITNESS SMITH: Yes, it's very clear they are the same assumptions.

BY MR. FLEISCHAKER:

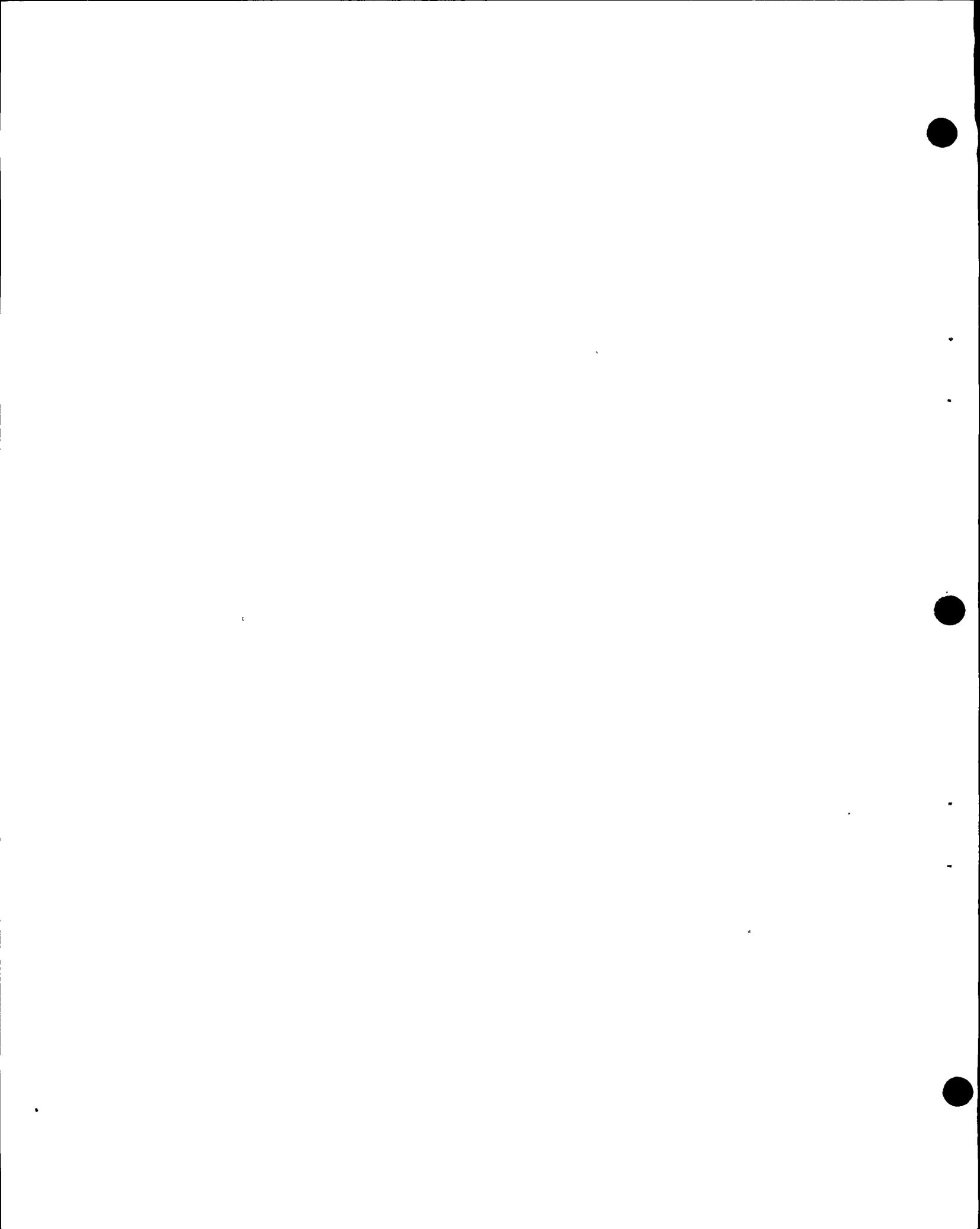
Q Now the equation here in the PSAR, didn't you state the same caveat with regard to that assumption? That is didn't you indicate that that assumption would lead or might lead to overestimates?

And I direct your attention to page 17, the last paragraph.

A (Witness Smith) Yes. Now what is your question?

Q My question is: The caveat that this method might lead to overestimates because of the assumption that you've been talking about, about maximum earthquake occurring during the Holocene period, you stated that caveat in '78 in this submission, did you not? --

A Yes.



eb3 Q -- '75? I'm sorry.

So has your opinion on that assumption changed?

A No.

I'm not sure where this is leading me. There are a number of assumptions that go into this technique and since they are not used in this proceeding, I have not reviewed carefully this in recent days, so I would have to say in general yes, I don't think my particular assumption on this has changed, but it might be important to review all of the assumptions to get a balanced picture of what the implication of that is.

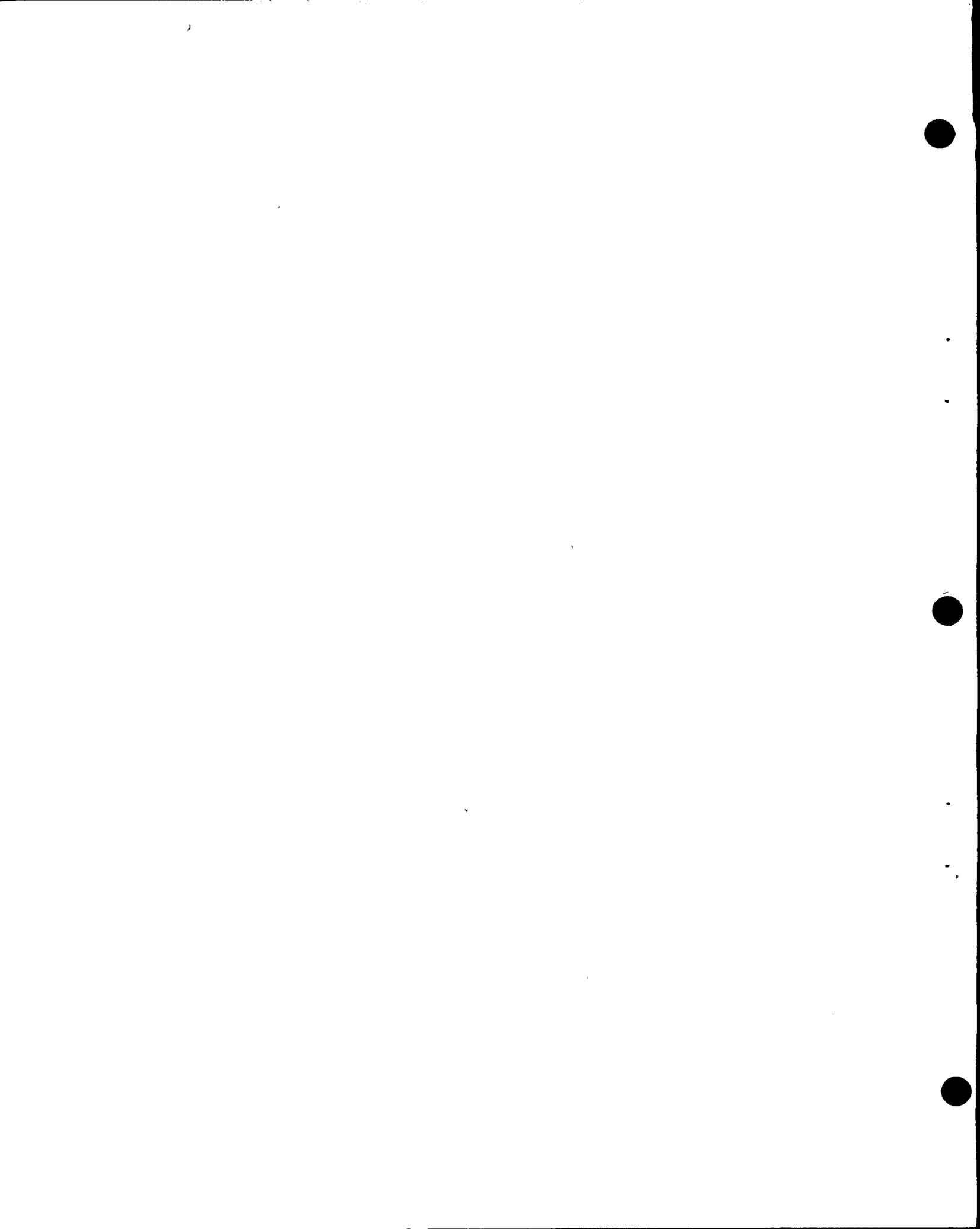
Q So you have no opinion regarding the validity of the assumptions then and now, at this moment; is that correct?

A No. You asked me specifically did I have an opinion about whether the technique would always err on the side of overestimating the maximum as long as the maximum has occurred at least once in Holocene time.

I believe, without looking in great detail, I believe that that is still a true statement.

Q Okay.

Can you identify any other assumptions upon which you have an opinion now different from that which you had in '75?



eb4

A Well, there are a number of assumptions and there have been a number of developments in the field in recent years. Some of them center on the relation between magnitude and moment, and on the definition of what kind of magnitude is appropriate to use, and on the amount of fault displacement that might be attributed to creep as opposed to sudden jerky motion during earthquakes.

I believe that all of these are subject to some refinements as a result of the continuing evolution of knowledge in the field.

Q Do you have an opinion as to whether this new data tends to discredit the method that you set out here?

A I don't think so.

Q Okay.

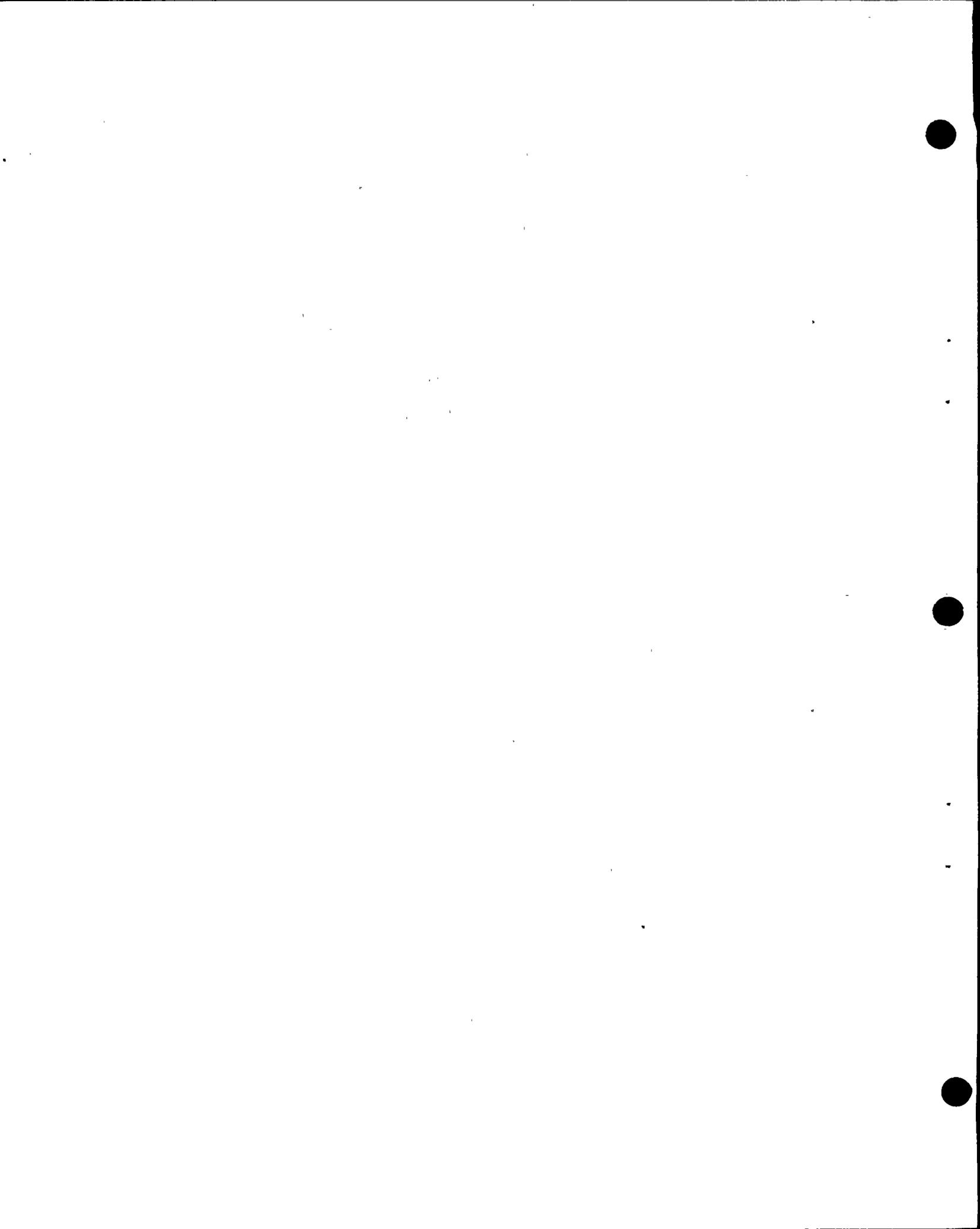
Now how does this new data-- Can you tell me how this data, new data, tends to refine conclusions that you might reach?

MR. NORTON: Excuse me. Can we take those one at a time, please, as opposed to a composite of each and every one?

MR. FLEISCHER: We can do that.

MR. NORTON: Well, you know, it's a multiple question otherwise. In other words they may go in different directions. I don't know, obviously.

MR. FLEISCHER: I thought about that, too. 2



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was trying to save time.

BY MR. FLEISCHAKER:

Q Would it be better to take them one at a time?

A (Witness Smith) I think so.

Q Okay, let's list them.

A Could you be very specific so that I know exactly what you want?

Q We're talking about the assumptions and how new data may have changed the assumptions. So what I'm asking is for you to list the assumptions.

A Well, I think the first assumption would be that all observed geologic fault slip is attributed to earthquakes.

Q Is that listed here?

A I'm not sure whether it is or not.

Q Is it listed in your 1976 paper?

A I believe it's referred to, yes.

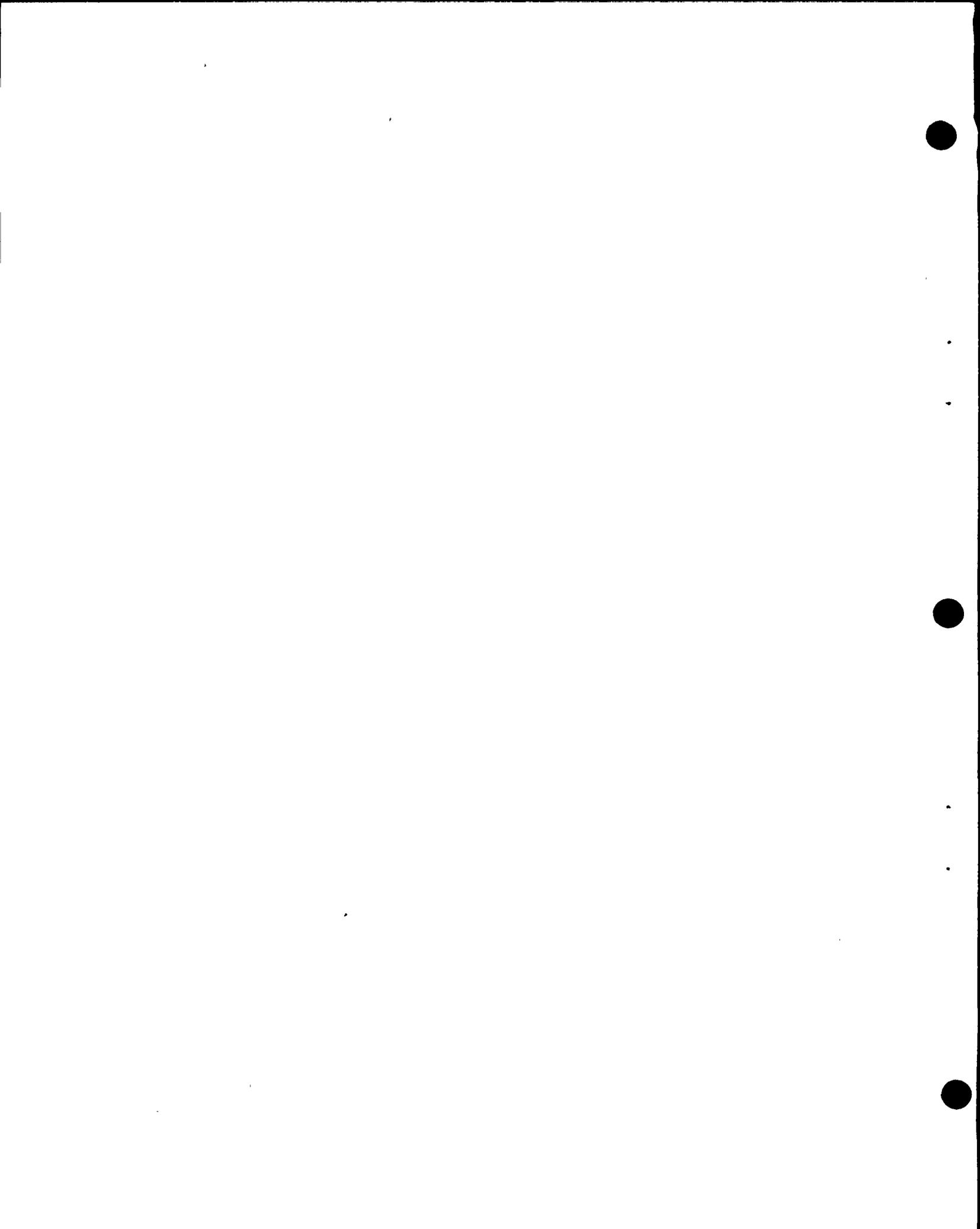
Q Okay.

A I'm not sure whether it is spelled out specifically.

Q Could I have that assumption back again, please?

A (That all observed geologic fault displacement can be attributed to earthquakes.

MR. TOURTELLOTTIE: I'm sorry, I did not get



eb6

the word. Is that "can't" as in "cannot" or "can"?

WITNESS SMITH: Can -- rather, must be. The implication is that all geologic slip is being attributed to earthquakes.

I believe that a significant amount of the geological slip that we heard described earlier in these hearings may in fact be due to motion on faults which does not produce earthquakes.

BY MR. FREISCHAMER:

Q Let me see if I understand what's going on.

Is there new data that has required people to change their opinion about this assumption since 1975?

A (Witness Smith) I don't know whether other people have changed their opinion about this.

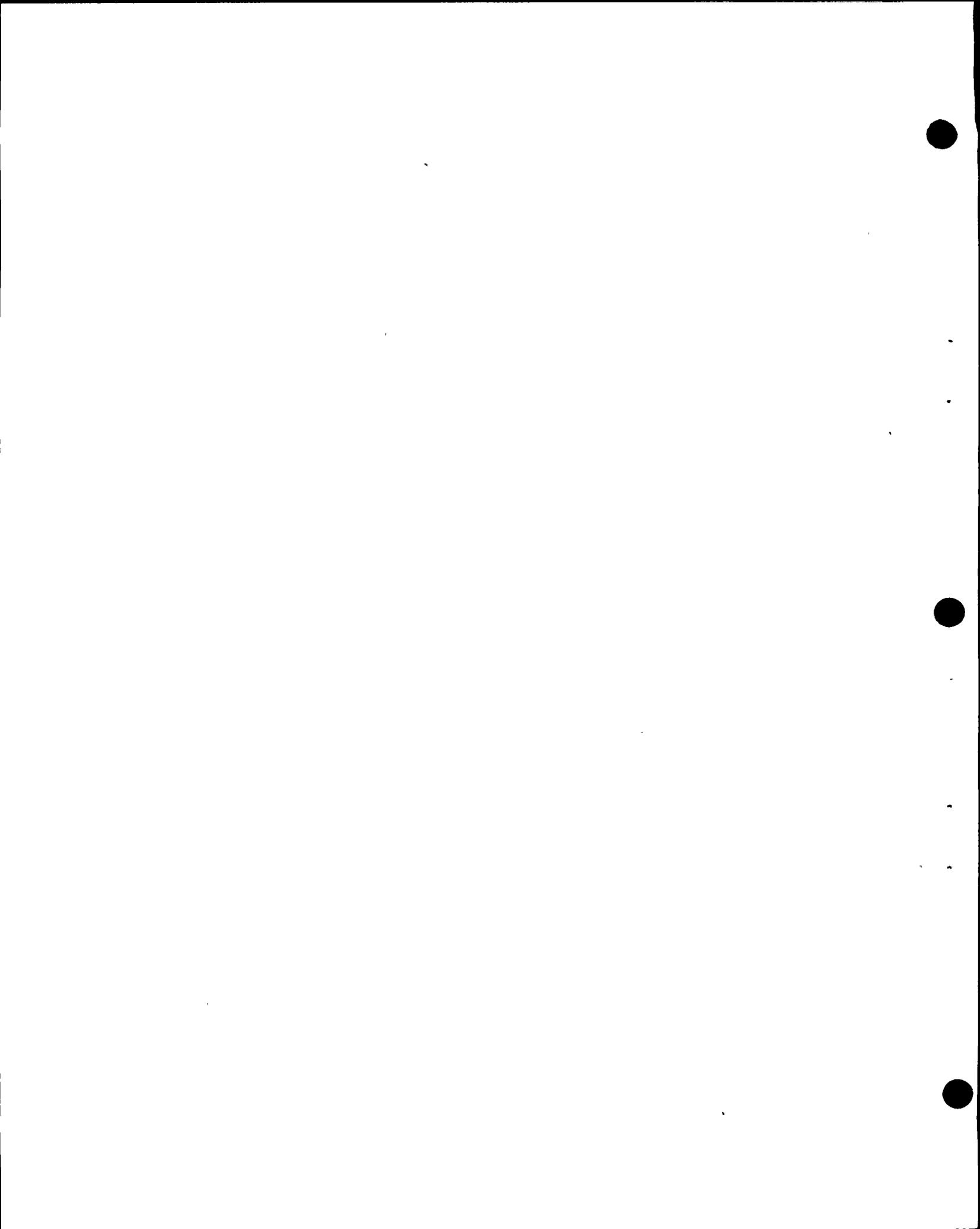
Q How about you? Prior to 1975 did you hold the opinion that all observed displacement is attributable to earthquakes?

A No.

Q Okay.

So how come we're listing this?

A Well, I think that there is a misunderstanding I think about the scientific view as to what is likely to be going on versus the conservative view that must be used in order to avoid the conservative view that would be used in making estimates for a hearing like this. In other words,



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if I don't specifically mention this assumption, that's because I'm assuming that there is so much conservatism necessary that I don't need to mention it.

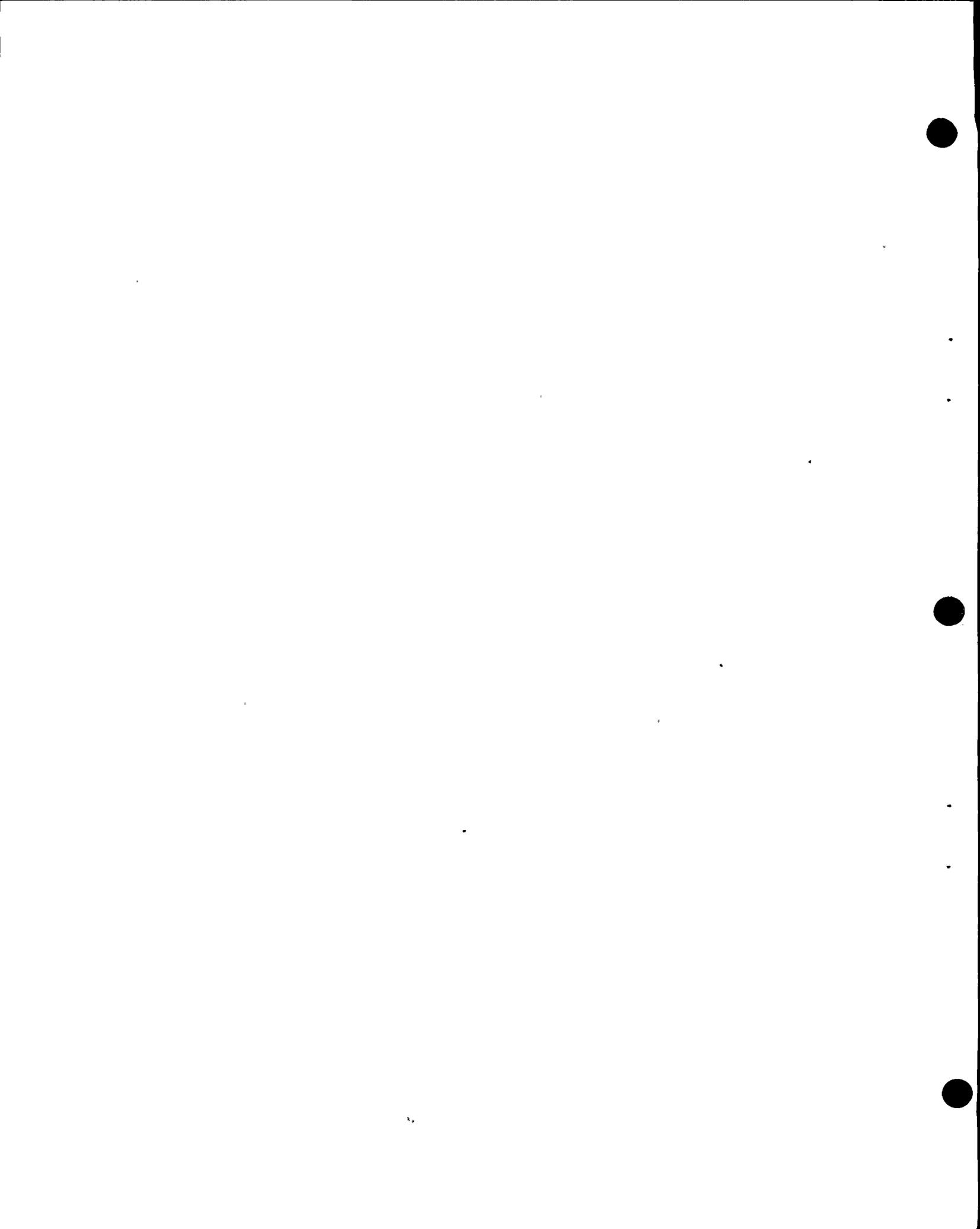
But I believe in my 1976 paper I mention specifically that no account was taken of fault creep.

I think maybe as we get into these assumptions it's clear why I responded the way I did yesterday, that as of this date, I did not choose to use this particular technique to make estimates to present to this hearing. And I don't really think it is appropriate to pursue this type of investigation of a paper published in 1976.

Q Well, let me make clear. I don't have any problems with the paper. It may be very good, and probably is. What I'm exploring is why you used it to submit information to the NRC and why you choose not to submit it now.

MR. NORTON: Excuse me, Mrs. Bowers. It seems like we're going round and round in circles. I think the witness amply testified the reason. In fact, Mr. Fleischaker established it was a question from the NRC, and Dr. Smith did the calculations and submitted it. He has testified that the sum or many or a portion of the assumptions, or whatever, that he based that calculation on in 1975 produced too conservative a result; he didn't use it for the purposes of these hearings.

I don't understand why we're beating it to death.



eb8

I don't know where we're going.

MR. FLEISCHAKER: Well, we're not beating it to death. And the reason that we're going down the path that we're going is because we've been led there by the Applicant's submission.

In particular we've been led there by the last sentence of the Applicant's submission on page 13 of the PSAR which states as follows in reference to this methodology:

"It does, however, incorporate more geological data than has been possible in other approaches and thus we feel it is a useful addition to the tools available in assessing earthquake hazards."

So what I want to do is to talk about this tool.

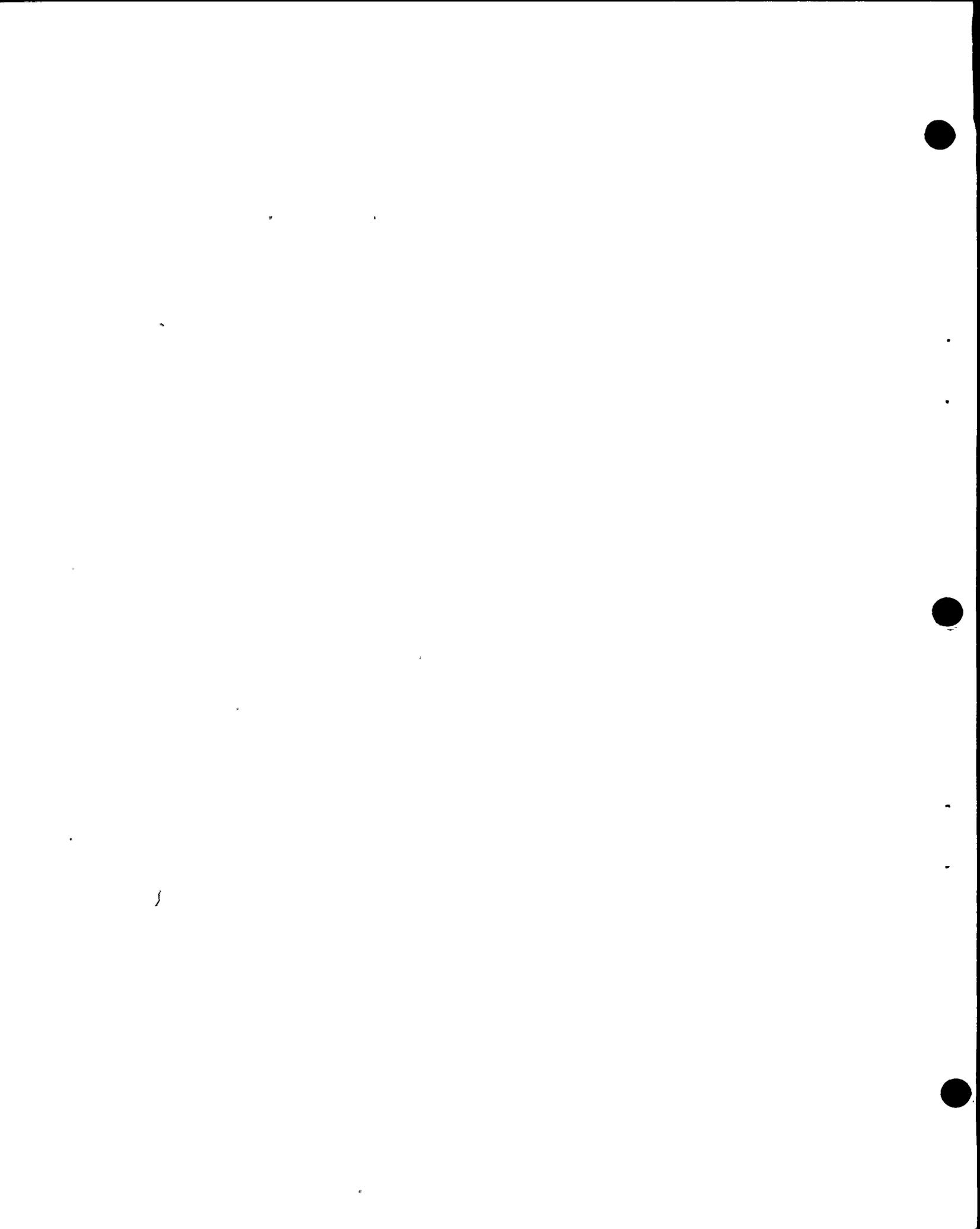
MRS. BOWERS: Mr. Tourtellotte?

MR. TOURTELLOTTE: May I have a moment?

MRS. BOWERS: Surely.

(Pause.)

MR. TOURTELLOTTE: I'm not sure that the real question here, in terms of relevancy, is whether this statement is in the PSAR or whether the relevancy really relates to did Dr. Smith use this particular methodology in arriving at his conclusion in this proceeding and if he did not-- He claims he did not use that methodology (a) and (b), he claims or has stated already that he doesn't



eb9

really consider that the methodology has any bearing upon the opinion which he is espousing today.

He is the one who is in a better position to determine whether or not it does have that kind of relationship to his opinion today and, having stated that, it seems to me that it's not relevant and that we should change the line of questioning.

MRS. BOWERS: Well, don't we have a situation, though, where the Applicant's FEAR is in evidence?

MR. TOURNELLOTTIE: That's true. But that having been in evidence and given the representations that Mr. Smith has made, what he in effect is telling us that inquiring into this matter is not going to yield any reliable and probative result. It is simply going to be an academic exercise.

(The Board conferring.)

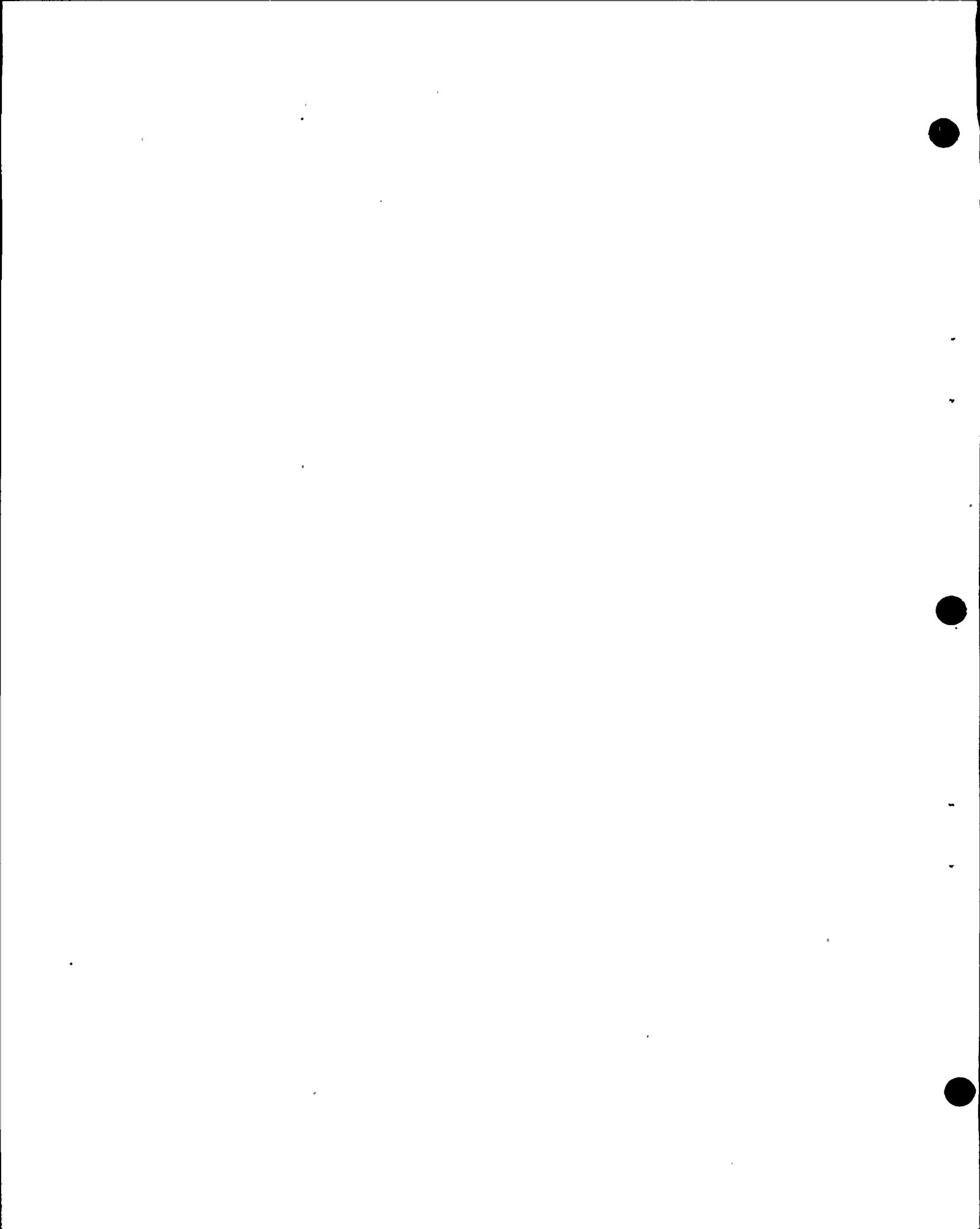
MRS. BOWERS: Well, I guess we need to ask a few questions.

Now, Mr. Fleischaker, when you referred to the 1975 document you're talking about these few pages that have come out of the FEAR, aren't you?

MR. FLEISCHAKER: That's correct.

MRS. BOWERS: And then there's apparently another article of some sort that was written in '76. Am I right -- that we have not seen yet?

MR. FLEISCHAKER: That's my understanding. I



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think the witness is better qualified to answer that.

MR. NORTON: That's correct.

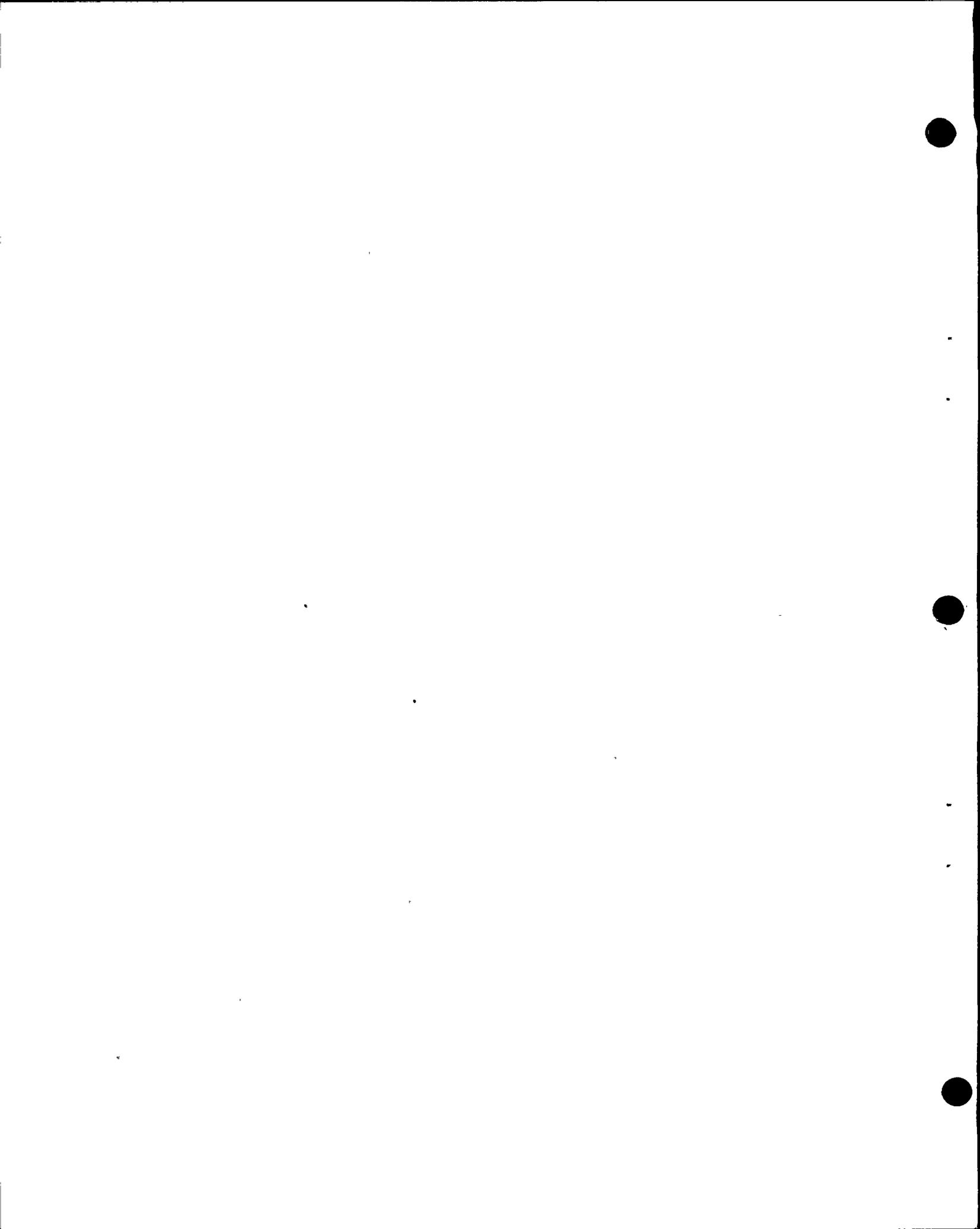
MRS. BOWERS: And are we correct in our understanding of the situation that the witness prepared the '75 information as a result of a specific request from NRC, and he is now saying that he would not take this same position today?

MR. NORTON: No, Mrs. Bowers. What he's saying is that the procedure he did in 1975 leads to a very conservative result. He chose to use a different method to arrive at a more realistic number for purposes of this hearing. That's what I understand him to be saying, and that you can go through this mathematical exercise and come up with a more conservative, unrealistic result, but bounding-- This was a bounding technique and that he chose not to do that in this hearing, but to deal with more realistic assumptions and methods, rather than a so-called bounding technique or a more conservative technique that he did in 1975.

MRS. BOWERS: Well, Mr. Fleischaker's questions are asking him what has changed?

Is that correct? What assumptions have differed?

MR. NORTON: But he's comparing apples with oranges, is the problem. Mr. Fleischaker is asking him to



eb11

compare the analysis he went through in preparation for these hearings to come up with a realistic number with a bounding technique that he did in 1975, of which he now says some of his assumptions have changed. In other words he's being asked to compare an apple with an orange instead of talking about just this or just what he's done for this hearing.

He's trying to compare one with the other and from what I hear, I don't think that can be done.

WITNESS SMITH: At the risk of interrupting, you should see what-- This submission in '75 was in direct response to an NRC question. It might be useful to see what it was.

MR. HORTON: To see what the question was.

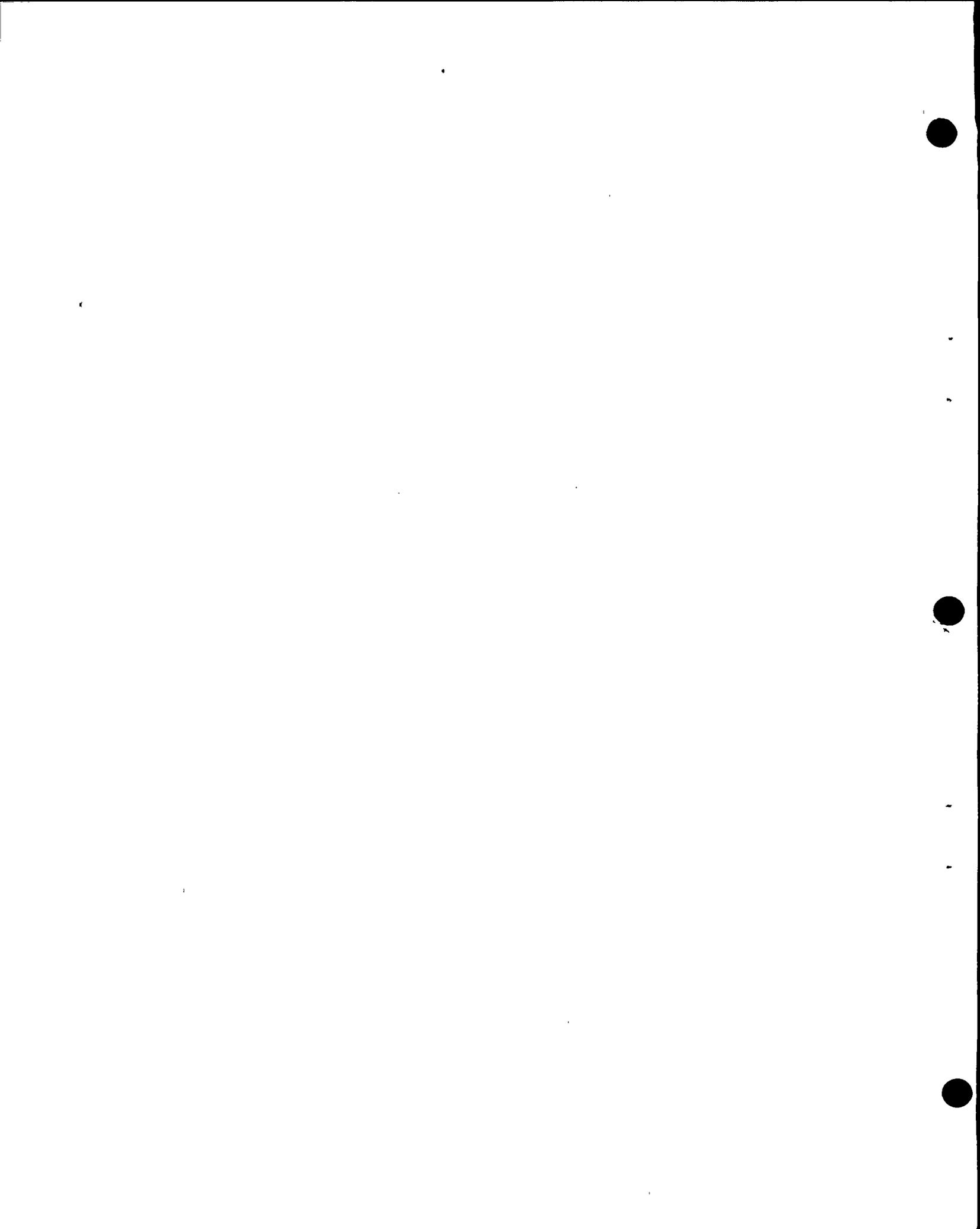
MR. FLEISCHAKER: I'd like to comment on that.

The NRC question 2.17 is:

"Provide additional discussion and arguments for determining the maximum earthquake that can be expected on faults of various ranks within the San Andreas system. Relate the discussion to historic seismicity."

Now that question just doesn't come out of the air, it comes out of --

MR. HORTON: Excuse me. May I have the citation to the question? I'm trying to find it.



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MR. FLEISCHAKER: 2.5-E-61.

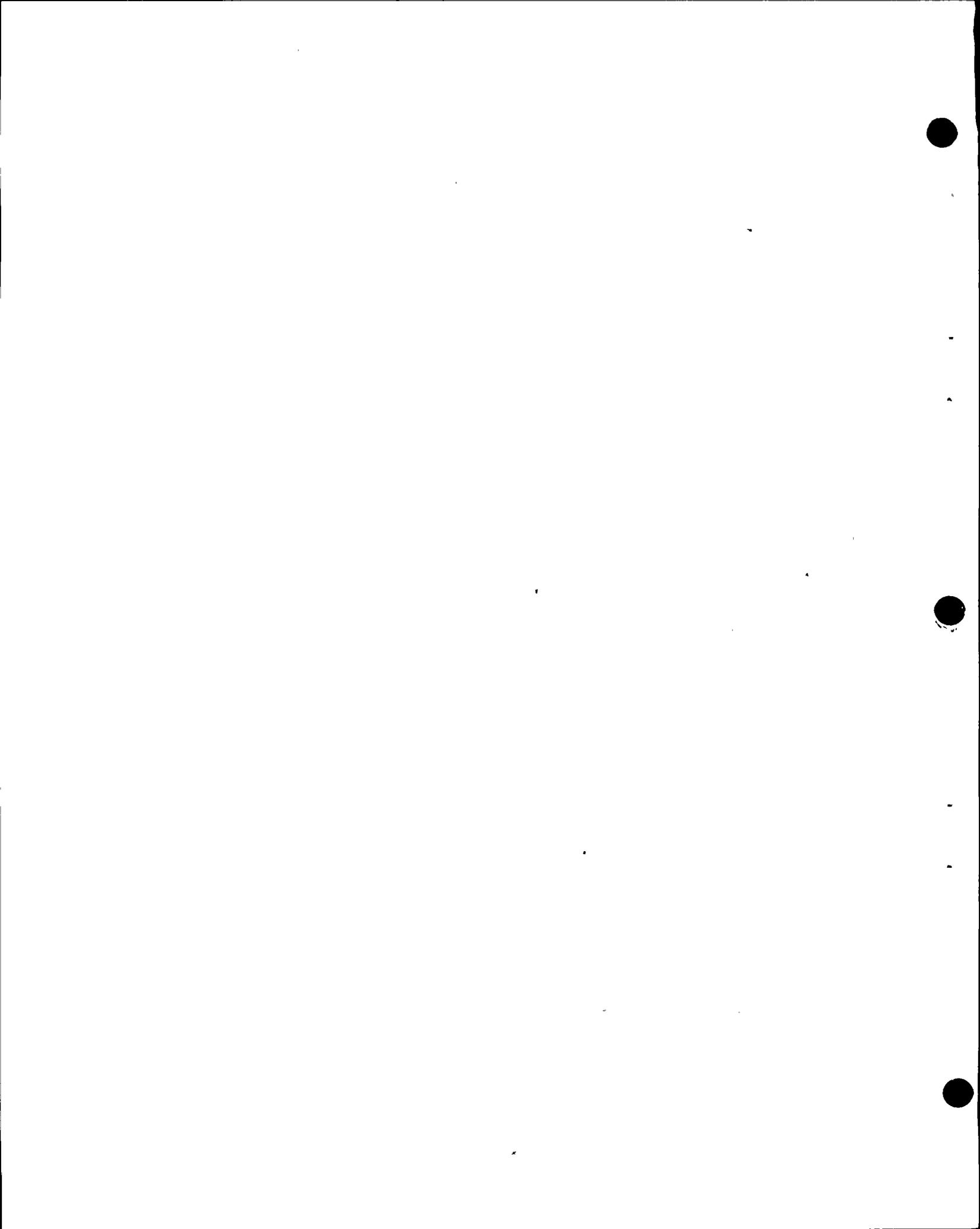
Now where do we suppose the NRC got that question? Well, if we turn to Appendix A, Part 100, and we look at 3, "Definitions," (c), we see that the safe shutdown earthquake is defined as follows:

"The safe shutdown earthquake is that earthquake which is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake which produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional...."

And it goes on.

The point is that the safe shutdown earthquake is based upon an evaluation of the maximum earthquake potential.

This question requests the Applicant to submit information regarding its estimates as to the maximum earthquake potential of the region, so the question was designed to obtain information directly relevant to resolving a question or -- or directly relevant to identifying the safe shutdown earthquake as that earthquake is defined by the Commission's regulations.



eb13

MR. NORTON: And Mrs. Fowers, in response to that, Mr. Fleischaker just read something and then argued what it didn't say. It is maximum ground motion, vibratory ground motion is what he just read, and now he's changed that back to earthquake, and that's a very technical matter that our next panel gets into, you know, and this panel, too. They're talking about ground motion.

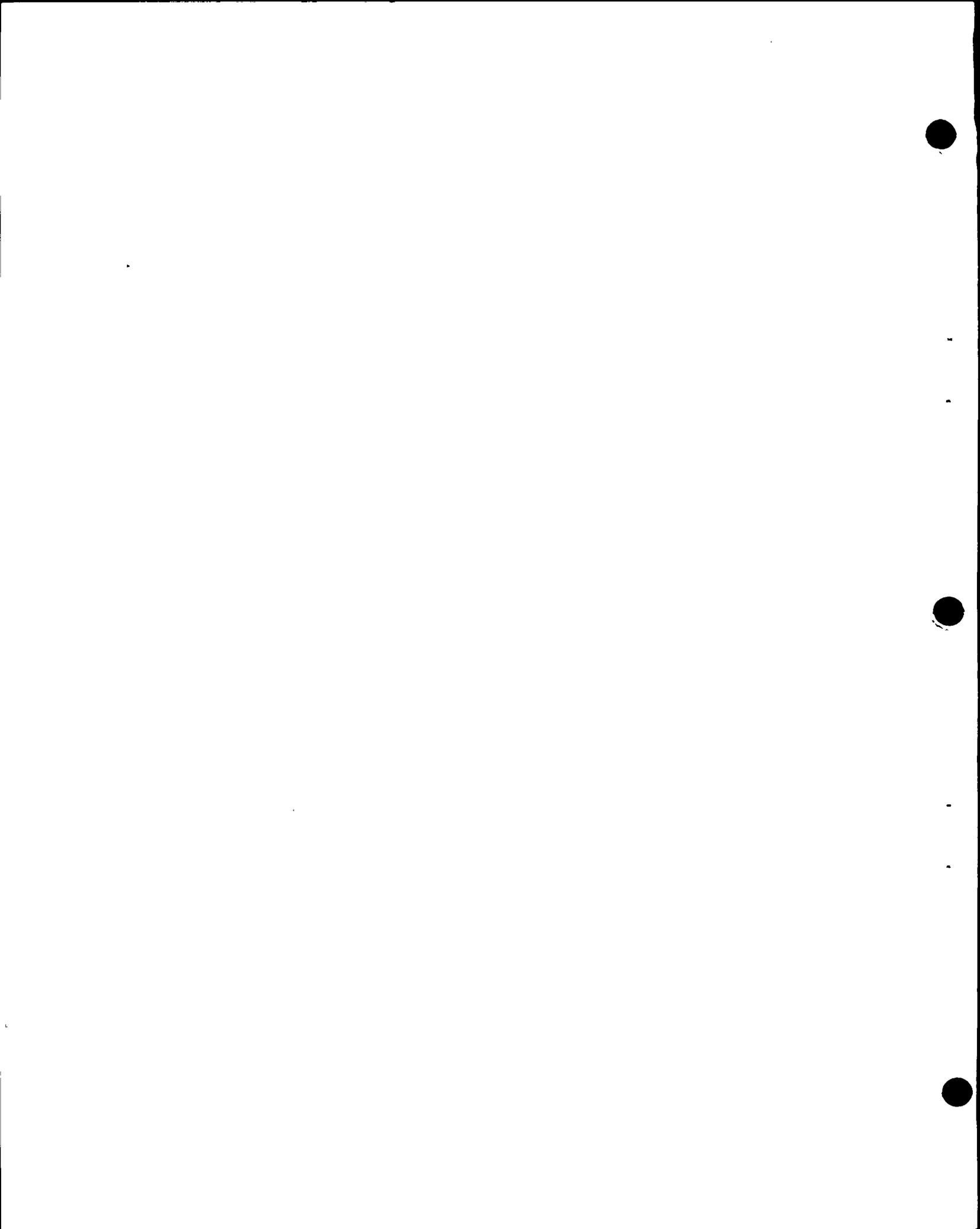
Mr. Fleischaker just read it and took ground motion and said earthquake.

In addition, the point is that Dr. Smith, what he calculated here was an ultracautious answer, and what he is saying now is that he thinks he can give us a much more realistic answer.

Again, I don't have any objection to Mr. Fleischaker asking him questions about this, but he keeps trying to get him to compare this with another method, another method of analysis, and saying How did your assumptions change? But they're not the same methods.

MR. FLEISCHAKER: Let us come back to Appendix A because I believe that Mr. Norton has misconstrued the analytical framework of Appendix A.

Appendix A requires first that you identify the maximum earthquake potential. Then once that has been identified by a whole set of rules that are set under IV, entitled "Vibratory Ground Motion," and these rules relate



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to whether you're dealing with capable faults or tectonic provinces or whatever.

But after you have identified the maximum earthquake potential in the region, from there you go on to identify the maximum vibratory ground motion which is, in turn, designated in terms of accelerations. That's according to the rules.

So the first step is to identify the maximum earthquake potential.

MR. WORTON: I don't disagree.

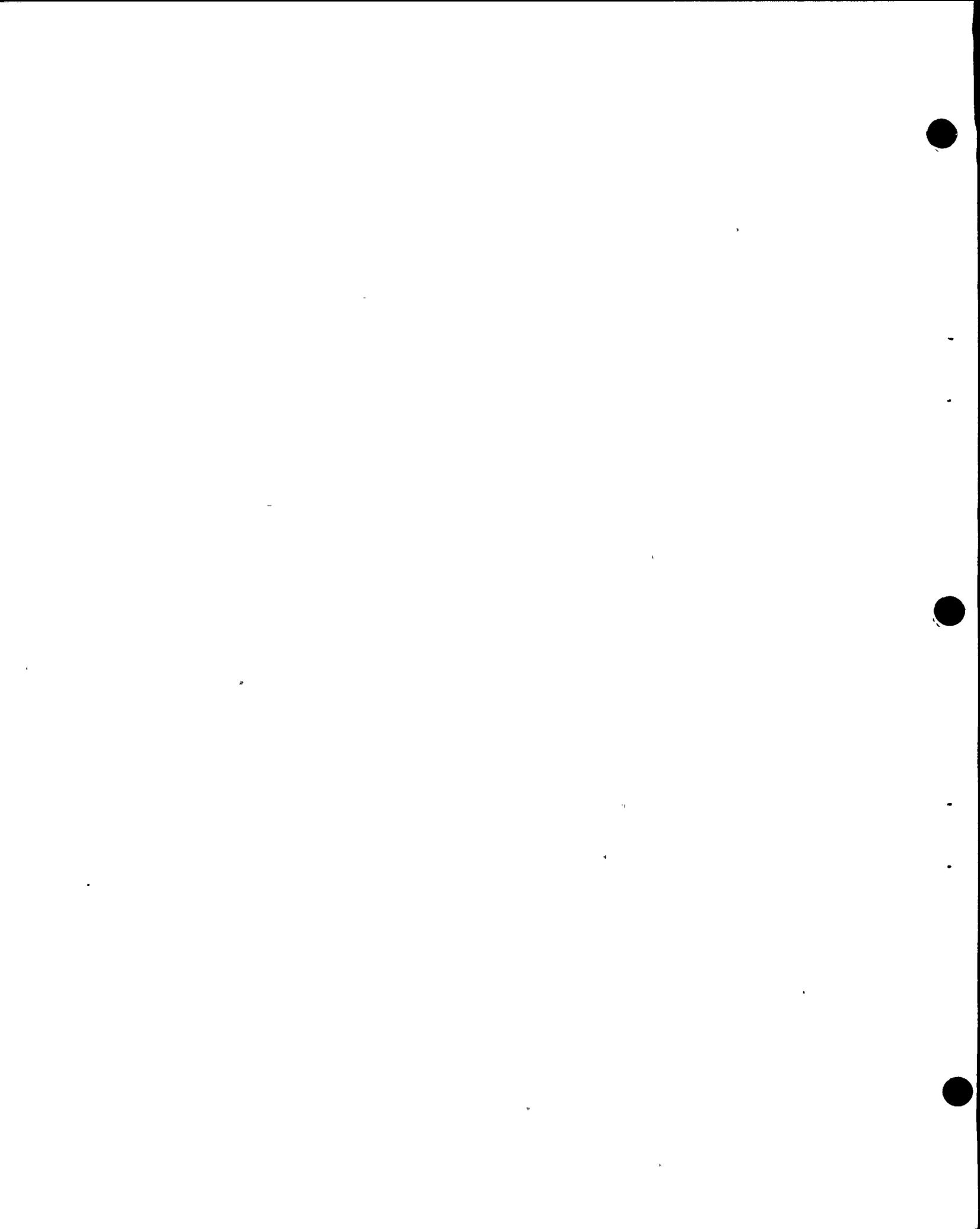
MR. FLEISCHNER: And this question --

MR. WORTON: I don't disagree with that. I have no problem with that we do have to define the maximum potential earthquake on the Hosgri Fault. No one is debating that.

(The Board conferring.)

MRS. BOWERS: We didn't have copies of the transcript last night. We got them this morning, per our order, just as the hearing started, and we do not have a total recollection of everything that was said yesterday.

We do think it's appropriate that Dr. Smith explain the difference between the '75 position and the position today, and whether going the route of pinpointing assumptions that have changed will do that or not, we're not sure.



MR. NORTON: Mrs. Bowers, it seems to me that's the basic question. And I don't see why it isn't asked and answered. What's the difference between '75 and today?

MR. FLEISCHAKER: I can throw softballs at him or I can try to probe his testimony, and I think that if the Board determines that this is an appropriate line then I ought to be able to prove his testimony.

MRS. BOWERS: Well we've got evidence in the record from Dr. Smith saying two different things, and we want to know--

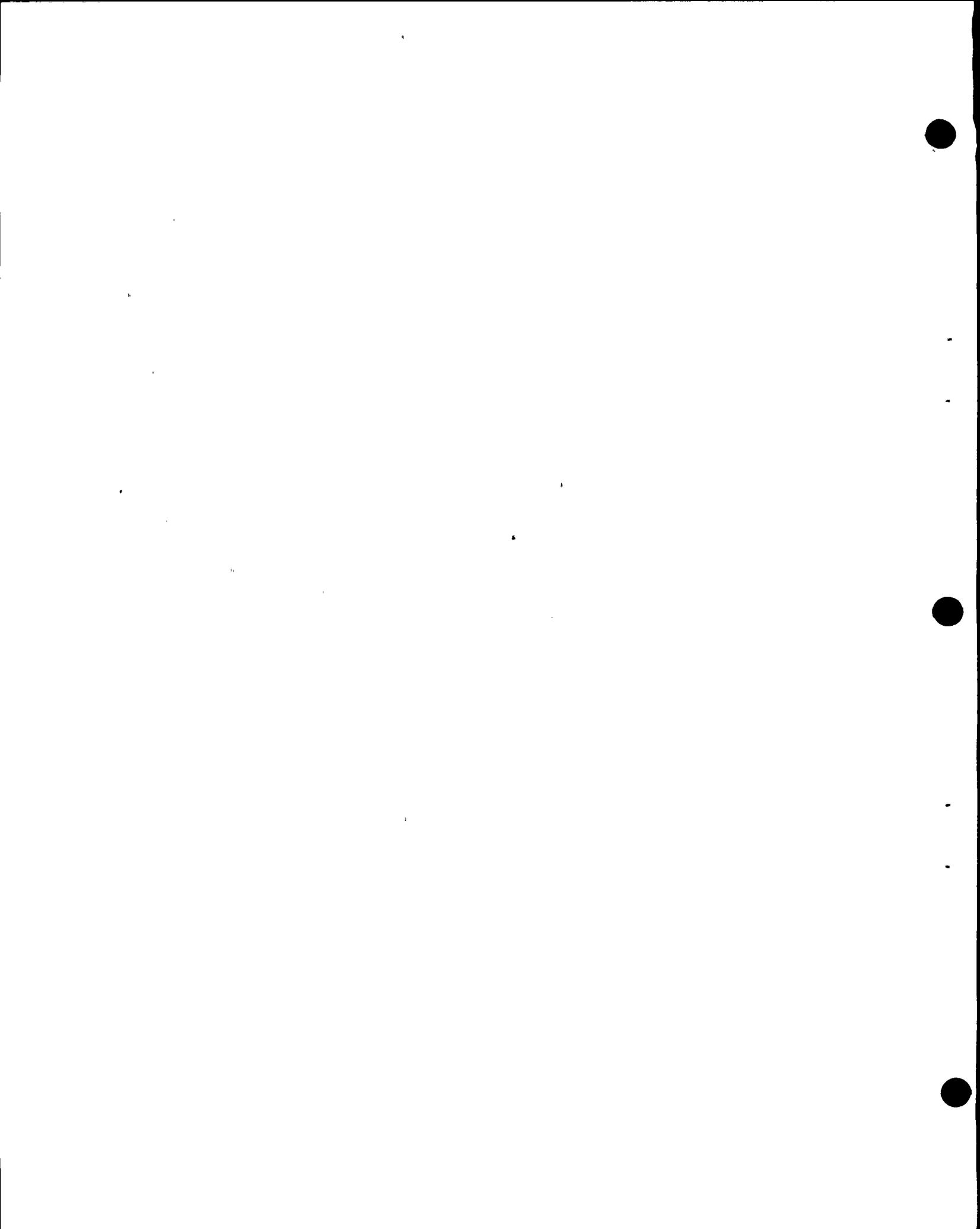
MR. NORTON: No.

MR. FLEISCHAKER: I think I understand. I think that'll come out, and if you need to bring it out on redirect, that's fine. But I'd like to probe it.

MRS. BOWERS: (continuing) --two different conclusions, maybe is a better way of saying it.

So not only do we want to know, but the record needs to reflect what's happened.

MR. NORTON: Mrs. Bowers, let me correct one thing. It's not our position that there are two different conclusions necessarily; there are two different methods. And I think that's important. And the finite answer of a method may be different. But I'm not so sure there has been testimony that his conclusions are the same. And I didn't



mean to imply that. And that is yet to be developed, I think.

MR. FLEISCHAKER: Well I think I see the Board's point, and I think it is well taken.

MR. TOURTELLOTT: Mrs. Bowers, I'm not sure how this has come out. I'm not sure whether Mr. Fleischaker is going to proceed to ask the questions in a very straightforward manner as the Board suggested or --as the Board's comment suggested, or whether he's going to go point-by-point. And I think maybe we ought to get a sense of the Board on that issue.

But I would invite your attention to the fact that under the rules you can place reasonable limits on cross-examination. And while it may be very academically interesting for Mr. Fleischaker to probe this with very sharp instruments, on the other hand we have some indications from this witness that it's not really relevant to what's going on. And if there is a question in the Board's mind about what is the significance, if any, between what was done before and what's done now, I think that straightforward question can be asked without unreasonable limiting Mr. Fleischaker's right to cross-examine. And then if the answer is not satisfactory, then maybe we can go back into probing it.

But I see that there's a potential for wasting



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a lot of time here. But I also see the potential of the Board to make some reasonable limitation at this time on the cross-examination so we can move on.

MRS. BOWERS: Well, we want to learn the difference between the two documents, positions, in the shortest time possible, with a thorough explanation. We don't know what it'll take.

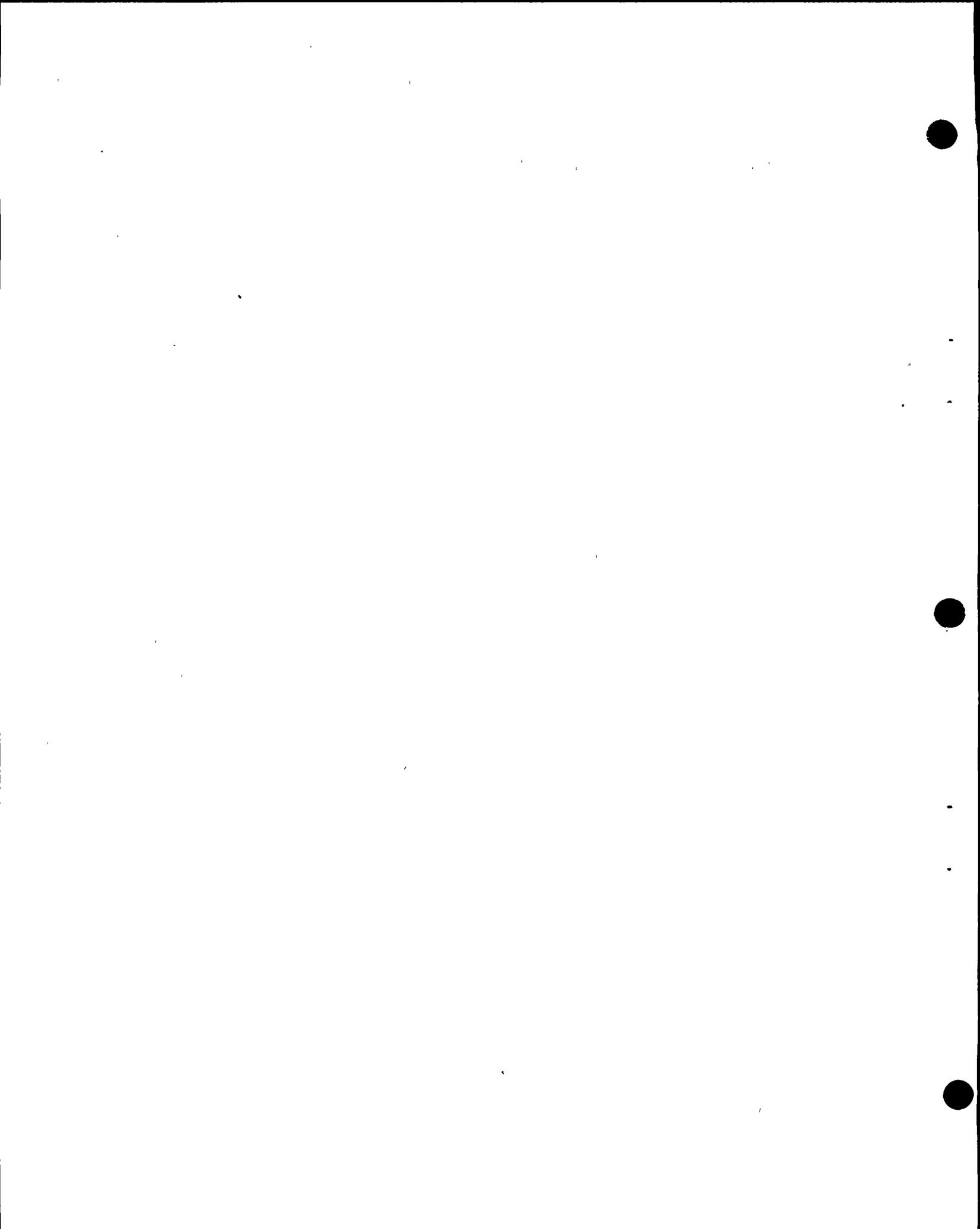
MR. TOURTELLOTT: Why doesn't the Board at this point ask him that simple question, and ask for his explanation? And then if it appears that further cross-examination is warranted, then let the Board rule further cross-examination. If not, then I think the matter can be put to rest reasonably.

MR. FLEISCHAKER: I would like to speak to that. I believe this is an unwarranted intrusion by the Staff into my cross-examination. And I would request the Board permit me to proceed.

MRS. BOWERS: Well, why don't you proceed? And we hope we have given some guidance.

BY MR. FLEISCHAKER:

Q Dr. Smith, my recollection of your testimony was that -- I wish I had the transcript, but I don't -- was that you chose not to utilize this methodology set out in the PSAR because you have a different opinion regarding certain assumptions. And you were about to list the assumptions



about which you had a different opinion.

Is that incorrect?

A (Witness Smith) Well I was also, about that time, trying to state what the conclusions were.

So there is no confusion as to whether there's any difference in conclusions, the conclusions in the 1975 submittal were: the second order faults of the San Simon, Nacimiento, Rinconada variety would have a maximum magnitude of 6.3 to 6.5.

Q That assumes a rate of slip?

A Those are the calculations described in the document you brought forward.

Q That assumes a given rate of slip, doesn't it?

A Yes; among other things.

Q Okay.

Let me go back to the assumptions. What are the assumptions that you have changed your opinion about? And I believe we were going to list them and then you were going to tell me about the data that has required you to change your opinion.

A Okay. The first one I listed was the assumption that all the observed geologic slip can be attributed to earthquakes. Some work that I have done, and work that I have read of others, leads me to believe now that perhaps a substantial amount -- perhaps on the order of 50



percent -- of the observed displacement that we see on faults can in fact be attributed to creep, or what we could call stable sliding. That is, faults do move without producing earthquakes. That's pointed out by some-- I believe in my direct testimony the first day I pointed out that in examining the seismicity of the entire plate boundary along the San Andreas that one got within about a factor of 2 relating the observed slip to the seismic activity, and that factor of 2 might well be the result of creep on faults.

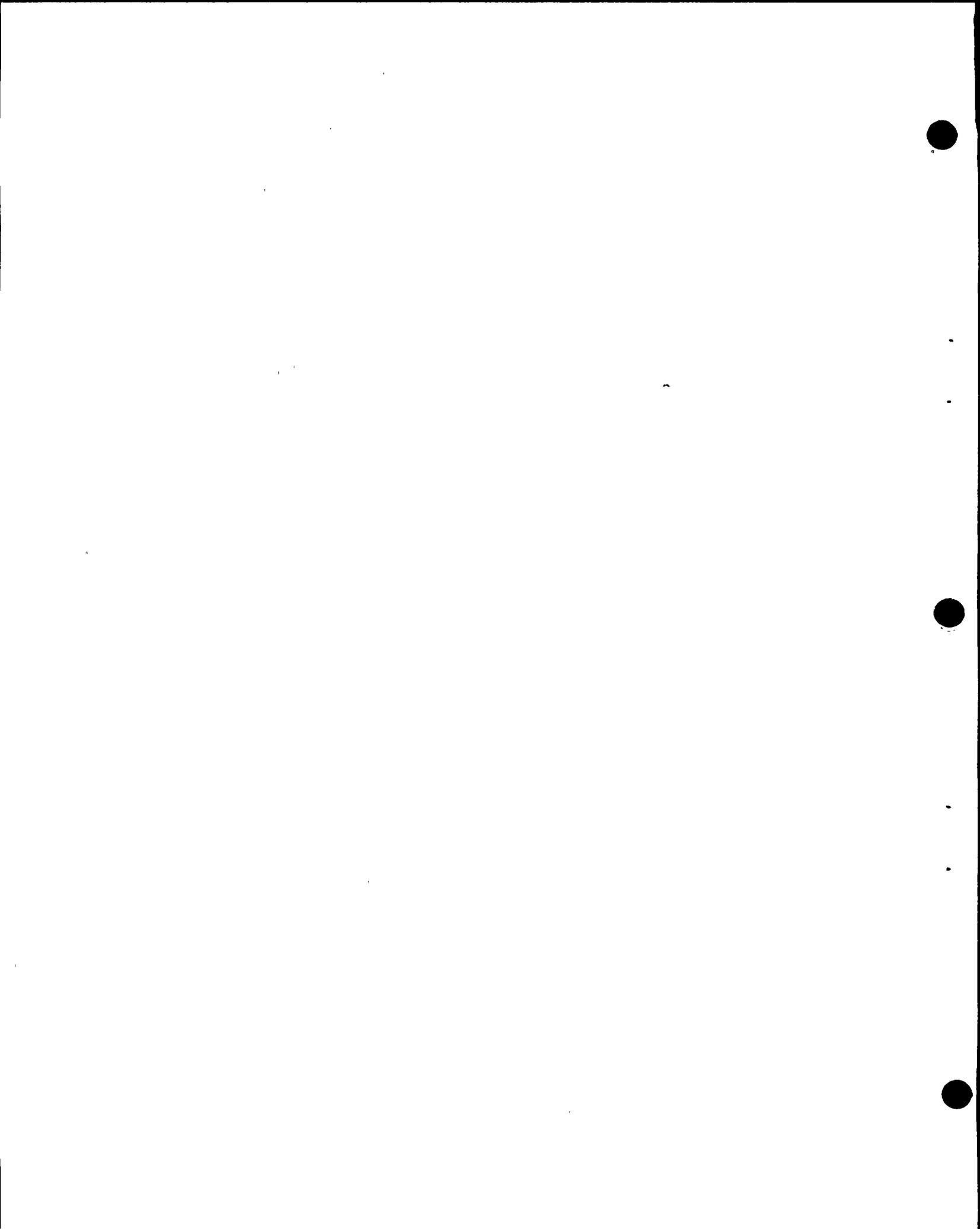
Q Can you tell me--

A Now you can imagine as to why I would not want at this particular time to use a technique which I might have to defend: What proportion of the fault slip is in creep? So I chose not to-- That contributes to one of the reasons why I didn't use this technique, because I have no direct evidence for the Hosgri as to how much displacement might be creep as opposed to how much might be earthquakes.

But my scientific opinion is that there might well be a substantial amount of the displacement, which is already very small, that is due to creep. In fact all of it might be creep.

Q Okay.

Did you have an opinion prior to submitting this data that the observed, all the observed displacement was attributable to earthquakes?



Q Yes, but I have not done the calculations, for example, for the San Andreas to see if, in fact, the seismicity would only account for half of the observed slip.

A And I'm not entirely sure that's a reliable number which again emphasizes the point that I didn't come here to argue that point.

Q Okay. Well your opinion is the same then, is that correct, with respect to this assumption?

A No, it's changed.

Q The weight of the evidence, in my view, seems to have gone somewhat more toward creep accounting for a significant portion of fault slip.

Q When was this evidence made available, and can you tell me what specifically you're referring to, what publications?

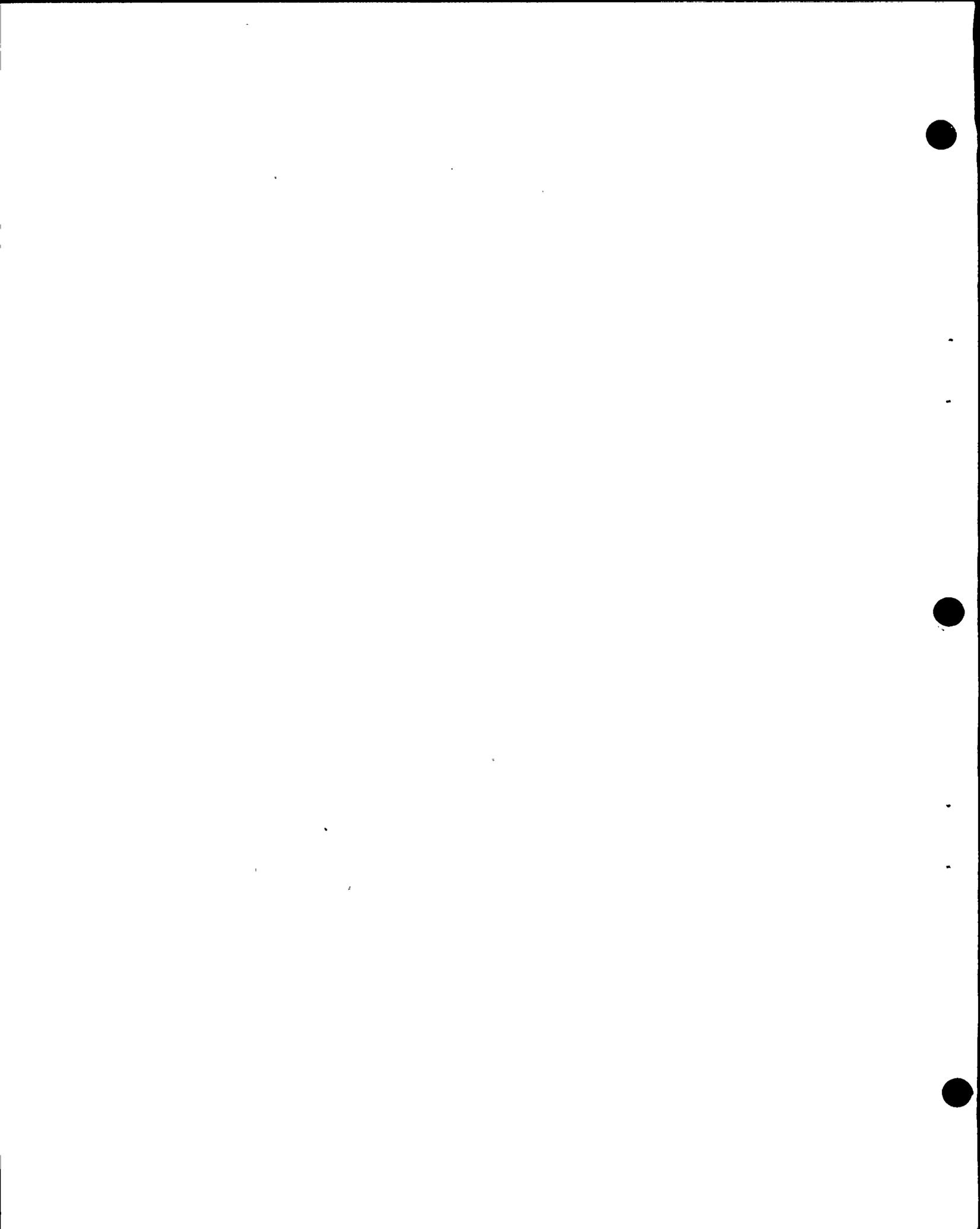
A No, I can't.

Q Are you certain in your own mind that this became available after '75?

A Well one particular piece of evidence came and that's what I described several days ago was a calculation that I did, perhaps, in the last 12 months or thereabouts.

Q Okay.

What other --



A But, you know, I would not offer that calculation for the San Andreas plate boundary as proof of anything for the Hosgri.

And I can't help but note that I've stressed throughout that the response to the NRC question was not calculating a design basis earthquake for the Hosgri, it was to provide a discussion of how fault size, or rather, how earthquake magnitude might vary among faults of different sizes and different orders in the San Andreas system.

