STATE OF MICHIGAN

STATE OFFICE OF ADMINISTRATIVE HEARINGS AND RULES

In the matter of:	File Nos.: GW1810162 and MP 01 2007
The Petitions of the Keweenaw Bay Indian Community, Huron Mountain Club, National Wildlife Federation, and Yellow Dog Watershed Environmental Preserve, Inc., on permits issued to Kennecott Eagle Minerals Company. /	Part: 31, Groundwater Discharge 632, Nonferrous Metallic Mineral Mining
	Agency: Department of Environmental Quality
	Case Type: Water Bureau and Office of Geological Survey

D R A F T   T R A N S C R I P T

HEARING - VOLUME NO. IV

BEFORE RICHARD A. PATTERSON, ADMINISTRATIVE LAW JUDGE

Constitution Hall, 525 West Allegan, Lansing, Michigan

Thursday, May 1, 2008, 8:30 a.m.

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TABLE OF CONTENTS

NOTE: Page numbers may change on final transcript.

EXHIBIT INDEX

NOTE: Page numbers may change on final transcript. Full exhibit list for today will be included in the final transcript.

Lansing, Michigan

Thursday, May 1, 2008 - 8:33 a.m.

JUDGE PATTERSON: Are we ready?

MR. LEWIS: Yes.

MR. REICHEL: Yes.

MR. HAYNES: Good morning, Dr. Bjornerud.

MARCIA BJORNERUD, Ph.D.

having been called by the Petitioner and previously sworn:

DIRECT EXAMINATION

BY MR. HAYNES:

Q When we left off yesterday you had been testifying about the RMR calculations that you observed in the Golder Reports and how they apparently had used 105 as the total rather than 100. Do you recall that?

A Yes.

Q All right. And in your review of the documents in this proceeding, did you come across any explanation of that apparent problem?

A Yes.

Q And what did you come across?

A The geotechnical report that I cited was dated February 2006, and there was a memo from Golder Associates, the geotechnical consulting firm that prepared that report for Kennecott dated April 2006 in response to David Sainsbury's review of their geotechnical report. And in that memo

Golder Associates acknowledged that they had made this error in using kind of a hybrid of the two RMR systems and said that it was a typographical error and that it had been corrected.

Q And did you then go through the reports to see if, in fact, the typographical error had been corrected?

A Well, there was just the memo stating that it had been corrected; the report stood as it was, and we had no way of verifying in the data itself whether those changed had been made because, again, as I mentioned yesterday, we have never seen individual scores for A-2, A-4 or A-5.

Q So are you saying that there is nothing in the reports that suggests that the change had been made or acknowledged or had not?

A The one-page response to David Sainsbury's comments was simply that there was a typographical error and it didn't affect the geotechnical analysis. But we never have had any details of the individual score, so we can't verify what the original score was nor whether it was changed.

Q Now, as part of your assignment were you asked to review the RMR values that were calculated by -- calculated in the appendices?

A Yes.

Q And what was your first task -- first part of your task when you went to do that work?

A Well, again, I evaluated the rock core images and assigned RMR ratings myself and then looked at the Kennecott values.

Q Now, Dr. Bjornerud, we've put on the screen the first image from what it Petitioner's Exhibit 116 which I will represent is a -- is all of the core photos that were provided -- or that we were -- that Petitioners obtained.

MR. HAYNES: Your Honor, the core photos, Exhibit 116, took up three disks, and we've provided those to the other side as part of our exhibit proffer.

Q Dr. Bjornerud, about how many photos or images did you review in your process?

A Well, there are about eight cores and they're divided into about three-meter segments, and the lengths of the cores vary from 85 meters to about 200 -- or 300 meters. So I haven't -- I did calculate the number of images, but many, many images, and it took me three to four hours per core to go down through from the surface to the bottom of the core and to do the --

Q So it took you approximately 30 or so hours to review all of these core photos?

A Uh-huh; yes.

MR. HAYNES: Petitioners offer Exhibit 116.

MR. LEWIS: Mr. Haynes has represented to me that 116 is composed entirely of these core photos. Based on that representation, I have no objection, your Honor.

MR. REICHEL: No objection, your Honor.

JUDGE PATTERSON: Okay. No objection, it will be entered.

(Petitioner's Exhibit 632-116 received)

Q Dr. Bjornerud, after your 30 or so hours of reviewing these core photos did you have a general impression of the core -- excuse me -- of the rock in the core photos?

A Yes.

Q What was your general impression?

A Much of the core was very poor quality rock.

Q And this was true for the eight cores in general?

A All of the cores at least some zones are very poor quality rock.

Q And, Dr. Bjornerud, were you able as part of your review to place the location of the cores in relation to the orebody?

A Yes. It was very difficult based on the information in the geotechnical reports to find the locations. But, as Mr. Parker presented, we were able to locate six of the eight with some confidence.

Q I'm going to pull up Exhibit 41. Dr. Bjornerud, we've pulled up Petitioner's Exhibit 41, and this is the first page from that exhibit. You were here yesterday when Mr. Parker testified?

A Yes.

Q And did you hear him testify concerning the location of

the -- at least him locating the boreholes on this image?
A Yes.
Q And is this what you worked -- did you work on this with him?
A Well, I had the same data available, --
Q Yes.
A -- and based on some graphics in the back of the geotechnical reports, I would agree with these interpretations.
Q That is, the approximately location of these boreholes?
A Yes.
Q And is there a way to summarize the locations in terms of the distance from the orebody or the distance around the peridotite or not?
A Well, they're all close to the edge of the peridotite. And in all of the cores there are both the surrounding metasedimentary rocks as well as the peridotite. And all of the cores that I looked at transect that boundary between them.
Q And the surrounding sedimentary rock, is that what's sometimes known as the host rock?
A Yes.
Q And sometimes known as country rock?
A Yes.
Q Not the music style; right? And I'm sorry. You say that

all the cores transected the zone between the sedimentary or host rock and the peridotite itself?

A Some start in the peridotite and go into the country rock. Others start in the country rock and go into the peridotite. And in some cases the zone is rather complex so you go in both rocks several times.

Q Thank you. And what was your purpose in examining all of these core photos? What were you supposed to be doing?

A Well, again, because we couldn't obtain the rocks themselves, it was the next best thing to trying to get a sense of the properties of the rock. So I was trying to characterize in some detail the rock strength and potential permeability properties.

Q And the rock strength and permeability properties, are those some of the A factors that you listed yesterday?

A Yes.

Q Which ones are those again?

A Well, all of them are germane. The intact rock strength has to do with just the rock type itself. I did not independently evaluate that, but I identified the rock so that then we could use the values that Golder had used for that particular rock type. Spacing of discontinuities, the condition of the discontinuities is directly related to their strength, and then the groundwater, A5, is related to the potential permeability.

Q So that the factors that you were looking at were which factors?
A A3, A4 and A5 and then identifying the rock so that an A1 value could be assigned.
Q I see. Now, I think you testified before that some of this task you set about involves some judgment.
A Yes.
Q Is that accurate?
A Yes.
Q And what kind of judgments are involved in classifying the A3, A4 and A5?
A Well, again it's trying to quantify something that is a complex 3-dimensional phenomenon. The surface condition of a fracture is usually described with many different adjectives and we're trying to assign a single number to that. So there's some subjectivity in deciding how to assign that.
Q And is there a way that you professionally try to reduce that subjectivity?
A Well, that's the point of Rock Mass Rating system, that it is a standardized system that has come into use and everyone agrees is a reasonable attempt to make this complex phenomenon quantifiable.
Q Then would the element of consistency be important then in your subjective --

A Very important.
Q -- analyses?
A Yes.
Q Now, Dr. Bjornerud, I've had put on the screen Petitioner's Exhibit 45 which is a photo of one of the sections of core. And can you identify which hole and which run this is?
A This is hole 04EA055, and the run is from 43.80 to 46.52 meters.
Q And what RMR was given this core by the -- in the tables that we saw yesterday from Jack Parker?
A The Golder Report RMR was 67.
Q And would you agree or disagree with that?
A I agree. This is fairly good quality rock and, in fact, my RMR value is 75.
Q So you actually gave this a higher RMR than did Golder?
A Yes.
Q Dr. Bjornerud, I want to go back to 45, and can you explain to us why in this core photo you assigned this a higher RMR than did Golder? What are the qualities of the rock here that you observed that caused you to give it a higher RMR?
A Well, again the absolute values, I don't place great stock in the absolutely numbers, but to me this was some of the better rock in any of the cores that I examined. The discontinuities that are there are fairly widely spaced. They're very clean breaks. They seem to fit back together

so they look like relatively fresh. The chalk markings -- and this was not done consistently in the photographs --
Q For instance --
A -- those are meant to represent natural fractures. If there are natural fractures, then they are marked with chalk.
Q For instance, in the top row here we have some chalk marks going from the upper left to the lower right. Are you referring to that chalk?
A Yeah. Eventually that should indicate a natural fracture and fractures that were caused in the drilling should have "X's."
Q I see.
A But these fractures, even if they are natural, are quite fresh and clean. So in terms of the condition of the fractures, I gave it a fairly high rating.
Q And as I recall, hole 55 was a hole that was drilled at a 45 degree angle?
A Yes, I think on the west side -- or south.
Q Okay. Let's go to 46. Now I've have put on the screen Petitioner's Exhibit 46. And can you identify this hole in the run for us?
A Yes. It's O4EA060, the whole number, and the run was 63.35 to 65.84 meters.
Q Now, what RMR did Golder assign to this?
A 68.

Q 68. So the RMR assigned by Golder to this run was higher than the RMR they assigned to Exhibit 45; correct?
A Yes.
Q And how would you characterize this rock compared to the rock in Exhibit 45?
A I would say it's significantly poorer quality rock. The spacing of the discontinuities is less, and the nature of the discontinuities is very different. And my RMR assignation was 55.
Q Now, Dr. Bjornerud, is it important for purposes of predicting crown pillar stability in your view to assign values to all portions of the cores rather than selected portions of cores --
A Yes.
Q -- for purposes of calculating RMR's?
A Yes.
Q All right. Let's pull up Exhibit 44. Dr. Bjornerud, we've had put on the screen Petitioner's Exhibit 44. Could you identify this hole and the run for us?
A It's hole number 04EA055, and the run is 115.30 to 117.50 meters.
Q Now, in your review of the tables that we saw from Jack Parker yesterday, did you -- can you tell us whether or not there was an RMR assigned to this particular run?
A There was no RMR assigned to this.

Q Do you find that unusual?
A Well, the point of the Rock Mass Rating system is, again, to provide some way of quantifying rock quality, and the point is to assign a number to the entire core length. So I find it unusual to omit RMR data.
Q And now I've had put up on the screen Petitioner's Exhibit 47 which is a core photo. And you identify the hole and the run?
A It's 05EA099, and the run is from 20.64 to 22.94 meters.
Q And in your review of the tables that Jack Parker testified about yesterday did you notice whether or not an RMR had been assigned to this run?
A No. No RMR was assigned.
Q And what RMR did you assign to this?
A 27.
Q And let me back up. I didn't ask you that question about Exhibit 44. Did you assign an RMR to Exhibit 44?
A I did. 22.
Q And, Dr. Bjornerud, in your review of these core photos, did you identify other examples of places where RMR's were not assigned to the various runs?
A Yes; yes.
Q And could you give us -- rather than going through these photos one by one, can you, for the record, just tell us which ones those were?

A So for all eight cores just the percent of the --
Q Well, you identified them, and then have you calculated -- thank you. Have you calculated the percentage of the runs for these eight cores that did not have RMR ratings?
A I did. And so it would be easier if I could just refer to the last two digits of the cores.
Q That's fine.
A For core -- for 55, 12 meters out of 137 not reported; that's 9 percent. For core 60, 11 meters out of 85 not reported, 13 percent. Core 62, 59 meters out of 300; that's 20 percent. Core 64, 51 meters out of 280, 18 percent. Core 67, 15 meters out of 280, 5 percent. Core 69, 33 meters out of 271, 12 percent. Core 99, 49 meters out of 142 meters, 34 percent. And core 101, 26 meters out of 121 meters not reported, or 21 percent.
Q And have you aggregated those percentages?
A I didn't.
Q And would you find these percentages of non-reported RMR's to be usual or unusual in structural geology and calculating RMR's?
A It's unusual. Again the point is to try to quantify rock properties, and you want to quantify the whole rock mass.
Q And in your view, would it -- is it possible to then predict things like crown pillar stability if one is missing these kinds of percentages from core runs?

A I wouldn't be confident in the results.
Q Now, based upon your review of the core photos of these eight cores, would you expect the rock in the general vicinity to be radically different in its character -- in the character of the rock from these core photos that you've -- the cores that you've looked at?
A No.
MR. LEWIS: Objection to form, your Honor. I think it's vague in terms of what is meant by "general vicinity."
MR. HAYNES: Okay. That's fine. I'll rephrase.
JUDGE PATTERSON: Okay.
Q Dr. Bjornerud, about how many cores that you know of are reported in the Golder Reports having been drilled around the crown pillar area?
A There may have 90 or so, I think.
Q And for those 90 or so cores that were drilled in the vicinity of the proposed crown pillar, would you expect the rock that's shown in those drilling cores to be significantly different than the rock that you've seen in their eight cores that you've reviewed?
MR. LEWIS: Objection.
A I don't think so.
MR. LEWIS: Objection; foundation, your Honor. There's been no foundation for that question.

MR. HAYNES: Well, I think the witness is qualified -- has shown she's qualified to testify concerning structural geology, geology, rock mechanics. She's reviewed these core photos. She's reviewed other core photos. I think she can opine as to that.

MR. LEWIS: My objection is not as to her qualifications, your Honor. It's as to the foundation for a question which apparently is asking her to comment on how representative eight boreholes that she looked at may be of a total of something like, in this witness' understanding, 90 total boreholes. And I have not heard any foundation for her to compare the representativeness of this small subset of that sampling.

MR. HAYNES: I'm only asking her what she would expect.

JUDGE PATTERSON: I'll overrule the objection.

Q Dr. Bjornerud?

A Based on, I think, our sound geologic understanding of the setting, I wouldn't expect there to be a significantly quality of rock in the other boreholes.

Q Dr. Bjornerud, in the field of structural geology, what is meant by the term "major discontinuity"?

A A major discontinuity in rock would be any usually planar feature that transects the rock mass, a zone of weakness like a fracture or a fault.

Q And for us who are not structural geologists, what do you mean by "planar feature"?

A Something that is approximately a plane, so some kind of surface that is breaking the rock mass and would be a surface of weakness so a fault or joint or vein. These are examples.

Q Did Golder report any major discontinuities?

A Yes.

MR. HAYNES: I'm sorry. Before we go there, Petitioner moves to admit Exhibits 45, 46, 44 and 47, which are the four photos we've just had up on the screen.

MR. LEWIS: Mr. Haynes, are those just individual photos in each of those exhibits?

MR. HAYNES: Yes.

MR. LEWIS: I have no objection, your Honor.

MR. REICHEL: No objection.

JUDGE PATTERSON: Okay. No objection, they'll be entered.

(Petitioner's Exhibits 632-44, 632-45, 632-46 and 632-47 received)

Q Now, Dr. Bjornerud, I've had put on the screen from Appendix C-3 of the application Table 4. This is on page 8 of Appendix C-3. And the section that we're talking about here is entitled -- it's Section 3.4.2 "Crown Pillar Major Structural Assessment." Have you reviewed this portion of

the Golder Report?
A Yes.
Q And what is your understanding of the purpose of this portion of their report?
A C-3 report was to determine the stability of the crown pillar and any potential subsidence. And so this particular table was identifying some major discontinuities, structural features that could potentially undermine the stability of the crown pillar.
Q Now, I noticed in the text -- I notice in the text that preceded Table 4 that the text notes that the database table labeled "TBL Major Structures" indicates 40 individual major structural zones. What does that mean to you?
A Well, I think the criterion they used was anything that had shown evidence of intense shearing or breaking of the rock that was longer than a meter in the core length. And that's what they entered in this table. So they defined major structures as anything thicker than one meter in the core.
Q Right. In the table.
A Uh-huh (affirmative).
Q What I'm looking at is the text above where they talk about individual major structural zones, and it talks about 40 individual zones. And then they say a total of 183 were recorded. Is that the one meter limit that you were talking about?

A Yes. So apparently the cutoff was one meter, but they identified more zones that had very sheared and broken rock than are --
Q That may have had a length of less than one meter?
A Yes.
Q And as many as 183; is that right?
A That's right.
Q And from a structural geology standpoint would you find zones that have -- that are sheared or gouged or broken of less than one meter significant?
A Yes. Failure can happen --
Q Why is that?
A Failure can happen on a zone that's much narrower than that.
Q I see. And the table lists a series of boreholes, and that's in the left-hand column where it says "Hole ID." The hole ID for these holes that are identified in Table 4, are those the same holes of the cores that you reviewed in Exhibit 116?
A Yes, they're the same ones.
Q I see. And, again, what was the -- this table is extracted based upon what criteria again from the text?
A Yes. Zones that they identified as major structural discontinuities one meter or greater in length.
Q And in this table what is the longest major structural discontinuity that was extracted in this table?

A In hole 62 there's one that's 55 meters in length.
Q So there's a shear zone or a fracture that's 55 meters long in this core?
A Yes.
Q And did you find that significant?
A Yes, and in most of these cases, no RMR's were reported for those lengths.
Q I see.
A That's a major potential zone of weakness.
Q Now, did you then in your examination of the core photos in Exhibit 116 attempt to verify this table?
A Yes.
Q And did you attempt to determine whether or not there were other major structural -- major structures in the core photos that you examined?
A Yes. I agree with this table that these are major structures, but I found other comparable intervals that I would add by the same criterion to the table.
Q Now, Dr. Bjornerud, you say that you attempted to identify other major structural discontinuities in the eight core photos -- in the eight cores that you examined; correct?
A Yes.
Q And you've prepared a table -- by the way, the table is included in your report that was submitted with the comments October 17 of 2007?

A Yes.
Q Okay. Thank you. And tell us the process by which you supplemented the Golder Table of Major Structural Discontinuities.
A Well, I looked at the areas that they had already identified as major structural discontinuities, and I found areas of comparably sheared and broken rock. And in general for my calculations, these were areas that ended up with RMR values of 40 or less. Again, I didn't have RMR values that they reported for most of these sections. But by my assignations, most of these zones had RMR values of 40 or less, and in general they were more than one meter thick. So in this table I've included the ones that were in Table 4 of C-3. And that's in regular type. My additions are in bold and they go across the last two columns.
Q I see. And you've added your description of what those discontinuities appeared to be in your view?
A Yes.
Q And how many total did you add to the Table 4 from the Golder Report?
A I didn't count, but in terms of length I did --
Q What's the length that you added?
A I added -- they had an original thickness and core length of about 80 meters of major structural discontinuities. I added 157 meters from the same cores.

Q And why is it important, in your view, Dr. Bjornerud, to list all of these major discontinuities?
A Because the weakest part of the rock is the part that will fail potentially, so that is the part that should be focused on in a stability analysis.
Q Now, during your review of the core photos, this 30 hours that you testified to, did you analysis the core photos in order to recalculate RMR's?
A Yes.
Q And did you prepare a table that shows your work?
A Yes.
Q Dr. Bjornerud, you prepared a table and I've put up a portion of it on the screen. And this is Appendix 1 to your report that was attached to the October 17 comments; is that correct?
A Yes.
Q And can you explain what you did to prepare this work?
A Well, again I looked at these images of the eight cores image by image in about three meter increments, and then I did the rock type.
Q Excuse me. Before you get to that, can you tell us what the columns represent --
A Okay. All right.
Q -- and then also the color assignations that you have?
A Okay. So there's the hole ID number and then the run. And

then these (indicating) two columns are reported by Golder Consultants, the RQD, as a percent, their RMR76 number. And then starting here (indicating) --
Q Let me interrupt you for just a moment. The RQD percentage and the RMR76, those are the same numbers from the tables that Jack Parker talked about.
A Yes. Yes, they are.
Q Are those the same numbers as Jack Parker?
A Yes, they are. Yes; yes. Okay. So then starting in the record columns are my added information, so I identified all the rocks and gave some descriptive information.
Q And let me again interrupt you. You identified the rock based upon your examination of the photographs; correct?
A Yes, and the fact that I'd seen the sights and I'd sampled sights while I was there.
Q And is it important for purposes of calculating RMR's to have the rock type designated?
A Yes, because the first A1 component is based on the rock type. So to get information about A1, which I did not do; Professor Vitton who's next, I think, or be examined next -- I identified the rocks, and then he used Golder's own intact rock strength values for the A1 parameter.
Q I see.
A The A2 parameter is based on the RQD percents reported by Golder, and yesterday I mentioned how those were converted

from percent to --

Q Right. Okay. Thank you.

A And then the three numbers that I assigned were A3, A4 and A5 based on the photographs.

Q And again, just so the record is clear, for A3 what is the range of values that can be assigned to A3?

A A3 is the spacing of the discontinuities. The maximum value is 20 and the minimum is 5.

Q And then for A4 what are the range of values?

A Okay. A4, condition of discontinuities, 30 maximum, zero minimum.

Q And then for A5?

A Groundwater conditions, maximum 15, minimum zero.

Q And, Dr. Bjornerud, do you recall how Golder assigned the A5 value?

A They stated in Appendix C-2 that they assumed completely dry conditions.

Q In your view, is that a correct assumption?

A It does not seem reasonable given that the water table in the area is close to the surface and so that most of the rock in these kinds of depths would be below the water table and also that much of the rock is very fractured and potentially very permeable.

Q And for some of the core photos that you examined, were some of them labeled "Wet"?

A Well, yes, but that's not -- they were wetted to make features more visible.
Q Thank you. Now, so the figures that are in this table that you assigned are the figures in columns A3, A4 and A5; correct?
A As well as the rock type.
Q That's right. That's the designation. But in terms of the numbers that were assigned, you assigned A3, A4 and A5?
A Yes.
Q And then if we could go down to the first yellow portion, please, in your table you have certain zones or runs that are highlighted in yellow. What does the yellow mean?
A These were the zones that I added to Table 1 of the Golder C3 report, Table 1 in my report. These were the zones that I considered equally major structural discontinuities.
Q So if we take your table of discontinuities, that translates to the yellow portions of this appendix; correct?
A Yes.
Q Now, I note for instance in the portion of the slide that we have here which is hole 55 and the run is 110.75 to 117.5. I noticed that there's no RMR value there; correct?
A Yes.
Q And does he table show other instances where no RMR was assigned by Golder?
A Yes.