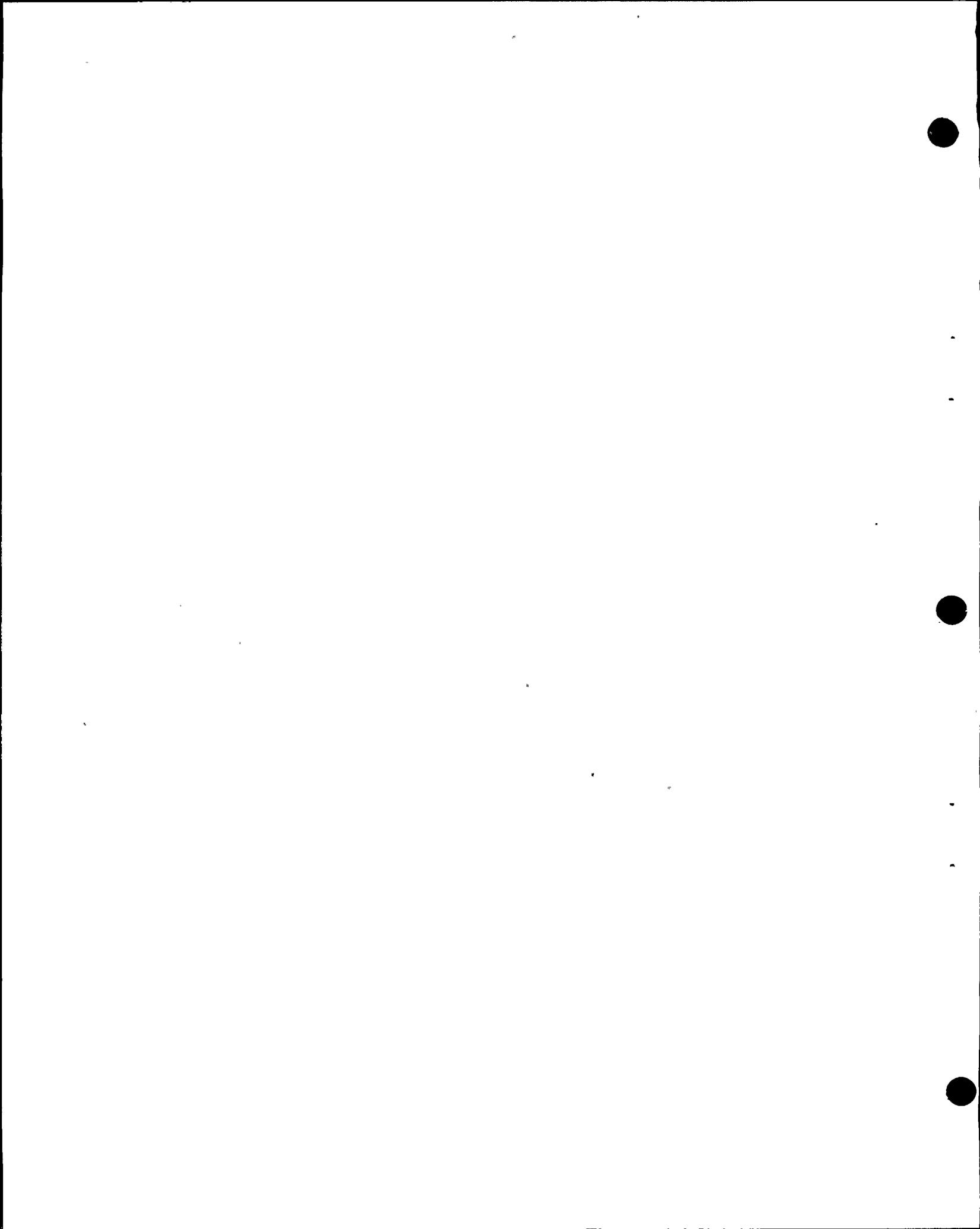
And I noted that the technique of -- Let's see, if the maximum magnitude earthquake has been obtained many times during Holocene, as one might expect for the San Andreas Fault or its first-order branches, then the technique will grossly overestimate the maximum magnitude. I still feel that's true.

But since I am unable to tell you precisely how grossly, I chose not to bring forward this technique and defend it in this hearing.

Q Okay.

Let me go back: What are the other assumptions with respect to which you've changed your mind?

MR. NORTON: Mrs. Zowers, I hate to keep interrupting, but Mr. Fleischaker keeps mischaracterizing the nature of these assumptions. He says, assumptions as to which you've changed your mind. I don't believe that's



Dr. Smith's testimony at all that he's changed his mind about these assumptions. I think this is an unfair characterization of the testimony repeatedly.

MR. FLEISCHAKER: Well if that's the case then, Dr. Smith, please correct me.

WITNESS SMITH: I haven't changed my mind, I still believe that this technique as applied will grossly overestimate the magnitude for a fault of any size.

BY MR. FLEISCHAKER:

Q Okay.

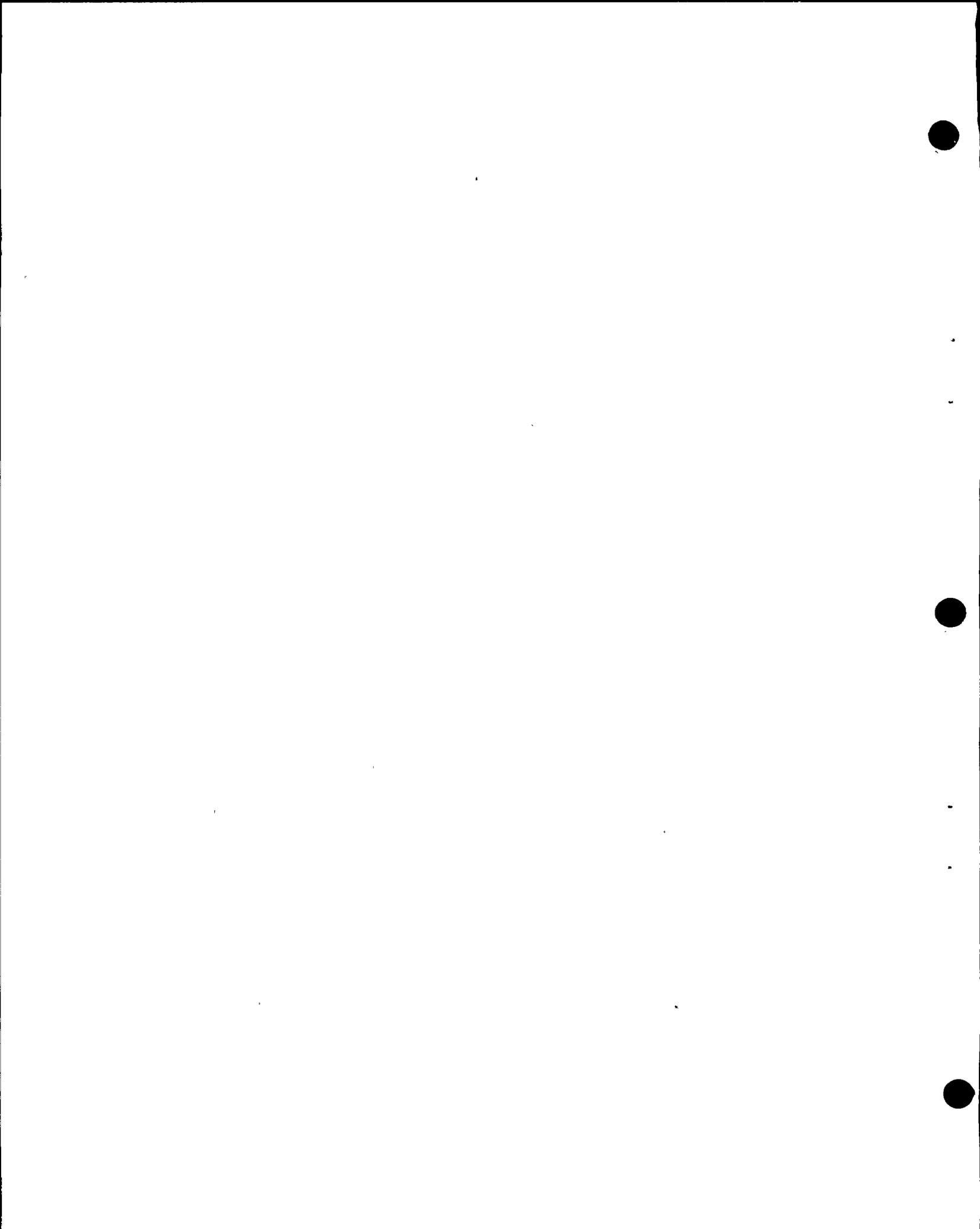
Well let's go back to the assumptions. Are there any others which you view differently?

A (Witness Smith) A number of changes have occurred. I think the relationship between local magnitude, M_L , and surface wave magnitude ---

MR. TOURTELLOTT: I'm going to object. I don't believe the answer is responsive. I think it would be beneficial -- not only is the answer not responsive, but several answers have not been responsive.

The question was asked a long time ago. And if Mr. Fleischaker doesn't want to insist on the answer, well, that's his business.

But it seems terribly inefficient to sit here when the witness has been asked: Tell me what the assumptions are and then tell me why you changed your mind and my



understanding was that's the way we were going to do it. And what I seem to be hearing is a lot of explanation and no listing of assumptions and no explanation, therefore, of why those assumptions were made.

Since the question has been asked by Mr. Fleischaker, I would like to see that answered so that I can make my notes and we can move on.

My objection was that the answer is not responsive. The question was, what are the assumptions. The response was an explanation of an interpretation of material.

MRS. BOWERS: Well right now, no, the witness is attempting to describe Assumption Number Two.

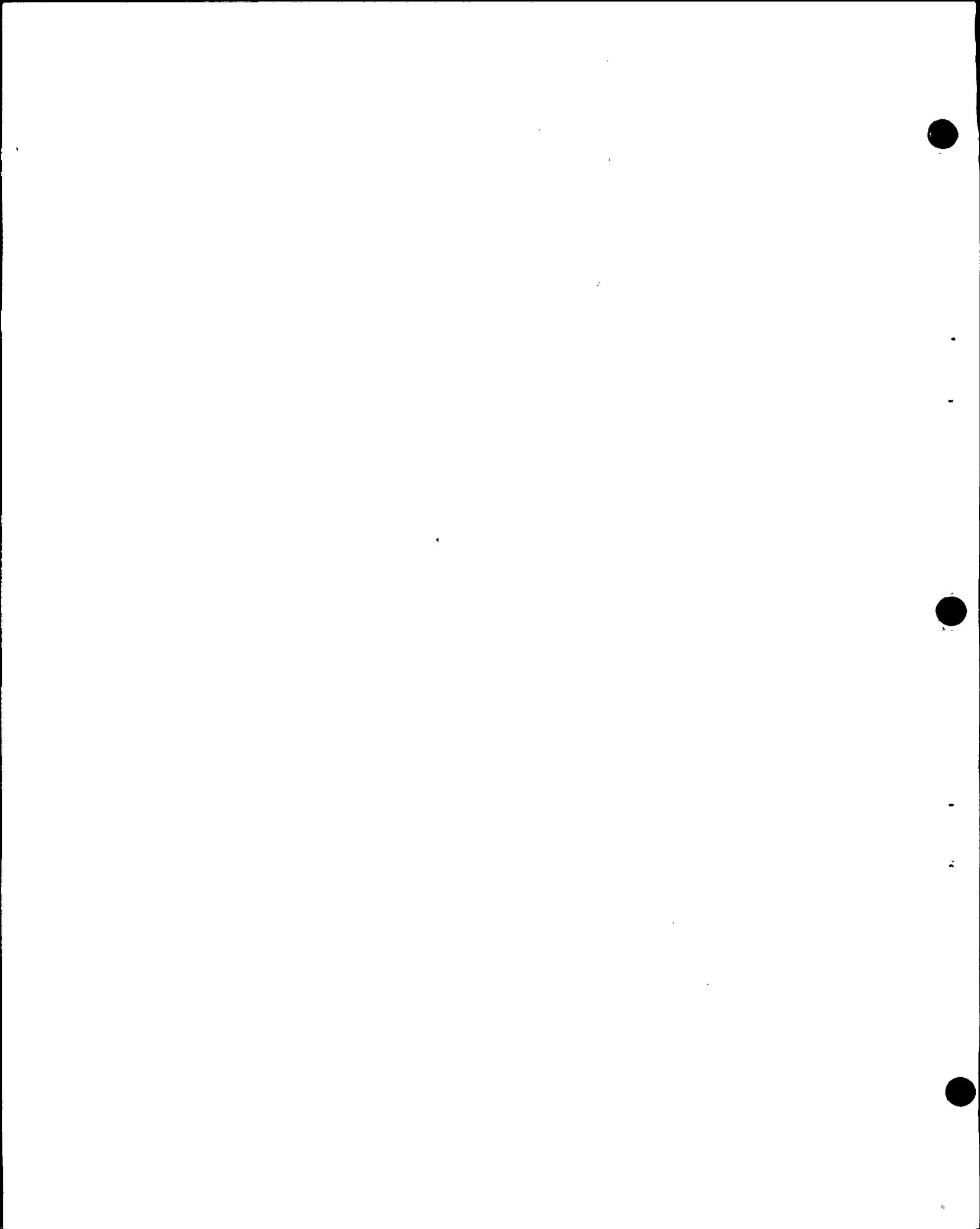
MR. TOURTELLOTTE: That wasn't my understanding of what was going on. What is Assumption Number Two?

MR. FLEISCHAKER: Mr. Tourtelotte, please.

BY MR. FLEISCHAKER:

Q Can you give us a list of assumptions, Dr. Smith?

A (Witness Smith) This is not necessarily an exhaustive list, but Assumption Number One we just discussed was that all slip is attributed to earthquakes. Assumption Number Two would be that the seismic moment can be related to the magnitude, the local magnitude, with the kind of relationship that I published.



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Assumption Number Three would be that the procedure of assuming that the maximum earthquakes occurred only once, during Holocene time, is appropriate.

Q Is that it?

A Yes. I believe at the moment those seem to be the important assumptions.

Q I think we discussed Numbers One and Three so far.

Let's go to Number Two. Has your opinion on the validity of that assumption changed?

A Yes.

Q And how so?

A I believe that the relationship used now has a sound theoretical framework when used with surface wave magnitude, but that the same functional form is no longer appropriate when one is using M_L , the local magnitude.

Q Aren't surface wave magnitudes and local wave magnitudes roughly equivalent to some level?

A Perhaps Dr. Bolt could answer that.

A (Witness Bolt) The surface wave magnitudes are calculated for large earthquakes because the Wood-Anderson instruments which give the local magnitudes are overdriven by the large motions of the ground.

And consequently, if it is not known just what the definite relationship is above about magnitude 7.2 --



I believe that a magnitude 7.2 which occurred in the Kern County earthquake of 1952 was the last -- was the highest Richter magnitude or local magnitude ever to be calculated in California. So we really have no guidance as to how the divergence goes above that level.

Q Which was used, surface wave, magnitudes or local magnitudes in your calculations here in the FSAR?

A (Witness Smith) There may be some mixture of data in the range, perhaps, where the magnitudes are equivalent. But primarily, the data would be -- from older earthquakes in Southern California would be attributed as M_s , surface wave magnitude.

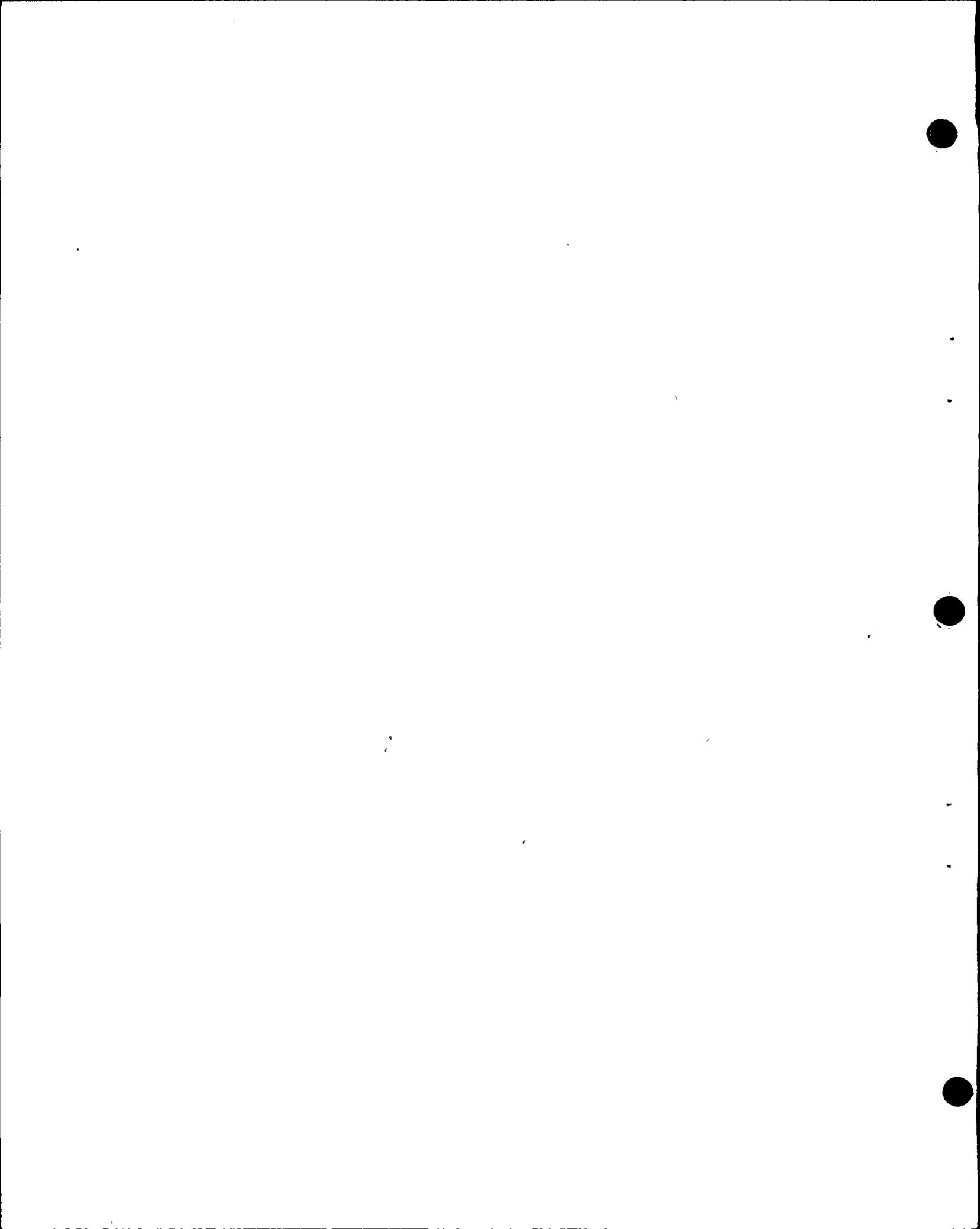
MRS. BOWERS: Mr. Fleischaker, I hesitate to interrupt but my notes, which may be incorrect, show that Assumption Number Two was that seismic movement related to local magnitude. Is that correct?

MR. NORTON: I believe that was seismic moment, Mrs. Bowers.

MRS. BOWERS: Seismic moment.

Now do I understand that, in the '75 FSAR, that that document or the model or the equation or whatever you want to call it was based on surface wave?

MR. NORTON: Mrs. Bowers, I think unfortunately the witnesses are discussing and didn't hear everything you said. They thought perhaps you were addressing this to Mr.



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Fleischaker. But I don't think Assumption Number Two was the seismic moment.

MR. FLEISCHAKER: Why don't we have Dr. Smith say it, he can probably say it more clearly than any of us lawyers.

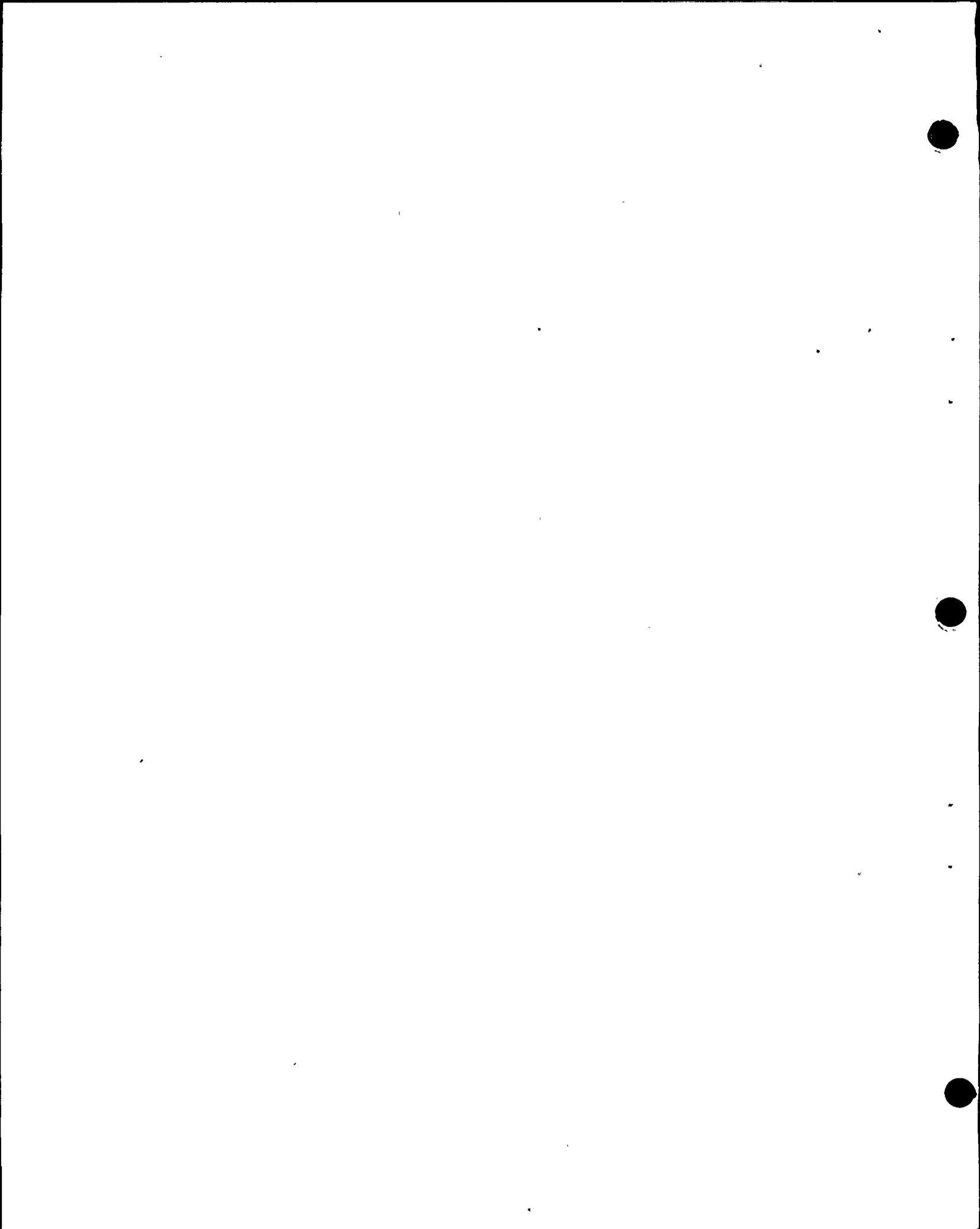
MRS. BOWERS: Dr. Smith, I'm trying to understand Assumption Number Two. I thought it was that seismic moment was related to local magnitude. And that was an assumption that you were now getting away from.

But I thought just a minute ago, you testified in preparing the '75 paper, that you used surface wave magnitude.

WITNESS SMITH: The distinction -- I did not really make the distinction clear enough in my earlier work on this. It's partly because this is a developing field and some of the ideas concerning the relation between different types of magnitudes have been developed and solidified only in the last several years.

In the paper that I wrote and in the FSAR submittal, there is an assumption, an equation that the logarithm of the seismic moment is proportional to the magnitude.

And I am just now stating that if one were to repeat this type of calculation now, I think it would be necessary to use perhaps a somewhat more -- well, to



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use different forms of the relationship to predict magnitudes of the different varieties, whether it's surface wave or local magnitude.

WITNESS BOLT: May I add something to that, Mrs. Bowers?

To help the Board in their thinking in this connection, I'd like to assure you that it has only been in the last two years that there have been some major papers published -- one that I can cite is by Kanamori, for example, from Cal. Tech. -- which have taken up the whole question of the basis of magnitude determinations and the relations between them in any serious way.

And this has been a subject of considerable discussion in the seismological community in seismological meetings. A few years ago it was common since this was a field of seismology that was just emerging, often because of the demands of Nuclear Regulatory hearings, to mix up magnitudes and not to finely distinguish between them.

It has been pointed out more and more that, since so much hinges on this, it's necessary to define more precisely what each magnitude means, what frequency range it's referring to, and this is certainly something that has reached a very high level of activity in the last two years.

WITNESS FRAZIER: I'd like to add a small



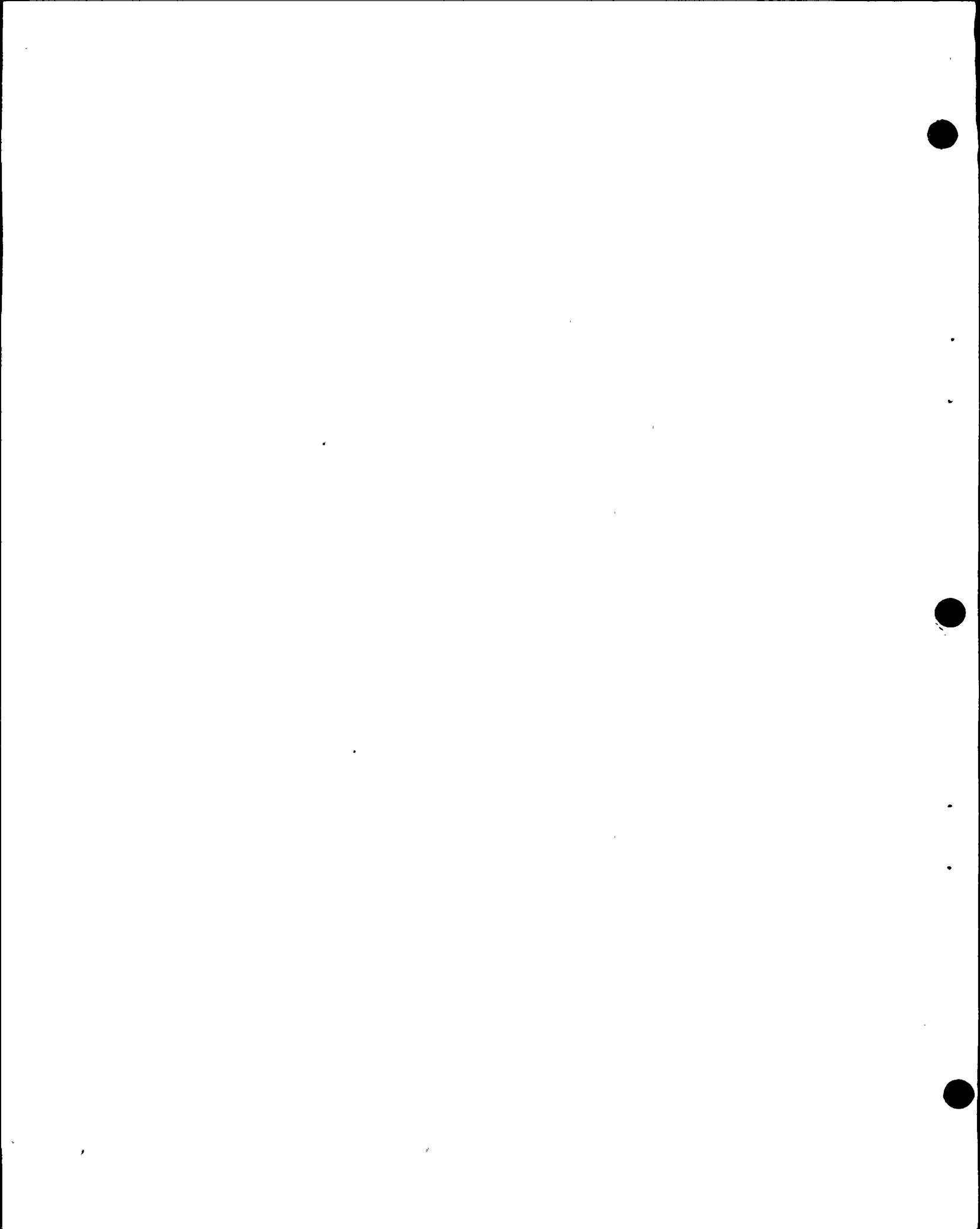
addendum to that.

Dr. Smith, in his testimony that he is presenting for this hearing, has switched to consistently using surface wave magnitude, and Dr. Bolt presented some other reasons for that, I'd like to present one more reason: that the role that plays in determining, or relating slip and magnitudes and so forth is that we're seeking a relationship between seismic moment, which is the best seismic observation we have for relating to slip and area of rupture and things of that type, it's a measure of what's going on in the earth. And the surface wave magnitude is a low-frequency long period measure of the waves coming out of the earthquake and it gives us a more consistent, more reliable relationship to relate with seismic moment.

So the current method has been more selective than using the magnitude relationship which more closely relates to seismic moment.

MR. FLEISCHAKER: Mrs. Bowers, I would like to say that we are bringing to the proceeding someone who also can address this, Dr. Jim Brune, who is listed in the FSAR submission by someone who introduced the concept so he also will have something to say about this.

MRS. BOWERS: Well it may have been, Mr. Fleischaker, that your question somehow didn't completely identify whether you were talking about '75 or the testimony

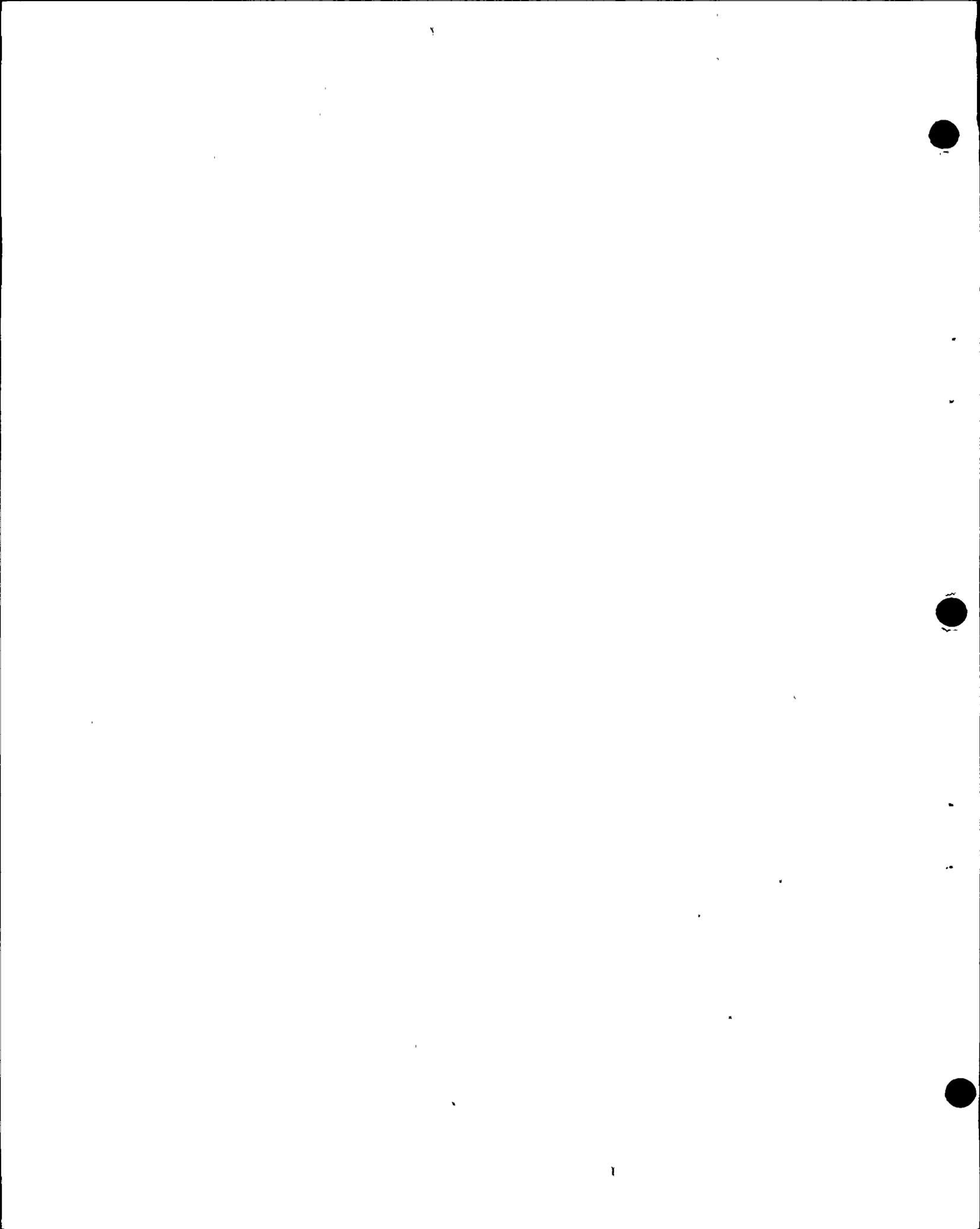


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prepared for this hearing or my notes could have been wrong.

But I thought, you see, that you were first saying local for the '75 paper and then saying surface waves. So I think it has been cleared up.

end@2c



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MR. FLEISCHAKER: I'd like to go back to that.

BY MR. FLEISCHAKER:

Q In your '75 paper you apparently didn't discriminate?

A (Witness Smith) That's correct.

Q So for purposes of those calculations, you were using some of both?

A I would say so, yes.

Q Okay.

Now today, if I understand Dr. Bolt's testimony today, if we were trying to calculate for earthquakes larger than 7.2, even today you would be using surface wave magnitudes?

A If we were trying to calculate what?

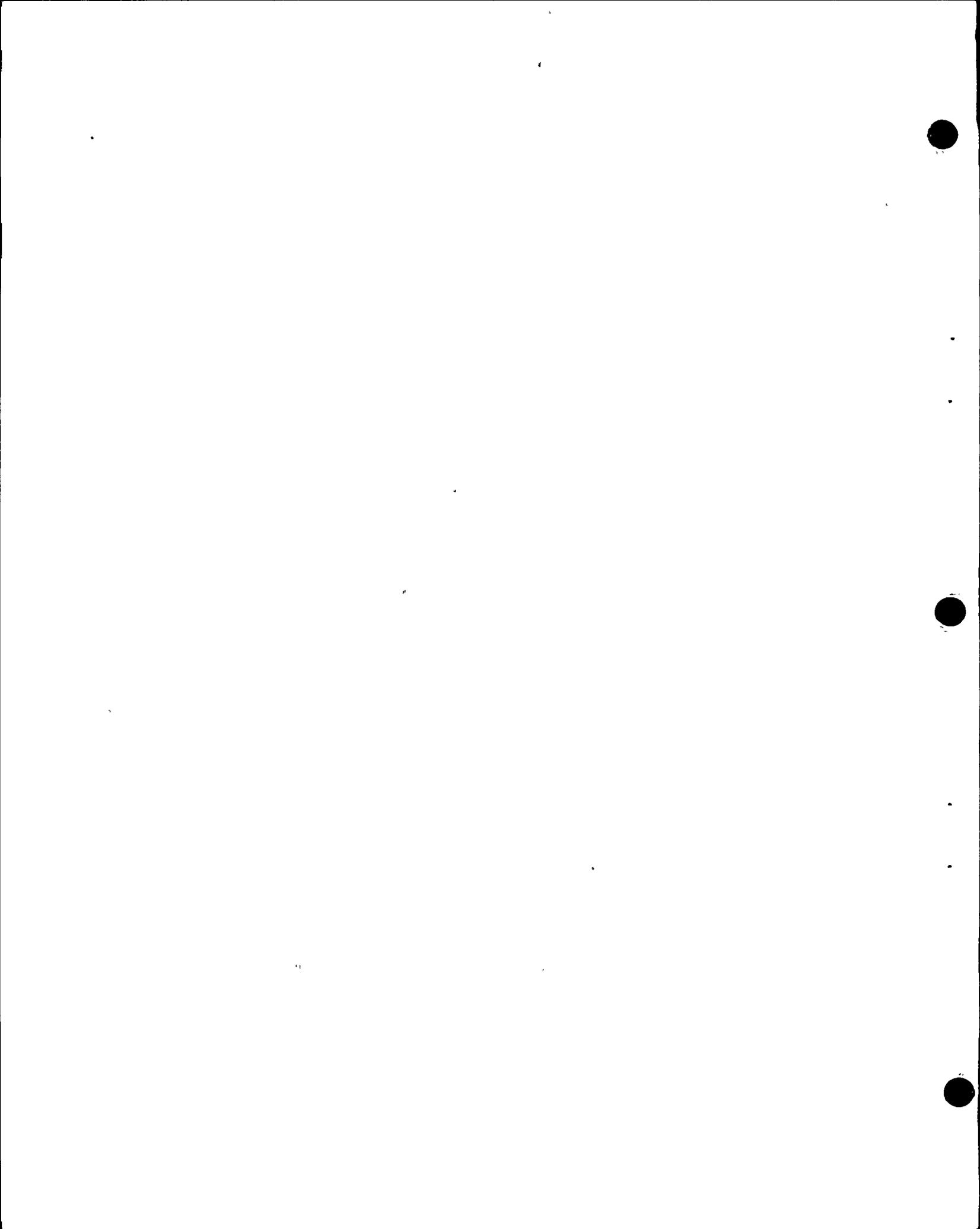
Q Moment.

A Yes, I believe the surface wave magnitude is the only one that can clearly be related to moment at the present time.

Q Is that for all --

MRS. HOWERS: We were told this morning by the public address man that he thinks this is a CB on an illegal channel. He said we shouldn't get this kind of noise if they're on a proper frequency.

MR. TOURTELLOTT: I don't know if you ever heard the story or not. This is a true story about they



cb2

had a revival and a rather lengthy prayer was given, and right toward the end, "Hear our prayer, oh Lord," and then over the PA system came, "That's a big 10-4, good buddy."

(Laughter.)

MR. FLEISCHAKER: Can we take our morning break?

MRS. BOWERS: Let's take ten minutes. Maybe our CS-er will go away.

(Rises.)

MRS. BOWERS: We'd like to resume, please.

BY MR. FLEISCHAKER:

Q Dr. Smith, let's go back to your method.

At the time that you wrote this paper, I believe that one of the assumptions that you utilized was that moment was proportional to magnitude.

A (Witness Smith) Yes.

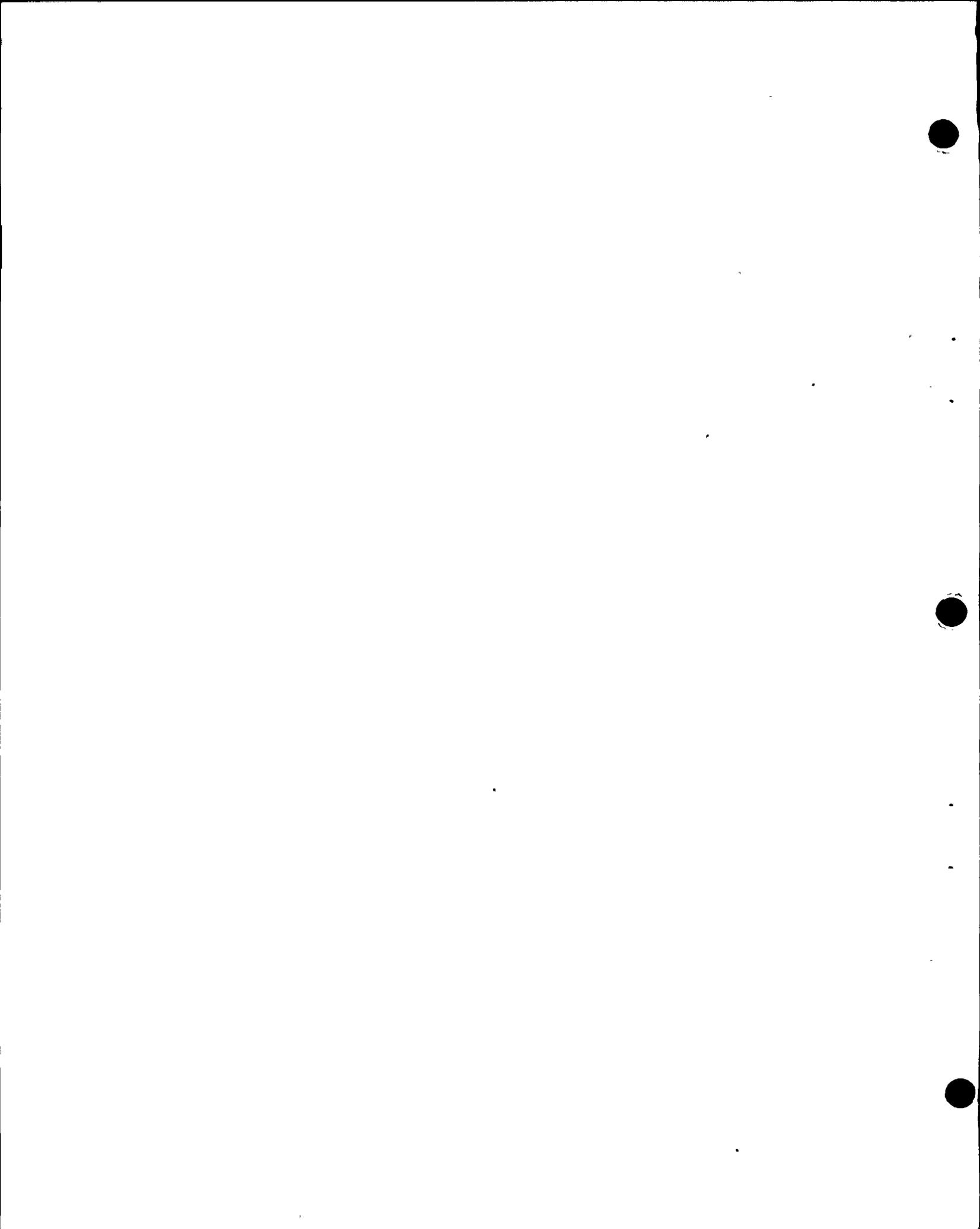
Q You did not discriminate between surface wave and local magnitudes?

A I would have to say, in light of the knowledge that I now have, I would have to say that in my data set I probably had a mixture.

Q Now today, do you have an opinion as to whether moment is proportional-- Excuse me.

Is it your opinion that moment is proportional to surface wave magnitude? Is that correct?

A That's correct.



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Q For what range?

A I believe that's valid for all surface wave magnitudes-- Well, perhaps at the very large magnitudes, that might not hold, say, up above 8.

Q Do you have an opinion as to whether moment is proportional to local magnitude?

A Yes.

Q Okay.

What is your opinion?

A I believe it is a much more complicated, functional relationship. It's not the simple form, the same simple linear relationship that I used.

Q And for what range?

A For what range is the more complicated fraction valid?

Q Correct, for what range of magnitudes?

A All magnitudes.

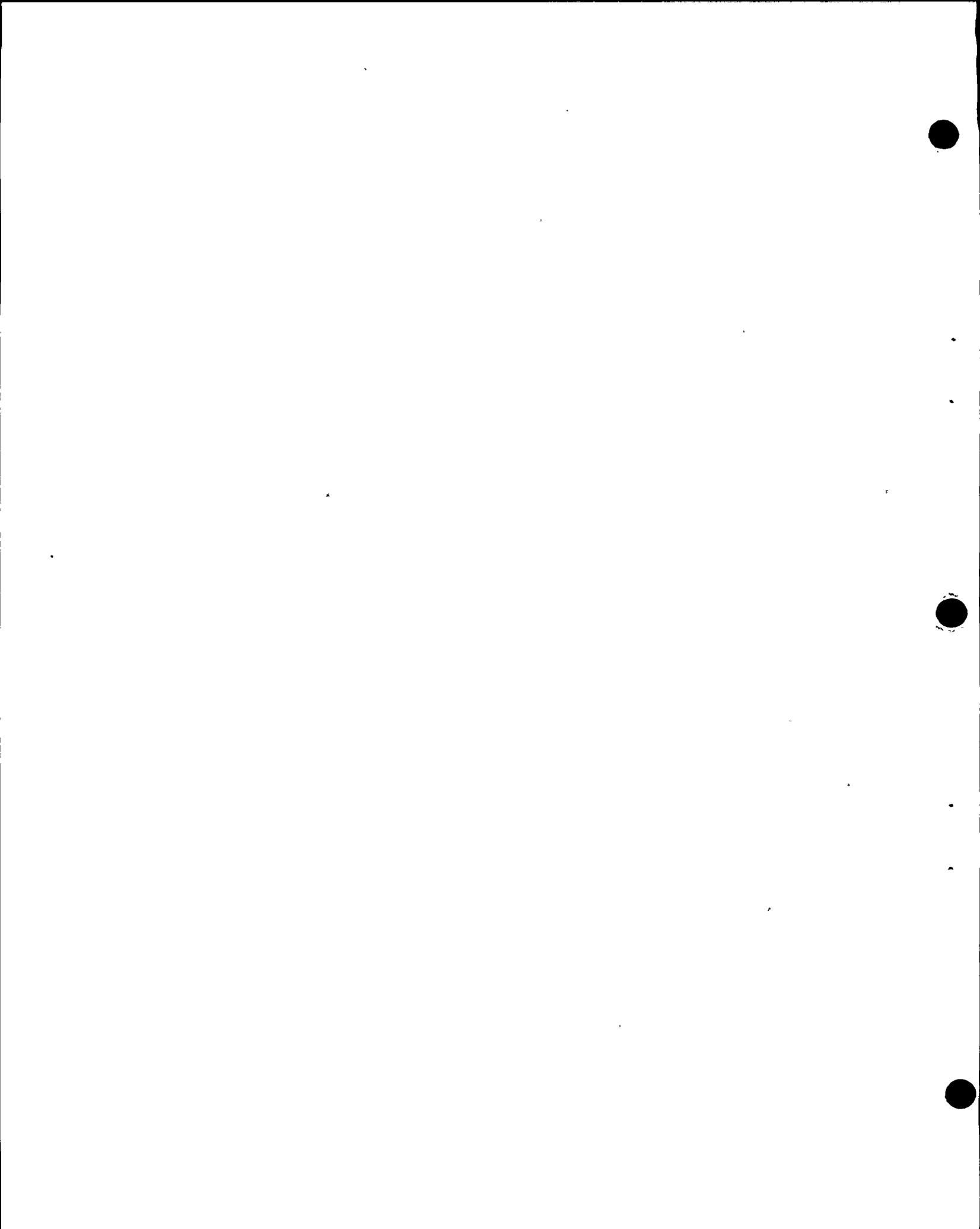
Q All right.

How to what range of magnitudes does "local" extend?

A My current belief would be that the local magnitude saturates at about 7, about magnitude 7.

Q Okay.

That means that-- Does it not mean that if we were doing calculations today for certain ranges we might



eb4

use different kinds of magnitude, local or surface-- Strike that.

Would you agree that the earlier calculations then, to the extent that you used local magnitudes, suffered from this failure to use the more complex relationship?

A I'm not sure.

Q So we might get the same result?

A You might.

Q Do you have an opinion then as to whether this method that is set out here is still valid?

A I have already expressed that opinion.

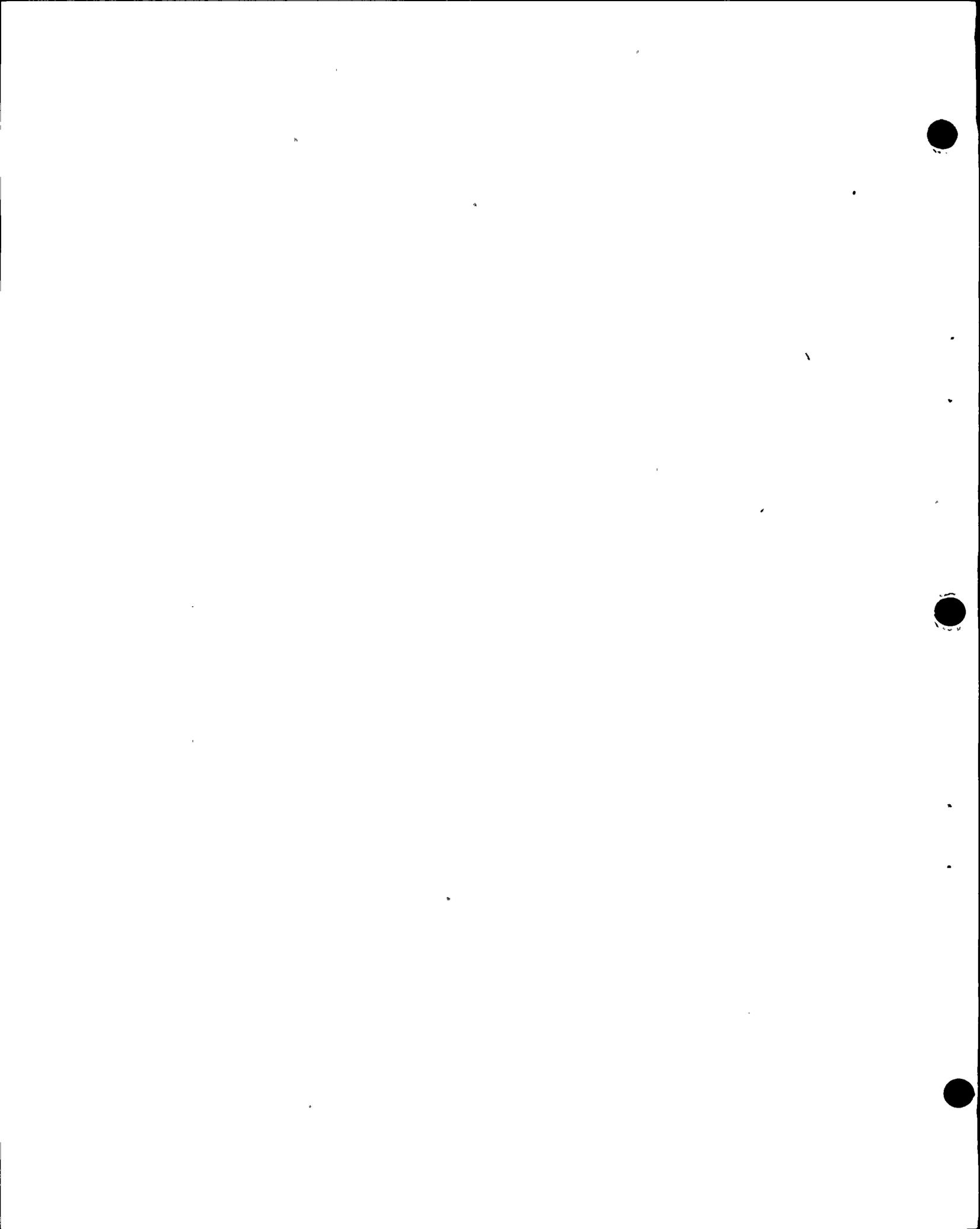
Q And for surface wave magnitudes it is?

A No, I've expressed the opinion that the method grossly overestimates maximum magnitudes and thus I no longer believe it's an appropriate approach to use. I still believe it grossly overestimates the magnitudes. I would have some difficulty telling you just how grossly, and so it is precisely for that reason that I chose not to use it in this context.

Q The maximum magnitude of which the fault is physically capable? This method grossly overestimates the maximum magnitude of which the fault is physically capable?

A I believe so, yes. I have stated that several times, and it's in the FSAR and it's in my published paper.

Q Now let me direct your attention-- In place



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of this method, what method did you use?

A MR. NORTON: Excuse me. "Method did you use."

My objection, Mrs. Bowers, in place of this method what method did he use -- for what?

BY MR. FLEISCHAKER:

Q Instead of using this method, what method did you use in your testimony?

MR. NORTON: Object again. That question assumes a fact not in evidence, that he arrived at the same number, that he did the same kind of a thing. That hasn't been established, and that was my original apples-to-oranges objection.

BY MR. FLEISCHAKER:

Q To establish the maximum earthquake magnitude?

MR. TOWNELLE: Mrs. Bowers, there's an objection made and no ruling. We need to do that; otherwise we're going to get into a double-objection situation.

MRS. BOWERS: Right.

For one thing, Mr. Fleischaker, you didn't clearly identify what you were referring to, and I assume the first method used for this was referring to the '75 FEAR, and we have heard, either from the witness or from Mr. Norton, that a different methodology was used in preparing the testimony for today.

So there's a proper question here but --

MR. FLEISCHAKER: Let me make it clear on the



eb6

1 record.

2 MRS. BOWERS: -- the objection is overruled on
3 the basis on which you stated it.

4 MR. FLEISCHAKER: It's unclear. I'll make it
5 clear.

6 BY MR. FLEISCHAKER:

7 Q In place of the method which is set out in the
8 FSAR submission dated August, 1975, upon what method did you
9 rely in reaching the conclusions drawn in your testimony?

10 A (Witness Smith) I believe that I stated that
11 several times. The issue was whether or not the magnitude
12 7.5 for the Hosgri as specified by the U. S. Geological Survey
13 was a conservative estimate, and I chose to illustrate that
14 in fact that was very conservative by showing the consistency
15 between the historic seismic record and the rate of geologic
16 slip.

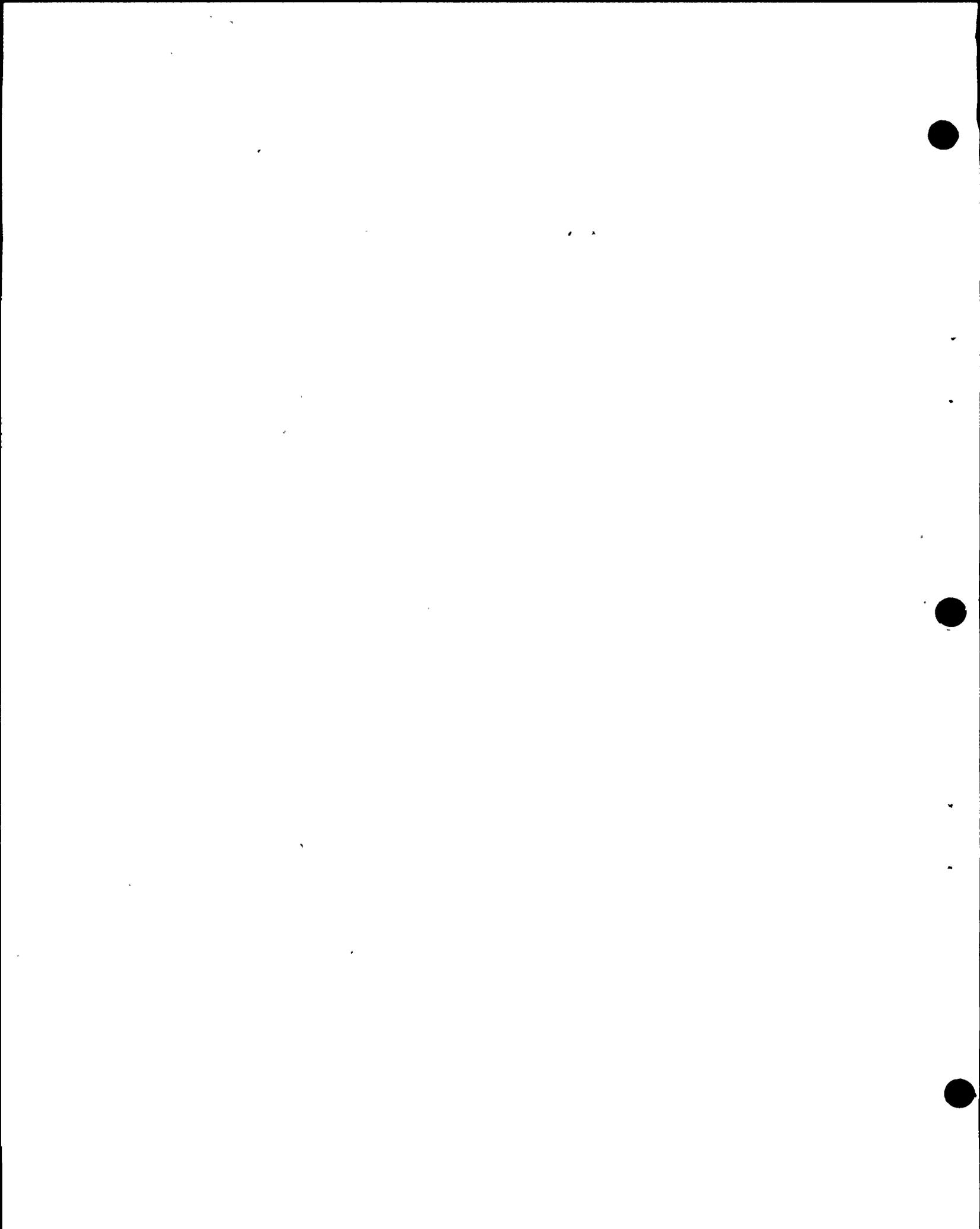
17 Q Well, down at page 17 you have an equation and
18 a lot of discussion about the seismic moment.

19 A That's correct.

20 Q And at the top of page 17, starting at line 5
21 you state:

22 "Seismic moment has come into common
23 use in seismology as an effective means to
24 characterize the size of an earthquake."

25 Did you not rely upon --



eb7

1 MRS. BOWERS: What document are you referring to?
2 You said at the top of page 17, and then you quoted some-
3 thing.

4 MR. FLEISCHAKER: Dr. Smith's testimony.

5 MRS. BOWERS: Oh. I'm sorry.

6 DR. MARTIN: I don't see that on the top of page
7 17.

8 MR. FLEISCHAKER: It's on line 5.

9 BY MR. FLEISCHAKER:

10 Q And then down on line 18 there's an equation
11 defining seismic moment. And then down at line 24 is an
12 equation that essentially says that moment is proportional
13 to magnitude.

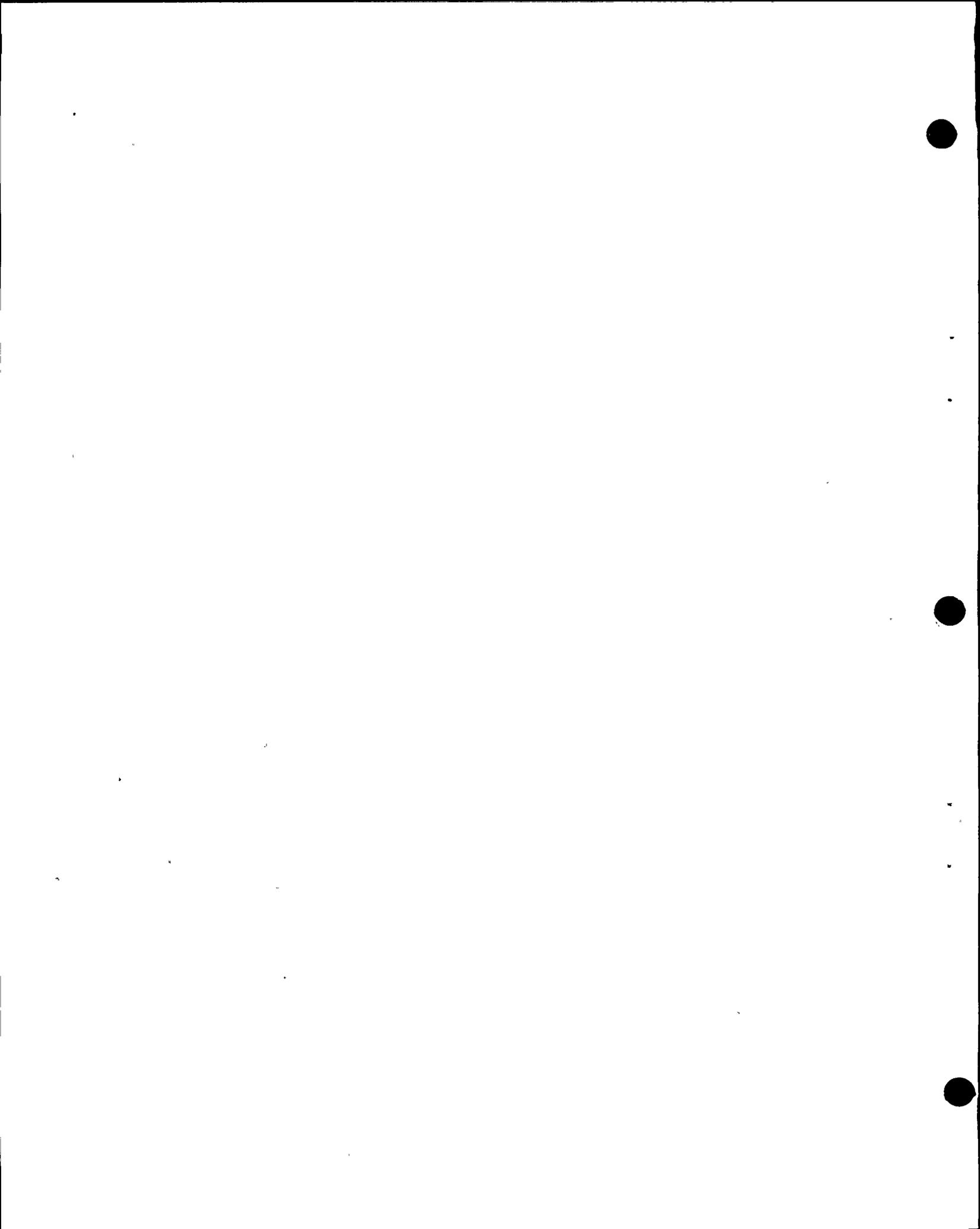
14 A (Witness Smith) Yes. And what was the question?

15 Q The question is, isn't this essentially the same
16 relationship upon which you relied in reaching conclusions
17 in your FSAR submittal?

18 A That equation is the same as one of those used
19 in the FSAR submittal, but the method is totally different.

20 Q How is the method different?

21 A As I tried to explain several times, the seismic
22 history was used in the direct testimony that I gave here,
23 that is, the instrumental history of about the last half
24 century, which gives us a rate of occurrence of earthquakes
25 of various sizes.



eb. 1 Q Is it your testimony that the computation of
2 recurrence intervals is more reliable than this method that
3 you've used here to calculate the maximum earthquake potential?

4 MR. NORTON: Excuse me, Mrs. Bowers.

5 MR. Fleischaker is having the same problem that the witness
6 is with the Viewgraphs. He keeps saying "here," and I frankly
7 am not sure whether he's talking now about the '75 FSAR or
8 the testimony. I suggest he might think that he's talking
9 to a blank piece of paper.

10 MRS. BOWERS: We'd like to have you clarify
11 that.

12 I may have misspoke a moment ago. Somehow it
13 seems to me I said your objection was overruled but for dif-
14 ferent reasons. Well, it was sustained but for reasons other
15 than what you gave. I got a playback on that.

16 (Laughter.)

17 BY MR. FLEISCHAKER:

18 Q Is it your testimony that use of the recurrence
19 intervals, calculating recurrence intervals is a more reliable
20 way of estimating the earthquake potential, maximum earthquake
21 potential of a region than by use of the seismic moment
22 the moment relationships that are stated both in your testimony
23 and in your paper?

24 A (Witness Smith) That is not a well-posed ques-
25 tion. You cannot use seismic moment relationships to predict



eb9

1 earthquakes.

2 Seismic moment is a measure of earthquake size
3 that we are able to relate to magnitude.

4 Q Well, I understood your testimony to be that you
5 were using recurrence intervals to come to some conclusions
6 regarding the maximum earthquake potential of the region.

7 A No, I believe that I read from my 1967 testimony
8 that I was critical of using recurrence relations on small
9 earthquakes to predict the occurrence of large ones.

10 Q I see.

11 So none of this testimony here then goes to the
12 question of the maximum credible earthquake?

13 A None of which testimony?

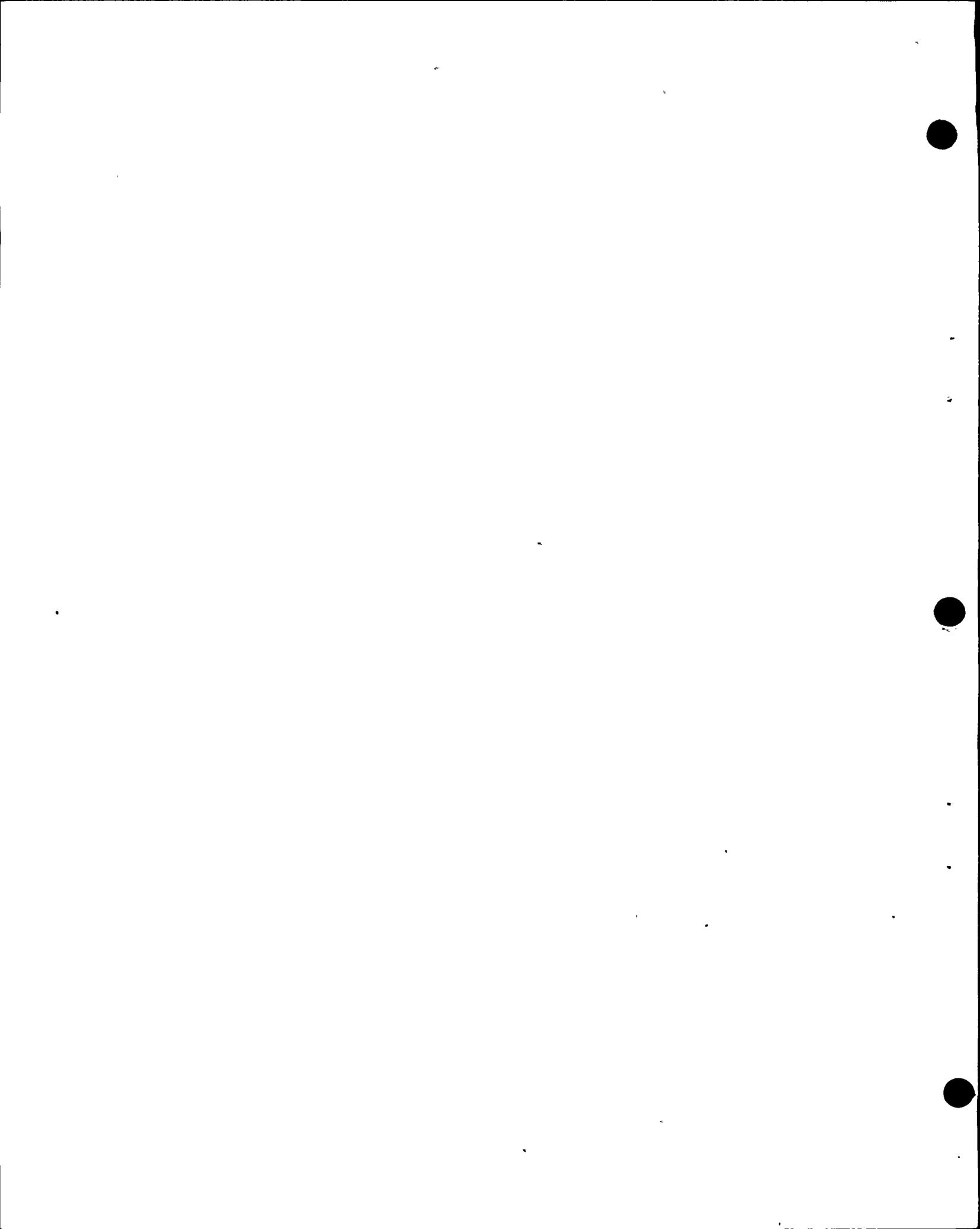
14 Q The discussion here of "E - Seismicity," on pages
15 14 through 17 or 18?

16 A No, quite the contrary.

17 I think I have been able to show quite conclu-
18 sively that, in the case at hand, the seismic history -- the
19 sample we have of seismic history quite well reflects the
20 geologic situation.

21 Q And the fundamental relationship or the method
22 you relied on to draw that conclusion is the computation of
23 recurrence intervals. Is that correct?

24 A The computation of the recurrence interval was
25 one part of the demonstration that I gave that in fact that



eb:0 1 recurrence interval is a valid one.

2 Q In fact, it is one side of the equation, isn't it?
3 6.5 magnitude comes from your recurrence interval calculations?

4 A No. I think you really do misunderstand this
5 whole process, Mr. Fleischaker.

6 Q Okay. Well, straighten me out.

7 MR. NORTON: Object. That's not a question.

8 MR. FLEISCHAKER: Okay.

9 BY MR. FLEISCHAKER:

10 Q How did you use your recurrence interval?

11 MRS. BOWERS: Wait a minute.

12 The objection is sustained. Rephrase your
13 question.

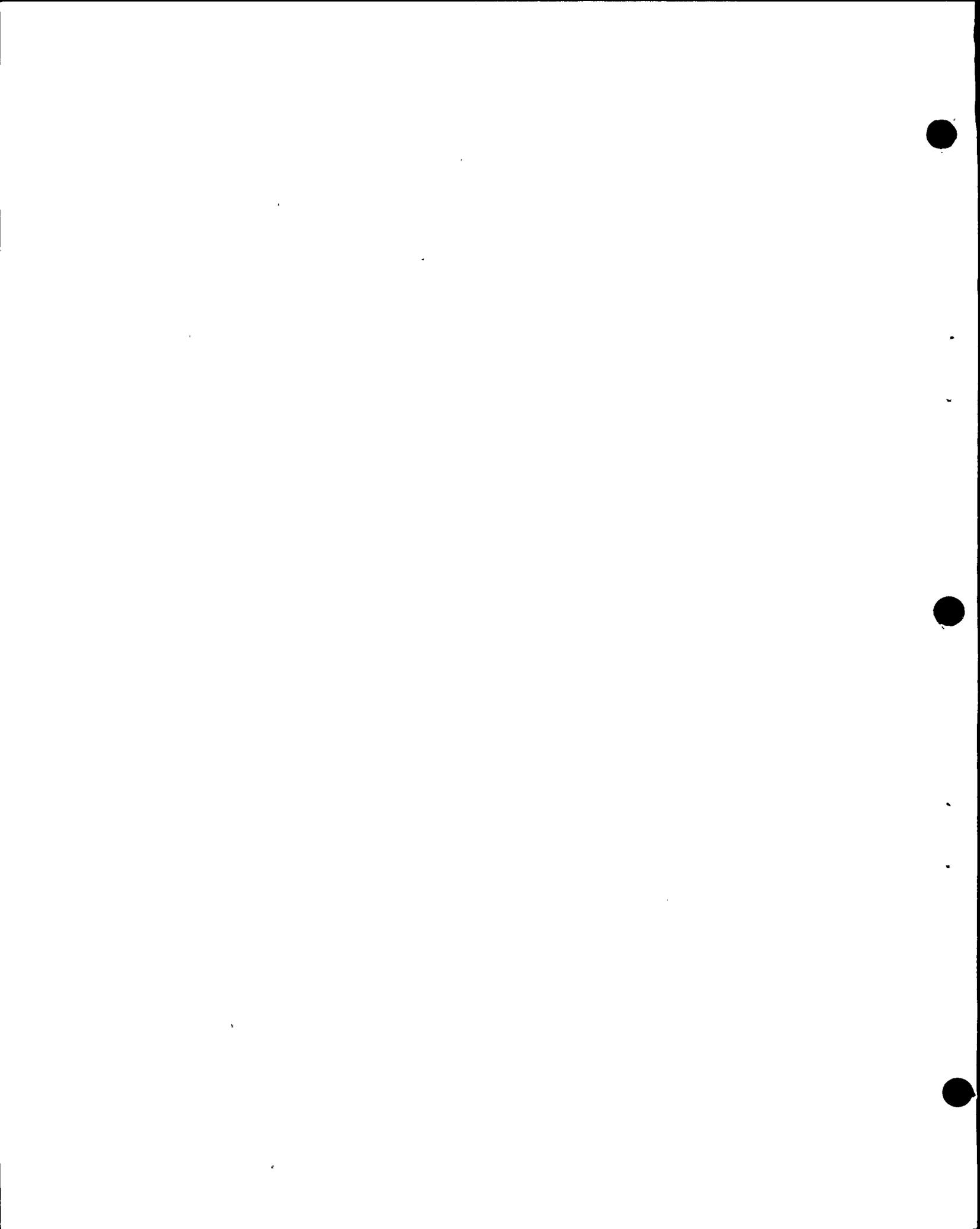
14 BY MR. FLEISCHAKER:

15 Q How did you use recurrence intervals in reaching
16 your conclusions?

17 A (Witness Smith) I used the recurrence-- Let me
18 explain a little bit about recurrence intervals here. It
19 might help.

20 We have a sample of some seismic activity in
21 this region, primarily small earthquakes. There is no problem
22 in making a distribution from that, plotting points and
23 drawing a line through them.

24 The difficulty comes in assessing whether or not
25 the sample is long enough in time so that we know how far out



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1 in magnitude we can extrapolate the line where there are no
2 data points.

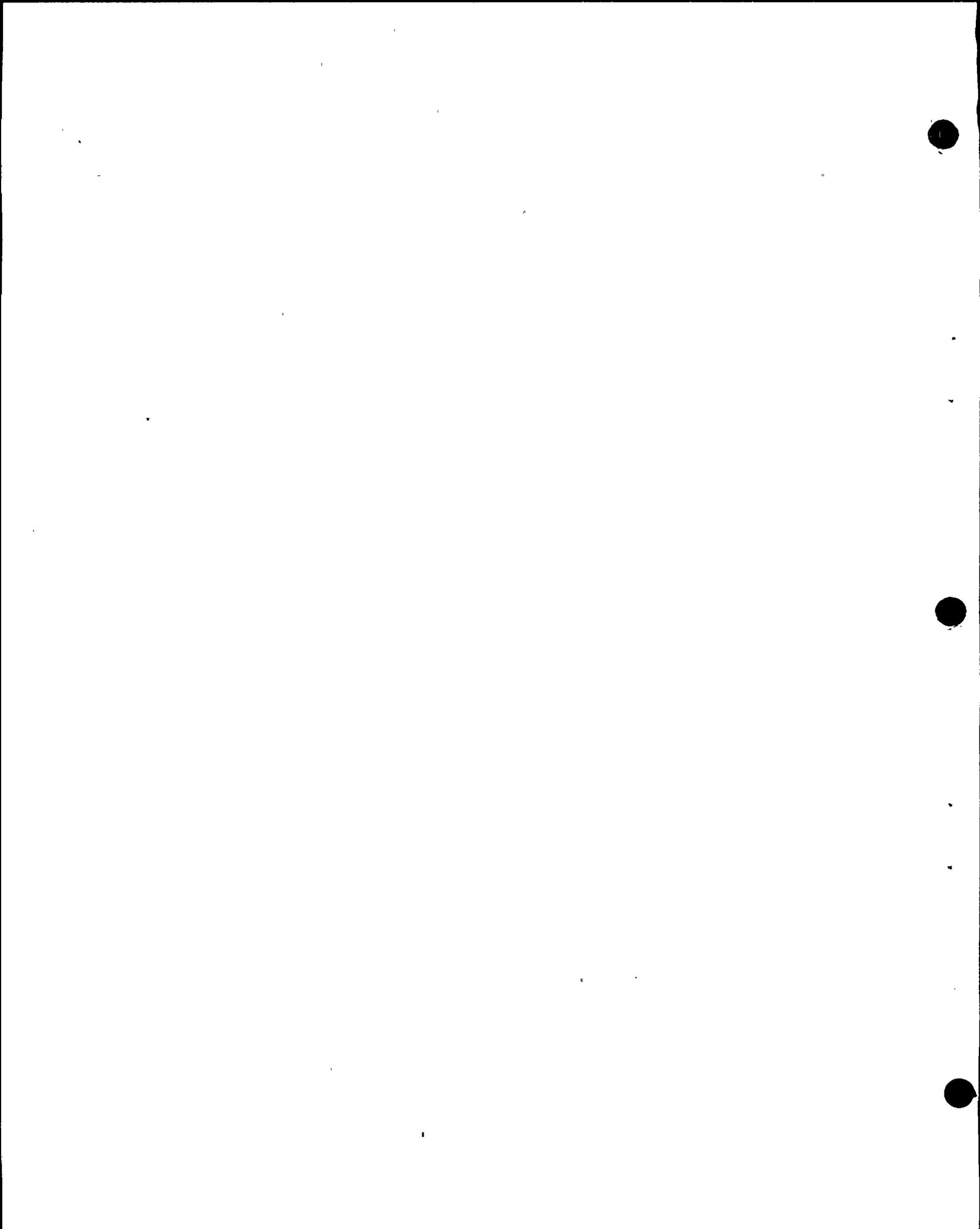
3 So I established a recurrence curve from the
4 best instrumental seismic history we have of the region which
5 is approximately the last half century. That recurrence
6 relationship contains data points primarily below magnitude
7 6 because magnitude 6 is the largest earthquake that has
8 occurred in this region.

9 It is legitimate to ask whether in fact there
10 might be larger earthquakes, and can we extrapolate that curve
11 out? Without any other information, I think it is very
12 difficult, if not impossible, to know how far to extrapolate
13 that curve.

14 So in that sense, as I stated in the testimony
15 I read or the submittal that I made in 1967, that I thought
16 it was perhaps poor practice to extrapolate the occurrence
17 of large earthquakes from small ones. It was in that context
18 that I said that, because no one knows how far legitimately
19 even to extrapolate.

20 In this proceeding I have taken the seismicity
21 as indicated by the last half century and posed the following
22 question:

23 If we were to extrapolate that to magnitude 6.5,
24 what are the geological ramifications of that extrapolation?
25 And it is in that process of determining the geological



ebl.

1 effects of extrapolating the recurrence curve that I used the
2 seismic moment-magnitude relationship.

3 Q Well, as I understand it, your conclusion is that
4 if we have a 6.5 earthquake, if it reoccurs as we expect it
5 to according to my calculations, then we would expect to see
6 the total average fault length that Mr. Hamilton sees?

7 A Yes. It makes-- Fault slip. It makes a con-
8 sistent picture, yes.

9 Q Okay. I understand that.

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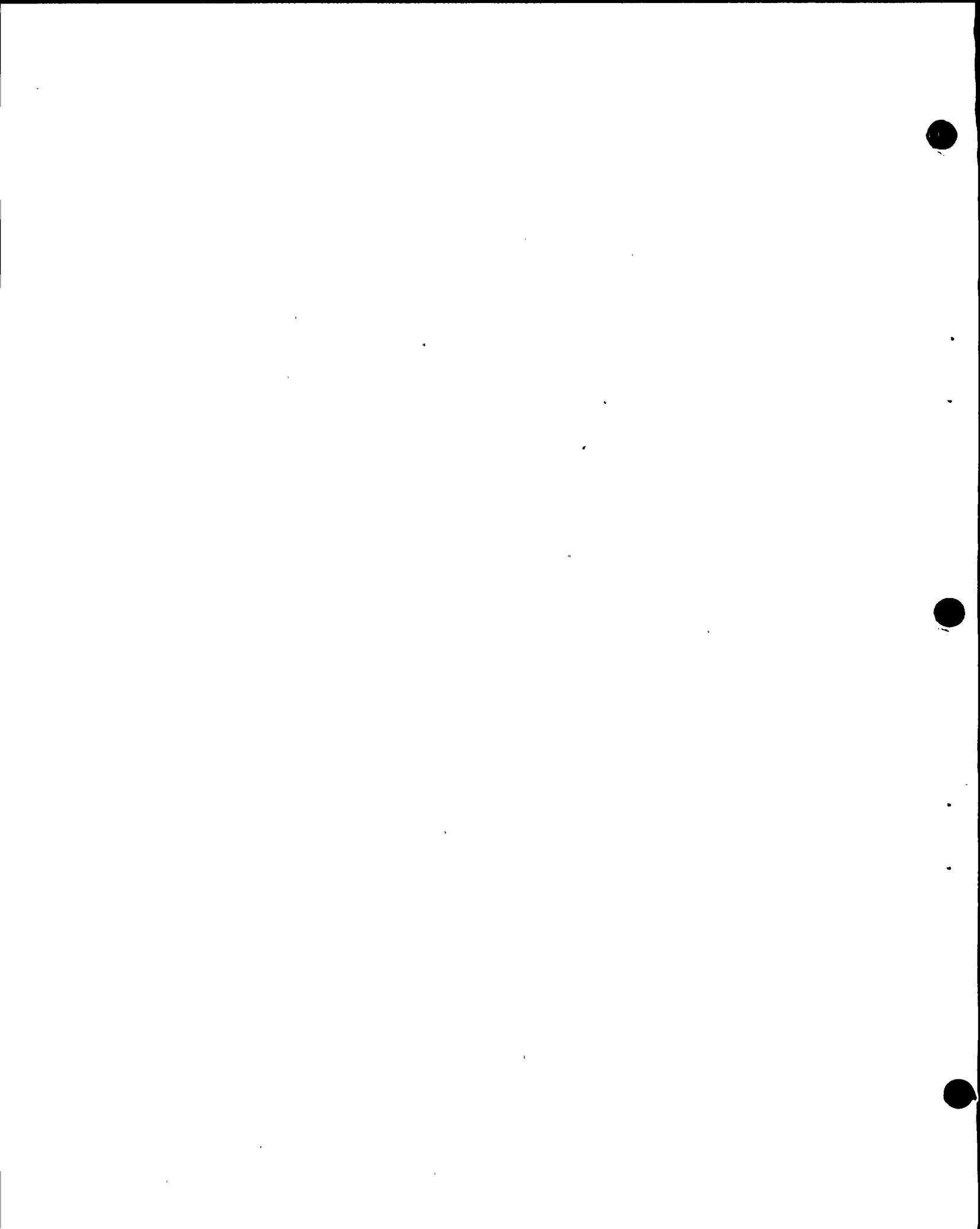
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24

25



1 Now let me look at one side of that. Does that
2 give us an estimate of the maximum earthquake potential of
3 the region?