Q And those are the -- again, those are taken from the same tables that Jack Parker talked about yesterday?
A Yes.
Q And would you find that be a best professional practice to not assign an RMR?
A No. The point of doing the RMR approach is to get a comprehensive understanding of the rock quality.
Q Are there any other aspects of this table that we have not explained for the court?
A I don't think so. The essential components have been explained.
Q Did you convert your recalculated -- excuse me. Did you convert the figures here that you have assigned for the A3, A4 and A5 to a chart form?
A Yes.
Q And did you do this for each hole?
A Yes.
Q All right. We put up on the screen Figure 2a. What does Figure 2a represent?
A Okay. This shows for hole 04EA055 the sum of components A2 through A5. Again A2 was based on Golder's RQD values, and then A3, 4 and 5 were my values. So this was only -- these four components, maximum possible value, 85 for the RMR. So I did not have the A1 intact rock strength values because I didn't assign those. I just identified the rock and then

Professor Vitton took those identifications and later made it into a full RMR. So these are RMR's less A1. And essentially everything has been shifted down by 15 because we don't have that last component.

Q That is, to take account of the fact that you didn't have the A1 factor. You simply gave it a maximum rating; correct?

A Right. And the two lines represent the 70 total RMR lines. So this line is at 55, and if you add 15 to that, that would be 70. That is sort of the lowest value of stability that is predicted in the Golder geotechnical reports. The red line represents 60 which is almost certain failure of the crown pillar according to the Golder geotechnical reports. And so, again, everything's been shifted down by 15, but this (indicating) would represent a total RMR of 70, and this would be 60.

Q So for your chart, to say it sort of easily, you'd say that 55 equals 70 and 45 equals 60?

A 45 is the new 60.

Q Right. 45 is the new 60. So what does this chart tell us based upon your plots of the RMR's from your tables?

A For this core, what we can see is the upper part is certainly well below 60. There are some parts that are above the 70 value, and then as we go down lower we encounter some of these major discontinuities, and again

there's some that are well below the 60.
Q And what qualitatively does that mean?
A Well, the upper part of the crown pillar seems to be unacceptably weak. And so in this shallow range, that's the greatest concern. And must of the data lie in this sort of gray zone in between marginally stable and unstable.
Q And again, for the record, what is the depth of the crown pillar as currently proposed?
A I believe it's 90 meters.
Q And hole 55 is located where again?
A It's on the south side. It's one of the inclined holes.
Q All right. Next chart. Now we are showing Figure 2b from your report, and this is for hole 60; is that right?
A Yes.
Q And hole 60 is located where again?
A On the west side of the orebody.
Q And what's this hole more vertical or was it a slanted hole?
A I'm not sure how inclined. I don't think it was as inclined as 55.
Q And for all these charts, the orange line represents the new 70 -- is that right --
A Yes.
Q -- at 55. And the record is located at 45 which really means -- scratch that. It would be 60 in the Golder Report; correct?

A Yes.
Q And for hole 60 can you explain what the chart shows us?
A Most of these RMR values fall below this 60 instability line. A few are a little bit above 70, but virtually all of them are 70 or below.
Q And for hole 60 what is the depth that a core went to?
A 85 meters.
Q And so this is -- this hole would be all within the crown pillar depth; correct?
A Yeah. Again, without good information about the inclination, I can't say exactly what actual -- this is depth in the core, not exactly depth in the ground, but it's all in the crown pillar.
Q We've had put on the screen Figure 2c which is hole 62 with the same yellow and red lines. And can you explain the significance of the chart?
A It's the same setup. The upper part of the core had very poor rock quality, well below the 60 line. Much of the core again lies in this zone between marginally stable and unstable. Some parts of the lower core had potential ratings about 70. Again, they may not be that high because the intact rock strength value may have not been the maximum.
Q I understand. Let's go to the next figure. We now see Figure 2d which is hole 64. And can you explain the chart?

A Yes. Once again the red line is 60 and the orange is 70 and the upper part of the core is the worst quality. Most of the core lies below 60 of in the zone between 70 and 60 total RMR.
Q We now see Figure 2e which is hole 67, and can you explain this chart?
A Okay. We again see that the worst rock is in the upper part where the crown pillar would be. Most of the data lie below the 60 line, and the remaining data lie between the marginally stable and unstable lines.
Q And for purposes of predicting crown pillar stability is it significant to know the RMR values even below where the crown pillar is supposed to be?
A Yes, for the mining process.
Q And why is that?
A Because again the stability of the walls will depend on the rock quality, but this was focusing really on the crown pillar stability. The 60 and 70 lines were based on Golder's analysis of the crown pillar.
Q We now Figure 2f which is the chart for hole 69, and can you explain this chart?
A Again, the uppermost the rock down in this core to a core depth of about 150 meters is generally very poor quality rock with some of the rock line between marginally stable and unstable.

Q We now have Figure 2g which is hole 99, and can you explain this chart for us, please?
A In this one almost all the rock mass lay in the upper part below the unstable line. Some area between and in the lower part of the core are somewhat better quality rock.
Q And how I have Figure 2h which deals with core 101, and can you explain this figure for us, please?
A In this core which we don't know the location of, actually, all of the core lies below the 70 line and almost all of it lies below the 60 lines.
Q And in your professional judgment, Dr. Bjornerud, what would you have recommended if you had seen these kinds of values from these cores for purposes of evaluating crown pillar stability?
A Well, I think one concern I had was that when you use just drill hole information, even rather dense drill hole information where you have lots of holes going into the ground, it's very difficult to map confidently in the subsurface discontinuities from one core to the next. When you're seeing discontinuities of this number and magnitude, it's really important to know how connected they are. And I think that more -- do physical work and more detailed scrutiny of the core so that maybe you could -- if you have 90 cores, maybe you could link up particular structures in different holes and get an understanding of whether these

things are connected or not. But if you just have sort of one dimensional pinpricks into the surface, it's very difficult to know how they link up with each other.

Q So you would recommend further study of the available information?

A Yes, and much more detailed attempt to understand the nature of these discontinuities and their three dimensional character.

Q And the conclusions that you have -- or the views that you've given us today, are these all contained in your report?

A Yes.

MR. HAYNES: Petitioners move the admission of Dr. Bjornerud's report which is Appendix 8 to Exhibit 3.

MR. LEWIS: Exhibit 3, Appendix A?

MR. HAYNES: Yes. Appendix 8.

MR. LEWIS: 8?

MR. HAYNES: Yes.

MR. LEWIS: Exhibit 3, Appendix 8?

MR. HAYNES: Yes.

MR. LEWIS: All right. This is a -- if I could just clarify, your Honor, formerly we had received in the -- is this the 31 exhibit list?

MR. HAYNES: No, 632.

MR. LEWIS: 632. Yes, this was all -- all of these public comments, this right here (indicating), we received as one combined Exhibit Number 3. So pardon me, but I just -- I need to be clear now we're getting some of these exhibits in a different form. And Dr. Bjornerud's report, Mr. Haynes, is titled "Independent Report on Rock Properties at the Kennecott Eagle Project," dated October 5, 2007?

THE WITNESS: Yes.

MR. HAYNES: Yes, it is.

MR. LEWIS: And can you tell me how many total pages there are in this Exhibit 3, Appendix 8?

MR. HAYNES: Yes. 62.

MR. LEWIS: Okay. And it is comprised solely of Dr. Bjornerud's report?

MR. HAYNES: Yes.

MR. LEWIS: Okay. I have no objection, your Honor.

MR. REICHEL: No objection.

JUDGE PATTERSON: Okay. No objection, it will be entered.

(Petitioner's Exhibit 632-8, Appendix 8 received)

Q Now, Dr. Bjornerud, is there such a -- is there something called a modified RMR?

A Yes.

Q What is that?

A It's a variation on this system that also includes in situ stress information.
Q And can you explain what the modified RMR purports to do?
A Well, I think it tries to take into account the orientations of discontinuities in the rock, given the regional stress field.
Q Can the modified RMR be used in the absence of stress data?
A No.
Q Have you had a chance to review Kennecott Exhibit 592?
A Yes.
MR. HAYNES: Just for the record, I want to put that title back into the record.
Q This is the report entitled "Evaluation of Possible Hydraulic Conductivity Changes Due to Mining-Induced Stress Effects, Eagle Deposit Crown Pillar, dated April 2008.
A Yes.
Q Does that report, Dr. Bjornerud, attempt to use the modified RMR?
A No.
Q Have you seen any reports submitted by Kennecott that attempt to use the modified RMR?
A I don't believe so.
Q Now, if you were to summarize your opinions concerning the structural geologists's analysis that were appended to the application and in subsequent exhibits submitted by

Kennecott to the DEQ, what would those summaries be?

A Well, first of all, it seems to me that the report by Golder did not really include the geologic context of the orebody. There were geophysical data and borehole data, but there was not a clear conceptual understanding of the geologic geometry in the sense of the orebody. And secondly, it seems to me that the Rock Mass Ratings were inconsistently assigned. Again, there's always an element of subjectivity to this exercise, but at least one should try to be internally consistent in the way the numbers are assigned. And as we've seen, sometimes rocks that had very different physical properties were assigned similar values. And I would also argue that the RMR values were, in general, slightly over estimated because of the apparent assumption that was made about the A5 parameter of dry conditions.

Third, large sections of these cores that we were given images of had no Rock Mass Rating values assigned to them, so apparently they were excluded from the geotechnical analyses, and that's not a standard practice. Fourth, many of these discontinuities once they're exposed to water and air will actually change their properties and in general become weaker. As the minerals become hydrated and oxidized, some of these zones of weakness can become weaker still. So I would say that the Rock Mass Ratings as we've assigned now are maximum possible values, and the actual values once mining would begin would be lower.

And then finally, in the absence of any meaningful stress data, it's very -- it's not possible to use the geotechnical models in a meaningful way because of all the discontinuities in the rock, especially the two bounding surfaces, the contacts between the dike and the country rock, and then the fractures within the igneous rock. Without a good understanding of the stress regime, the inputs into the geotechnical models are really kind of guesswork.

MR. HAYNES: Thank you, Dr. Bjornerud. I have nothing further at this time.

JUDGE PATTERSON: Can we take a short break?

MR. LEWIS: Yes, your Honor.

(Off the record)

MR. WALLACE: Your Honor, I have a couple questions.

JUDGE PATTERSON: Okay.

DIRECT EXAMINATION

BY MR. WALLACE:

Q First of all, Doctor, can you obtain any stress data from existing boreholes?

A Yes. Either through the hydrofracturing technique that I mentioned yesterday and Mr. Parker spoke about as well, or a very low-tech way is to take existing boreholes that have

been around for some years. And they will actually change their shape slightly because of the lateral stresses. And they go from being circular in plan view to slightly elliptical according the direction of the maximum stress. So it's not extremely quantitative, but at least you can get some magnitude information and qualitative -- I'm sorry -- direction information and qualitative magnitude information if you know something about the rock strength.
Q Is this concept of a modified RMR that adds stress data -- is it a more useful tool than RMR's without stress data?
A Potentially. If you have those stress data, then you can make a more rigorous assessment of stability of a fractured rock mass.
Q Is there any reason why obtaining this stress data from existing boreholes would be particularly important at this mine site?
A Yes. Well, again because of the major discontinuities that we can see in the core images that we had that correspond in general to the sides of the intrusive body, the dike, as well as the fractures that transect the peridotite and others that I haven't even mentioned in the wall rock, the host rock, the metasedimentary country rock, there are many discontinuities also in that rock. So, yes, having stress information, in my view is critical.
Q Do you have to start mining to obtain lateral test data?

A No. You can do it before you start using hydrofracturing or borehole breakouts, they call it, formal deformation or overcoreing. There are ways of doing it before you start.

MR. WALLACE: Thank you.

MR. LEWIS: Dr. Bjornerud, I'm Rod Lewis. I represent Kennecott Eagle Minerals Company in this proceeding.

CROSS-EXAMINATION

BY MR. LEWIS:

Q I guess we'll start in the usual place with some questions about your CV. I see that -- first of all, I'll ask you some questions about at least my observations from your CV and you can tell me if I'm not correct in some of these observations. I do not see any indication that you worked in any industry related to mining; would that be true?

A That's true.

Q In looking through your employment history, I think, in general, it's been academic oriented; is that correct as well?

A That's true.

Q And you've done -- you have not worked for industry at all outside of academia; is that correct?

A That's true.

Q You have no training or experience in mine engineering?

A No.

Q Prior to your preparation for your testimony here today, again it would be my observation from your CV that you had had no particular experience in actually calculating and predicting the stability of the crown pillar of an underground mine. Would that also be true?
A Not that particular geometry. But all of my training has to do with understanding how rocks respond to stress fields. So I think it's exactly the same kinds of techniques that we use in geologic contexts.
Q Would it be true that you have had no particular experience in actually calculating or predicting the likelihood of a subsidence event above an underground excavation?
A That's true.
Q And your opinions in this case as to the analysis or predictions of the likelihood of subsidence in this mine were prepared for the purpose of this litigation?
A Yes.
Q Now, you, like I think Mr. Parker who spoke with us yesterday, testified about some -- your contrary opinions as to what the RMR values ought to be for various of these eight boreholes; correct?
A Yes.
Q And I believe that it's correct that you, like Mr. Parker, based that testimony solely on the photographs we looked at of eight boreholes; is that also true?

A Yes. We had hoped to have more information and requested that but the eight borehole image files were all we had.
Q And it's your understanding that there may be something in excess 100 total boreholes in the vicinity of the crown pillar?
A Something in the order of that magnitude.
Q Now, Dr. Bjornerud, you indicated or listed early in your testimony the various parameters that go into the RMR calculations, the A1 through A5 parameters; true?
A Yes.
Q And I believe that it was in particular the A3, A4 and A5 parameters that you recalculated?
A Yes.
Q And I believe you acknowledged in your testimony that the valuation of, in particular, A3 and, I think, A4 parameters is -- inherently has some degree of subjectivity?
A I would say A4 and A5 are probably more subjective than A3 which has to do with the spacing of the discontinuities.
Q Prior to this case, Dr. Bjornerud, had you ever been given samples of rock bore for what may be the roof of a mine and asked to perform RMR calculations on it?
A Not for the roof of a mine. But this kind of analysis is very standard. It's something that we teach undergraduates. Again it's an attempt to quantify what -- normally when you have outcrop at the surface, this is the kind of

observations that the geologists would make of rocks that are exposed at the surface. It's just kind of systematizing geology in a borehole. It's a protocol for the sequence and nature of the observations that you make. So it's pretty standard analysis. I haven't done it for a crown pillar case. But I have done RMR value assignations in other contexts and have students do it all the time.
Q And are you familiar with the standards or published -- let's say, published standards for the proper technique and procedures for evaluating in particular these more subjective parameters of the RMR calculations?
A Yes.
Q And it is true, is it not, that the generally accepted practice would be to physically inspect and handle these bores?
A Yes.
Q And you did not follow that accepted practice?
A Well, I did not have access to the bores.
Q I understand. You had limitations; right?
A (No verbal response)
Q And despite that limited access, Dr. Bjornerud, you nevertheless did proceed to calculate and present your findings today of these recalculated RMR numbers?
A Yes. I've made it clear that they were based on the images. But I do have extensive geologic experience in many parts of

the world. And I have looked at many, many rocks. And I looked closely at these images, and they represent my best professional judgment about the rock mass readings.

Q Now, have you reviewed the log quarrying procedures that was followed by the engineers at Kennecott in actually reviewing, handling and cataloging the information from these bores?

A I have not seen an extensive account of that. It was not in the primary application materials that I reviewed.

Q I just wondered, because we had submitted it as an exhibit some time ago. And I thought perhaps you had a chance to review that. But you have not?

A I don't think so.

Q All right. I think you indicated at some point in your testimony that -- and I take it, because of what you said about the nature of this characterization being somewhat subjective, I think you mentioned ways you could try to control that degree of subjectivity. I think things such as perhaps having either one person or, if it's more than one person involved, be kind of following the same protocol. I assume that would be important?

A Yes.

Q And perhaps some knowledge amongst the team as to how they're going to evaluate these various parameters so that there's some consistency in the approach?

A I agree, yes.
Q And you don't know, I take it, Dr. Bjornerud, whether, in fact, Kennecott may have had some fairly detailed procedures in place to do exactly that?
A Well, I do recall in appendix C2, I believe there -- again we never saw component values for A3, A4 and A5. There's only a short statement that an algorithm was developed to assign those. So I understand they must have had some procedure. But we neither have the actual values nor in that appendix a detailed explanation of what this algorithm was.
Q And you're referring to a Golder document?
A Golder document C3 -- sorry -- C2, page 5.
Q And I -- you're not assuming, are you, Dr. Bjornerud, that Golder did the actual logging on these bores?
A I assume they probably contracted it to someone.
Q Okay. And if, in fact, Kennecott's engineers, in fact, did that logging and had these procedures that I referred to, that was not made known to you?
A No.
(Witness reviews notes)
Q Doctor, I wanted to talk about a bit about a portion of your testimony where in, I believe, you talked about the RMR's reported by Golder in their reports, whether it was 60 or 70 or 75 and so forth. And some inferences you made and, in

fact, I think discussed in your report as to the difference in the calculated stability numbers for predictions if instead the RMR numbers were the ones that you had recalculated. And I think we looked earlier in your testimony at, for instance, some figures, some graphs, where you had plotted, I believe it was, RMR on one side and on the vertical axis was depth of core?
A Vertical RMR and horizontal depth, yeah.
Q Or horizontal was depth of core? I'm sorry. Horizontal is depth of core and vertical is RMR.
A (Nodding head in affirmative)
Q And the reporter will need a verbal response if you can.
JUDGE PATTERSON: You need to say "yes."
A Yes. Sorry.
JUDGE PATTERSON: She can't record a nod.
THE WITNESS: Okay.
Q And then you offered testimony to the effect that, if rather than the RMR that Golder reported for a particular core or length of core, that the RMR instead was the number that you had recalculated and at least in those figures you were asked to talk about it was instances where you had recalculated a lower RMR, that therefore the result would be that the factor of safety or probability -- factor of safety would be less or that the probability of subsidence would be greater?

A I'm not sure what the question is. But, yes, that was the intent of those graphs. And again it wasn't that I always calculated a lower RMR. There was no RMR reported for many of those segments. And in a meaningful assessment of the stability of any rock mass, the rock that will fail is the weakest rock. And so it's important to try to ascribe some kind of number to the weakest parts. That's the critical part. And so that was what I did in those graphs. And again I think there is reason to say that the RMR's that were reported in the Golder Report make some best-case scenario assumptions especially about the groundwater condition and also don't take into account potential changes in the rock that might happen once it's exposed to water and oxidizing conditions.

Q All right. But I'm trying to a more simple point here. And I think -- I'm not saying it very well. I apologize for that. But I think what you were doing was you were -- you were saying that, if, in fact, the RMR is a number lower than what Golder reported -- okay -- then according to Golder's reported relationship between RMR and probability of subsidence, that, in fact, the probability of subsidence would be greater?

A That's correct. Except that again sometimes they didn't report an RMR.

Q I understand that.

A Yes.
Q Now, you indicated that you had had some experience in actually calculating RMR's. But have you had particular training and experience in calculating factors of safety or probability of subsidence?
A No.
Q Do you understand, Dr. Bjornerud, that the RMR is merely one variable in a calculation or formula for predicting subsidence probability?
A Yes.
Q And do you understand that it's only one variable in a calculation or formula for calculating the factor of safety?
A Yes. And I understand that one of the other important variables is knowledge of the in situ stress state.
Q That's your understanding?
A That's one of the other important variables, yes.
Q Do you know what some others are?
A Orientation of the discontinuities in the rock, which again was a sixth RMR parameter that wasn't included apparently in the Golder analysis. And then kind of transient things that might change during the development of the mine including changes in core pressure in the rocks, which can effectively pry apart rock surfaces and reduce the frictional interaction.
Q Where did you learn that these other variables are part of

the formulas for calculating factors of safety?
A Well, based on my background in rock mechanics, I understand the kinds of things that can affect rock strength. And all of these things come into play.
Q I think Mr. Haynes mentioned in your examination the term CPillar analysis. Do you recall that?
A Yes.
Q And do you recognize that as an analysis that Golder discussed in their reporting?
A Yes.
Q And do you recognize it to be an analysis of the predicted stability of the crown pillar?
A Yes.
Q Did you review that portion of the report?
A Yes.
MR. LEWIS: For the record, this is one of the mine permit application reports that has been admitted. It is listed in -- or it is included in Intervener Exhibit Number 2, and it's referred to as appendix C3 of the mine permit application.
Q Dr. Bjornerud, do you recognize that to be one of the Golder reports that you discussed earlier?
A Yes.
MR. LEWIS: Could we go to page 11 of that report, please?

Q All right. I think this is page 11. Yes, it is. And do you see the discussion there in paragraph 4.2 about crown pillar stability assessment?

A Yes.

Q And there's a reference there in the paragraph under that heading as to crown pillar assessments using scale span concept method and CPillar. Do you see that?

A Yes.

Q And it sets forth there the crown pillar configuration, and it refers to crown bottom elevation, crown pillar stand, strike length, bedrock surface elevation and crown pillar thickness. Do you see that?

A Yes.

MR. LEWIS: And if we look at the next page, page 12, please.

Q Do you see there near the top of the page a formula that relates to the scale span analysis for defining crow pillar stability?

A Yes.

Q And if we look at the variables in that formula, they include, do they not, crown pillar span, density of the rock mass, thickness of crown pillar, span ratio and dip of the orebody?

A Yes.