4 A In the sense that if one postulates larger
5 earthquakes than that that they would appear to be violating
6 all the data that we have, yes.

7 Q Violating Mr. Hamilton's observation of geologic
8 offset?

9 A That's correct.

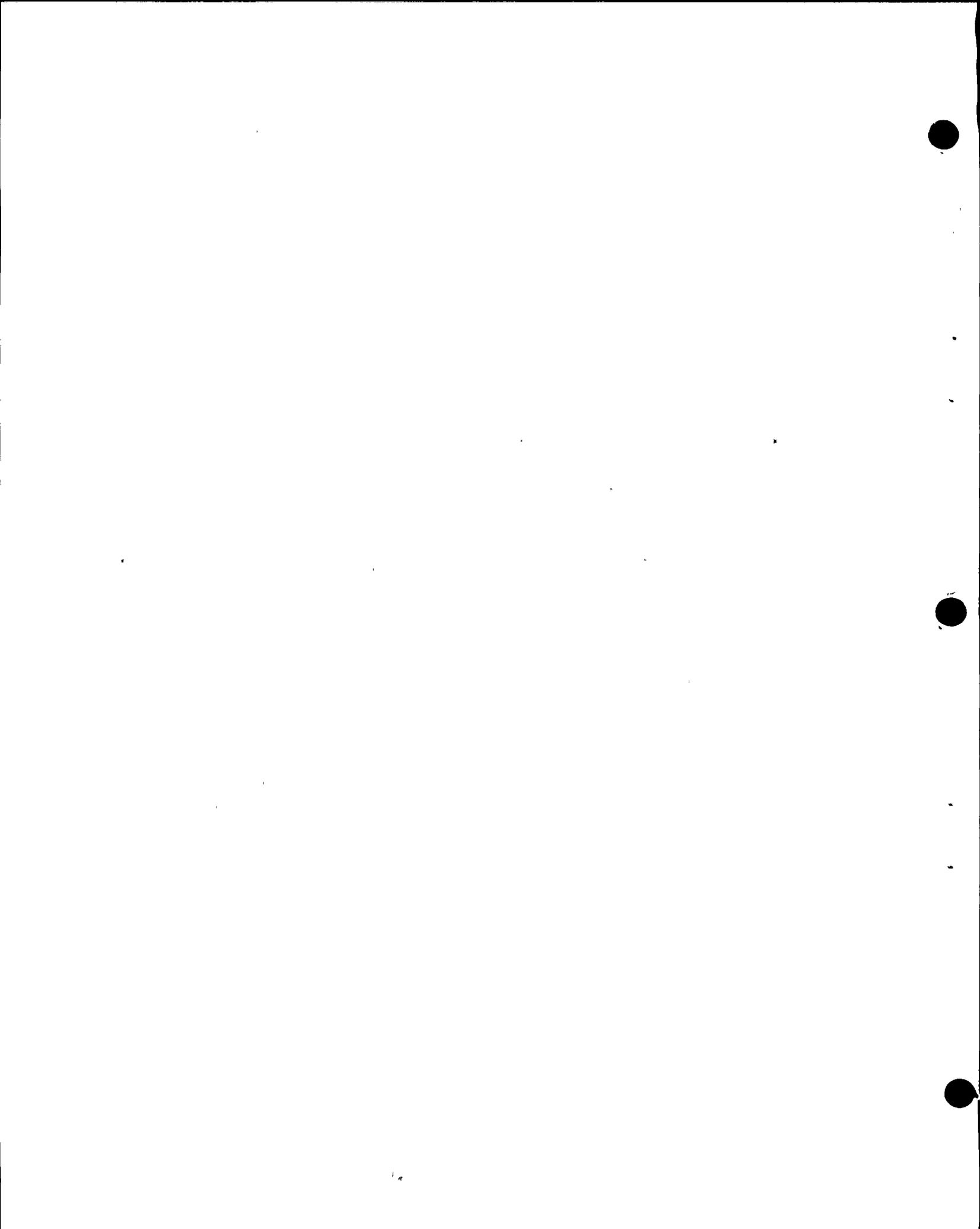
10 I think one has to stay, to be conservative, to
11 stay with the original assumptions that we made, namely,
12 that the geologic record primarily of the last 17,000 years
13 is the single most important line of events we have for
14 the rate of tectonic or earthquake activity in the region.
15 And I stay with that, no question.

16 Q Notwithstanding the fact that we have a fault
17 discovered only within the 10 years, most of which is under
18 water?

19 A Clearly -- the question is, do I stay with that
20 assumption?

21 Q Do you find that that kind of evidence, the
22 evidence that we have dug up regarding offset is -- what kind
23 of real liability should be placed on that?

24 A Well I think it is just fine that it's covered
25 with water because it makes it possible for us to get good



agb2

1 measurements of the type that we might not get if it were
2 exposed on land. And it's particularly important that the
3 record of displacement has been preserved on the sea floor,
4 has been removed from the influences of erosion during
5 the last 17,000 years.

6 Q So is it your opinion that if this--without the
7 area of your expertise, let me know -- is it your opiho
8 that seismic reflection profiles give us a better sense of the
9 displacement than trenching, as for example Carry Sieh has
10 done on the San Andreas?

11 A In certain instances I would say that's true.
12 For the Ssn Andreas with a record of large
13 earthquakes, that may not be -- I would depend more heavily
14 on the trenching because that enables us to see other geolo-
15 gic effects of shaking during the past.

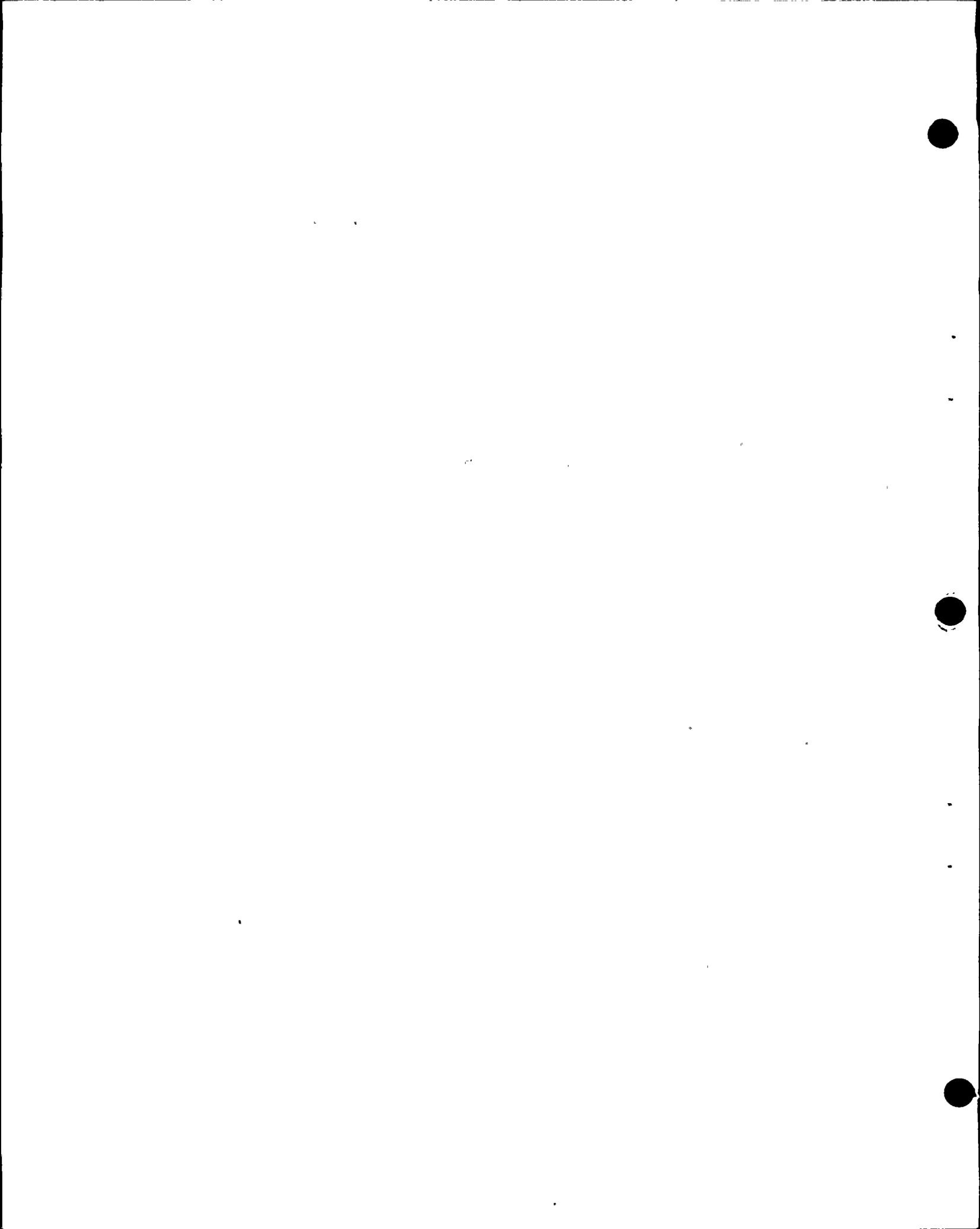
16 Q Let me refine that question: Is it your opinion
17 that observations we can make about offset on faults that
18 might demonstrate, over their history, significant horizontal
19 offset, have a right lateral sense of motion -- Strike that.

20 Is it easier to determine horizontal offset
21 through the seismic reflection profile than on land, when you
22 have the fault on land?

23 A Repeat that, please?

24 Q Okay.

25 Is it your opinion that the estimates we have



aqb3

1 regarding horizontal offset drawn from seismic reflection
2 profiles are as accurate as estimates regarding horizontal
3 offsets drawn from stratigraphic relationships for faults
4 on land?

5 A I think you're mixing up two different techniques.

6 The heart of your question is, I think, are we
7 paying a penalty for having the fault underwater, is that
8 what's bothering you?

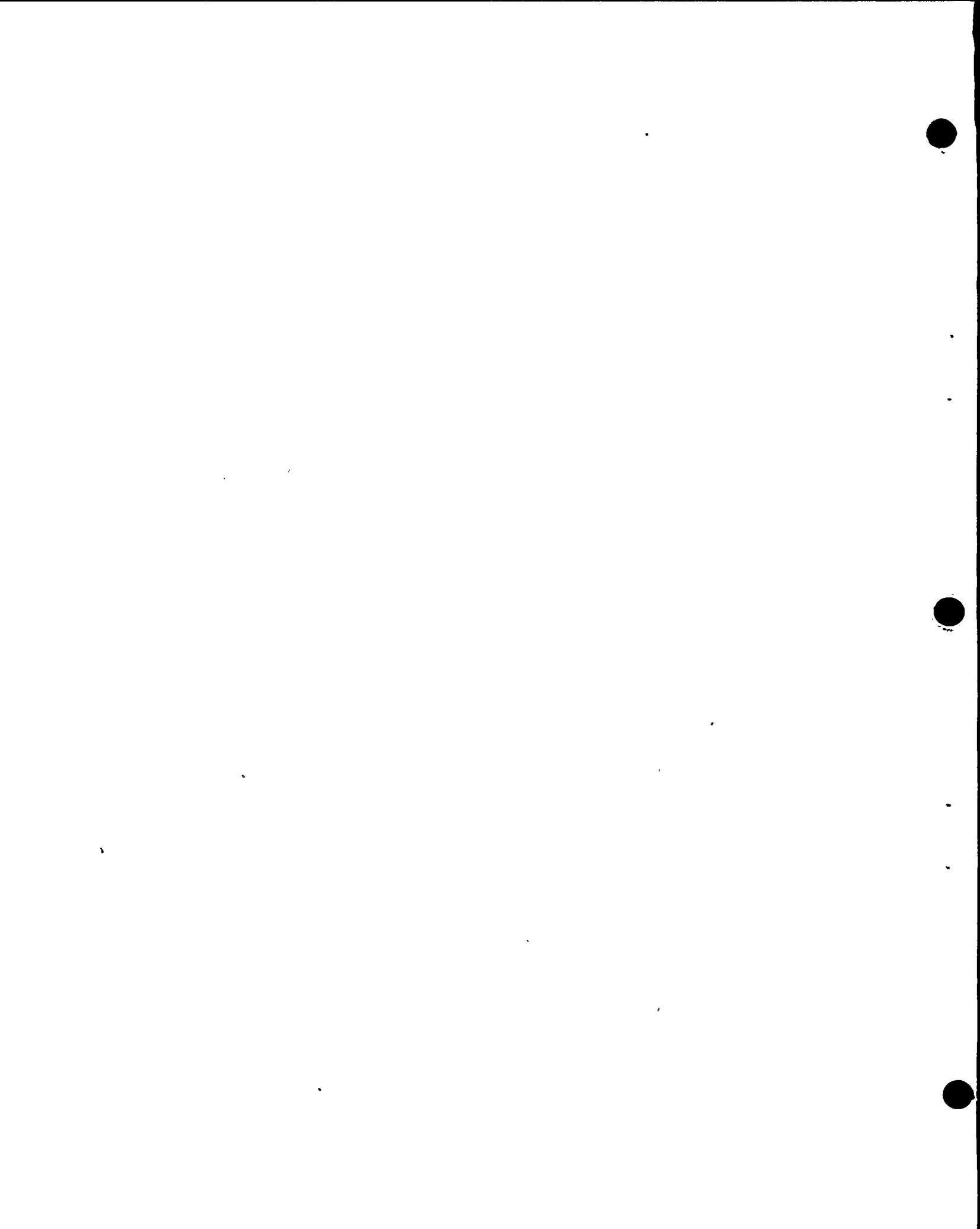
9 Q Right.

10 A I have an opinion about that, but I suspect that
11 Mr. Hamilton's opinion might be more valid so I would like
12 to hear his response to that.

13 A (Witness Hamilton) Well as I've listened to
14 this discussion, it seems to me there are several issues
15 involved and some of them seem to be of a more general
16 hypothetical case and some seem to relate more specifically
17 to the case of the Hosgri Fault, as we are able to examine
18 it through seismic reflection profiles.

19 I think it is perhaps most important here to
20 look at the Hosgri Fault itself, since that's the feature
21 that is being considered as the generator of the earthquake
22 And the earthquake that might be generated has been assessed
23 partly on grounds of the amount of offset that we are able
24 to discern on the Hosgri Fault.

25 In making an examination of any fault any place



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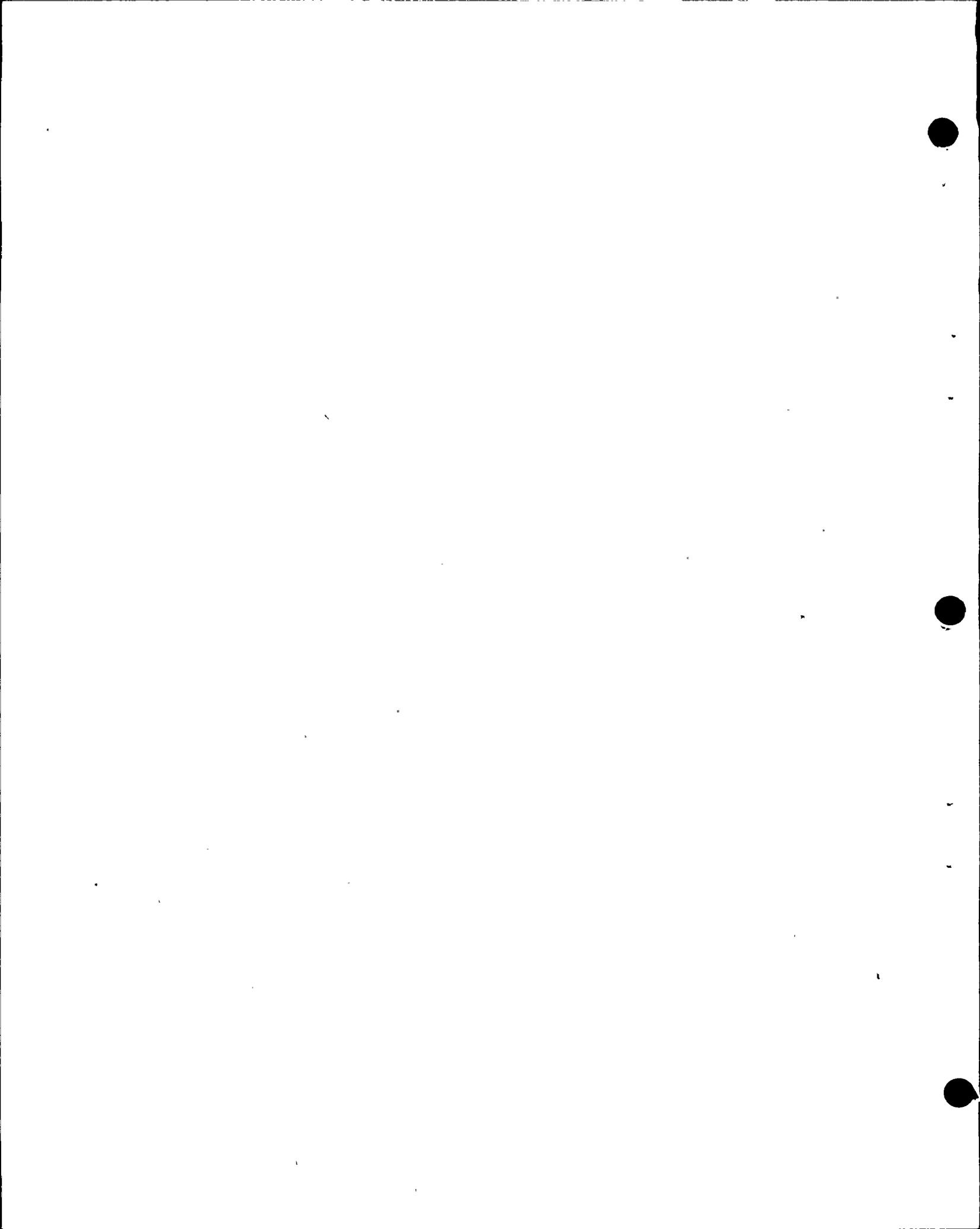
1 by any technique, I think it's very important to consider
2 all that we know about that fault and about the setting
3 within which it exists.

4 Now in the case of the Hosgri Fault, we have a
5 lot of seismic profiles that cross it. And I'm afraid that
6 a misimpression may have been left from earlier testimony
7 that related only to what can be seen on one seismic profile
8 of whatever resolution across the fault that we have, there-
9 fore, no gauge as to what lateral slip there might be as
10 opposed to the vertical slip that is more specifically re-
11 corded in a particular seismic profile.

12 In fact, I testified earlier that in actual
13 nature that we don't find examples, I think, of any significant
14 amount of lateral slip that might exist without some vertical
15 dislocation or distortion also occurring.

16 Thus, I think it's outside of geologic experience
17 to suggest that a large amount of lateral slip might exist
18 along the Hosgri Fault in places where we see no vertical
19 distortion at all. And to suppose that there might yet be in
20 that area a large amount of post-Wisconsin lateral slip,
21 that just doesn't accord with what I believe is known from
22 all land exposures where we can examine both the horizontal
23 and the vertical record directly.

24 Secondly, to look at the totality of knowledge
25 that we have about the Hosgri Fault, we have not only to

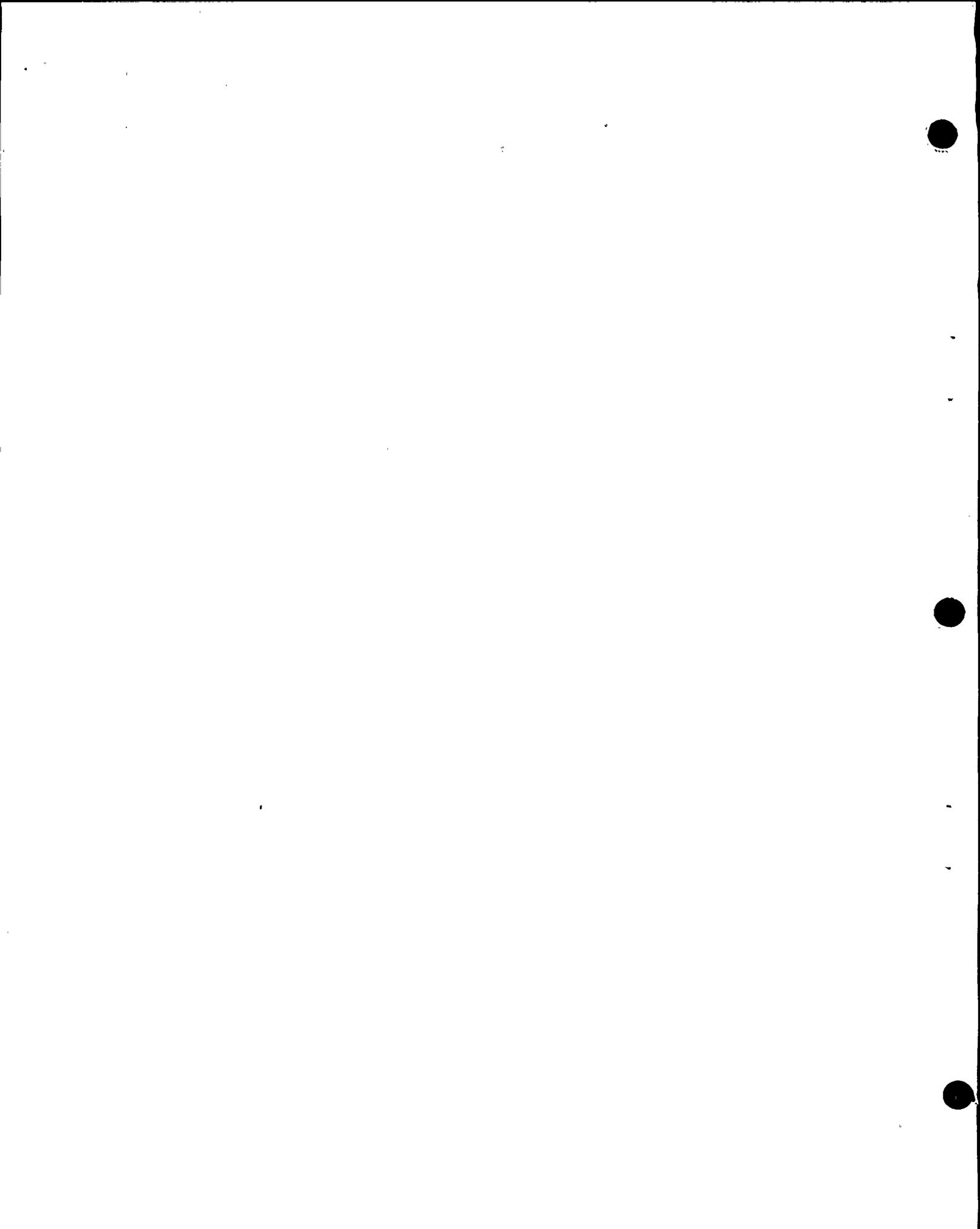


agb5

1 consider any individual seismic reflection profile, but we
2 have to take into account what else we know about that
3 individual fault, that fault zone and the whole system of
4 faults that runs along the coast.

5
6 And what we know from that, what we know about
7 that includes rather consistent evidence from the focal
8 mechanism solutions that Dr. Smith and Dr. Bolt discussed
9 yesterday which tell us that with all the records we have
10 there's always a component of vertical movement that is a
11 significant part, as well as a component of right lateral
12 movement that is a significant part of movement on that
13 fault and faults in that area when they move to great
14 earthquakes.

15 Beyond that, and more specific to my area of
16 expertise, we have a number of exposures that allow us to
17 examine directly the way in which other faults along the
18 coast have moved, and these include at least three points
19 or four points, rather, at which we can see relatively young
20 movements, by that I mean late-Pleistocene movements in the
21 San Simeon Fault area, at least two or three good exposures
22 where we see the last movement -- and here, let's say, we
23 can see what the last movement that took place, be it late-
24 Pleistocene or earlier, along faults in the San Simeon area,
25 along faults in the Sur area and along faults in the San
Gregorio area. And they all have a large fraction of vertical



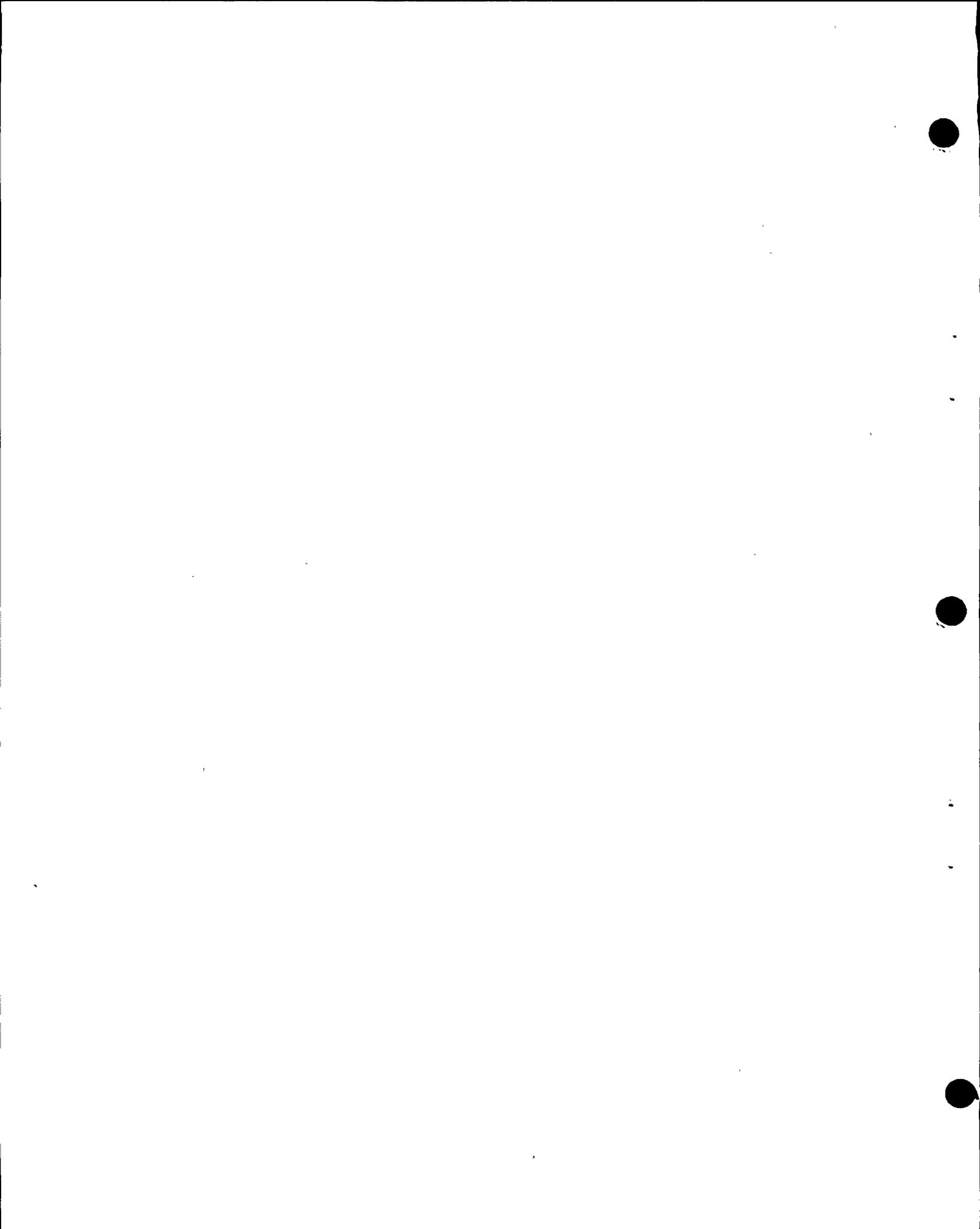
aght

1 component to them.

2 You can get right in along the fault zone,
3 you can see the orientation of fabric caused by slickensiding
4 and you can see that there's a big component of vertical
5 movement.

6 And that tells me that--if a fault like the
7 San Gregorio that is generally recognized as having a
8 significant component of lateral slip, when you look at it
9 also has vertical slip--that it's certainly not reasonable
10 to expect that a fault like the Hosgri would not also have
11 a component of vertical slip.

12 Consequently, I think that we can say with a
13 great deal of confidence that when we do see movement on
14 the Hosgri as expressed in a vertical offset seen in a
15 seismic reflection record, then we can be confident that
16 that's not just part of a larger horizontal component
17 of movement, rather, that the horizontal movement is prob-
18 ably there, but it probably doesn't much exceed in magnitude
19 the vertical movement that we can see -- in places where we
20 don't see any vertical movement at all particularly along
21 the number of crossings, that we have good reason to think
22 that no movement at all has taken place during the time of
23 record that the seismic reflection allows us to see, which
24 is about 17,000 years or somewhat younger in some parts of
25 the zone.



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A (Witness Smith) I would have given a simpler answer, namely, that I think if we had the Hosgri available to trench, we probably would miss it in the trenches that we dug, you probably would not see any record of anything going on.

Q Well, rather than cross-examine Mr. Hamilton's answer, I would refer the Board to the four days of cross-examination.

But I do have one question, Mr. Hamilton. The vertical movement that you observe in the slickensides at San Simeon, you mention something about that, correct?

A (Witness Hamilton) Yes, I just did.

Q Okay. What's the date of those rocks?

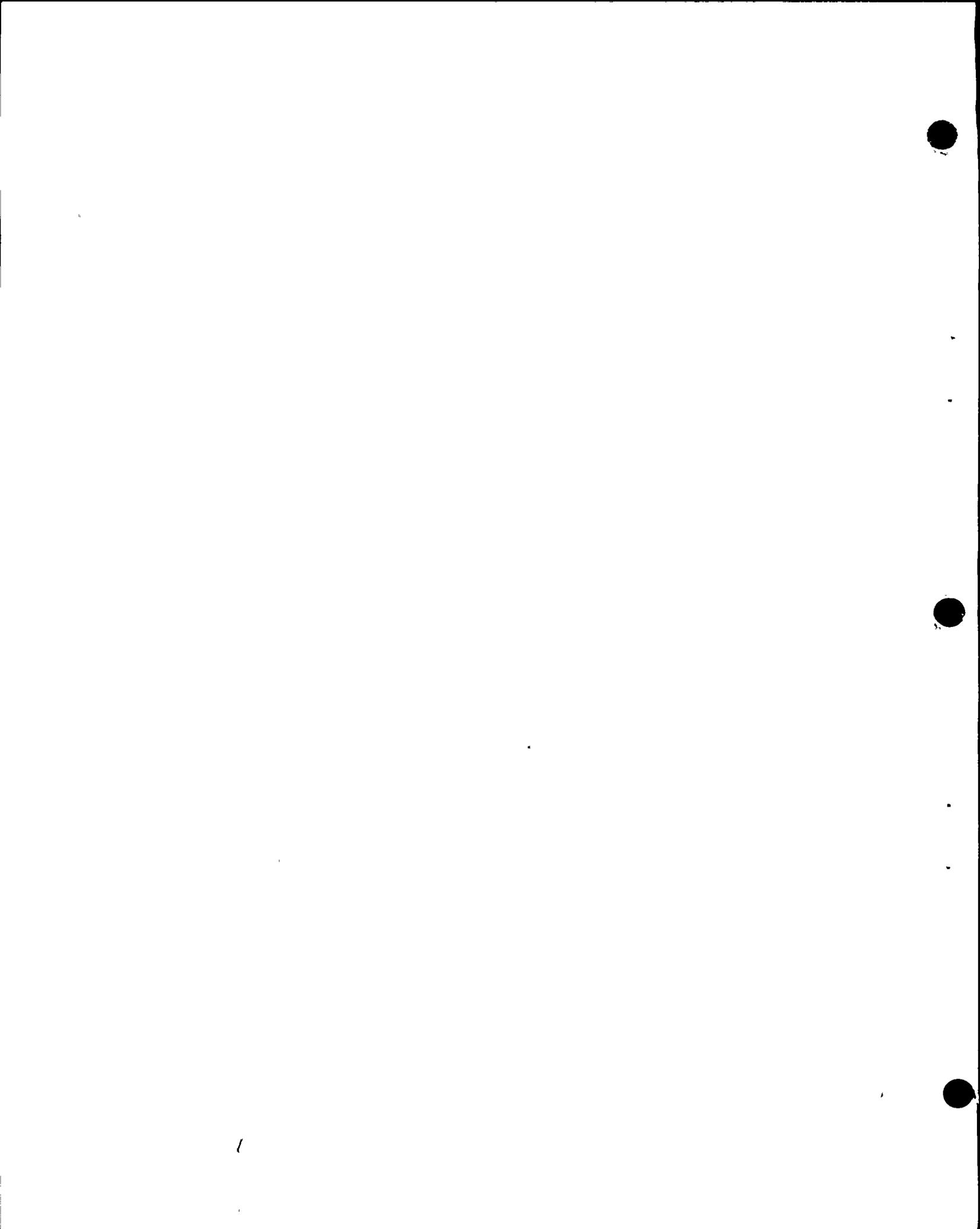
A The rocks that I see the movement in are quite old.

Q How old?

A Well, one of the best exposed -- let me give you a range.

The vertical movement that we see there is in terrace deposits that may be as young as of the order of 100,000 years, back to rocks that are much older on the order of more than 100 million years.

But let me add to the significance of the age of the rock here: if the fault is confined within a body of rock, and the rock records the orientation of the last



agb8

1 movement of the fault -- and so the rock may be 100 million
2 years old, but the last movement of faulting of any age is
3 the movement that you see indicated by the pattern of
4 slickensiding or other linear fabric elements along the
5 fault zone in that rock.

6 And I am speaking now of exposures of rock that
7 are along the main part of the fault zone or along the
8 youngest breaks that have been identified. I neglect the
9 many other old fault breaks that can be seen contained within
10 the rock, I'm only speaking about either young breaks or
11 breaks that are along the main zone.

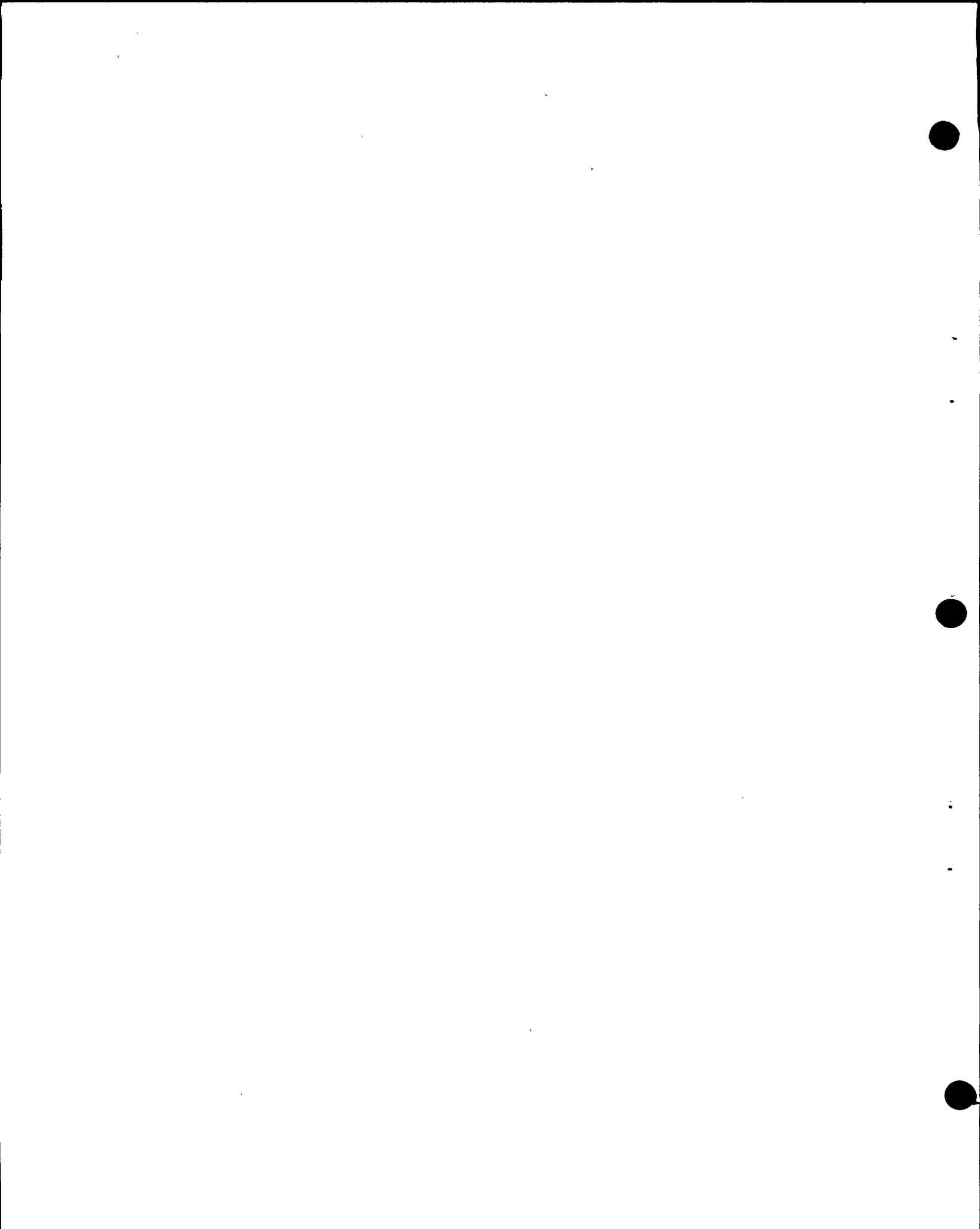
12 Q How did you select that as the main zone?

13 A I did that on the basis of mapping that was
14 performed by my associates and myself in 1974 and comparing
15 that with the corresponding mapping that was done by Dr.
16 Clarence Hall in 1975.

17 There are definite criteria that allow you to
18 identify where the principal displacement has taken place
19 along the San Simeon Fault. Really Dr. Hall --

20 Q You mean you relied on Dr. Hall for something?

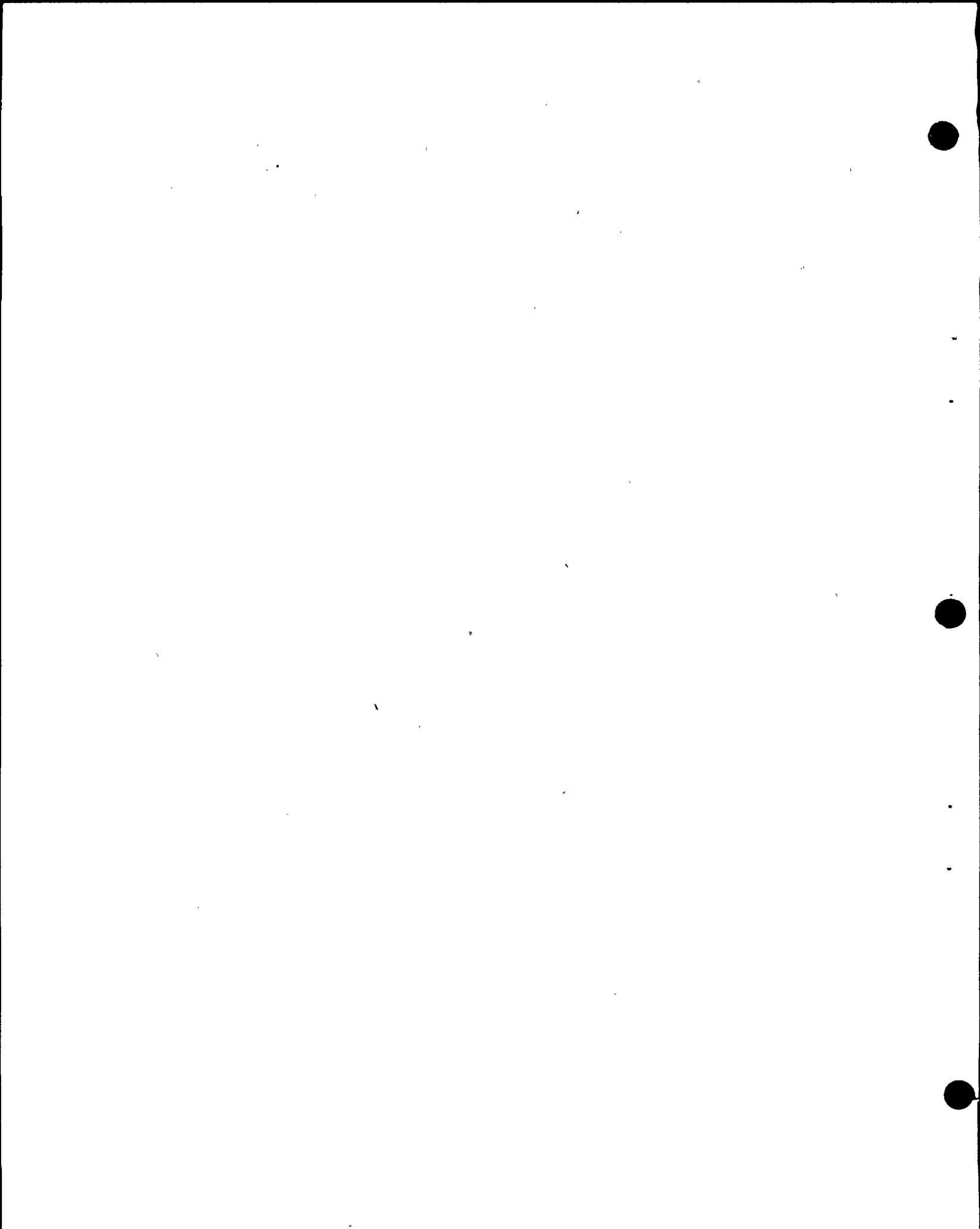
21 A Well actually Dr. Hall relied on us, but he
22 didn't come up with answers that were any different after
23 he had gone out and, I presume, done his independent work.
24 If you compare his map with our map you'll find that the
25 fault zone, or the fault pattern, looks essentially the same.



1 And I might add that I've relied on Dr. Hall's
2 writings for many things. And only in a case where I find
3 a real inconsistency in some conclusion do I then come to
4 not rely on some portion of them.

5 Q Okay. I think we've gone rather far afield.
6 Let's come back to the method that is outlined in Section E,
7 I believe.

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end2E



1 Now you've determined a recurrence interval for
2 this 6.5 magnitude event in the region of the Hosgri. Is that
3 correct?

4 A (Witness Smith) Yes.

5 Q Okay.

6 And then you plugged that into your relationships
7 between surface magnitude and moment, and you say that on the
8 other side is total average slip, consistent with that which
9 Mr. Hamilton has observed.

10 A Yes.

11 Q Is that an estimate of the maximum earthquake
12 potential of the region?

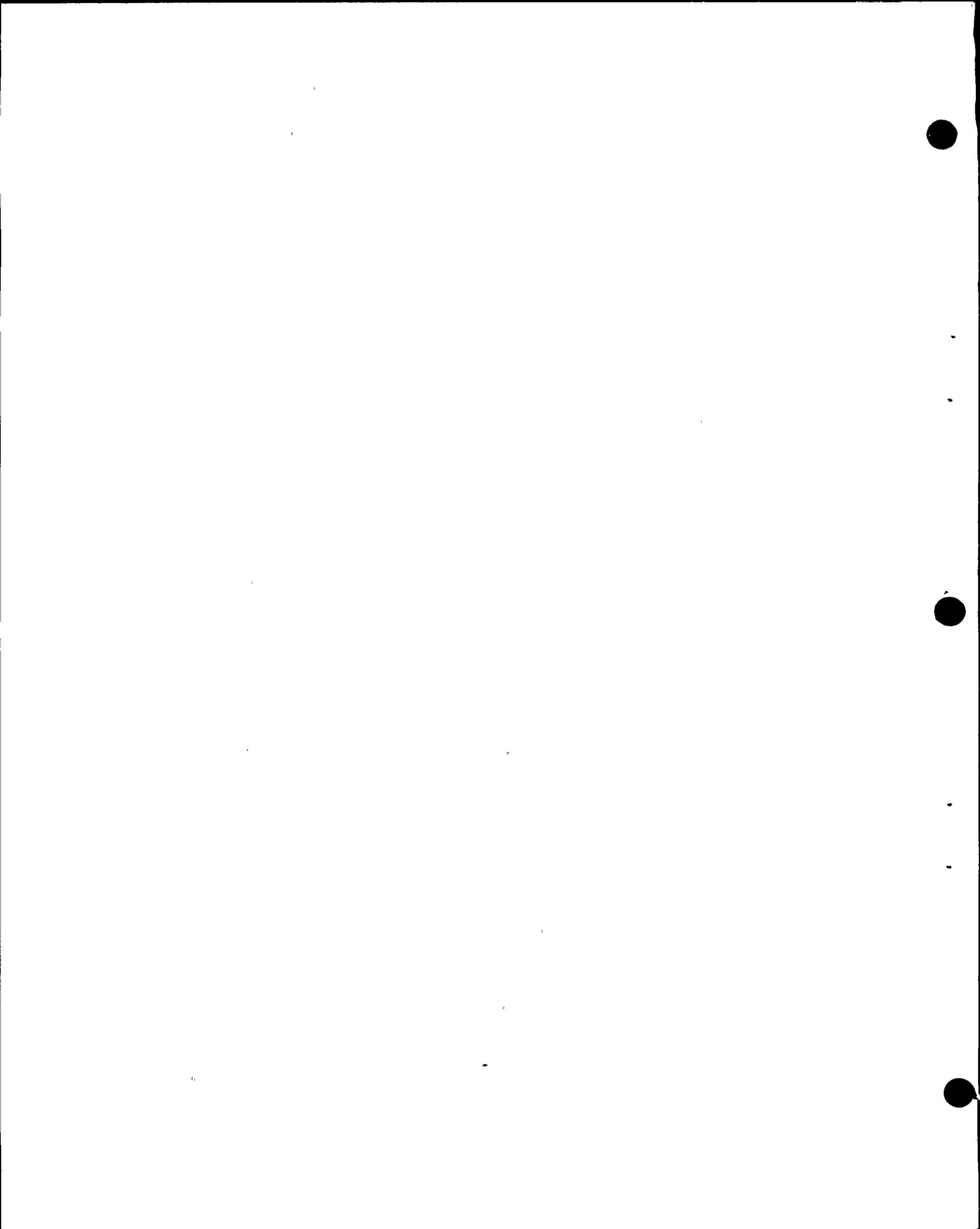
13 A Yes.

14 Q Well, that estimate would break down, would it
15 not, if either side of that relationship was found to be un-
16 certain or -- excuse me -- the uncertainty in the estimate
17 would necessarily reflect the uncertainty in either side of
18 that equation, would it not?

19 A Would you restate that again?

20 Q Would the certainty of your conclusions with
21 regard to the maximum earthquake potential depend upon the
22 certainty that you could attach to the recurrence interval
23 that you place on the 6.5 earthquake?

24 A Well, it would appear from the question that you
25 are trying to -- you are assuming that I am presenting a



eb2

1 procedure to determine the maximum earthquake and I, a moment
2 ago, responded that I thought the procedure that I described,
3 assuming a magnitude of a certain level and showing it was
4 consistent with the geologic and seismic record, that that
5 did in fact yield an estimate of the maximum potential earth-
6 quake for the region.

7 Q Yes, that's how I understood your testimony, so
8 let me repeat my question.

9 Doesn't that estimate-- Isn't that estimate a
10 function of the certainty that you can place on this
11 recurrence interval assigned to the 6.5 magnitude earthquake?

12 A Well, I would simply say that changing the
13 recurrence interval would lead to different conclusions regard-
14 ing the slip.

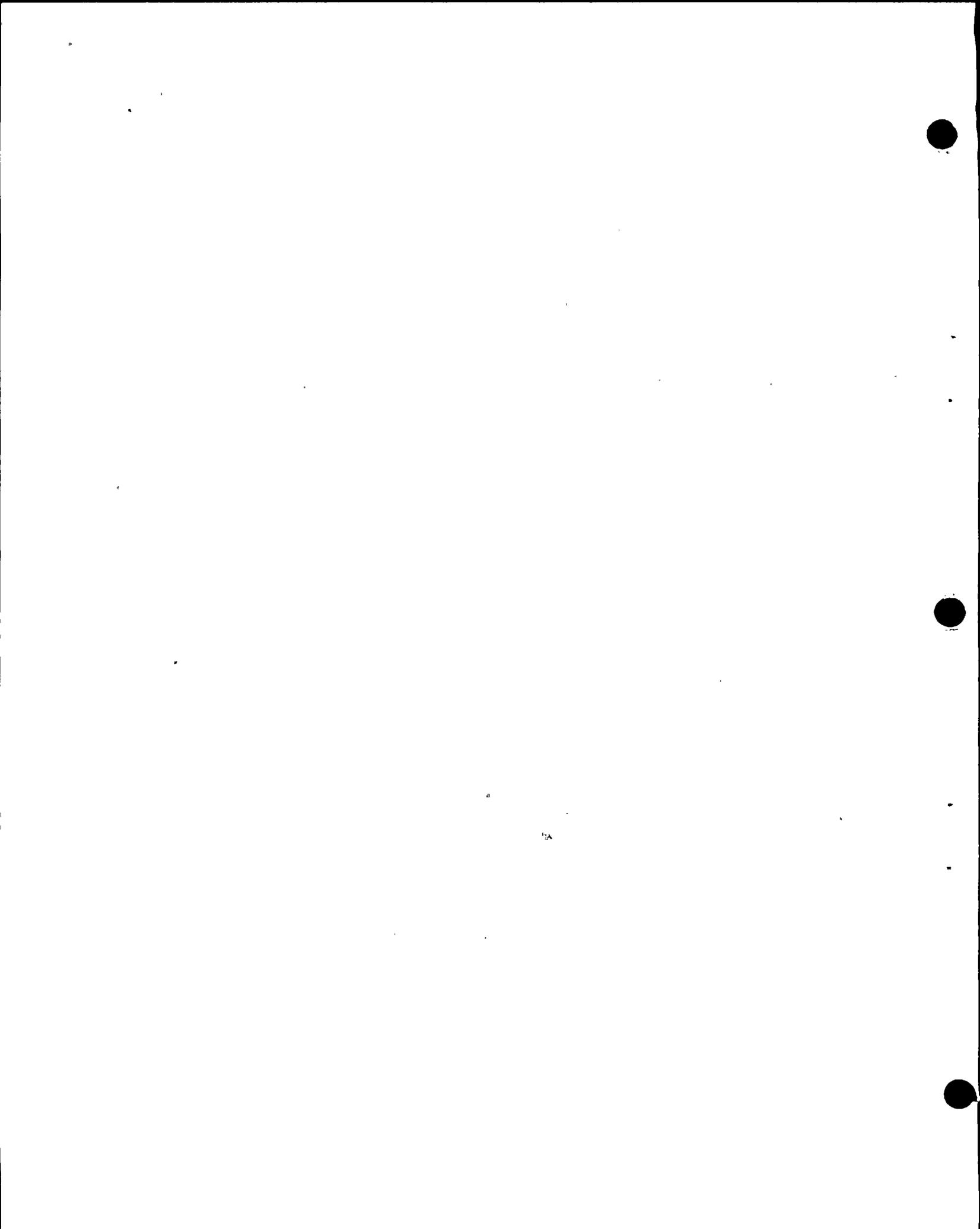
15 Q Okay.

16 A Perhaps you could make a hypothetical.

17 Q I don't think so.

18 Let me direct your attention to something else
19 you have written; at the top of page 15 of the PSAR you wrote:

20 "The fundamental premise taken here
21 is that the seismic history of California over
22 about 200 years is too short an interval from
23 which to determine the maximum earthquake possible
24 on various faults, and empirical relationships
25 between fault length and magnitude are not well



eb3

1 enough defined to provide useful estimates."

2 Now with respect to your comments there on
3 utilizing seismic history to determine maximum earthquakes ---

4 A I find that consistent with the view that I'm
5 taking now.

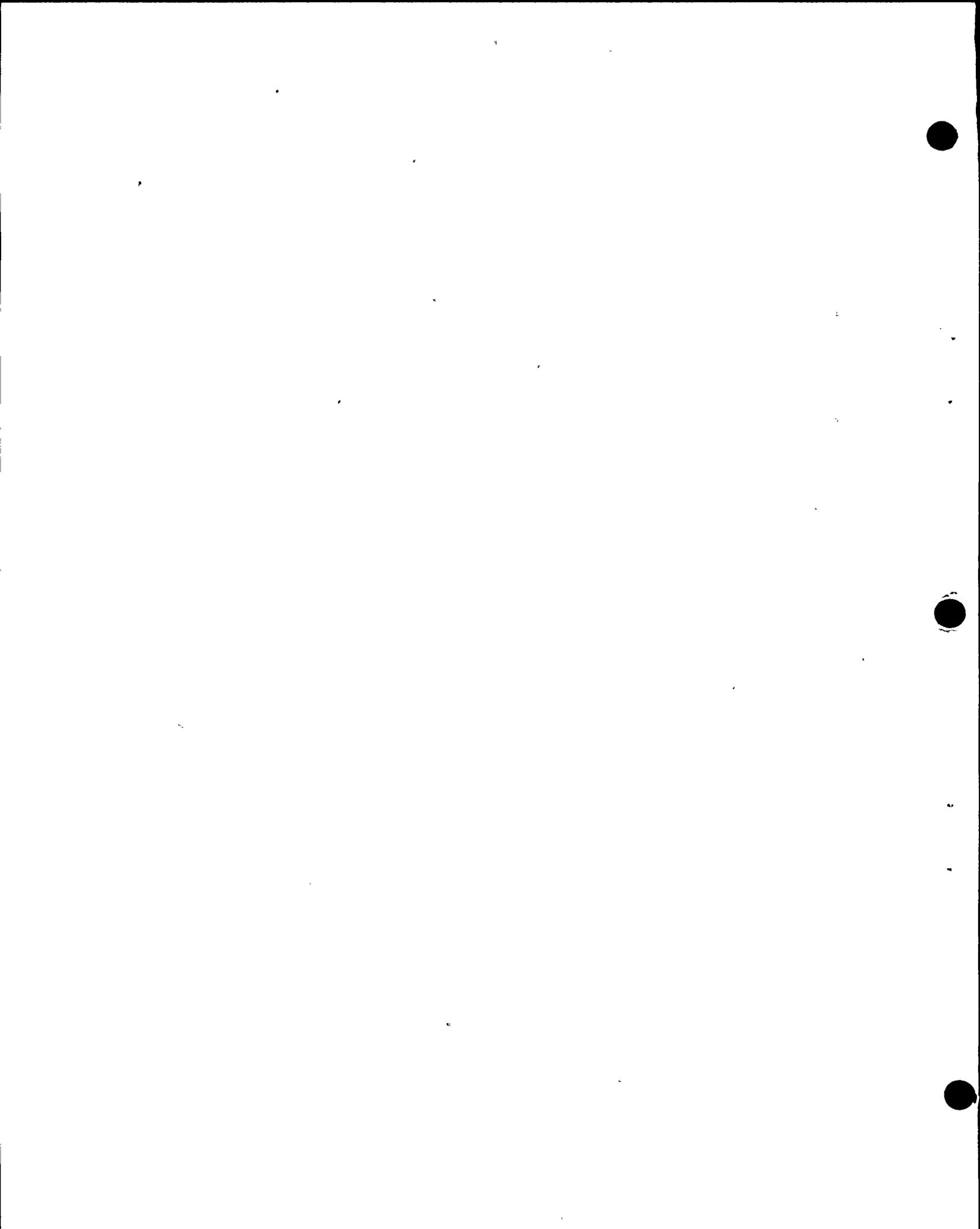
6 Q Okay.

7 What is your opinion on utilizing a seismicity
8 model that has as its data base 50 years of recorded observa-
9 tions to determine the recurrence interval for earthquakes of
10 various magnitudes?

11 A I think it is an excellent method for characteriz-
12 ing the recurrence interval of those size earthquakes which
13 have already occurred and are in the statistical sample. The
14 entire problem comes in how one can extrapolate that
15 result to larger magnitudes for which there have been no
16 occurrences, and the only way to determine whether there may
17 have been larger occurrences beyond our historic and pre-
18 historic record is to see what the geological effects are.

19 But I think the representation of the statistics
20 of earthquakes in the range where there is data is quite a
21 legitimate one.

22 Q Well, the conclusions you reached then could be
23 off substantially if the time period -- if a significant
24 earthquake within the region of interest falls without the
25 time period chosen.



eb4

1 MR. NORTON: Object. That's not a question.
2 It's a statement by Counsel.

3 BY MR. FLEISCHAKER:

4 Q Could it not?

5 MR. NORTON: That doesn't make it a question
6 either. It makes is a compound question.

7 MRS. BOWERS: I would like to ask you again to
8 hold correction following objection until we have an oppor-
9 tunity to consider it. I assume when the other Counsel are
10 involved, the purpose will be to respond to the objection
11 rather than to clarify or to move on.

12 So do you want to respond to the objection?

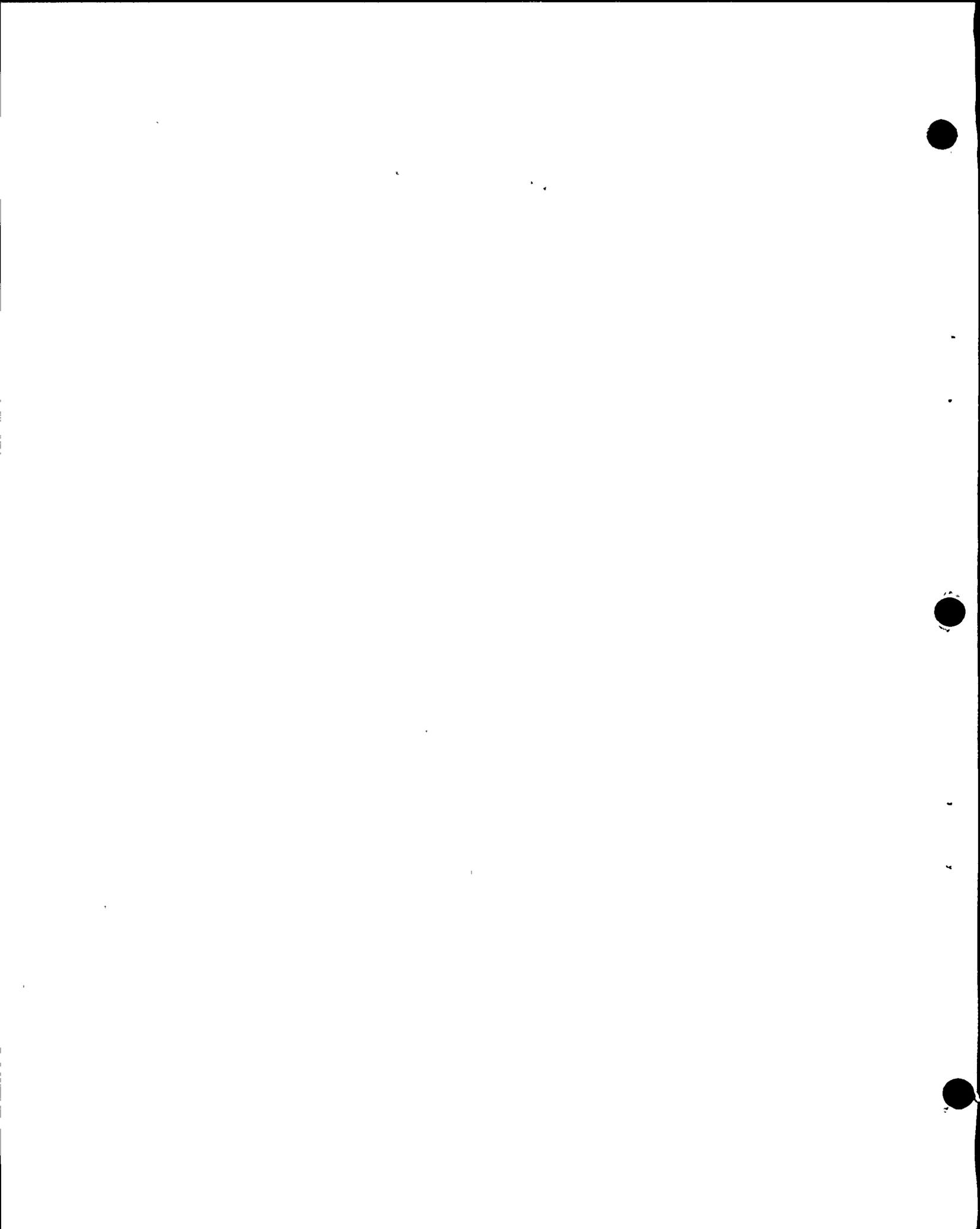
13 MR. NORTON: Mrs. Bowers, may I make a sugges-
14 tion first?

15 I was thinking about asking for a bench con-
16 ference when we finish this morning, but I think we can do
17 this very quickly now.

18 MR. FLEISCHAKER: I would like to get on with
19 this line of questioning.

20 MR. NORTON: I have been as guilty as
21 Mr. Fleischaker and I think Mr. Tourtellotte has, too. When
22 we object it seems to me we should get an immediate ruling
23 from the bench because if the ruling is "Objection overruled,"
24 the argument from everybody else is just wasted time.

25 If the ruling is "Objection sustained," then the



eb: 1 person whose question was, you know, not allowed should of
2 course have the opportunity to explain to the court or to the
3 bench why he wants -- you know, why he wants to proceed in
4 that fashion.

5 But it seems to me we spend a lot of time arguing
6 where, you know, you're going to overrule me anyway, and I
7 don't know why we have to go through this argument each time.
8 And I'm as guilty of it. I'm not pointing any fingers. I'm
9 as guilty of it as anybody else.

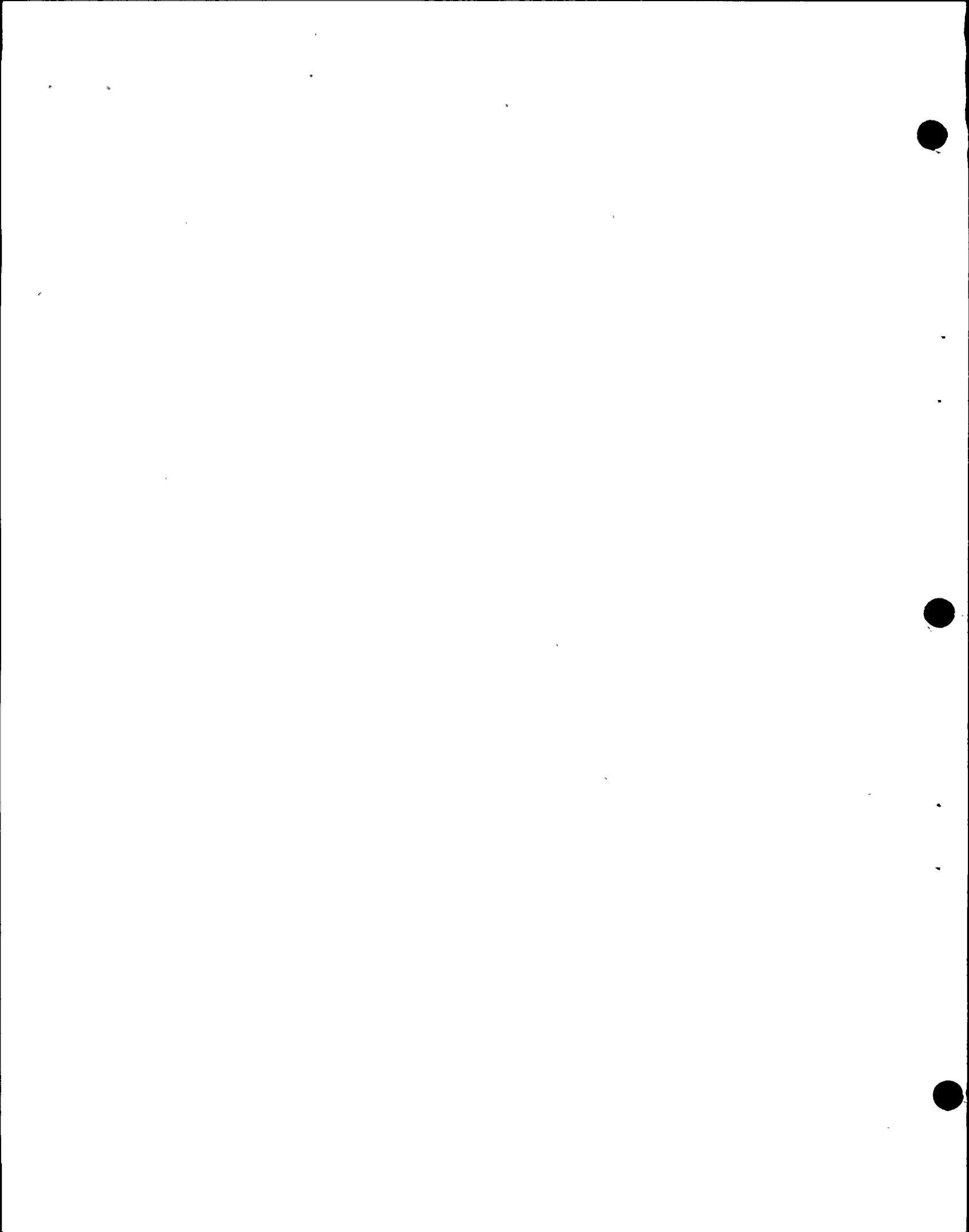
10 I just think it would be a much faster way to
11 proceed -- When the objection is made, if the bench would
12 rule and overrule the objection, the all the rest of the
13 conversation is wasted, and if it is sustained, then I think
14 it's appropriate for the other Counsel to comment if they want
15 to.

16 MRS. BOWERS: Well, I've always proceeded the
17 other way, with the idea that if there's an objection, there
18 should be a basis stated for the objection, and the person
19 that it is addressed to should have an opportunity to respond
20 before the Board would rule.

21 MR. NORTON: Well, but if you're going to over-
22 rule the objection they don't need the opportunity to respond.

23 MRS. BOWERS: We don't know until we hear from
24 them.

25 MR. STAENBERG: It would seem to the Staff that



eb6

1 it is within the discretion of the Board to decide whether
2 it wants to hear arguments from the various Counsel or
3 whether it wants to summarily rule on the objection without
4 hearing response by the other attorneys.

5 MR. NORTON: Absolutely. I was just offering it
6 as a suggestion to speed up a little bit.

7 MRS. BOWERS: I don't want to say I've always
8 done that because some objections are so clearly established
9 that, you know, you don't need to proceed with comments from
10 the other parties.

11 MR. FLEISCHAKER: Where are we?

12 MR. NORTON: I objected to the question, and I
13 believe you were giving Mr. Fleischaker an opportunity to
14 respond.

15 MR. FLEISCHAKER: I withdraw the question.

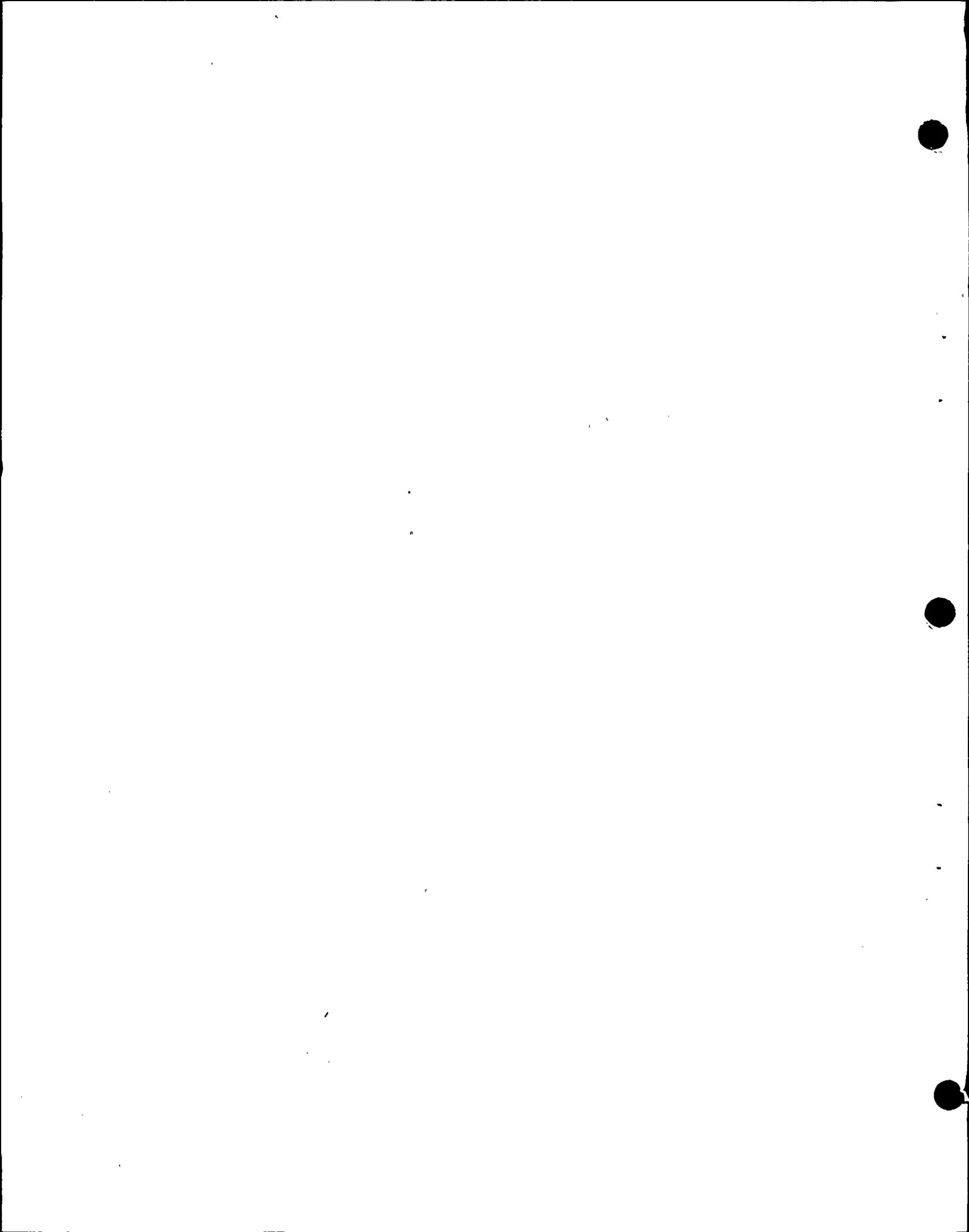
16 I would like to have the question back though.

17 (Whereupon, the Reporter read from the record
18 as follows:

19 "Well, the conclusions you reached
20 then could be off substantially if the time period --
21 if a significant earthquake within the region of
22 interest falls without the time period chosen.")

23 BY MR. FLEISCHAKER:

24 Q Dr. Smith, how would your conclusions change
25 regarding the recurrence interval of a given earthquake if the



eb7 1 period of time you chose from which to draw your data excluded
2 an earthquake of a larger magnitude than that which was in
3 the data base and which could conceivably be in the area of
4 interest?

5 MR. NORTON: Object; multiple.

6 MRS. BOWERS: Objection sustained.

7 Could you separate that out, Mr. Fleischaker?

8 BY MR. FLEISCHAKER:

9 Q Dr. SMith, how would your conclusions regarding
10 the recurrence interval of a 6.5 magnitude earthquake change
11 were your data base to reflect a 7.3 earthquake?

12 A (Witness Smith) I don't believe there would be
13 a significant change because we're talking about the addition
14 of one data point out of hundreds of thousands, and I don't
15 believe it would significantly change the form of the function.

16 Q Did you say hundreds?

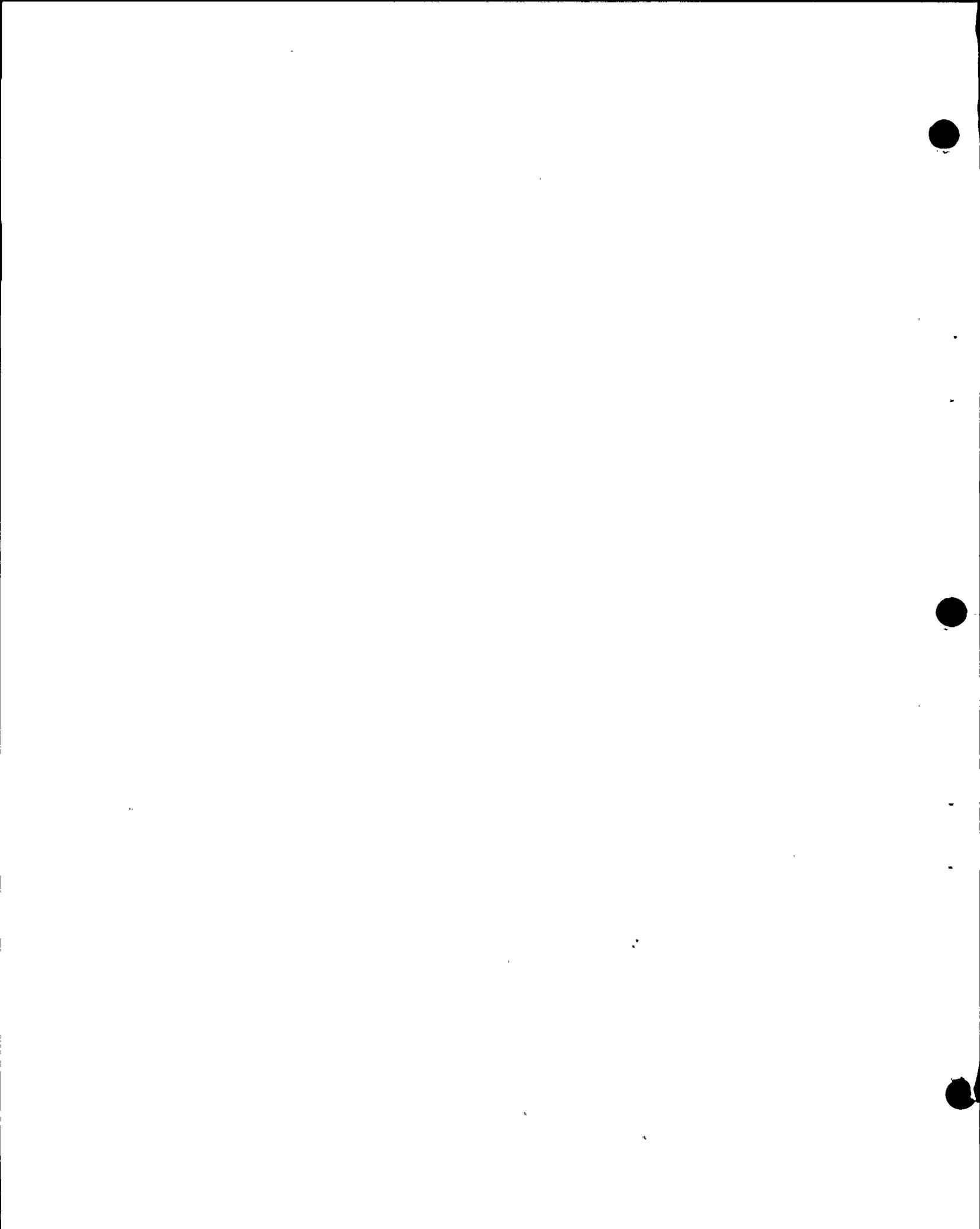
17 A I said hundreds of thousands of earthquake data.
18 For example, there are that many earthquakes in the California
19 catalogue.

20 Q How many earthquakes-- Let me ask you-- Strike
21 that question.

22 How many earthquakes did you include in your
23 calculations?

24 A Between four and five hundred.

25 Q Where did you get-- Do you have an opinion as to--



ec8 1 Strike that.

2 Have you done a calculation to determine how your
3 recurrence rates would change if you included the 7.3 earth-
4 quake in your data base?

5 A No.

6 Q What is the basis for your opinion that the
7 recurrence rate would not change much?

8 A Well, my opinion is based on the experience I
9 have with fitting recurrence curves to distributions of
10 earthquakes, and there are a variable number of data points
11 for different size earthquakes. And typically the fit is a
12 very good one at the lower magnitudes and there is a great
13 deal of scatter at the larger magnitudes, simply because one
14 is dealing with the statistics of small numbers.

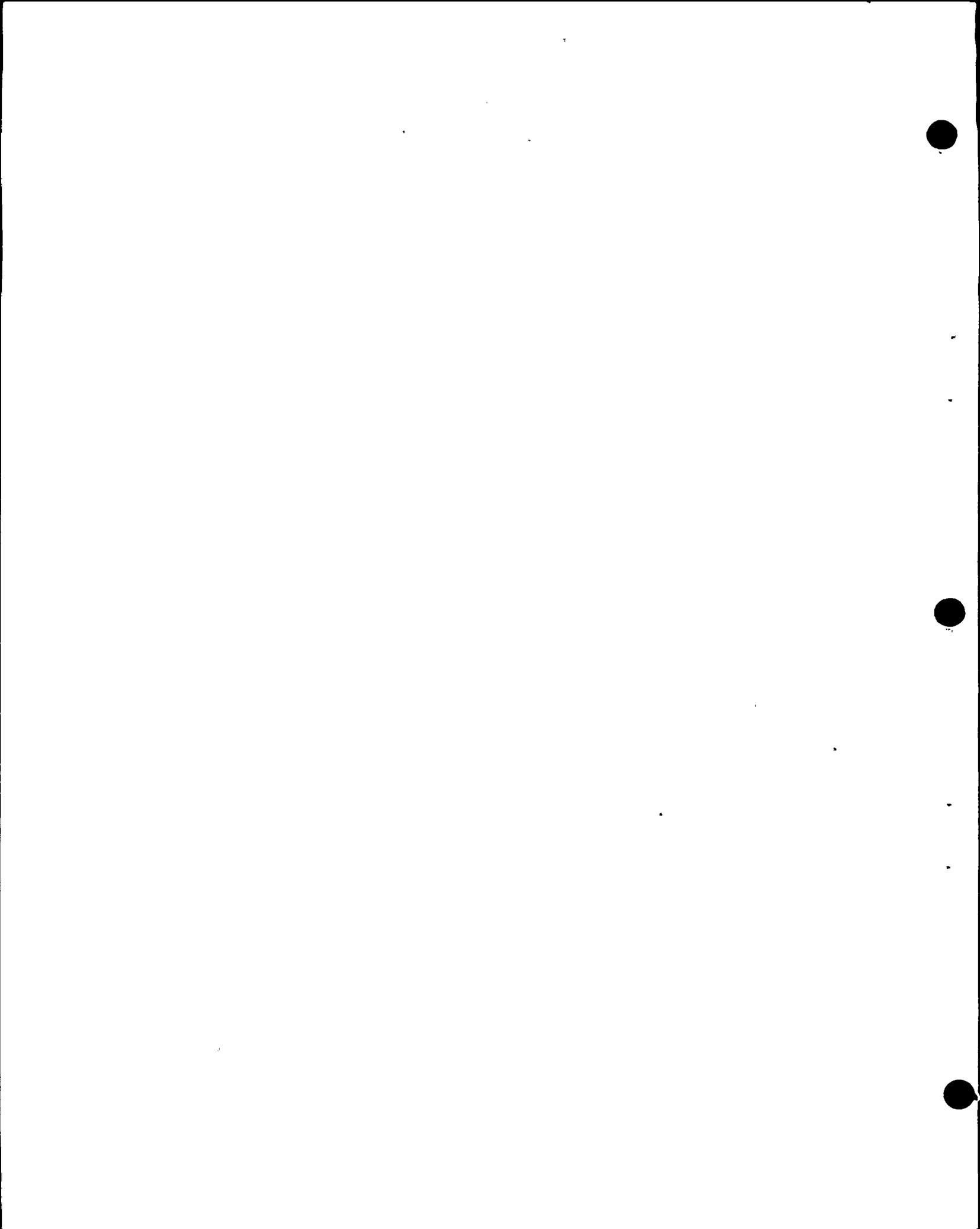
15 And so that's the basis of my opinion of saying
16 the addition of one earthquake at the upper range would not
17 greatly affect the position or the slope of the curve.

18 Q Are you aware of other scientists who have
19 computed recurrence intervals for different magnitude earth-
20 quakes --

21 A Yes.

22 Q -- for purposes of estimating the maximum earth-
23 quake potential of the region around Diablo Canyon?

24 A To my knowledge, the only application of this
25 type of earthquake statistic has been as input to a



ebs

1 probabilistic seismic risk analysis, the purpose of which is
2 to determine the probability of exceeding certain levels of
3 ground motion.

4 This is a more complex issue which takes into
5 account where the earthquake occurs and how large it is and
6 what the resulting ground motion would be.

7 I'm not aware of anyone who has attempted to use
8 recurrent relationship and extrapolate it to determine what
9 the maximum size earthquake would be; no.

10 Q Are you talking about the Trifunac and Anderson
11 studies?

12 A Yes.

13 Q Isn't the first thing that they have to determine
14 in reaching the question-- Why don't we strike that?

15 MR. FLEISCHAKER: Can we continue after lunch?
16 I know what I want.

17 MRS. BOWERS: Fine. We'll break and resume at
18 one o'clock.

19 (Whereupon, at 12:00 noon, the hearing in the
20 above-entitled matter was recessed to reconvene at
21 1:00 p.m. the same day.)

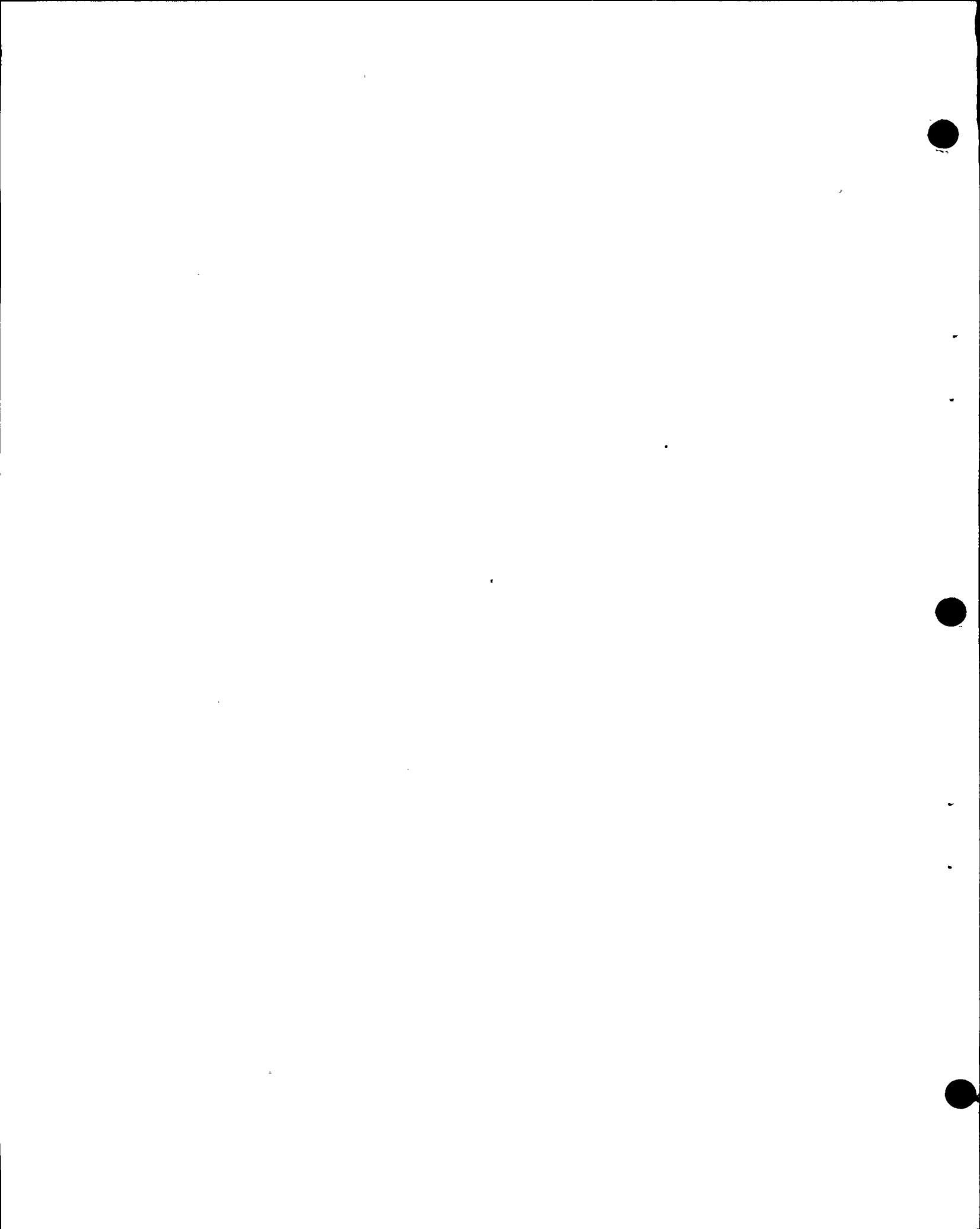
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AFTERNOON SESSION

(1:00 p.m.)

2
3 MRS. BOWERS: We would like to begin.

4 Whereupon,

5 STEWART SMITH,

6 BRUCE BOLT,

7 GERALD FRAZIER,

8 and

9 DOUGLAS H. HAMILTON

10 resumed the stand on behalf of the Applicant and, having been
11 previously duly sworn, were examined and testified further
12 as follows:

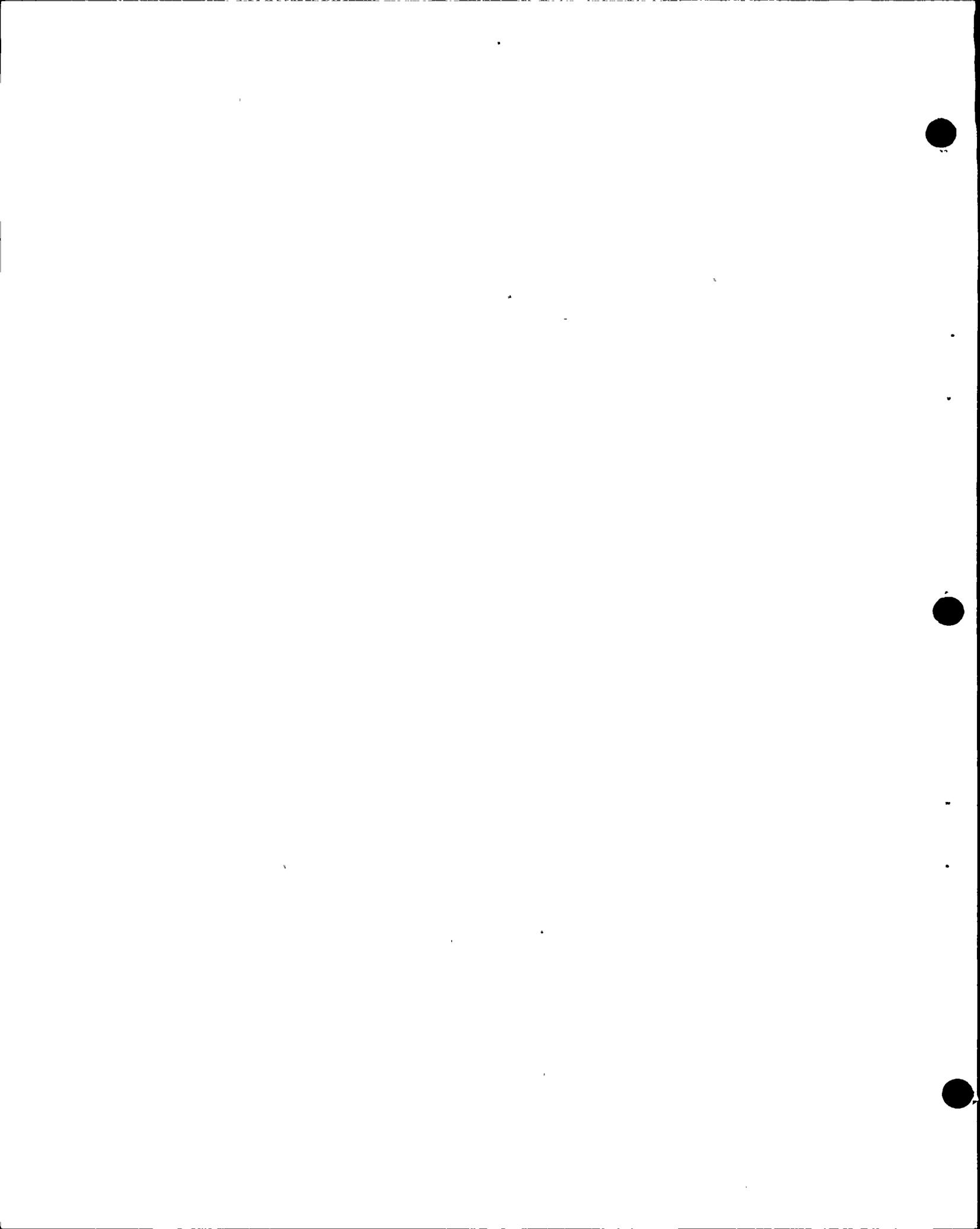
13 CROSS-EXAMINATION (Continued)

14 BY MR. FLEISCHAKER:

15 Q Dr. Smith, before lunch we were discussing the
16 recurrence intervals, and I would like you to-- I asked you
17 some questions about additional data, et cetera, and I would
18 like to explore that a little more thoroughly with you.

19 Before doing that I have a question though.

20 Could you explain briefly how you have computed
21 your recurrence intervals?22 A (Witness Smith) I calculated recurrence intervals
23 in two different ways for this region. The first way was a
24 region primarily of the central California and off the coast.
25 And one simply goes through the catalogue, finding earthquakes



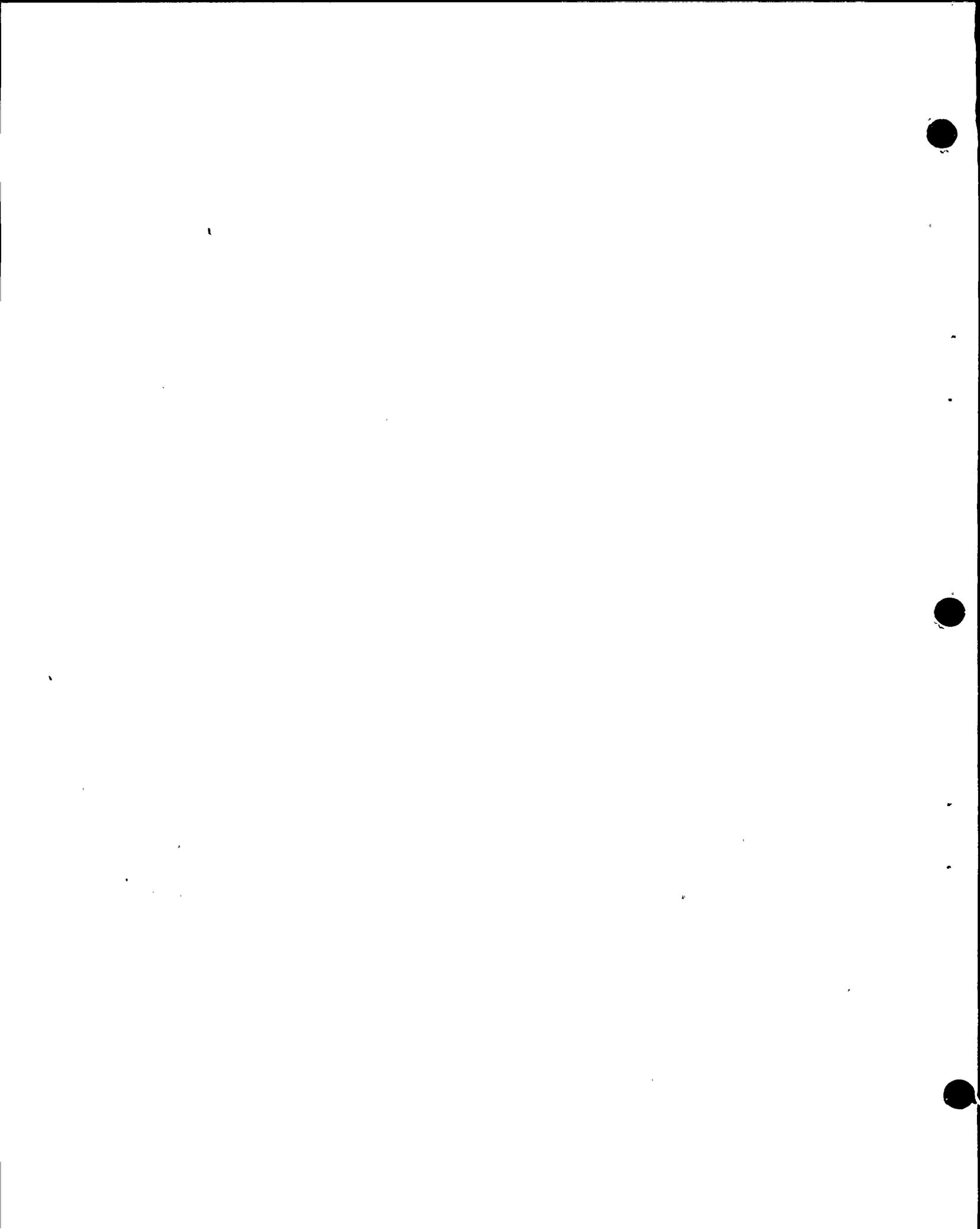
eb2 1 "the catalogue," by this I mean the Berkeley Catalogue and
2 the Cal Tech Catalogue and the National Earthquake Information
3 Service Catalogue -- making note of all events which have
4 occurred in the region and their magnitude.

5 Then a plot of this information is made on
6 standard -- with a standard approach in which one plots the
7 logarithm of the cumulative number of events that exceed
8 certain magnitude levels. Typically this data can be repre-
9 sented by a straight-line fit.

10 There is always a question in doing this kind of
11 recurrence analysis as to whether one has a long enough
12 period of time and whether one's catalogue of events is
13 statistically complete over that period of time, and whether
14 the region that one is selecting earthquakes from is large
15 enough to give a statistically valid sample.

16 The primary purpose of the recurrence relation-
17 ship was for the purposes of a seismic risk analysis. And
18 after completing this study for the smaller region in the
19 central California and offshore region, I then repeated the
20 analysis for the recurrence relationships for the entire
21 Pacific-North American Plate boundary; that is, the San Andreas
22 fault between Adelphi, California, and Cape Mendocino.

23 Both of these recurrence relationships were
24 considered in the seismic risk analysis that was done by
25 Dr. Blume.



eb3

1 Q Are your methodologies set out in the report
2 that is part of the FSAR Amendment 59, and marked as D-LL-45?
3 I think it's in volume 6 of the Seismic Evaluation for
4 Postulated 7.5 Magnitude Hosgri Earthquake. I believe that
5 one is marked-- Excuse me, the title of the one I just gave
6 you was Diablo Canyon Plant - A Plate Boundary and Diffused
7 Areal Probabilistic Considerations.

8 Then as to an appendix to D-LL-11 -- and let me
9 give you the date of that document, D-LL-11, that is, Diablo
10 Canyon Nuclear Power Plant, Probabilities of Peak Site
11 Accelerations and Spectral Response Accelerations from Assumed
12 Magnitudes up to and including 7.5 and All Local Fault Zones,
13 John A. Blume, dated May 27th, 1977.

14 As an appendix to that particular document there
15 is a document which is entitled Seismic Recurrence Curves
16 for Central Coastal California by Stewart W. Smith, and it is
17 numbered D-LL-11A.

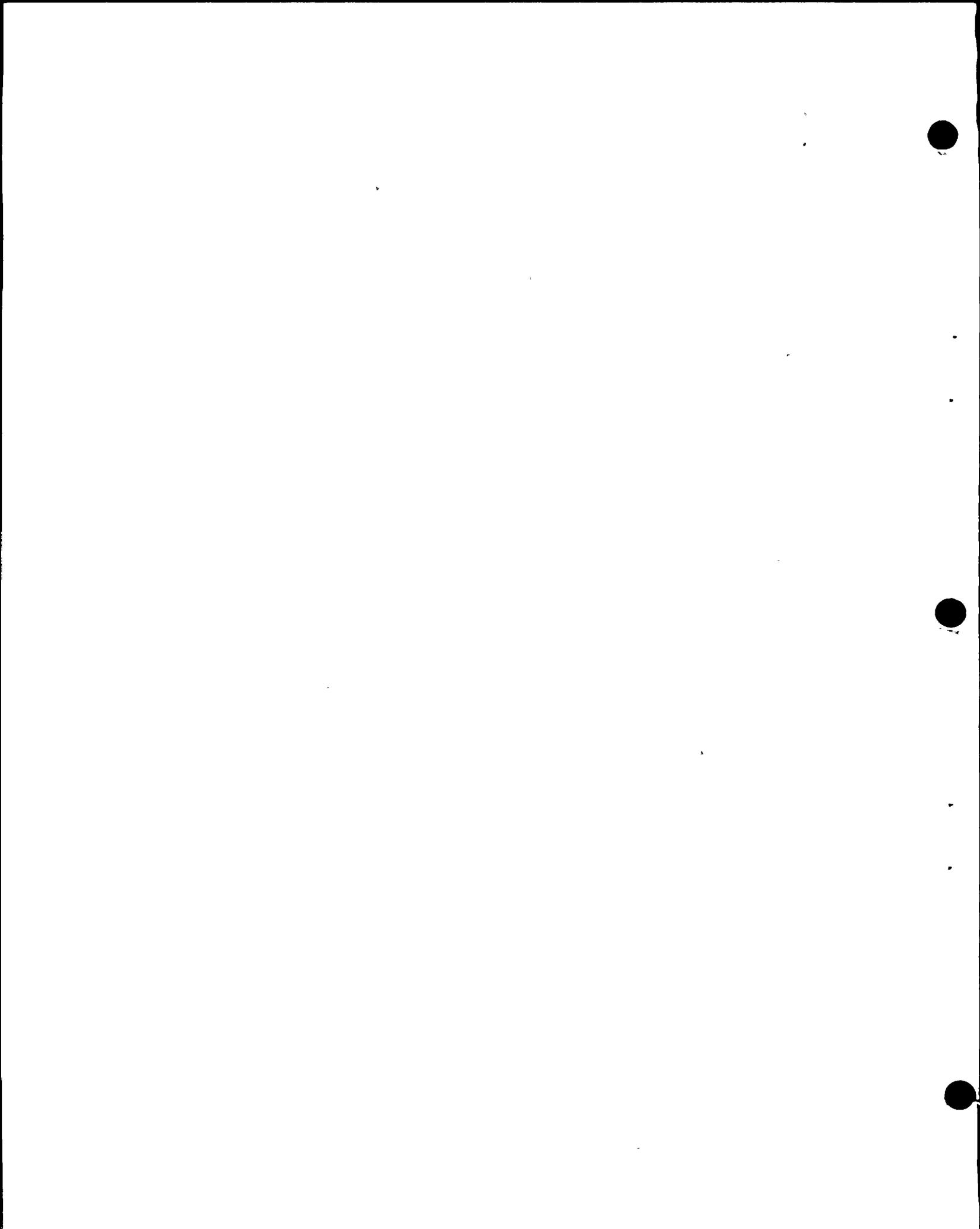
18 A What was the question?

19 Q Does that identify the two studies? Are those
20 the two studies that you're testifying about today?

21 A Yes.

22 Q Okay.

23 Now if we turn to-- Do you have that document,
24 the Seismic Recurrence Curves for Central Coastal California?
25 Do you have that document before you?



eb4

1

A Yes, I do.

2

Q Okay. That's D-LL-11A.

3

Let me explain. D-LL-11 refers to the first document by Dr. Blume. And D-11A is the number given to the second document which is an appendix to the Blume article.

4

5

This appendix is entitled Seismic Recurrence Curves for

6

Central Coastal California by Stewart W. Smith.

7

8

Going to page 3 of that document, I just want to

9

make sure I understand. Does that picture represent the

10

various earthquakes, the location of the various earthquakes

11

that were considered in your study?

12

A Yes.

13

Q Now what is the period, the time frame?

14

A It's stated on the figure, 1930 through 1975.

15

Q And NEIS refers to what catalogue?

16

A National Earthquake Information Service.

17

Q Okay.

18

Now previously I had asked you-- Let me turn

19

to the next figure which has a long-- It's a graph and on

20

one side the vertical axis is labeled "Number of events" and

21

the horizontal axis is designated " M_L ," magnitude local, I

22

believe, and you have a straight line.

23

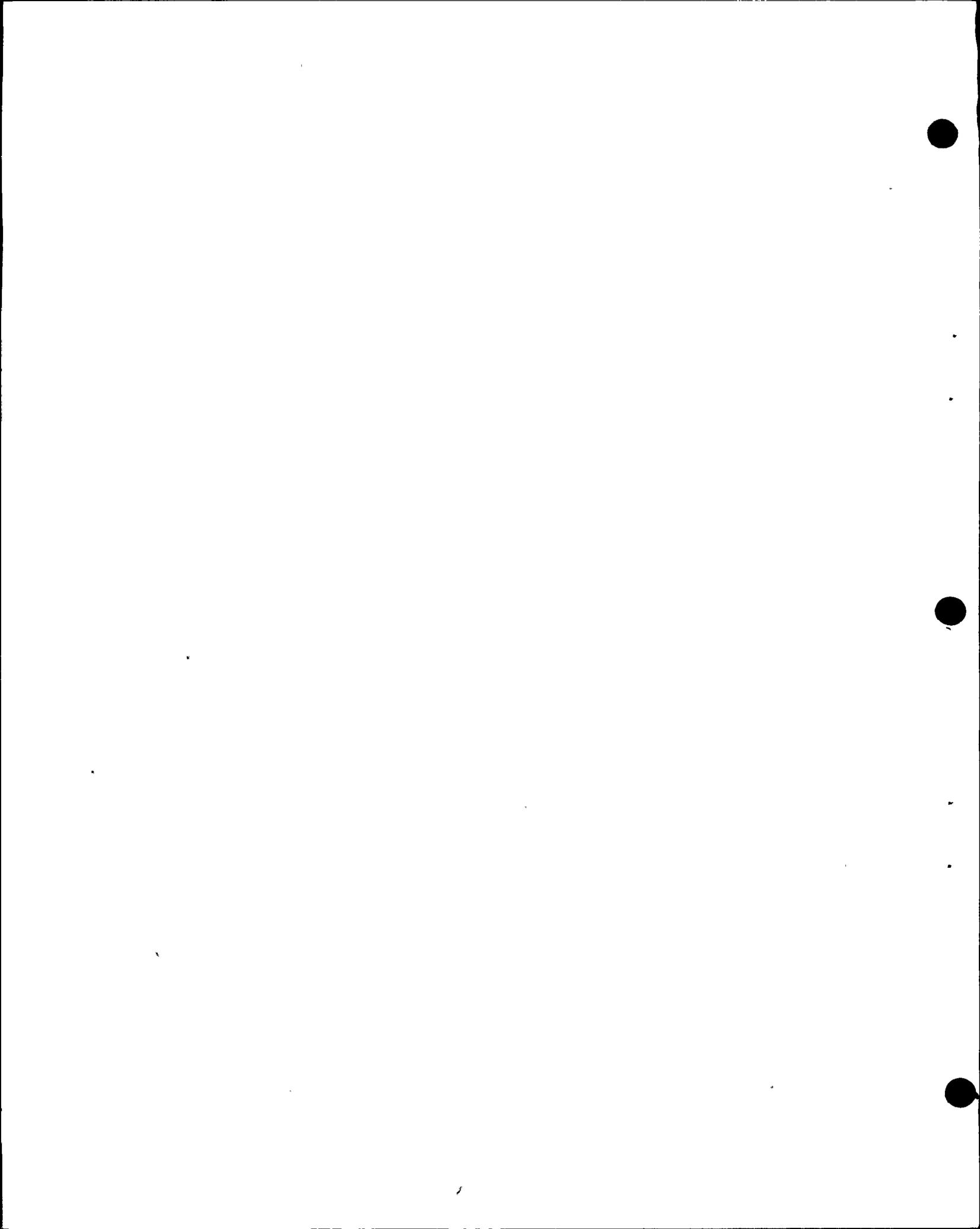
Is that the line that is used to select-- Is

24

that the best fit? How did you get that line?

25

A In this particular study, the line was fit by



eb5 1 taking the slope, .92, from -- I believe from the earlier
2 seismic risk analysis paper by Anderson and Trifunac. They
3 had considered a somewhat larger area, and I was anxious to
4 make sure that my study would not be biased or controversial
5 so I chose to adopt their slope.

6 And I believed, and I still do, that it did
7 represent an adequate fit to the data. But my recollection
8 is I did fix the slope at .92 and then adjust the line until
9 it fit the bulk of the data points.

10 Q So you've adopted the Trifunac and Anderson
11 slope.

12 A That's correct.

13 Q But you have a different data base?

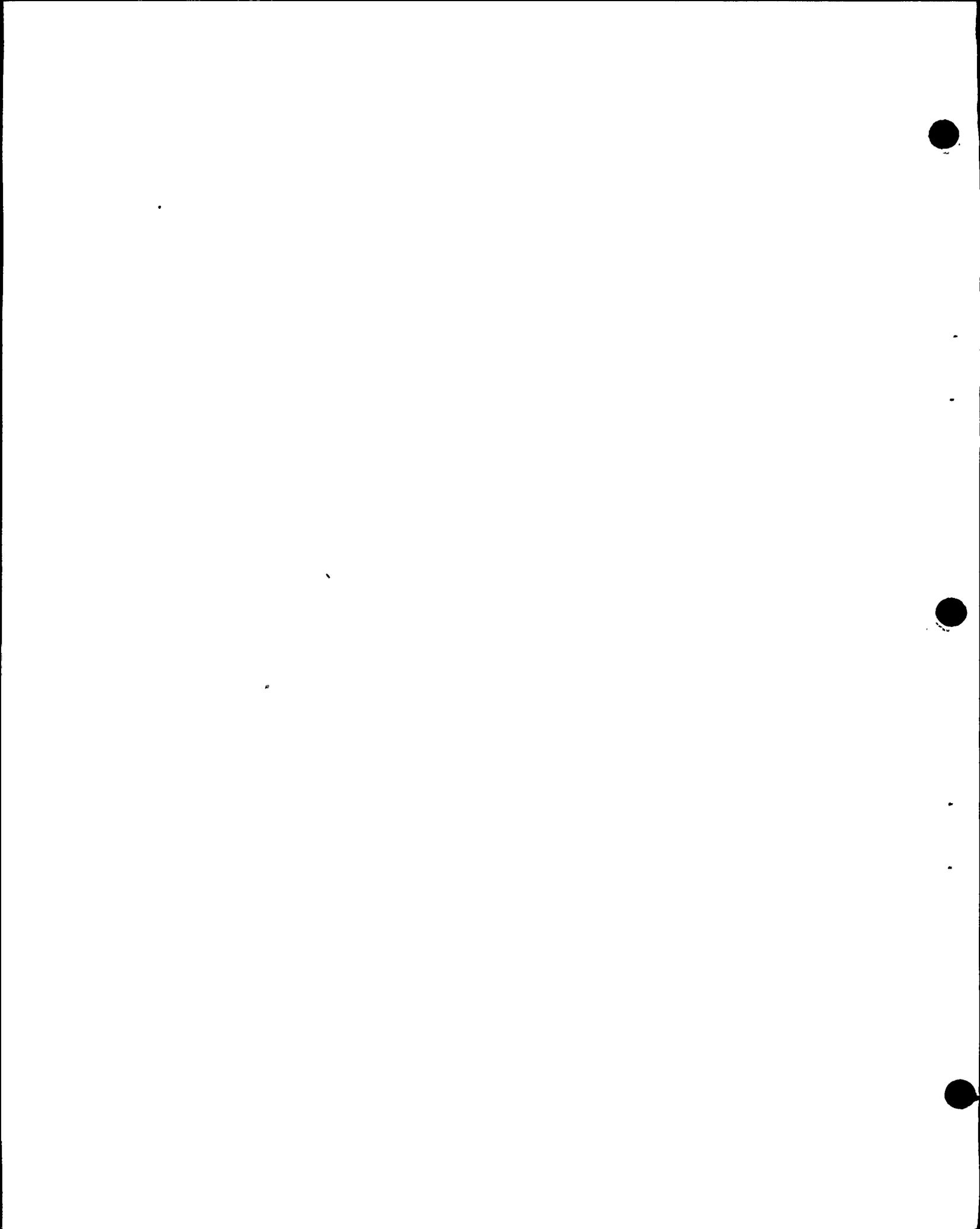
14 A That's correct.

15 I should point out that the selection of the
16 area and the time interval and so forth are matters of
17 importance and they require some careful professional judg-
18 ment. For the purposes for which this appendix was designed,
19 my best professional judgment was this was the appropriate
20 time interval and this was the appropriate region for a
21 sample.

22 Q I believe yesterday you indicated the reasons
23 for choosing the time interval.

24 A Yes.

25 Q My recollection is that that was the same time



ebf 1 interval used by Trifunac and Anderson. Is that correct?

2 A I'm not sure it was exactly the same time in-
3 terval but I used the figures by which they demonstrated that
4 the Catalogue of Earthquakes in California is extremely
5 incomplete before about 1932.

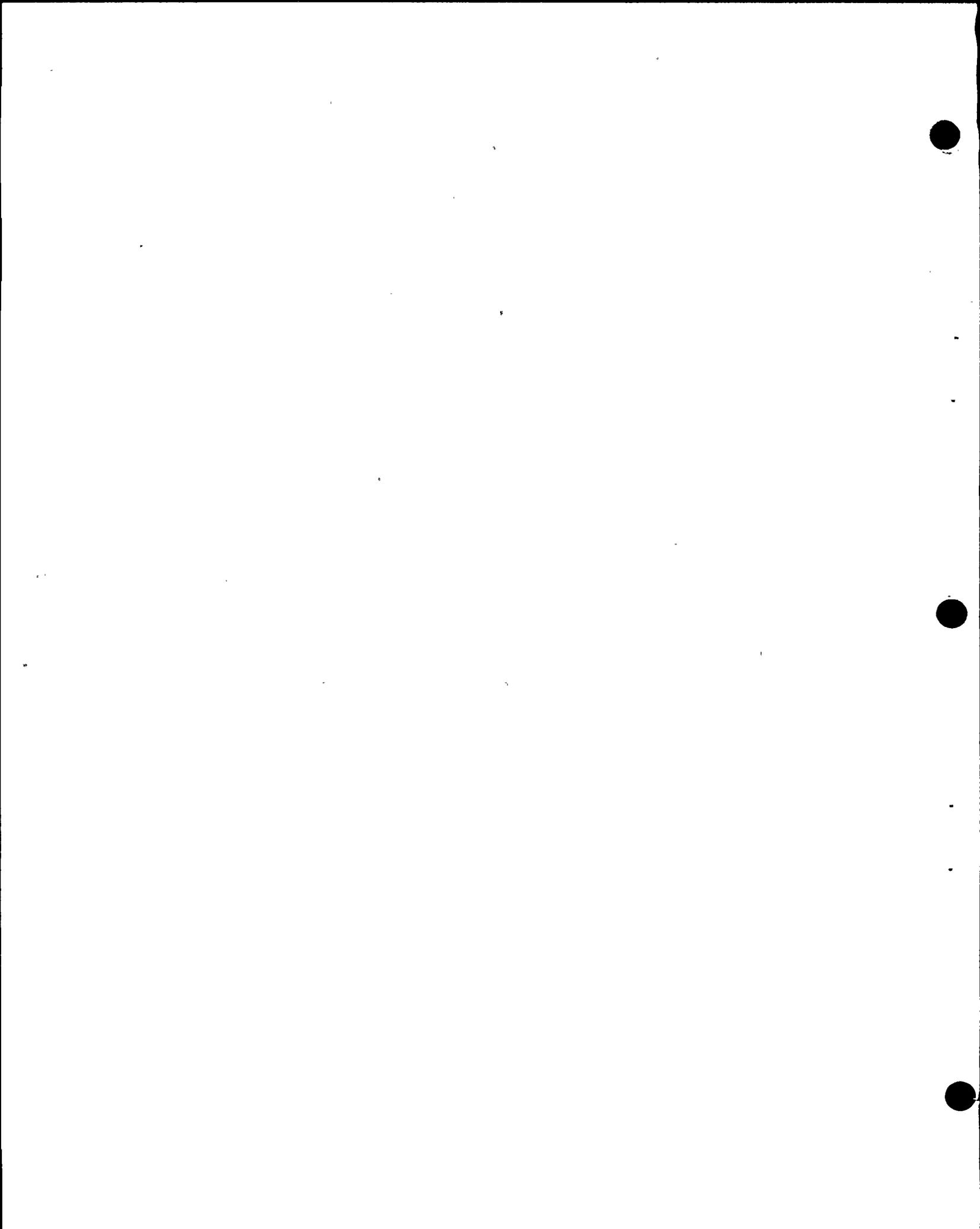
6 Q Now what was your basis for selecting the parti-
7 cular-- What was the basis for defining the areal extent
8 to be included in this study?

9 A Well, I think it is well put in the appendix.
10 I said:

11 "In order to increase the statistical
12 validity of the sample of earthquake occurrence,
13 it is generally considered appropriate to consider
14 as large an area as is possible, the constraint
15 being that one must consider only one seismological
16 or geological province if the rate of activity
17 determined is to have validity."

18 That was the underlying basis. I chose the
19 largest possible area and the longest possible time interval
20 that in my judgment appeared to be most appropriate for
21 representing the seismic activity in this region.

22 As an example, it would make no sense in my
23 professional opinion to include in this statistical sample
24 earthquakes on the San Andreas Fault or, say, the San
25 Fernando earthquake in the Los Angeles area, regions, as



eb7

1 described by Dr. Jahns earlier, that are in a totally different
2 tectonic regime.

3 Q So as I understand your testimony, you excluded
4 earthquakes from the Transverse Ranges area?

5 A That's correct.

6 Q Okay.

7 And you excluded earthquakes related to the San
8 Andreas Fault?

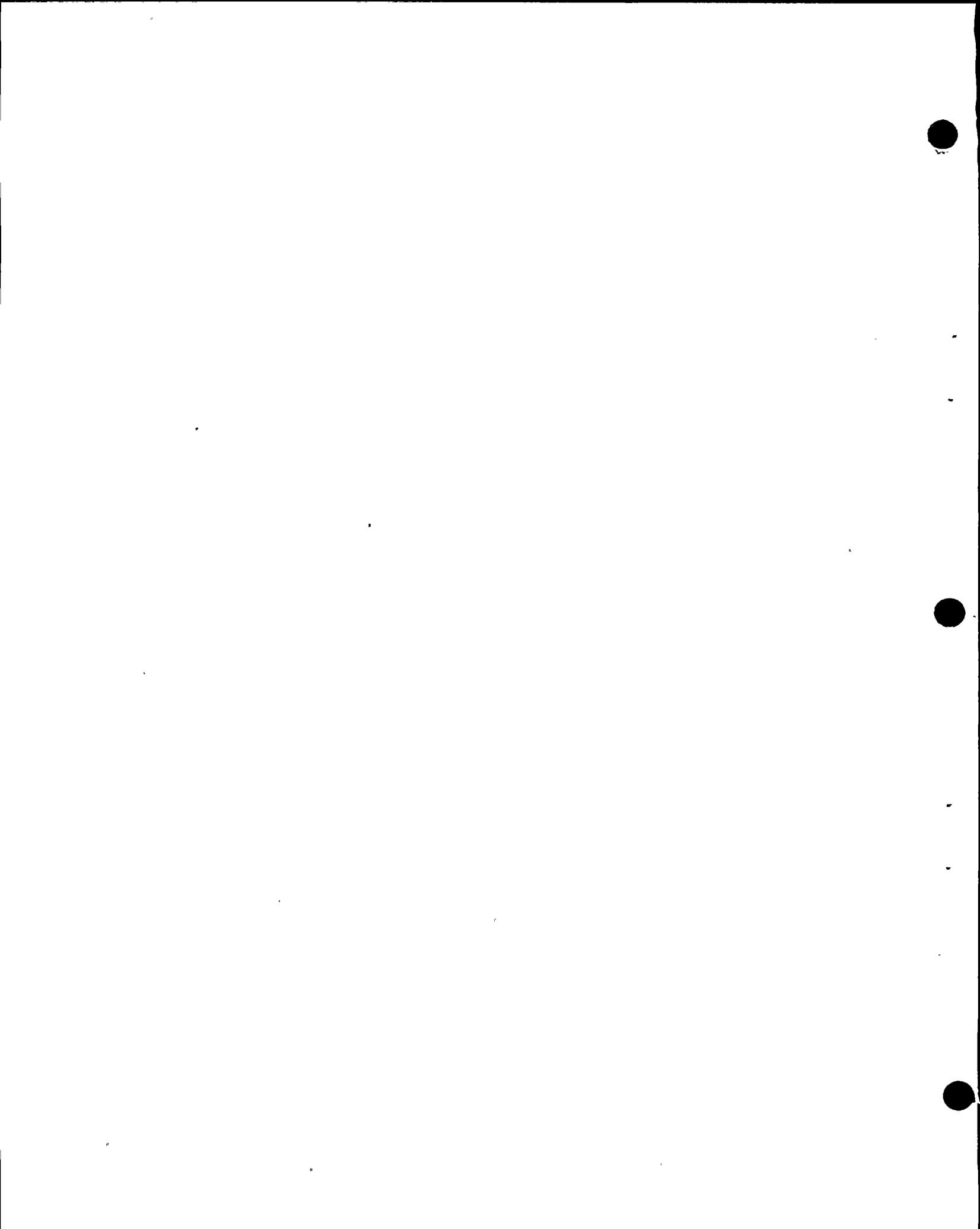
9 A That's correct, for this particular study, and
10 as I indicated, as a result of questions that people had as
11 to how this might compare with the seismicity of a larger
12 piece of the plate boundary, and I believe in response to an
13 NRC question, the study was repeated with the entire plate
14 boundary, some 13 or 14 hundred kilometers, including essen-
15 tially all the earthquakes in California.

16 Q How did you define the San Andreas Fault when
17 you decided what to exclude?

18 A I believe that's shown--- Oh, in this....

19 Well, I've quoted the boundaries of the region
20 that I used, and I did that by looking at a map of the seis-
21 micity and was simply adjusting the lines so that it appeared
22 to exclude the bulk of the activity that was associated with
23 the San Andreas Fault.

24 As you may appreciate from Dr. Bolt's earlier
25 comments, there are uncertainties in some of the locations of



e3 1 earthquakes in California, and some that really are on the
2 San Andreas Fault appear in the catalogues as some distance
3 away:

4 But in general, looking at the distribution,
5 you can tell where the areas of high seismicity are related to
6 the San Andreas.

7 Q Let me repeat my question: How did you decide---
8 Let me give a little preface.

9 We've heard the San Andreas Fault described
10 several ways, and I can't tell from the map here whether you
11 also excluded activity associated with, for example, the Hayward
12 and the Calaveras and various other branches of the San Andreas.
13 Could you explain?

14 A Well, in the latitude of central California, in
15 this sample there are no branches of that nature. The
16 Calaveras and the Hayward are much farther north.

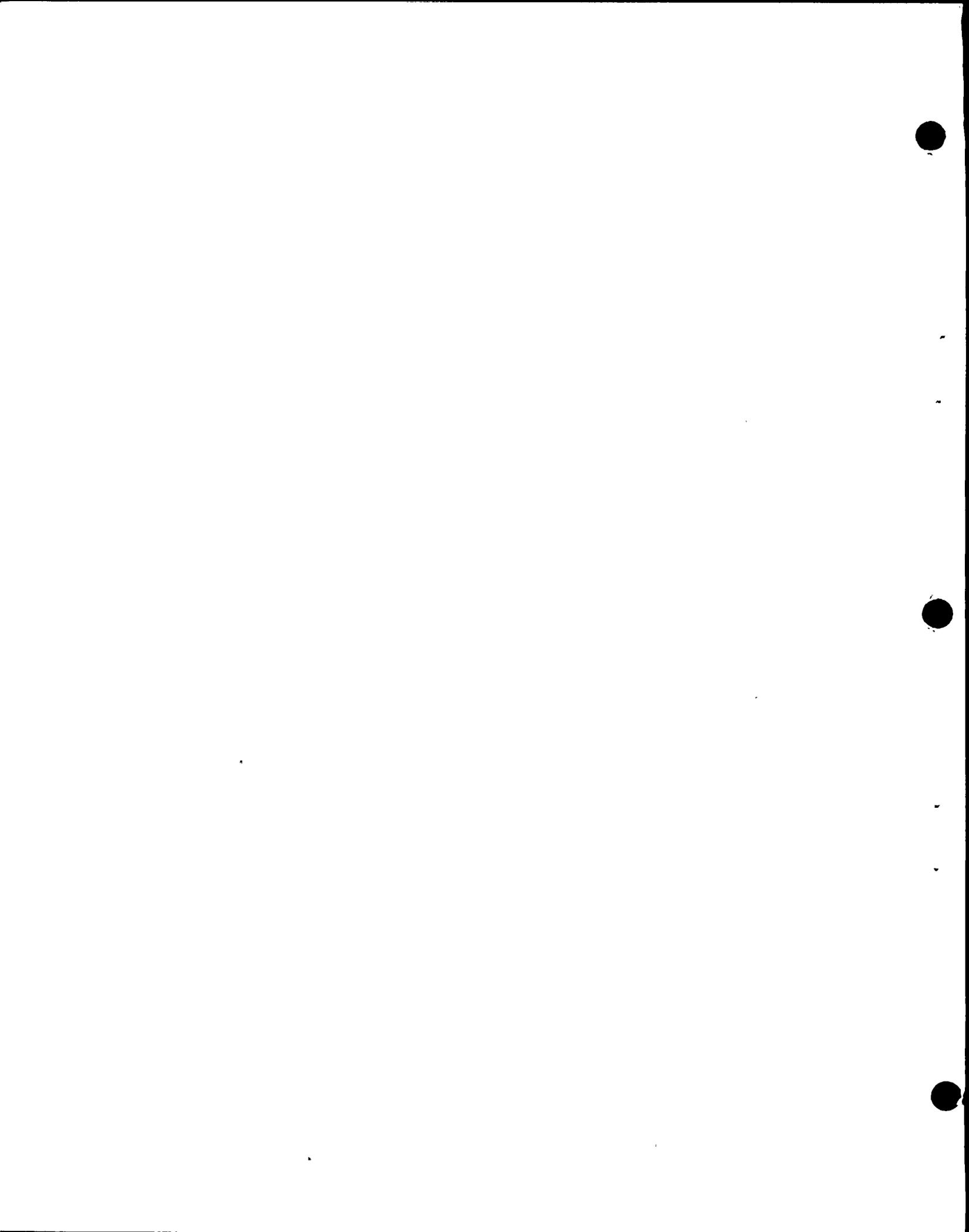
17 Q So what was the basis of excluding the seismicity
18 associated with those particular branches?

19 A Well, for seismic risk analysis they are totally
20 irrelevant.

21 Q Why is that?

22 A Because they are hundreds of miles away.

23 Q Now when I asked you the question of how the
24 addition of that one data point would affect your conclusions,
25 I believe you indicated it wouldn't affect your conclusions



eb9

1 at all. And again referring to Figure Number 11A --

2 MR. NORTON: Excuse me, Mrs. Bowers. I want to
3 object to the statement of Counsel which is prelude in his
4 question when he said that the addition of that data point
5 would not change his conclusion at all. That is not what
6 the testimony was.

7 MR. FLEISCHAKER: Okay. I'll withdraw the ques-
8 tion.

9 MRS. BOWERS: All right-- You never let me rule
10 on these objections.

11 (Laughter.)

12 BY MR. FLEISCHAKER:

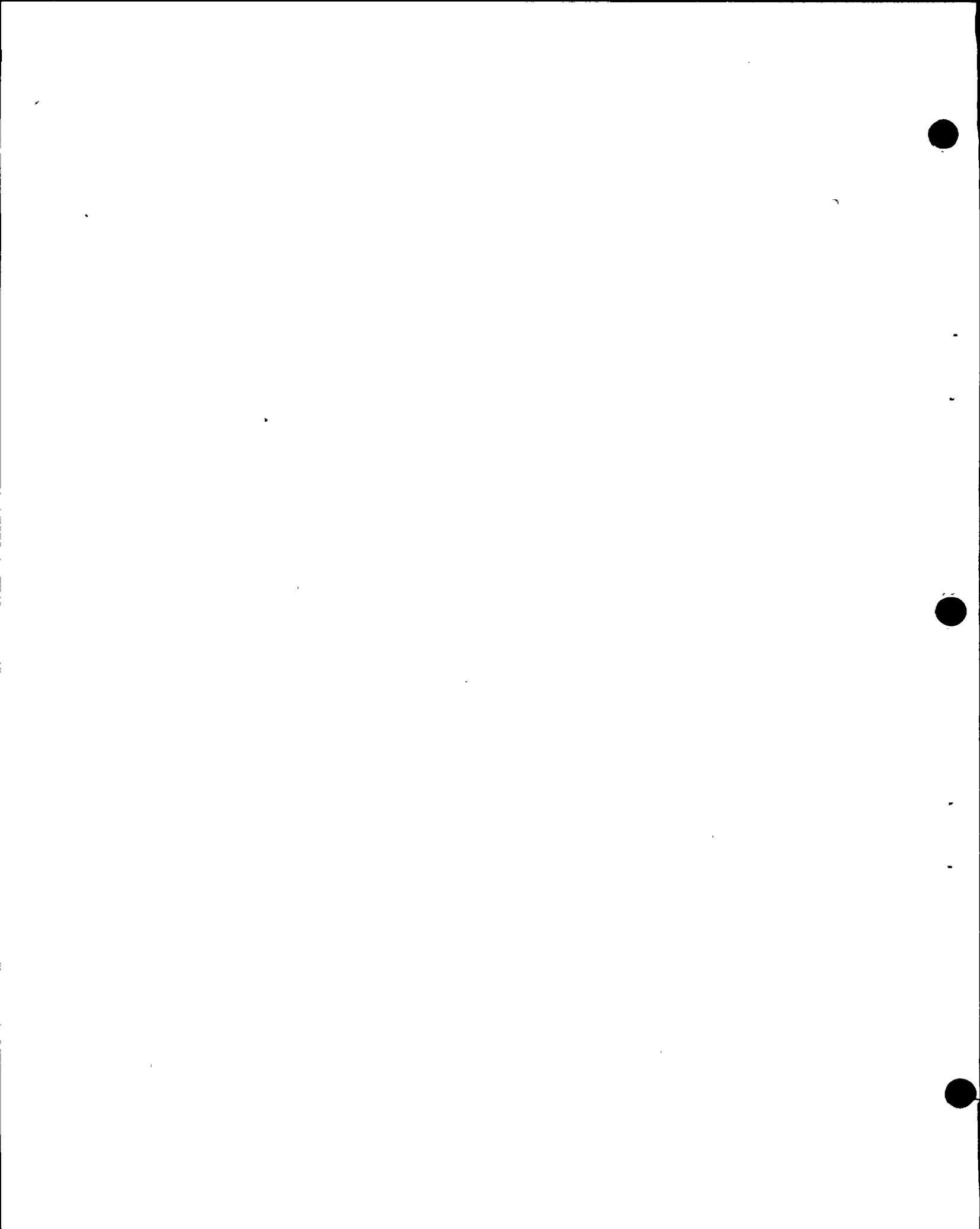
13 Q We had earlier discussed what effect, if any,
14 the inclusion of an additional data point would have, and
15 I'm referring you now to Figure Number 11A-2.

16 Will you explain why the addition of that data
17 point would have little effect on -- or what effect it might
18 have, and why, on your conclusions?

19 A (Witness Smith) Well, the addition-- If I could
20 just have a moment, perhaps I could have a transparency made
21 of one of Trifunac's figures that might assist in the explana-
22 tion.

23 I'll proceed with an answer to your question and
24 I think that maybe it will --

25 Q I would rather use your figures, Dr. Smith.



1 A I have no figure that illustrates this point.

2 MR. NORTON: Excuse me, Mrs. Bowers. I think the
3 witness has been asked a question and he needs to put a figure
4 up on the Viewgraph to answer it. I don't see anything
5 improper with that.

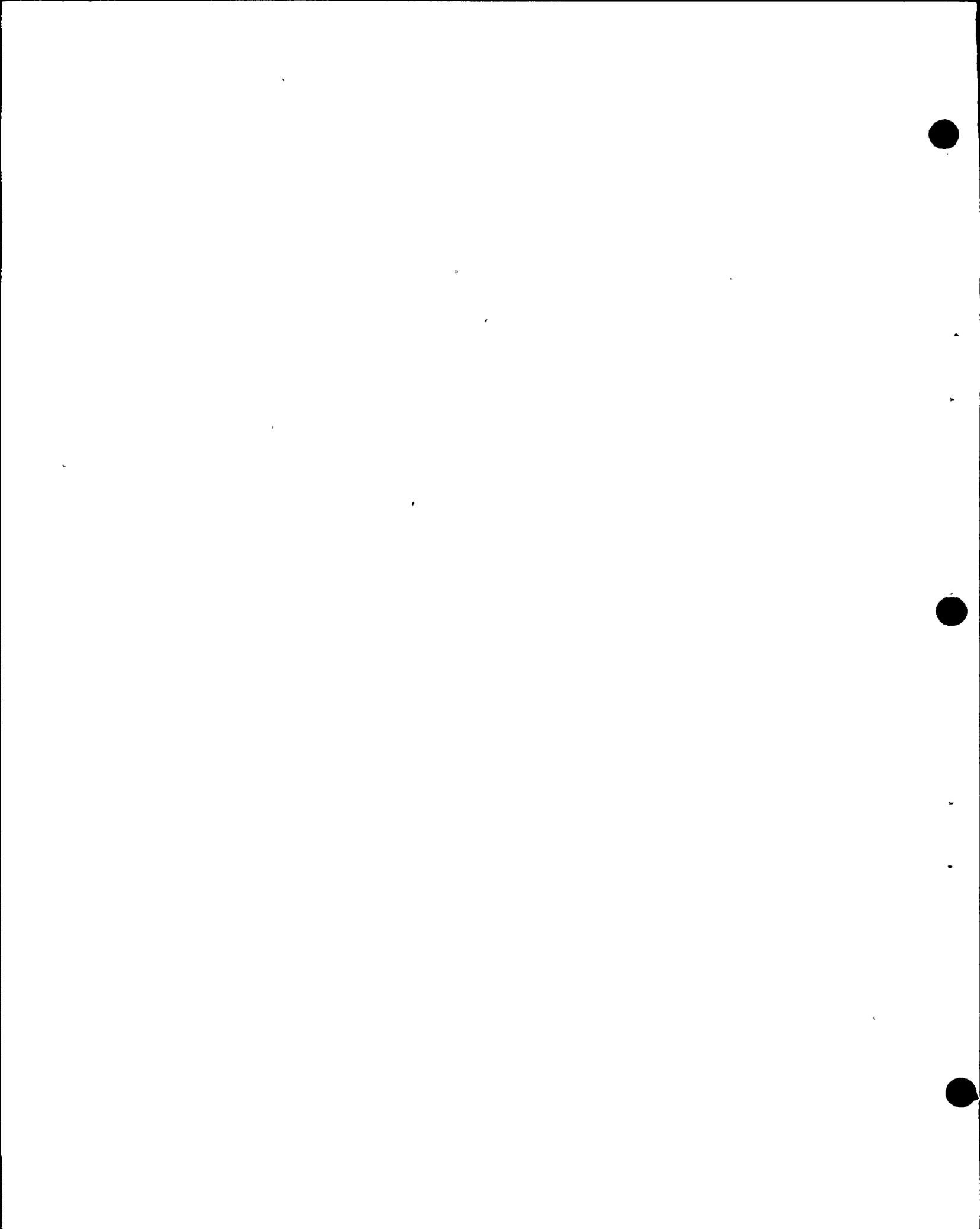
6 MRS. BOWERS: Well, we'd like the witness to go
7 ahead as he suggested.

8 Now if you're not satisfied, Mr. Fleischaker,
9 why of course you can pursue with more questions.

10 WITNESS SMITH: Referring to my Figure 11A-2,
11 I would preface the statement by saying that it would be
12 statistically invalid to add -- to take the record back to
13 1927, and add the one earthquake. And I think when we see these
14 transparencies you'll understand why that's true.

15 Secondly, if, as a hypothetical question, one
16 were simply to add one additional data point to Figure 11A-2
17 without applying any kind of seismological judgment as to the
18 significance of doing that but simply as a statistical thing,
19 one would take each and every point on this curve and increase
20 it by one count or one unit.

21 For example, on the left-hand side the logarithm
22 of the number of events is plotted. This means, for example,
23 that at magnitude 4 the distribution shows approximately 53 --
24 I'm estimating this from the curve -- 53 earthquakes have
25 exceeded magnitude 4. That number 53 would now be changed to



eb11
1 54.

2 If you go down to magnitude 4-1/2 and so forth,
3 each point is moved up by one. And since it's a logarithmic
4 scale an increase by one has a more significant appearance on
5 the curve, the larger magnitudes we go to. And it's a well-
6 known fact that distributions of this sort show a large
7 scatter at the large magnitude end because typically one only
8 has one or two events out here.

9 And that's the basis of my statement, my saying
10 that adding one more earthquake at the large end of the dis-
11 tribution would not materially affect the appearance of the
12 curve.

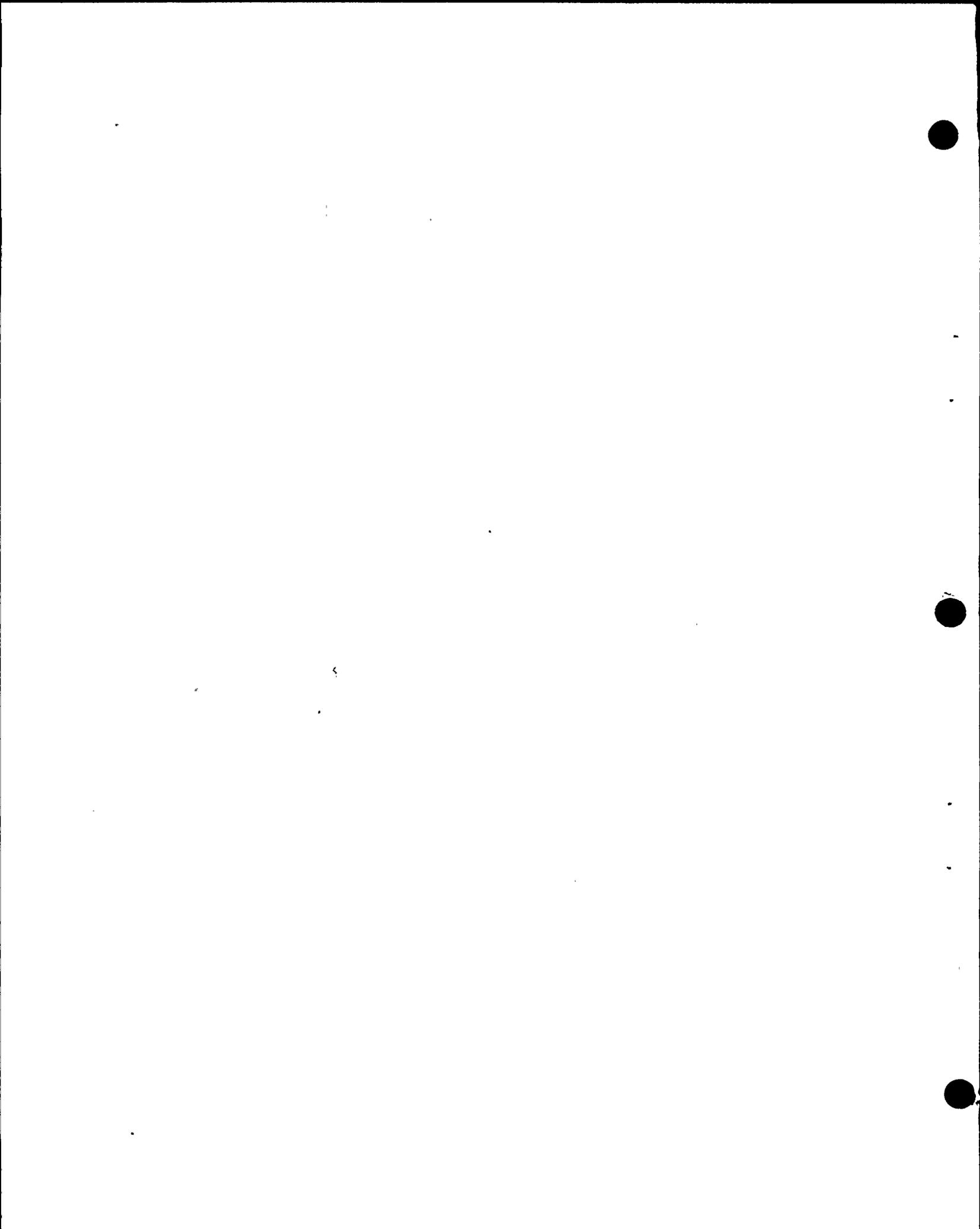
13 BY MR. FLEISCHAKER:

14 Q So one would tend to ignore that point and draw
15 his lines mainly with reference to the other points?

16 A (Witness Smith) Yes, I believe so. That would
17 be my-- And I believe that it would be representative of the
18 practice in the seismological community.

19 Q Now have you ever applied this-- Other than the
20 other study that was mentioned here for the larger area,
21 have you ever applied this particular technique to a discrete
22 region, a smaller region like you have here in this study which
23 we're talking about which is designated as D-11A?

24 A Yes, I have used this technique to look at earth-
25 quakes in a number of different localities. Typically when



eb12 1 one records earthquakes in a region they want some convenient
2 way of illustrating what the rate of activity is and what the
3 relationship between large and small earthquakes would be.
4 And yes, I've done that.

5 Q Okay.

6 In doing that have you ever found-- Strike that.

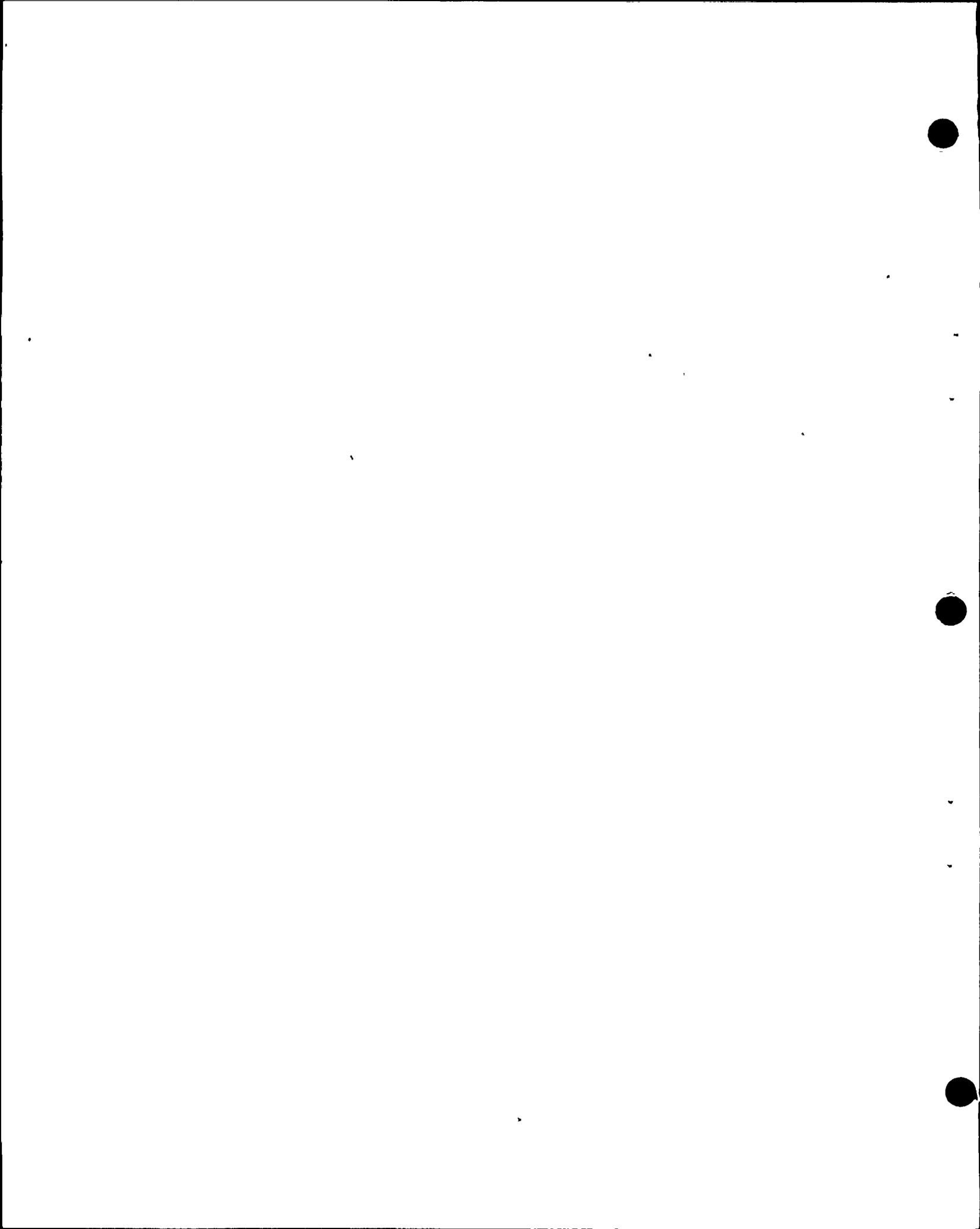
7 Are you familiar with the writings of Dr. Clarence
8 Allen?

9 A Yes, I am.

10 Q Are you familiar in particular with his discus-
11 sions of the reliability of recurrence intervals in predicting
12 large earthquakes?

13 A Yes, I discussed that in detail with him at the
14 time he was writing the paper that you're describing. Yes.

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1 Q What is his opinion, as best you can recall?

2 A Well I believe that I'm in total agreement with
3 Dr. Allen in this regard, and I think that my comments about
4 the size of the region, the length of time that's required
5 and so forth, are in complete agreement with his views.

6 Basically, what he's saying is that you must
7 look at the geologic record and the seismic history, and
8 that you cannot rely on the seismic record alone in some
9 reaches that are very quiet, the geologic record indicating
10 a lot of displacement has gone on and one should expect
11 larger earthquakes.

12 The most impressive example of that is the Big
13 Bend section of the San Andreas Fault.

14 Q Did we talk about that yesterday? I think we did.

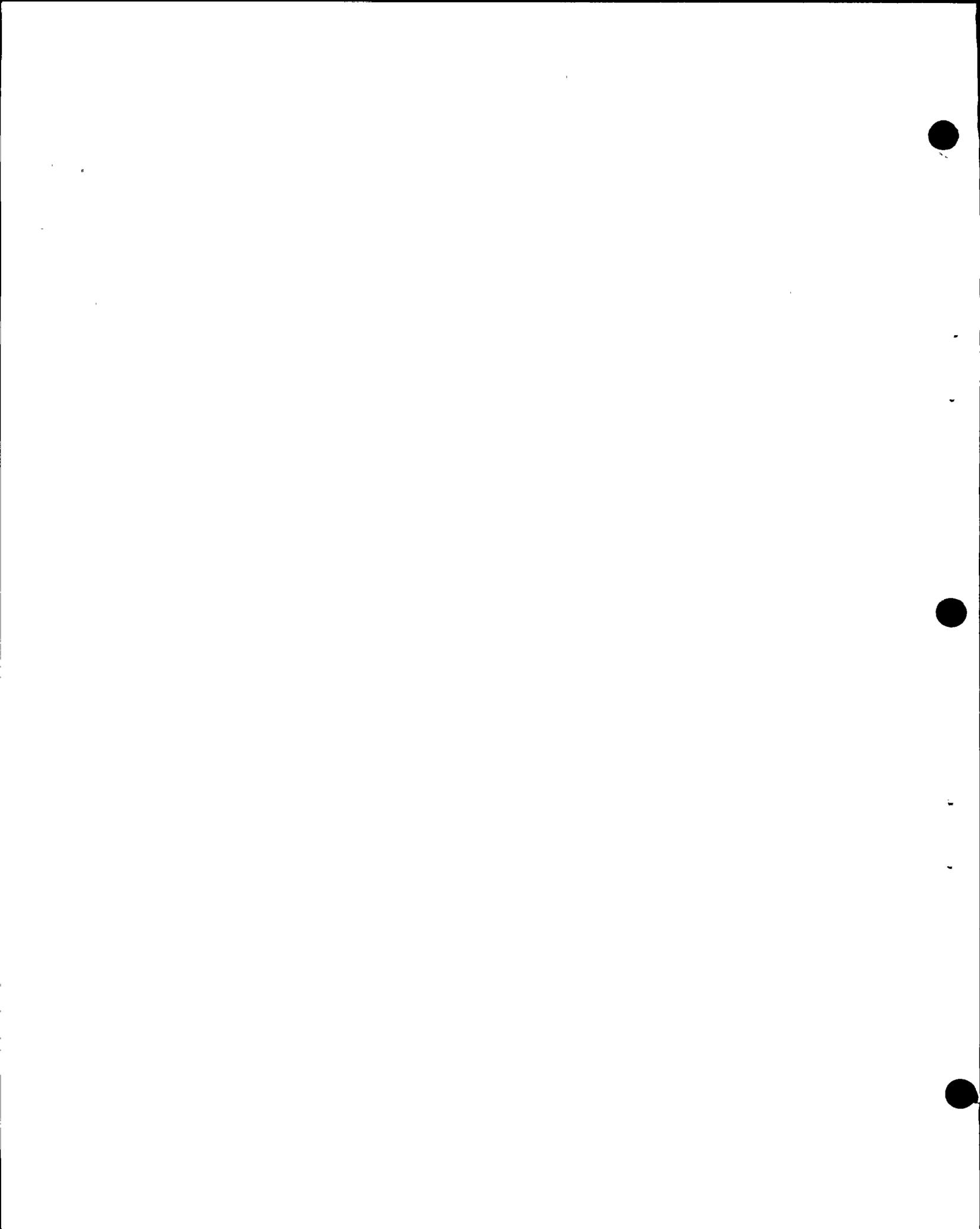
15 A Yes.

16 Q Are you in reference to the Carrizo Plain?

17 A No, I was speaking more of the section of the
18 fault just north of Los Angeles.

19 Q Do you have an opinion of the reliability of
20 this recurrence interval technique for, say, predicting
21 earthquake greater than magnitude 7 considering seismicity
22 for, say, the last 50 years on the Carrizo Plain?

23 A Yes, I'm on record as being violently opposed
24 to that. In my testimony, I've said this many times and
25 I'll repeat it again that from my 1967 evaluation, the use



agb.

1 of such data, however, can produce misleading results if
2 the region considered is too small or the data covered too
3 short a span of time -- in particular, extrapolation of data
4 on small earthquake to predict the occurrence of larger ones
5 are unreliable.

6 This was written not long after Dr. Allen's
7 paper was published, I believe. And I was very sensitive to
8 and very much in agreement with the analysis that Allen and
9 others had done, and I had been very critical of simple
0 extrapolation of recurrence curves to try to guess how large
1 an earthquake in a region might be.

12 MR. FLEISCHAKER: May I just have a moment? I
13 just completed that line of questioning.

14 (Pause.)

15 BY MR. FLEISCHAKER:

16 Q Dr. Smith, do you have a copy of your testimony
17 available?

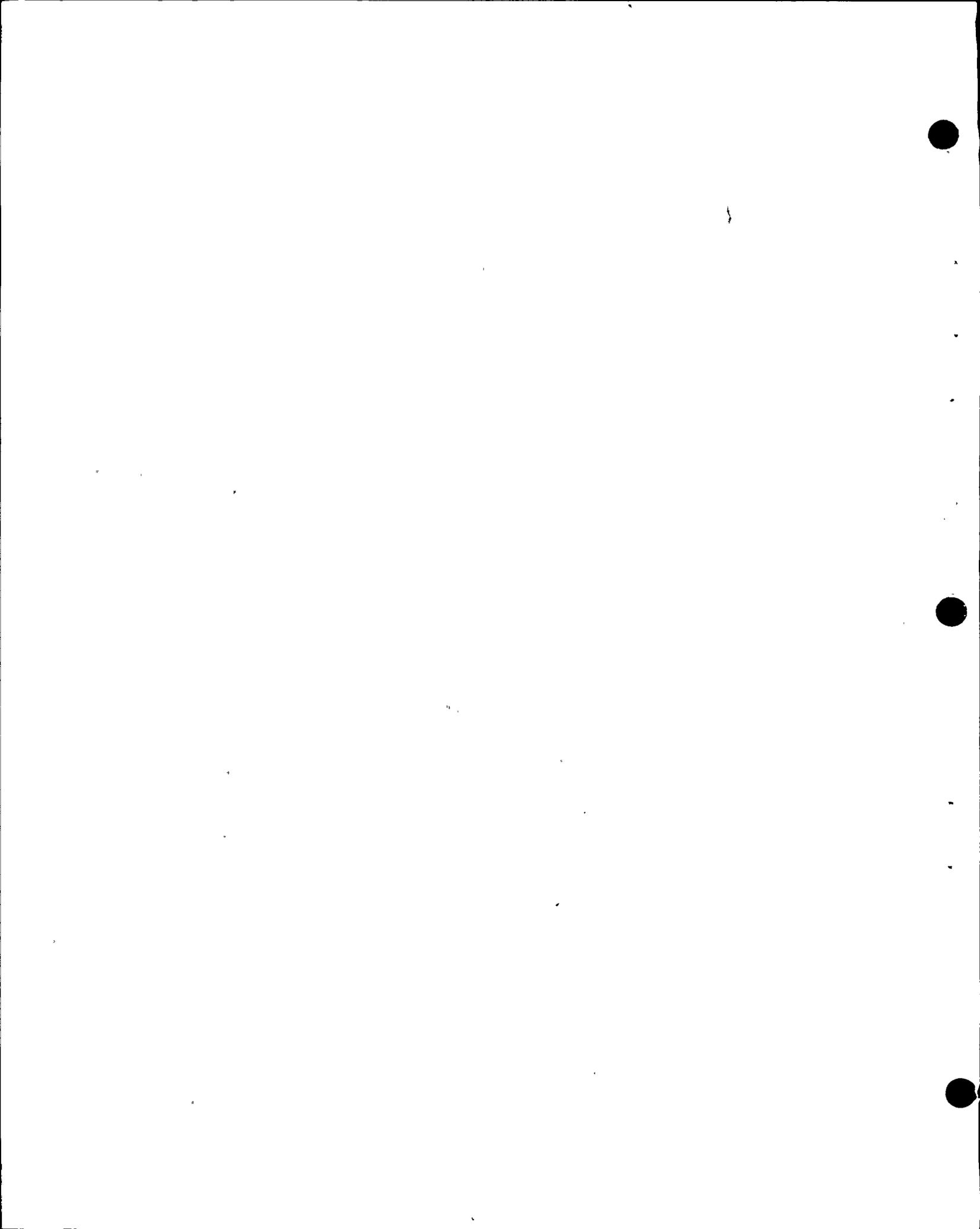
18 A (Witness Smith) Yes, I do.

19 Q Let's go to Page Three.

20 A Okay.

21 Q I'm sorry, Page Four, at Line 20. Would you
22 state:

23 "This period of time is certainly
24 long enough to characterize the activity of
25 this fault for the purposes of seismic hazard



agb3

1 evaluation."

2 What period of time are you referring to?

3 A The most relevant geologic period of time,
4 the past 10,000 to 20,000 years. Specifically, this period
5 of time would be the last 17,000 years in this instance.

6 Q Now is that your opinion or one that is held
7 generally in the seismological community?

8 A That's my specific opinion. I haven't made a
9 real poll of the community.

10 MR. NORTON: Excuse me, may I interject a
11 question?

12 I'm not clear whether this line of questioning
13 is as to the Hosgri Fault specifically or to all faults
14 all places.

15 If it's the latter, I would object that it's
16 not relevant in these proceedings. And if it's the former,
17 it clearly is relevant.

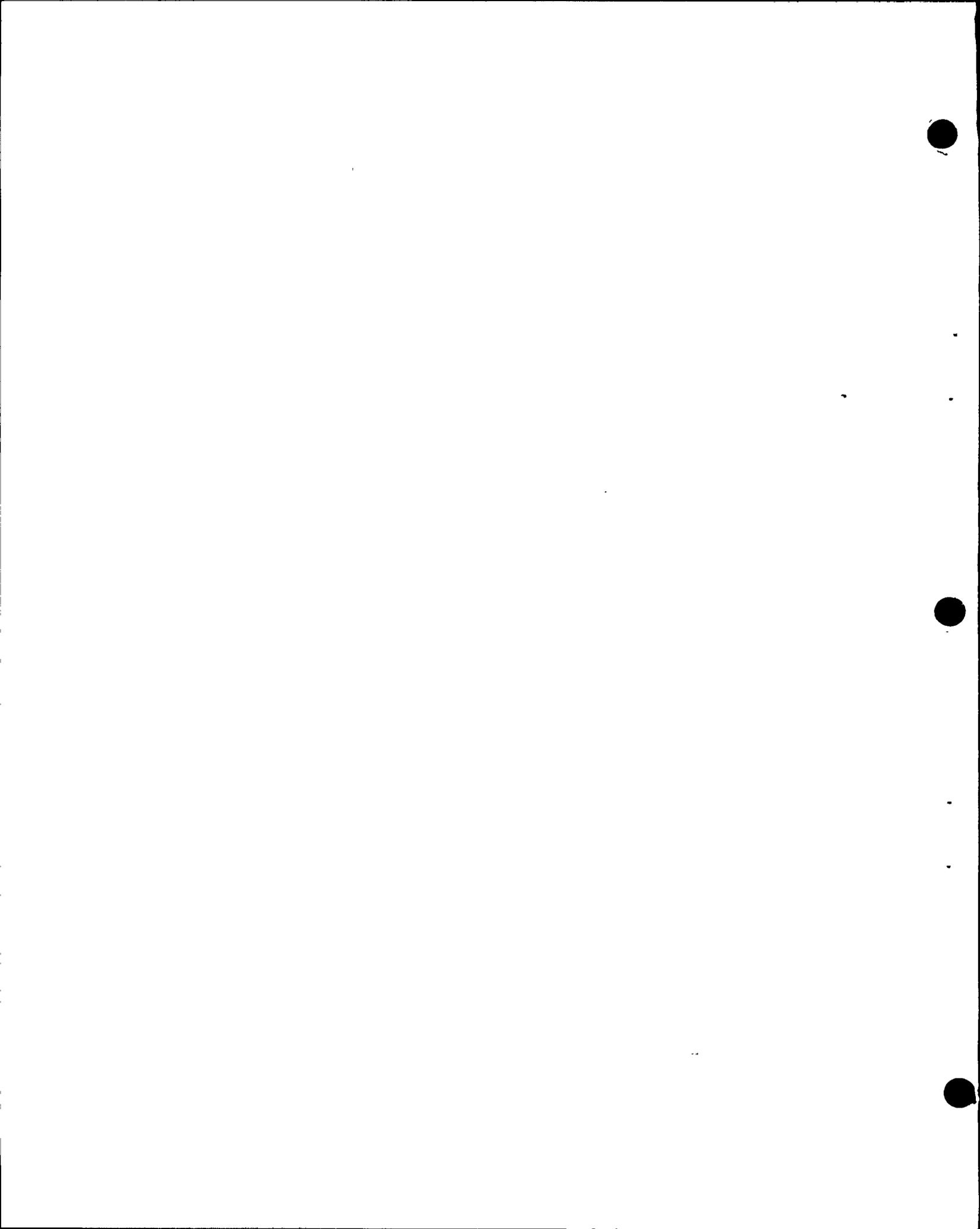
18 And I gather from the testimony that it is,
19 at least the testimony is related to the Hosgri Fault and
20 I'm not sure that Mr. Fleischaker's questions are.

21 MR. FLEISCHAKER: Well let me ask the witness.

22 BY MR. FLEISCHAKER:

23 Q When you wrote this statement, what was your
24 frame of reference?

25 A (Witness Smith) The frame of reference for the



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1 17,000 years is the Hozgri.

2 Q This is your opinion?

3 A Yes.

4 Q What's the basis for that opinion?

5 A My examination of world-wide seismicity lead me
6 to believe that there's a convenient trade-off between the
7 time of recorded history of earthquakes and the size of the
8 area over which they're sampled.

9 In looking at the size distribution of earthquakes
10 world-wide, I'm impressed by the fact that the distribution
11 appears to truncate above magnitude 8, 8.5, it depends in
12 this case, how you define magnitude when you get really large
13 events.

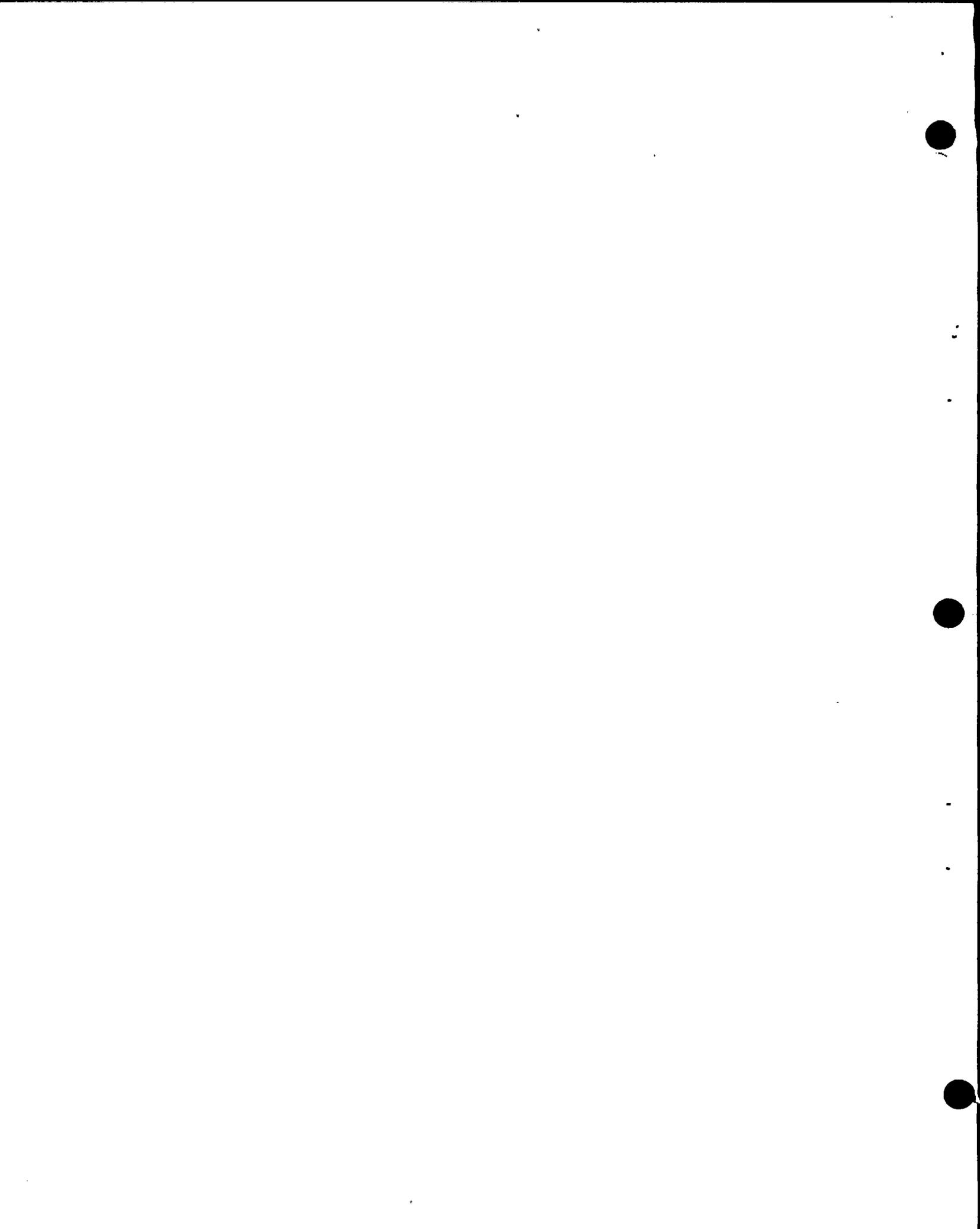
14 But it would appear, in a recorded history --
15 which varies from country-to-country -- but nonetheless, the
16 recorded history, we would appear to have a sample worldwide
17 of the largest earthquakes that are ever going to happen.