Q And do you see then, Dr. Bjornerud, that, in the

calculation -- or in the variables in that calculation include not only a reflection of the density of the rock but also thickness of the crown pillar and some dimension of the void for the mine?
A Yes.
Q The factors that you mentioned having to do with discontinuities and so forth are not listed as variables there, are they?
A Well, this is not the entire analysis. The scale span method does use the RMR's. They're compared to something called Q. So this is part of the scale span analysis. But it also incorporates rock mass values.
Q But you're aware that it also includes your variables, thickness of the crown pillar?
A Yes; uh-huh.
Q And it also includes the variables of dimension of what would be the void?
A Yes.
Q And if we simplify things -- and again I understand this may be an oversimplification. But just for purposes of discussion, we might have a formula that says A times B times C and let's put D in there for some other things -- okay -- equals probability of subsidence or factor of safety. All right?
A Yes.

Q And A might be this RMR thing. B would be thickness of crown pillar. C would be dimensions of the void. And then D, we'll put in the other things that, between you and me, might be in there. All right?
A Right. Can I say something? As a geologist -- and that's how I was called to be involved here -- all of these things are -- I know they're standard engineering practice. But what seems to be lacking in this particular project is the understanding of the larger geologic context. And sometimes those things don't get entered into these formulae. And there needs to be a symphysis of the engineering approach with the geologic understanding.
Q All right. And I don't mind where you have to make some correction or clarification. But keep in mind here you generally need to answer my questions. And counsel will give you an opportunity later if you want to add something else. All right?
A I'm just reaffirming that I'm a geologist and not an engineer.
Q Okay. So then if we look at page 13, Dr. Bjornerud, do you see the table there near the top, Table 6?
A Yes.
Q Is that a table that you referred to earlier?
A I didn't specifically refer to this, no.
Q Okay. I think -- getting back to what I was asking you

about earlier, we see in this table that it has various parameters listed across the top; correct?
A Yes.
Q One of those parameters is RMR; right?
A Yes.
Q And that's the parameter that you spent some time discussing here this morning?
A Yes.
Q We also see the parameter called T; correct?
A Yes.
Q And that relates to the crown pillar thickness, does it not?
A Yes.
Q Now, in your testimony earlier today, again as we discussed earlier, my understanding was that you generally went back to this table or a table such as this and, instead of using, for instance, Golder's reported RMR of 70, that you used a recalculated RMR that you had recalculated?
A I did assign RMR values to the entire lengths of all of those cores.
Q Yes.
A And in many cases, there was no RMR reported for some of the worst quality rock.
Q I understand that. I think you said that several times now. But what you did beyond that, beyond recalculating the RMR's and pointing out that there weren't some for some holes and

so forth, you came back to the Golder Report with a proposition that if, in fact, the RMR numbers were lower than Golder reported, then they would correspond to a particular probability of subsidence?
A Yes. I took -- I said, if their analysis of the crown pillar stability using the scale span and CPillar methods is accurate, then I would predict instability based on my own best judgment of the rock quality.
Q And what you failed to do in that analysis, Dr. Bjornerud, was take into account the conditions that had changed, the other variables that had changed between the time of this Golder Report and the time of the Golder final recommendations for the crown pillar dimensions. Do you understand that?
A Tell me what the changes were.
Q Okay. Let's go to -- well, first of all, before we go to the next one, look in the left-hand column -- or excuse me. Just before we go on, in the T column, do you see that in this table?
A Yes.
Q And again we've talked about that represents crown pillar thickness. You understand that?
A Yes.
Q Okay. And that says 57.5 meters; true?
A Yes.

Q One more thing before we leave this document. Also on page 13, in addition to what I'm going to ask you about about changes to the crown pillar thickness, I want you to look at the bottom of this page. And you see the paragraph under CPillar analysis where it says, "A number of basic assumptions were made"?
A Yes.
Q And would you look at the little iv one? It says, "To be conservative, all the stopes are assumed to not have the benefit of active pressure from backfill below." Do you see that?
A Yes.
Q So I want you to keep in mind here -- well, do you understand that this report and this analysis assumed that there would be no backfilling?
A Yes.
Q Okay. And in other words, that the void would be open?
A Yes.
Q So two things I want to ask you about in the next report then, thickness of crown pillar and whether there was going to be open voids in this mine. As relating to this formula we've been talking about A times B times C and so forth --
MR. LEWIS: Now could we look at Intervener 24, please?
Q Is that the Golder Associates Technical Memorandum dated

July 7, 2006? Can you see that, Doctor?
A Yes.
Q Thank you.
MR. LEWIS: And for the record, that's Intervener Exhibit Number 24. I believe we also inadvertently put that in as Exhibit 79, the same document.
Q And just for point of reference, the report we looked at before, the Intervener Number 2 report we just looked at, Dr. Bjornerud, was dated February 8, 2006?
A Yes.
Q This report we're looking at now is dated July 7, 2006. Now, let's look at page 12, please. Let's look at page 2, please. Can you see the section there under "Kennecott Mine plan"?
A Yes.
Q And at the bottom, number 1, it says, "The primary and secondary sequence limits the open excavation spans beneath the crown pillar to one stope." Do you see that?
A Yes.
Q "Single stope dimensions will be approximately 15 meter by 50 meter." Do you see that?
A Yes.
Q Will you go to the next page, please? Do you see point 2, there, Dr. Bjornerud? It says, "The stopes will be tightly backfilled"?

A Yes.
Q And do you see point 3 where it says, "The primary and secondary sequence requires that backfilling be completed before an adjacent stope is brought into production"?
A Yes. There will be a void there at some point, and I would argue that the poor quality of the rock no matter how thick the crown pillar is --
Q If you would, Dr. Bjornerud, wait for a question.
A Okay. I'm sorry.
Q Page 8, please. In the middle of the page, Dr. Bjornerud, there's a paragraph that starts with, "On the basis of these results." Do you see that?
A Yes.
Q It says:

> "On the basis of these results and in order to ensure a factor of safety greater than what and a corresponding probability of failure of less than 5 percent for the initial mining layout arrangements for the worst-case geometry conditions (full width unsupported crown), the phase three mining limit is recommended to be set at an elevation of 327.5 meters corresponding with a crown pillar thickness of 87.5 meters."

Do you see that?
A Yes.

Q And I think you were here yesterday for Mr. Parker's testimony?
A Yes.
Q And do you recall that I read from the actual permit for this mine that the crown pillar thickness is limited under the permit to this 87.5 meter thickness?
A Yes.
Q And do you recall I also read from parts of that permit that says one stope at a time is to be mined and then backfilled?
A Yes.
Q So back to our formula, Dr. Bjornerud, it's true, is it not that, when you went back and reassessed the RMR's and then made statements about what the corresponding probability of subsidence would be, that you failed to take into account both the increased thickness of the crown pillar and the lack of an open void under the mine?
A I will answer your question. First of all, the -- many of the recalculated RMR's that I did showed that very weak rock well below 60 extended to depths deeper than the thicker crown pillar does. So that would be one reaction I'd have to that. But still those rock mass ratings are relevant to the revised crown pillar thickness.
Secondly in this document much of the factor of safety calculation was based on assumptions of the rock being elastic, meaning it's like a stiff spring and

characterizing the moduli of the rock like the stiffness of a spring. This is not the soundest approach to a rock mass that is heavily fractured. So I think that the observations that I made and the re-calculated RMR values are still relevant and still are germane to the issue of the stability of the crown pillar. But I am not an engineer and so I don't feel I can comment in detail on the crown pillar stability recalculations in this geotechnical report.

Q Fine. Now, listen to this question again, if you would, please, Dr. Bjornerud. It's true, is it not, that, when you put your recalculated RMR's back into Golder's calculations for crown pillar stability, that you failed to take into account the thicker crown pillar and the fact that there would not be this open void in the mine?

MR. HAYNES: Objection. Asked and answered.

JUDGE PATTERSON: I don't think her last answer was particularly responsive to the question, so I'll overrule.

Q Do you want me to asks it one more time?

A Sure.

Q It's true, is it not, Dr. Bjornerud, that, when you put your recalculated RMR numbers back into the calculations for stability of the crown pillar reflected in the earlier Golder Reports, that you failed to take into account the change in thickness of the crown pillar and the fact that

there would be not be a completely open void in the mine?
A My interpretation was based on the original design. But as I said before, I think it still is relevant even with the revised.
Q Dr. Bjornerud, yesterday you illustrated some of your opinions about this case with this wooden model down here. Do you recall that?
A Yes.
Q And as I recall, we're looking at this again.
MR. LEWIS: If I may approach a moment, your Honor?
JUDGE PATTERSON: Sure.
Q As I recall, what you did with that model was first you pulled out a solid plate on the bottom; is that correct?
A Yes.
Q And then you took off one or two rubber bands at a time?
A Yes.
Q And what happened was, as you removed more rubber bands, more little sticks fell out from the middle of the block model?
A Right.
Q If you had left the solid piece of wood in the bottom, those sticks would not have fallen out, would they, Dr. Bjornerud?
A No.
Q I take that during your testimony at various times you made

the same point that Mr. Parker was making yesterday that you felt -- you feel that in situ -- so-called in site stress measurements ought to be made of the rock above the crow pillar before mining; is that correct?
A I do think so, yes.
Q And you recall yesterday -- if you need me to look at these permits again -- but I went through with Mr. Parker the fact that, before mining commences, in fact, Kennecott is required to obtain additional drill core information and characterization of the crown pillar including in situ stress data?
A Okay. I think that should have been done as part of the characterization of the stability of the mine.
Q But you understand it is required to be done before mining of the ore commences?
A Yeah. I haven't -- I don't know what the regime is on how many stress measurements have been required, but I understood that from yesterday's testimony.
Q Now, you cited David Sainsbury's report -- one or two reports -- I forget which -- as one of your fairly short list of sources in your report. Do you recall that?
A Yes.
Q Is there some significance to that?
A Why I cited it?
Q Yes.

A I looked at the report as I prepared mine.
Q Is that the only significance? You were not citing it as support for your opinion?
A I was citing as a relevance source of information about this particular site and the stability of the crown pillar.
Q Were you citing particularly as support for your opinion?
A Mostly as additional information.
Q Are you aware that Mr. Sainsbury's deposition was taken in this matter?
A Yes.
Q Were you given an opportunity to review the deposition transcript?
A No.
Q Prior to today, had you been given an opportunity to review the later Golder Report that I just showed you parts of?
A C3 -- C2 and C3?
Q No.
A Or the July 2006, yes.
MR. LEWIS: That's all I have, your Honor.
JUDGE PATTERSON: Okay.
MR. REICHEL: Dr. Bjornerud, my name is Robert Reichel. I represent the Department of Environmental Quality in this matter. I think I have a very limited line of inquiry.

CROSS-EXAMINATION

BY MR. REICHEL:

Q During your direct examination, you testified that, as part of your work on this project, you reviewed the document -- the appendix C3, the subsidence analysis report submitted in connection with the permit application?

A Yes. Yes, I did.

Q And you talked about -- actually you were asked to look, I believe, at page 8 which had a discussion and a Table 4 of major structures in the crown pillar area?

A Yes.

Q And you noted -- you acknowledged, did you not, that the eight holes from which core samples were discussed in that table were the same boreholes from which you observed photographs of the cores; correct?

A That's correct.

Q And -- but just so the record is clear, it is your understanding, is it not, from reading the text of this document that there were considerably more than eight holes in which cores were selected that intersected or were in the vicinity of the proposed crown pillar; correct?

A Yes.

Q And that -- is it further your understanding that the Golder document, the C3, selected a subset of what they identified or referred to as a larger universe of borehole data for the very reason that this subset, these eight, using a certain screening technique described in the report were ones that the authors of this report identified as a particular potential concern with regard to the existence of major structures; correct?

A Apparently; it's not entirely clear whether some of the other cores also had similar features, but these were listed in table 4 as ones that did have major structural discontinuity.

Q Right. I'm not asking you whether it's your opinion as to whether the other ones did or didn't.

A Yeah; right.

Q But I'm just asking just to be clear, isn't it true, based upon your review of this report, that these eight holes where the core -- review of photograph evidence of the core that you participated in were selected by the authors of this report or identified by the authors of this report as being ones that were more likely to have a major structural feature; correct?

A Correct.

MR. REICHEL: I've nothing further.

MR. HAYNES: You're not quite done.

JUDGE PATTERSON: Not so fast.

MR. HAYNES: Can't escape yet.

REDIRECT EXAMINATION

BY MR. HAYNES:

Q Dr. Bjornerud, in order to calculate RMR's it does not require one to engaged in the mining -- to have been engaged in the mining industry, does it?

A No. I would argue as a geologist that geologists perhaps are better qualified having looked at more rocks and better understand the genesis of features in the rocks and the mineralogy, but -- no.

Q Mr. Lewis asked you about the crown pillar scale span formula in appendix C3 to the application pages 11 and 12?

A Yes.

Q Do you recall that discussion?

A Uh-huh; yes.

Q And as I recall during your answers to his questions, you mentioned that one of the factors that goes into the scale span analysis is the Q factor; correct?

A Right.

Q And isn't the Q factor really another version of RMR?

A Yes, it is. There's a formula that relates RMR values to this Q that's used in the scale span method.

Q And so the RMR values really can be substituted into the formula for scale span; is that right?

A Yes.

Q And in any mathematical computation, Dr. Bjornerud, if one

variable has significant problems, is inaccurate, is invalid for a number of reasons, or contains missing data for that variable as you've demonstrated, would that then cause the result of the formula to be inaccurate?
A Yes. It's usually called propagation of error. If there's an uncertainty in one of the input values it should be taken into account in the output.
Q So if in fact the RMR values were incorrect and they were inputted into this scale span formula, there would be propagation of error for the results?
A Yes.
Q Now, Mr. Lewis asked you about the charts that we illustrated, the eight charts that you plotted the recalculated RMR values. Do you remember that?
A Yes.
Q And did those charts include the depth of the cores to the depth of the new crown pillar proposal, which was 87 meters?
A Most of them did. I think the shortest core length was 85 meters, but most of them went deeper. Again, that's core length, not absolutely depth. But for the more steep cores it's close to depth.
Q So those charts actually can be used for purposes of the currently proposed crown pillar depth; is that right?
A Yes. They correspond to rocks including the thicker crown pillar.

Q So your conclusions, Dr. Bjornerud, would not change depending on if the crown pillar were -- and I think we discussed this yesterday with Mr. Parker -- a hundred feet thick or 200 feet thick or the 87 meters, which is give or take 300 feet; correct?
A Not substantially, no.
Q Mr. Lewis also asked you about the Golder Geotechnical Memoranda dated July 7, 2006, which is also labeled attachment 7 -- and for the record, he identifies as Kennecott Exhibit 24 or 79 -- and asked you about the width of the stopes. Do you recall that?
A Yes.
Q I'm going to read you from page eight of that document the following sentence: "As described in the Kennecott mining plan the unsupported span of the crown would be limited to one stope approximately 15 meters by 50 meters." Now, can you tell us for those of us that aren't comfortable working in meters what the dimensions of 15 meters by 50 meters would be in feet?
A In feet? Fifteen would be about four- -- 15 would be 45 feet, and fifty 150 feet.
Q So the stope that we're talking about is going to have an area in a horizontal plane of about 45 feet by 150 feet, if these figures are correct?
A Yes.

Q "Yes"? Now, does your analysis of the RMR ratings that were assigned here -- is that analysis changed by having -- by considering this stope area of 45 feet by 150 feet, or if we compare that with the unsupported crown span of 68 meters, would your analysis change?
A Now, and I'm not a mining engineer, but I can say that this -- the discontinuities in the rock mass are much more closely spaced than even the smaller stope size and some of them are substantial enough to cause failure and not knowing the kinds of stresses that may or may not be holding the rock mass in, it's -- I don't think a meaningful stability assessment can be made.
Q Mr. Reichel asked you about the eight boreholes that were selected in the Golder appendices. And for purposes of your review, would you have preferred to have looked at the borehole data and the core photos of all hundred or so cores?
A Yes, I would have preferred to see them; I'm not sure I would want to do RMR analyses of all of them just given the time it takes. But yes, I would certainly have preferred to see all of them.
Q All right.
MR. HAYNES: Thank you. Nothing further.
MR. LEWIS: Yes. If I may, your Honor?

RECROSS-EXAMINATION

BY MR. LEWIS:

Q I just want to be clear, Dr. Bjornerud. We went through this and then I wasn't sure about your answer to Mr. Haynes' question, but do you recall we looked at simplifying the formula of -- where A, B and C would be simplified variables that might go into the equation for calculating crown pillar subsidence probabilities?

A Yes.

Q And so that Y would represent the result in the formula?

A Yes.

Q And I think we talked about the fact that we would assign to one of these variables the RMR number?

A Yes.

Q And that's the number that you recalculated and reported on; right?

A Yes.

Q And I think we also talked about the fact that the crown pillar thickness was one of those variables at least; right?

A Yes.

Q And the size of the void is one of those variables; right?

A Yes.

Q And do I understand you correctly in response to Mr. Haynes' question that even though you did not account for the change thickness of the crown pillar and did not account in the formula for the fact that the void would only be one stope at a time, it's still your testimony that Y would be the same?

A In that formulation it would probably be -- not be, but again, my testimony has not been engineering; it has been the geology and I feel that there aren't enough parameters to constrain the answer. That is my argument; that you can't solve this equation because we really don't have substantial enough input values.

MR. LEWIS: Thank you.

MR. WALLACE: Your Honor, I have just a couple follow-up questions.

JUDGE PATTERSON: Okay.

REDIRECT EXAMINATION

BY MR. WALLACE:

Q By altering crown thickness -- crown pillar thickness by 60 percent or whatever the difference between 57 and 87 meters is, do you address the issue of in situ stress at all?

A Rephrase that question. I'm sorry.

Q I mean, we've been looking narrowly at this formula for a couple times now. But I want to ask you this: By changing that variable in the formula, does that address in any way your analysis and your concern about lateral stress?

A No. Again, we don't have that information; that is one of the input variables that's still lacking. And again, the rock mass rating numbers are so low that even given a thicker crown pillar I would expect Y in that equation not to be substantially changed.

Q Does this somewhat --

A But I'm a geologist, not an engineer.

Q Does this somewhat thicker crown pillar -- it's not double the size but from 57 meters to -- 57 and a half to 87 and a half meters -- does that in any way deal with your concerns about significant faults in the area?

A Not really, because in many of the cores that I had the opportunity to look at the entire thickness of rock that is in the crown pillar area is equally bad and we have no information on the stress regime. So making a thicker crown pillar in very poor rock with unknown stress conditions won't necessarily help.

MR. WALLACE: Thank you.

MR. LEWIS: Nothing further, your Honor.

MR. REICHEL: Nothing further.

MR. HAYNES: Nothing further.

JUDGE PATTERSON: Now you can leave. Thank you very much.

MR. HAYNES: Thank you, Doctor.

(Witness excused)

JUDGE PATTERSON: We'll take ten minutes.

(Off the record)

JUDGE PATTERSON: Ready?
MS. HALLEY: Petitioners call Dr. Stanley Vitton.
REPORTER: Do you solemnly swear or affirm the testimony you are about to give will be the whole truth?
DR. VITTON: Yes.

DR. STANLEY VITTON

having been called by the Petitioners and sworn:

DIRECT EXAMINATION

BY MS. HALLEY:
Q Please state your name, spelling your last name for the record.
A Stanley James Vitton; last name is V, as in "Victor," i-t-t-o-n.
Q What is your address, Dr. Vitton?
A 239 Mason Avenue, Hancock, Michigan.
Q Could you describe your formal education?
A My bachelor's degree was in geological engineering from Michigan Technological University. I stayed on and obtained a master's degree in mining engineering in the area of rock mechanics. And then later on I returned to school and got a PhD at the University of Michigan in civil engineering in the area of geotechnical engineering.
Q Would you describe your master's thesis, please? Both the -- your original project and why that project was ended and the next project.

A My master's started in 1976 and my first project was to work on in situ stress measurements in the Centennial Mine in -- near Calumet, Michigan. Homestake Mining Company wanted to reopen the Homestake Mine and we were asked to do in situ measurements in the 30th level of that mine. But the project -- the mine shut down before we finished those.
Q And that was in the 1970's?
A 1976; the fall of 1976.
Q Thank you.
A My master's thesis work. Okay. That was the first one, then we were -- purchased a -- one of the first sort of hydraulic testing systems to measure rock behavior. It was a million-pound axial load system. I put that together or got it up and running and also developed or got running a triaxial testing chamber that could go up to very high stresses, almost 40,000 psi stresses, to look at the behavior of rocks under very high stresses and triaxial stress field. And then my final project, which ended up being my master's thesis, was looking at the problem with iron ore from the Tilden Mine. They were having problems during the wintertime with crushing it, and so they wanted to look at what happens to the mechanical behavior of this rock when it got very cold, you had cold temperatures. So I looked at the effects of cold temperatures on the mechanical behavior of iron ore from the Tilden Mine.

Q Are you a member of any professional organizations?
A Yes. American Society of Civil Engineers, American Society of Engineering Educators. I'm a faculty member of the -- it's called ASFE, Association of -- it's changed its name many times, but it's a -- "ASFE" used to stand for "Association of Soil and Foundation Engineers"; it's now a liability organization to prevent -- or to help companies avoid litigation. I'm also a faculty member of the American Drill Shaft -- ADSC, American Drill Shaft Association. I think that's nature of it. I might --
Q Are you a member of the International Society of Explosive Engineers?
A Yes, I am a member of the International Society of Explosive Engineers and I'm on their program committee.
Q How about the International Society of Soil Mechanics and Foundation Engineers?
A Yes, that's an international association that the American Society of Civil Engineers is a part of.
Q Okay. How about the International Land Slide Research Group?
A Yes. Yes.
Q And the International Association of Foundation Drilling?
A Yes, that's the ASD -- ADSE.
Q Okay. Could you talk about your professional experience starting with your current position?

A My current position, I'm an associate professor at Michigan Technological University in the area of civil engineering and teach geotechnical engineering classes. I conduct research in the area of dynamic loading of concrete, dynamic fracture of concrete. I look at settlement characteristics of aggregate materials. I'm the director of the Institute for Aggregate Research at Michigan Tech. We do research for the Federal Highway Administration, Michigan Department of Transportation. Do you want me to --
Q And before you went to Michigan Technological University?
A I was a professor at the University of Alabama in Tuscaloosa, Alabama for three and a half years.
Q What did you teach there generally?
A I taught civil engineering classes, foundation engineering, soil mechanics. And I did a number of projects there also.
Q Did you oversee PhD candidates?
A Yes. I had one PhD candidate who analyzed the -- he used a three-dimensional finite element model to measure the roof collapse of a long wall mine and that model was to look at the deformation characteristics of the collapsing roof as the long wall panel moved through the coal seam.
Q And prior to that, Dr. Vitton?
A Prior to that I was with the Shell Oil Company for eight years.
Q What position did you hold there?

A I was a mining engineer with Shell Oil company. The first four years were working on projects in the Powder River Basin; specifically I was the environmental permit manager for the Buckskin Mine. We submitted a permit in 1980 to the Department of Environmental Quality in Wyoming. This permit was very extensive; it was 31 volumes long. I think the total cost was 4.6 million at that time. That permit was one of the first ones that was issued under the Office of Surface Mining regulations on surface mining that were enacted in public -- Surface Mine Control and the Reclamation Act of 1977. The regulations came out in 1978 and then this permit had to conform to all those regulations.

Q Did you design mines?

A Yes. Yes, we -- I designed mines. My first four years were in the Powder River Basin. I worked -- as I mentioned earlier, I was the permitting manager for the permit application but I was also the mining engineer that put the mine plan together. I also worked on the Crow Indian Reservation for the -- on the Young's Creek Mine. This mine never was developed, but I was in charge of the design of that mine in Montana. And then for four years I was in Ohio; I was engineering manager for the R and F Coal Company, which is a wholly owned subsidiary of Shell Oil Company, and in that capacity I oversaw the design of the

mines there, which were mostly all surface mines. I did all the economic analysis. We worked a contract. And I was heavily involved in litigation, especially involved in blast-end litigation.
Q Did your work include dealing with abandoned underground mines?
A Yes; fairly extensive. The R and F Coal Company more or less specialized in the extraction of abandoned mines, underground mines that came out to the surface. We would come in and surface mine the abandoned underground mines and then reclaim the site. That was one thing that we did very successfully.
Q And did you assess the effects of surface mine blasting on the stability of underground mines?
A Yes. We worked with the Shell Development Company; we were under a lot of litigation for blast damage from our blasting operations. We used a very large amount of explosives, about 32 million pounds a year. And we knew -- we got sued a lot. And so we did a -- we had a number of research projects, the vibration levels of the blast from the surface mines. One of the issues was the effect on surface mine blasting on the stability of abandoned underground mines, and we did look at that.
Q Have you published articles in peer reviewed periodicals?
A Yes.

Q Could you list just a few of them?
A Well, the most recent dealt with the dynamic fracture of cork and cement concrete used in pavements. Another one was looking at uniaxial compression dynamics for fracture of uniaxial compression samples coming up with a new model to look at how fracture of the rock occurs in uniaxial compression tests in a dynamic mode.
Q And did you co-author a report called "Dynamic and Static Strength of Aggregate and Estimate of Rate Sensitivity of Geologic Materials" for the Institute of Lake Superior Geology?
A Yes.
Q Okay. How about a paper called "The Application of Anchor Geosynthetic Systems for In Situ Slope Stobilization of Fine-Grained Soils"?
A Yes. That's "stabilization," yes.
Q Sorry.
A That was a U.S. Bureau of Mines project that was funded by the Office of Surface Mining and that was to look at stabilizing slopes -- abandoned mine slopes in Appalachia.
Q Okay. How about "The Significance of Particle Crushing"?
A Yes, that was a reply to a technical paper on how my -- how particles like backfill settle, and that paper discussed the issue of particle crushing. My response to that paper -- I found it a very good paper, and my response was that was a

highly applicable paper to mine settlement and spoil settlements and that's what that paper was.
Q Okay. How about a paper called "Determination of Compaction Criteria and Verification of Construction Compaction Quality for Rock Fill Materials"?
A Yes, that paper dealt with the Three Gorges Dam in China, and the issue of how do you compact very large particles and the difficulty with it.
Q How about "Blast Damage Investigation of Foundations Constructed on Collapsible Soils"?
A Yes. That was a paper with the International Society of Explosive Engineers dealing with the problem of blasting near homes on unstable soils.
Q How about "The Engineering Significance of Shrinkage and Swelling Soils and Blast Damage Investigations"?
A Again, that was another paper looking at the issue of blast damage litigation in area -- basically looking at other issues that cause settlement other than the blast damage, blast vibrations.
Q How about "A Case Study of Acoustics and Vibration of Mine Fans"?
A That project took place in the Jim Walters Mine in Alabama. The extremely -- it's an underground long wall mine operation. Extremely gassy mines, very high methane amounts and there's issues with the mine fans that exhaust those

fans, and that paper dealt with looking at the vibrations that are caused both the airborne vibrations as well as the ground-borne vibrations. And that's what that paper was.
Q And "A Liquefaction Failure During Seismic Exploration"?
A That paper dealt with -- in the Upper Peninsula of Michigan where oil company was exploring using vibroseis trucks and the vibroseis trucks shake the Earth and they were going over a lake and they caused 250 feet of lake -- of road collapse into the lake causing four of the trucks to go under the water. And that paper was a soil liquefaction issue; it had -- it was a dynamic issue in the stability of the -- of that slope of the highway going over it.
Q Are there a number of other articles you have published in peer reviewed publications?
A There's a number of them.
Q And they're all outlined in your --
A Yes, most of them are in the ---
Q Your résumé here?
A Yes.
Q Thank you. And you currently teach at Michigan Technological University?
A Yes.
Q What classes do you teach now or have you taught.
A Classes; I'll start from what I'm teaching now. I'm teaching a course called Rock Engineering for Civil

Engineers. It's a new class. I teach a course in the fundamentals of soil behavior, which is a graduate level class. I teach another class on the stability of Earth structures which deals with the stability of Earth structures such as dams, landslides, slopes, things of that nature. Then I teach an undergraduate course in the applications, use synthetics; that was a class that evolved from a landfill class I used to teach that came out of my experience dealing with the coal refuse impoundment design when we were building a coal refuse impoundments in Ohio. And then I teach the basic course in geotechnical engineering for -- to civil engineers, geological engineers and surveyors now called Soil Mechanics; undergraduate level class.

Q How about Design and Construction of Landfills?

A Yes, that was an older class that when we went from a quarter system to a semester system it changed from landfills to geosynthetics dealing in geosynthetics, which are textiles, landfill lining -- liners, things of that sort, geogrids.

Q Dr. Vitton, are you involved in other research activities in addition to your academic pursuits?

A Yes, I do a number of projects; some of them are funded research projects and some of them not funded. Some of them are consulting projects that I take on periodically.

Q Do you currently have a project for the Michigan Department of Transportation?
A Yes, I have two projects, both of them have -- are ending or the final reports have been submitted. One deals with the stability of the old Michigamme Iron Ore Mines. U.S. 41 crosses over these old abandoned underground iron mines and they want to relocate the road to where -- weave through the existing mines and they asked me to analyze that situation and make a recommendation as to the stability of the area, the surface stability based on the underground mines. That report was just submitted this month. The second report deals with a project north of Baraga, Michigan. It deals with the -- there's a cliff that's made out of Jacobville sandstone. And the road goes over it and it's a beautiful lookout over Keweenaw Bay and that cliff is collapsing. And we drilled, we did the analysis of the drill core, created our RMR's, RQD values and made a recommendation to them as to the stability of the cliff.
Q Okay. How about the Assessment and Characterization of Fugitive Dust Emissions of the Gribbon and Empire Tailings Basins? Is that project you've been involved in?
A Yes, that was funded by the Cleveland Cliffs Iron Company; that's an interesting problem in which they get massive dust storms off of their large tailing impoundments in the fall time of the year. It's a process in which the ground

freezes, the tailings freeze, and then in the morning you -- there's a separation of the water as the freezing process occurs and you end up with succination occurring, which is more like a dry freeze where the ice converts to a vapor and you end up with dust on top of the ice and then the wind takes it. So there was massive dust storms there. And that project dealt with looking at those issues.
Q	And what about a project called, "The Application of Anchor Geosynthetic Systems for Abandoned Mine Lands, Landslide Remediation"?
A	I mentioned that one already. That was a U.S. Bureau of Mines project looking at the stability of slopes and abandoned mines.
Q	Do you have any patents?
A	Yes, I have two patents.
Q	Could you describe them to us?
A	The first one is the seismic detection of tornadoes that dealt with the issue when I was at the University of Alabama of being able to detect tornadoes on the ground through seismic observation by putting a seismometer and then as the tornado touches down -- it's a very turbulent system. And it turns out that that tornado creates a pressure fluctuation on the surface of the Earth and that fluctuation is -- becomes a seismic wave and that travels at about 5- to 7,000 feet a second, and so we can actually detect them out 20 to

25 minutes ahead. So that's with that patent. And then the second patent dealt with -- it deals with the same observation but using the tilt of the Earth's surface. The Earth's surface tilts. There's an Earth tide in our crust. And it also -- atmospheric disturbances can create a tilt in the crust of the Earth, and so we were using that technique using Earth tide -- very high-precision tilt meters to monitor that.

Q Have you conducted any work for the Douglas Township Quarry in the -- in Dakota County, Minnesota?

A Yes. I was asked by a company called TKDA -- it's a engineering -- civil engineering company in St. Paul, Minnesota -- to write -- or do the assessment of the mining reclamation and in particular the blasting issues with a quarry that they're proposing about 30 miles southeast of St. Paul, Minnesota. The problem with that project -- proposed project is that there's a major gas transmission line along it and there are significant issues with the regulations that govern the blasting near these lines.

Q Have you been involved in work at the Kentwood underground gypsum mine in Grand Rapids, Michigan?

A Yes. I was asked to do the assessment of the roof stability of the gypsum mine -- of the Kentwood gypsum mine. That project was done for a developer by the name of Damone. That project we obtained as much information as we could.

That project was in consultation with Mr. Parker. Mr. Jack Parker and I went down to the mine after reviewing the information. We then found the former superintendent of the mine. We got the hoist operating. We went down into the mine and we toured through the Kentwood mine from end to end to do a stability analysis of the roof rock, and ultimately a stability analysis of the surface of that mine.

Q And what about the former Domtar Gypsum Mine?

A The Domtar Gypsum Mine is on the west side of Grand Rapids, Michigan. The Kentwood mine is on the east side in Kentwood, which is a city next to Grand Rapids. The Domtar was a very old mine that started in 1850's, 1857; had many, many types of -- different types of mining -- underground mining systems in it. It closed in 2000. Domtar had closed briefly in the early '80's, reopened. It was a very complex mine where they started mining. There's a number of seams and they mined the top seam out and they started to mine down into the lower seams. And Mr. Parker had been the consultant to Domtar on that mine, and so I contracted again with Mr. Parker to work with me on working on that mine. The issue there was the -- Grand Rapids wanted to relocate the John Ball Park Zoo across that interstate highway 96 over this abandoned mine. And there extensive sinkhole development, a number of sinkholes that are developing in this area, so I was asked to do an assessment of the stability of that roof and the surface in that project.

Q Have you ever done any work at the White Pine Mine?

A I did one other thing. We were asked by the Michigan DOT -- it turns out that I-196 crosses over -- a section of that Domtar Mine about a half mile of that interstate sits over that mine and we were asked by the Michigan DOT to make an assessment of that, stability of the interstate over that section of the mine. That was a funded project through the Michigan Department of Transportation.

Q And have you ever done any work at the White Pine Mine?

A Yes. When I moved to Michigan Tech from the University of Alabama -- the White Pine Mine at one time was the largest underground mine in North America, the United States. It isn't any longer, but it was a very large underground mine that was shut down in 1995 due to environmental compliance issues with their smelter and they chose not to continue with their smelter, and instead they investigated a process called "solution mining" in which the -- they estimated they had a very large extent of copper in the pillars, the remaining support pillars of the mine. And the plan was to blast these pillars and then to permeate sulfuric acid through them to extract the copper underground and collect that and then to use electrochemical methods on the surface to remove the copper from the -- what I -- I did a couple things on that project. Number one, I had a graduate

student look at the design of the concrete bulkheads, which are required to go between the pillars to contain all the solution in one area, and they were to put concrete walls between -- which we call "bulkheads" -- between the pillars and then they were going to blast the pillars. Before that they put PVC pipes with their sulfuric acid and then they blast the pillars, the roof comes down and crushes everything, rubblizes it and that helps the fragmentation process, and then they -- a solution. And they did two panels, two large panels; I think about a hundred pillars each. So I had one -- I my graduate student look at the -- optimizing the design of those bulkheads to contain the solution. The second thing I did is I monitored the collapse at the surface using seismometers.
Q What does a seismometer do?
A It measures the vibrations of the collapse. And the other thing I did then was look at the subsidence that occurred by surveying the surface above where the roof collapsed. This is also done in conjunction with Los Alamos National Laboratories. There is a professional paper that Los Alamos did on this collapse mechanism.
Q Using your data?
A They didn't use my data, but they collected data alongside. I had a seismograph and they had a seismograph. And they -- I worked with them giving them information about the

blasting pattern, the timing and how the roof came down. Oh, yes, one more -- Inmet (phonetic) hired me then. There was an issue of something referred to as induced seismicity and that was an issue which in my opinion was a nonissue, but White Pine had chosen not -- or in that the White Pine Mine had chosen not to continue with the solution mining project; they discontinued it. And they then decided to fill the mine up with water about three-quarters full and there was some roof collapses during that process, and there was some concern about what's referred to as induced seismicity. And so in that hired me to monitor the surface for -- to protect -- in case there were large we know the magnitude of the vibration at the surface from these collapsing features underground as the mine filled up with water.

Q Have you done any work in Los Angeles Harbor, California?

A Yes. That was a project in which they freeze soil and then excavate down the middle of this frozen block of sand; it was out in the ocean. It was out on a sandbar in the ocean. And they freeze it down about a hundred feet and in that -- and they excavate inside of it and at about 80 feet when they're excavating it collapsed. And so they asked me to investigate the strength of the frozen sand/ocean water mixture and determine what strength it was and look at creep properties and how it -- the ice creeps. And that's a process in which it takes time and then it fails. And I looked at that process.

Q Have you conducted any work at Bay Harbor, Petoskey, Michigan?

A Briefly; I looked at the stability of their cement kill -- CKD, cement kill dust piles.

Q How about looking at blast effects at a quarry located in Tarrent City, Alabama?

A That was a consulting project while I was at the University of Alabama. That was a lawsuit in which homeowners were -- had filed a lawsuit against a quarry operator and I was hired by the quarry operator to review the -- inspect the homes for damage and to inspect the blasting logs and to make an opinion as to the potential for damage of these homes in Tarrent City. It's Tarrent City, T-a-r-r-e-n-t.

Q And have you done work for the Drummond Coal Company?

A Yes. Again, it dealt with blast damage litigation.

Q And you may have talked about this before. Have you worked on an analysis of the stability of the Michigamme Mine?

A Yes. Yes, I --

Q Can you describe where Michigamme is?

A Michigamme is between Marquette and L'Anse/Baraga area. It's on US-41 and the US-41 goes through -- it has a very tight vertical, horizontal curve through those mines. There are some mines on the south side of it and some mines on the north side. But it mined the iron formation in the Marquette area and they were underground mines about -- there were seven underground mines, but there were about ten or eleven different shafts that had to be investigated.

Q And how about at the Quincy Mine and where -- if so, where is the Quincy Mine?

A The Quincy Mine is associated -- it's a copper mine on the Keweenaw Peninsula that mined the Portage Lake lava series and that mine dips at 55 degrees. The number two shaft -- there were a number of shafts but the number two shaft was the deepest; it went down at about a 55 degree incline 9,600 feet. They stopped the pumps in that mine in 1945 and since 1945 the mine has been filling up with water. At about the seventh level of that mine there was a drift that had been made to allow water that comes in from the surface -- there's a series of mines, 1 through 13. This is the number two. All those mines are connected and all the snow runoff and rain, everything comes into this -- to that level, all comes to one point and then comes out. And that -- in the 1970's Michigan Tech then enlarged that to be an experimental mine and -- but yet, the water hadn't gotten up there yet; it was still rising. and then in the year 2000 they knew that the water was getting very close to the -- to that -- to where their tours come in -- let me back up. The experimental mine was later given to the Quincy Mine Hoist

Association to do tours so people can take a tour of an underground copper mine to look at the stopes and how they mined, the drilling technology. And that water; they were concerned about when that water would reach these -- that level which the tour came in, and that's where it was to come out. And I put the -- I put equipment in the mine to determine the water level rise and -- so I could tell them when it was going to reach the surface -- or the number seven level.

MS. HALLEY: For the record, Dr. Vitton's Curriculum Vitae is Exhibit 123, which all parties have stipulated to.

JUDGE PATTERSON: I'm sorry. 120- --

MS. HALLEY: 123.

Q Do you have experience in mining engineering?

A Yes.

Q How about geological engineering?

A Yes.

Q And civil engineering?

A Yes.

Q Have you ever testified in court before?

A Yes.

Q Who were you testifying on behalf of?

A The R and F Coal Company where I was the engineering manager there in our coal company and we were being sued for blast

damage from our use of explosives at our operation. And I testified to our -- I testified in one of the many cases that we had.
Q In your past endeavors have you ever testified for an environmental group before?
A No. I gave testimony in the White Pine Mine in support of the solution mining project there, both written and verbal. I think it was a good project.
Q I couldn't hear that last part.
A I think it was a good project. I think it was a very environmentally sound project.
Q Okay. We've heard from Mr. Parker that he used himself as a practical rock mechanics practitioner, and from Dr. Bjornerud that she brings a fairly academic approach to geology. What is your approach, Dr. Vitton?
A Well, I like to consider myself in between that. I worked in industry that I have an academic background that I -- I like to split the difference, be in the middle. I like to look at -- apply practical, to be able to understand the practical side and also be able to understand what's going on on the academic side and try to work between those two areas.
Q Have you reviewed Kennecott's application particularly the subsidence crown pillar stability, backfill, and TBRSA liner discussions in that application?

A Yes.
Q Have you also reviewed information on the DEQ's website regarding those same topics?
A Yes.
Q And how about subsequent memos from Golder and others relating to those same issues?
A The ones that are on the DEQ -- the Michigan DEQ website, yes.
Q And have you at this time reviewed many of KEMC's exhibits related to rock mechanics?
A Yes.
Q Could you briefly describe the mining plan as it is outlined in the application? This is from DEQ's Exhibit Number 25.
A Should I just explain it while you're putting it up there?
Q Let's just wait. Dr. Vitton, could you describe to us the basics of the mining plan as illustrated in this figure?
A The -- I guess as an overview this is a mine plan that's going -- that's attempting to do 100 percent extraction of a mine. They want to take out 100 percent. There's no support -- rock support left in it. And that's the issue of bringing backfill into the mine, then, to support the mine after you've done 100 percent extract -- or as much extraction as they can get out of it. And it's going to be mined starting at the bottom. They're going to make a very long, very steep entrance portal into this.

Q Does it not work?
A It doesn't work on that. It works down here (indicating). There it is. Okay. They're going to go in at East Eagle, which is about a half mile to the east of this deposit.
Q What do you mean by "go in"?
A They're -- my understanding of this section of the permit is that they will enter above the ground at the East Eagle outcrop, which was discussed later -- or earlier in other discussions.
Q Commonly -- is that commonly known as Eagle Rock?
A Eagle Rock, yes. And the portal, which is the entrance, will go due east, make a 180-degree turn and then make a very long, very steep -- I understand the incline will be at 12 to 15 percent incline, which is very steep, coming down in here to the mine about halfway. And the mine is sped in what they call the upper zone and the lower zone. But the plan, then, is to in the -- then is to make these blue ramps that are very circular and go down to get the grade to get to the bottom of the mine, and then they will start mining what they call level one, bottom here, level two, level three, and so on, as they go up. And the discussions earlier about the crown pillar thickness go off of these terms here, this level here, 383, 353, not quite, but there's got to be some room for -- if you notice in this area here (indicating), there's got to be room to be able to

do the drilling of the long hole stoping operation and the transfer stoping operations here. If you go back to the geology here, this is a dike, a very thin structure.

Q Dr. Vitton?

A Yes.

Q Just a minute. SO this represents the mining application and the mining plan that was laid out in that application?

A Yes. My understanding, yes.

Q And has that plan been altered over time as far as the upper limits of what would and would not be mined?

A Yes. The original -- the permit has three appendices that I look at extensively. C1, which is the geology of the deposit which described the geology and the ore grades. C2 is the geotechnical report which relied on drilling that was done up to a certain date. And then there was additional drilling done and additional analysis that was done. And C3, that was described as the subsidence report.

MS. HALLEY: For the record, those are -- that's DEQ Exhibit 26.

Q Go ahead.

A I guess. Your question was, has there been alteration? And the one alteration to the mine plan, the way I understand it, has basically remained the same but they have -- okay. The issue at hand is the thickness of the crown pillar. And that has changed between C1 to C2. And then there was a later attachment that was on the Michigan Department of Environmental Quality website that was conducted, a report that then looked at it and then even lowered it even lower, so there were three changes to the thickness of the crown pillar.

Q Thank you.

A Other than that, it's basically the same.

Q Could you describe the basic geology of the mine site according to page 13 of the application?

MR. HAYNES: I apologize. It's page 13 of Appendix C1 of the application, not the application itself.

Q While we're waiting, could you describe the basic geology of the mine site?

A Okay. As described earlier by Mr. Parker and Dr. Bjorerud, the deposit is a dike. It's a relatively thin deposit that's come up in the Michigan basin sediments or metasediments. And later it appears that the metals have come up in there and intruded into that dike area. And so this is a relatively thin structure. And so it's a peridotite is the dike material. And then intruded into that peridotite are sulfides, which they characterize as semi-massive and massive sulfides that have come into that deposit. And that's what the mine is attempting to mine out.

Q Are you familiar with other mines in the region?