18 Furthermore --

19 Q Excuse me, in what time period?

20 A That's what I mentioned, it's variable from one
21 continent to the next. The recorded history in Western
22 U.S. is shorter than in Europe, it's shorter than in Asia
23 and so forth.

24 But the general impression is, looking at the
25 statistics of the last several hundred years, for example,



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1 that there is an adequate sample of the really large super-
2 earthquakes, and that we shouldn't be concerned with postula-
3 ting some new giant variety of earthquake that has never
4 occurred anywhere in the world ever before in recorded history.

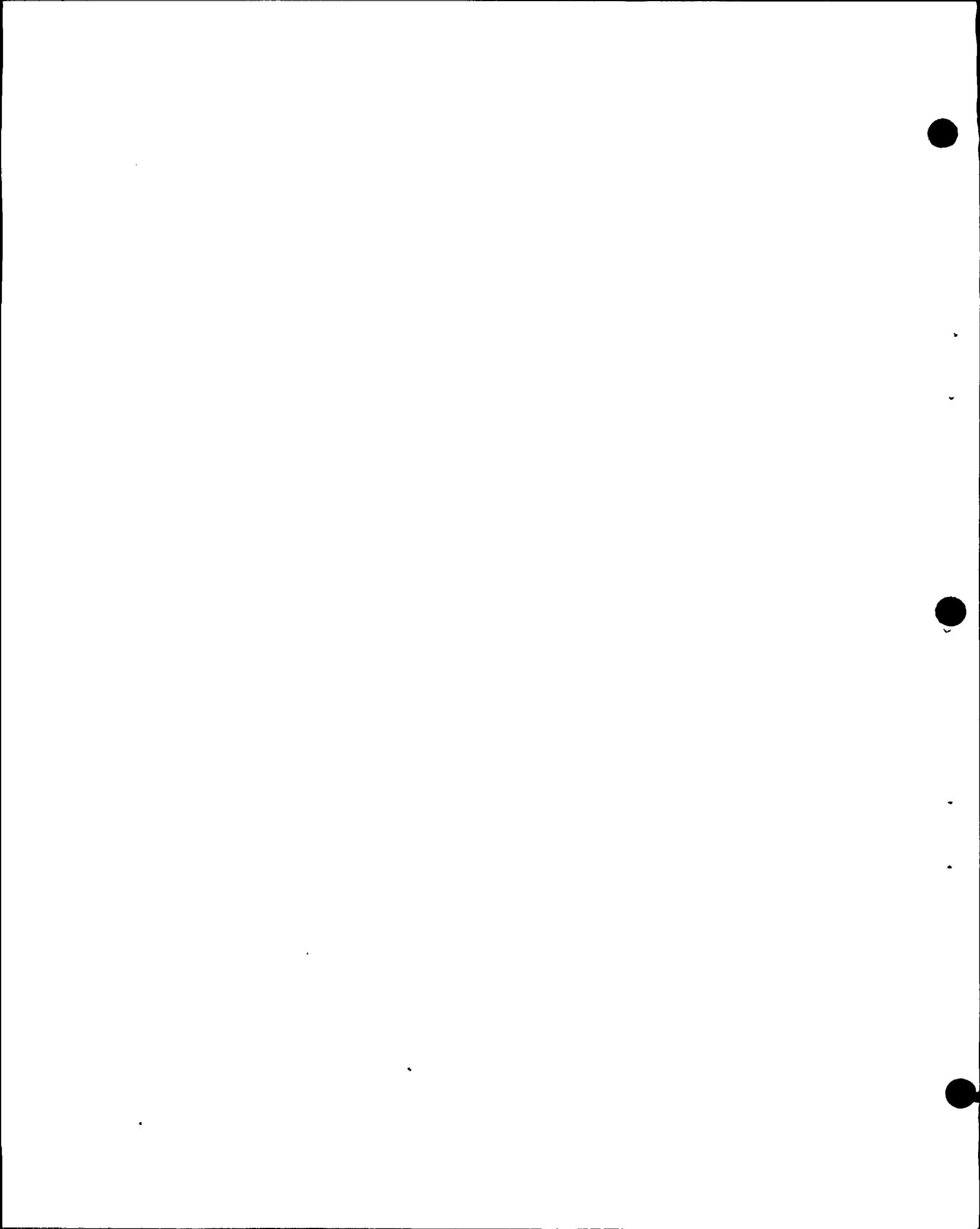
5 I started with the assumption that the statistical
6 data set for the entire world seems to be complete. The
7 problem comes when you look at a smaller area.

8 And the trade-off that I mentioned earlier is
9 in order to get a statistically complete sample to the largest
10 possible event, clearly the smaller the region you're looking
11 at, the longer time you're going to have a history of.

12 So I did some calculations, very simple calcula-
13 tions in terms of zone, the dimensions of worldwide zones
14 of seismic activity, and I came up with a rough figure that
15 for a region of the dimensions of 100 kilometers or the
16 kinds of things that are typically of importance in a hearing
17 like this, that a sample length of between 10,000 and 20,000
18 years for a region of that dimension was statistically
19 roughly equivalent to the historic record of several
20 centuries of the entire world's seismic zones.

21 I have not seen anyone else put forward that
22 hypothesis. And I've gotten some informal feedback from
23 scientific colleagues that it seems like a reasonable
24 approach. And so that's the basis of my opinion.

25 Q Where are these calculations?



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A They're in the paper we referred to earlier, the 1976 paper on maximum earthquakes.

Q Well let's see now, so did you do these calculations in connection with your work on utilizing moment to predict maximum credible -- maximum magnitudes?

A It's generally useful in other contexts, but that was the context in which I undertook the study. I needed an answer to the question that you posed: What's a good interval of time that you can have reasonable assurance that you have an adequate statistical sample to the largest sized earthquakes.

And since I did agree with Allen regarding the possible inadequacies of short recording time periods, I looked about for a rationale for how one might define this time interval.

I believe that some people would say that it's too long a time interval, that in fact -- you know, I may have overestimated the time interval. I don't think many would say that it's an underestimate.

Q What's the basis for your conclusion that these calculations that you did for the '76 paper to determine an areal extent and a time are transferable to a different methodology, that is, recurrence rate kind of predictions?

A I was basically trying to answer the question that I think is the heart of what you're trying to get at,



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1 namely, if you're worried about whether your time interval
2 is long enough then you have to develop some rationale to
3 explain whether or not it is.

4 Also in the back of my mind in doing this was
5 newly obtained data from China at that time and the Mediter-
6 ranean which seemed to indicate that periods of seismicity
7 could change significantly over a time scale of centuries.

8 And you have to understand that in those
9 days we were having to argue against using recurrence curves
10 to describe -- we had to argue against people using re-
11 currence curves obtained over a short period of time to
12 represent what averages might be over a very long period
13 of time; so that's the framework in which I sought this
14 answer.

15 Q Who's "we?"

16 A My colleagues and people like Allen and generally
17 those professional seismologists who are asked questions
18 about the significance of earthquake occurrences.

19 Q Is it your conclusion that this rule can be
20 applied worldwide? Let me be more specific:

21 Is it your conclusion that this areal extent and
22 time -- that is, 20,000 years, 100 kilometers -- is applicable
23 worldwide?

24 A That was the basis on which it was developed,
25 yes. I stress that this is not a very precise business but



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1 it appeared to me to be a definite advance rather than
2 guessing without any basis at all, in particular, with
3 respect to the variation in seismicity over periods of
4 centuries.

5 Q Dr. Smith, could I direct your attention now
6 to Page Nine? And on Page Nine, you're discussing some of
7 the factors that you consider relevant to determining the
8 future seismic potential of a region.

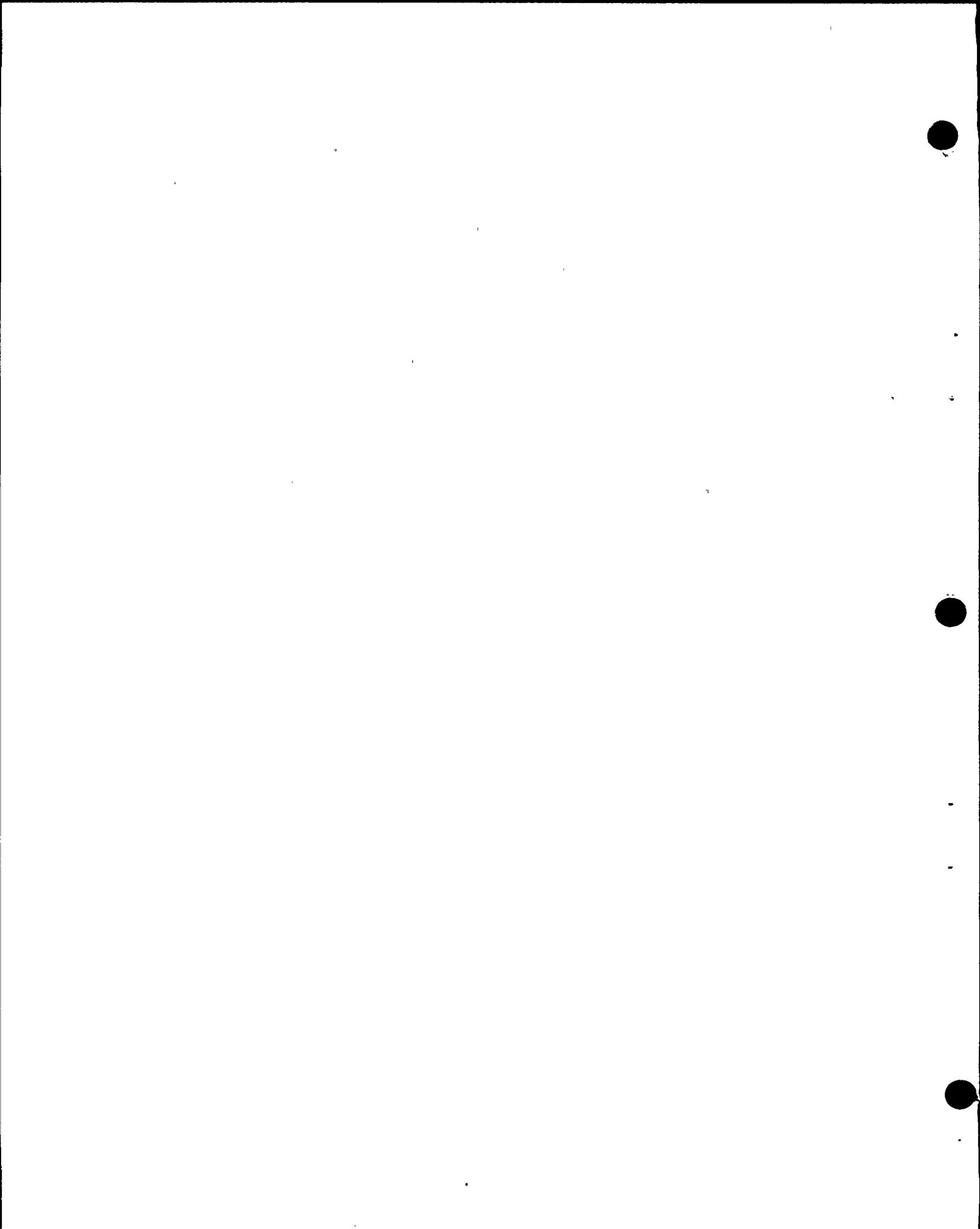
9 On Page Six you list four factors: fault length,
10 slip, type of faulting, proximity of plate boundaries. I'd
11 like to ask you about this type of faulting.

12 On Page Nine, on Line 17, you say:

13 "Regions undergoing normal
14 faulting, a situation characterized by
15 horizontal tension, typically produce lower
16 stress earthquakes than those associated with
17 thrust or reverse faulting in which hori-
18 zontal compression is dominant."

19 What measurements of stress release from earth-
20 quakes do we have that support that conclusion?

21 A Well, there's a variety of papers that have been
22 published in the last decade, since stress drop and other
23 parameters have been investigated. Most impressive data
24 is for the San Fernando earthquake for which, also, we have
25 the best data set and perhaps the most is known, which



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1 was a thrust fault. But there are numerous other examples
2 that illustrate this.

3 I would say that there is abundant data for
4 high stress in thrust faults, somewhat less for strike-slip
5 faults. And we have the least data for normal faults.

6 I have generalized a bit here from some models
7 of faulting where one expects, in a thrust fault situation,
8 to have the horizontal stresses which are holding the sides
9 of the fault together. Those stresses are larger and,
10 therefore, for the fault to move it has to overcome larger,
11 you might say, frictional stresses.

12 So the characterization I've given here is
13 partially related to the current seismological theories
14 about stresses operating on a fault zone and also to that
15 data which we do have.

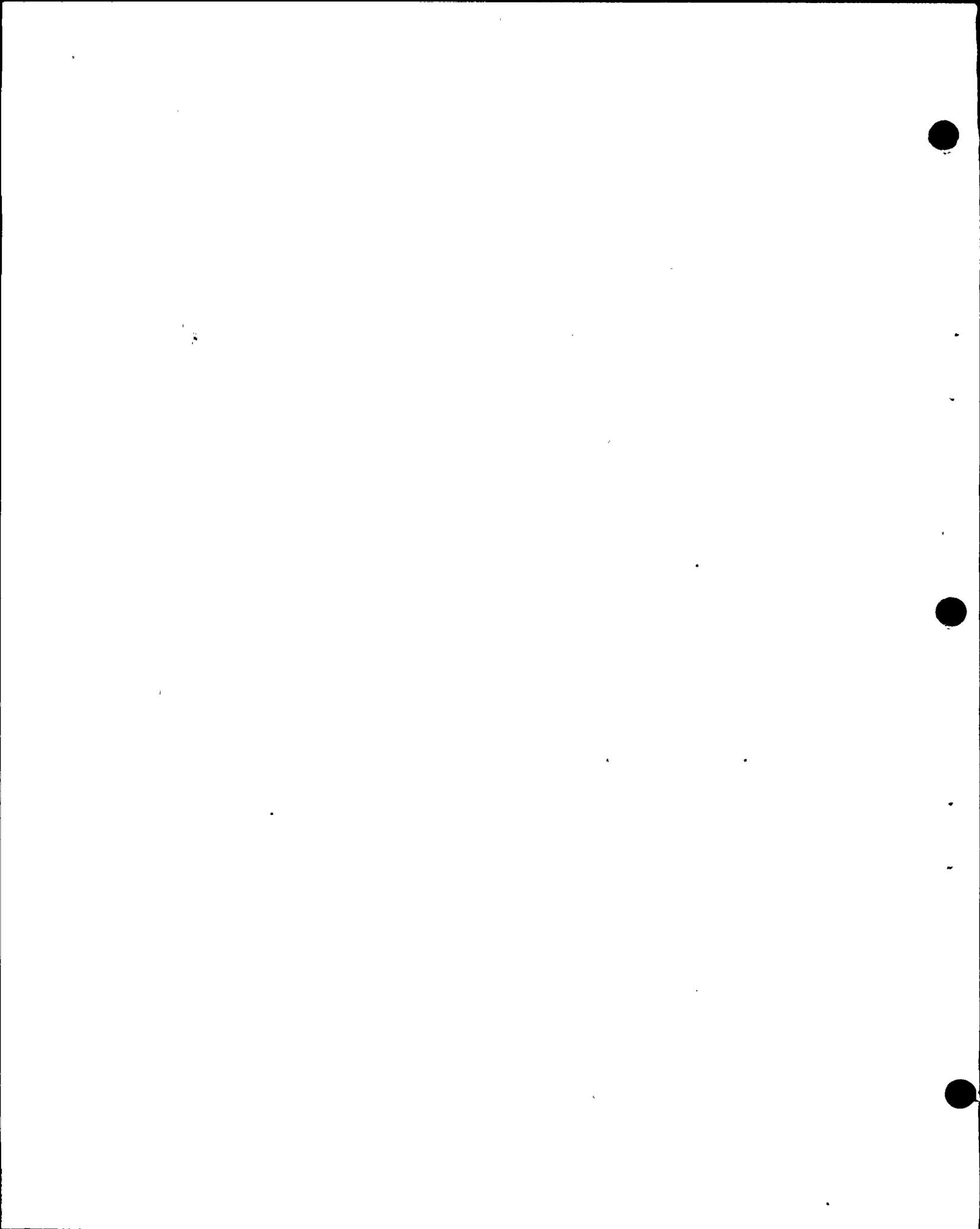
16 Q Let me ask you--I want to ask you a little bit
17 about the data, but before we get into that, you used the
18 term, "stress drop." What is that?

19 A I think we might get a very clear explanation
20 of that if we could let Dr. Frazier explain that perhaps
21 in the context of other fault parameters because it is
22 an important one.

23 Q Sure.

24 A (Witness Frazier) I'm sorry, I was reading here.

25 My understanding of the question is what is



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1 "stress drops."

2

Q Correct.

3

A Oh, boy. I'm going to try and make this very
4 simple.

5

As in magnitude, I think the Board has learned
6 there are several different kinds of magnitude. The same
7 is true with stress drop.

8

Seismologists have sought the use of the word,
9 "stress drop" primarily to indicate the difference in the
10 average stress over the rupture surface of an earthquake,
11 the difference of that stress before and after the earth-
12 quake.

13

That's a physical phenomenon that exists in the
14 earth, and if we could just get down there and measure
15 that stress before the earthquake at many, many different
16 points and then after the earthquake, measure it at many,
17 many different points and then average over the rupture
18 surface, that would be what we mean by stress drop.

19

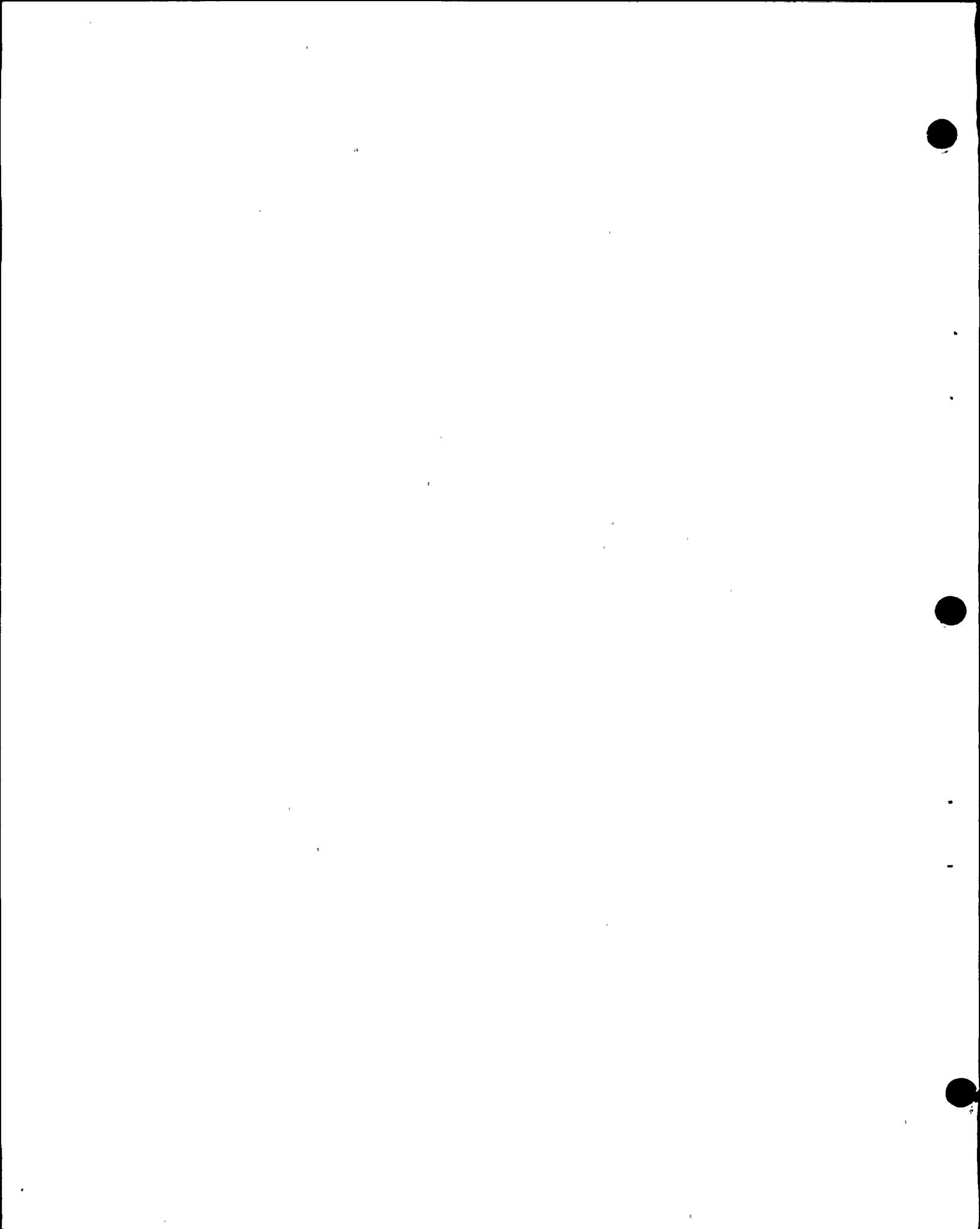
Unfortunately, that number is inferred, it's
20 an indirect phenomenon that we infer in many different ways
21 and, consequently, it takes on different nuances, but that's
22 primarily what the word means.

23

Q Well, whatever this is, we get it from seismograms,
24 don't we, this measurement?

25

A Yes, we do. However I, personally, have a little



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1 difficulty with that and I think the other members of the
2 panel do, too.

3 There are examples in which, when we deduce this
4 thing, this average stress before and after the earthquake,
5 when we deduce that from seismic records there are cases
6 where we can go to the field and observe the amount of slip
7 and try to get confirmations on how good our seismic techni-
8 ques are for ascertaining that physical number.

9 In a large number of cases, the stress drop
10 deduced from seismic observations is a measure of something
11 other than what actually happened in the earth. It's something
12 different than the physical phenomena we're trying to get
13 our hands on. So there are exceptions to that.

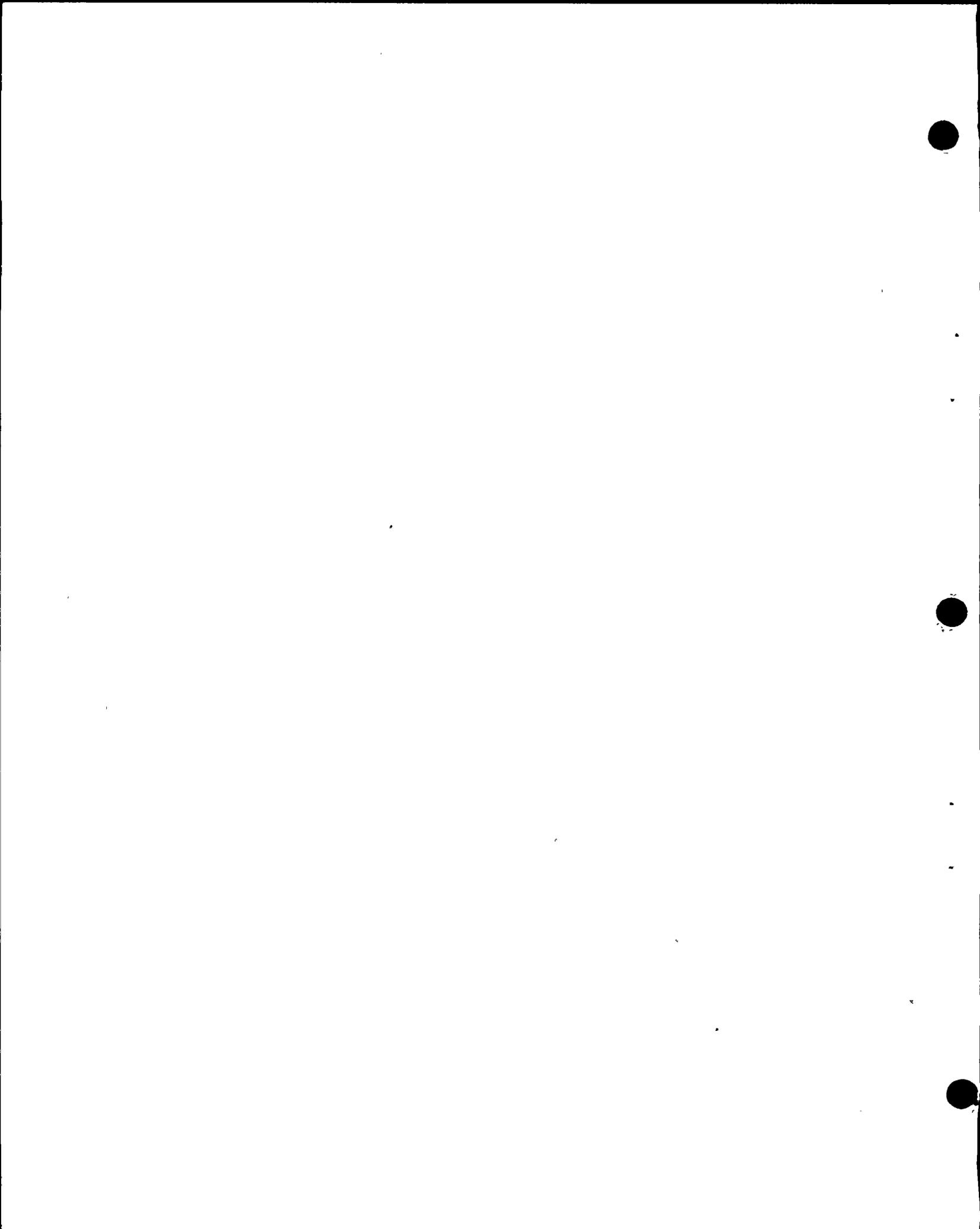
14 It's a look at the observed recordings and a
15 number that comes out of the seismic recordings that may
16 portray other phenomena than average stress differences.

17 Q Well how do we know what kind of stress is
18 being produced by earthquakes of different -- different kinds
19 of sense of faulting?

20 A Could I get some context? It would really help
21 me, I think.

22 Q I'm looking here at Page Nine and reading the
23 sentence:

24 "Regions undergoing normal faulting,
25 a situation characterized by horizontal tension,



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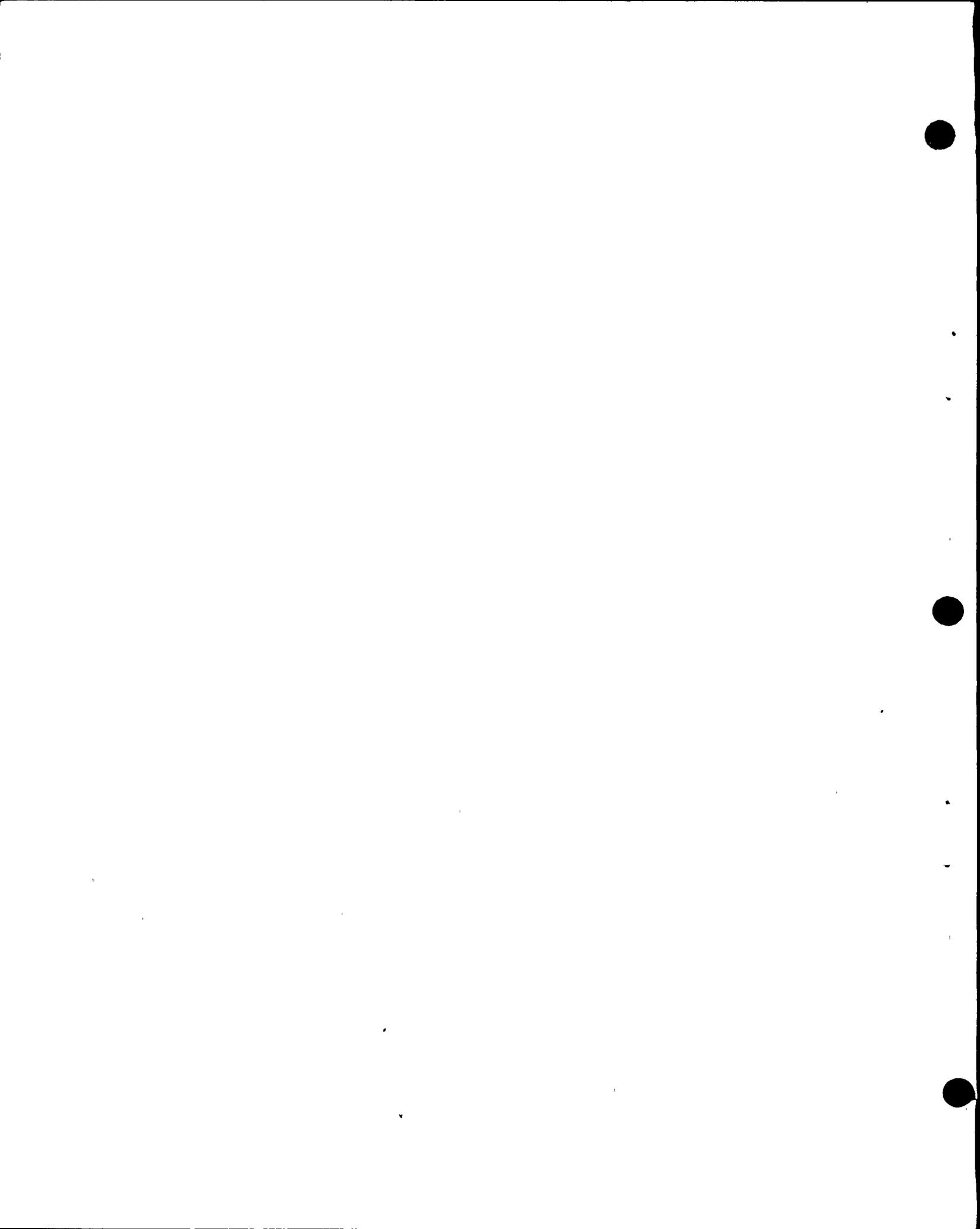
1 typically produce lower stress earthquakes
2 than those associated with thrust or reverse
3 faulting..." and I'm trying to figure out what the
4 data is that supports that, whether there are studies
5 that have been done for each of these types of different kinds
6 of faulting, what the spread of the data is for each of
7 these different kinds of faulting so we can know what the basis
8 for that statement is.

9 A Yes, I think we can get at that statement directly
10 without getting into several of the nuances of stress drop.

11 Dr. Smith pointed out or indicated the San
12 Fernando earthquake is an example of that kind of phenomenon.
13 A thrust fault is a situation in which there are large
14 horizontal compressions causing subsurface materials to
15 fracture. And a normal fault is one in which the horizontal
16 stresses are being relieved and the material fractures because
17 of lack of horizontal support. It's a spreading, whereas
18 a thrust fault is a compression.

19 And we know from laboratory experiments and
20 other things that compression, when a material is being com-
21 pressed, it typically takes more stress to cause the
22 fracture to occur.

23 And an example of that is the San Fernando
24 earthquake, in which, from recollection, the stress drop for
25 the San Fernando earthquake was on the order of -- in excess



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1 of 100 bars which is rather anomalous for earthquakes that
2 large.

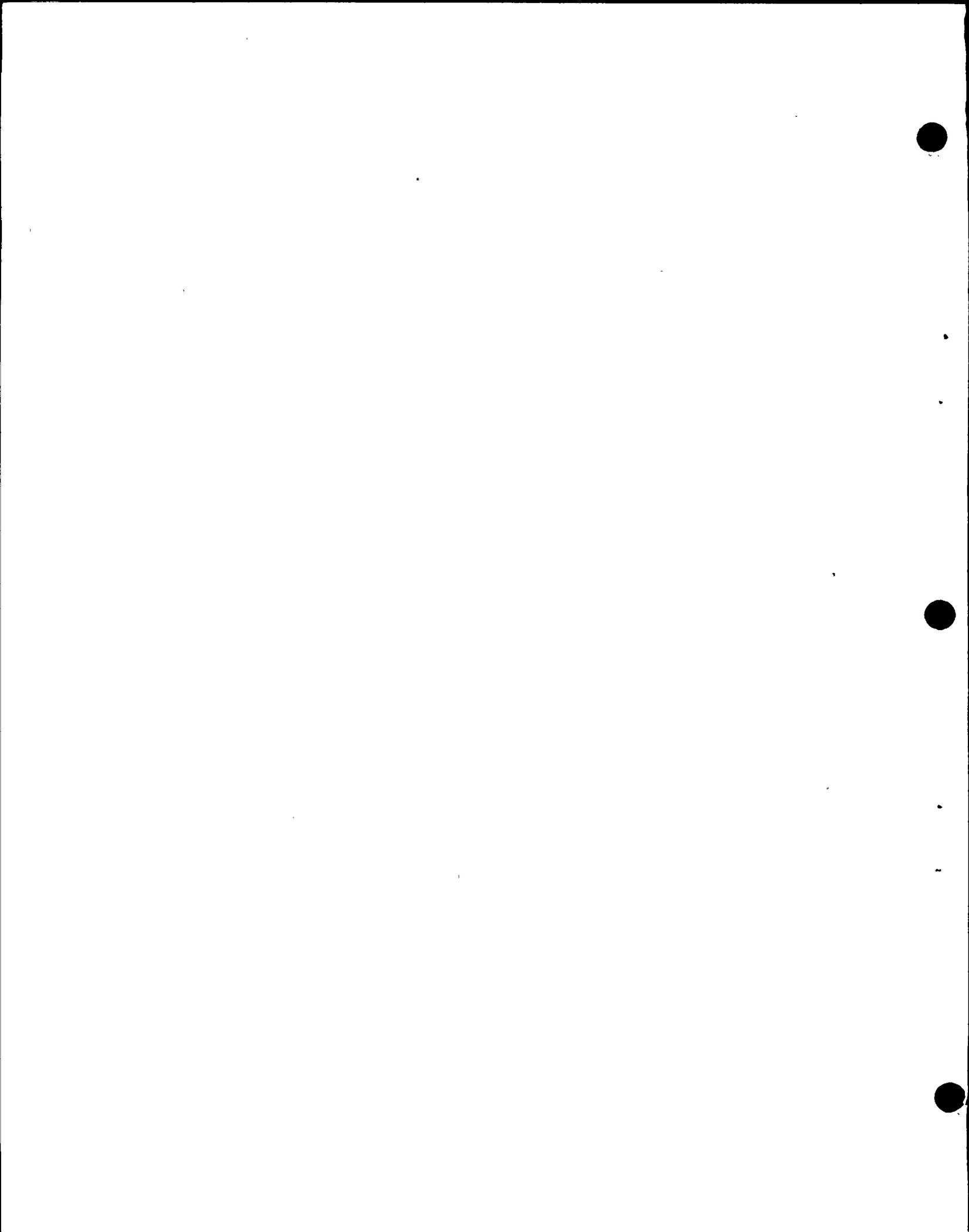
3 The average stress drop for earthquakes along
4 continental boundaries or plate boundaries is 30 bars. And
5 here's an earthquake of something on the order of 100 bars
6 or greater. And aftershocks for the San Fernando earthquake
7 which are also compression features, thrusting-type after-
8 shocks, several of these are in excess of 200 bars, which
9 is really quite anomalous for observed behaviors, just as a
10 kind of an example of what we're seeing here.

11 The Transverse Range, Dr. Jahns pointed out that
12 there's a lot of compression in this region, and in that
13 region, we would expect to get fairly high stress drops.

14 Q If I understand your testimony, the current
15 theory is that this is what we would expect to see and
16 we have a data point, the San Fernando, that suggests that
17 we have very high stress drop in faults that are associated
18 with thrust characteristics, a large thrust component.

19 I'd like to know how many data points we have
20 for thrust faults.

21 A If you would like a tabulation of data for thrust
22 faults on one side and a tabulation of normal faulting on
23 the other side so that we could, by eye, scan through those
24 that would take me some time to accumulate those, I don't
25 carry those kinds of numbers in my head.



agbl4

1 A (Witness Bolt) If I could add something to that,
2 Mr. Fleischaker?

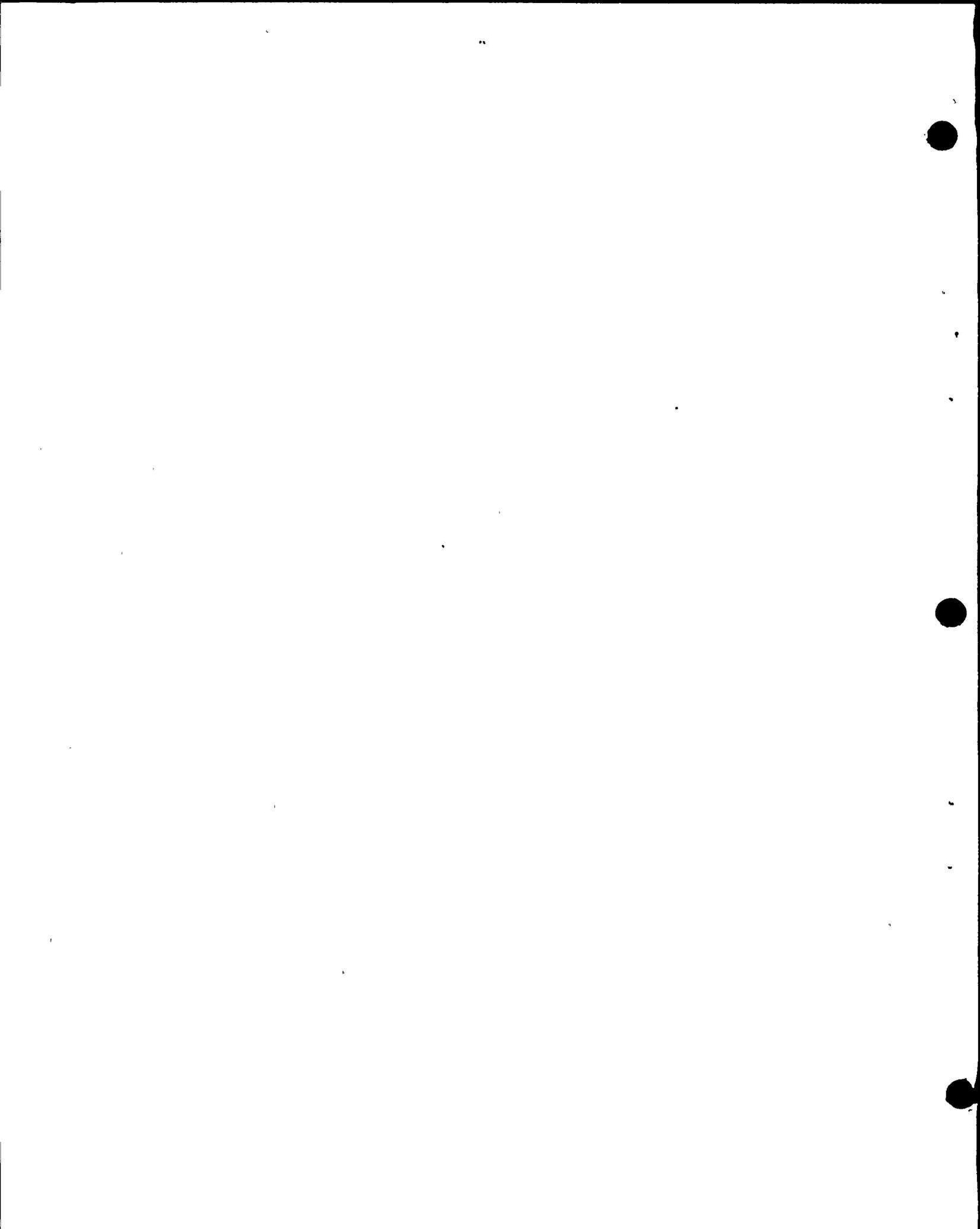
3 Since the notion of stress drop has been published
4 in the literature, the number of papers that deal with this
5 has grown enormously, not only in this country but also over-
6 seas including Japan and the Soviet Union.

7 And I would hazard that one could find over a
8 thousand measurements of stress drop published in known
9 seismological journals and those stress drops would relate
10 to earthquakes, down to very small magnitudes of one and two,
11 up to the 1906 earthquake, I calculated that myself in the
12 chapter in Earthquake Engineering. So that we have an
13 enormous number of measurements, I don't think anybody has
14 ever catalogued them, it would be a matter of cataloging.

15 We do know that the average sort of stress drop
16 that one gets in California for the usual small-to-moderate
17 earthquake which, as everyone knows, is generally associated
18 with the San Andreas Fault system and, hence, is strike-slip
19 faulting predominantly, is about 60 bars.

20 And the San Fernando earthquake which was quoted
21 which was thrusting on the San Gabriel Mountains over the
22 Los Angeles Basin gave something three to four times greater
23 than that. That has been carefully documented. There's
24 one example.

25 The measurement of stress drop, however, by looking



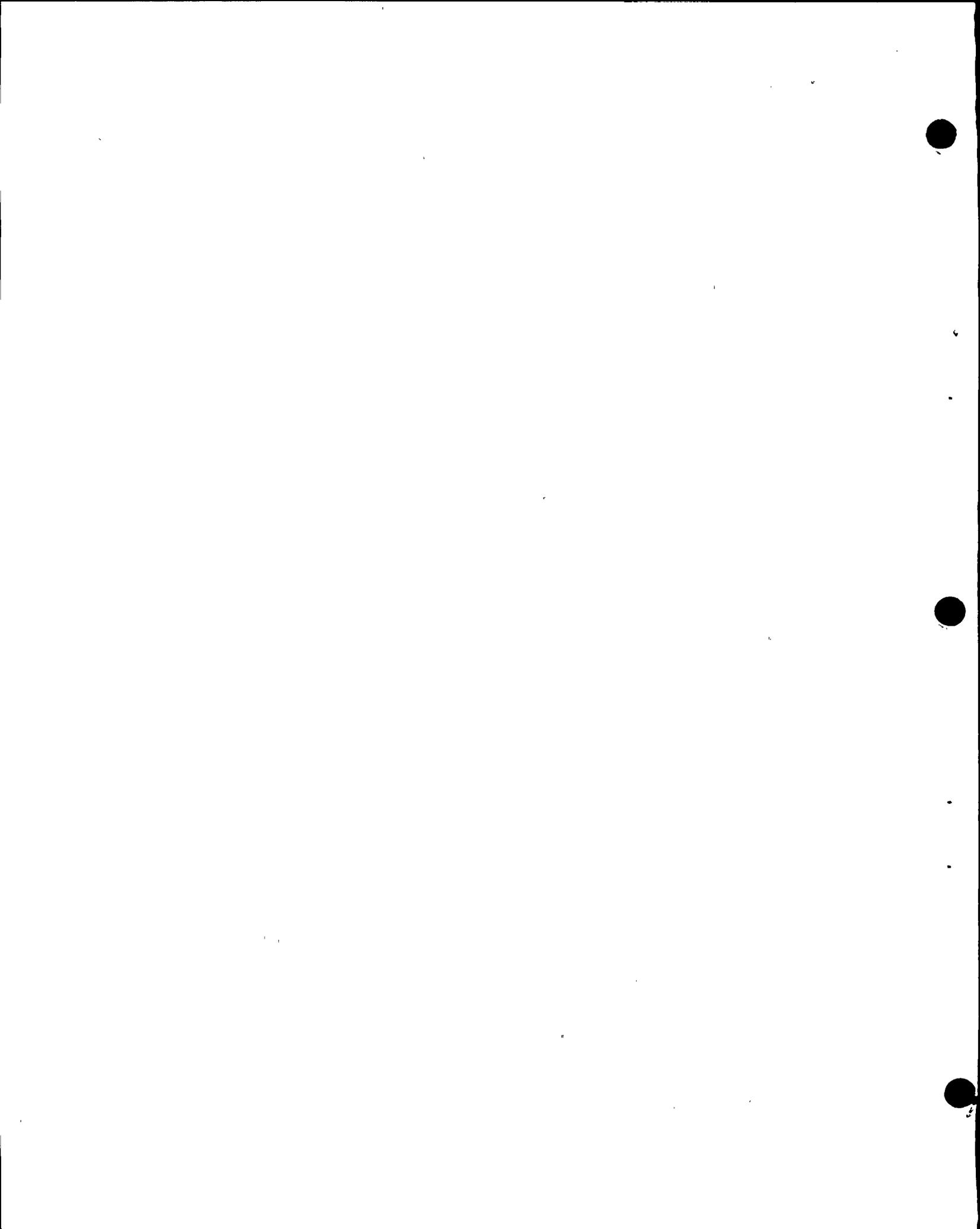
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1 at seismograms is a matter of inference, as Dr. Frazier
2 mentioned. And my own feeling about it is that I would give
3 much more weight to stress drops which were calculated from
4 the field evidence.

5 Stress is related to strain, as you know, through
6 Hook's Law, stress is proportional to strain. And if we
7 calculate the strain along a fault in a simple way -- and
8 I'm a great believer in simple models for these matters --
9 they usually give fairly good results when it comes down
10 to the point, we could take say the displacement observed
11 on the surface which for the 1906 earthquake was about three
12 meters, and divide that by the width of the fault which could
13 be taken to be about 10 kilometers and that ratio is a
14 measure of the strain.

15 To get the stress, we would then multiply that
16 by the rigidity which -- there was a question of the Board
17 on that and it was pointed out that rigidity has the same
18 dimensions as pressure -- so that then we have something which
19 is equal to -- the rigidity of the rocks. This would give
20 us then a stress drop associated with that particular dis-
21 placement over that particular length or width of the fault.

22 And when one calculates those figures, then
23 one finds that this relationship that Dr. Smith was referring
24 to is generally the case.
25



SC wbl 1 Q On how many occasions have those kind of field
2 measurements been derived? Is that something that has been
3 done a lot?

4 A Well in my chapter on Earthquake Engineering
5 I think I myself did it for the 1906 earthquake, which is
6 strike-slip, and at least two other examples that I gave.
7 And I think that you'll find where geological measurements
8 are available in this country, one way or the other in the
9 literature somebody has done that.

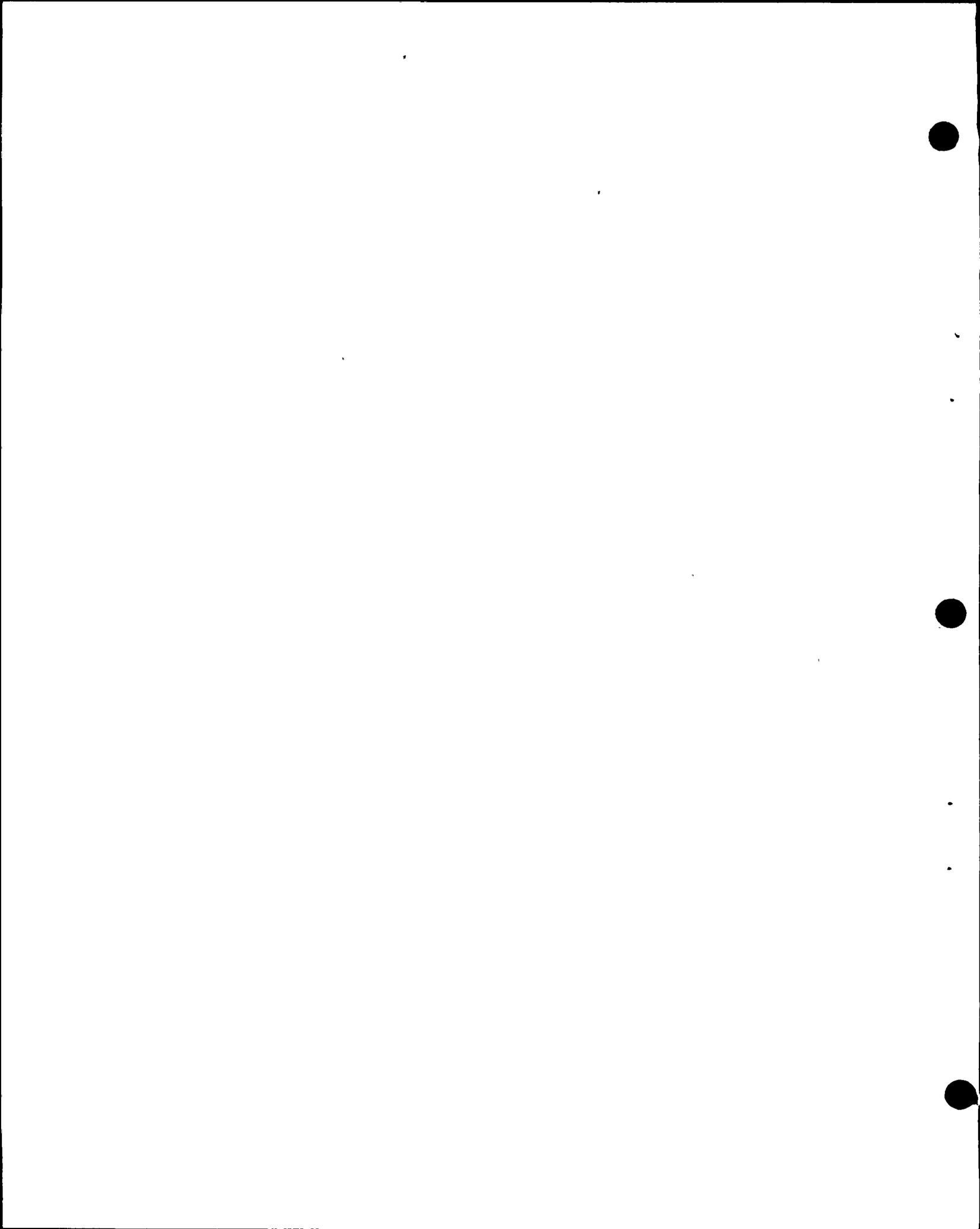
10 That is to say, when a geologist like Bonilla
11 publishes the amount of the slip and something about the
12 dimensions of the fault, somewhere or other someone would
13 have done just what I described. But it's very difficult to
14 keep track of it. Maybe hundreds.

15 Q Are you aware of any study which has catalogued,
16 or has drawn conclusions on the basis of field observa-
17 tions; and, if so, do you have any recollection of how many
18 faults were actually looked at for those conclusions?

19 A I don;t recall any study of the whole set that
20 I just spoke to you about. But there are studies which, in
21 the course of discussing the matter, would compare the
22 different kind of faults.

23 Q For the calculation of stress drop, whatever it
24 is we're calculating from seismograms--

25 A Excuse me. In the method I describe, which I



wb2

1 prefer, the seismogram is not involved.

2 Q That's based on a field study, I understand.

3 A Yes.

4 Q Okay. But we'll go back to the seismogram.

5 And I think your testimony is there have been hundreds of
6 publications of these kind of things.

7 A. Many hundreds.

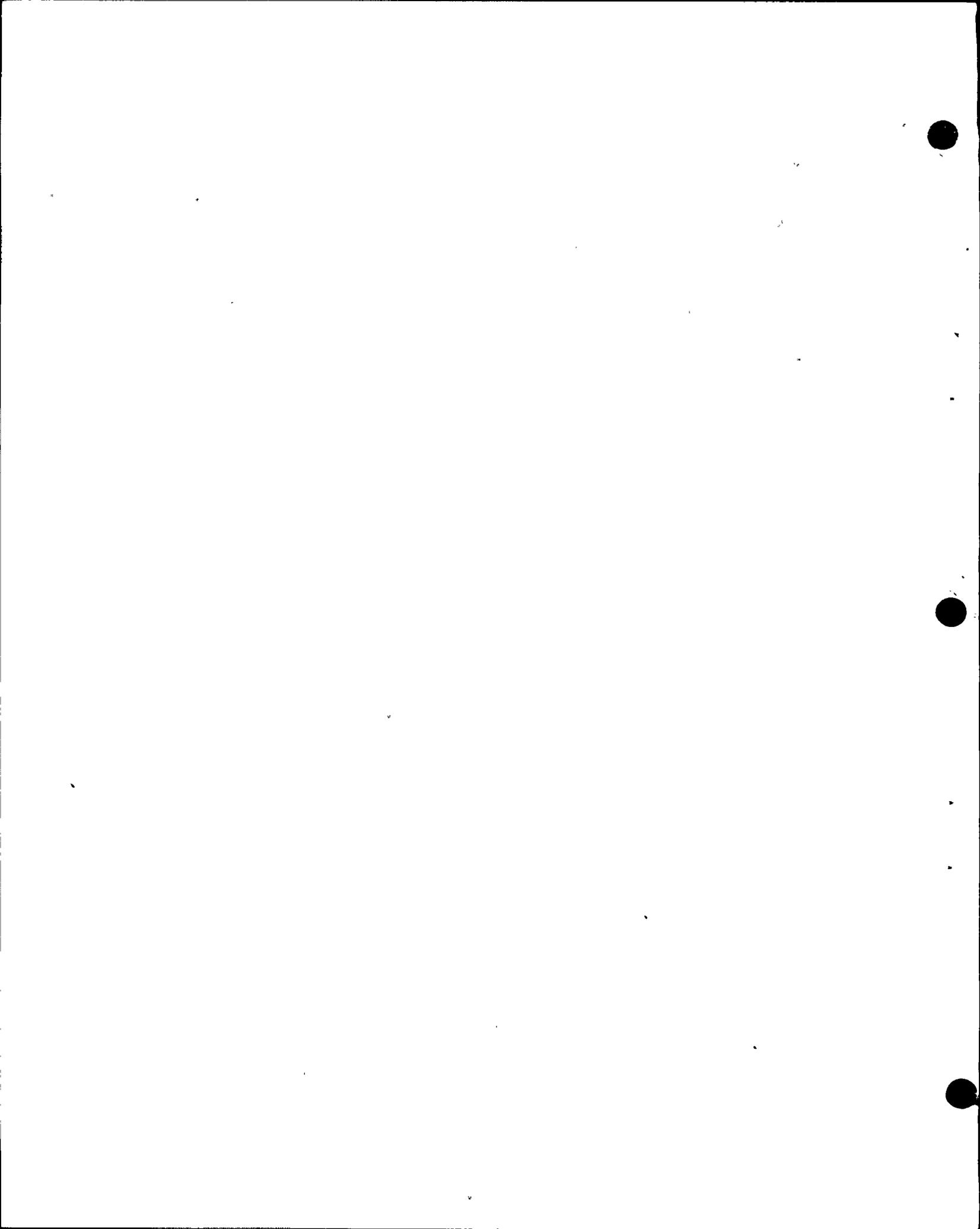
8 Q Are there lots of calculations for each of the
9 types of faulting? --that is, strike-slip, reverse, thrust,
10 and normal faulting?

11 A There would be many representatives of each type,
12 yes.

13 Q All right.

14 Now with respect to each of those classes, can
15 you characterize the spread of the data?

16 A I would say that there was considerable scatter
17 which is not understood. And many seismologists feel that
18 it goes to the actual validity of the mathematical model
19 that's involved in taking something from a seismogram recorded
20 on the other side of the earth to say something about the
21 reduction of stress on the source which produced the earthquake
22 itself. There's a long series of mathematical developments
23 between those things, much more complicated than I went
24 through yesterday following the seismic ray from California
25 to Paris, or wherever we went to yesterday.



wb3

1 (Laughter)

2 Q Okay. Let me move on, Dr. Smith, to another
3 statement.

4 The sentence that begins at the end of line 22,

5 "In addition to the local style of
6 faulting, the proximity of the region to major
7 plate boundaries is important in assessing what
8 the stress conditions are likely to be."

9 Then I'd also like to direct your attention to a
10 statement on page 11 at line 20,

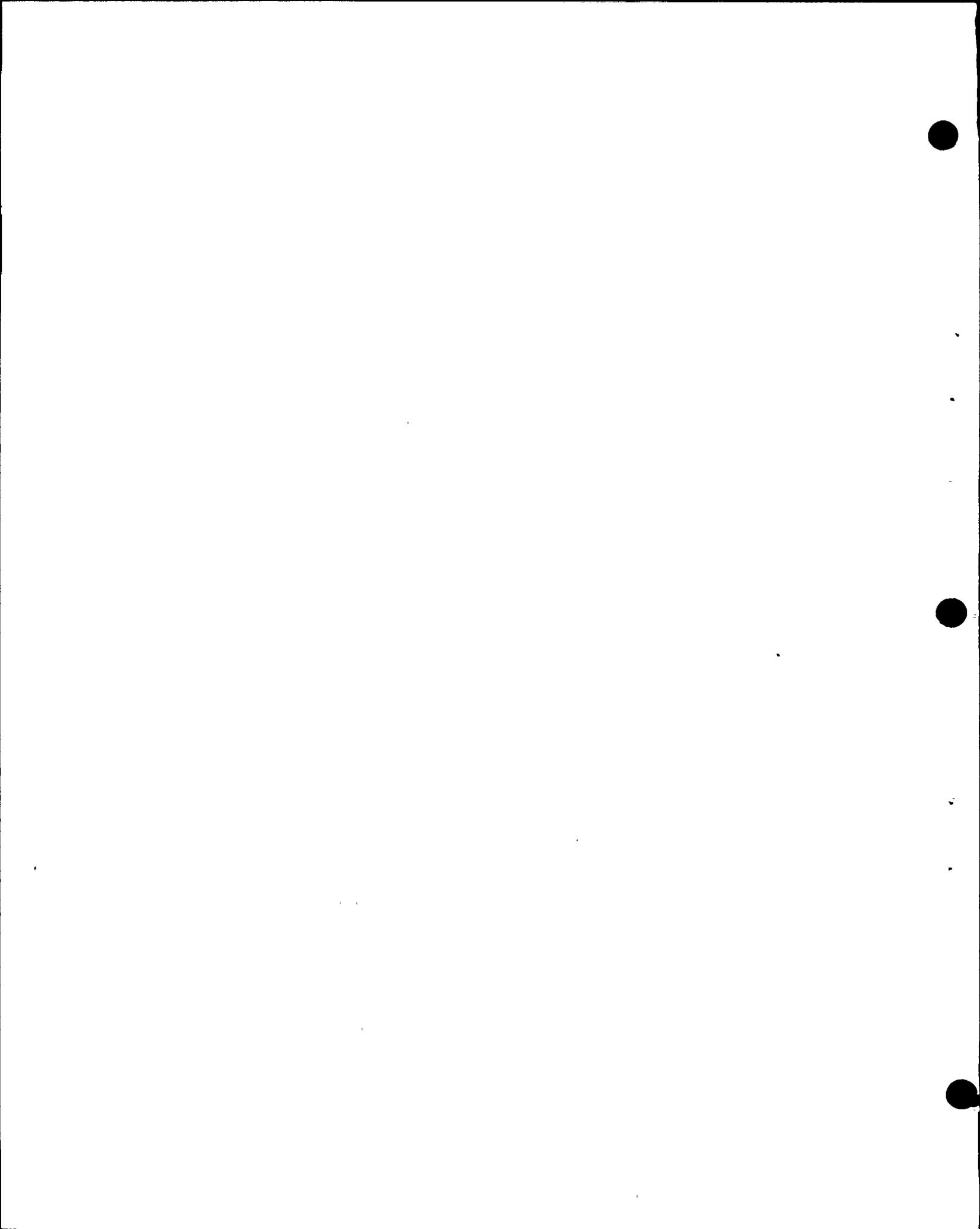
11 "Although still influenced to a certain
12 extent by the stress field for this plate boundary,
13 it is much less affected than those faults which
14 are closer to, or intersect the San Andreas, and
15 thus the stress levels and the earthquake potential
16 are correspondingly less."

17 Now with respect to your statement regarding
18 stress levels, what's the basis for that conclusion?

19 A (Witness Smith) The basis for that conclusion
20 is my perception of how the plate tectonic model works.

21 Q Now, could you explain to us briefly a little
22 more as to how your perception leads you to this conclusion?

23 A If one imagines plates of a given thickness that
24 are slipping by one another riding on a fluid or plastic
25 material underneath them, as our current view of the earth's



wb4

1 surface is, then in a general way you expect the stresses to
2 be concentrated near the fault which is the zone of low
3 strength, and generally to decrease as you go away from
4 the fault.

5 Q Are you aware of the measurements of Kanamori
6 and Anderson with respect to stress relief from intra-
7 plate earthquakes?

8 A Yes, I am.

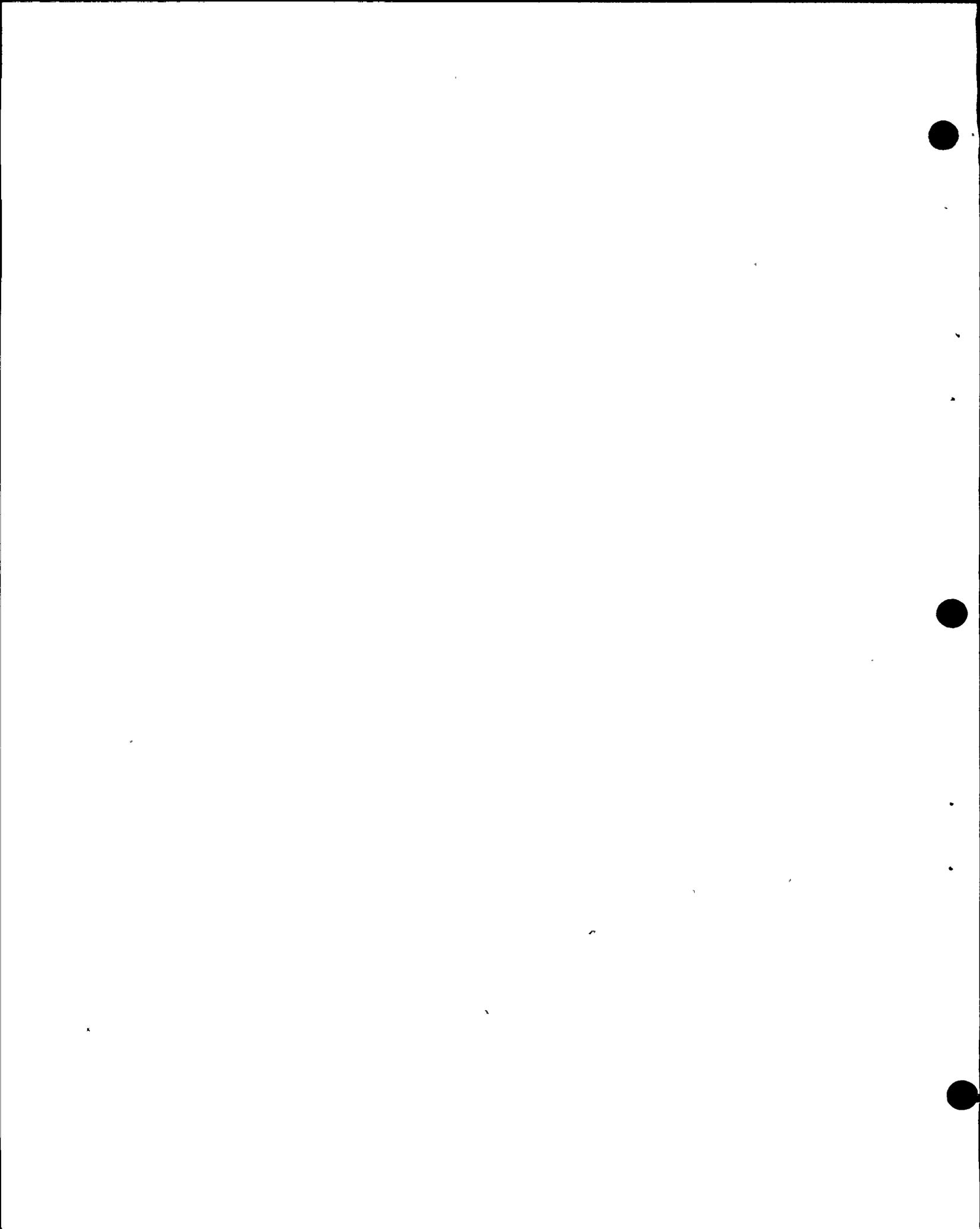
9 Q Now are those stresses,-- Do those stress
10 releases tend to be higher or lower on the average than those
11 we see from earthquakes on plate boundaries?

12 A I'm trying to recall. Typically what we're
13 dealing with here are those like in the eastern U.S. The
14 framework of the operative process that is causing the
15 stresses appears to be different in the interior plates.
16 I don't recall specifically whether-- The stresses may well
17 have been comparable to plate boundary stresses in some of
18 these regions, particularly where the earthquake seems to be
19 controlled by some local kind of inhomogeneity in the earth's
20 crust.

21 Perhaps my colleagues might correct me on my
22 recollection of Kanamori's paper.

23 I can check that.

24 Q Let me ask you: Do you at this time have a clear
25 recollection as to Kanamori's observations as to the stress



wb5

1 release from intraplate tectonics and their comparative
2 levels? --their levels in comparison to earthquakes on plate
3 boundaries?

4 MR. NORTON: Excuse me, Mrs. Bowers.

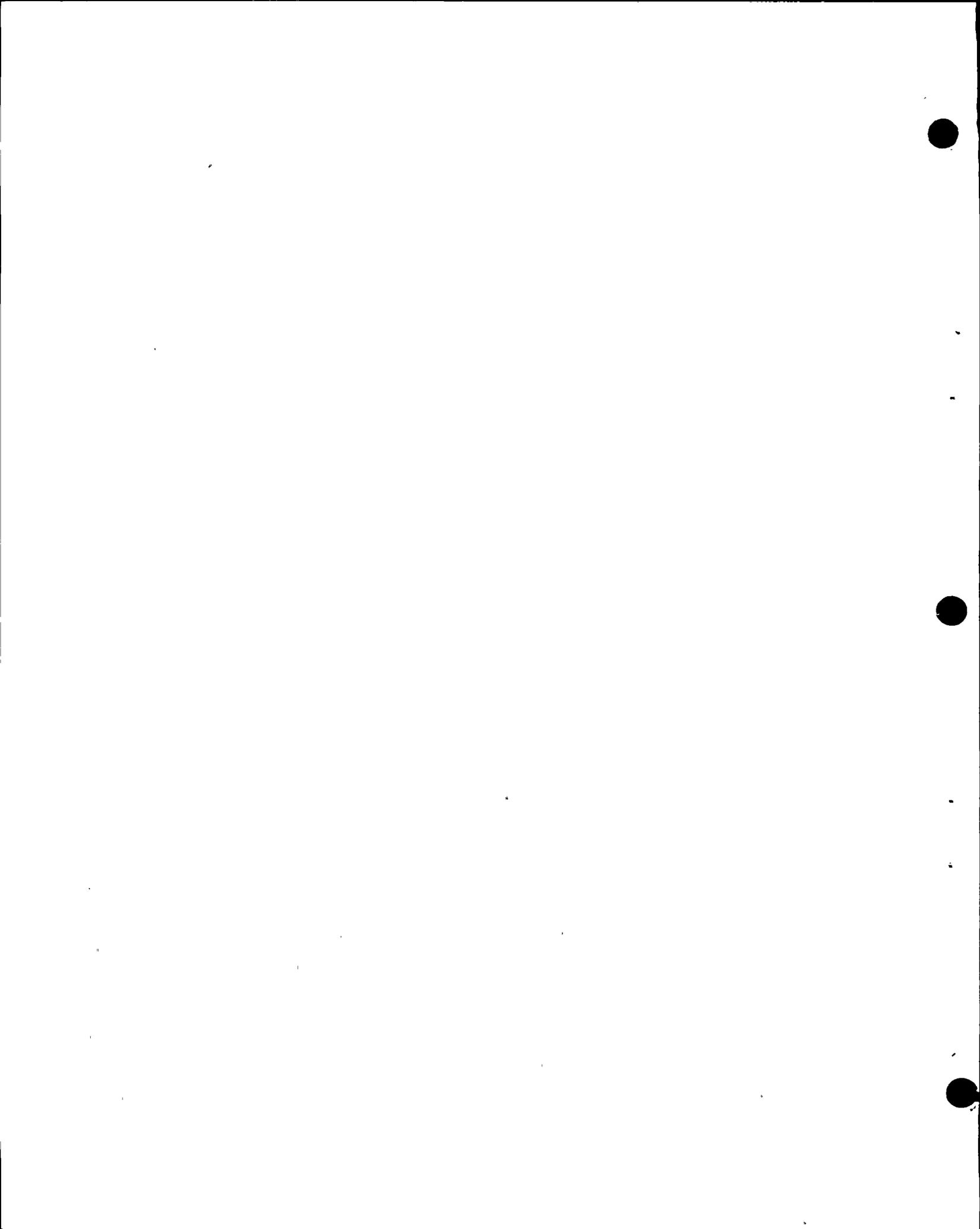
5 I gather from the witness' last answer -- I.
6 didn't realize this was a study done on other than the
7 San Andreas, this Kanamori study that's being referred to,
8 when the first question was asked. But as I gather from the
9 response of Dr. Smith, I'm not at all sure that this study
10 is in any way relevant to the California plate boundaries.
11 And maybe we ought to have some foundation.

12 I would object, on the basis of lack of foundation,
13 to questioning on that paper if it is not in any way related
14 to the situation at hand. And there has been no foundation
15 laid that it is.

16 MRS. BOWERS: Would you respond to that objection?

17 MR. FLEISCHAKER: Well what I understand is that
18 from reading Dr. Smith's testimony, the bottom of page 11,
19 he makes a statement which suggests that stress levels are
20 correspondingly less as we move from plate boundaries. And
21 I'm trying to determine how he's reached that conclusion and
22 how that conclusion fits with the observations of other
23 scientists that stress levels are indeed very high when we
24 remove ourselves from the plate boundaries.

25 MR. NORTON: Excuse me, Mrs. Bowers. That



wb6

1 explanation assumes facts not in evidence, too. I haven't
2 seen any paper that says that, nor have I heard any witness
3 say that. And I understand that maybe that's what
4 Mr. Fleischaker is trying to probe, but he's not laying any
5 foundation for it that I've seen. There's just no foundation.
6 I've heard the name of an author, period. And I haven't
7 heard that that paper is in any way related to stress drops
8 along the San Andreas plate. They may be, I just don't know.
9 And that's what I'm asking for, is a proper foundation.

10 MR. FLEISCHAKER: Well let me address two of
11 those things.

12 First of all the substantive issue. It's not
13 stress drops along the San Andreas plate; what we're talking
14 about is the diminution-- or the relationship of stress drop
15 and distance. or proximity to a -- quote -- plate boundary.
16 That's the subject.

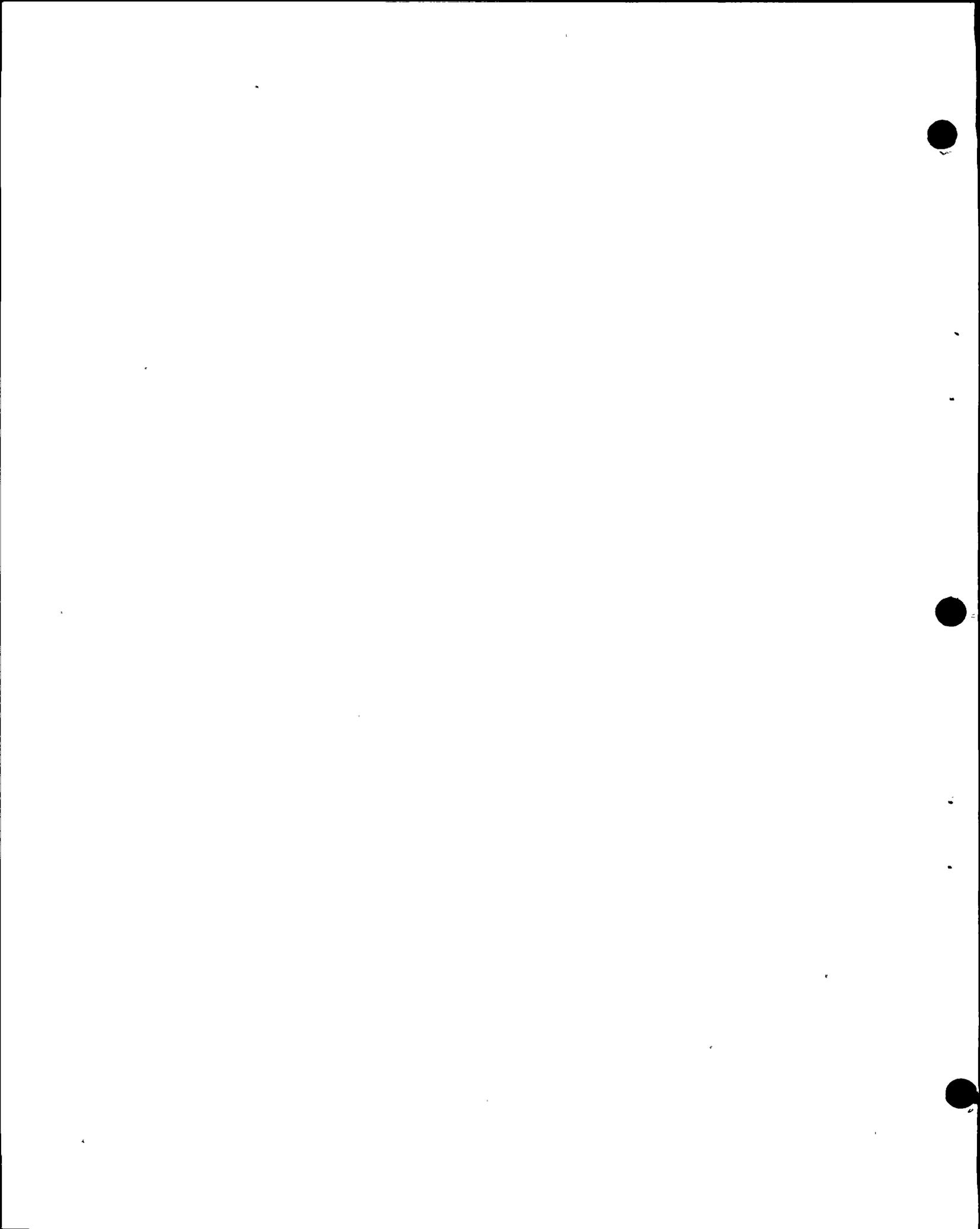
17 As to the fact in evidence, that's right. And
18 I'm asking Dr. Smith if he recalls it. If he doesn't recall
19 I'll move on, because I don't have the paper here.

20 MRS. BOWERS: Does the Staff want to respond?

21 MR. TOURTELLOTTE: No.

22 WITNESS SMITH: Perhaps I could clarify by saying
23 that I was trying to--

24 MRS. BOWERS: Well, first, there was an objection
25 because of lack of foundation. And that objection is sustained.



1 BY MR. FLEISCHAKER:

2 Q Let me ask it this way: Dr. Smith, are you
3 familiar with the writings of Kanamori and Anderson and
4 their conclusions relating to measured stress drops in the
5 intraplate earthquakes?

6 A (Witness Smith) I'm generally familiar, yes.
7 I don't recall the details of just exactly what the stress
8 levels were.

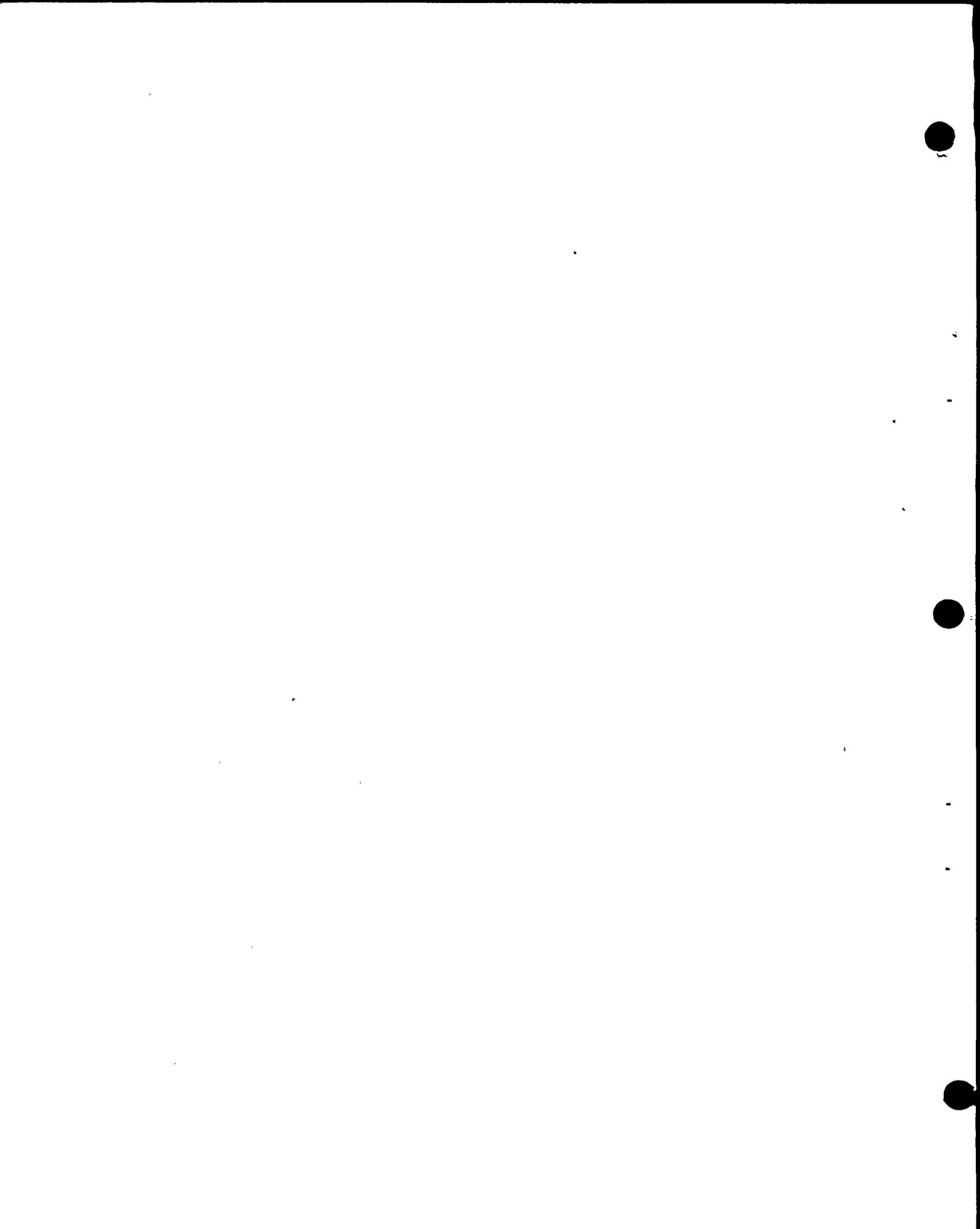
9 Q Okay. No further questions.

10 MR. FLEISCHAKER: Can we take a break?

11 MRS. BOWERS: We'll take a 10-minute break.

12 (Recess)

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End 3A



3d ebl 1 MRS. BOWERS: We'd like to proceed.

b3 2 MR. NORTON: Before we start with the examination,
3 as I understand it, we met during the break and Mr. Fleischaker
4 said he fully intended to finish with this panel today.

5 As I understand it, the Staff doesn't have a
6 great deal of cross, and I presumably will not have any signi-
7 ficant redirect. So I expect we'll be done with them certainly
8 before noon tomorrow, probably well before noon.