A Yes; yes.
Q Could you name a few?
A Well, the Michigamme Mine, because I've studied it quite extensively with all the old mine maps; the White Pine Mine; and certainly all the Quincy Mines, because I grew up there, and as a young person went in many of them and went underground in many of them.
Q How about the Chapin Mine?
A The Chapin Mine I was asked to investigate for a group in -- a community group in Iron Mountain, Michigan. It would like to take the Chapin Lake, which is the -- which is a large collapsed structure of the Chapin Mine collapsed, the entire mine collapsed, and that's what created that lake as you go into Iron Mountain, Michigan, Chapin Lake. And they wanted to put a science parkway or an area to walk around it and try to identify the geology and the mining. And it would then be connected with the Cornish pump that's there that was used to dewater that mine.
Q Okay. Have you -- can we go back to describing this illustration and the basic geology of this deposit?
A Okay. These are called Yellow Dog peridotites. And the -- apparently this is the Eagle Mine and this is East Eagle. And apparently there's a dike that comes through this.
Q Why do you say that?
A Well, they don't show one on there, although clearly there

is, because that's where the deposit is. But there's lineaments that go right through it. But in any case, this is where the mine is located. And the materials in which its intruded into are what we refer to as sediments or metasediments. Sediments that have lithofied to rock and then been slightly metamorphosed would be the host rock of the surrounding rock. Where all that development work that I mentioned, all those -- when that incline comes down to the deposit, about halfway --
Q Could you just outline that on this map with your pointer there where the portal would be and then the route?
A Okay. The portal's going to go in here (indicating), go down and come all -- from all the way over there all the way here. If you look at that scale, it's in meters. It's 500 meters. It's probably 700 meters. Come down there and then it's in those sediments where they certainly need to consider the stability of that rock, which is not as good as the dike material. It's going to go in and be developed in those sediments down to the bottom and then the mine will be mined from the bottom to the top.
Q How far in miles is it approximately from the portal to the ore?
A Approximately a half mile.
Q Half a mile?
A Yes.

Q So you're describing approximately a half a mile long tunnel under the ground from the outcrop called Eagle Rock to the orebody?
A Yes. And one of the things that was hard to determine is whether that tunnel portal is going to be in the sediments or it's going to be in the dike material. And it's going to cross a fairly significant fault through there, which is identified in the permit application. But it's not clear what that development rock is going to be -- what it's going to consist of. Because I assume the rock that's going to be coming out of there, that's going to be the development work that make all those access tunnels. It's going to go into the temporary development rock storage facility. It's not clear to me exactly how that type of rock that's going to be in -- it's an issue.
Q What is that bottom line sort of going across the bottom corner there?
A This (indicating) one?
Q Yeah. Could you read that and explain what that means?
A Well, that's a major thrust fault that, again, has been identified through electromagnetics. But this whole area is very close to the Great Lakes tectonic zone. And this whole area had been thrust up. And that's just a -- it's a major feature through the Upper Peninsula of Michigan.
Q Is that significant?

A Well, I think when you look at the structural history or the tectonic history of this area, you've got a lot of things happening at different times. Mr. Parker mentioned the development -- or mentioned the mid continental riff zone, which was the initiating factor in the development of the Great Lakes or at least Lake Superior. And then after that many things occurred tectonically. You had high compressional stresses at one time that created these thrust faults, and then they moved away and then dikes moved up in them. It's a very complex site.
Q Okay. Have you ever been to the Athens Mine area?
A Yes.
Q And what did you observe there?
A There's a significant amount of caving ground. There's the whole area around Negaunee has got a lot of caving ground that occurred from a number of mining operations. Not just the Athens Mine, but there's a lot of collapsed structures in the Negaunee-Ishpeming area. But we specifically went and looked at the Athens Mine collapses.
Q And why was that of interest to you?
A Well, the Athens Mine was referenced in the Sainsbury report. And I referenced it in my initial report to the National Wildlife Federation when you asked me to review this permit. And I thought it was a significant event. And it's referenced in just about every textbook on plug

failures on subsidence will mention the plug-type failure will reference the Athens Mine as the classic example of a plug failure.
Q Have you read this document here described as chapter 16 of a textbook by authors Brown and Brady?
A Yes; Brady and Brown.
Q So you've read this?
A Yes; yes, I've read this chapter.
Q Can you help us understand why this is relevant to the discussion we're having about the Athens Mine?
A Well, the title is "Mining-Induced Surface Subsidence," and it goes through the different types of subsidence that you can get; different from pillars collapsing to chimney failures, which is technically what they refer to as a plug failure. And typically they will give examples of those types of failures. And this particular book which dealt with mining, rock mechanics and mining, again used the Athens Mine as an example of a failure. It's -- if you go farther down you will see that their collapse.
Q How thick was the crown pillar of the Athens Mine when it collapsed?
A It was 1800 feet thick.
Q The crown pillar was 1800 feet thick and it collapsed?
A Technically, what would be considered the crown pillar, which was everything from the old void that they created to

the top of bedrock was roughly 1800 feet. This one right -- yes. This is from -- this was mined underneath here. These were the dikes that caused the structural weakness. And according to Crane, who investigated this in 1943 -- 1934 for the U.S. Bureau of Mines -- he studied this fairly extensively -- and he identified these dike structures as zones of weakness. He also identified the fact that there was a progressive type of failure in this failure where the -- once you opened up that mine underneath it allowed water and oxygen to move down along those zones of weaknesses. And over time it actually caused an oxidation of the rock types and a weakening of that interface structure by allowing water to move through it down to the bottom, and then that water was pumped out. And he suggests that that was the -- one of the reasons that this large 1800 foot chunk of rock collapsed into the openings underneath.

Q How far is this site from the Eagle Mine, the proposed Eagle Mine?

MR. LEWIS: Wait a minute. Objection, Your Honor. I merely want to restate the objection I made at some length yesterday as to the relevance of discussions by the Petitioner's experts as to other mines without a proper foundation. And if I can rely on the objection I made yesterday, I will do so.

MS. HALLEY: Your Honor has already made a ruling on this issue.

JUDGE PATTERSON: Right; just reaffirming the objection.

MR. REICHEL: Yes. And again, just for the record, we have a parallel objection.

JUDGE PATTERSON: Understood.

Q How far away from the proposed Eagle Mine is this site, the Athens Mine?

A I believe it's about roughly 25 miles.

Q And yesterday we saw some photographs of the Ropes mine that was also collapsed in a similar fashion. How far away from the proposed Eagle Mine is the Ropes gold mine?

A I believe it's about 15 miles -- 12, 15 miles.

Q Is it your understanding that there are other collapsed mines in the region?

A Yes. The paper I reference by Crane 1934 looked at the -- specifically was looking at the collapses in mines, both on the Keweenaw in the copper mines and then the Marquette mines. And the paper discussed the issues why there are so many more collapses in the Marquette region versus the Keweenaw in the copper mines.

Q Is it your opinion, Dr. Vitton, that the geology of the proposed Eagle Mine is very similar to the geology of the Athens Mine?

MR. REICHEL: Objection; leading.

MR. LEWIS: Objection; foundation.
JUDGE PATTERSON: Can you rephrase?
Q Is the geology of the Athens Mine similar to the geology of the proposed Eagle Mine?
MR. LEWIS: Objection; foundation.
MS. HALLEY: We've discussed the geology of the proposed Eagle Mine. We've discussed the geology of the Athens Mine. I'm simply asking the witness to make a comparison.
MR. LEWIS: I haven't heard much about the geology of the Athens Mine, I don't think, Your Honor. That's my objection.
JUDGE PATTERSON: I don't recall there being much testimony about that either.
Q Dr. Vitton, could you describe the geology of the Athens Mine?
A In general, it's the --
Q Yes.
A It's called an iron formation. It's in the Marquette synclinorium in which there's a basin and sediments that squeezed and metamorphosed. Iron got concentrated in certain formations. This is again an iron formation. I think it's jasper, but it's similar in the sense of the Eagle in that it has dikes that come up. And this is a diorite dike -- and diorite is mentioned right there -- that

came up. And there's a number of these dikes and there's a lot of cross dikes here. So they're similar in the sense that this deposit is vertically orientated, has dike structures on both sides that form the planes of weakness that allowed it. So in that sense it's similar.
Q Thank you. This type of failure that was experienced at the Athens Mine and as you testified other mines in the region, is that commonly called a plug failure?
A Yes.
Q Did Kennecott analyze the likelihood of a plug failure at the Eagle Mine?
A Yes. They used two methods to analyze.
Q While this is going on, Dr. Vitton, could you please describe generally what type of analysis KEMC did?
A The permit application C2, C3 and some of the attachments that were later utilized two methods to analyze a plug failure analysis. One was called CPillar, which has been mentioned earlier. And the second one was a scale span concept. Both are put in -- both are in the analysis and both are -- yes, they did analyze for plug failure.
Q We're going to look at figure 29 of Appendix C2 of DEQ Exhibit 26. Is that the correct figure?
A Yes, that's it.
Q Thank you. Dr. Vitton, could you describe the CPillar analysis to us?

A Yes. It's a very, very simple method. It's simply similar to what others have explained. It's simply you identify the geometry, and that's -- this is, again, in the permit application. So this is technically the crown pillar. It consists of the -- this part up here is the overburden and then this is the rock material. And it's simply the weight, gravity pushing down and the strength of the surrounding rock to hold it up. So it does what we refer to in academics, I guess, as a limit equilibrium method. It simply means does the forces holding it up, are they greater than the weight pulling, pushing it down, the gravitational pull pushing it down. So it's a very, very simple program. And it has very simple inputs. The total input to this program are the rock mass rating values, quote, "RMR," the RMR values. That's the only real input and the uniaxial compressive strength values. So you input the geometry, you put the RMRs in -- that's what that is right there -- you give it what you think the horizontal stresses are going to be, and it gives you a factor of safely of simply how much strength is holding it up versus the weight of it pulling down.

Q Is horizontal stress a key component of RMR?

A Yes. Oh, I'm sorry. No. Rephrase your question, please.

Q Is horizontal stress -- or we've been calling it lateral stress. But are lateral stress and horizontal stress the

same thing, different terms?
A Yes.
Q Okay.
A They're the same thing.
Q Is horizontal stress a key component of RMR calculations?
A No, not directly.
Q Okay. All right. Is horizontal stress a key component of this CPillar model?
A Yes.
Q To your knowledge, has there ever been a horizontal stress measurement at the proposed Eagle Mine site?
A Not that I'm aware of.
Q Does the application reflect any?
A No. And in my comments I -- they use a paper that was done on the Canadian shield of stress measurements that were made in Canada. But not to my knowledge that they made an assumption of a lateral stress field of two; meaning that the horizontal stresses are two times what the vertical stress is. But there are horizontal stress measurements in the U.P., the Upper Peninsula of Michigan.
Q Dr. Vitton, does this look like the analysis of the CPillar that you have studied in the application?
A Yes.
Q Could you describe this CPillar process to us?
A The C -- if you look at their assumptions that they put in

here, the basic assumptions that were made in the CPillar analysis, I can go through these, but in general they assume that there's no accurate water level measurements known, so they assume that it's the groundwater was at the surface.
Q Is that a reasonable assumption?
A I think that's a reasonable assumption, yes. The Salmon Trout River is above the formation, so I think that's a very reasonable assumption.
MR. LEWIS: Can I get the page reference again, please?
MS. HALLEY: We're on page 32 of Appendix C2.
MR. LEWIS: thank you.
JUDGE PATTERSON: Counsel, it's noon. Do you want to break for lunch?
MS. HALLEY: Maybe we should before we go through this.
JUDGE PATTERSON: Okay.
(Off the record)
JUDGE PATTERSON: Ready?
MS. HALLEY: Ready. Before we adjourned, I neglected to offer Exhibit 49 which was the section of the textbook.
JUDGE PATTERSON: Oh. Mr. Lewis, any objection?
MR. LEWIS: Is it a section of a textbook?
MS. HALLEY: It's chapter 16 of the textbook.

MR. LEWIS: No objection, your Honor.
JUDGE PATTERSON: Mr. Reichel?
MR. REICHEL: I'll just look at it again. It's -- I believe we have no objection.
(Counsel reviews exhibit)
MR. REICHEL: No objection.
JUDGE PATTERSON: All right. No objection -- it was Exhibit 49? --
MS. HALLEY: Yes, sir.
JUDGE PATTERSON: -- it will be entered.
(Petitioner's Exhibit 632-49 received)
Q Dr. Vitton, I also neglected to ask you, have you ever been to the proposed mine site? Have you ever been to the proposed mine site?
A Yes, a number of times.
Q How many times?
A At least four.
Q When have you gone to the site?
A When? When I started reviewing the permit I went out at least twice, and this past summer at least twice, in the fall, once with Dr. Bjornerud and her students.
Q What types of activities have you done at the site?
A Well, I brought my gradual students out, and we looked at the site, walked around the site, looked if they had done any additional drilling on the site. There are some unusual

features of the site. There's -- in my report to you I listed three what appear to be gouge zones that have a north-south orientation to them, looked at those; tried to find some loose rocks which were peridotite that's great for sauna rocks for saunas, collected some of those. We went over to the Salmon Trout, looked at the outcrops over at -- on the Salmon Trout River, walked through the plains quite a bit.
Q Thank you. Now, we were discussing the likelihood of plug failure at the Eagle Mine. And I had asked you whether Kennecott had analyzed the likelihood of plug failure.
A And I said "yes."
Q And what two methods did they use for analyzing plug failure?
A They looked at -- they used C pillar which we've discussed already. That's this exhibit. This is the output of their -- one of their outputs of the C pillar model which is from a company called Rock Science. And that's the output. But the second method is a scale span method, and that's also in the permit.
Q Now, we were discussing this page, the application.
A Yes.
Q Could you resume your explanation of this page starting with little "I"?
A Okay. These were the assumptions that were used in the

analysis. Again, the C pillar is a fairly simple analysis of the weight of the structure and then how much strength does the rock -- does the strength have -- or does the rock have to hold that crown pillar up or that section of rock that we call the crown pillar. So they've made a number of assumptions in this analysis. Now, the first one was the groundwater. As I said, it was at the surface, which is a reasonable one. They -- for in situ horizontal stresses they lowered them to approximately one. In previous testimony we were discussing horizontal stresses at two times. The vertical stress which is what the "K" represents. "K" means -- 1 means that the horizontal stresses equal the vertical stresses. It would be equivalent to being in water. You'd have the same stresses or pressure in that case. And then they even reduced them down to approximately 0.7 meaning that the horizontal stresses were actually lower than the vertical stress by about 30 percent or 70 percent of the weight -- the vertical stress of the rock. So that's a very conservative assessment. The dip of the orebody in the region of the crown pillar was vertical, so it was vertically -- and the idea is, for this analysis, is that you assume a geometric object which is typically rectangular, and then the depth of the crown pillar, which has been discussed earlier -- roughly I'm going to use 3. Roughly 100 feet was the original crown pillar thickness. The second was roughly 200 feet, and the third one was 300 feet. And this is one of the problems with this permit is the use of metric or system -- SI system over the British system, our feet, it's very confusing. When Marcia was discussing 55 meters of rock, that's really 160 feet of core. So I'm going to try and stay with the British system of feet if I can. But in any case, it's vertical deposit, and then underneath is a void. And that's the analysis.

All the stopes are soon to be open beneath, so we have an opening underneath. Then they added some variability. They assume that are values were plus or minus 10 percent, which is typical. The entire analysis is based on the RMR value, so the RMR values that were used for the analysis were based on the contour plots shown on the figures. In other words, there weren't just the eight. They took the entire database which I assume is 101, maybe more. It's probably 100 -- I don't remember anymore what the data base is, but there's a lot more. So that database was then used to create these colored contour maps which are in the permit. So that one RMR number is the number that describes the strength all the way around holding that block up. So that's why the RMR numbers are very important.

There's one other number that they use and that's this "M" number which hasn't been discussed. But that "M" number becomes a function of the RMR number. They selected an "M" off a table, and that was 25, which is reasonable, that under -- this whole system is based on the work of Everett Hoek and Brown. And Brown is the Brown of the previous exhibit, Brady and Brown, created what's called the statement criteria; in other words, how strong is rock? And that criteria uses a value "M." And that "M" is correct. It comes off the table as 25 plus or minus 5. I think they use 25. My point being is that the RMR, they took one number based on the contour plots that are in the back of the permit. They came up with two numbers, RMR of 75, RMR 85. So that's the number that got put into that C pillar program if we could go back to the output. As I said, it's a very relatively simple model. That would be down in the appendices, Figure 29.

So if we look at this table here, the date of the water height, the overburden height, that's -- this (indicating) is -- essentially those together, that would be the water height. Then this analysis use 1. That just happens to be -- I'm sure they did many. This happens to be one of them; 1 and then 75 with a plus or minus 8 on it. So that's the RMR value they used so they can come up with a distribution of what's called a factor of safety. And the factor of safety in this case would be if I knew the weight of that object, which in this case is the crown pillar, gravitational weight pulling down, they have enough strength plus 20 percent to hold it up. That's what the factor of safety is in this case. So they came up, then, with a series of factors of safeties. So we could look at their table for 75.

Q So page 33, Tables 23 and 24?

A If you could blow those up a little bit, we'll just look at the 75 table. So the discussion this morning centered around things like the span width, how wide it is, how thick it is. This is with T value so you had to do the --

Q Just a minute. Dr. Vitton, can you -- could you walk us across the top of these columns and explain what those symbols mean?

A Okay. The symbols, this is the Eagle Crown Pillar C pillar Analysis. So this was the analysis. There were two presented in the permit, one at 75, one at 85. We'll just talk about the 75 one. The top of the crown pillar elevation in meters, 380, 375, and so the thickness of the pillar is increasing as we go down. And in this analysis -- well, that's crown pillar. This is the dimensions of that block, X by Y, what width and length and then the width. So that defines the block. And then they have the water depth here in this case. It's up at the surface It's zero, meaning it's fully saturated.

Q What about the "T" and the "OB"?

A That's the overburden. If you go back there's a little yellow. They're assuming that there's an overburden sitting on top of the bedrock. And that was an issue I had too in that they claimed the surface of the bedrock is at 415 meters. But on some of the data the bedrock is at 405 which reduces their crown pillar thickness by 10 meters or 30 feet roughly. But we'll assume it's at 415 at this analysis.
Q And what is the "T" column? What is "T"?
A That's the thickness in meters, I believe. Yeah, so 25 would be -- so 25, that would be 405. Okay. So that's 405. They're assuming 405 in this one. So that's the -- the water's all the way to the surface. That's the height of the water. The "K" is the horizontal stress. That's the "K" value, meaning that the vertical stress and the horizontal stress are equal. And then that's (indicating) the assumption of the RMR, 75. That end value, that again is strength. That's the interface -- that's the strength of that interface, not necessarily the rock but the interface strength the way this program analyzes it. And they use 25, but it's actually reduced to 7 in the analysis, I believe. I would hope they didn't put 25 in there.
Q Do you believe it's reduced to 7 from 25?
A Well, if go back to the list of assumptions -- sorry. It's page 33, I believe. Again, the problem is I can only go with what's in the permit, what I was reviewing. Right

here, the "m" value was determined to be -- using this equation here -- okay? And again they've picked 25 off the table. That's published data in Hoek -- Hoek and -- I can't remember the publication, but it's a standard table that's used throughout -- so 25 came from there. Then they use this (indicating) equation to reduce it to 7.5. What that is, technically it's an -- my academic. "M" represents the intact rock strength. It had no fractures and no other discontinuities. That's what it is if I were to take a perfect sample and test it in the acts of compression. But we know that rock has fractures. It has -- it's anisotropic. It had lots of *?1:16:48heterogeneity* and so therefore you have to reduce that strength, and that's what that equation right there does. And that's why the RMR is in there. That reduces the intact strength to what we refer to as the rock mass strength. That's what those sides have to hold up. So they use 25, but I'm assuming the program, they use 7.1 in that program.

Q From looking at this table, can you tell --

A Well, no. This is correct. It's "m," subscript "I." And that's what the "I" stands for, intact strength. So the program internally -- once you put RMR into it, I think the program internally calculates then, although a 75 would not give a 7. But I think this is correct. Then basically then your factor of safety comes out in this analysis here

(indicating), 2.7. That's what factor of safety stands for here. And then there's a probability of failure here.
Q Can you explain the probability of failure?
A Well, the probability of failure, if we go back -- sorry -- they put that -- you can't just use one deterministic strength. You have to have a distribution of strengths in geological material. And that's what that 10 percent in your column came up with. So if we go back to that -- okay. Go down a little bit. Okay. So this analysis here, the results of this is using k=1, a crown thickness of 25 is required. And that gives them greater than a 2 factor of safety based on 75. So, however, if we consider the worst case rock mass of 70 in the crown pillar, the "k" value reduced to .7, they end up with greater than a 2 factor of safety. The problem with this analysis, I believe, is that in the RMR calculation, they did not take the adjustment factor. They have the A1 through A5, but the adjustment factor for vertically orientated structure should have been a minus 12. So they should have simply reduced that RMR value of 75 by a minus 12 or 62 in this analysis. Now, this is just an example. We need to go to their data. This is an example. Farther down, I believe. Okay. We need to get to the more realistic. That was just an example. Okay? This is where they're optimizing their scale. I think we're in a scale span. Okay. Go back, back up.

Q We'll come back to this. Okay?
A Okay.
Q So in your opinion, are the -- could you explain the meaning of the factor of safety numbers that Kennecott arrived at in this analysis?
A Okay. Well, this is the scale span. That's the other method. And the other -- we're looking at the wrong data. We need to be in C3, the tables and appendix C3, not C2.
Q But I'm asking you to explain the last column.
A The probability to failure?
Q Yes.
A Okay. The probability to failure, I can explain it if I go to Exhibit -- or Figure 29 in this. All right. In this analysis here -- this is an actual analysis here, came out with a factor of safety of a little over 2. That's where their value -- and what we mean by "probability of failure," meaning that it could be plus, meaning it has a higher factor of safety, or lower using some type of probability distribution. Usually we'll a normal distribution which means you have an equal probability either way, which means that it could be as low as a minus 1.7 -- 1.74 and as high as 5.85 giving the variability of the data.
Q Let's just take this example. So the range for the factor of safety in this example is 1.74 --
A To as high as 5.85 here. Again, in this case here it's

giving us 2.05 plus or minus 1.26, so that means that 69 percent of the data falls on either side of the peak. So that's the result of this analysis.

Q What is the factor of safety of 2 correlate?

A Means the strength of the wall of the strength holding it up is 2 times the weight of the object of the block.

Q So would that probably stand up?

A Yes, in that case it would stand up. But again, it's all predicated on the RMR of 75.