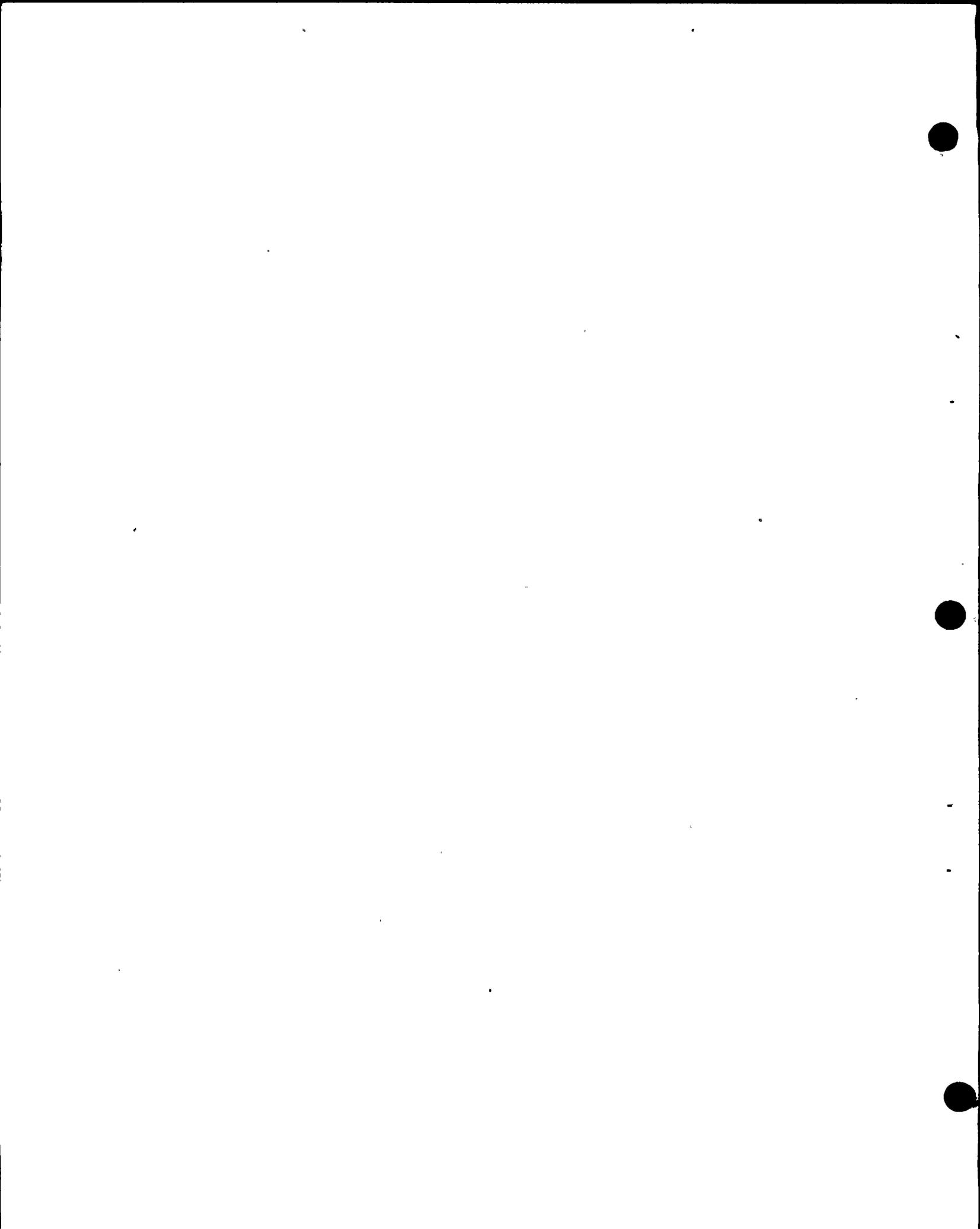
9 That being the case, our next panel will be
10 Dr. Blume, Dr. Seed, Dr. Cornell, and either Dr. Smith or
11 Dr. Frazier. I'm not sure which yet. In any event they would
12 go on Saturday. My guess would be they would not be finished
13 Saturday with cross-examination.

14 And then Dr. Silver and Dr. Graham,
15 Mr. Fleischaker's witnesses, would come Monday morning and
16 we would send our panel home for Sunday, Monday and Tuesday
17 probably, and we would call them some time Monday to tell
18 them whether they should be back Tuesday or Wednesday to
19 re-take the stand.

20 That's kind of the way we see things unfolding
21 for the next few days.

22 MRS. BOWERS: This panel of witnesses will be
23 here tomorrow morning?

24 MR. NORTON: Yes. Hopefully we'll be able to
25 finish very early tomorrow morning, if not this afternoon



eb2 1 then, you know, for an hour or so tomorrow morning, and then
2 we'd put the new panel on.

3 MRS. BOWERS: You didn't figure in any Board
4 questions. I don't know how extensive they may be.

5 MR. NORTON: I appreciate that. We're just try-
6 ing to give you our best estimate, that's all.

7 MRS. BOWERS: Very good.

8 BY MR. FLEISCHAKER:

9 Q Dr. Smith, I'd like to direct your attention
10 to page 26. Before I get into specific questions about this
11 section, will you state what it is you're concluding in this
12 section?

13 A (Witness Smith) I'm concluding that for peak
14 instrumental ground motion, the figures quoted in USGS
15 Circular 672 are conservative.

16 Q Well, what's the basis for that conclusion?

17 A The body of strong motion data that's available
18 to us.

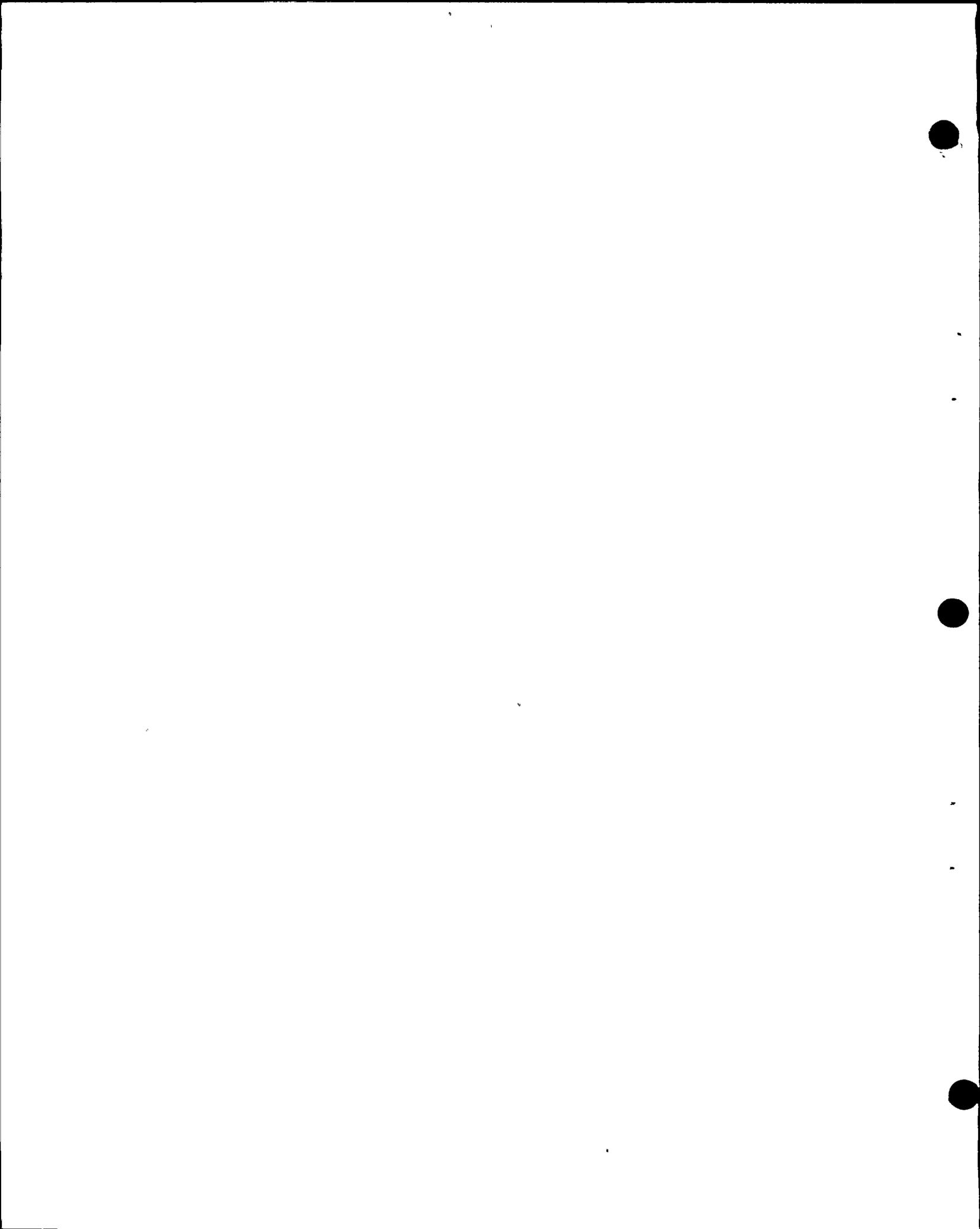
19 Q Is this for all ranges of magnitudes?

20 A The conclusion refers specifically to the postu-
21 lated magnitude 7.5 earthquake in the close-in distance.

22 A (Witness Bolt) May I add something?

23 Q Surely.

24 A I would like to follow up on Dr. Smith's answer
25 with my own view that I think that the value that he is saying

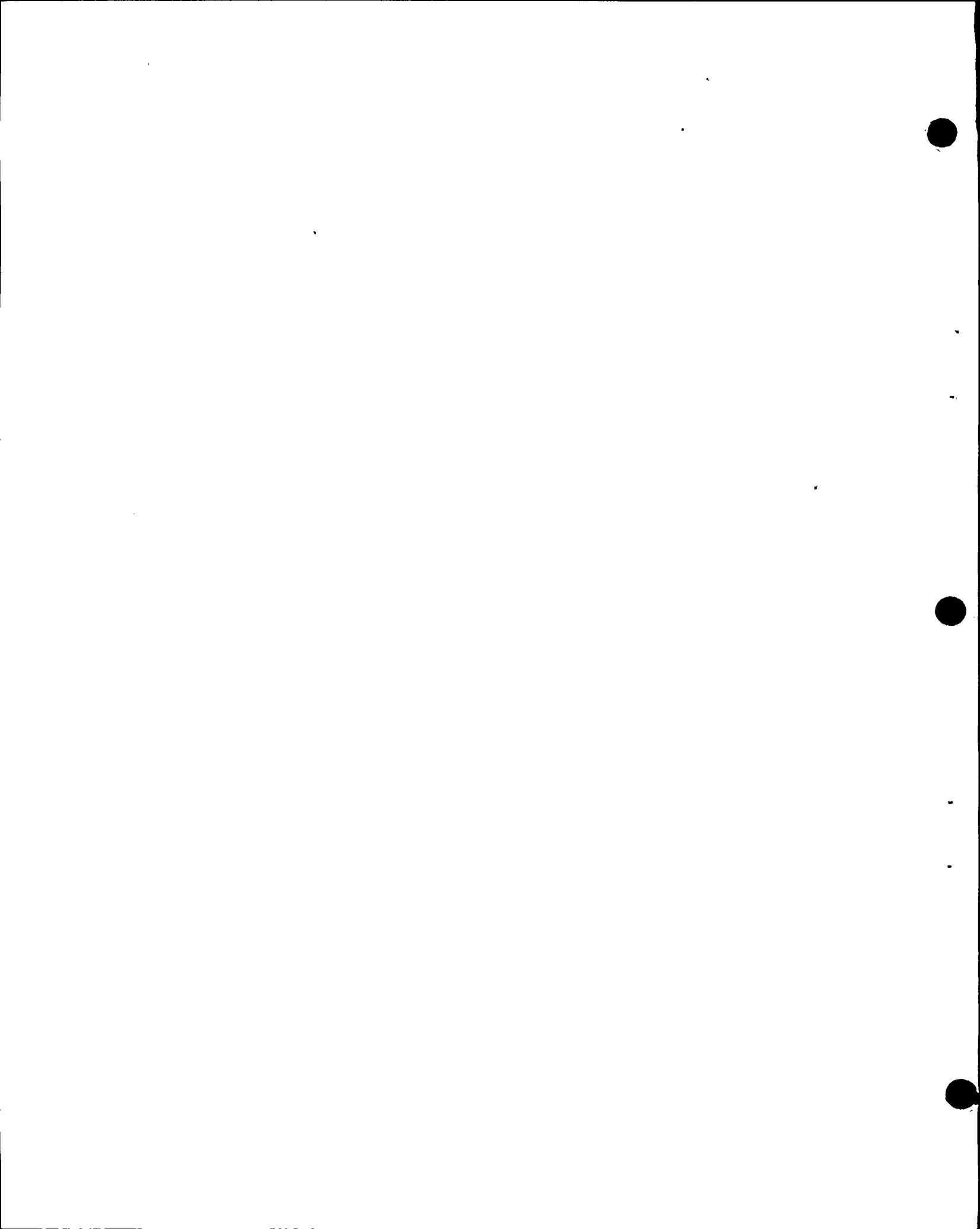


eb3 1 is conservative is very conservative. I was involved with
2 the Alaska pipeline work which was the reason for the writing
3 of this circular by the people at the U. S. Geological Survey
4 and I'm very much aware of the arguments that went on at that
5 time.

6 I think that the evidence has become even
7 clearer since the circular was written that the procedure that
8 was used by the U. S. Geological Survey people to scale up
9 from a small data base, so far as earthquakes of moderate
10 magnitude are concerned, to the larger size earthquakes,
11 larger accelerations, had fatal flaws, and that a direct
12 scaling using magnitude is not very sound.

13 If you read their circular carefully you'll find
14 that they work to a large extent with a pivot point on the
15 1971 San Fernando earthquake which was a thrust earthquake
16 which happened to be recorded on a strong motion accelero-
17 graph at Pacoima Dam. The accelerograph was located on a
18 narrow ridge and showed a peak acceleration of about 1.2g
19 It is variously measured by people, but about that level of
20 acceleration.

21 Now for many, that was a surprise. It didn't
22 surprise me particularly. There are many reasons why one
23 will get high spikes of acceleration at higher frequencies.
24 If I bang the table with my fist, I can make pencils jump
25 up in the air. That is to say I can achieve very easily



1 accelerations greater than 1g, but it certainly doesn't
2 affect the safety of this building.

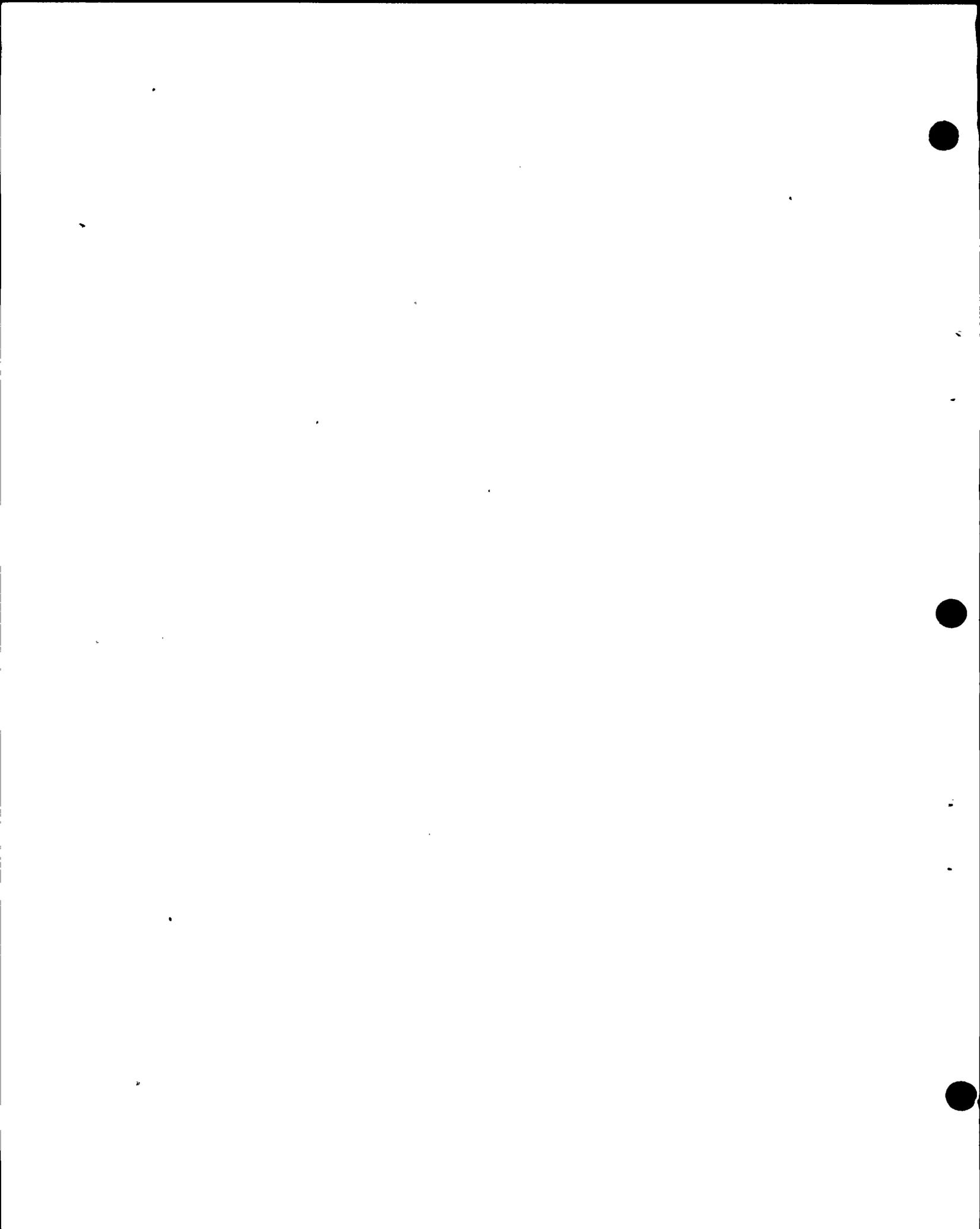
3 The Pacoima record and this acceleration of 1.2g
4 was a very important pivot point in their argument. Since
5 that time we have had one other record which bears I think
6 more importantly on the assessments. That was on September
7 16th in Iran, a record obtained in the City of Tabataz which
8 was five miles from the end of the fault rupture.

9 The fault rupture, again according to the U. S.
10 Geological Survey people just published in the Newsletter of
11 the Earthquake Engineering Research Institute, was thrust-
12 type faulting, so this is, according to the testimony that
13 we have given in this submission, likely to be on the high
14 side. And the magnitude, the M_s magnitude for this earth-
15 quake is variously given as 7.7, 7.8. We got 7.8 at Berkeley
16 on our calculation.

17 So this would be the highest acceleration-- I'm
18 sorry, this would be the closest acceleration ever obtained
19 on an instrument near to a great earthquake, 7.7, 7.8 magni-
20 tude, and the peak acceleration was about .8g, in flat
21 contradiction to the extrapolation that was carried on in this
22 particular circular which reinforces my view that the basis
23 of that particular argument is on very -- shall I say shaky
24 ground? --

25 (Laughter.)

-- and that I am certainly not prepared in my own thinking



eb5

1 to go nearly as high in these peak accelerations if we're
2 talking about accelerations which have engineering signifi-
3 cance.

4 And I don't believe anyone in the room or who
5 would be involved in the hearings really cares too much
6 whether we're talking about -- if we're talking about 50 hertz.
7 Essentially everybody has to apply some sort of window to
8 what they're talking about. You don't have to be engineers
9 to realize we're talking about ground motions in the range
10 of interest for structures.

11 Consequently, frequency is terribly important.
12 I have no doubt that it's possible to get very high accelera-
13 tions at very high frequency ranges. If you'll give me a
14 hammer I'll pound on a piece of concrete and a penny will jump
15 up next to it. It's easy to get high's; it has nothing to do
16 with the engineering range of interest.

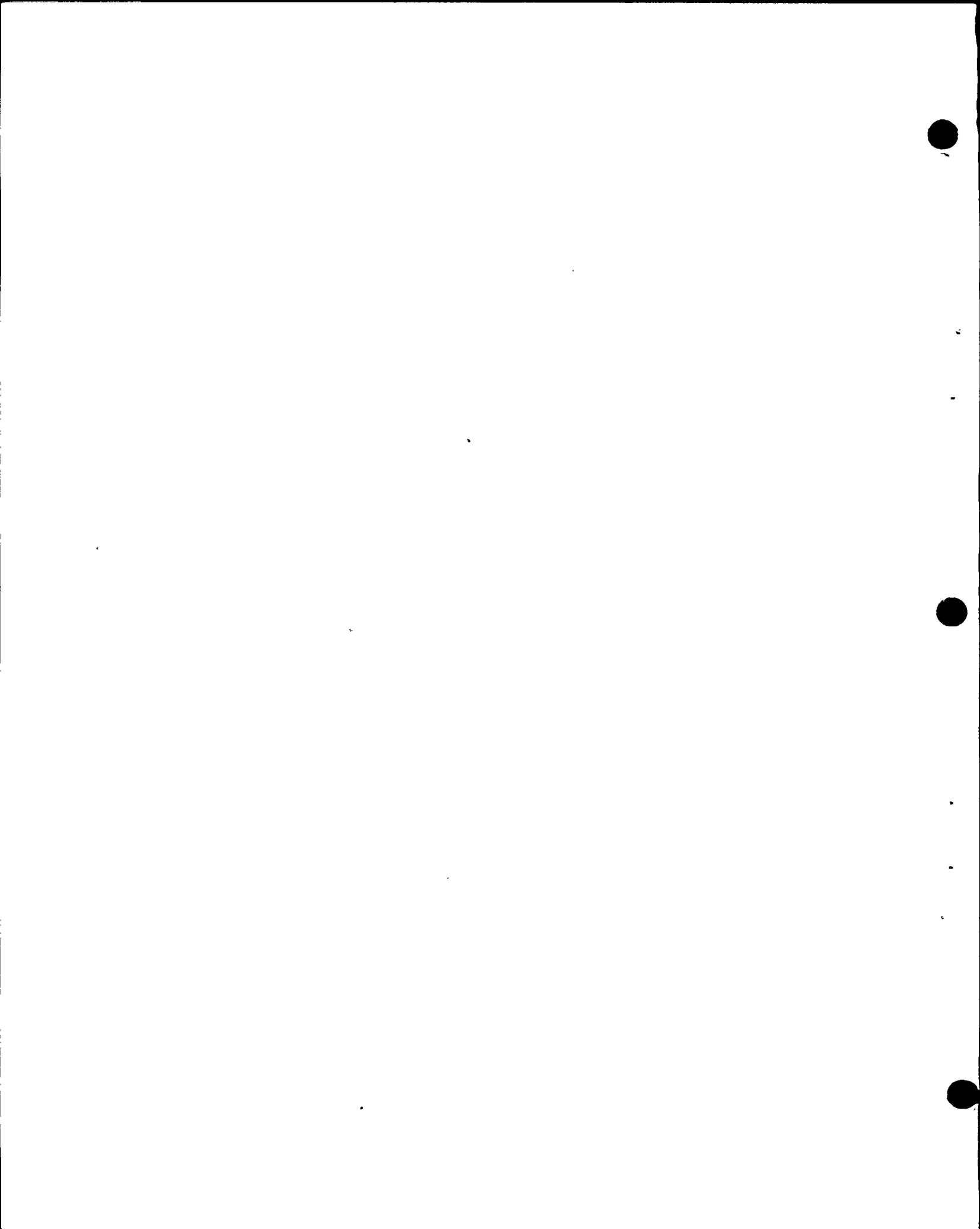
17 And if we look at it in that context it seems to
18 me that Dr. Smith, in preparing this work, has been -- not
19 addressing just conservative but he's addressing a value which
20 in my mind is extremely conservative.

21 I just wanted to follow up with that comment.

22 Q Dr. Bolt, have you studied the Diablo Canyon
23 structure?

24 A Have I studied the structure?

25 Q Yes.



eb6

1 A I paid a visit to it but I'm not an engineer so
2 I can't comment on the detailed engineering of it. It looks
3 mighty strong to me.

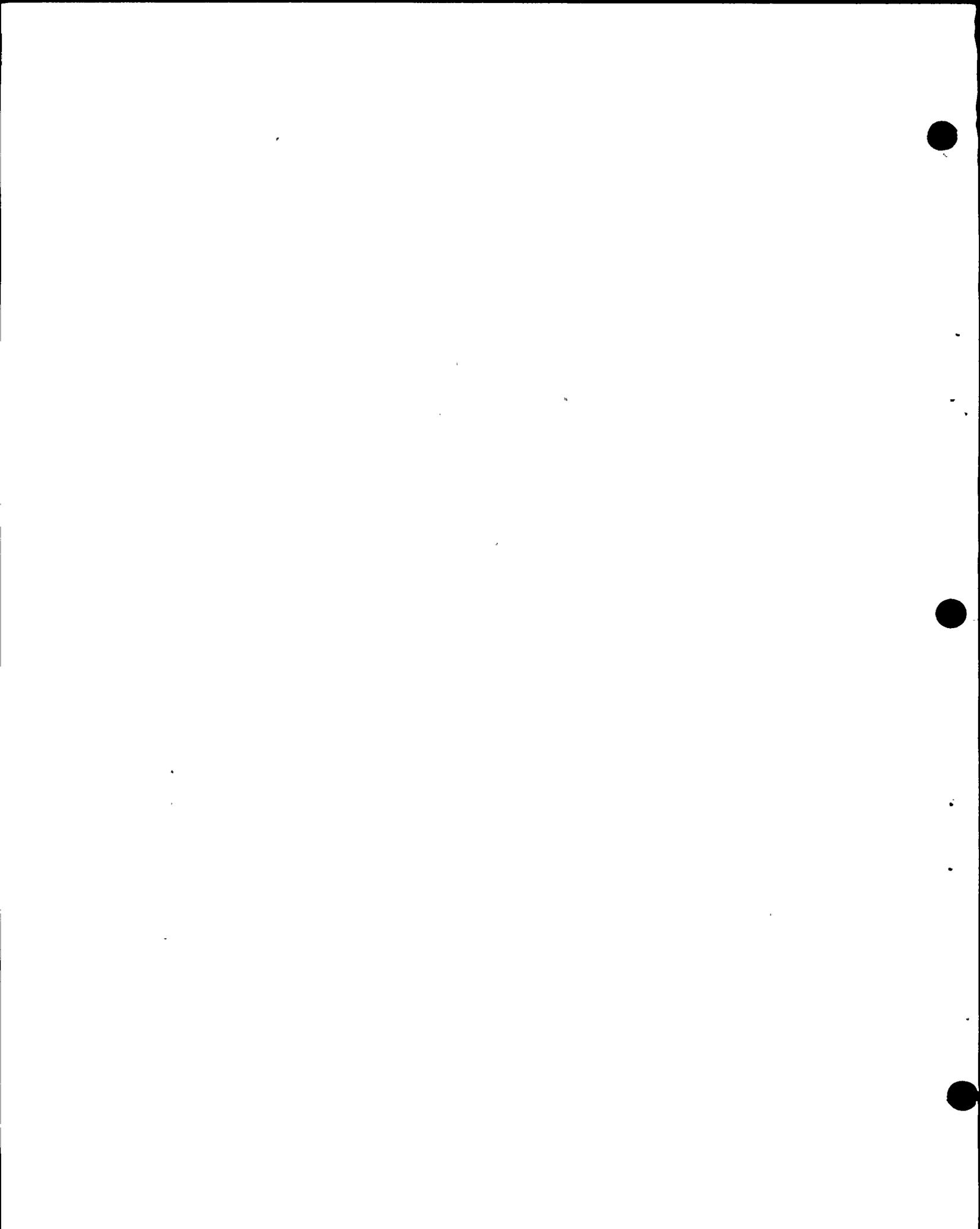
4 (Laughter.)

5 MR. FLEISCHAKER: On the basis of that response,
6 I'm going to move to strike all of that part of Dr. Bolt's
7 testimony that has to do with the response of this structure.
8 The Applicant is going to present a panel which will testify
9 about engineering response, about the subject of effective
10 acceleration versus instrumental peak acceleration, which I
11 think has been raised here in Dr. Bolt's comments.

12 However, I think it is inappropriate to get into
13 it at this time, and because Dr. Bolt has not participated
14 in the analysis of the response of this facility, I would move
15 to strike those -- only those portions of his comments that
16 have to do with accelerations and possible response on the
17 Diablo Canyon structure.

18 MR. NORTON: Mrs. Bowers, before the Board
19 makes a decision or I respond, I would like to have Mr. Bloom
20 read back Mr. Bolt's comments, please.

21 I'm absolutely certain Dr. Bolt said absolutely
22 nothing about the Diablo Canyon structure in his prior response
23 until he was asked by Mr. Fleischaker "Have you seen the
24 structure?" I don't think Dr. Bolt said one word about the
25 Diablo Canyon structure. I don't even have to hear it back.



eb7 1 I'm 99.99 percent he did not.

2 MR. FLEISCHAKER: Okay. Let me hear it back and
3 I may withdraw my objection.

4 MRS. BOWERS: Mr. Tourtellotte, do you want to
5 comment?

6 MR. TOURTELLOTTE: I think I'd like to hear it
7 before I comment.

8 (Whereupon the Reporter read from the record
9 as requested.)

10 MR. NORTON: Mrs. Bowers, my response is, he
11 didn't say anything about the Diablo Canyon structure whatso-
12 ever, or any other structure.

13 MR. FLEISCHAKER: Let me withdraw my objection
14 and ask a few more questions.

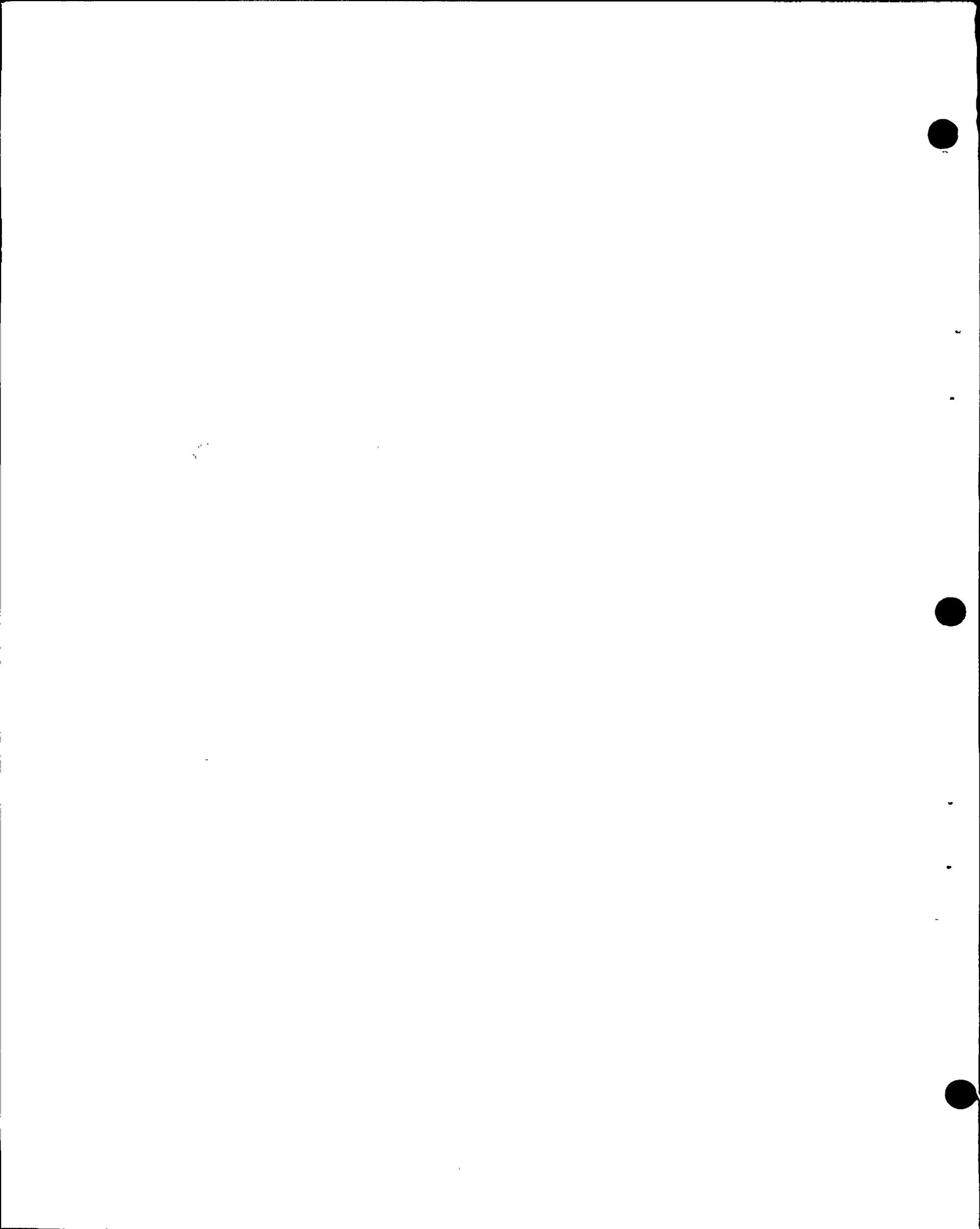
15 BY MR. FLEISCHAKER:

16 Q Dr. Bolt, you talked about a range of frequencies
17 in the engineering range of interest. Was that with respect
18 to Diablo Canyon?

19 A (Witness Bolt) Well I've been asked over the
20 years to give engineers advice on ground motions for many
21 structures, and I was speaking generally when I said that.

22 Q All right. So that remark was not directed
23 specifically to Diablo Canyon, was it?

24 A I didn't have Diablo Canyon in my mind when I
25 said that.



eb8

1 Q I believe you concluded that the accelerations
2 at the site were-- Well, were your conclusions with respect
3 to the conservatism of the accelerations at the site, .15g,
4 were they referenced -- was there any reference to a
5 frequency range of interest?

6 A I think .15g is too low for the site.

7 Q I'm sorry, 1.15g.

8 A When I think in terms of something that is mean-
9 ingful in the engineering context I generally think of
10 frequencies of 15 hertz and lower. Some big structures like
11 long bridges, these days the engineers want to go out to ten
12 or more seconds, so that's the kind of frequency range that I
13 have in mind, .15 hertz up to fractions of a hertz.

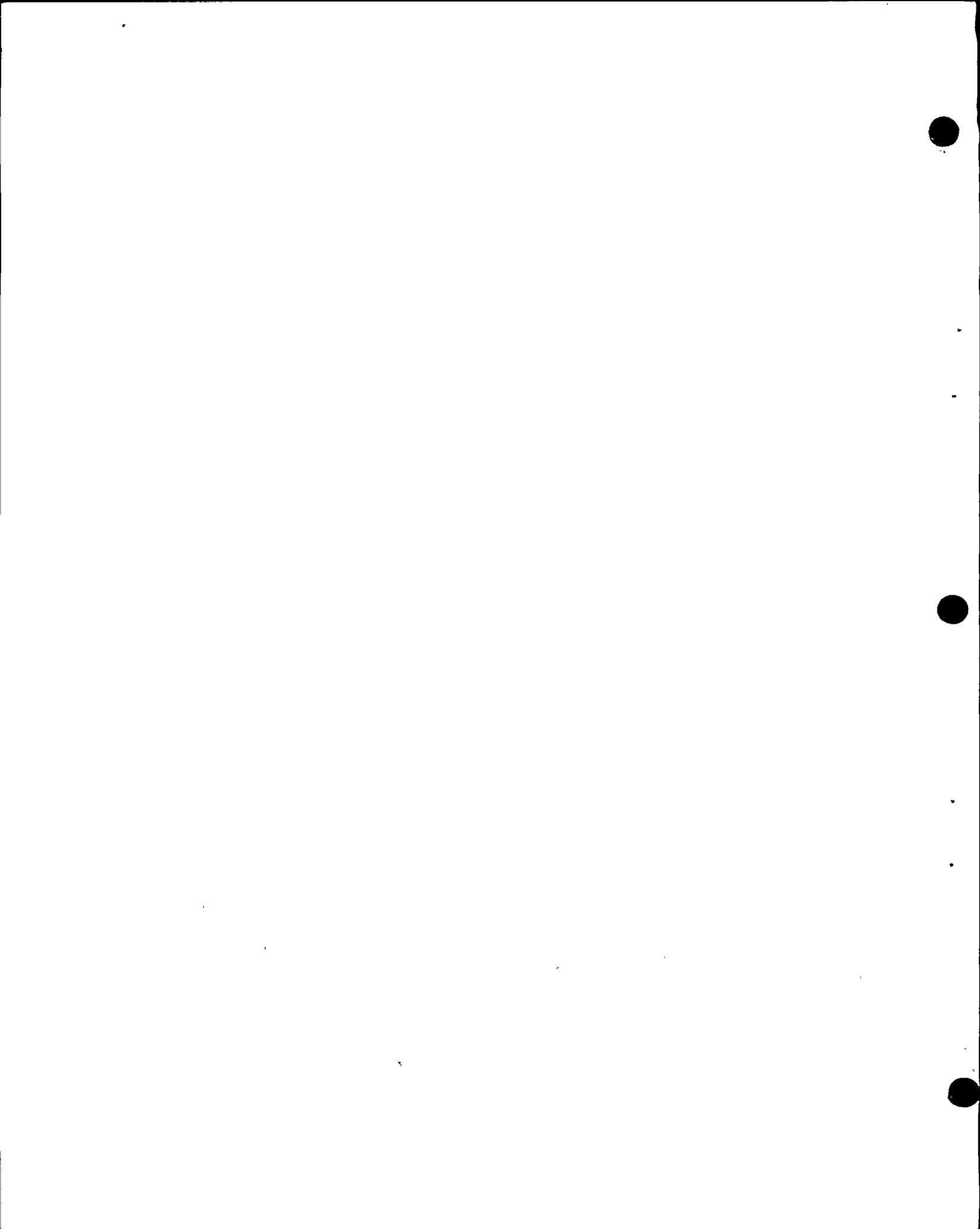
14 Q Well, how then can you-- Are you familiar with
15 the frequency range of interest at Diablo Canyon? I think
16 you've answered that question, haven't you?

17 A I'm familiar with it because I've seen the kind
18 of spectra that Mr. Blume and others have worked with. I'm
19 quite familiar with response spectra. I calculate them and
20 I lecture students on them.

21 Q Okay.

22 A I give a course called "Strong Motion Seismology"
23 in which I deal with these things, and hope to write a book
24 on the subject in the next year or so.

25 Q Well, Dr. Bolt, your conclusions regarding the



eb9

1 expected peak instrumental accelerations at the site, how are
2 those related to structural response, if at all?

3 A Well, the peak acceleration that is given by
4 seismologists to an engineer?

5 Q No. Let me ask you a foundation question.

6 A Yes.

7 Q The figure 1.15g on page 29 of the testimony:

8 "A peak ground acceleration of 1.15g
9 at Diablo Canyon for a maximum earthquake on the
10 Hosgri is a very conservative estimate."

11 A Yes.

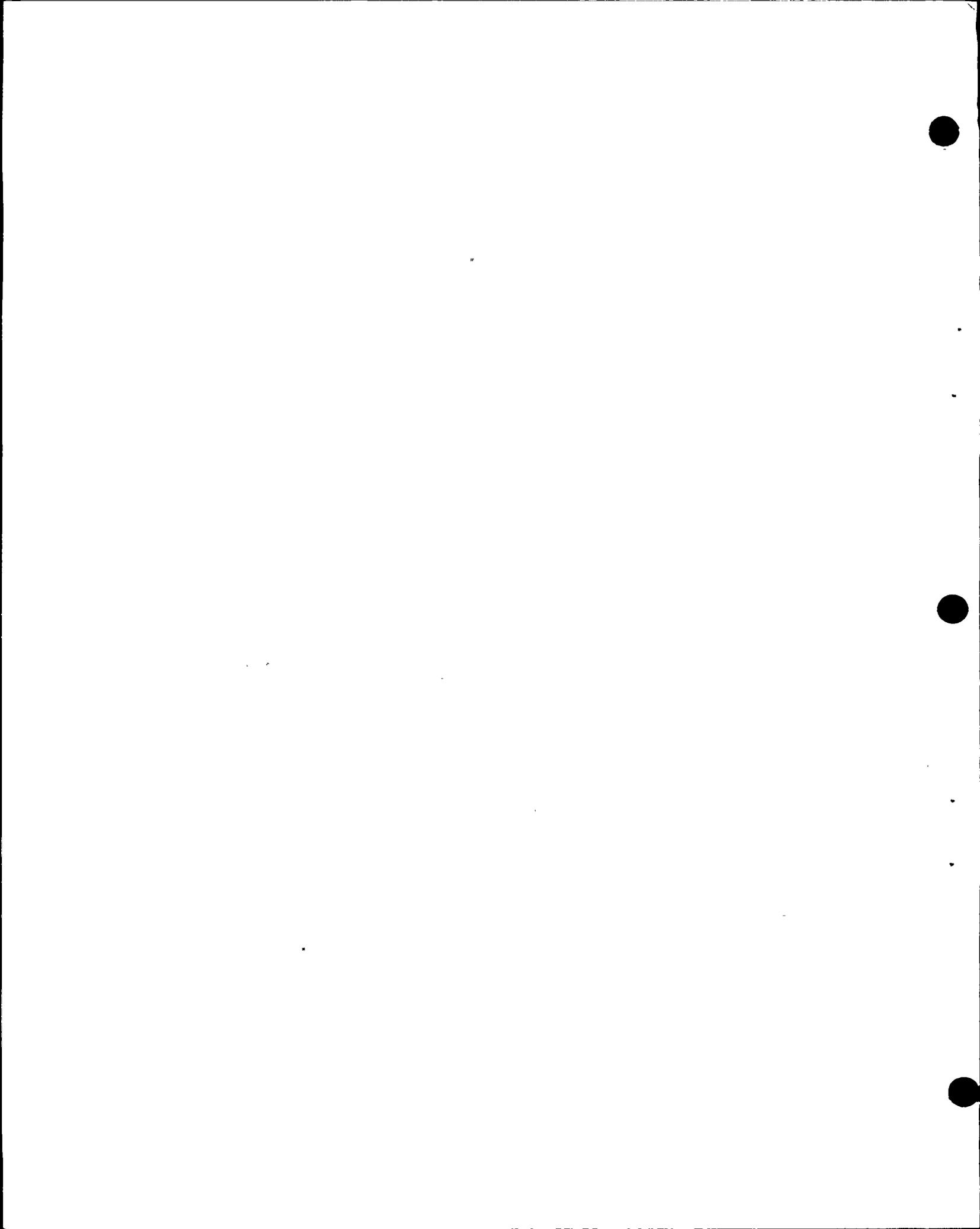
12 Q What does that figure, 1.15g, represent?

13 A Well, my understanding of it, since the demand
14 on seismologists to provide figures for peak ground
15 acceleration is that it goes to the maximum swing, the
16 maximum amplitude of a wave of acceleration at the site in
17 a frequency range normally somewhat lower than 15 hertz be-
18 cause the strong motion instruments that we have in this
19 country don't give accelerations directly much above 15 hertz
20 and there is not very much interest in the very high fre-
21 quencies. There may be some for small items. So that's what
22 I have in my mind.

23 Q Is it what we call a free-field measurement?

24 A It's a free-field measurement.

25 Q What does that mean?



eb10

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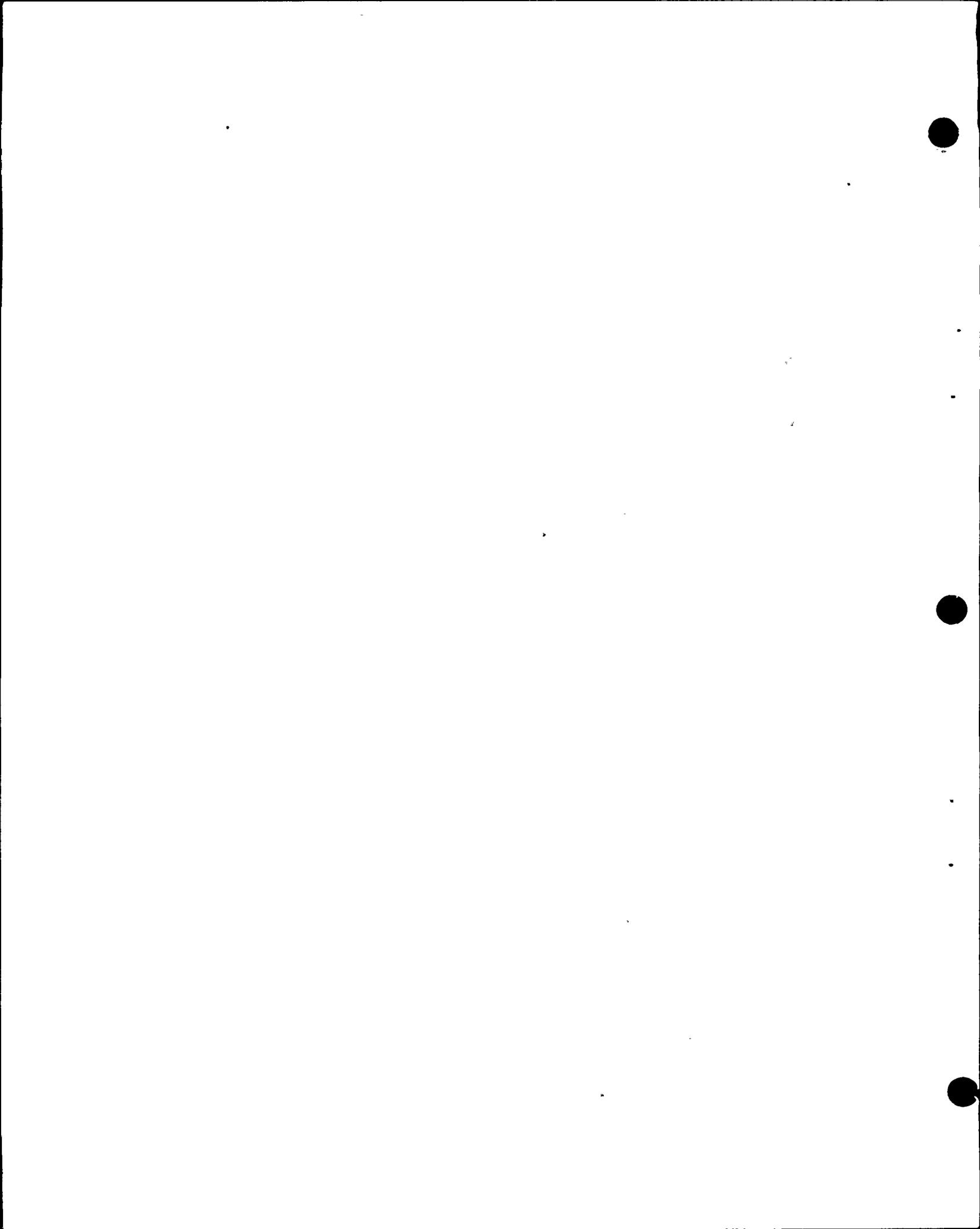
A That means there is no structure made by man big enough to affect the ground motion.

MR. FLEISCHAKER: I'll withdraw my request to strike that I had earlier.

MRS. BOWERS: I thought you did.

MR. FLEISCHAKER: I'm sorry.

3d



1 MR. FLEISCHAKER: I'd like to mark as Joint
2 Intervenor's Exhibit number 45 a document entitled USGS
3 Bulletin 672, and as Joint Intervenor's Exhibit number 46
4 a document entitled "Estimation of Ground Motion Parameters,
5 US Geological Survey Open File Report 509, 1978". I'd just
6 note that both of these are listed as reference materials
7 in Dr. Smith's testimony.

8 I'd also note just for the record that in his
9 testimony, Dr. Smith -- well, there's a typographical error
10 in USGS Circular 673; I believe it should be 672.

11 BY MR. FLEISCHAKER:

12 Q Is that correct, Dr. Smith, on page 32?

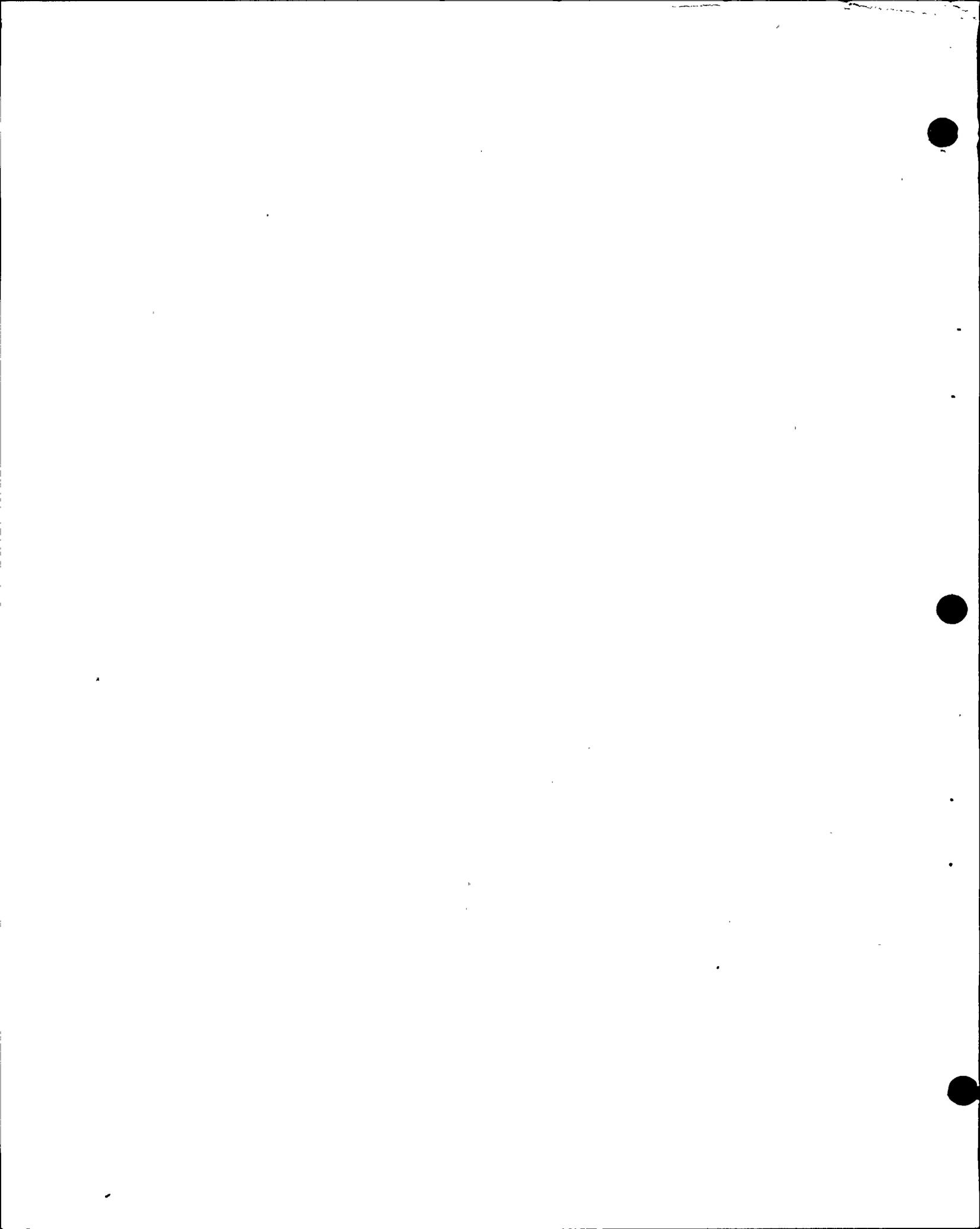
13 A (Witness Smith) I apologize. I didn't hear
14 your question.

15 Q On page 32 -- it's just a small point -- on page
16 32, line 3, you list USGS Circular 673. I believe that should
17 be 672?

18 A That's correct.

19 (Whereupon, the documents
20 referred to were marked as
21 Joint Intervenor's Exhibits
22 numbers 45 and 46 for
23 identification.)

24 WITNESS SMITH: There were some other typos
25 in that bibliography.



mpb2 1

MR. NORTON: Excuse me, Mrs. Bowers.

2

Am I correct in understanding that we now have marked as an exhibit one page, page 20 of an article by Moore and Oliver? I'm not sure if that's what's happening.

5

MRS. BOWERS: That's what happened.

6

MR. NORTON: I would object to, you know, a page that's out of an article without the whole article. I would object to any questions being asked on that page. If it is just being marked and no questions are going to be asked of it, I have no objection. But if there are questions to be asked of it I, as a lawyer, can't do a very good job without the whole article to base an objection or to look and pursue where it's going.

14

MR. FLEISCHAKER: We're running into the same problem. This is the article.

16

(Indicating.)

17

And I understood.... I know that this is cited by the Applicant as a reference and I assumed they would have a copy of it.

20

MR. NORTON: Well, we do have a full copy of the article here with us, but I don't know about the witnesses and Mr. Tourtellotte and the Board.

23

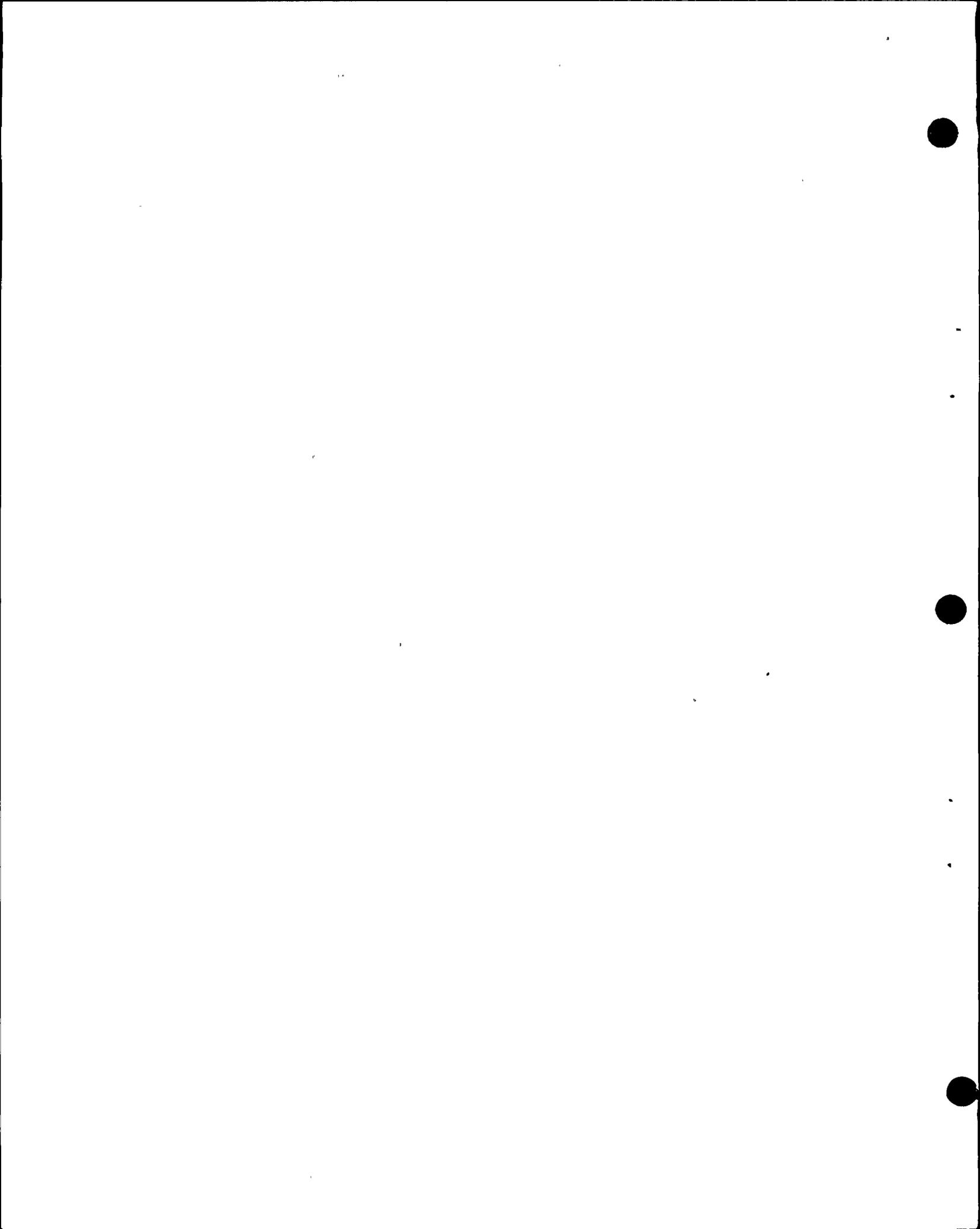
MR. FLEISCHAKER: Excuse me.

24

Does the Staff has a copy of the document?

25

What I would propose is that we proceed and we



mpb3 1 will submit full copies for the record. And I don't think,
2 since the Applicant has a copy of this, that he's at a dis-
3 advantage in terms of his redirect.

4 I'll be happy to xerox copies of it to submit
5 to the record, three full copies for the record.

6 MRS. BOWERS: Fine.

7 Well, let's see if the Staff can locate their
8 copy.

9 While some of this was going on, Dr. Smith
10 mentioned there were other errors in the reference, I believe.
11 Isn't that correct?

12 WITNESS SMITH: Yes.

13 MRS. BOWERS: Perhaps those should be corrected.

14 MR. TOURTELLOTTE: We don't have a copy.

15 WITNESS SMITH: These are mostly spelling errors
16 in the bibliography. I don't know as they are of substance.
17 But would you like me to make the corrections?

18 MRS. BOWERS: Well, would they be misleading?

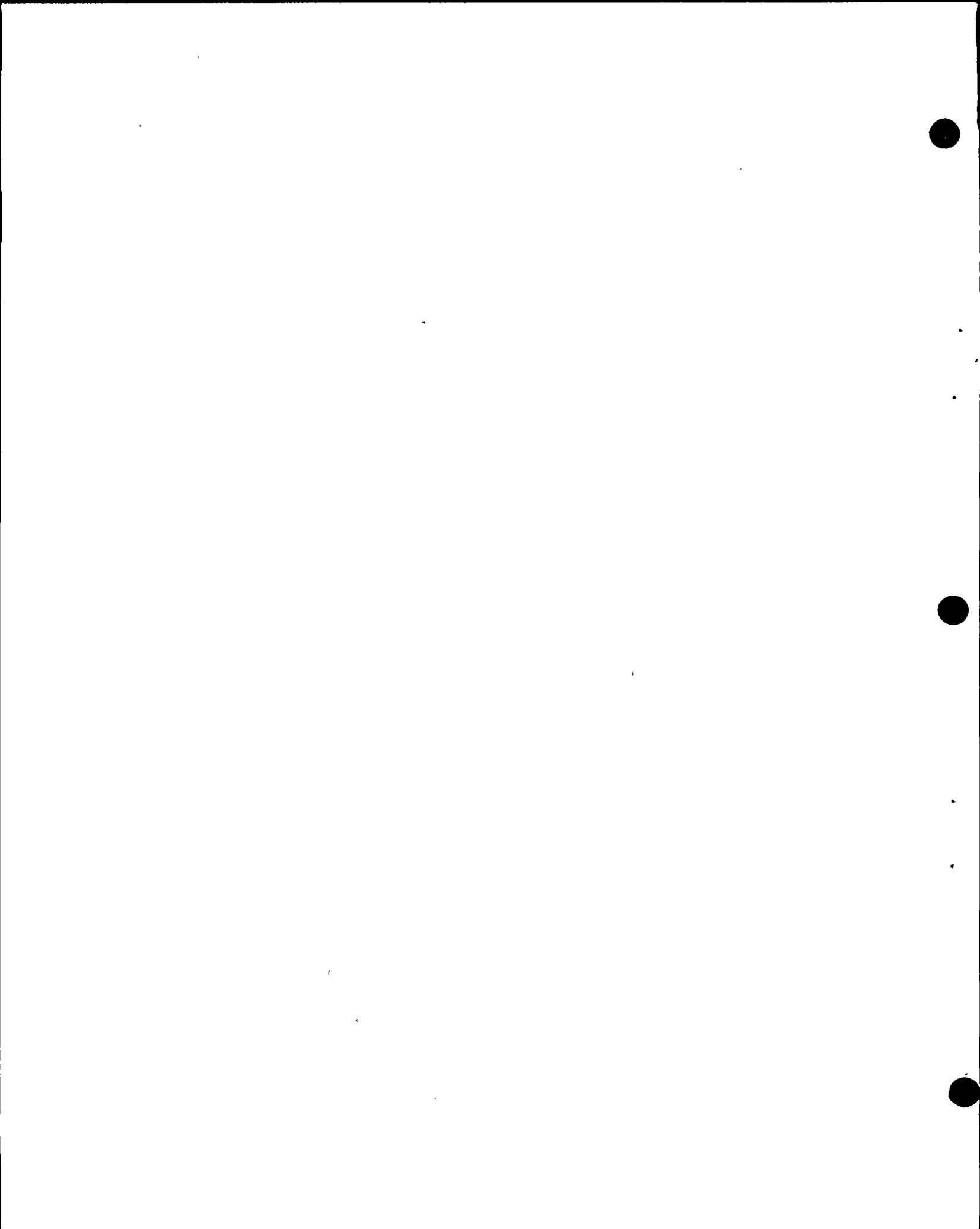
19 WITNESS SMITH: I don't really think so.

20 MRS. BOWERS: We don't need them, as long as
21 they wouldn't be misleading.

22 Did the Staff find a copy?

23 MR. TOURTELLOTTE: Intervenors gave us one of
24 theirs.

25 MR. FLEISCHAKER: I'll provide a full copy for



mpb4 1 the Board for purposes of cross-examination.

2 MR. NORTON: Do you also have a copy for the
3 witness?

4 MR. FLEISCHAKER: I do not have a full copy for
5 the witness. I'll give this full copy to the witness, and
6 should we go beyond this and get into this report in any
7 detail, I will save my cross-examination and get a full copy.

8 MR. TOURTELLOTTE: The Board can use our copy.
9 (Document handed to the Board.)

10 BY MR. FLEISCHAKER:

11 Q Dr. Bolt, you made mention in the beginning of
12 your statement of USGS Bulletin 672.

13 A (Witness Bolt) Yes.

14 Q And you have a copy of that before you, is that
15 correct?

16 A I do.

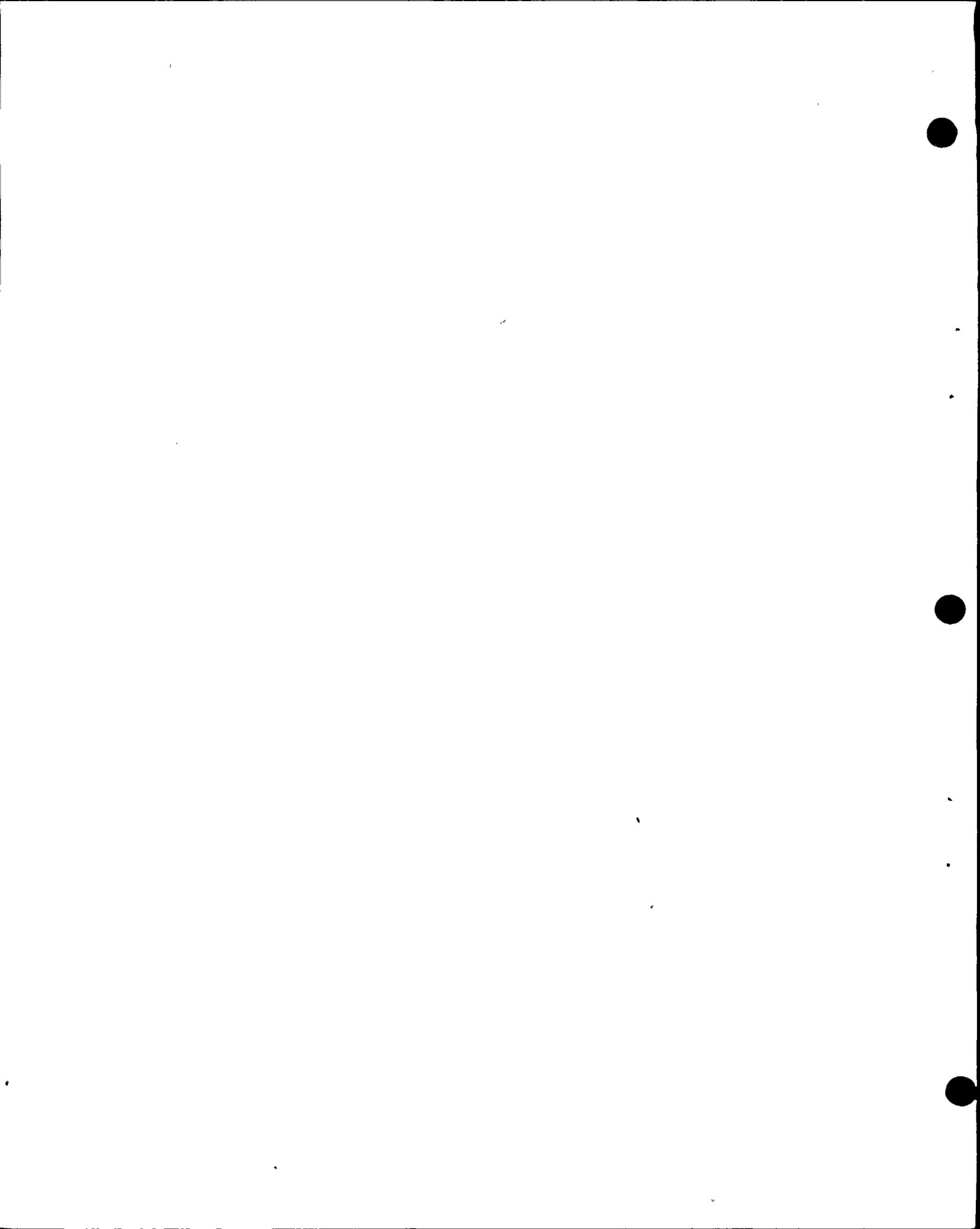
17 Q What was the purpose of that article?

18 A The purpose of the article was to provide ground
19 motion values for use in the seismic design of the trans-
20 Alaska pipeline system.

21 Q Now I'd like to direct your attention to the
22 bottom of page 3.

23 A Yes.

24 Q There's a table designated as Table 2 at the
25 bottom of page 3.



mpb5 1 A Yes.

2 Q Would you explain that table to me, please?

3 A This is a table which gives the horizontal
4 ground motion in terms of acceleration, velocity, and dis-
5 placement, and duration for a list of magnitude earthquakes.
6 And there are footnotes which are important, which I won't
7 read now. But for example acceleration says that it is peak
8 absolute values. The velocity says peak absolute values.
9 And we are supposed to take these values at a distance of a
10 few, they say, they say in brackets three to five kilometers
11 from the causative fault.

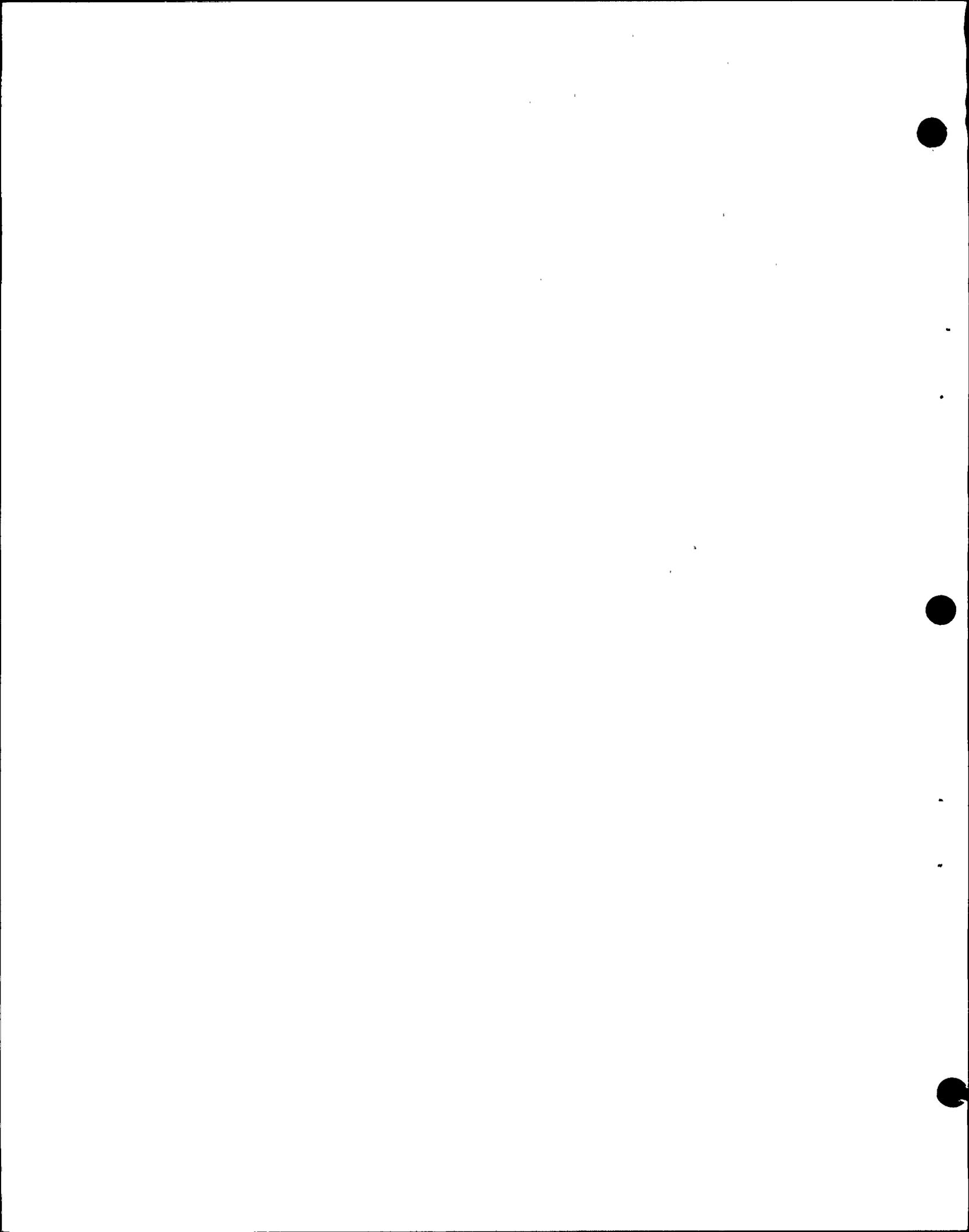
12 I think those are the main points that have to
13 do with the table.

14 Q Now as I examine this table I see over in the
15 left-hand column a series of numbers under the title
16 Magnitude. And as I read across the page on the top column
17 it has acceleration, the velocity, displacement, and the
18 duration.

19 A That's right.

20 Q And then under Acceleration it has -- well, the
21 title is Acceleration Peak Absolute Values, then it has four
22 columns, first, second, fifth, and tenth. And then under
23 Velocity it has Peak Absolute Values, first, second and third.
24 It just has one figure for displacement.

25 Could you explain what those columns, first,



mpb6 1 second, fifth, and tenth, and then the three columns under
2 Velocity represent?

3 MRS. BOWERS: Before the witness starts, Mr.
4 Fleischaker, there is some underlining by ink and other
5 things. Is that a work product of Counsel?

6 MR. FLEISCHAKER: Yes. Any underlinings or
7 anything in here is Counsel's work product, and I apologize
8 to the Board. I thought we had eradicated it before xeroxing
9 it. I'll be more careful next time.

10 Also I notice that on my copy there is a line
11 going across from 7.5 across, and I don't know whether
12 that's in the Board's copy or not. But these are pencil
13 marks made by Counsel, and I apologize for that. And we'll
14 be more careful in the future.

15 BY MR. FLEISCHAKER:

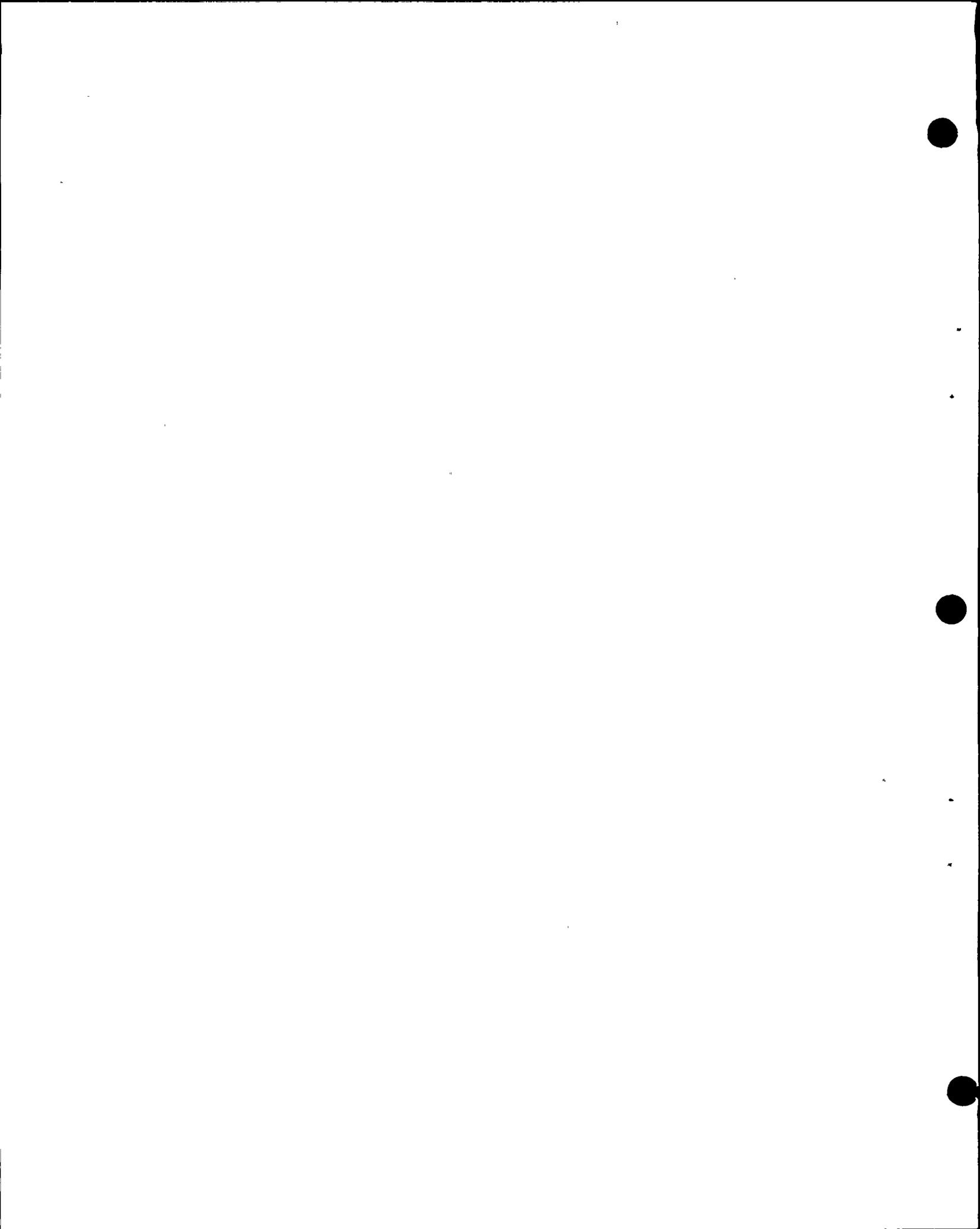
16 Q Okay.

17 We were back on explaining this table.

18 A (Witness Bolt) Yes.

19 Q What are these columns, first, second, fifth,
20 and tenth? What do they represent?

21 A Well, I'd like you to think of an accelerogram
22 of the kind that Dr. Smith drew earlier in the hearing which
23 would be an oscillatory line with various peak or maximum
24 amplitudes. And this table says that the largest of those
25 peaks would have for a magnitude 8.5 earthquake an acceleration



mpb7 1 according to this table of 1.25g; that is to say one and one-
2 quarter times the value of gravity.

3 The second column would say that the next high-
4 est amplitude would have a value of 1.15 times g.

5 The fifth would be 1g.

6 And the tenth highest peak would have .75g as
7 the value. And, of course, velocity would be the same. The
8 first, second, and third peaks would have those values under
9 those columns in centimeters per second.

10 Is that an adequate response?

11 Q Yes, that was perfect.

12 Now, I assume the same thing applies -- well,
13 does the same thing apply to the velocity columns?

14 A Yes, the same thing applies to the velocity
15 column.

16 Q So the columns are first, second, and third
17 peaks?

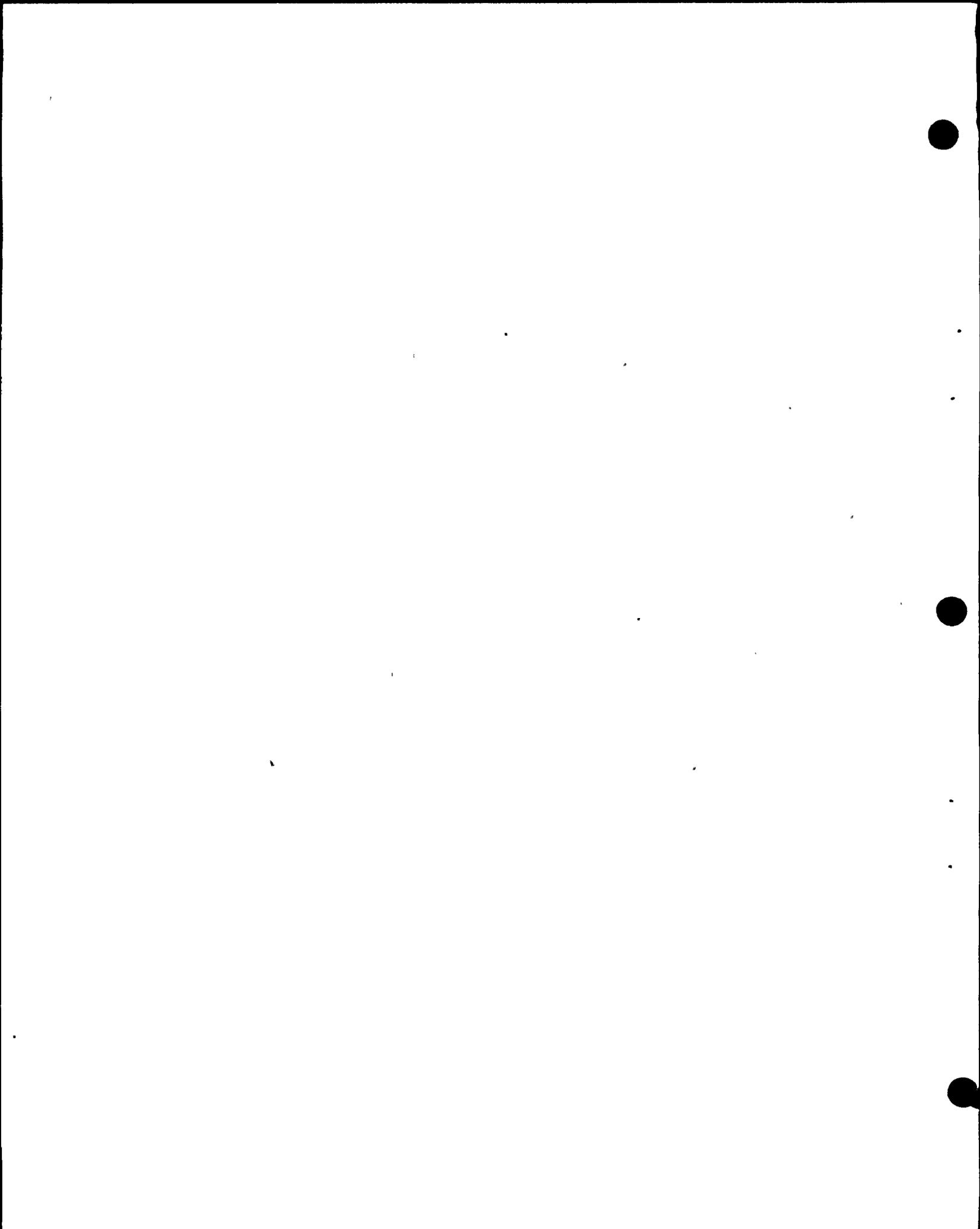
18 A That's correct.