Q So, given that, do you believe that this is an accurate analysis of the factor of safety?

A I think it's a very simplified analysis of the factor of safety. This is a very simple model.

Q Is horizontal stress a key component in a C Pillar analysis?

A Yes.

Q And to your knowledge, are there any in situ horizontal stress measurements included in the analysis?

A Technically the RMR value is the main input to this program. They came up with one value for RMR which is the assumed value around the outside of that block. That's the input number RMR. The second input, then, is the horizontal stresses or the -- we don't know what the horizontal stresses are. We're making the assumption. We can calculate the vertical and we're going to multiply by two times that to get the horizontal or 1 or .7.

Q So my question was, is there any measurement, actual measurements of horizontal stress in the application?
A No, there are no physical measurements.
Q Dr. Vitton, have you ever met Mr. Jon Cherry of Kennecott Eagle Minerals Company?
A One time --
Q One time?
A -- after he gave an presentation at Michigan Tech showing the Eagle Project. I think there was a group of people, Jon Cherry, Joe Maki, I think he was there, Ted Bornhorst and Alex Mayer (phonetic) I believe was at that meeting.
Q When was that?
A It was in the fall a couple years ago.
Q In the absence of actual measurements, would it be helpful to have information from other mines in the region about the horizontal stress fields there?
A I think so. It would be useful, very useful.
Q Did you ever offer any data to Mr. Cherry?
A Yes. When the White Pine Mine closed down I asked for all of the stress measurement data that they had taken in the White Pine Mine. And there was a company by the name of Agapito that had done fairly extensive underground overcoring measurements and other stress measurements in the mine and I didn't want to lose that data, so I have that all -- I have all that data, so --

Q And did you --
A And I did offer it to him if he was interested in it.
Q What was that last part?
A I did offer it to Mr. Cherry if he was interested in it.
Q Did he take you up on your offer?
A No. No.
Q Is there any reason that horizontal stress measurements could not have been gathered at the site?
A Well, they have a lot of boreholes, and there's two measurements they could have taken that would have helped in this analysis. One would have been what we've been talking about by other -- Mr. Parker and Dr. Bjornerud dealt with hydraulic fracturing-type measurements which may have been useful, might have been useful at the site, given an estimate of a number of things; how the ground would respond to stress, pressure.
Q And is gathering that sort of data after mining begins the best method?
A Well, I think again this is an unknown mining area. This is an area they had -- there are no mines specifically in this Yellow Dog intrusives and the Yellow Dog peridotites. So it's similar to wildcatting in the oil industry where you put a well in where you don't know anything there. I think that getting as much information from the drilling program as they could have would have been wise and useful because

of the method of mining that they planned to undertake, which is to start mining at the bottom of the mine as opposed to starting at the top of the mine where the stresses are lower and that sort of thing.

Q Have you seen an exhibit called Intervenor 592? It's titled --

A Is that the --

Q It's by Golder Associates called "An Evaluation of Possible Hydraulic Conductivity Changes Due to Mining-Induced Stress Effects, Eagle Deposit Crown Pillar," submitted in April of 2008 as an exhibit to this proceeding -- proposed exhibit?

A Yes, I have a copy of that, and I have looked at it.

Q Does this document recognize any measured horizontal stress at the site?

A Not that I know of. That has to -- that is an analysis of the permeability of the crown pillar, and I think all of the input parameters to model were assumed based on information they may have -- already have or -- but there were no measurements. And one of the critical parameters for that particular analysis is the stiffness of the rock or the modulus of the rock.

Q Let's come back to that when we talk more about this document. So if the horizontal stress that's been assumed here is incorrect, what does that do to the calculations about RMR?

A It doesn't change the RMR values.

Q Okay. And what does it do to the C pillar calculation?

A Well, if the horizontal stresses are higher in a -- the other thing we have to consider is these -- we're assuming that we -- when we -- in this model because it's a relatively simple model, it's assuming that the horizontal stresses are the same in all directions. They're not. Typically we're going to have a principal stress in one direction and a minimum horizontal stress in another direction. So it's not as simple as having one horizontal stress around the entire block. We could have a major stress in this direction and typically the minor stress, 90 degrees to it, in the other direction. And that model doesn't take that into consideration.

Q Let's move on to the scale span method of assessing the likelihood of plug failure. We're going to look at Appendix C2, Figure 28 of DEQ Exhibit 26. Could you describe in a general way the scale span method?

A Yes. This figure here is extremely relevant to that analysis.

Q Could you describe it just in words before we talk about the graph?

A The scale span method is a method that takes actual data of mines around the world and scales them to a certain value called C sub s so we can compare them all. So they're different sizes and different crown pillar thicknesses. And we want to come up -- we want to be able to compare them. And then we're going to compare that to the rock quality. And some failed and some stayed -- did not fail. And so this method then is going to look at the scale spanned of the crown pillar and then plot it on this figure to determine whether it sits below in a stable condition position or above the red line in the unstable region. So this separates those that fail from those that have not failed. In general, there's -- there's a spattering of both on both sides, but in general that was the estimate made in this method.

Q Now could you describe how that idea is portrayed on this graph?

A This axes here is a scale C sub s, and that's -- again, this is a number in which we attempt to normalize, to get all these crown pillar on a similar basis. So you come up with this. And then this value up here on the top in this case is called NGI Rock Quality Index Q, which is very analogous to RMR. The entire permit is based on RMR's. They then have a little equation in here that converts them to Q. So you have C sub s and Q. You plot it on your -- in this case here, their analysis came for an RMR 85 in this region just below the line in which this region up here is unstable. This (indicating) is the stable region. And this section

right here is -- crosses over from stable up into the
unstable region with their -- this is their data.
Q The small orange dots that appear to be above the red line,
what does that represent?
A That would represent that the -- if this was --
theoretically it would mean that they would have failed or
be unstable.
Q That what would?
A Or be unstable. They would be unstable. And that's --
again, this is an RMR 75 and RMR 85. And it's based
strictly on the one number of 75 and the one number of 85.
Q So this graph is directly out of the application?
A Yes, this is figure 28 of the application.
Q Thank you. So just so that I understand exactly what you're
saying, the numbered -- the colored dots on the left-hand
side that are orange --
A These numbers right here (indicating).
Q -- and then going down to blue, some of those cross that
line of likely failure?
A Yes. This red line here is called -- if you can see this,
it's called the stability line. And the way it's
theoretically to work is that above this line a scale span
would not be stable and is likely to collapse. If it's
below line, then it's likely to be stable.
Q And of the next series of dots, the green dots --

A This (indicating) region?
Q -- uh-huh (affirmative) -- did those approach the failing line?
A Well, they were getting pretty close. Again this is an RMR of 85 which is very competent rock, very good rock.
Q Dr. Vitton, if you were designing a mine like this, would you be pleased with these results and want to proceed with the project?
A No. I would be concerned. It is getting close to that stability line, and this is just your first rough cut. And you're already assuming 75 and 85 for your RMR. If we could go to the this -- to the equation that shows how you get the scale span, I think their assumptions are important here too. This figure right here, this whole section is the 1976 RMR classification, so this is what we've been talking about their RMR's are based on, so that's fine. Just keep going to the next page.
Q Just a minute there. Let's -- you've said a number of times at this point that the RMR is the basis for this analysis?
A Yes.
Q Is that reflected in this table someplace?
A This is the table that they utilized to come up with their RMR. They used the 1976 version of this system. And so it's very similar to what Dr. Bjornerud went through. You've got your A1 parameter which is your strength. Your

RQD was A3, spacing A3, the condition of your joints, A4, and then your groundwater A5, each one of them giving different values for -- to develop their RMR. And then there's -- and if you go back here (indicating), here's the rating -- this is the adjustment for joint orientation. This is very important for tunnels, and that is where this permit would be; for tunnels that -- very unfavorable orientation. In the analysis of the crown pillar you have this body of rock that's vertically orientated with a void underneath; that is, your vertical orientation is 90 degrees would give you a minus 12. So all their numbers should have been for the crown pillar assessment subtracted -- had 12 points taken off of them. That figure was not included in their -- any of their discussion in C2 or C3. That's not including -- if we could go to the equation for scale span that's up on page 31 or 33. I can't remember.

Q Page 31.

A Oh, just leave it right there. I just want to make this point too. This is how they got to the Q, by simply taking their RMR, 75, 85, minus 44 divided by 9, take the exponential of it, and that's how they got Q. There was no separate Q developed for this. I believe, in what I've read that they used -- well, they did use this equation to come up with Q to plot the scale span numbers.

Q And with the RMR assumed value of 75, one analysis at 75, one at 85?

A Yes. That's their analysis for the stability -- for the crown pillar stability.

Q Thank you.

A So, if we could, go up to page 33, I believe.

MS. HALLEY: So we're on Appendix C2, page 31, Tables 21 and 22 of DEQ Exhibit 26.

A Yes, we're on C2 right now. That's where they explained the analysis.

Q Dr. Vitton, can you explain the pertinent pieces of this analysis for understanding the scaled span method?

A Yes. I'm trying to get to the equation of what it's based on. I thought it was below this or just above it or below it, one or -- it's above it. Okay. Yes. I'm sorry. Here it is, right there. Okay. All right. So this was discussed this morning, and this is the C sub s, and that's the crown pillar span is S, and that's the term right there. So we want to go through some way to make it normalized with other ones. We want to be able to compare it so I can put it on that chart. So S is the span -- crown pillar span. This is the density of rock which is just the density of rock. It could be 180 pounds per foot cubed, although the units a little odd. They have T, and that's T, thickness of the crown pillar, but that's tons per meter cubed. So anyway, that's the thickness of the crown pillar. T goes there. And then this is the ratio of this crown pillar to the length of the crown pillar. This whole thing basically -- this term right here is a little complicated, but the dip is -- the cosign of 90 degrees is zero, so this whole term drops out in this analysis here. So it turns fairly simple, but this is a way to take any span and to normalize it so I can put it on that chart, and this is where this came from. So if you go down a little bit. Okay. Now, I want to read this point right here.

"In this equation, all the parameters are relate to the geometry of the crown pillar. The effects of groundwater and clamping stresses are included within the determination of RMR."

They did not assume any groundwater conditions for their RMR. They assumed that it was dry.

Q Well, they assumed something. What did they assume?

A They assumed dry conditions. So, in effect, this analysis is assuming there's no water in any of the joints.

Q Is that a reasonable assumption?

A In my opinion, no, not with the fracturing that we saw and the condition of the cores that we saw. So I wanted -- so that's -- everything's tied up to RMR. That's why it's so important. This point right here (indicating), then, simply says that of the -- this is again -- this is another equation to compare your scan -- span pillar -- can't get

these terms right here. But basically the width of the crown pillar has to be greater than this (indicating) value here. So this is just another factor of safety issue.
Q Let me go down to the tables.
A Okay.
Q Dr. Vitton, this is a similar table to the table we saw before on the C pillar analysis.
A Yeah, and that -- this is more realistic data in this one.
Q Could you walk us across the top of the table and tell us what the columns mean, please?
A Okay. The first one is a top of crown pillar, 380, 375, so it's going thicker as we go down from 380 to 340. The dip is consistently vertical the whole way. This is the thickness in meters. This is the span, the length of the -- that's the width -- it would essentially be the width of the dike that they're mining in that section. And this is how it's scaled using that equation that I -- so the RMR value is put in here. They are assuming 75 here. They use that equation to get the equivalent. And this is the scan to scale spanned number which is the equation above that, and then this is the factor of safety. So using this method of -- RMR of 75 for, for example, a crown pillar of 365 gives them a 103 which is right at failure. All these numbers above means that it failed.
Q Above what? All the numbers above what?

A All numbers less than 1, .82, .87, .96, assume failure. 1 is just about at -- just a little above failure. And then these are the numbers above the -- as the crown pillar gets thicker, then this shows that it's getting safer, but not by much 'cause you're only up to 1.35 at a 340 crown pillar.
Q So with a factor of safety of 1.35, what is the likelihood of failure?
A Well, it has about a 35 percent -- 1.35?
Q Yes, the bottom --
A It has about a 35 percent -- it's got an additional 35 percent margin of error, if you will, from failure. Again, it's all based on 75 being the -- so if this (indicating) number drops, then all these will drop.
Q Has the DEQ done any calculations on the factors of safety for the C pillar method or the scale span method?
A I don't know.
Q I mean in the materials you've reviewed.
A The DEQ?
Q Right, their consultants, either Mr. --
A No, I have not seen any; no.
Q Okay. Thank you. Back to the changes in the thickness of the crown pillar from roughly 100, 200, 300. They've changed over time. Even with the thickest crown pillar, do you continue to have concerns about the stability of the crown pillar?

A Yes. In my analysis based on the information that I reviewed in this report, there's two adjustments that I believe should have been made that reduces that RMR 75. The first one is that it should have had a reduction of minus 12 because of the vertical orientation of the crown pillar. Then it should not have had a dry condition for the A5 parameter.

Q We're going to talk in more detail about that in just a few minutes.

A Yes. So my assessment is that based on what I reviewed, that it is not a stable condition based on the information in the permit.

Q So do you believe that plug failure is likely to occur at the Eagle site?

A Yes, based on the mine plan presented in the permit.

Q And the whole rock mechanics analysis is based on these RMR figures?

A Yes. The two analyses used, C pillar and scale span method, all rely on the RMR value.

Q If the RMR values are flawed, what is the impact of that on the stability analysis overall?

A If the actual numbers are lower than the stability analysis, it means that it's less stable. And if the values are higher, then it means it's more stable.

Q And is your believe that the numbers are higher than

reflected in reality or lower than reflected in reality?
A My opinion is that they're lower.
Q Let me rephrase that question. Do you believe that the RMR's in the application are higher than the actual value of the rock or lower than the actual value of the rock?
A They're actually higher than the -- they're higher.
Q Okay. Would it be best to be able to look at the cores and at the drillers logs in order to assess rock stability?
A Yes. That's when we -- when you asked Mr. Parker and I to review this permit, we asked you if we could see the drilling logs -- the drillers' logs of the drilling information that went into creating these values that go into the RMR calculation.
Q Okay. Would it be best to actually see the cores and the drillers logs in determining RMR values?
A Yes, I think that would have been helpful. The drilling lots would have been very helpful. I would have liked to have know when they were drilling -- when they're drilling, they have to use water. And when you get into a lot of these fracture zones, you're going to lose your water, which is telling you something about the condition of the rock at depth. We were not able to evaluate any of that information to see what -- how the drilling operation actually went.
Q When did RMR's and RQD's become part of the rock mechanics field, sort of standard practice?

A In general, RQD was developed by Deere and Miller. Deer I think was at the University of Illinois. It was primarily made for civil engineering applications and then later usefulness of it became apparent in the 70's and 80's, and then Bieniawski at Penn State developed the RMR calculation and came out with his 1976 RMR. There are a number of others -- of Mass Rock Rating systems developed. Probably the most common ones are the RQD, RMR and the Q system which was developed by the Norwegian Geotechnical Institute, NGI. But they were primarily developed for civil engineering applications and evolved into the 80's and 90's and today into mining applications.
Q So these are relatively new arrivals in the rock mechanics field?
A Relatively, yes. When I went to school, we didn't necessarily talk about -- in the 70's RQD's and RMR's.
Q So without using RQD's and RMR's what would a mining engineer use?
A A mining engineer, I assume, would have looked -- if I was designing a mine, would have investigated all of the core that came out of the -- out of the -- that were drilled. They would have talked to the drillers, gotten the drilling logs, got in as much information as you possibly could have to understand the rock. There's no mine nearby that they could go into to look at the Yellow Dog peridotites.

There's mines -- in the surrounding areas there are extensive mines, but not in the Yellow Dog peridotites.
Q Are there other important components to assessing crown pillar stability other than RMR's?
A Well, as Dr. Bjornerud stated this morning, it's very relative. It's a rough estimate of how the rock's going to behave. It's a system that tells us in general how the rock should behave based on prior experiences and knowledge from other operations. The change from 1976 system to the 1989 was to include more information in mining-related operations. And so the '89 system was more adaptable, had more information, more experience in it into applying it to what the rock behavior will be.
Q If you were contracted to assess the crown pillar stability of this mine, what general steps would you follow?
A Well, I would have -- I would have certainly wanted to talk to the geologist. The geologist would understand the geologic formation of the deposit. This is -- in one way it's relatively straightforward being a dike and host rock. But in another situation it can be complex, but I want to understand and get an idea of the model -- or what the geology of the site is. I want to know what the structural geology is and then how the ore was put in place, what their best knowledge is. And then I would work with the drillers to get as much information as I could from the drilling, the

core logs and, of course, I would certainly want to talk with the person who was at the site. When the core came out of the core barrel is when those fractures should have been looked at to determine whether they were broken while they were taking them out of the drill core or whether they were actual joints and fractures that exist in the rock. Otherwise, once they're put in those boxes -- they're broken and put in those boxes, it's very hard to make that determination.

Q Have you had an opportunity to look at Kennecott Exhibit 303, which is --

A The Coombs? Is the Coombs one?

Q Yes.

A Yes; yes.

Q Page 17. Could you look at those paragraphs at the bottom of the page there and describe the procedure this talks about?

A Well, one of the parameters that's used to come up with the RMR number is the RQD which forms the A2 parameter. And this does describe their RQD. It says:

"Rock Quality Designation, RQD, was recalled as the length of all solid core greater than 10 centimeters long. Driller breaks were put in red," meaning to get them in the box you had to break them. "Artificial broken joints and artificial broken zones were ignored when measuring RQD. The RQD core measurement was directly entered into the 'RQD' field of the Access Geotech form. Alternatively non-RQD core could be measured and entered into the 'calcRQD'" -- again, that's all they say about RQD in this writeup.

Q Could you read the first sentence again?

A "Rock Quality was recorded as the length of all solid core greater than 10 centimeters long."

Q Is that a proper way of recording Rock Quality Designation?

A It's part of it. The RQD is a -- you divide. You have to divide by the length of the run, so if their core barrel was -- if they drilled ten feet, then the length is ten feet. And then the solid core could be less that came out of the -- or it could be ten feet. It could be something less, but you divide that summation. So they added all those core -- solid core greater than 10 centimeters long, but then they have to divide it by the length of the run.

Q Does this document discuss dividing it by the length of the run when they're recording the RQD's?

A No. It's confusing to me what they did.

Q What would be the impact on the RQD's if, indeed, a driller simply followed these examples -- these directions -- excuse me -- directly from the handbook?

A Well, I'm assuming that this calculation of adding up all the lengths that are greater than 10 centimeters, which Mr.

Parker refers to as two diameters of the core which is 2. -- 2-1/8 inch diameter, so it's roughly 10 centimeters. You would add them up. That's good. But then you have to divide it by the length of how much rock did they drill? Did they go from a point to a point? That's the length that has to be divided by that.

Q My question is, what if the division was not done as it not discussed in the Eagle project's data collection and analysis procedures document? What would the impact on the RQD's be?

A You would have incorrect RQD numbers.

Q So if someone followed, in fact, this document, the RQD's would be incorrect?

A Yes. If they took and called that number, the length of all the core added together, RQD, that would be incorrect.

Q Is that what this seems to indicate to you?

A This is what's written there. Yes, that's what it says.

Q Have you ever asked to see core logs or cores from the Eagle project?

A Yes. We asked you many, many times if we could see -- or get some information about how all those numbers are generated in the permit. What we had to review was simply the colored, computer-generated pictures at the end of the permit of C2 appendix and Appendix C. That's all we had.

Q So what was the outcome of your request?

A The first -- I think we asked numerous times, but the first time we were successful at getting the core -- or drilling information, you sent it to me. I looked at it. And I was a little surprised because I was at that time working on the Michigamme mine, and the rock types in the Michigamme mine were the same as this core that I received. And they happened to put the latitude and the longitude in it, and I figured it out that it was 48 miles from the Eagle Project in the Marquette mining -- or Marquette air mine area near the Blueberry mine, I believe. So it was in the iron mine area.
Q Was that information useful to you in any way in reviewing the Eagle project?
A No; no.
Q And did you ask again for drilling logs and core information?
A Yes; yes. Mr. Parker was especially assistant that we get that information. And so we many, many times asked you to keep attempting to get it.
Q Did you eventually get some of the information you had requested?
A Yes. I believe in August of this year, 2008, we --
Q In August of 2008?
A 2007. I'm sorry.
Q Thank you.

A I'm trying to get out of here.
Q What did you get in August of 2007?
A We got two CD's which included eight boreholes, six of which we could locate, two which we could not which were done later, 99 and 101. We received those and then the core boxes were photographed in a dry condition, and then they sprayed water on them to help bring out the -- be able to identify them. And so we had two pictures of the same core box, one dry, one wet, through each of those eight boreholes. And then below that was a Excel file -- set of Excel files that gave the RQD and the RMR numbers for those eight boreholes.
Q Did you look at the photographs?
A Yes.
Q Did you examine the tables?
A Yes.
Q What was your initial reaction related to the quality of the rock that you observed in the material?
A My first reaction was that it seemed fairly fractured up in that the -- I was surprised. It was fairly fractured based on the pictures that I saw.
MS. HALLEY: For the record, these are the photographs that have been admitted in Exhibit 116 -- Petitioner's Exhibit 116.
JUDGE PATTERSON: Okay.

Q Why were you surprised by the, as you described it, fractured nature of the core in the photographs?
A In my non-geologic -- I'm not a professional geologist -- had a simple model of the mine. It was a dike and host rock. I expected the contact to be a problem. Because as you intrude this up or this intrusive comes up -- and as Crane pointed out in his, that typically those sidewalls tend to be relatively fractured. I expected to see that. But I expected the metallic or the sulfides to be relatively intact just for no other reason than I assumed it would be. So I was surprised how fractured it was, how broken up it was. Clearly something is going on in this deposit that's not normal, to me.
Q What is your understanding of a rock mass reading? A simple explanation at this point.
A It's very similar to the previous witnesses, Mr. Parker, Dr. Bjornerud. The rock mass reading is a combination of five parameters with one adjustment that attempts to give you a sense of how the rock performed under various types of stresses in that type of analysis.
Q Okay. And this report by Trevor Carter and Miller, does this report discuss Rock Mass Rating?
A Yes, I believe it does. There are a number of them by Dr. Carter. Again indirectly the *2:0457* Q&R Mar method is typically the method used.

Q I'm sorry. That's not the correct exhibit. I apologize. Okay. Are there two -- at least two industry standards for determining RMR's developed, one earlier, one later?

A Technically there's one method that Bieniawski developed at Penn State called Rock Mass Rating. And other people have adopted it. But --

Q Okay. Is there a method called RMR 76?

A Yes. That's the first method -- the first method -- the first system that was developed. It was later evolved with additional information to come out with the 1989 method, which is identical. They made -- they added additional information to it, more experienced, to come out with hopefully a more -- a system that's going to be more useful.

Q And in either of those methods, is it acceptable to ignore RMR data when assessing the crown pillar strength?

A No.

Q Is it your understanding that the application did that?

A When I first reviewed the application, it was sort of a moving target trying to review this application. Information seemed to be coming -- finish it, then there'd be another report that you had to review. The -- so we didn't have any RMR information. So all we had were the -- that's not correct. We had all of the colored computer-generated images at the end of C2 that were used, in part, and some in C3. So we assumed that the data that went into that was all of the RMR information that they had available. What was disconcerting about the permit application to me was the end of section -- appendix C2 when they had a section called "discrete features." Yes.

Q This is from --

A Yes.

Q -- appendix C2 --

A Yes.

Q -- of the application. Could you read the portions of this that are of concern to you?

A Yes. They identified -- they did -- all of the drilling information was put into a computer database -- an access database according to this. And then they used a modeling program called GoCAD, which is a program that will take information and interpolate as well as extrapolate the data so you could get an image of it over an area. So you had points. Somehow you have to be able to see how that relates -- those points related to each other and come up with an image. And that's what the GoCAD model did. So they put it in there, which is fine. There's certainly no problem with that. And then --

Q So there's no a problem with the GoCAD model itself?

A I have one problem with it, and that dealt with the fact that, in C1, the geologist who interpreted the drilling information utilized an older method. They did not use --

my understanding they did not use GoCAD; they used some other model that used the method called inverse distance squared. And it's hard to relate that data. That's an older type of analysis. They came out with -- the deposit shown in C1 was done with a different interpolation model. The GoCAD is a more modern model that uses a geostatistical method called Kriging that is a better method to relate this data. So there's a disconnect between C1 and C2 when we're looking at this. But all the information they had put in there. And then they went through what they called a -- I can't say the word -- they went through the model and found all these discrete features that Dr. Bjornerud talked about this morning. And they looked at, for example, the estimated strike of a fault plain, and asmuth* 2:1027 and dip is -- RMR values the fault plain are 60. So they are recognizing some structure. But this where I got surprised and made me wonder about whether that information in those models were actually all of the information. And that came in this paragraph. Based on the information in the two Microsoft access databases, there have been other discrete structural features identified in the Eagle project. These discrete features have been stored in a separate table of database instead of being included in the main database. A review of these discrete features indicate there are three types of structural features; broken core zones, shear zones and fault gorge zones. The broken zones, 1 to 7 meters roughly, up to 21 feet length -- or 25 feet, make up the majority of the discrete features compared to the gouge zones, which are .1 to .4 meters of core lengths and the shear zones approximately 3 to 12 feet in length.

Q In plain language, what does that mean to you, Dr. Vitton?

A It appears that they had all these structural features in their drilling information and they pulled it out and didn't include it in the analysis of the RMR values for the deposit. That's what it appeared to me that they did. But I can't state, in fact, they did.

Q Based on the application, is that your belief?

A Yes. And so when I went to the first image that compared RQD and --

Q Just a minute. We'll do that. Could you keep reading?

A "These structural features identified during the logging have not be incorporated into the GoCAD model" meaning that they left out all those features. And so that set an alarm bell off in my mind that -- to start asking more about where these RMR's and RQD's came from and how they got into the -- what got in there and what constitutes those images. Because, remember, the CPillar and the C span are all based on those images -- the RMR images.

Q We're going to look at an image in just a moment. Dr. Vitton, does this table give more detail about those --

A Yes; yes. Yes, these --
Q -- structural features? Could you describe and explain what this table means to you?
A Well, the title is "Major structures crown pillar area." So this is what they found in the crown pillar. And they identified hole 55, 60, 62, 64, 67, 69, 99 and 101 were problematic holes with these features that I just mentioned about in there. And so they have lengths -- depths, lengths, zones, sheared, broken, broken, that sort of thing, and then comments on that. So it appears that this information wasn't modeled in that GoCAD model.
Q Does it appear to you that Kennecott's RMR's included the data from these discrete features?
A When I was -- no.
Q Does the application --
A No.
Q Should it have?
A Yes.
Q Does the application demonstrate that an acceptable RMR determination method was used?
A The application does not in the sense that I can't -- I don't know how they did their -- I don't know how the information from the drilling go into all those models, all those images at the end of the permit application appendix C2 and C3.

Q And why don't you know that?
A Well, they explain -- if you go in the section of the permit where they describe A1, A2, they say this is how we did it -- or this is how you do it but not how we did it. Well, that's not true. That's not correct. They created -- you've got to remember they're taking core and somehow have to get it into a computer program. So they have to make algorithms or ways to take that data and get it into the computer. And they explained that, but that's all. There's no other data in this permit application except at the end of the C2 and C3 applications or appendices.

MS. HALLEY: Your Honor, we're at a breaking point here. I mean, I can keep going if you want. But we're going to start sort of another big piece.

JUDGE PATTERSON: You want to take a break now?

(Off the record)

Q Dr. Vitton, before we move on, could you explain Table 6 to us, please?
A Table 6 is -- I believe this is appendix C3?
Q That's right.
A This was a later -- this was titled "the subsidence analysis," appendix C3. They've corrected their last tables that were saying "top of crown pillar," should have said "bottom of crown pillar." This is correct.
Q Okay.

A The other ones were not. But this is the bottom of the crown pillar, vertical height. Thickness of 57.5 meters, a span of 68 meters, the length is 50 meters, and then using the equation which we've talked about gives a scale span of 9.7. There's three RMR's analyzed here; 70, 66.4 and 60. And what this says -- this analysis in Table 6 says -- or indicates that a factor of safety with RMR of 70 gives a factor safety of 1.2, meaning there's about 20 percent additional strength in the crown pillar to hold it up whereas, at an RMR 66.4, you are at equilibrium. In other words, the weight of the crown pillar equals the strength holding it up.
Q Does that mean it's likely to fail or not likely to fail?
A Well, theoretically if you were to take -- although this method is based on real data. The scale span method takes actual collapses and actual cases where they don't collapse and makes this analysis. But at 1, it wouldn't know what to do, it could or could not. But if it's below at 60 -- 60 you would have -- it's really irrelevant to have a .7. It just means that it's -- the weight of the structure is higher than the strength holding it. So it theoretically should collapse.
Q And this document was created before or after the crown pillar was thickened?
A After. This is at the --

Q After.
A -- 57. -- yeah, this is the second one, not the third one. There were three crown pillars discussed; one that was roughly 90 -- I call it the 100 feet roughly. That was in the first analysis. The second analysis increased it to roughly 200 feet or 57, and that's what this is roughly. The third one, an addendum, I guess you call it that was on the DEQ website from a report that Dr. Carter did I believe, or Golder did then brought it down to 300 feet.
Q So this the --
A This is the middle one. This is --
Q The 200?
A Yes, the 200.
Q Roughly 200 feet. Okay. Would your interpretation of this change if the crown pillar column there, T -- if that was thicker? Would it really change the factor of safety?
A In this case, yes, it would change the factor of safety. The factor of safety should go up in this one.
Q Okay.
A And if you read the crown pillar -- under this analysis, the crown pillar is predicted to be potentially unstable when considering minimum values around 60.
Q What would you expect the factor of safety column to look like at, say, 3 with the thickest crown pillar?
A Well, in my opinion, it would depend on what your RMR is for

that analysis. So if the RMR's went down, then the factor of safety would go down.
Q Do you think it's reasonable to rely on a RMR of 70 based on the materials you've seen?
A No.
Q Thank you. Dr. Vitton, we've talked about RQD's and RMR's. This is a picture. What is this a picture of?
A This is what I've been referring to as the images at the end. This is where the data that the GoCAD model generated with the input data that it had. And this was the -- the upper one is RQD and the lower one is RMR.
Q Now, just to refresh our memory, what is RQD?
A Rock Quality Designation. It's the A2 parameter in the RMR calculation.
Q Okay. Could you compare these? Are these of the same area?
A Yes. If you go down a little farther in this image, it'll show you where it is. So this -- that plain or that sheet going through is going through the upper part of the -- of the crown pillar at an elevation of 405. So it's right at the top of the crown pillar.
Q Could you compare these two pictures and explain what the colors mean?
A The color scheme that's used, although it's not listed on here -- it's explained elsewhere -- but the dark blue means very good rock, it's got a very high RQD, 90 to 100. And

then as the color goes to green, that's a lower -- and I think 70 to 80 range. And then 70, I believe, is yellow. And you start getting below 70, 60, 50, the color starts going down to red as a very low -- I'm speculating on this, but it looks like it's 30 or 40, in this range here (indicating).
Q Over there where you're pointing in the upper left-hand corner, there's a sort of a reddish-orange blob over there. What does that represent?
A That would mean that this section of that plain has very low RMR -- sorry -- RQD values.
Q And what section would that be?
A Well, you can't see this. And this was very hard in this image. The quality of the data -- if I'm supposed to take in data off of this, it's very hard to do. It's very hard to read these images. But assuming -- this line right here, which is very hard to see, is the outline of the crown pillar. So that section is the --
Q What color is the line?
A This -- see it? This here (indicating)? Actually they call it the outline of the intrusive. You can see it better on this one right here?
Q Maybe you can go up with that wooden stick and show it that way. It's really very hard to see.
A Pardon?

Q Could you go up to the screen and outline it with your pointer? Thank you.

A These are the same plain. And so I'll start at the lower one, because you can see it better.

Q Okay.

A But this image here (indicating) is the outline of the -- I can't tell -- this is a fault -- for example, this is a fault that goes through at the east end of this deposit here. You can see it here. This is the fault. It's a green line. It's very hard to see this information. But this term says "intrusive envelope," meaning -- I assume it means that that's the outline of the crown pillar that the orebody is in. So this right here (indicating) -- if you go down a little more, that outline is -- you can see it, I think, three-dimensionally if you go down a little farther. That's that plain right there. So you see the purple is the dike material. So that's that outline that you're trying to see right here (indicating). And it goes off the page. Actually it shows the deposit ending right at that fault. And just looking at this, I would have thought you would seen more interpolation of the data showing more lower RMR's along the fault. By definition, a fault has to move. I mean, it has to have movement. And if you have movement, you're going to have a lot of fraction to the rock. But you can see one data point right here and a little one right here showing low, low numbers but then a lot of blue around it. This surprised me to see that.

The second thing was the issue of the difference between the RQD and the RMR. I would expect that, if you have RQD's, you would have low RMR's. If you have high -- good rock like this core here that we've been -- if you have good rock, you have a very high -- this would be blue. It would be this stuff here -- that you'd have comparable blue high RMR's. It didn't seem to be visually -- it just didn't seem to match up in this data. And this is before we got the eight cores that started showing that -- it appears that information was missing and the inter- -- what was put into the model, the GoCAD model, that created these images.

Q Is it your opinion that these images represent the real rock quality at the site?

A No. After reviewing those eight boreholes, again I had questions about the R- -- how the RQD was determined. It's not clear to me how the RQD was necessarily done. I don't know how it was done. So I -- and then when I saw the 8 centimeter bar -- scale there, I just -- why would they put an 8 centimeter scale if they had to measure the length of these rock fragments? So the question was do I believe they're right? I think they're in the ballpark, but I think there's questions about them.

MR. REICHEL: Excuse me, Counsel. Just so the record is clear -- I'm sorry to interrupt. I don't think you stated on the record, but shouldn't it reflect that the images that the witness is now testifying appear to be Figure 3 in Appendix C2 to the report?

MS. HALLEY: Yes.

MR. REICHEL: Because we've been going back between C2 and C3.

MS. HALLEY: Yes. This is Figure 3 of C2.

MR. REICHEL: Thank you.

MS. HALLEY: Thank you.

Q Okay. You may sit down. Dr. Vitton, are you confident that all of the discrete features have been accounted for in the company's analysis?

A No, not at all.

Q Why not?

A Well, I got back to the paragraph in C2 that discussed the fact they took that data, put it into a separate database. And from what it says, it wasn't included in the modeling that created those images that we just looked at. So that was a question then. When we got -- the Appendix C3 has additional information had those eight boreholes that we subsequently saw later. But there was also an additional image that came along with this that showed us in general where the location of these eight boreholes were. They're very difficult to see. That's the figure --

Q Okay. But right now we're talking about this. We're talking about discrete features in the crown pillar.
A Okay.
Q And could you read the first sentence of paragraph four? Just a moment.

MS. HALLEY: This is Appendix C3, page 9.

A Okay.

"Additional discrete structure may be present in the crown pillar which could have a significant effect on the behavior of the crown. Current contours of RQD and RMR show low value zones. One such zone extends approximately east/west across the northern contact of the intrusion that may indicate the location of discrete structure. The potential presence of such structure and the nature of these structures should be determined as part of the planned underground drilling program prior to establishing the upper levels of the mine and the crown pillar."

Q As a mining engineer, is it your professional opinion that, if there is any question about additional significant discrete features, those should be investigated before any mining begins?
A Depending on the mine, the answer is yes. In this mine, I would say yes. Because if the assessment of the crown pillar is flawed and you start mining at the bottom of it,

you could potentially have a plugged failure right after you start mining that mine if you open up an opening at the bottom. So I would -- yes, I would consider that as being something that should be investigated.

MS. HALLEY: This is Appendix C3, Figure 20.

Q Dr. Vitton, have you seen this illustration before?

A Yes; yes. This -- yes.

MS. HALLEY: Could you go down to the next one, the bottom half of the page there?

Q You've seen this illustration before?

A Yeah. This is -- we attempted to see this. It's very -- extremely hard to see in having a black background. This is the major structure identified in the crown pillar area. And there's color coding on this indicating where the drill holes penetrated whether it was the host rock or the sediments, metasediments we've been calling them, where it's peridotite or whether is sem-massive or massive is the color code here. But what this shows --

Q Just a minute. Are there notations on this illustration?

A Yes. There's notations here.

Q Could you go closer up and try to read them to us, please?

A Yeah. This -- they're identifying these discrete features in here; broken, broken, broken, gouge, shear, shear, gouge, shear. But we couldn't tell which holes. Very, very difficult to tell what holes they were. But apparently this is that information on the discrete features was in this. And this was very, very hard to see. But it shows a lot of discrete features in the crown pillar. I think they mention at least 143 discrete features that are in that crown pillar.

Q 143 discrete features in the crown pillar?

A I believe that's -- it's written in the text in the discrete section in Appendix C3.

Q Dr. Vitton, could you in a general way first describe the components of an RMR calculation?

MR. LEWIS: Your Honor, asked and answered maybe three times between -- maybe four times between three witnesses by now.

MS. HALLEY: Your Honor, Dr. Vitton is the first mining engineer that we will hear this information. I think he probably has a slightly different take on it. I've asked him to go through it quickly. He will do that.

JUDGE PATTERSON: All right. Go ahead.

A The eight -- one parameter is the rock strength. And they did point load testing. And one of the criticisms in the Sainsbury report that I mentioned was that they were relying solely on the point load test and making a conversion to the uniaxial compression strength of it using a formula that was above here. It's -- actually it right there (indicating). And basically -- and they did do this later on. They

actually did some uniaxial compression tests to very. But they only did it for three types. But this is an important parameter. Uniaxial compressive strength is used in the CPillar analysis. It's used in the strength -- when they look at strength of rock, this value is put in there. That's the A1 parameter.
Q And what's the A2 parameter?
A The A2 parameter is the Rock Quality Designation, RQD, which we talked a lot about.
Q Okay.
A We had concerns about that. Two concerns primarily was did they, in fact, use into 10 centimeter which is hard to believe they didn't. But when we saw the 8 centimeter, it surprised us -- as far as me. The second thing is, there seems to be a lot of fracturing in this core that doesn't correlate with the -- with the values that we saw in the eight cores that we were given -- were able to review. So we have concerns about the RQD. A3 is the spacing of the discontinuities, which was discussed by Dr. Bjornerud. A4 is the condition of those. And A5 is the moisture in the -- in the joint crack itself. And the permit assumed that it was dry in all their fractures and conditions.
Q And is there another parameter?
A Then there's an additional one, which was not related, in here called the adjustment factor. That's a function of

what type of excavation you're going to do. If you're working with slopes, you'd have -- there's a series of parameters for slopes. If there's other types -- for excavation tunneling, the number I gave earlier was from zero to a minus 12. You should reduce your RMR values by that amount. And that did not appear to be done in this data.

Q Did you try to assess whether Kennecott's input data into their RMR equations were reasonable and realistic?

A Yes. We went through the eight boreholes. We noticed -- or saw that there were RQD values but no -- in some sections, not all of them. But there were some sections missing. We wanted to know -- I wanted to come up with a better estimate of -- or to see what they are. We had the core. We could make an assessment of the A3 and A4 parameters and identify it to come up with the A1 parameter, which is the strength parameter. That's when I asked Dr. Bjornerud to assess the core by using those pictures to identify what the type was to get the A1 parameter and then for her assessment for A3 and A4 and A5.

Q Okay.

A Then I took the information and I plotted it out using their table and then came up with this is value RMR, 76.

Q Okay. Just a minute. Please start on the left-hand column and let's work our way across.

MR. REICHEL: Excuse me.
A The hole ID, which has been discussed, this is hole --
Q Just a minute, Dr. Vitton.
MS. HALLEY: I'm sorry. This is --
MR. REICHEL: I just wanted the record to reflect in the transcript what --
MS. HALLEY: This is Appendix 9 to Exhibit 3.
MR. REICHEL: Thank you.
MS. HALLEY: I apologize.
Q Go ahead.
A So this is hole 55. The 04, I believe, is the year, 2004. East -- or Eagle, EA, and then I think 55 is hole 55. From 0 to 10.67 is the length. They drilled from 0 to 10.67. It must have been in clay. It says overburden. And so they then came up with an RQD where that -- I'm assuming it's in their database information. But it was collected and an RQD was reported. For example, 63 for this series from 13.11 to 15.24, they provide an RMR value of 83 for it. Dr. Bjornerud identified the rock type, which allowed us then to get the 81 parameter, which we used their information, their strength data that came from point load tests. And I'm assuming that that equation got converted to uniaxial compression. But in any case, you could still go with the point load test. So we used their values for the A1 parameter. We used their values for the RQD values. We

take 63. It gives us a radiant of 13. Then Dr. Bjornerud calculated A3, A4 and gave an assessment for A5. The AB parameter, again we could have -- this was a general. We weren't just looking crown pillar. I would have put minus 12 there. But that's a general try to be consistent among all orientations meaning that that orientation can be -- it's perfectly horizontal. You could put 0 in there in this case. If it's perfectly vertical, you'd put minus 12 in there. But we went with a minus 2 being conservative and then came up with RMR 89, and that's the column on the right.

Q And just so I understand, you used Kennecott's data for A1?

A That's correct. And Dr. Bjornerud's identification of the type. So we need to know the type of rock. We went to their table and got the strength and then put it -- then went to the 89 table and came up with the rating.

Q So for A1, Dr. Bjornerud assigned the rock type, which you accepted the strength applied to that type that Kennecott provided?

A Yes. You'll see --

Q And you used that strength?

A -- 12 for gabbro, 12 for gabbro. So when it changed rock type, then the strength changed and the rating changed.

Q Understand that. And for A2, whose data did you use?

A The data that was in the Excel sheet that I assume was

Kennecott's data.

Q And for A3?

A Dr. Bjornerud calculated that.

Q And A4?

A Likewise, Dr. Bjornerud calculated that.

Q And A5?

A Dr. Bjornerud calculated that.

Q And AB?

A I assigned that.

Q Okay. Now, how typically do your RMR values compare with the values that Kennecott arrived at?

A In general, they're all lower and primarily due, I'm assuming, to the A5 parameter not being dry. If this was dry, this would have been 15. So -- although there's a couple that are not. But in general RMR values are typically in the upper -- in this case they're -- if you look at this, 83 and we got 38. So we're quite a bit lower. 66 versus 33, 68 versus 65. So in some cases, we're very close; in some cases, we're quite a bit off. But this allowed us then to give RMR values for the crown pillar given the data of the eight holes that we had.

MS. HALLEY: Page 37, please. Page 37 of this same Appendix 9 of Exhibit 3.

Q So, Dr. Vitton, after going through those calculations, you arrived at an average RMR for the crown pillar based on

those eight holes?
A Yes.
Q And what was that?
A I believe I came up with an average for the crown pillar of 45.
Q 45.
A And 51 for the entire eight holes as a weight average.
Q Okay.
A Yeah. The RMR was 51 compared to 68 for -- I tried to make it consistent between their number of how they got -- what I believe where this came from and my number 51 and then for the crown pillar was 45.
Q 45?
A And this would essentially be including those discrete features in the RMR calculation.
Q Do you believe that a crown pillar with an RMR of 45 is stable?
A It depends on the dimensions of the crown pillar, the span of the --
Q Do you believe this crown pillar with an RMR of 45 is stable?
A No, not according to the -- again we plot this in Figure 29, compare it.
Q That's what we're about to do. Could you go to the screen there, Dr. Vitton, and show us where a crown pillar RMR of

45 puts us on this table?

A Yes. What I have to do is convert that Q to RMR.

Q I understand.

A And as -- this is not linear; this is log scale, so you have decades here; meaning it goes from .01 to .1 to 1 to 10 to a hundred to a thousand, so it's not easy to do this. I mean, there's a very simple equation to do it, but I can't do it in my brain right away. But this column here (indicating) is 75 and that's 80. And RMR of -- and I'm trying to remember because it's not my -- I mean I -- the data that I put on this is not here. Roughly it would be in this region about point -- or about 2. That's 1, 2, 3, so it would be in this region right about here. So we bring these scan scales -- span C scales crown pillar over here, then it would be above this stability line. So theoretically this would fail.