19 Q In the time history?

20 A That's correct.

21 Q Now displacement is just one value?

22 A Yes, displacement is just one value because
23 usually you find when you integrate the accelerogram, which
24 has many wiggles, you tend to smooth it, and the velocity
25 looks smoother. It has fewer peaks. And the displacement,



mpb9 1 The question is multiple. It lists many things.

2 It could be asked much more simply, I believe.

3 MRS. BOWERS: Can you rephrase it?

4 MR. FLEISCHAKER: I'll withdraw the question.

5 - The objection is well taken.

6 BY MR. FLEISCHAKER:

7 Q Dr. Bolt, is there any statistical significance
8 to this value, 1.15g listed as the peak absolute acceleration
9 for a 7.5 magnitude earthquake in the 672 bulletin?

10 A (Witness Bolt) I'm not aware that they went
11 into any statistical discussion, certainly not in the paper.
12 I see no calculations here based on statistical formulae
13 or distributions.

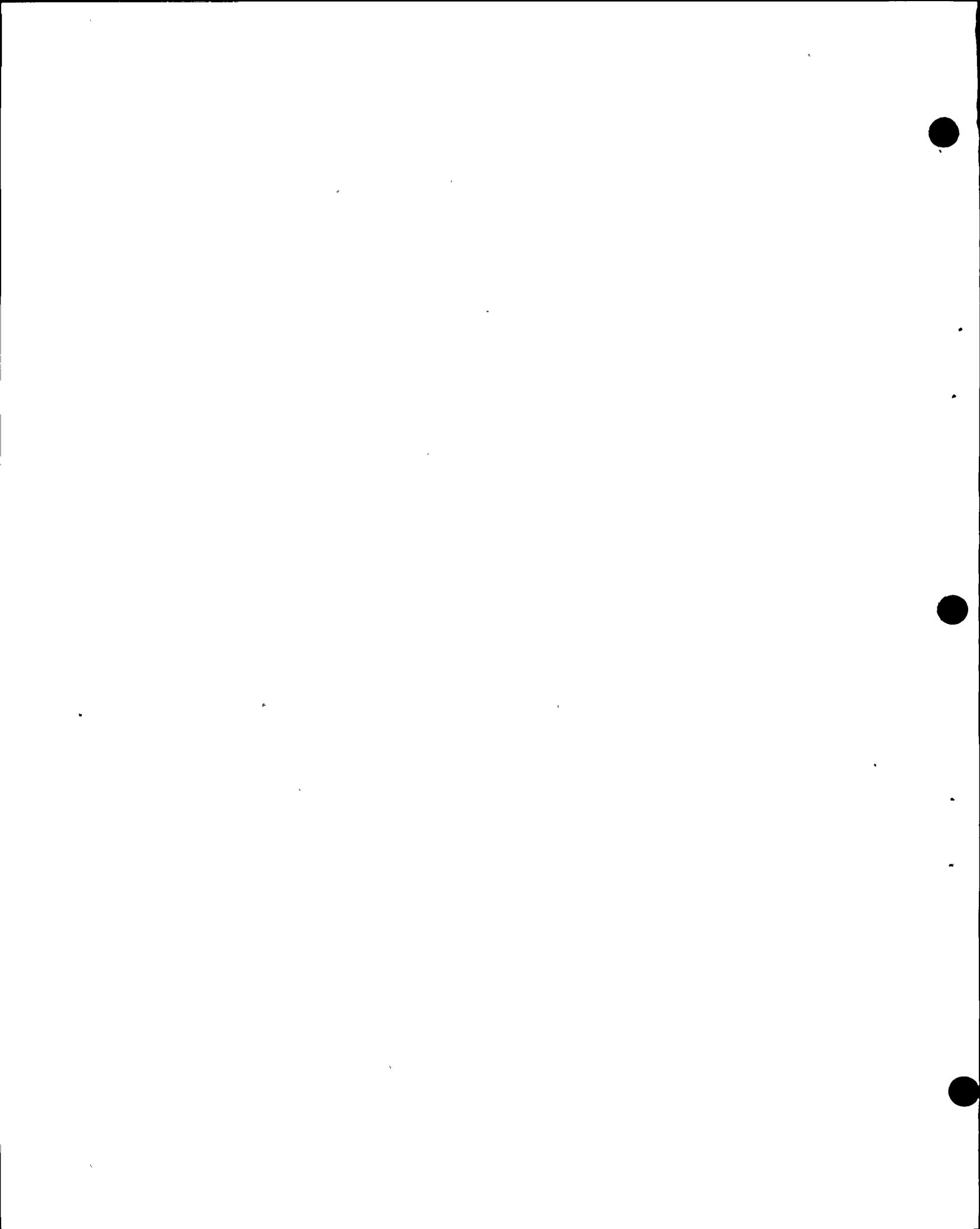
14 Q Well, what is your understanding of what this
15 value represents?

16 A Well, my understanding is that they are suggest-
17 ing that this is an appropriate value to design the engineers
18 -- to design the Alaska pipeline to.

19 Q Well, when you say "an appropriate value", do
20 you mean....

21 Is it your understanding that this is a strong
22 ground motion parameter, or some sort of engineering --

23 A Well, it's not entirely a strong motion para-
24 -meter because in here the authors do go into some sort of
25 discussion that I can refer you to if you'd like about how



mpbl01

seismologists have to keep in mind the engineering purposes for which these motions are used, and they explicitly spell that out in here. That's not uncommon.

Q Well, is it your understanding of this paper that this figure 1.15g represents an estimated peak acceleration in the free field?

A That's correct. But they did have in mind that there was going to be a pipeline which would be designed based on these values. They say so explicitly. But they do not give an indication as to exactly how they would have changed the values if it had been a hospital, for example.

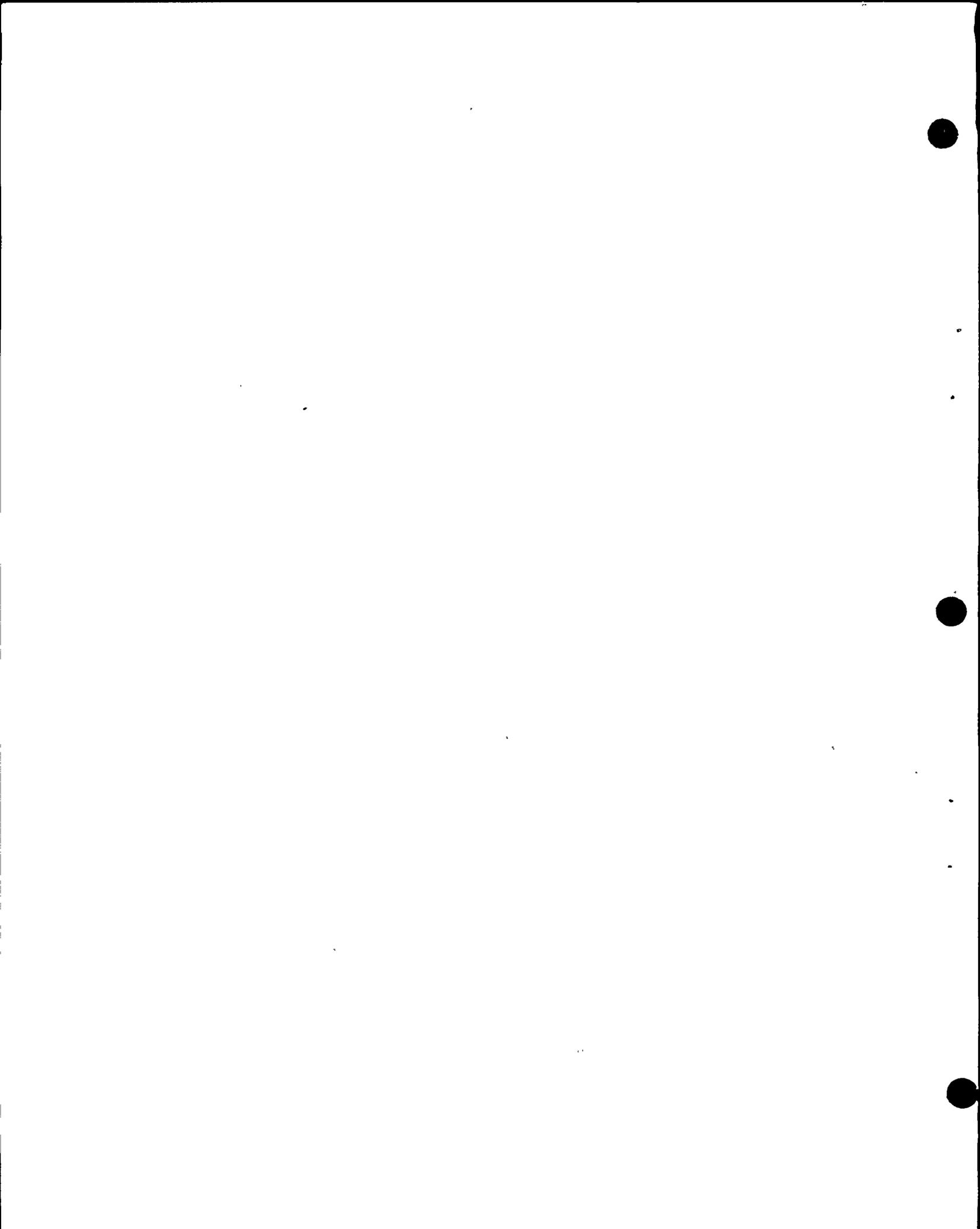
Q I'd like to direct your attention to the paragraph immediately above the tables, that begins:

"The ground motion values in Table 2 are subject to several conditions."

Down toward the bottom of that paragraph it states:

"They characterize free-field ground motion, that is ground motion not affected by the present substructures. They contain no factor relating to the nature or importance of the structure being designed. They are not the maximum possible."

Now, what is your understanding of those sentences I just read?



mpb111

A Well, I believe they are in agreement with what I said earlier, that they felt that these were the values that an engineer designing this pipeline should start with before his structure was placed on the ground. That's the free-field part of it.

Q Would you agree they're not talking about pipelines?

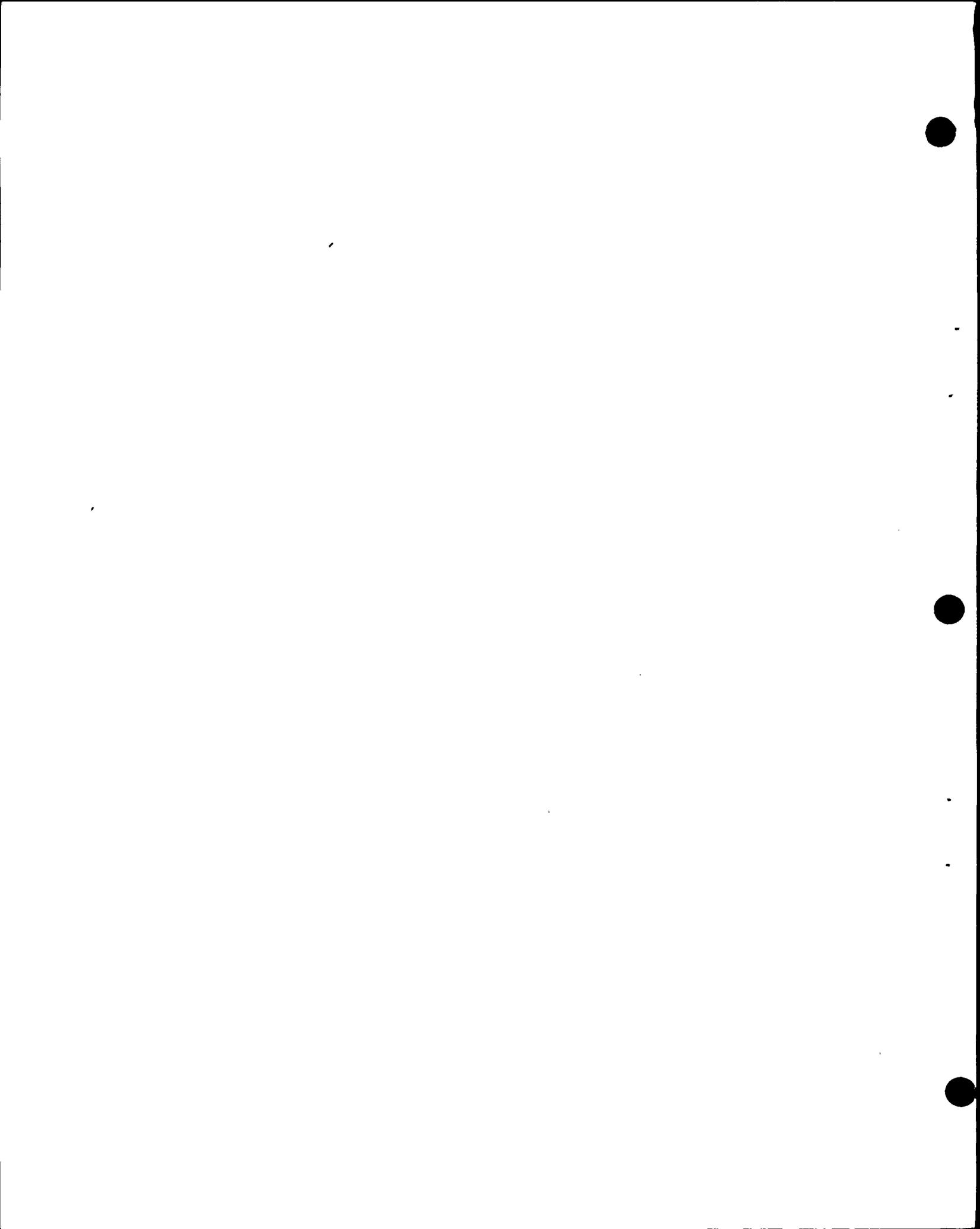
A Well, I'm not sure that they're consistent on that because -- I would just like to refer you to the paragraph above, the bold-faced-type ground motion values on the same page:

"The choice of parameters with which to specify ground motion was guided by the design approach adopted for the pipeline project. A useful set for the derivation of tripartite structural response spectra includes acceleration, velocity, displacement and duration of shaking."

So I don't really think they're consistent if they're trying to say that they haven't got in mind that there's going to be a pipeline built there. You see, that's my difficulty.

Now it may not have made any difference, but when I read this they do talk about the pipeline.

Do you see my problem?



mpbl2

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Q Yes.

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A And I don't know what's in their minds. You'd

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have to ask them about that. But I have some problems.

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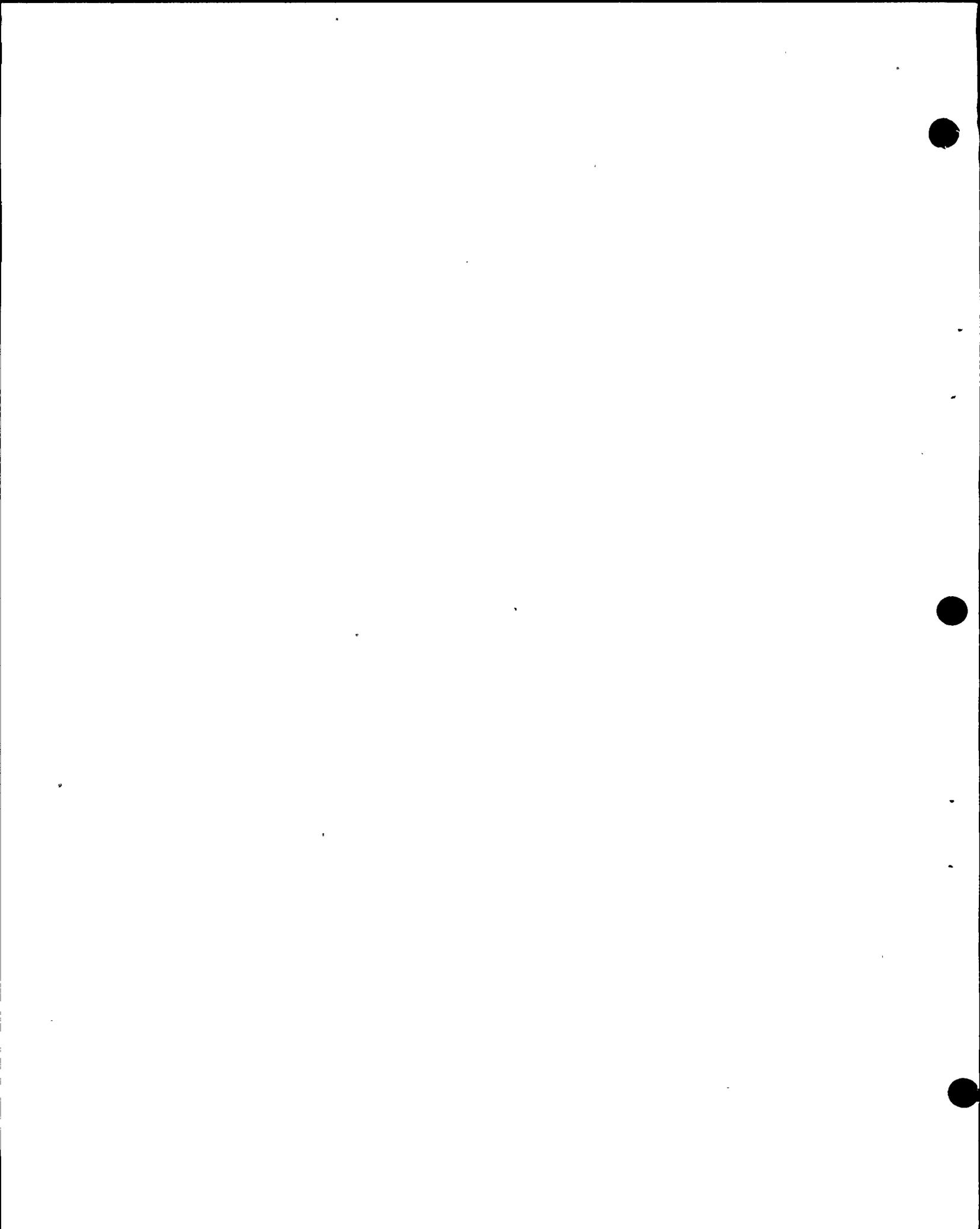
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3F wbl 1

Q I understood from your testimony that you had participated in some of this work.

A I did.

Q Did you participate in the writing of this paper?

A I didn't write the paper, of course. I did have one great effect, which may have been the only effect that my discussions had at the meeting at Menlo Park. And that was at that stage that the draft had the title "Representative Ground Motion Values," and after I attacked that they took out the word "representative."

So that's my only claim to having any major effect on this paper.

Q I'd like to go back to that paragraph about ground motion values that you just read and see if maybe we can reach some understanding as to the meaning of that paragraph.

In that paragraph on the second line it says:

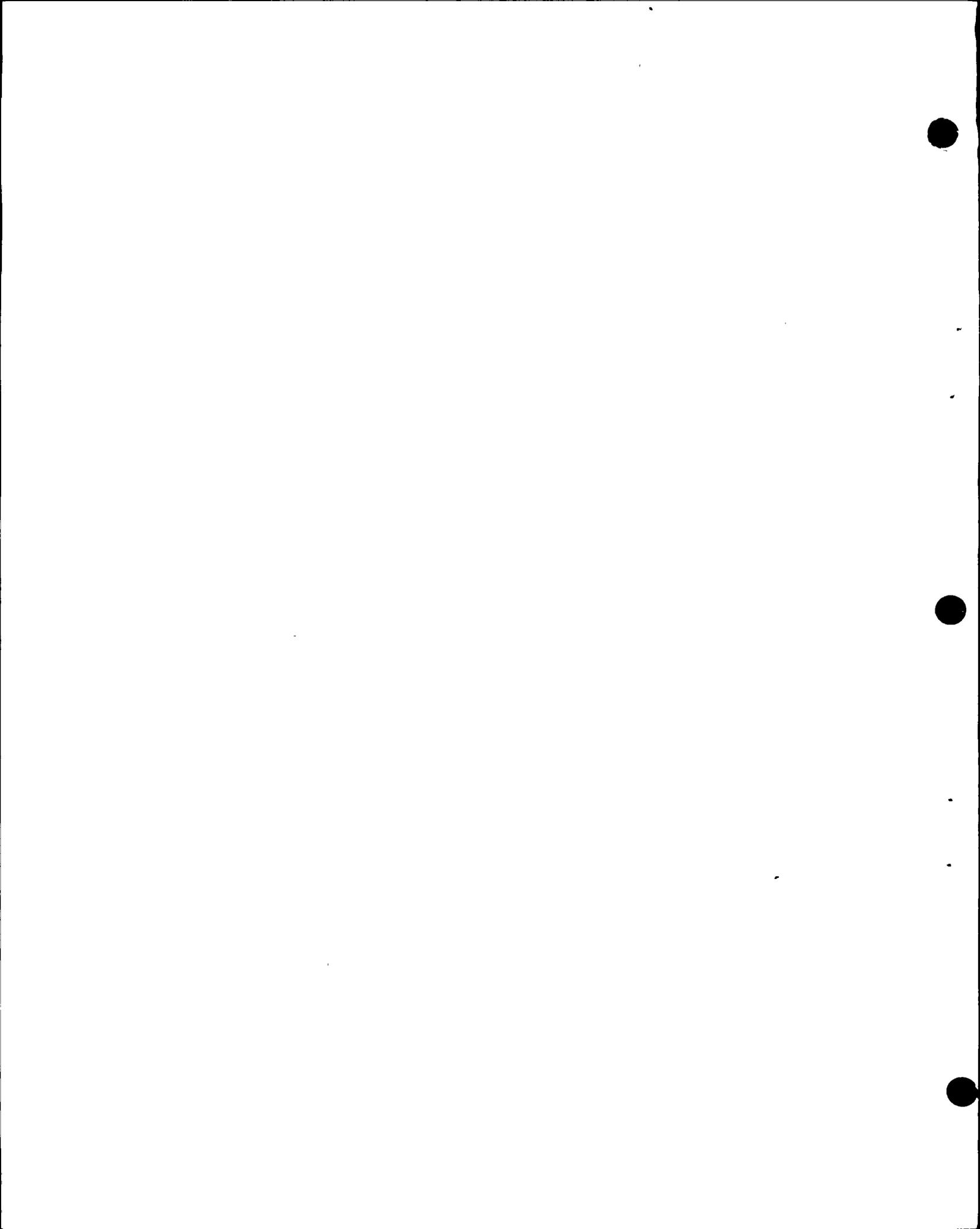
"The choice of parameters with which to specify ground motion was guided by the design approach."

Does that say anything about pipelines or structures?

A Design approach adopted for the pipeline project.

MRS. BOWERS: Where are you reading, Mr. Fleischaker?

MR. FLEISCHAKER: Above "ground motion values,"



wb2

1 which is in bold type, and then in that paragraph there just
2 immediately above that.

3 MR. NORTON: I would suggest that this line of
4 questioning is taking on the tenor of argumentative, and would
5 object on that basis. The words say what they say. They've
6 now been read three times and counsel is trying to argue as
7 to what they say.

8 BY MR. FLEISCHAKER:

9 Q Well, would it be consistent with--

10 MRS. BOWERS: Wait a minute. There's an objec-
11 tion here.

12 Do you want to respond to the objection?

13 MR. FLEISCHAKER: Is there an objection to a
14 specific question?

15 MRS. BOWERS: Do you want to restate the
16 objection?

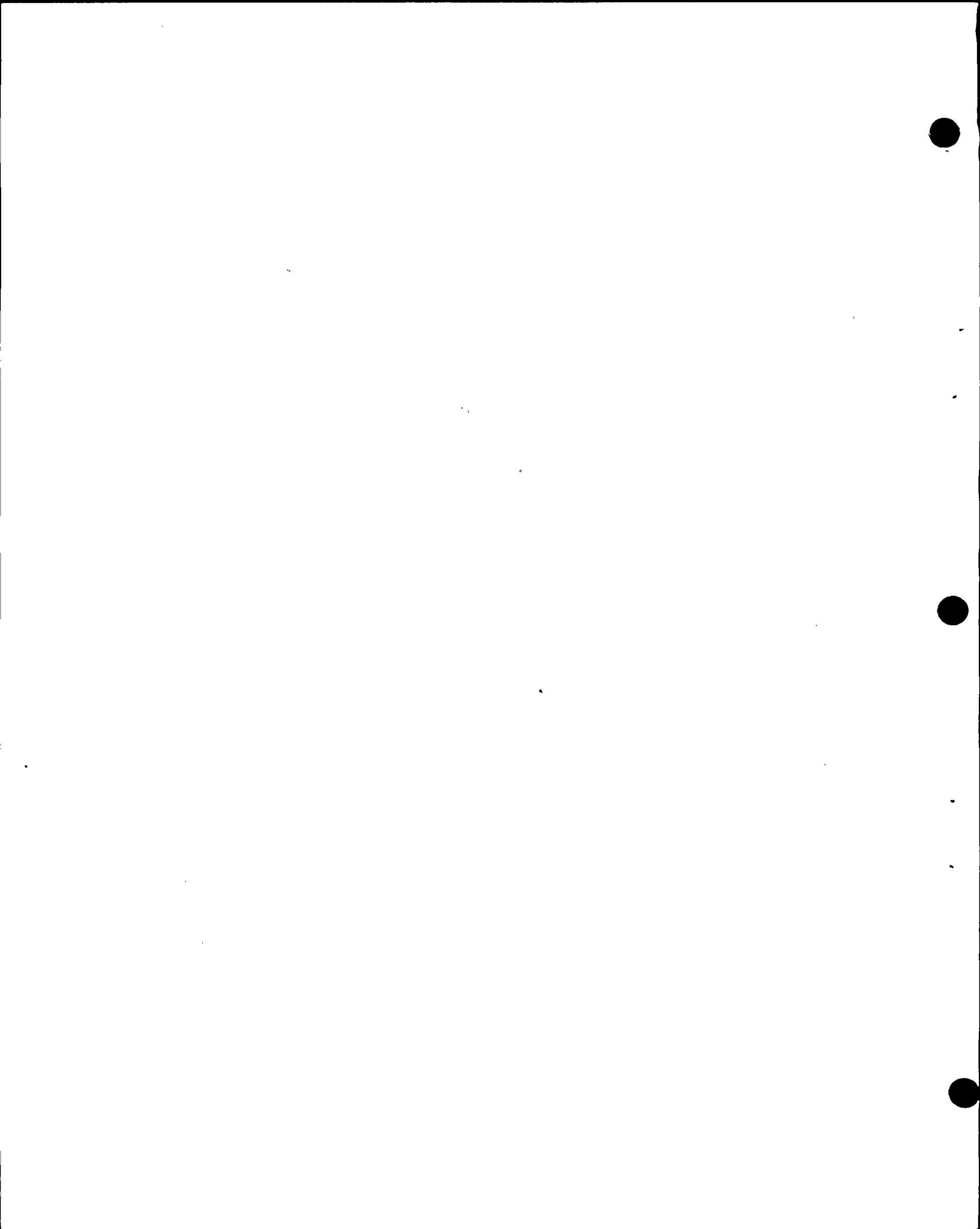
17 MR. NORTON: The objection is he keeps arguing
18 about what the words say. And I think the door is now closed
19 as to what the words say. And I'm just objecting to further
20 questioning along this line.

21 MRS. BOWERS: Well the witness testified that he
22 did not participate in the writing of this document.

23 Isn't that correct, Dr. Bolt?

24 WITNESS BOLT: That's correct.

25 MRS. BOWERS: Does the Staff have a position on



wb3

1 this?

2 MR. TOURTELLOTT: No.

3 MR. FLEISCHAKER: I can ask him a question without
4 being argumentative. If he doesn't know the answer I'll
5 move on.

6 MRS. BOWERS: All right. Fine. The objection
7 is sustained.

8 BY MR. FLEISCHAKER:

9 Q Would it be consistent with your understanding
10 of the meaning of the words in this first sentence here that
11 by "design approach" USGS is referring to an approach which
12 specifies utilizing a free field peak instrumental accelera-
13 tion?

14 A (Witness Bolt) Yes.

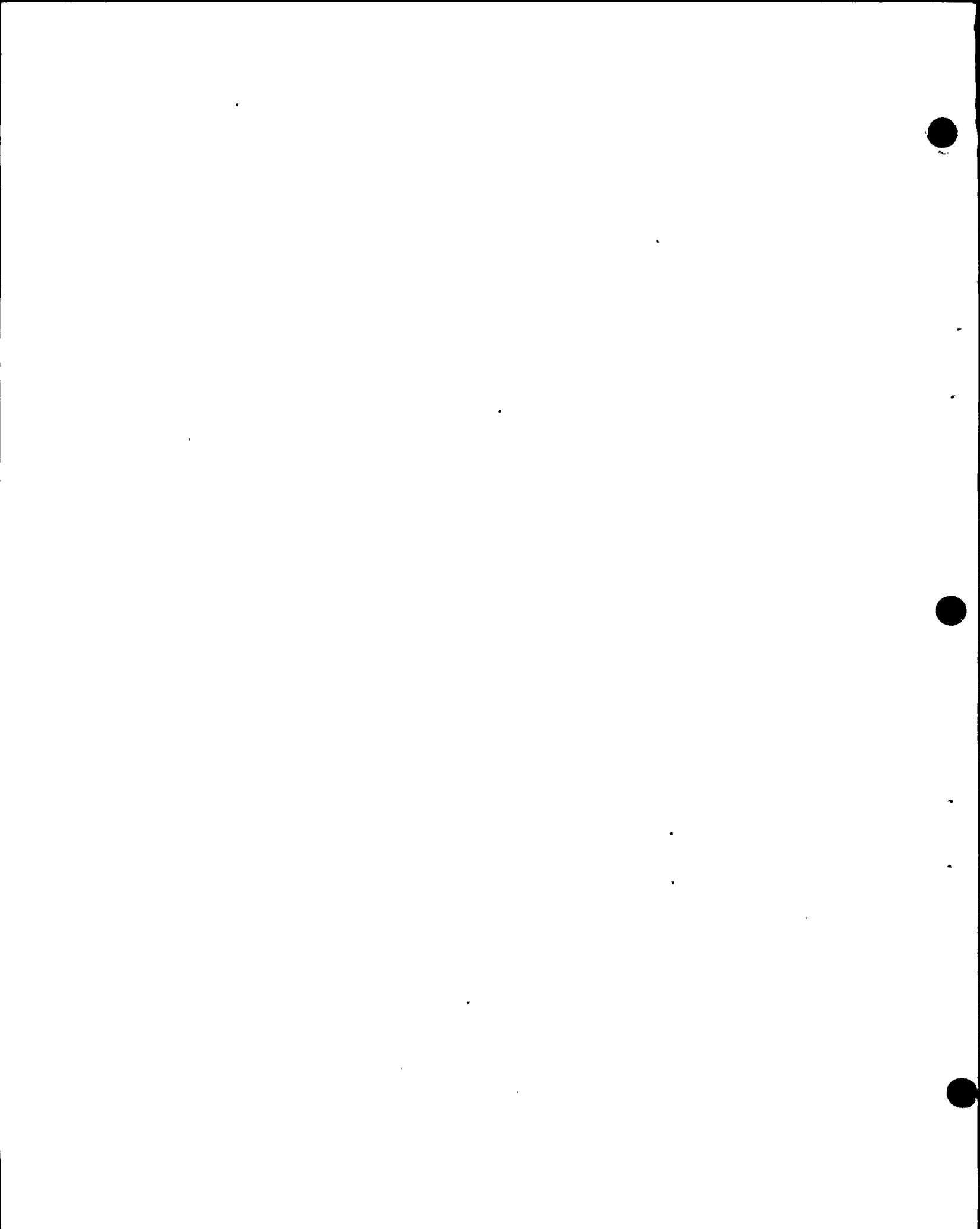
15 Q Well, Dr. Bolt, we got off on this by trying to
16 decide -- by my asking you a question about the meaning of
17 1.15.

18 A Yes.

19 Q And I direct your attention now to page 4, the
20 top of the page. And there in the top of the paragraph there
21 it says "They are not the maximum possible."

22 A Yes, I see that.

23 Q Does that refresh your recollection with respect
24 to what the 1.15 means in terms of earthquakes with a
25 magnitude of 7.5?



wb4

1 A Well I would repeat what I said earlier. My
2 impresson was that they felt these were not the smallest
3 possible and they may not be the largest possible, but these
4 were the values that they took to be important for the
5 engineers to use since they gave them no other values. This
6 was the important table in their design of the pipeline.

7 Q Does that mean for a range of 7.5 earthquakes
8 on average we would expect to see a peak absolute value
9 acceleration of 1.15g as you understand the meaning of this
10 table?

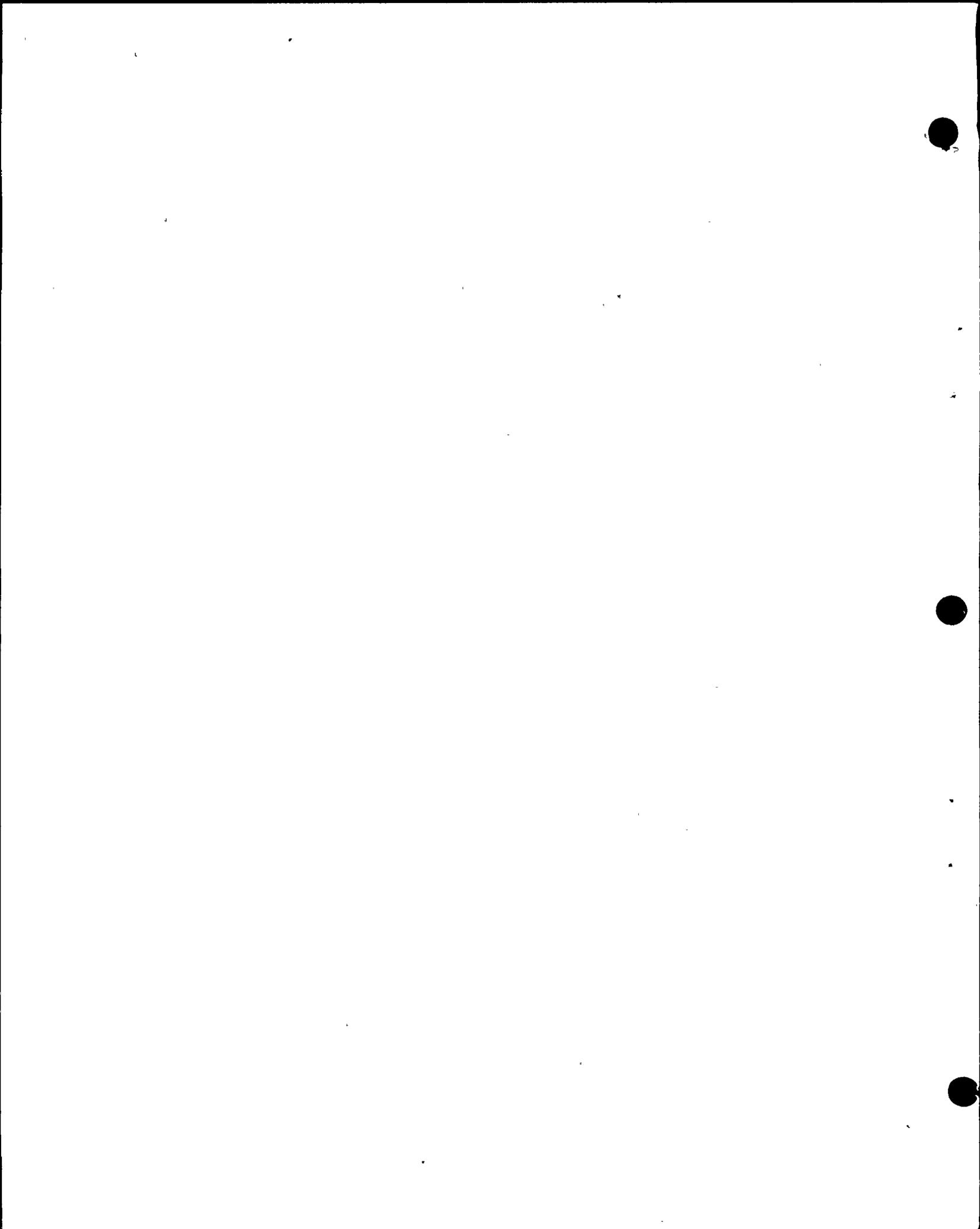
11 A I'm not prepared to agree with that statement,
12 because the way that this table was used was that certain
13 zones in Alaska were specified as being zones in which a
14 magnitude 7.5 earthquake was likely, or a magnitude 5.5
15 magnitude was likely in another zone.

16 And the suggestion was that one would enter
17 this table and read off 1.15 against the 7.5 and use that in
18 the zone.

19 Now I don't know what deeper meaning was involved
20 than that. It was just a rather straightforward intent. And
21 as to the statistical side of it, I think this is not the
22 paper which deals with that.

23 I could help you perhaps by reading part of the
24 abstract in which they say, at the bottom:

25 "For magnitudes 5 and 6 for which sufficient



wb5

1 near-fault records are available, the adopted ground
2 motion values" -- they call them adopted -- "are
3 based on data. For large earthquakes the values
4 are based on extrapolations of data for small shocks
5 guided by simplified theoretical models of the
6 faulting process."

7 So they themselves -- and I guess I must follow
8 their own writing -- call them "adopted" values, whatever
9 that means.

10 Q Okay. I wanted to get to that. But let me
11 ask you one last question on this sentence, "They are not
12 the maximum possible."

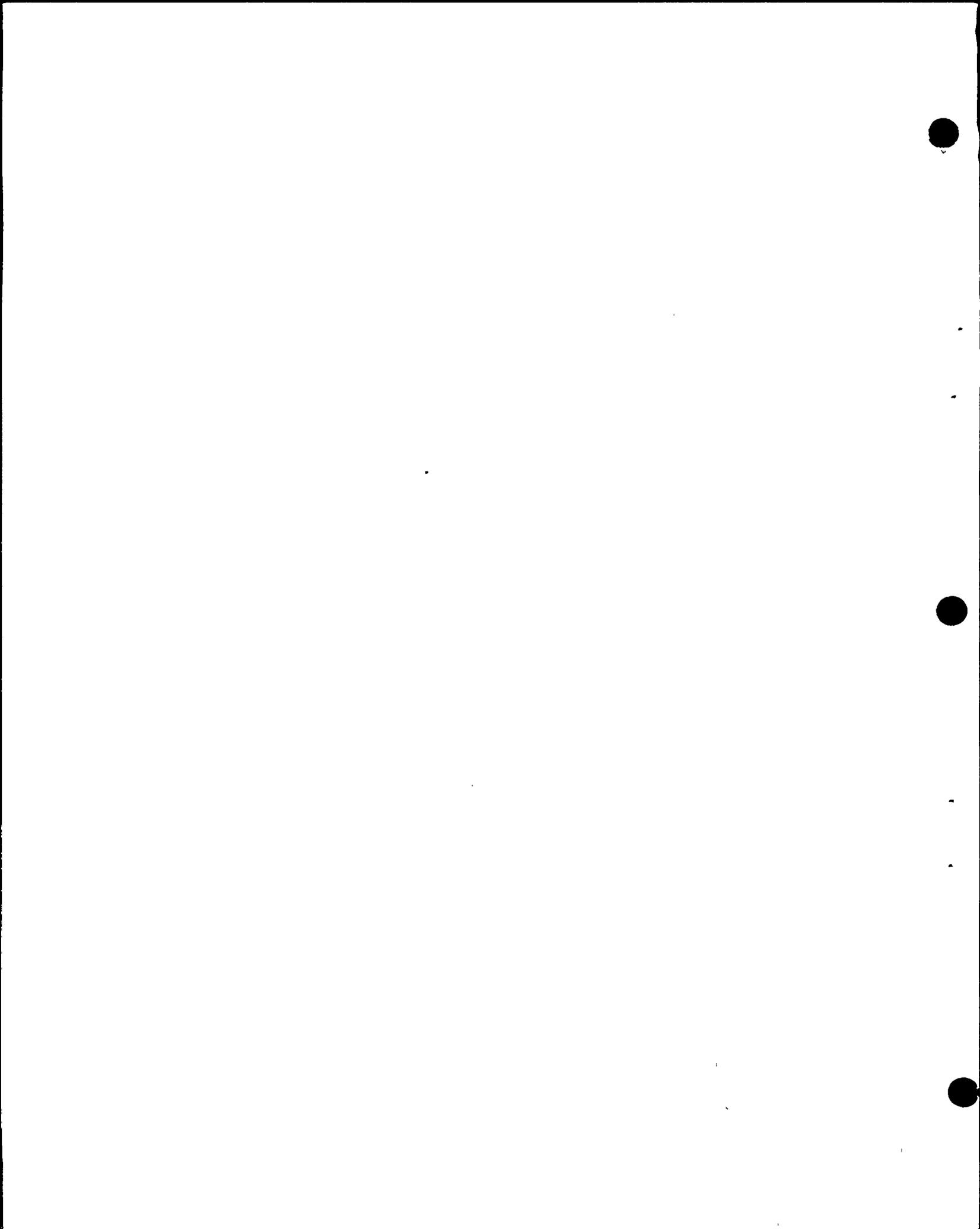
13 Do you understand that to mean that should they
14 have a 7.5 magnitude earthquake U.S.G.S. indicates we may
15 see first peaks, absolute peak accelerations greater than
16 1.15?

17 A I would have to say that in the way "possible"
18 is used these days, they're saying it's not impossible that
19 such things would happen. But "may" usually refers to some
20 probability. And they're avoiding probability here. That's
21 why I don't like the word "possible."

22 It's possible that I might get home at five
23 o'clock this afternoon, but it's not very probable.

24 (Laughter)

25 Q Well let me go back to your statement that Mr. Bloom



wb6

1 read back, where you indicated that you were not in agreement
2 with the procedure used to scale up from small data base
3 for larger size accelerations.

4 A That's correct.

5 Q I think you indicated that had fatal flaws.

6 What is that procedure with which you disagree?

7 A Well as I mentioned, a key to their procedure
8 was to pivot on the value obtained at the Pacoima Dam site
9 from the 1971 San Fernando earthquake. And I felt at
10 the time, and I think there's some further evidence, that
11 that was a high value on which to base an extrapolation;
12 that if one wanted to go more to an expected value on which
13 to extrapolate one would have chosen a somewhat lesser value.

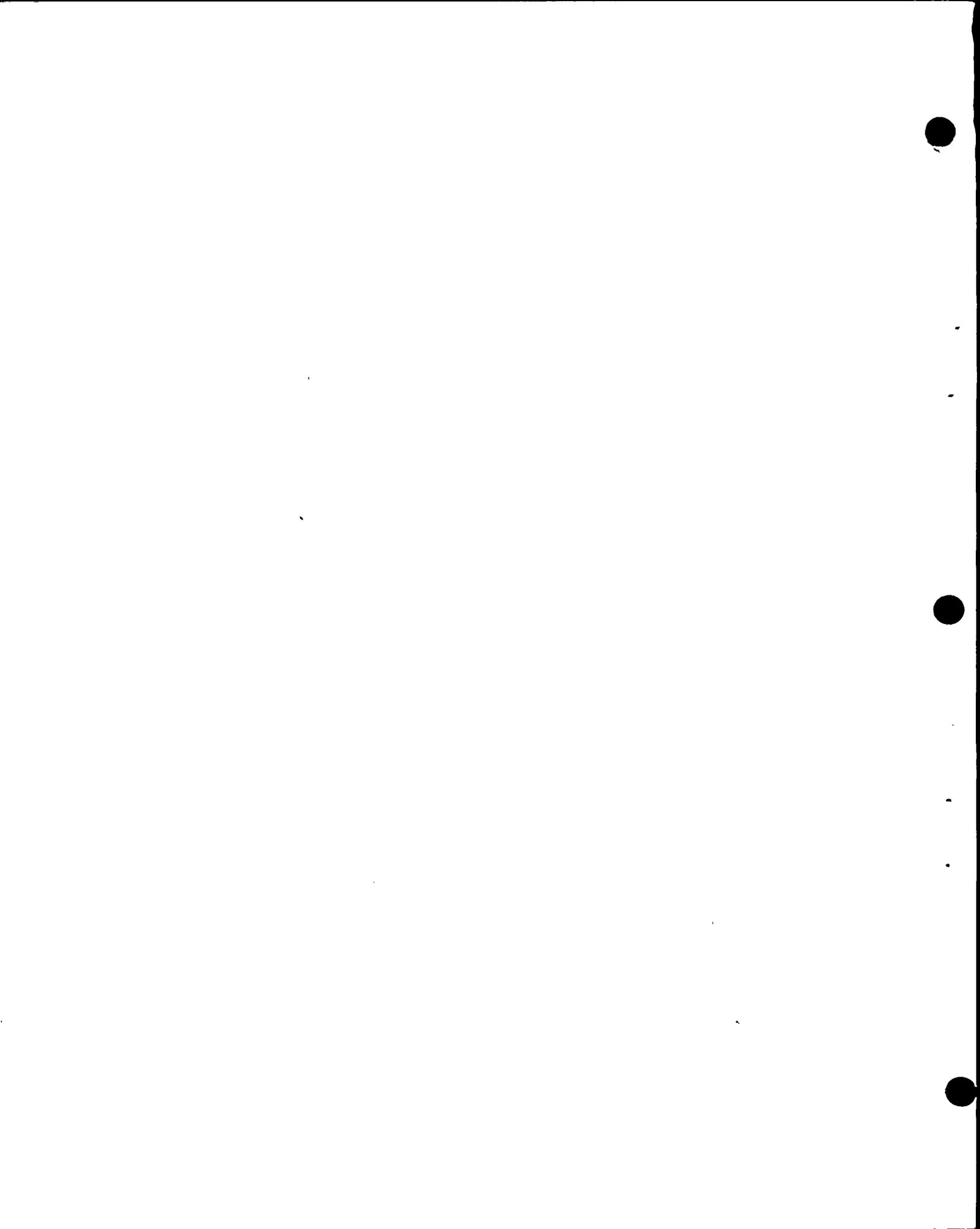
14 The other procedure that they used was to go to
15 magnitude 8-1/4 earthquake -- I believe it was 8-1/4.
16 Excuse me a moment till I find the explicit figure.

17 (Pause)

18 No, I'd like to correct that, Mr. Fleischaker.

19 On page 8 they say that a value of 1.25g was
20 adopted for magnitude 8.5, and the values for intermediate
21 magnitudes were interpolated between 1.25g and the value of
22 0.9g for magnitude 6.5.

23 Now in the first place, nobody has ever recorded
24 an acceleration for a magnitude 8.5 earthquake. And,
25 consequently, the only place that I can see where you can get



wb7

1 the 1.25g is because you believe it's a nice looking number.
2 And it seems extraordinary to me that one would suddenly
3 pull that out of the air and use that to then linearly
4 interpolate between -- back down to a value of .6.5, which is
5 generally recognized as a rather unusual recording. I would
6 have preferred it if they had explored the possibility of
7 extrapolating using some other geometrical curve such as a
8 parabola. Why not use a parabola? Many people extrapolate
9 with parabolas. I don't see why a straight line should be
10 used.

11 Why should a straight line be used? I can't
12 understand. You clearly can't keep going straight on up
13 with a straight line forever. There has to be some truncation
14 of the moment. So the very mathematical basis of it seems
15 to me to be somewhat hard to defend.

16 Q Well I guess the bottom line is that you're not
17 in agreement with their straight line extrapolation: Well,
18 is it your testimony, then, that the straight line extrapola-
19 tion was utilized in order to--

20 A This is what they did.

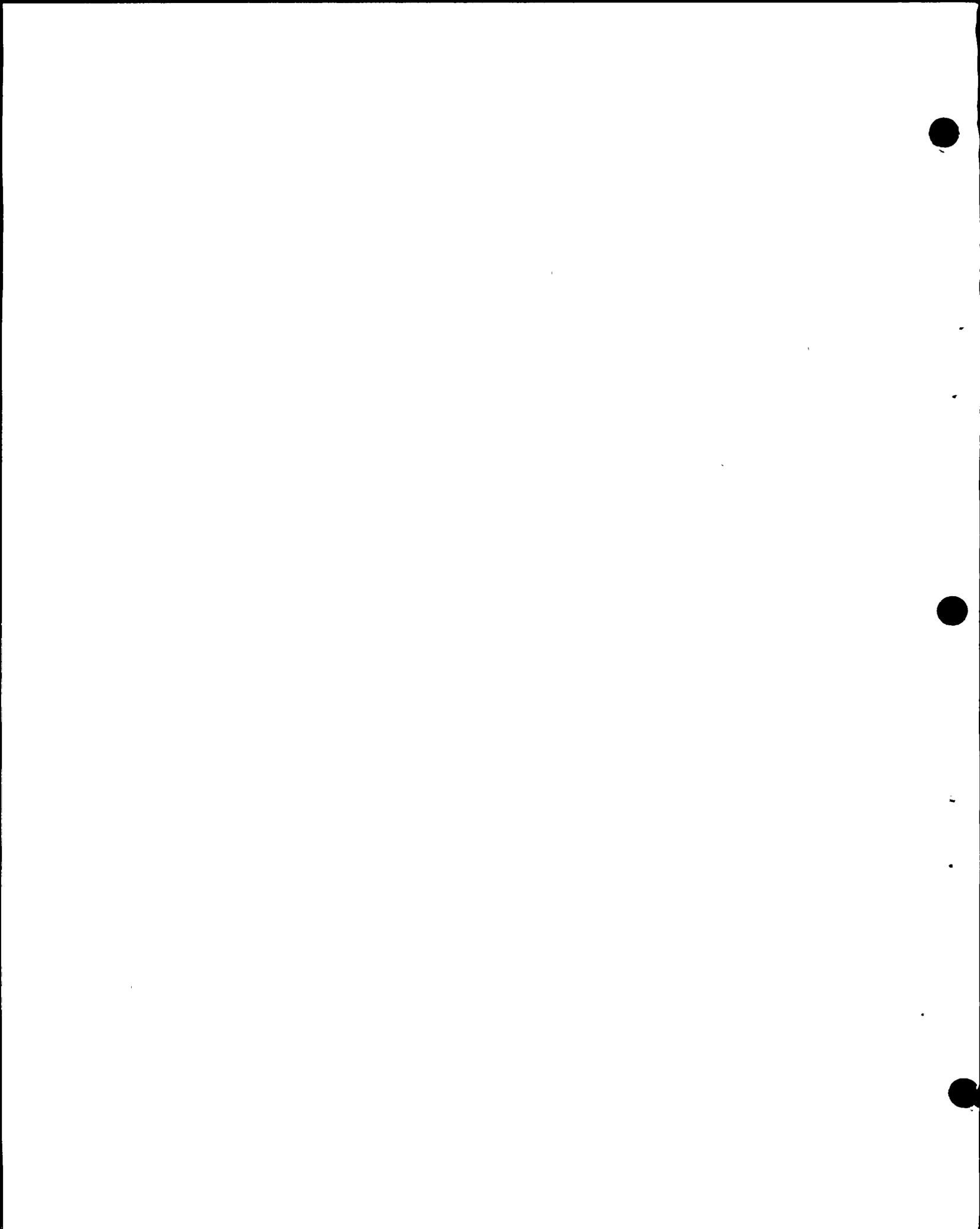
21 Q And you're not in agreement with that?

22 A A I'm not in agreement with it.

23 Q Okay.

24 Dr. Bolt, have you had an opportunity to --

25 MR. NORTON: Excuse me, Mrs. Bowers. I hate to



wb8

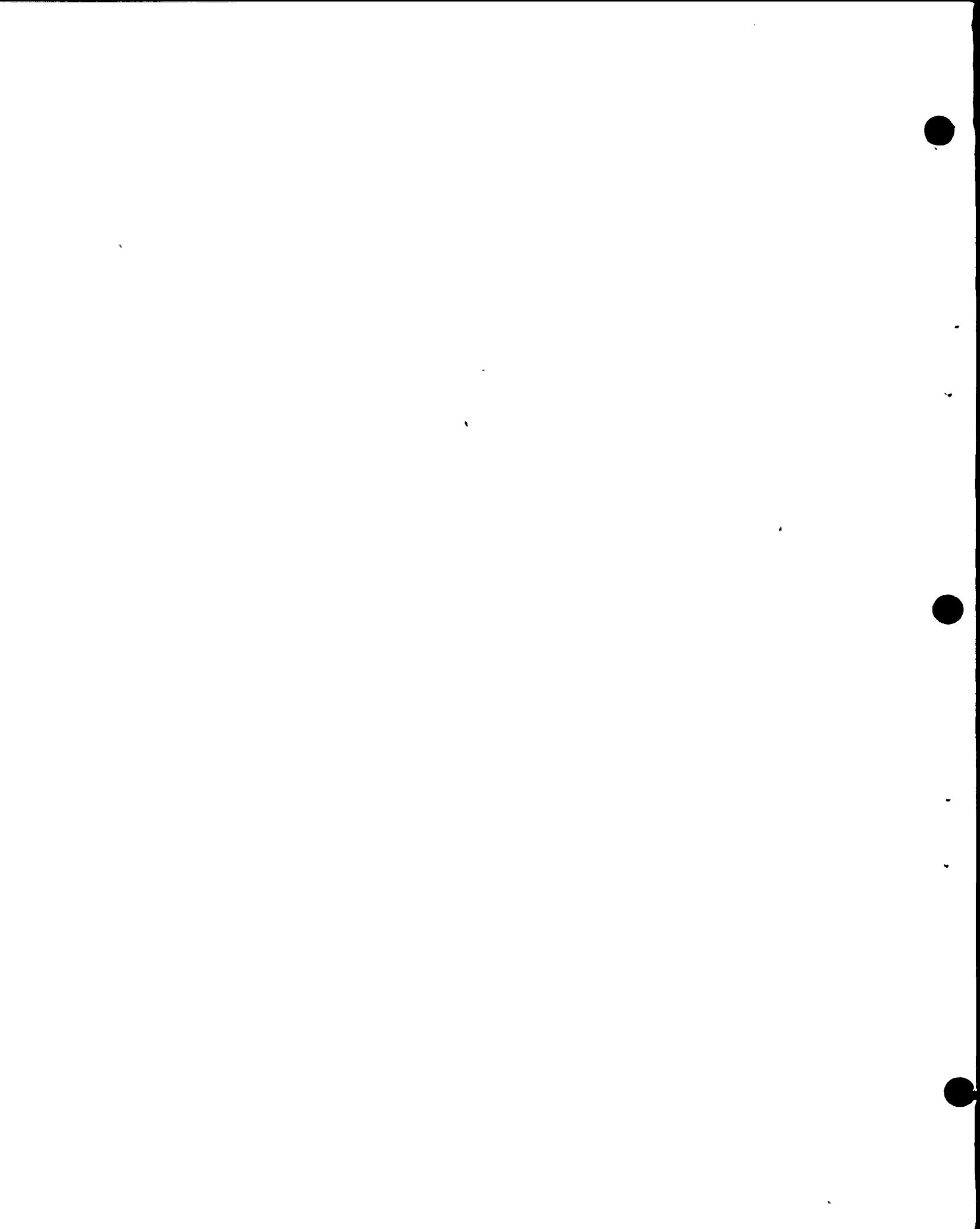
1 interrupt, but I really need to take a break.

2 MRS. BOWERS: Ten minutes, please.

3 (Recess)

4A fls

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4A agbl

MRS. BOWERS: We'd like to begin, please.

2
BY MR. FLEISCHAKER:

3 Q Dr. Bolt, could I turn back to Page Three
4 again of the 672, USGS Circular 672? And again, I would
5 like to direct your attention to Table Two.

6 MRS. BOWERS: Wait a minute, I'm not with you.
7 What part are you looking at?

8 MR. FLEISCHAKER: This is Table Two at the bottom
9 of Page Three.

10 BY MR. FLEISCHAKER:

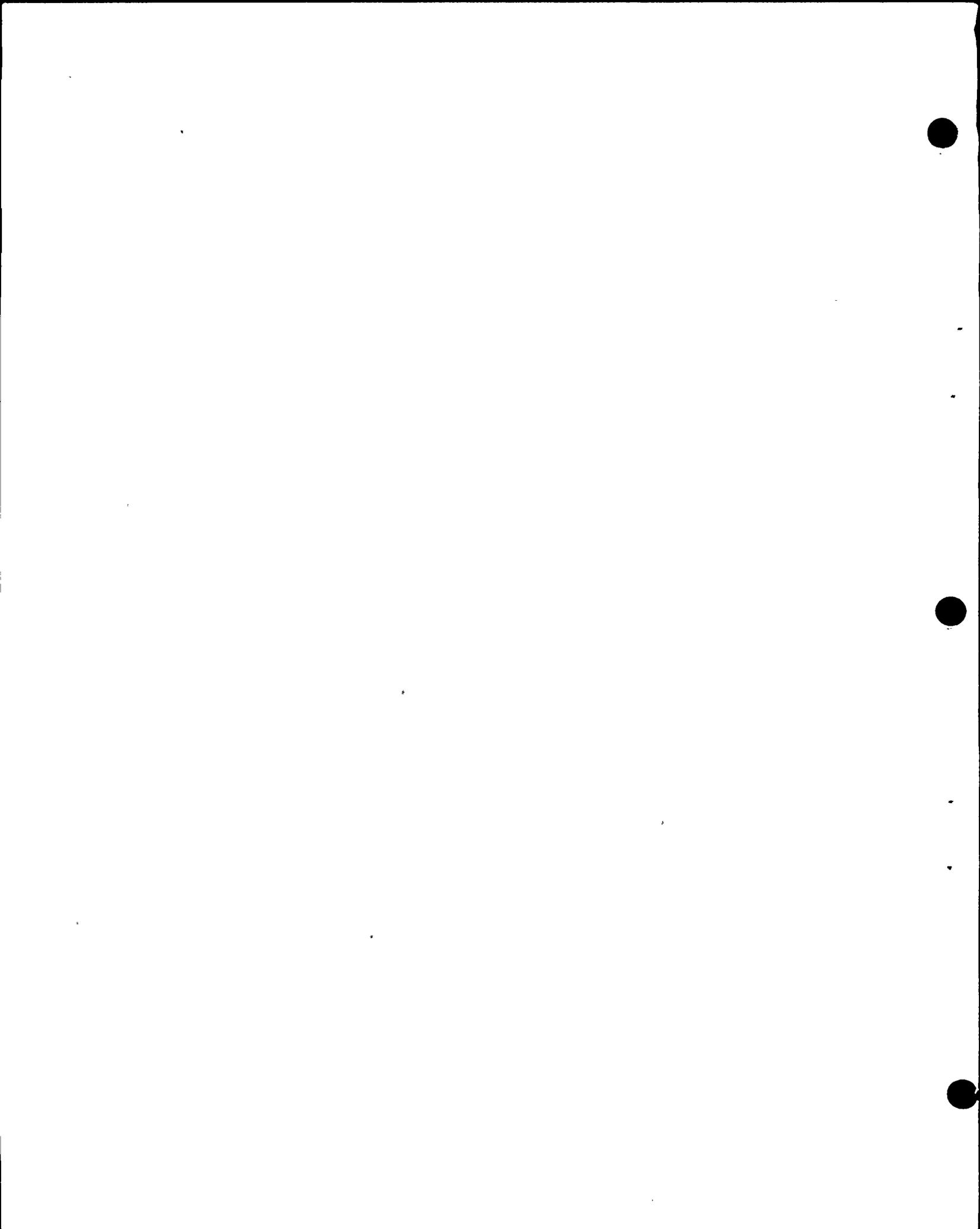
11 Q Is it your understanding that the extrapolation
12 here is a straight-line extrapolation?

13 A (Witness Bolt) The extrapolation at the end,
14 from 3.5 to 7.5, is straight-line. If you take those differences
15 you find that that goes up by units of five over the whole
16 range, 7.5 to 8.5 which -- I thought we were talking about
17 extrapolations above 7.5.

18 Q Well, let's look at -- let me clarify the
19 question then.

20 If we look at the data from 5.5 to 8.5, is it
21 your understanding that that's a straight-line extrapolation?

22 A No, that's not a straight-line extrapolation, no.
23 Because they say explicitly that the earlier icons in the table
24 are from observation from their graphs. So that doesn't
25 need to be extrapolated at the lower end.



agb2

1 Q Well, how about -- they have here for magnitudes
2 -- directing your attention to Page One in the abstract, it
3 says there in the third paragraph:

4 "For magnitudes 5 and 6 for which
5 sufficient near-field records are available,
6 the adopted ground motion values are based
7 on data."

8 Now, directing your attention to the bottom of
9 Page Three, Table Two, is the extrapolation from 6.5 to 7.5
10 a straight-line extrapolation?

11 A Just taking the first differences, no, that's
12 not exactly a straight-line extrapolation in that range.
13 Of course, the 9.0 is an observed value, according to their
14 estimate.

15 Q So it is not a straight line from 6.5 to 8.5?

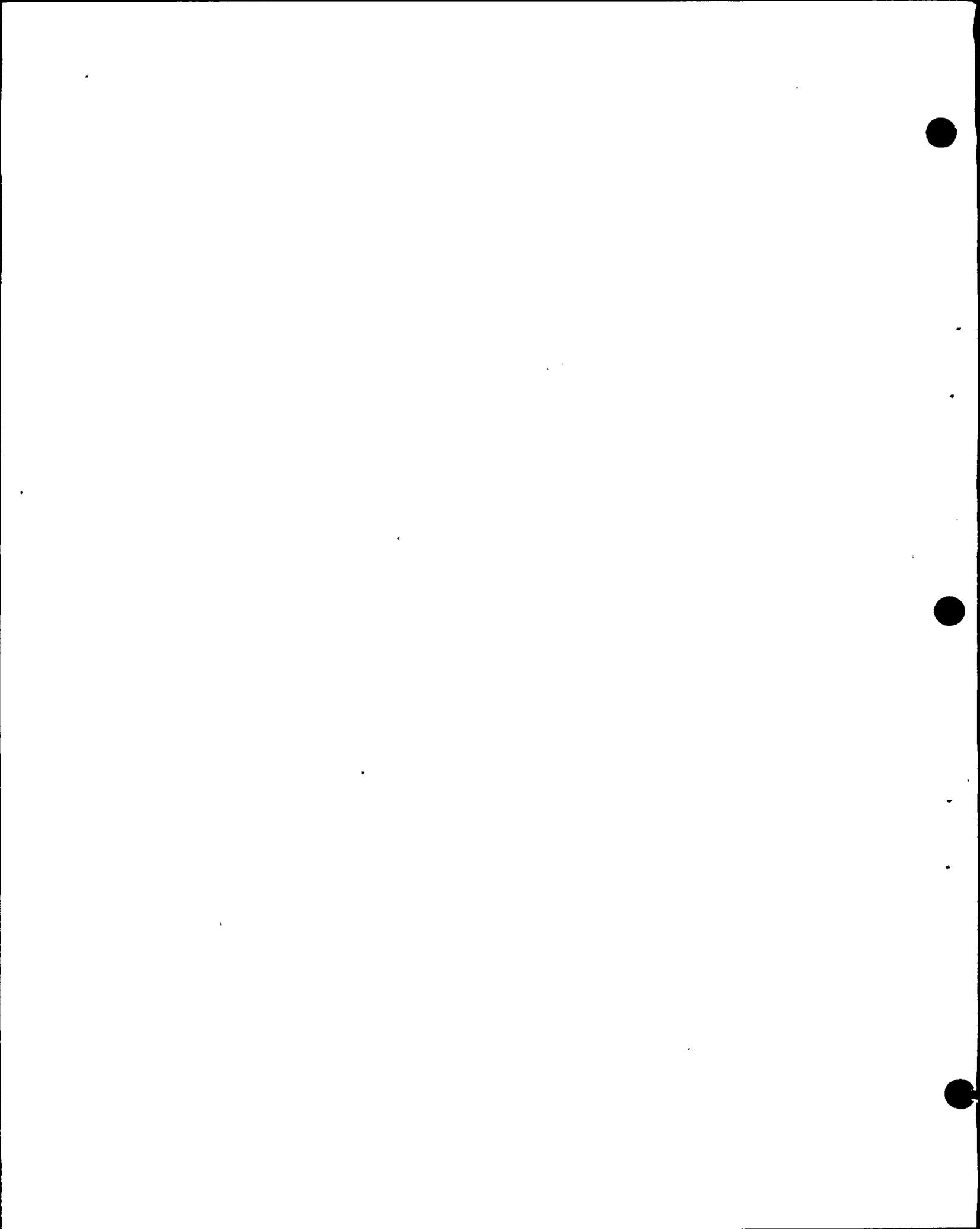
16 A No, it's a straight line from 7.5 to 8.5 in the
17 table. Of course, that has an effect on the whole extra-
18 polation, of course, that's what I was getting to.

19 Q Dr. Bolt, are you familiar with the exhibit
20 that has been marked as Joint Intervenors' Exhibit 46, which
21 is entitled, "Estimation of Ground Motion Parameters," by
22 Boore, Oliver, Page and Joyner?

23 A Yes, I'm familiar with it.

24 MR. FLEISCHAKER: May I have a moment, please?

25 (Pause.)



agb3

1 BY MR. FLEISCHAKER:

2 Q Let me withdraw that. I'll come back to that
3 later.

4 Let me ask you, Dr. Bolt, you indicated that you
5 do not agree with the procedures utilized in 672.

6 A (Witness Bolt) No.

7 Q What procedures would you utilize to derive the
8 maximum --

9 A Well I have come more and more to the view that --

10 Q Excuse me, let me finish my question so we
11 can make sure we're talking about the same thing.

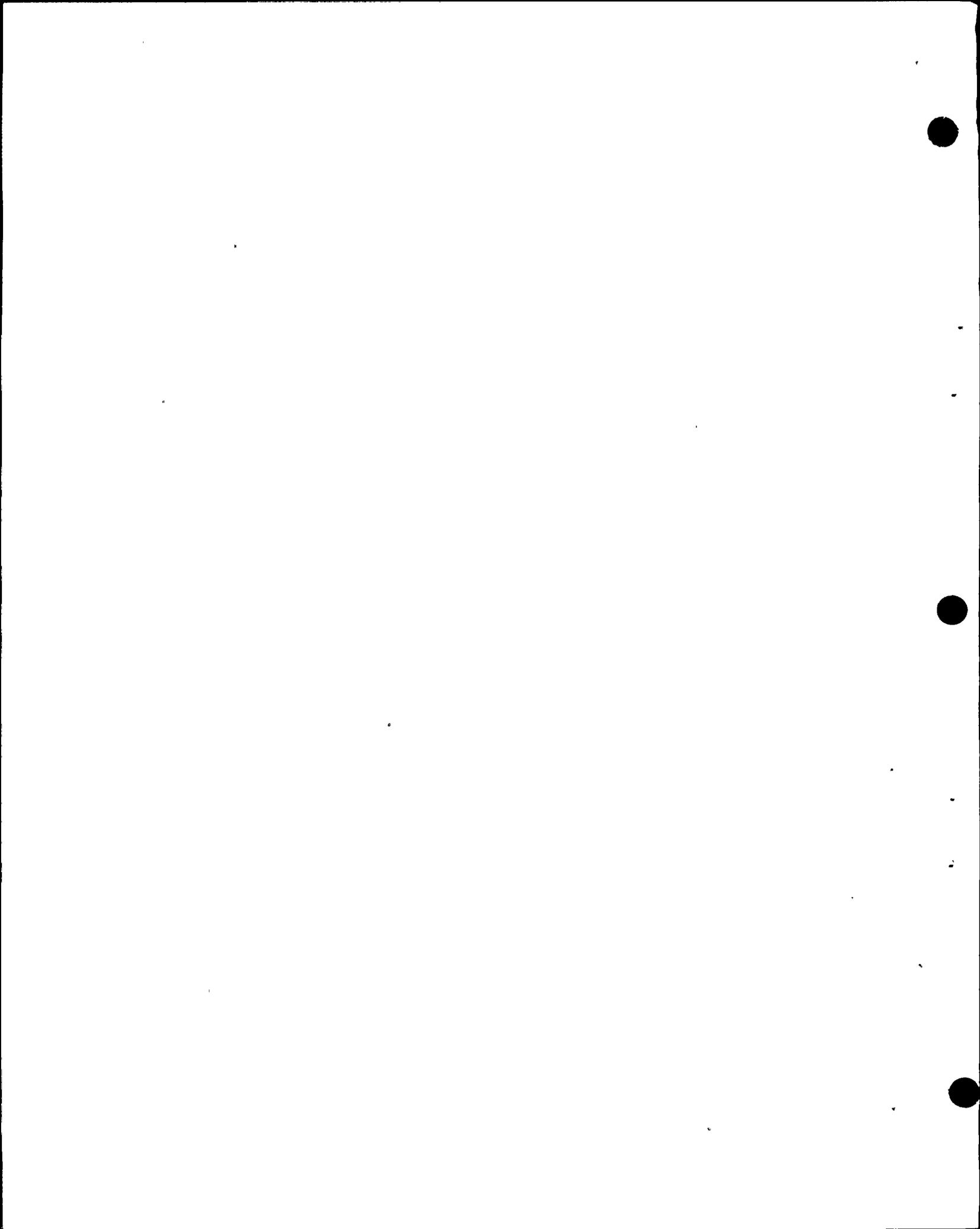
12 A I'm sorry.

13 Q What procedures would you use to derive the
14 expected peak accelerations in the free field for magnitudes
15 of the earthquake range 6.5 to 8?

16 A I have a difficulty with the whole approach which
17 uses magnitude as the only scaling value. And I've written
18 about that in various places and given my arguments.

19 It seems to me that, so far as the site is
20 concerned near to the source, the radiating antenna, the
21 energy, the fact that the fault ruptures out quite a way
22 from that site means that the peak acceleration is going to
23 be limited.

24 In other words, my house at Berkeley doesn't
25 much care that the San Andreas Fault keeps on rupturing up



agb4

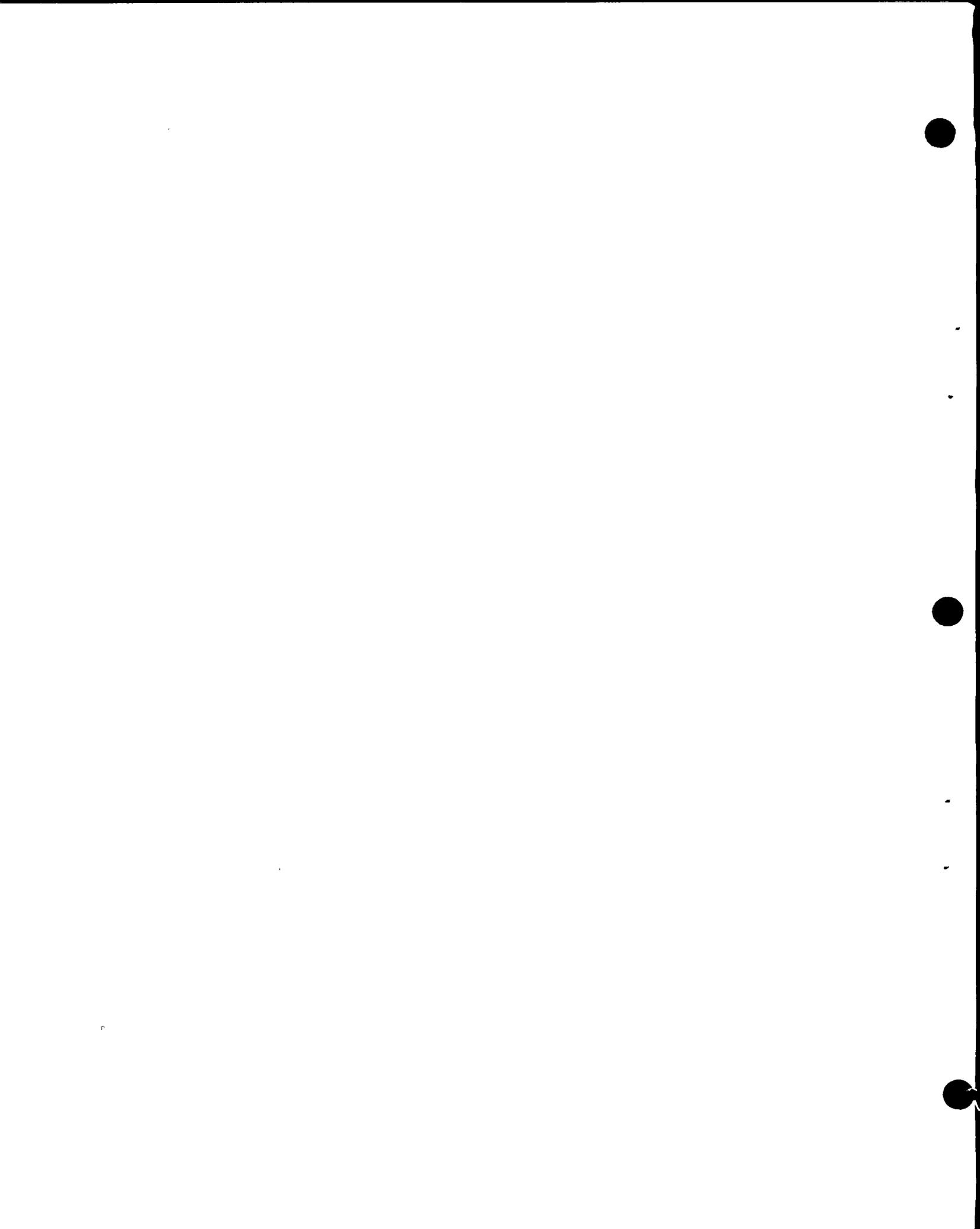
1 past the Golden Gate to Cape Mendocino, because the waves
2 coming back from the ends of the fault will be very much --
3 will move to the longer periods. So that so far as the peak
4 accelerations are concerned which are coming from the part
5 of the source which is adjacent to the site, they're not
6 going to be affected by these seismic waves coming from
7 further away.

8 So on that model, I think that there will be a
9 fairly strong limit to the peak acceleration on the average,
10 that the physics of the situation indicates that the strong
11 shaking at a site near to a source in the frequency range
12 of 10 Hz to 1Hz will not be very different, on the average,
13 for magnitude 6.5 earthquake than it will be for an 8-1/4
14 earthquake.

15 That may surprise a lot of people because they
16 think, Oh, 8-1/4 earthquake, that would be dreadful. Well,
17 of course, a 6.5 earthquake can also cause damage and
18 does to weak structures. ...

19 And so it's not just a matter of looking at
20 damage. What happens in a bigger magnitude earthquake is,
21 of course, that the damage is spread out over much greater
22 distance. That is to say, over a distance which depends on
23 the dimension of the fault that's rupturing.

24 So that so far as your question on the peak
25 ground acceleration, in the way that I would estimate it,



agb5

1 I would be limiting the extrapolations to something like
2 0.6 to 0.8g and, at the moment, I would think that that's
3 about enough. I wouldn't go up much higher than that.

4 Q Well you said two things, it seems.

5 First of all, you said that on the average you
6 would tend to see -- in a range of magnitude 6.5 to 8, you
7 would tend to see the same peak accelerations, is that
8 correct?

9 A That's correct.

10 Q And then you also said you would limit your
11 assignment of the expected peak acceleration to 0.6 or 0.8g
12 throughout that range of magnitude.

13 A The evidence suggests that to me, that that's
14 about the limit.

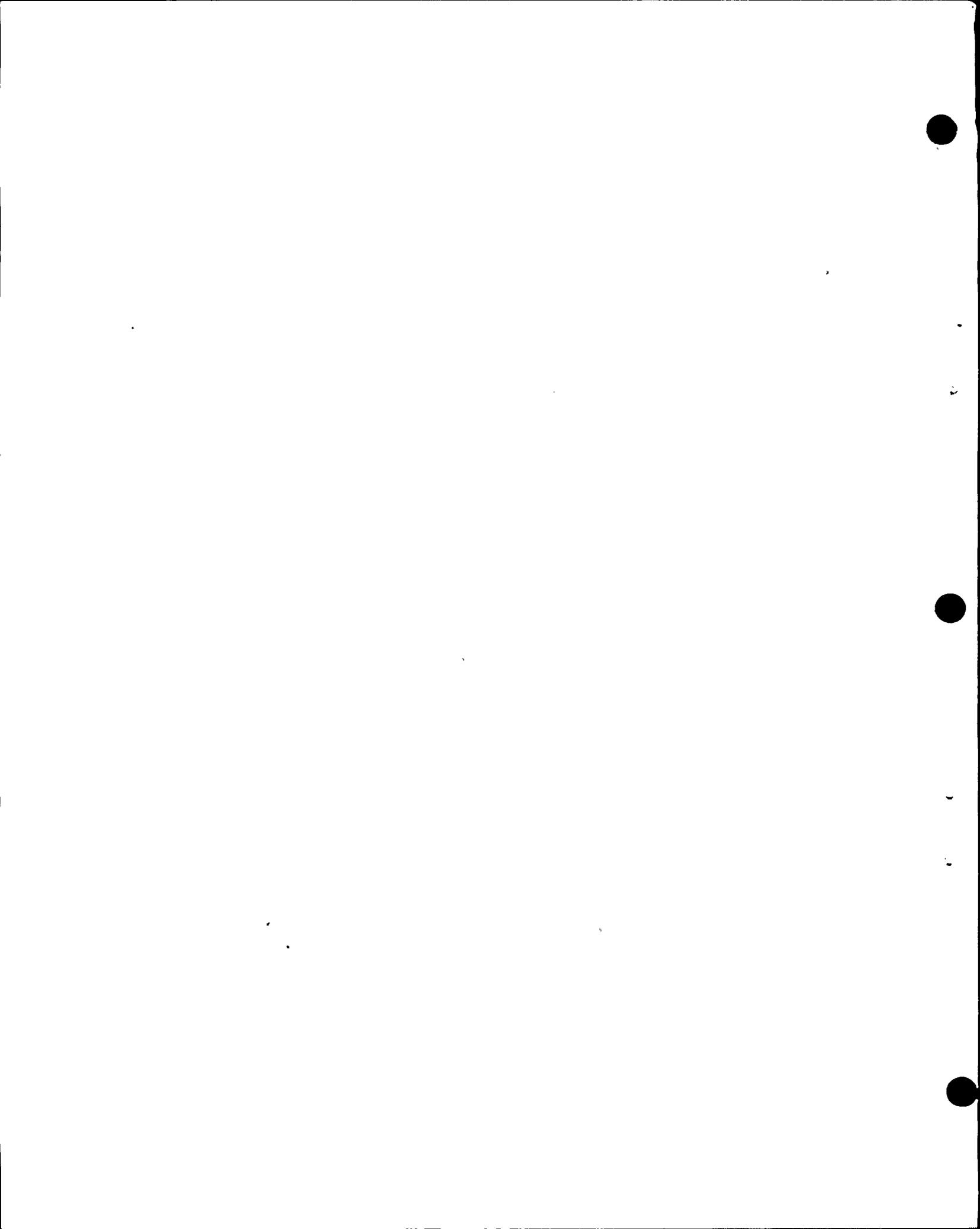
15 I'm not taking into account yet topographic
16 effects such as the ridge at Pacoima. If one was building
17 a structure on some special feature, of course, there would
18 have to be a special adjustment made for that as part of
19 the seismological assessment. I'm talking about flat
20 territory.

21 Q Are you also discounting the possibility of
22 directivity?

23 A I don't quite know what you mean by directivity.

24 Q Focusing.

25 A I define focusing in a different way than some



agb6

1 people, so I would have to have your actual definition of
2 that. I'm sorry.

3 I could talk to my definition of focusing but
4 that, I think, is not the only way it's defined.

5 Q Well there's some mention in the testimony
6 about the causes of the high accelerations recorded on the
7 accelerometer at Pacoima Dam.

8 And I believe at Page 26 there are two reasons
9 given. One of them is amplification due to the placement
10 of the accelerometer high on a granite rock, and the second
11 one has to do with some -- with the conclusion that there
12 was focusing of energy.

13 That's at Page 26, Lines, I think it is, 14
14 through 18.

15 A Well on Page 14, focusing is given in parentheses
16 following rupture propagation. And so I can speak to it
17 in that sense, specifically.

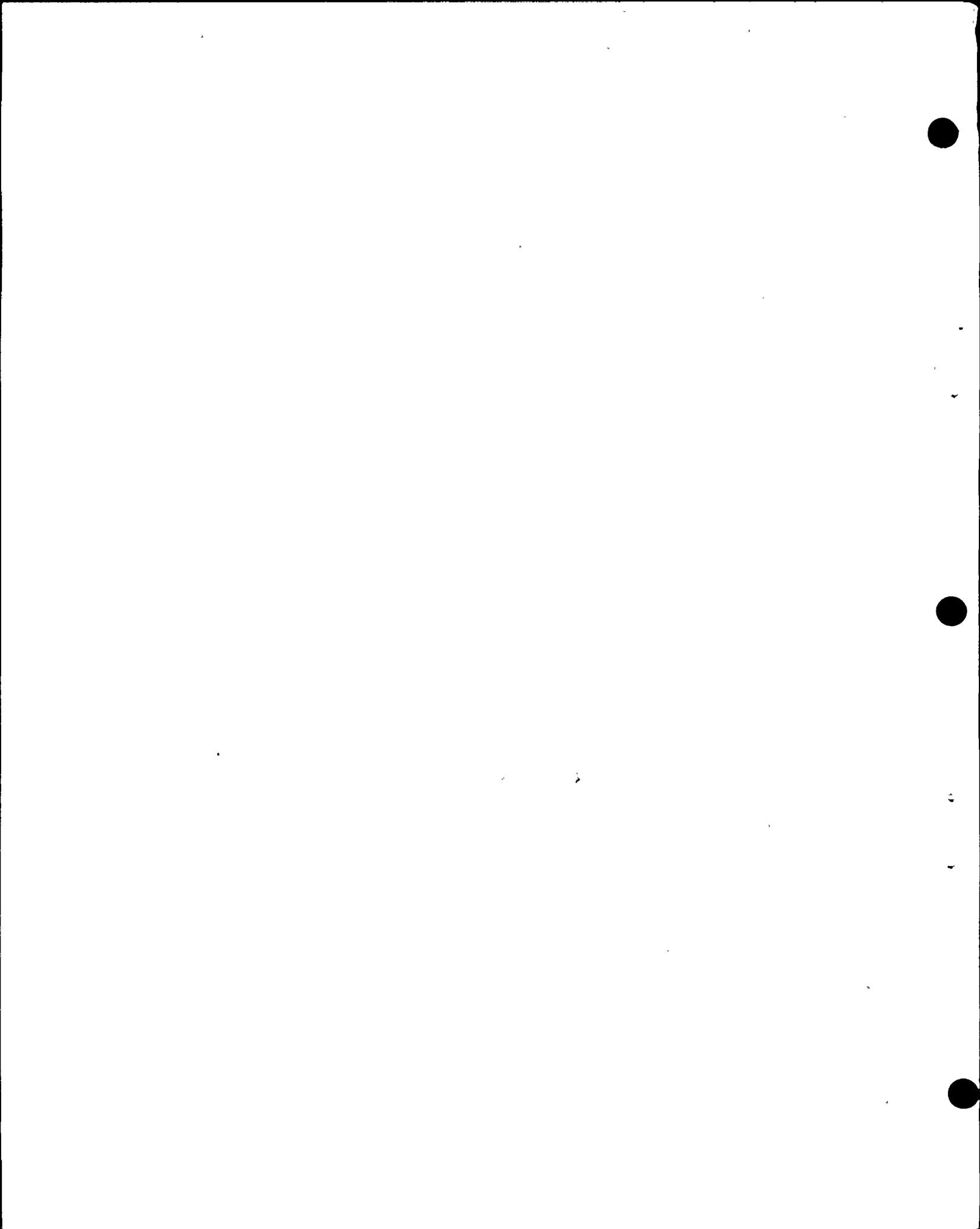
18 In other words, the notion is that --

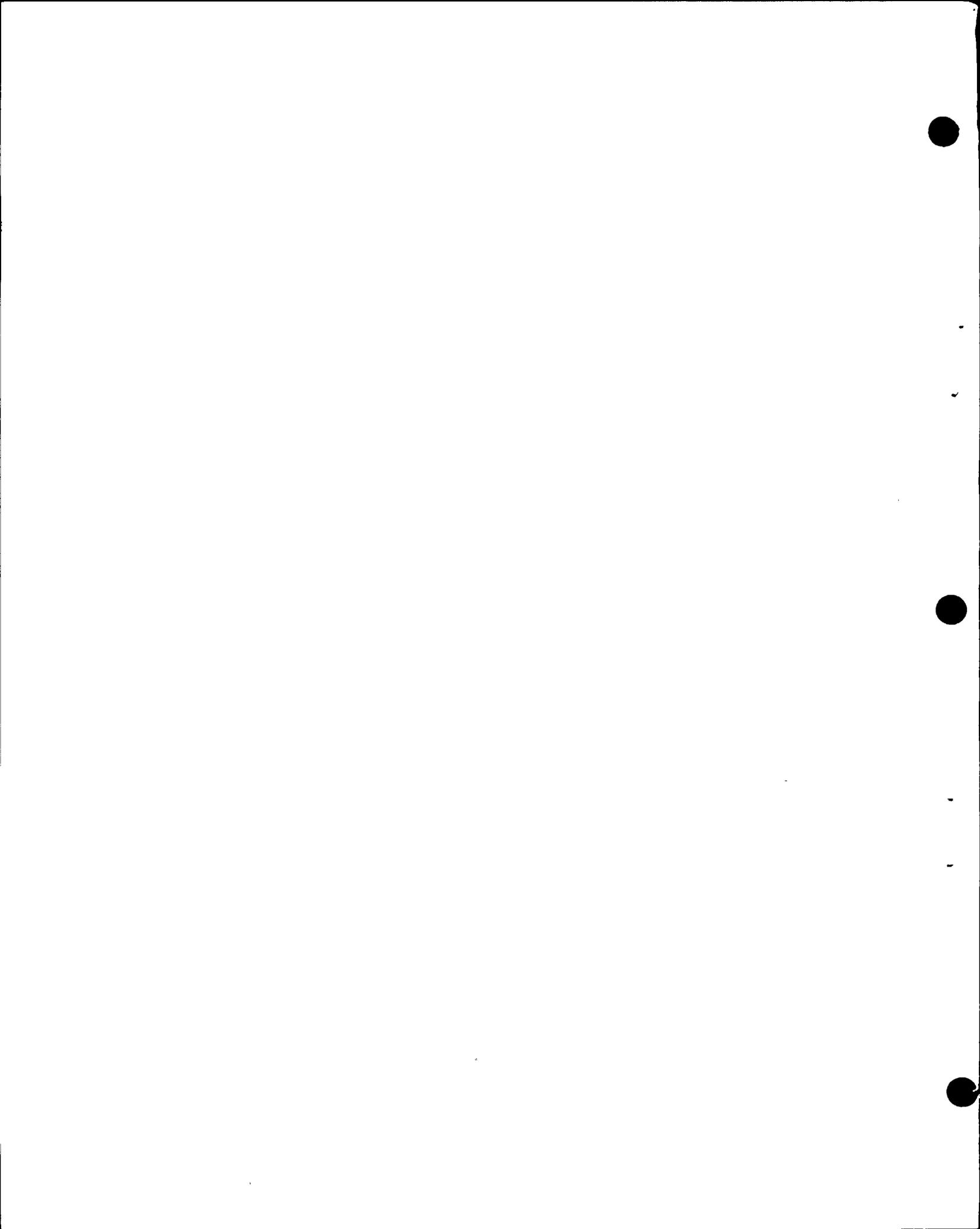
19 Q Excuse me, is that Line 14?

20 A Line 14 on Page 26.

21 Q All right. Thank you.

22 A The notion there is that as the propagation goes
23 along the fault, there may be some enhancement of the energy
24 in the direction of movement of the front of the dislocation
25 on the fault, the break.





agb8

1 and so I'm not sure whether I'm excluding it or not.

2 Q Well, I mean, it's part of the data.

3 But -- does that mean that we throw out data
4 points where we suspect that they may be focusing?

5 A No, it doesn't mean that. It means that, if you
6 need another topographic feature you can see it, you know
7 you're on a ridge.

8 But focusing is something which, by its very
9 essence, I suppose, in this sense, is contained within the
10 record itself. You don't see focusing.

11 And so then when I look at observations, if
12 there is such a thing as focusing, it is contained within
13 the observations. But I can't point and say, there's the
14 focusing, as I can point and say, there's the rigid Pacoima.

15 So I wouldn't say that my conclusions are much
16 affected by the motion.

end4A

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NRB/mpbl 1 Q How do we determine how much of the Pacoima
2 accelerations were due to focusing the high acceleration
3 there, the 1.25?

4 A 1.2g's we mentioned.

5 Q Right.

6 A The idea is that since the hypocenter of that
7 earthquake was 12 kilometers down in the earth's crust, and
8 we saw a fault rupture at the surface along the edge of
9 the San Gabriel Mountain, that the rupture or dislocation
10 spread out from depth up the fault and passed upwards and
11 underneath Pacoima and reached the surface, came out at the
12 surface.

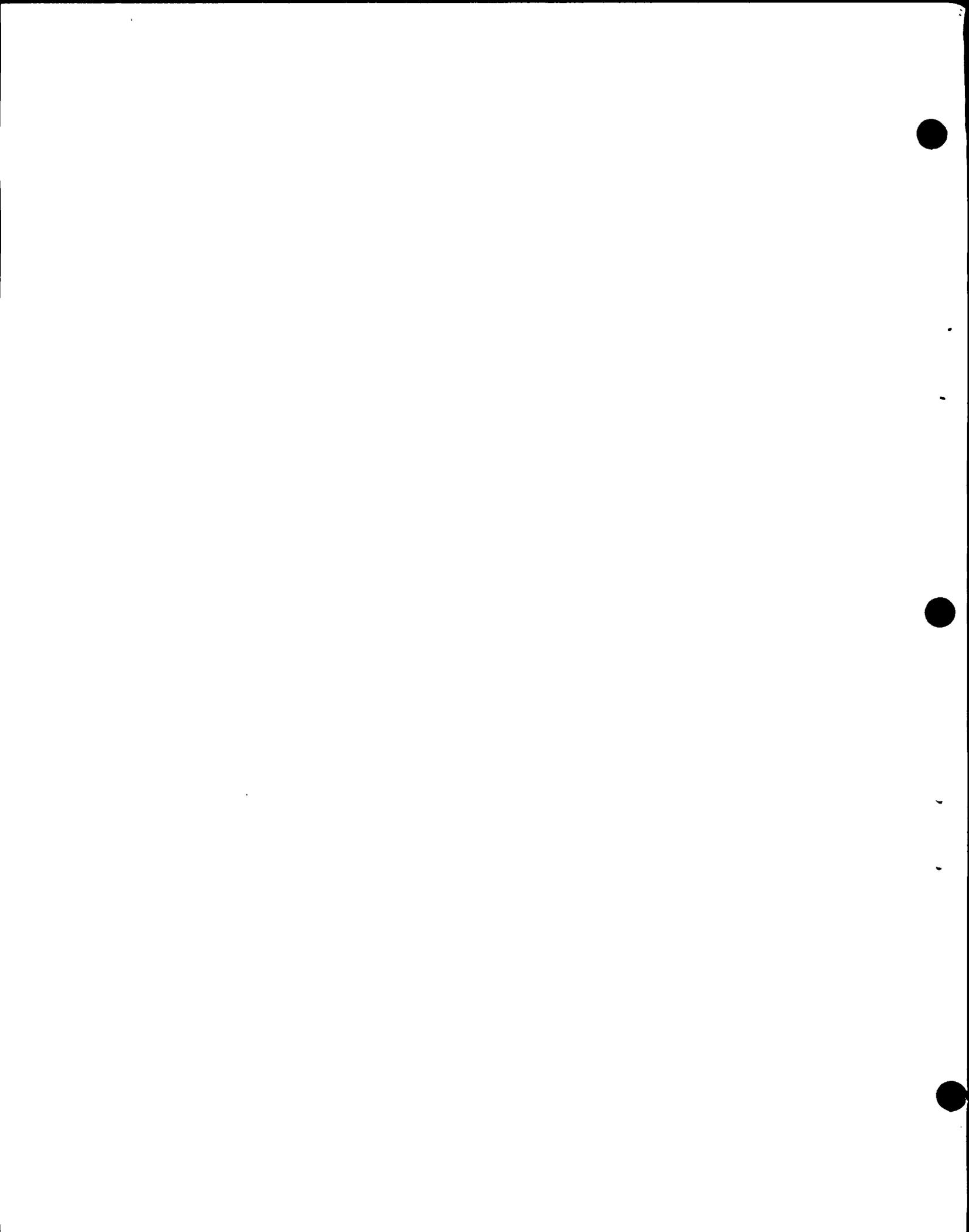
13 If there is anything in focusing, it would tend
14 to -- as I said before, this idea of focusing is that if
15 you're in the direction of movement of the rupture, that it
16 would tend to increase the amplitude somewhat. So the Pacoima,
17 since it was in the direction of movement of the rupture,
18 would be -- would contain this focusing effect.

19 But I made no attempt to take that out in any
20 way. I just -- if it is there, it's there.

21 Q Can we have focusing with respect to both accel-
22 eration and velocity?

23 A I think it makes no difference so far as the
24 actual dynamical parameter.

25 Q Are you aware of any -- are you aware of



mpb2 1 the work of T. H. Eaton and the specific reference is
2 generalized ray models of strong ground motion. This is a
3 Ph.D. thesis at California Institute of Technology which
4 studied the effect of focusing at Pacoima.

5 A I'm not very familiar with that work. I think
6 maybe Dr. Frazier may be, and he could speak to it.

7 Q Okay.

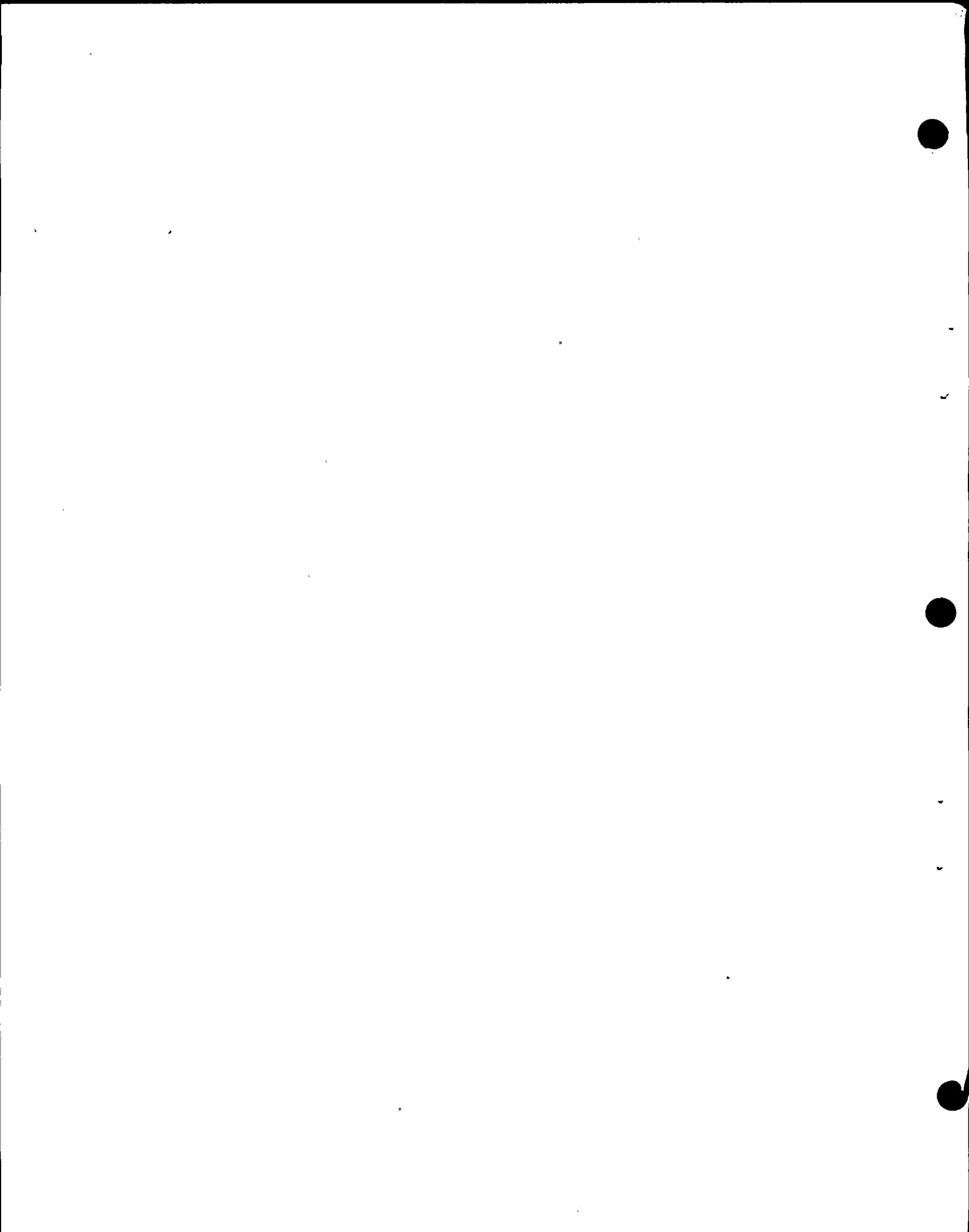
8 Dr. Frazier, are you familiar with that work?

9 A (Witness Frazier) Yes.

10 Q What were Mr. Eaton's conclusions with respect
11 to focusing of the velocity pulse at the Pacoima Dam?

12 A It's funny. I observed the geologist sitting
13 up there trying to answer a question very simply. That
14 doesn't have a very simple answer.

15 He did several rupture models in his thesis,
16 and two things he found with regard to the focusing phenomena.
17 One was that when he didn't have a coherent rupture coming
18 from the hypocenter up the rupture surface -- I hope the
19 Board is grasping this, it's a little complicated. There's
20 a fracture surface involved in the San Fernando earthquake.
21 And, as Dr. Bolt pointed out, the hypocenter -- that is, the
22 depth of first rupture was approximately 12 kilometers deep,
23 and this rupture broke and the fracture surface spread
24 toward the free surface fairly deeply, and this rupture
25 surface is best -- in common seismology everybody working on



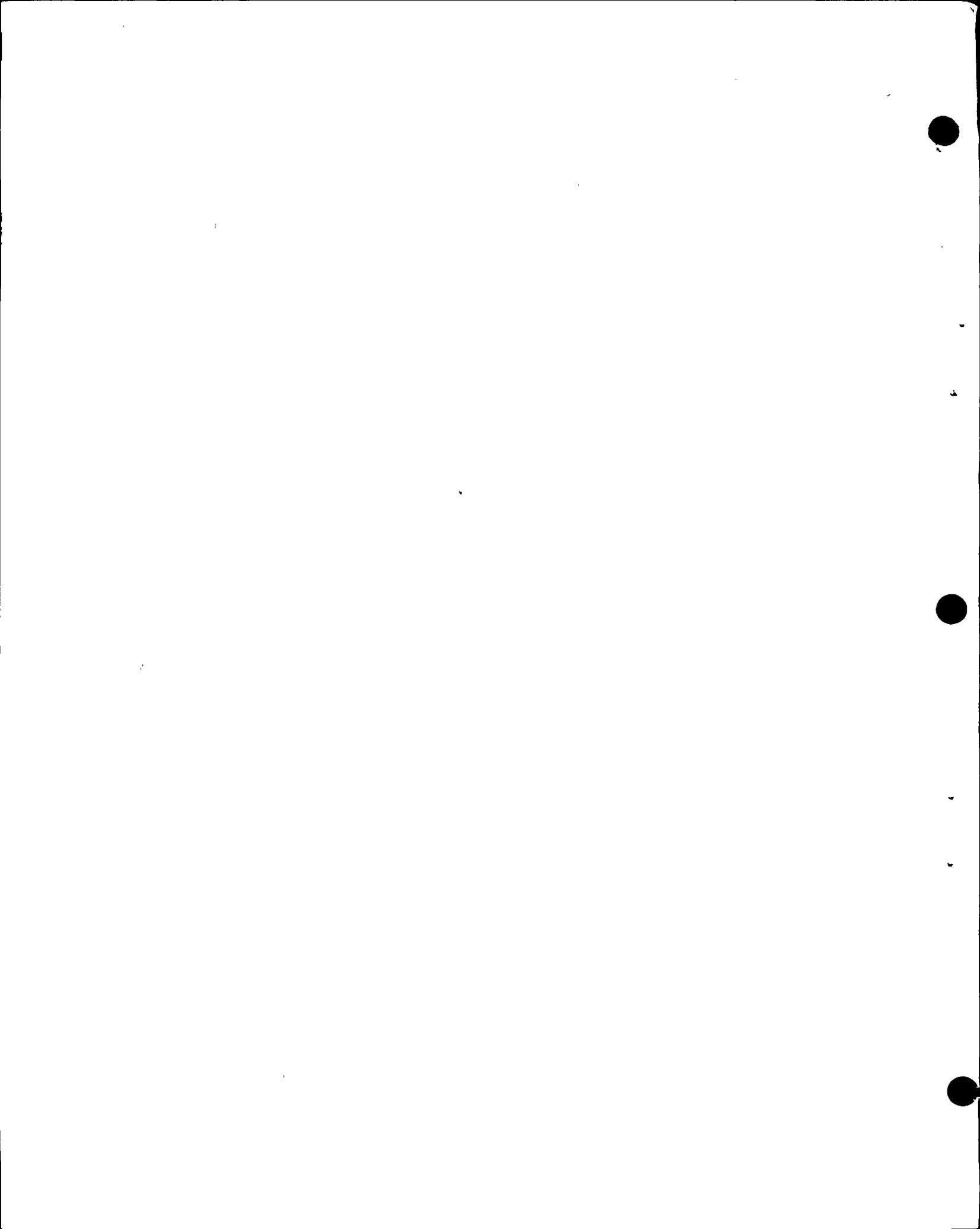
mpb3 1 it has a point just about exactly at this Pacoima Dam record
2 which was up near a dam on the surface of the earth. This
3 rupture went right toward that record for a distance of
4 approximately six or seven kilometers, and at a depth of
5 something like three kilometers the rupture changed directions
6 and actually almost fizzled out and turned at a lower angle
7 and ruptured onto the free surface and broke out some dis-
8 tance to the south of the Pacoima record.

9 And what Mr. Eaton found in his studies and
10 others have found also is that when he modeled this process
11 he needed to have the rupture rather coherently rupturing
12 toward that record in order to explain certain phenomena
13 earth observed at -- the ground motions recorded at Pacoima
14 Dam.

15 And as Prof. Bolt has pointed out in many meet-
16 ings, that there is in the velocity record -- there's a large
17 extrusion when you look at the wiggly lines and velocity
18 there's a big walloping thing that Dr. Bolt calls "fling".
19 Every time he has used the word I chuckle to myself. Now
20 I'm using it.

21 To get the fling at Pacoima record require:
22 indeed that there is considerable focusing right at that
23 record. The same was observed at the Iranian earthquake
24 that Dr. Bolt referred to earlier.

25 Dr. Bolt and myself have both looked at the record,



mpb4 1 and we see a fling associated with that record. So indeed
2 there is focusing in the velocity of that record. And
3 neither Dr. Bolt nor myself would take that out of the data
4 set.

5 That also occurs at Parkfield Station too, there
6 is indeed focusing occurring.

7 Q Didn't Mr. Eaton conclude that focusing or
8 directivity worked in the opposite direction with respect
9 to the acceleration pulse?

10 A Oh, indeed not. The acceleration record is
11 certainly influenced by the rupture moving toward the record.

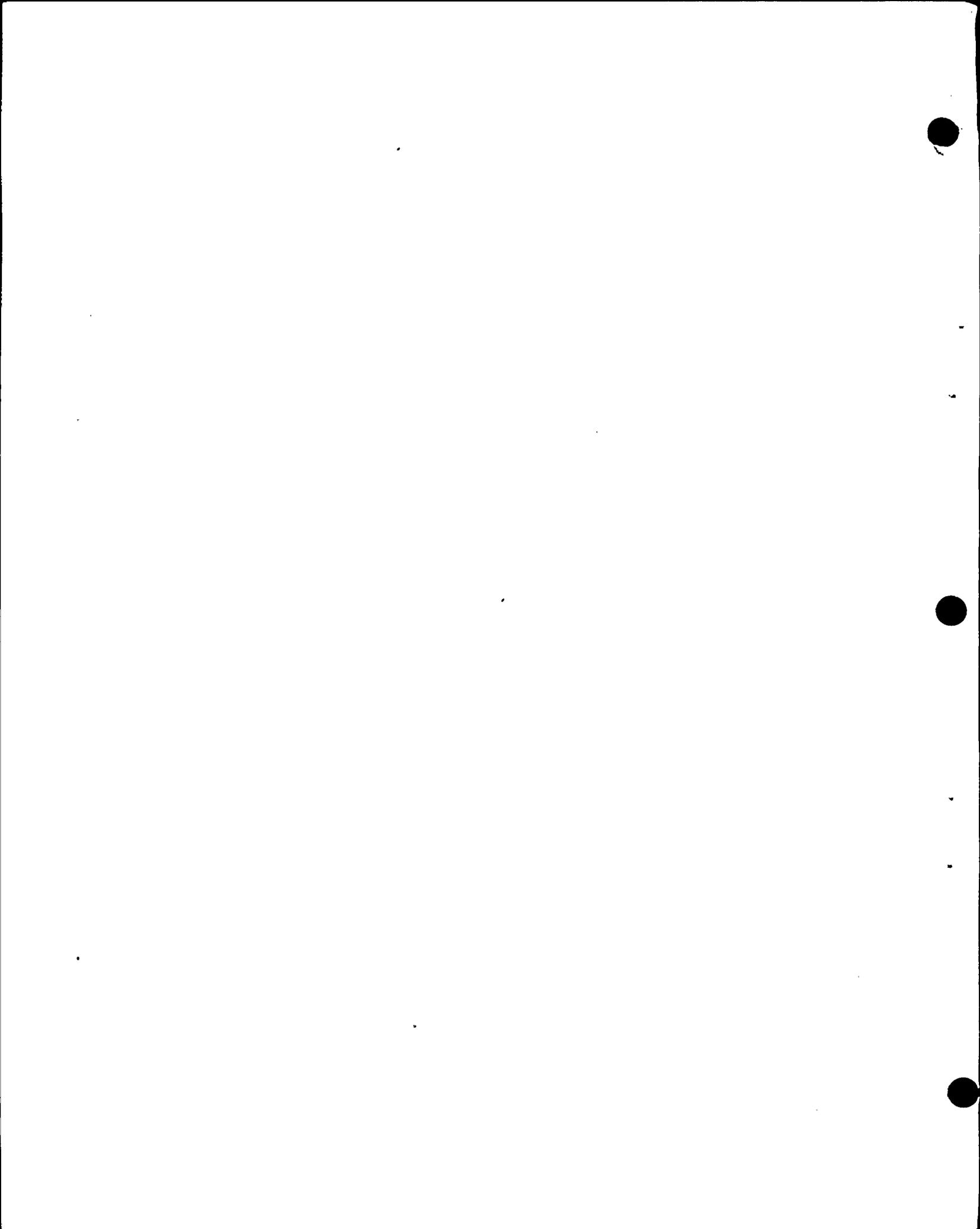
12 The thing that you may be referring to is that
13 Eaton as well as myself and many other researchers on this
14 subject have found that from all available data the peak
15 acceleration of 1.2g at Pacoima Dam probably was not a direct
16 result of this focusing, no. It probably occurred from a
17 slightly different phenomenon which simply means that you
18 have a remarkable rupture going right at that instrument,
19 and it did not cause accelerations that were excessive.

20 Q So that the Pacoima Dam record for accelera-
21 tion doesn't reflect a significant component of focusing?

22 A No, I think it does. I think it's very clear
23 that it does.

24 Q For accelerations?

25 A Yes.



mpb5 1

Q Okay.

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A (Witness Bolt) If you're puzzled about that, could I clarify it a little for you?

4

Q Yes. I guess I don't understand.

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Q I'm surprised.

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Let me see. Maybe I haven't heard properly what it is that you've said.

21

22

There is on the accelerogram recorded at Pacoima Dam a peak acceleration which has been set at 1.25, or 1.20g?

23

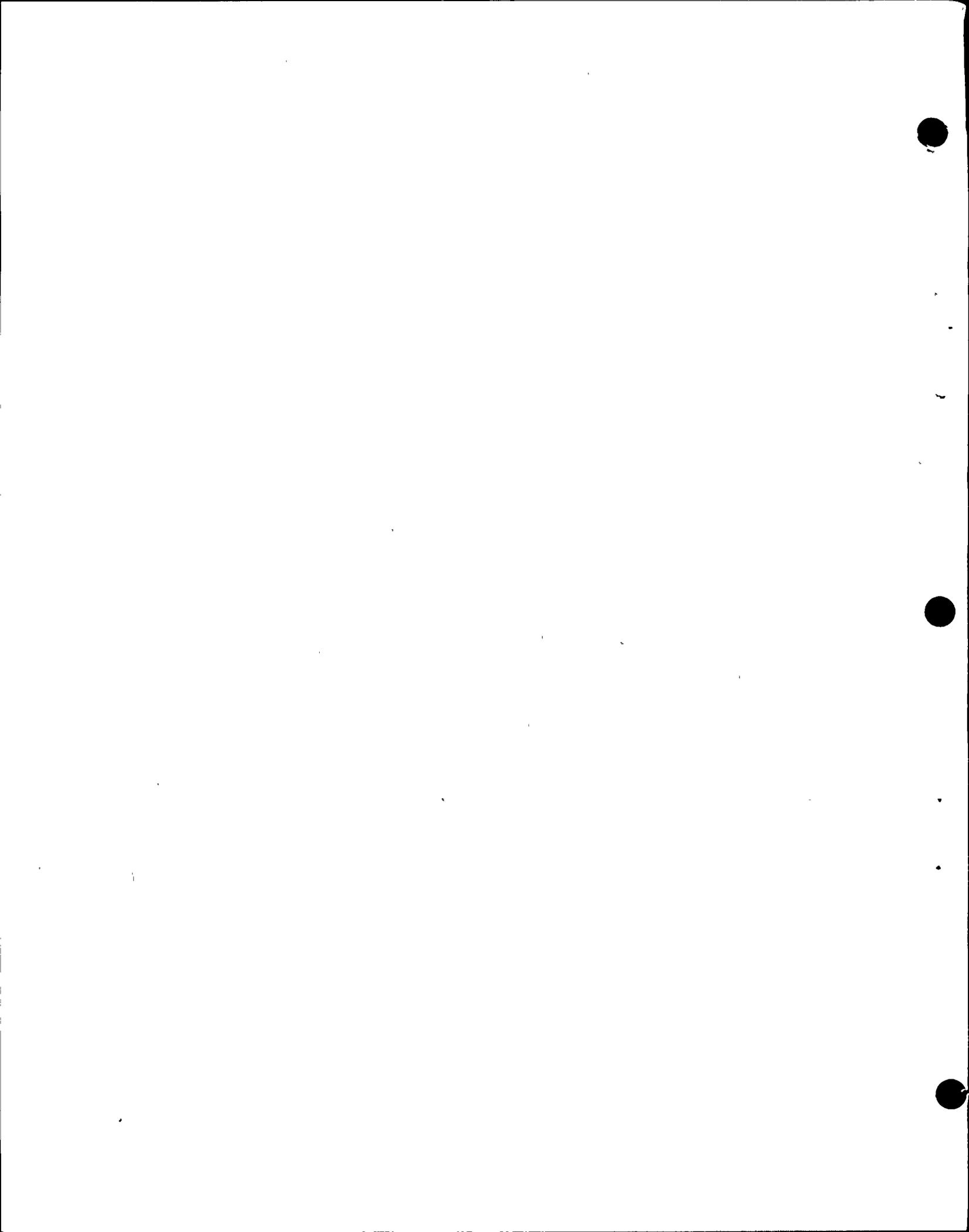
A (Witness Frazier) Yes.

24

Q Is that correct?

25

A Yes.



mpb6 1 Q Now, is it your testimony that focusing contribut-
2 ed to that peak acceleration?

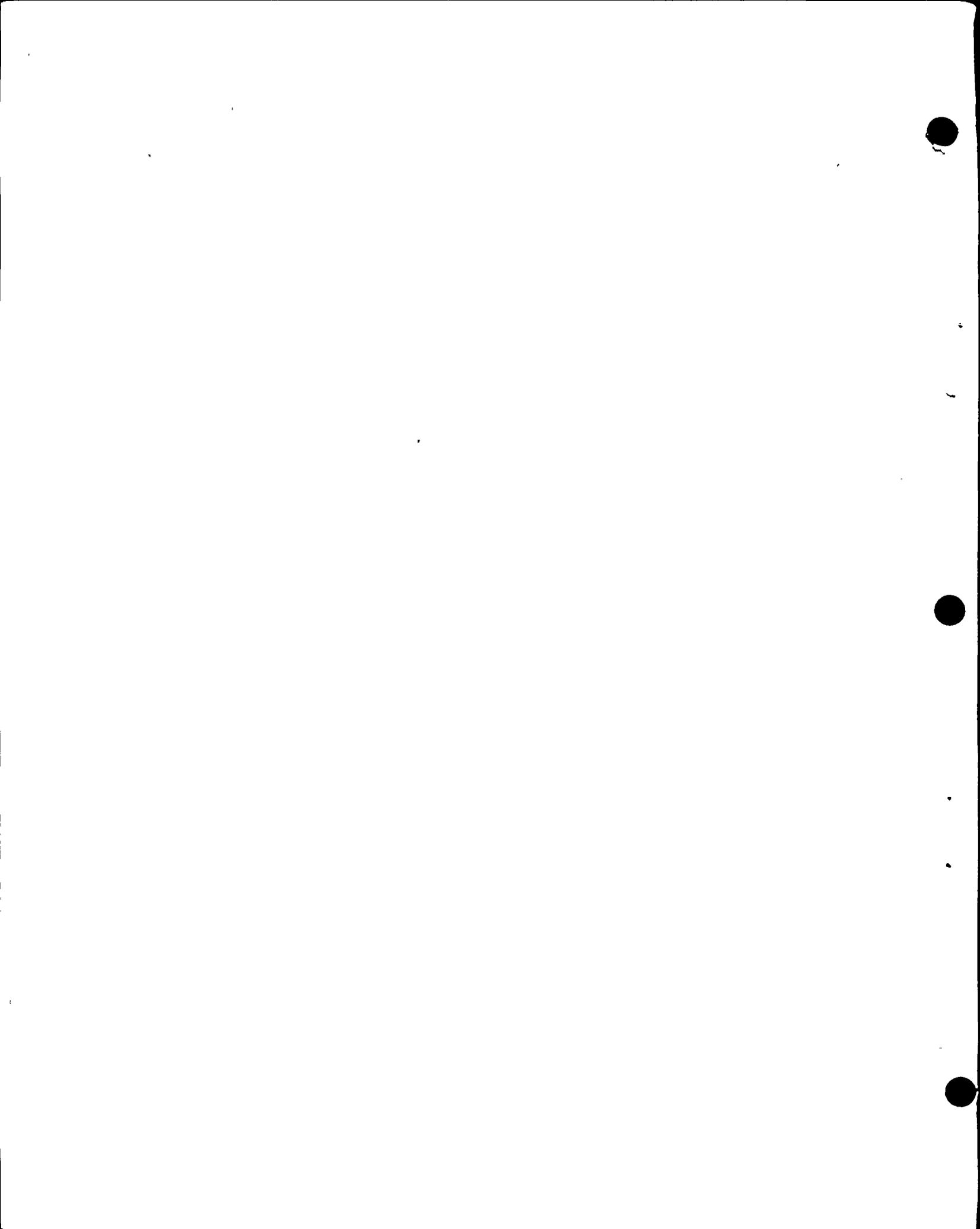
3 A The type of focusing that resulted from the
4 deep rupture rupturing toward the record, toward Pacoima Dam
5 Recording Station in the early six kilometers of the break-
6 ing part of the rupture probably did not contribute signifi-
7 cantly to the recording at 1.2, or thereabout, peak accelera-
8 tion.

9 Q Well, can you explain that statement with this
10 statement? Can you explain that statement -- how is that
11 statement consistent with this statement in the testimony
12 at page 26, lines 14 through 18:

13 "As an example, the Pacoima record of
14 the San Fernando earthquake which showed acceler-
15 ations up to 1.15g, was most likely a result of
16 both focusing of energy due to rupture propaga-
17 tion and amplification due to the location of the
18 instrument on a ridge."

19 A (Witness Bolt) That's very simple, because
20 here we're talking about the Pacoima record. That's the
21 whole time history. And so we're saying that to explain the
22 whole record -- we're not saying we're explaining the 1.15g
23 here, if you read that sentence, but to explain the whole
24 record. That's the noun, the subject of the verb.

4B 25 Q I understand.



4C wk.1

1 Let me to, Dr. Bolt, to the first point you were
2 making about average peak accelerations one would expect to
3 see in the range of 6.5 to 8.

4 Have you done statistical correlations on this
5 matter, or any kind of--

6 A When you say 6.5 to 8, you're speaking of magni-
7 tude?

8 Q Magnitude. Yes.

9 A For the Alaska Pipeline I made a study which
10 involved some statistics. And that was done for the pipeline
11 company at the request of Professor Newmark.

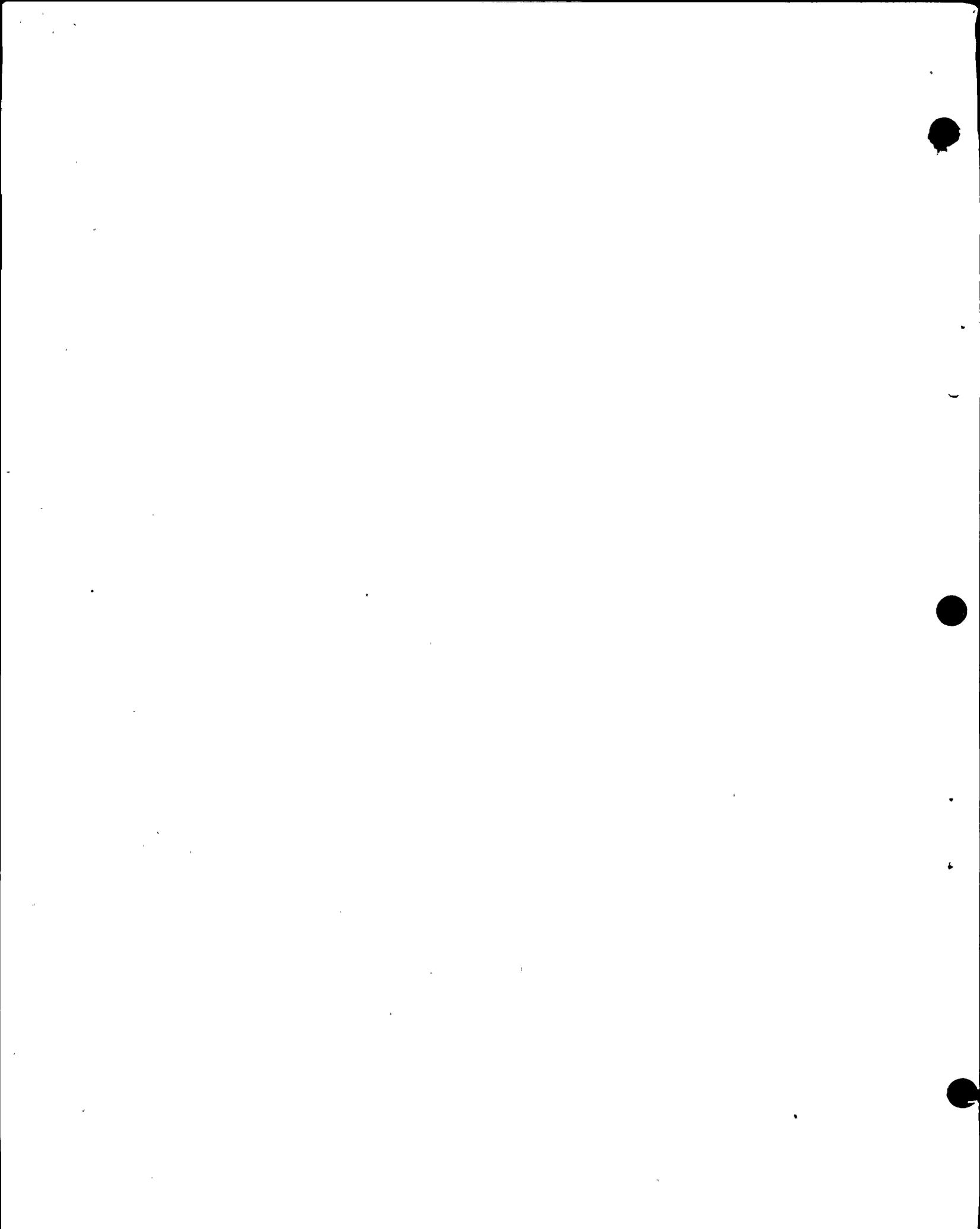
12 Q Okay. That's not in the testimony, is it? It's
13 a reference?

14 A Well that was proprietary, of course. But you
15 asked me had I done it, and the answer is Yes, I have.

16 Q Okay.
17 There is a paper cited in the testimony by Hanks
18 and Johnson called "Geophysical Assessment of Peak Accelerations."
19 Have you had an opportunity to review that particular document?
20

21 A I have read it. That was in 1976. I would have
22 to follow through the paper with you. I don't recall any
23 detail about this paper.

24 Q Well I'm not sure I ought to be talking to you,
25 Dr. Bolt, or to Dr. Smith, because I think he wrote the



wb2

1 testimony. And rather than cross-examine you on the basis
2 of a paper you haven't read, let me talk to Dr. Smith.

3 Dr. Smith, let me direct your attention to
4 page 28, at the top of the page, lines 1 through 3, where you
5 quote Hanks and Johnson.

6 Now this is a paper that you relied on to reach
7 some of your conclusions here? --Hanks and Johnson?

8 A (Witness Smith) Yes.

9 MR. FLEISCHAKER: I'd like to mark this paper,
10 Hanks and Johnson, as Joint Intervenors Exhibit 47 for
11 purposes of identification.

12 (Whereupon the document referred to
13 was marked for identification as
14 Joint Intervenors Exhibit 47.)

15 BY MR. FLEISCHAKER:

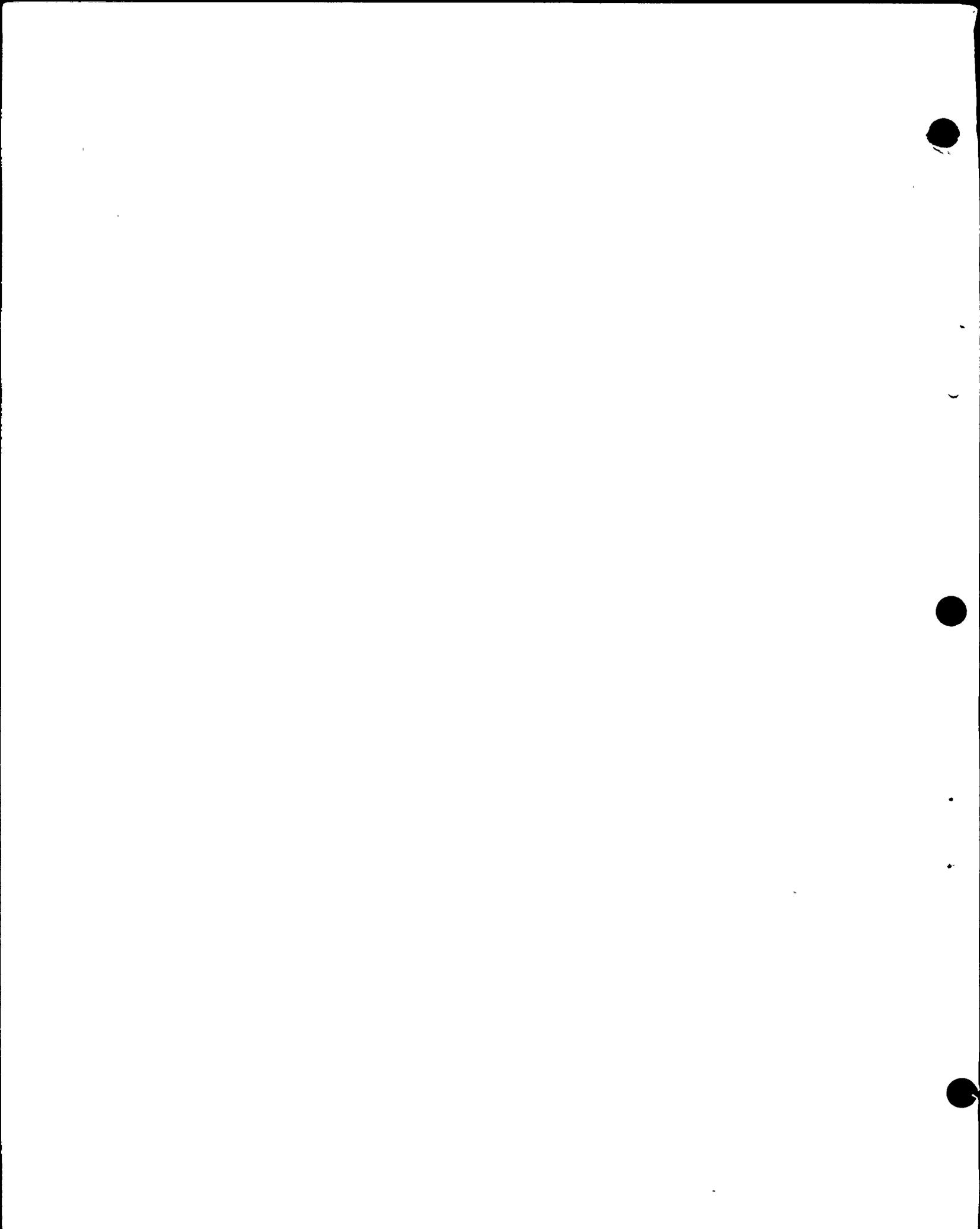
16 Q You quote Hanks and Johnson as having reached
17 the conclusion that there is no magnitude-dependence of
18 peak accelerations above magnitude 4.5.

19 A (Witness Smith) Yes.

20 Q Where do you find that conclusion in this paper?

21 A Page 964, about two-thirds of the way down.

22 "Nevertheless, the principal observation-
23 al interpretation of this study is that, in the
24 absence of these effects, peak accelerations at
25 distances of less than 10 kilometers would be



wb3

1 independent of magnitude and, therefore, that
2 causative processes in the source region are
3 independent of magnitude."

4 Certainly this interpretation seems reasonable
5 for magnitudes between 4.5 and 7.1.

6 Did you find that? It's two-thirds of the way
7 down on page 964. I think the conclusion is phrased in other
8 ways throughout the paper. And one would reach the same
9 conclusion by looking at their figures where they plot --
10 like Figure 1 on 962, where the logarithm of peak accelera-
11 tion is plotted as a function of earthquake magnitude.

12 Q Where is this?

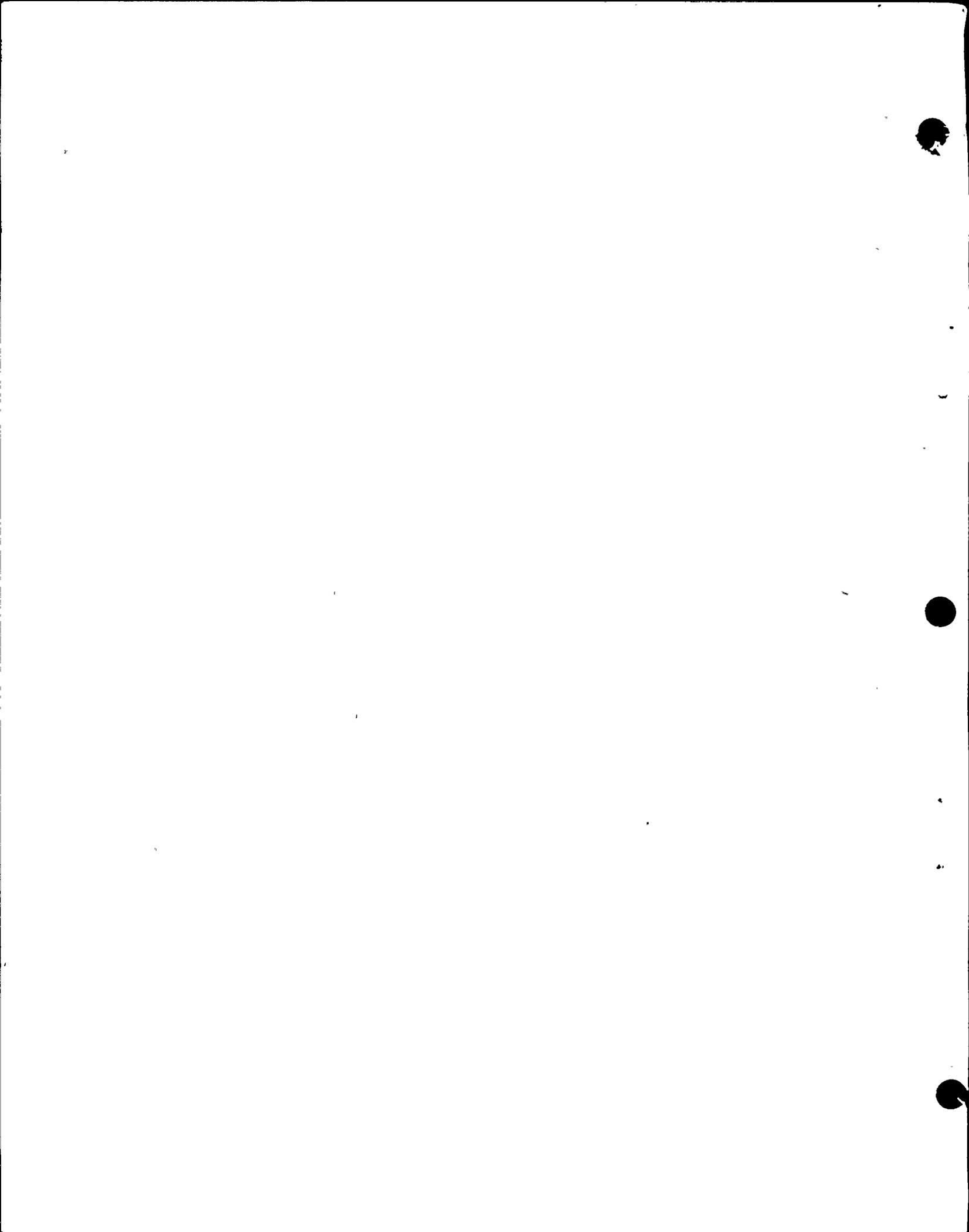
13 A Figure 1 on page 962.

14 Q Doesn't this data indicate that the
15 probability of high peak accelerations increases as you
16 go up the magnitude scale?

17 A No, the principal point that Hanks and Johnson
18 are trying to make is that the peak accelerations seem to be
19 controlled more by the local stresses than they do by the
20 magnitude. This is a fairly new concept, but that's the
21 principal thrust of this paper.

22 Q Have they reached any conclusions in this paper
23 regarding the probability of large magnitudes with respect
24 to-- excuse me; large accelerations with respect to magnitude?

25 A I don't believe so. There are, I believe, some



1 comment in here regarding the accidental superposition of
2 waves from different parts of a large fault surface that
3 might, on the average, give you a slight statistical increase
4 in probability.

5 Q What are those comments?

6 A Well I just noticed--

7 MR. NORTON: Excuse me, Mrs. Bowers. I would
8 suggest if he's asking a range of questions and then asking
9 where to pinpoint in the paper, that Mr. Smith be given a
10 minute or two to glance through the entire paper so that he
11 can more readily answer the questions.

12 I It's not that long a paper, and I would suggest
13 that maybe in a few minutes he could skim through it and
14 make notations of where the different conclusions are,
15 rather than jumping around trying to find them. Because,
16 as I'm looking at these papers I see conclusions all over.
17 They're not just in one spot.

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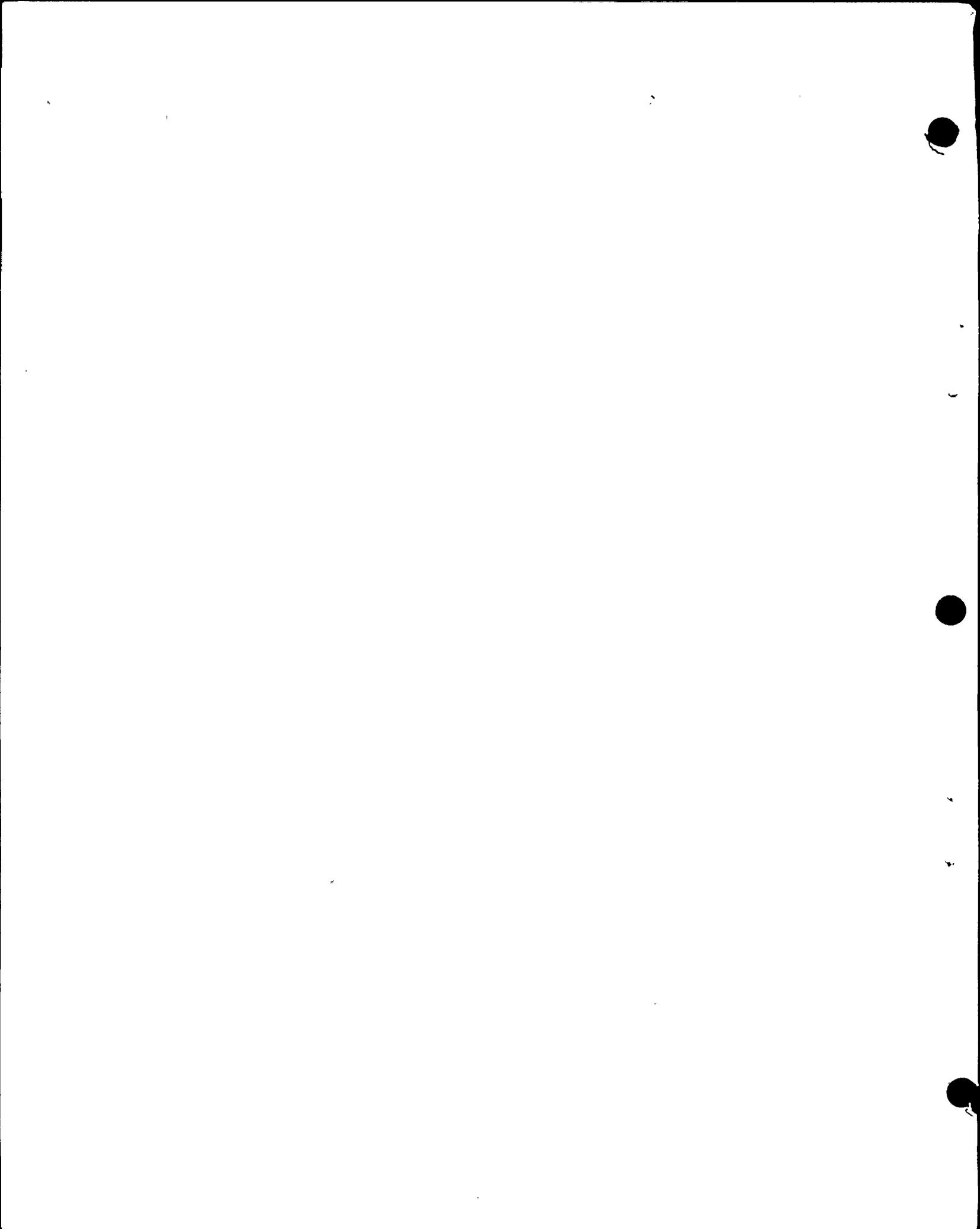
23

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End 4C



4d 3ebl

1 MRS. BOWERS: Well, that's a very reasonable
2 suggestion.

3 MR. NORTON: Thank you.

4 (Pause.)

5 MRS. BOWERS: Am I correct that we will not be
6 finishing with these witnesses by five o'clock?

7 MR. FLEISCHAKER: That's correct.

8 MRS. BOWERS: Well, then it might be better for
9 us to recess now rather than for us to sit here and --

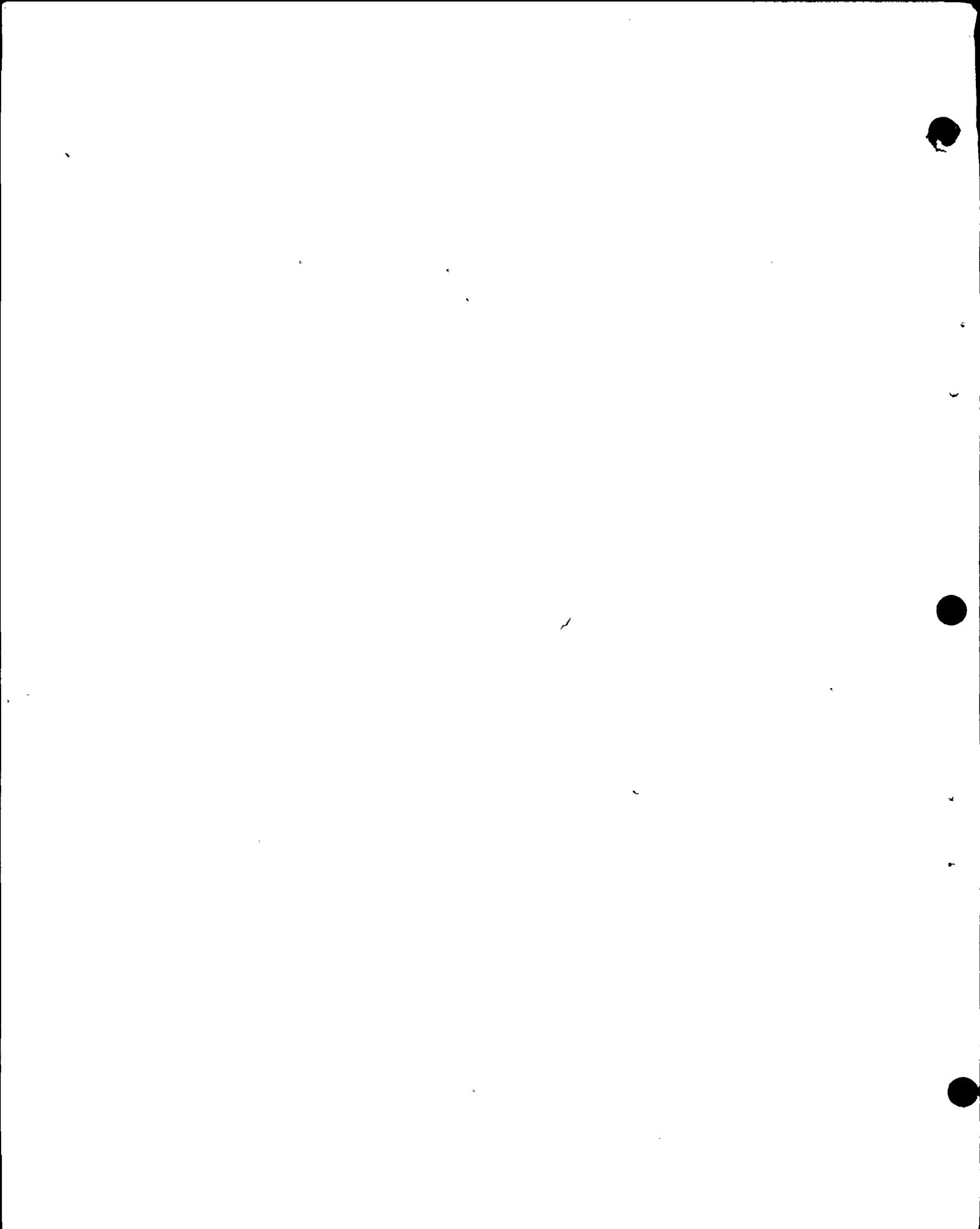
10 WITNESS SMITH: I'm essentially finished with my
11 review.

12 MR. NORTON: If there aren't a lot of questions
13 perhaps we can dispose of it.

14 WITNESS SMITH: I think there is little doubt
15 that the principal conclusion of the paper is as stated in
16 numerous places, like on page 963, the section headed "The
17 Dependence on Magnitude."

18 "Although there is considerable
19 scatter in the observed peak accelerations at
20 any magnitude level in Figure 1, the peak
21 accelerations at $R \approx 10$ km considered in this study
22 are essentially independent of magnitude for
23 magnitudes greater than 4-1/2."

24 Now there are a number of other discussions about
25 the model that Hanks is proposing which are interesting and



e-2 1 in some cases call for some possibility of some statistical
2 probability of increasing peak acceleration with magnitude
3 but this effect seems to be--

4 For example, as described at about the middle of
5 page 964 -- I think this is the point you're getting to -- he
6 says:

7 "Clearly the probability of such
8 interference occurring for phases with predominant
9 frequencies of 20 hertz or less decreases with
10 decreasing magnitude."

11 So he's getting at-- Let's see.

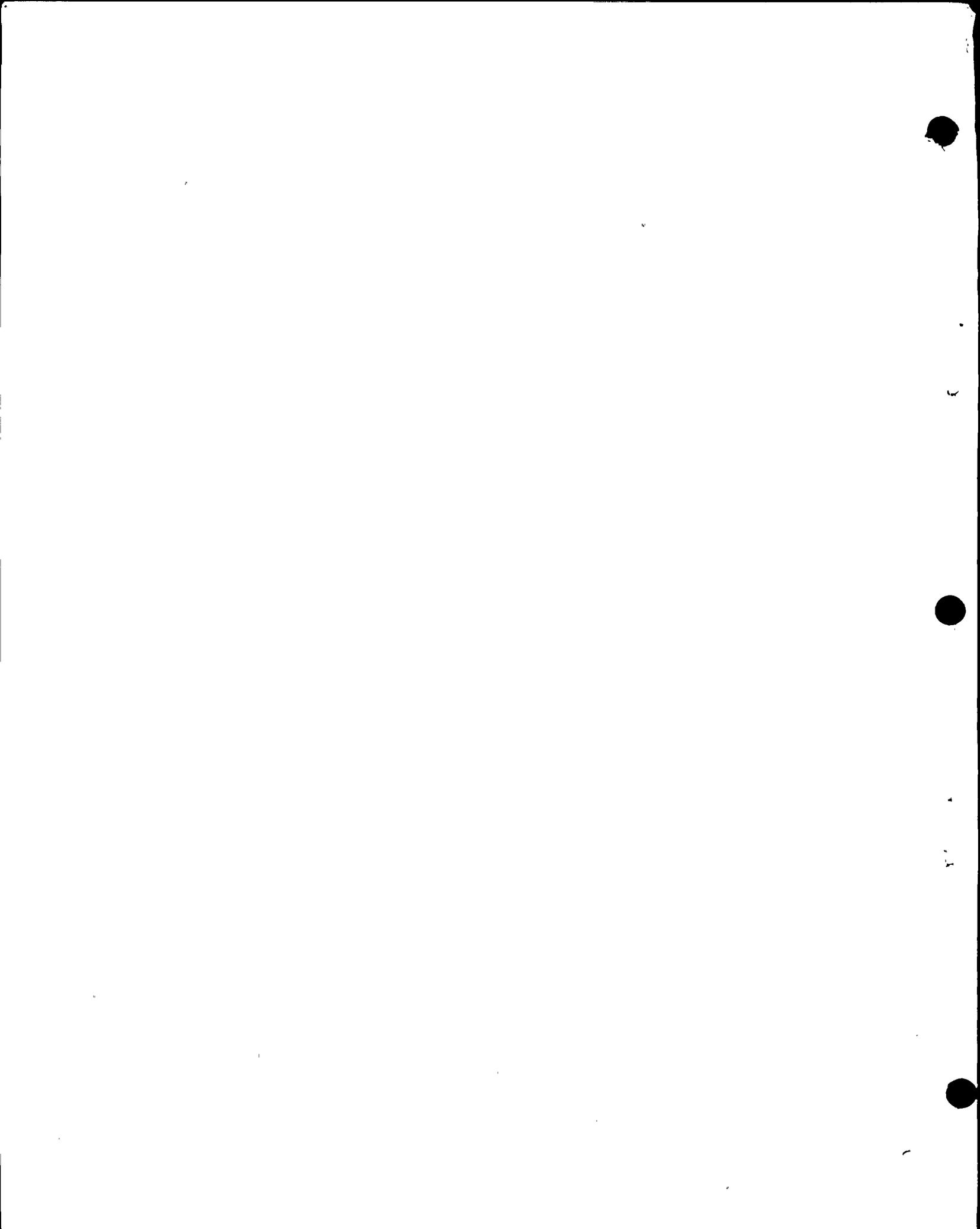
12 "In this connection, it is note-
13 worthy that almost all of the indicated increase
14 of peak accelerations at distances of 10 kilo-
15 meters with magnitude across the entire range
16 between 3.2 and magnitude 7.1 occurs in the
17 restricted range, magnitudes between 3.2 and
18 4-1/2."

19 So he's proposing a physical process here and
20 giving some arguments about what one might expect to see in
21 the data.

22 BY MR. FLEISCHAKER:

23 Q I didn't mean to cut you off. Go ahead.

24 A (Witness Smith) I guess I'm puzzled by your line
25 of questioning because it sounds in some way that you're



eb3

1 implying that I misinterpreted Hanks and Johnson's result
2 in my testimony. Is that what you're asking?

3 Q No. If we were to restate this as Hanks and
4 Johnson had, they would say that your testimony would read,
5 I suppose, as their sentence is, that it's essentially
6 independent, that magnitudes are essentially independent for
7 a given range.

8 Now my question is haven't Hanks and Johnson
9 also made statements about the probability of high peak
10 accelerations as one moves up the magnitude scale?

11 And I direct your attention specifically to the
12 first full paragraph on page 964 and the second full para-
13 graph on page 964.

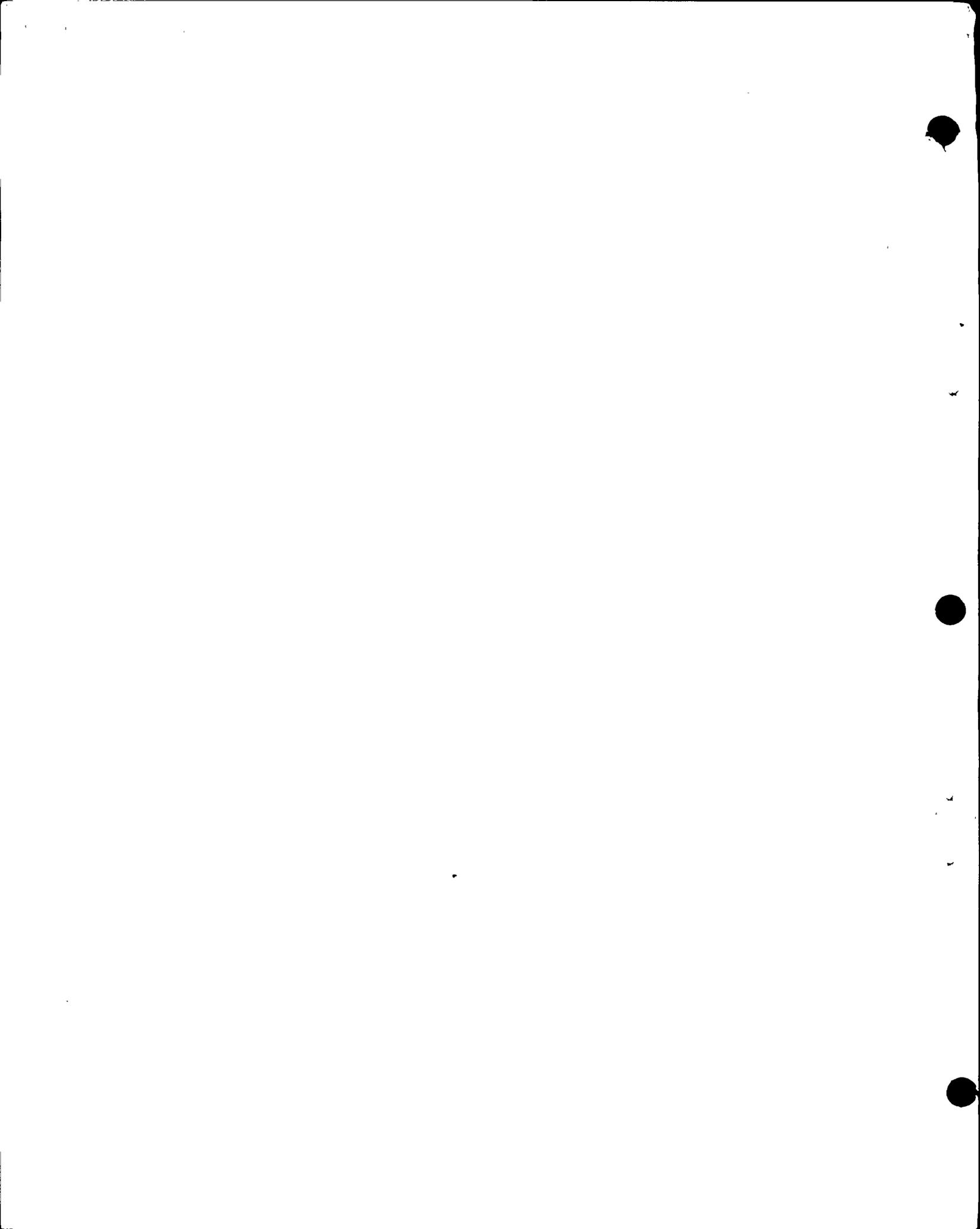
14 A Yes, I see the paragraph and as part of the model
15 he's proposing he has given the rationale for why one might
16 expect to see a statistical probability of increasing peak
17 motion, and he seems to be using that to explain the 1.15g
18 at Pacoima Dam.

19 Q Do you disagree with that conclusion?

20 MR. NORTON: Excuse me, Mrs. Bowers. I'm not
21 sure which conclusion "that conclusion" is.

22 MR. FLEISCHAKER: "That conclusion --"

23 MR. NORTON: I haven't heard Dr. Smith say any-
24 thing about a conclusion, and as I read the paragraph in
25 question I don't see anything about a conclusion, so I'm not



eb4

1 quite sure what conclusion we're talking about, other than
2 Mr. Fleischaker's. And I would suggest if he read the
3 paragraph carefully he would rephrase his question.

4 BY MR. FLEISCHAKER:

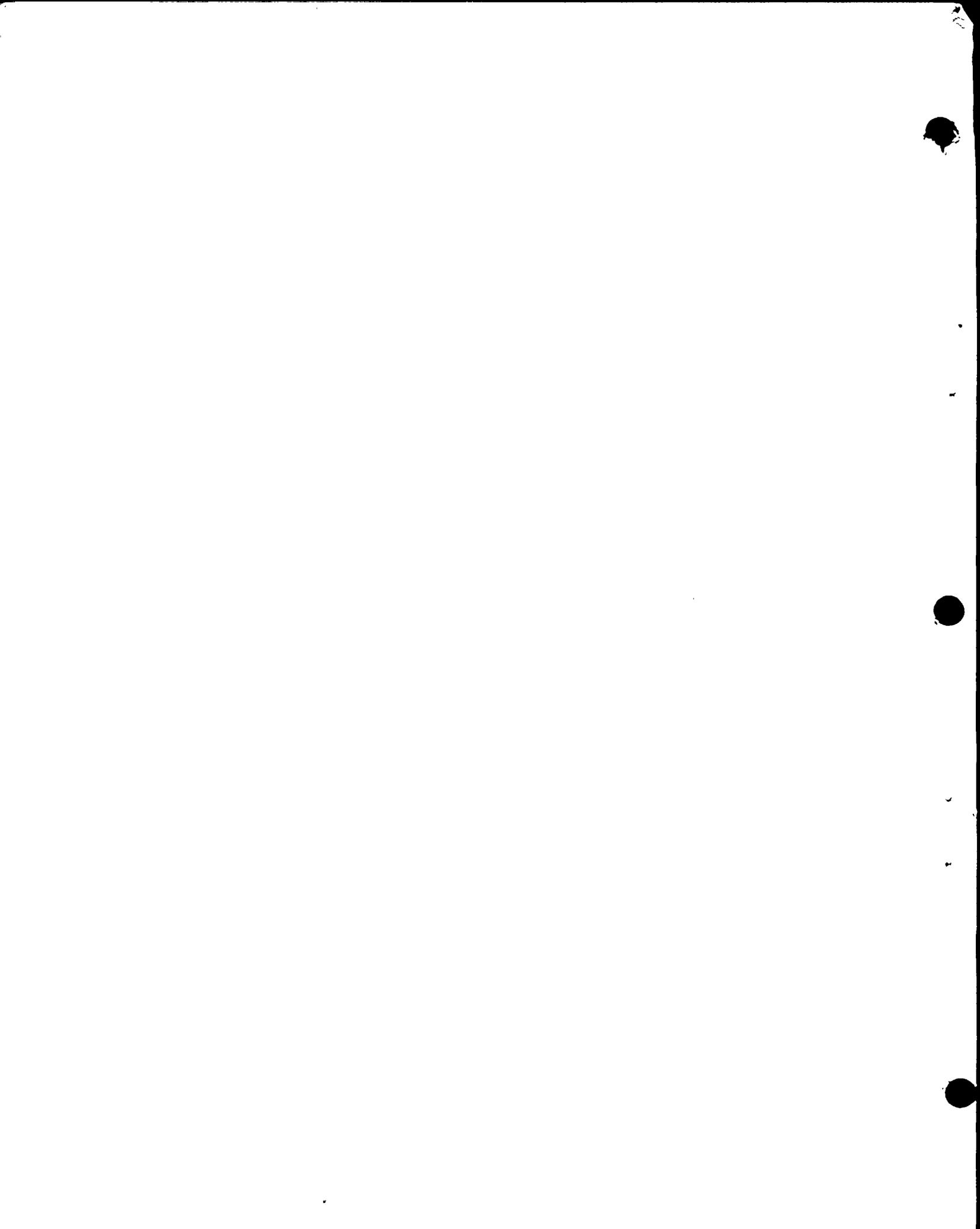
5 Q The sentence that I focussed on was "For exactly
6 the same reason, of course; Peak accelerations at
7 R approximately equivalent to 10 Km in excess of
8 lg for magnitudes greater than, or approximately equal to
9 4.5 earthquakes are not difficult to rationalize. And the
10 probability of such an occurrence clearly increases with
11 increasing magnitude."

12 A (Witness Smith) Right. I agree totally. And
13 the point of reference is the preceding sentence where he
14 says,

15 "In this sense the 1.15g value
16 obtained at Pacoima Dam need represent little
17 more than expected scatter from a magnitude-
18 independent value of perhaps 1/2g," etc., etc.

19 Q In plain English, does this all mean that for
20 magnitude, say 5.5 to 8 we would see the highest peak that
21 we could expect to observe -- excuse me; at magnitude 5.5 we
22 could see the highest peak acceleration that we could expect
23 to see at a magnitude 8?

24 A I believe that's what he's attempting to state
25 here.



wbl

1 Q And he also says , however, as we move from
2 magnitude 5.5 to magnitude 8 we can expect to see higher peak
3 accelerations, higher probability of--

4 A I think it's a sampling problem, basically; that
5 you have instruments out and larger magnitude areas affect
6 larger regions, so it's more likely that you'll come back
7 with a record of a higher peak acceleration. But there's
8 no doubt in his conclusion here that the expected value of
9 acceleration, about 1/2g, is dependent upon source properties
10 which are magnitude-independent. And he points out that--
11 By the way, I don't agree in detail with his interpretation
12 of the Pacoima Dam record. Because he has chosen not to
13 take any account of the location of the instrument, and I
14 believe there is a significant effect in that.

15 But I think the conclusion could equally well
16 be applied to any of the records which have ever been
17 observed for large peak motions.

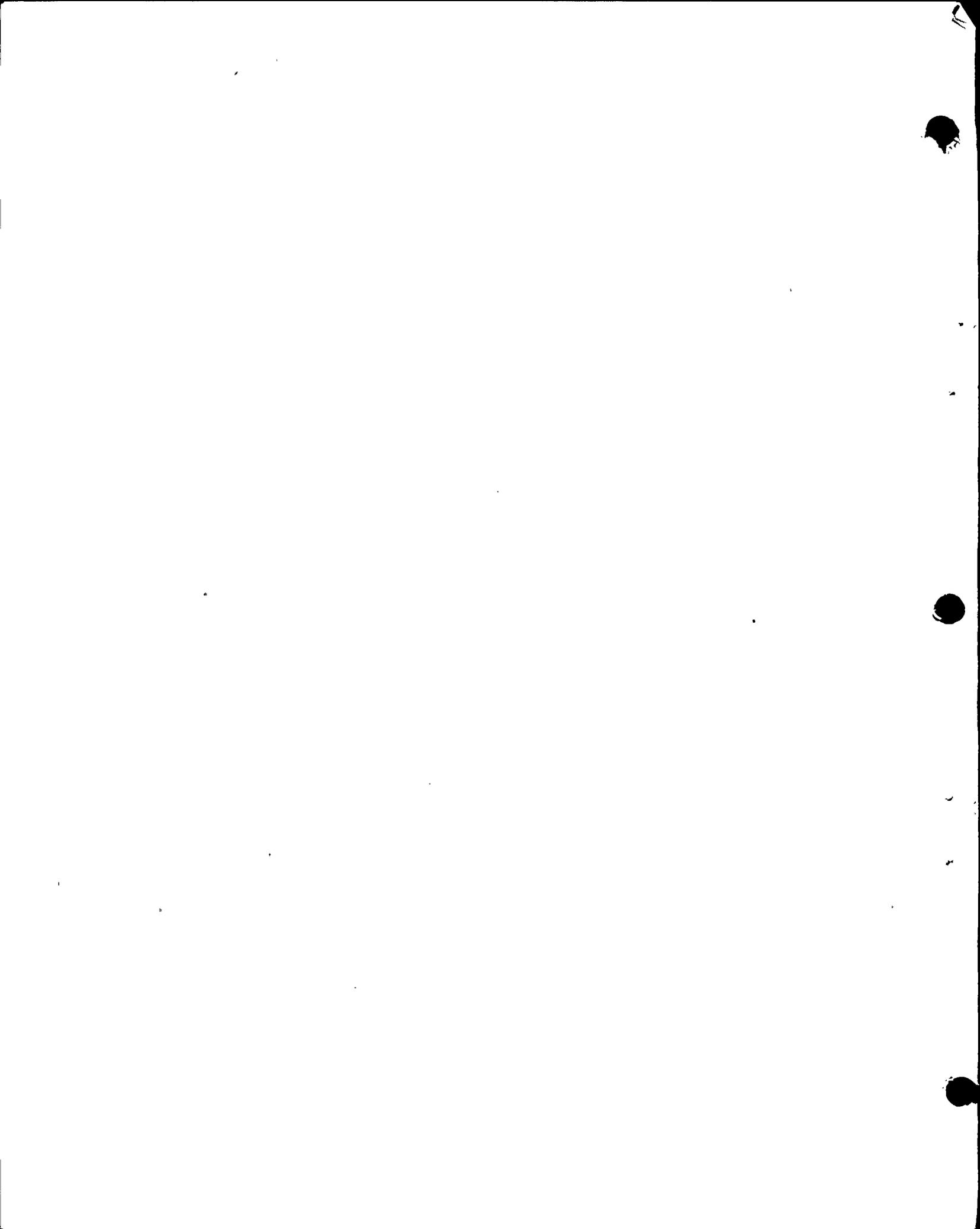
18 Q Does the data to date that he has collected and
19 utilized suggest -- Strike that.

20 Let me see if I understand your opinion.

21 Your opinion is that the probability of recorded
22 high peaks does not increase with respect to magnitude; is
23 that correct?

24 A No.

25 Q Okay. What is your opinion on that?



wb2 1

A The larger the earthquake the larger the area that will be influenced by large accelerations, and therefore the probability in your data set that you will have some high peak values is increased. If you happen to be lucky enough to be in just the right spot for a small earthquake you can also see high peak motion.

2

Q All right. I understand.

3

MR. FLEISCHAKER: I can go on.

4

MRS. BOWERS: Are you starting a new line of

5

questioning?

6

MR. FLEISCHAKER: Yes. I wanted to come back and explore further Dr. Bolt's limitation-- I wanted to explore with Dr. Smith his view on the limitations of peak accelerations and magnitudes, and a couple of other lines that I wanted to cover.

7

MRS. BOWERS: Well, we'll recess now and we'll see you at eight-thirty tomorrow morning.

8

(Whereupon, at 4:55 p.m., the hearing in the above-entitled matter was recessed, to reconvene at 8:30 a.m., the following day.)

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