Q So you did plot this?

A Yes, I did plot this.

MS. HALLEY: Could we go to appendix 9, page 31? We're going to Petitioner's Exhibit 3, appendix 9, page 31. Just try to scroll up or down.

Q So, Dr. Vitton, this is -- you took the table from C2, appendix C2, figure 28; is that correct?

A Yes.

Q And what did you do to it?

A What I did to it was -- again, this is their data; this is the -- what they call the stability line that comes along here (indicating). These didn't show up, but this is RMR 75, RMR 85. This would be RMR 51 in this column.
Q Which represented your measurement for the RMR --
A The whole line, the -- all the data that we had from those eight holes. It would fall here. The crown pillar would fall in this region right here, and then this was the lowest section which was 31. I think that was -- 31 would be way over here. So if the RMR's were to drop that low that's where the -- that scan -- for that -- see, so that scan pillar, that's where it would fall.
Q With an RMR of 45 is the crown pillar stable or unstable?
A Based on this analysis it's unstable.
Q Okay. Thank you.
(Pause in dialogue)
Q Would you explain to the Court what the time-dependency factor of crown pillar stability is?
A If you go back to the example of the Athens Mine, Athens actually was a progressive type of failure. It failed suddenly but it was progressingly in a fail. In the time-dependency issue and the data that was plotted in that data some of those failed immediately and some of those failed quite a bit later, upwards to 80 years later.
Q How many years later?

A Eighty years later. So it's not an issue that they collapse right -- you make that void and the thing drops. There's deterioration of those planes of weakness which causes the strength that holds that up to decrease. And that's why you get a time-dependency issue with the collapse of crown pillars.
Q Has Kennecott or the DEQ considered in any of the information you've looked at including the most recent up to April of 2008 -- have they considered the time-dependency factor of crown pillar failure?
A Not that I know of.
Q Okay. And who came up with this notion about the time-dependency theory?
A This is work done by Dr. Carter at Golder and Associates and Miller.
Q Dr. Carter of Golder and Associates?
A I believe that's the same; Trevor Carter, I believe.
Q Okay. And he works for Golder and Associates?
A According to that paper he works for Golder and Associates.
Q Okay. And do you know who did the bulk of the crown pillar stability analysis for this application; what firm?
A My understanding that -- from the names associated with the documents that's -- the information in appendix C2 was done in Sudbury, Canada at their office.
Q Whose office?

A Golder and Associates; Golder Associates, from what I can tell. And C3 was done also there. Again, I --
Q "There" being?
A Sudbury, Canada.
Q And whose office there?
A Golder Associates.
Q Okay. So would you expect that Golder and Associates would have addressed this component of crown pillar stability?
A I think so, yes. Most of the work on crown pillar analysis has been done in Canada by Canadians. Hutchinson was another researcher. There's a manual; Canada has a complete manual on -- an analysis of crown pillars.
Q But talking specifically about the time-dependency component, --
A Okay.
Q -- would you have expected that that would be a part of this permit application? That analysis; should it have been a part of this permit application?
A Yes, I think so, because the -- you're expecting this to last a long time and -- or at least even through the mining aspect. Once you introduce oxygen, water flowing through cracks you're going to start changing then, and once you start changing then you're going to start changing the strength of that ability of that crack or that rock mass to -- you're going to be decreasing it, especially if you

have zones of weakness, planes of weakness. And in this model or at least -- not this model but this mine, if the -- if they mine out to the host rock that zone there in my mind would be a zone of weakness just because it's a dike in -- that's been intruded up into -- that would be a plane of weakness.
Q So Kennecott's application does not contain a time-dependency factor analysis?
A Not that I know of.
Q And the DEQ's consultants or staff did not consider the time-dependency factor of crown pillar stability?
A I don't think so. The Sainsbury report might have but I don't remember if they -- if that was --
Q Do you have an opinion about the time-dependency of failure for this particular mine?
A Well, I do. The idea of this mine plan, again, as you -- total extraction; you take the entire ore body out that's economically mineable and then replace it with a backfill material, and my concerns of the backfill are that over time it will settle or have potential to settle. If it does settle there would be a void developed and -- although they talk about tight backfilling. I think there is issues long term. I don't know that we have knowledge long term about this mining method into the 80-year area. I don't think backfilling and this primary and second pillar concept has

been around long enough for us to know how it's going to behave into the future.
Q So you don't think we can predict at this point whether the backfill will perform its intended function, therefore making -- well, go ahead. Answer that question.
A It's a concern I have, and that's why I thought the time-dependency issue was also. If the crown pillar is stable, it doesn't matter what the backfill does. It can settle; it can do what it wants to do. It'll be stable. But if it isn't stable, then you have to consider long term what's going to happen.
Q Okay. But that wasn't done in this case?
A No; I don't believe it was.
Q What is backfill?
A The backfill is the -- it's an idea now of being able to extract more material, reduce -- traditionally most mines had to have some type of support: room and pillars where the pillars held up the roof. And as you attempt to take more and more of the support out so you can extract more and more of the material as ore -- it used to be in room and pillars about 50 percent extraction; you left 50 percent in the mine. I think White Pine is roughly that. I could be wrong, but that's why there was so much copper left in the White Pine Mine. As you try to extract more of the support -- and in coal mining we have long wall mining where

you take out all of the ore but the roof falls behind you. So the backfill was a way in which we could take more of the support out as a product, as ore, and then backfill it. And then if the roof -- the span is too wide and the roof does come down there would be some support to hold it up. That's the idea of backfill.
Q How long is backfill meant to stay stable?
A Indefinitely; it has to if -- if your span of your opening is such that it will fail and you are relying on the backfill to hold it up, then it has to last indefinitely or should last indefinitely.
Q Indefinitely. In this mine plan is there a proposal for backfilling?
A Yes.
Q And what type of materials are planned to be used for the backfill?
A From the discussion in the permit they talk about a cemented backfill -- a rock fill, cemented rock fill type of backfill and they're going to mine what they call a primary and a secondary type of stoping. The primary stopes would be filled with a cemented rock fill, and then the secondary, which would be in between there, would be filled with I think materials: sands, gravels, other materials, development rock possibly. It's not clear in the permit what they plan to do put in there.

Q This cemented rock fill, what is the strength of it? What is the strength of the cemented rock fill?
A According to the permit -- it's sort of an unusual number in the sense that it's so exact, but they state 218 pounds per square inch would be the strength of the cemented backfill -- rock fill -- cemented rock fill. I'm sorry. There's two kinds in general I guess: cemented paste backfill which you take a very fine material -- in some mines it would be tailings or crushed material -- and mix it with cement to come with paste backfill. That's a stronger material. And then this is a rock fill where they take larger particles and try to cement it together.
Q Does the application describe any quality control on the concrete mixing?
A No. No. There's very little information. One of the questions I had was where -- what material are going to be used for the -- for adding to the concrete. They will have development rock, but that's a small percent. You have to backfill the entire mine back up and I believe it was about four million tons already coming out; you've got to put something back equivalent to it, so -- and I think that the development rock is only roughly about 300,000 or 400,000 yards. So they're going to have to come up with materials from other sources to bring into that mine, both to create the cemented rock fill and then as materials -- the support

materials in the secondary stopes. The quality controls -- I'm sorry. That was your question. Quality control in this is, I think, a big issue, because -- there is one paper by Dr. David Stone who is an expert -- listed as an expert here.

Q Is this (indicating) the paper, Dr. Vitton?

A Yes.

MS. HALLEY: This is Petitioner's Exhibit 55.

Q Have you had a chance to review this paper?

A Yes, I did.

Q Could you describe its contents to us?

A Yes. This is an interesting paper that discussed the issues of some problems and quality control problems of trying to take rock material, crushed material, I'm assuming, and then mix it with concrete and water to make a cemented material that will have some support characteristics. One of the critical things one this cemented backfill, rock fill is that it has to stand up approximately a hundred feet high and then have a 30-foot secondary pillar of rock and then another cemented and they're going to blast that rock between it. So that's going to be subjected to blast vibrations, and so that material has to be strong enough to support that. And if it isn't, it will come down and you'll have a problem; you'll have a dilution problem and other issues. So this paper talks about some of the issues, some of the problems: how to maintain moisture. Moisture, when you mix concrete -- when we do our research in -- concrete research trying to come up with very consistent concrete it's not easy. And in this operation where you're doing such large amounts of materials you're going to get a lot of -- a lot of scatter in the properties of the cemented backfill, it would be my opinion. And this --

Q A lot of what?

A A lot of variability; you're going to get a lot of variation in the strength. And this had some interesting data in it concerning the quality control program in Nevada, because they were having problems maintaining the moisture content of the aggregate that was going into the cement that -- to make the cemented rock fill. And there's a figure here. If you go down it shows.

(Pause in dialogue)

A Okay. This is a plot here (indicating), figure 5. This is -- shows over time how the -- how their quality varies at this mine. I think it's a mine in the Carlin District of Nevada. I'm not sure exactly the mine, but they are using some primary, secondary method of mining. If you look at some of the values here, this is --

Q Just a minute. Could you describe what the notations along the sides there mean?

A Okay. This is the unconfined compressive strength where

they take a cylinder and test it. And this is the data here (indicating) and this is over time how it varies. And these are -- and I can't remember; I think they were shooting for around 800 or a thousand psi strength and it's just all over the place. I think there's another figure here.
Q Just a moment. Just a moment.
A Okay.
Q What is the psi of the rock fill that's being --
A For this operation they needed, I believe, a lot higher strength backfill. The one that Kennecott's proposing is 200, which is down here in this around here. So when they were shoot -- you're getting data all over the place, but the Kennecott proposed backfill strength is at this point right along there (indicating).
Q Do you think that's an adequate strength for what this backfill is going to be used for?
A My initial -- my opinion is that it seems very low for cemented rock fill that's going to be subjected to blast vibrations while they were taking out the secondary pillar. They're going to be blasting right next to this material.
Q And what would the result of that be?
A Well, it's hard to imagine that -- I mean, the rock strengths that we're talking about here are up around 10-, 20,000 psi. That's the rock strength. And then you're going to put a cemented backfill strength at 218 psi and

blast next to it, it seems difficult. In addition you're relying on some interesting -- I believe some interesting things. For example, at the bottom of the mine the first level they've got three stopes: two cemented, one primary -- or secondary. When they fill that first one up with cemented backfill, if they don't get a good bond with the host rock, with the peridotite, there's going to be -- there's going to be openings. When that blast vibration comes through there's going to be essentially a free face and you're going to get rebounding, which is going to cause fracturing in the cemented backfill. I just -- it seems very problematic to me in this when you look at other operations and what strengths they're using.
Q So it's not comparable to what seems to be --
A No, not this operation.
Q -- used in the industry?
A And I think these stopes are only 60 feet tall, I believe.
Q Compared to the stopes here?
A There are a hundred, roughly.
Q A hundred. Can you describe the method by which the backfill would be placed into the mine?
A Well, again, this is a very large volume and they're going to have to be -- and I, from what I've read -- I've not done this type of mining -- they use an end dump, they're going to have a batch plant somewhere either in the mine, mix it

up and then haul it and then dump it down a hundred feet. That's problematic too. Some of the problems you get is segregation of the materials. And this is a problem in the construction industry where we tend to have to tremie the concrete. If we have a long distance we're dropping concrete, we typically put it in a tremie tube and drop it to the bottom so it gets -- it slows down 'til it gets to the bottom, and then it comes out at the bottom. And that way we can maintain and not get segregation of the -- we're talking big particles here from what I can understand of the aggregate they're going to be putting in here. If you --
Q About how big?
A Well, if you go back up there's a Talbot equation here which we use extensively in aggregate engineering when we start talking about crushing materials and trying to come up with an optimum size distribution to help in our -- to make good concrete or a high-strength concrete.
Q So my question is what is the problem with dumping the -- this rock fill in there without a tube?
A You have two problems and it's been discussed in these types of papers. One is the segregation of the particles. The big particles tend to -- will go -- work their way upward and the cements at the bottom will get very strong and the top will get very weak. The other thing you can -- with the liquefaction problem and that's more of a soil mechanics. I

had a paper on that on the liquefaction issue. And they describe having liquefaction problems, meaning that it drops down -- the pour pressures get up so high that it just blows it out; it causes it to move and then heavily segregate --
Q What is liquefaction? Let me back up a little bit.
A Liquefaction is a soil mechanics term in which when a ground that's saturated is shaken the -- as the particles want to densify there's water in the way and it wants to squeeze the water so the pour pressure goes up. As the pour pressure goes up, it pushes the particles out and they lose all their strength. So it's liquefaction, meaning I'm turning my solid more into a liquid. And that's very problematic when you're dumping this materials into these stopes, these open stopes. So that's an issue that's well described by many of these papers.
But if you go up to the Talbot equation, what I don't know is, again, the size distribution that they have planned to use for their rock fill, if they mix with the cement. And this equation right here is they're going to put -- this is a distribution you get based on percent passing but you put in the -- a maximum particle size. So I don't know what that is. And this assumes we're going to get a particle size distribution; that's what this paper is -- the ideal grading for a cemented rock fill aggregate has been shown to follow this Talbot equation, which is

true, so if you can come up with this distribution. But if you're -- again, if you're going to be using development rock in this, I don't know what size distribution it's going to be. They could be particles that are half a foot, a foot. So I'm assuming they're going to have to crush this material, process it into a grain -- some type of distribution and then add the cement and the water to mix as well as other materials like flyash to try to reduce the attack from acidity which is probably going to occur in this mine to come up with this backfill -- cemented backfill and have strength that stand at a hundred feet set in place and then withstand a production blast adjacent to it.
Q Do you think that's a reasonable expectation of this material in this mine with this mining plan?
A It seems overly optimistic that that 218 psi number is realistic in this type of operation compared to other cemented backfill operations that use cemented rock fill. It seems very low. But it's an economic issue; it's -- they're using five percent cement and I think that's the minimum for rock fill if it's five to ten percent cement. It's typically what the -- the range that they use.
Q And what would be used in the secondary pillars?
A I don't know. They could use sand out in the Yellow Dog --
Q Well, what does the application --
A Pardon?

Q What does the application --
A I'm assuming something that's easy to handle, something that's cheap, something that doesn't produce a lot of dust. Something that's relatively inert, easy to use, easy to handle, cheap to put in. And this represents a very significant expense to the mine, to the operation of this mine.
Q Does the application discuss where this material will come from?
A I do not think it does.
Q And would it remain stable?
A My assumption was -- and I could be wrong -- was that they were planning to use some of the development rock as -- for cemented backfill, which is one of the problems discussed in this paper.
Q I'm asking about the secondary pillars. What is the material the application describes would be used in those pillars?
A Okay. The term "stopes" --
Q The secondary stopes. Sorry.
A Stopes; that's the opening after they've mined it. I do not remember what they said, but I don't remember them specifically or explicitly stating they were going to use aggregate, sand, mine tailings, things of that sort. I don't know.

Q Okay. Will materials of that sort remain stable?
A Depends. If it's sands, glacial materials that have already been ground down and gone through essentially a beneficiation process, they probably would be relatively stable. If they start utilizing the host rock, some these metasediments which are slates, shales, sandstones, sedimentary type rocks, I think that they will degrade and break down and that's an issue that's discussed in this paper in terms of use in concrete or the cemented backfill; talk about the problems with clays and silts and that sort of thing.
Q At some point the application was changed to reflect that the -- all of the stopes in the upper layer would be cemented with this rock fill material?
A Yes, I think that was in the permit requirements, the -- everything above the 357 line, the top three levels if they were mined they would be all cemented rock fill.
Q Does that alleviate your concerns about the settlement of backfill?
A Well, no. In soil mechanics, in surface mining, for example, one of the first problems I encountered was when we put our backfill -- our spoil back in a surface mine it settles over tens of -- 20's, 30, 40, 50 years. So it's continually settling. Even when you compact it it still settles. Road bases; the reason we get faulting on roads is

because they settle; although there is dynamic running of vehicles. But in general materials, if they're not compacted, will naturally settle over time.

Q Thank you. What was your opinion about the stability of the crown pillar before you got the photographs from the eight cores?

A I didn't necessary have an opinion per se, except I had questions about the input of the -- the input parameters that went into their assessment -- on their assessment. But in the -- if you look at the scale span method it's very close to the stability line, so they're very close with the information that they had in the permit.

Q And that has nothing to do with the core photos; that's a different assessment?

A Yes. Again, I mentioned earlier that I have concern when I read that they used the -- they took those discrete features and put them in a separate database and that apparently was not part of the modeling in the data that was used to do the stability analysis.

Q And even when you consider the revised and thickened crown pillar and the backfilling, what is your opinion of the crown pillar stability?

A My opinion is the RMR is representative of the numbers that we obtained and the dimensions of the mine as in the -- that are in the permit, that it had a likelihood of being

unstable.
Q Have you reviewed the DEQ's materials about subsidence crown pillar stability and backfill? I mean specifically the reports by Dr. David Sainsbury and Wilson Blake along with the materials on the DEQ website and the 91 questions and answers that -- the 91 questions posed to Kennecott by DEQ?
A Yes.
Q Yes. What did you notice about the Sainsbury Report?
A I thought the report paralleled pretty much my thinking. I thought he did a -- I thought he did a good job. I thought that -- well, it's similar to what I had said in my report. So it sort of confirmed what I had in my review of the permit application. It supported my opinion.
(Pause in dialogue)
Q Did Dr. Sainsbury mention anything about lateral stresses?
A Well, I think, again, he had the same concern I had that there was no effort made -- well, that's not true; there was an effort made. They did utilize information from a paper in 1988 that was done in Canada by Hergert -- H-e-r-g-e-r-t I believe -- where they made a broad assumption that the horizontal stresses are two times the vertical stresses; which again is a very, very simplistic assumption because as the stresses as you go downward, that ratio changes. They do not stay -- you can't say it's two all the way down, so that was a very broad assumption. And there are other

sources in which you could get information, and Dr. Sainsbury utilized Mr. Parker's paper on -- referenced it in there on the lateral stress field in the White Pine Mine.
Q Is this (indicating) the paper that Dr. Sainsbury referenced?
A I believe it is.
Q "Mining in a Lateral Stress Field at White Pine Mine"?
A Yes.
Q Or at White Pine. Sorry. What is the general idea behind Dr. -- Mr. Parker's paper?
A What I believe that I got out of this paper and what Dr. Sainsbury's looking at in this paper is, again, this issue idea that -- yes. The horizontal stresses are -- it's hard to determine what they are, but there are some factors we can say about them and one of the ideas -- or two of the ideas in this paper that are very relevant, I believe, to this analysis of this -- the Eagle Project is that, number one, through any mine the horizontal stresses and -- are going to vary. You're going to get variations. They're not going to be the same -- if I took a plane through the White Pine Mine I'm going to find that the stresses vary rather dramatically. And so the first point in this paper is that horizontal stresses are not constant through a mine; they vary. And they vary to a point in which you can get areas with high compression stresses with very high pushing and if

you know what that is -- in the case of this White Pine Mine they did and they took advantage of those horizontal stresses by orientating their drifts in such a way that they took advantage of it; whereas if they were mining away from it, from the principle maximum stresses they had problems. So the lateral stress field varies throughout the mine.

The second thing -- and if you go down on this one, and this is a corollary of the first point I got out of this paper. Again, part of the corollary is if you orientate -- if you understand where they are, you can take advantage of them. And that's an important point here. Almost there. Almost there.

MS. HALLEY: This is Petitioner's Exhibit 37, for the record.

A Okay. This here. And what this shows is a portion of the White Pine Mine and it shows that major faults will really alter rather dramatically the horizontal stress field to a point where you can go from very high compressional stresses to zero to tension. You can actually get tension where the rock is pulling apart. And that's part of what this -- and this is a very good data set of measurements in the mine that made these -- it was able to look at these measurements. So this is a very significant paper and it -- I felt and I think Dr. Sainsbury felt that it was one that could have been reviewed or should have been reviewed in looking at this project.

MS. HALLEY: I'd like to offer Exhibit 37.

MR. LEWIS: Same objection based on foundation and relevance that I put on the record before, your Honor.

JUDGE PATTERSON: Okay. It can be reaffirmed.

(Petitioner's Exhibit 632-37 received)

Q And, Dr. Vitton, did you also read the report by Wilson Blake related to this project?

A Yes. There are two of them, I believe. Yes.

Q Did you notice anything about those reports, particularly the second one?

A Well, I'm going on memory. I think he was surprised or -- at some of the data we presented in my report. And was that the October 17th report, I believe?

Q That's right. So just to be clear, you're referencing our exhibit, Petitioner's Exhibit 3, appendix 9?

A Yes. So we questioned the RMR values and other issues of the project. I believe in reading his evaluation that he still believed though that the crown pillar was stable. And I guess I would -- I don't -- I didn't understand exactly why; what information he had that maintained that opinion, was my reaction to that paper. I was curious what information there was out there that I was -- we did not see.

(Pause in dialogue)

Q Dr. Vitton, could you read the last paragraph here of Mr. Wilson's last report to the DEQ?
A It states --
MR. REICHEL: Excuse me. Counsel, just for the record --
MS. HALLEY: This is --
MR. REICHEL: -- I believe this is Petitioner's Exhibit -- excuse me -- Respondent's proposed Exhibit 112 by Dr. Blake.
MS. HALLEY: That's correct. Thank you.
Q Go ahead, Dr. Vitton.
A The paragraph states: "While the issues and concerns raised by the National Wildlife Federation through Vitton, Parker and Bjornerud are legitimate, I still recommend that the revised mining permit application of the KEMC be approved."
Q That sentence seems to represent two different ideas, the first section being that the concerns raised by you, Mr. Parker and Dr. Bjornerud are legitimate, and the second that Mr. Blake recommends that the application be approved?
A Dr. Blake.
Q I apologize. Dr. Blake. Does that sentence make sense to you? Do those two ideas fit together?
MR. LEWIS: Objection; leading and the form of the question.
JUDGE PATTERSON: Can you rephrase?

MS. HALLEY: Yes.
Q Dr. Vitton, would you interpret that last sentence for us, please, in your own words?
A Well, my words -- he agreed with the report we wrote, but makes a recommendation to approve the permit. And my -- what my -- I guess I would ask what additional information that Dr. Blake reviewed that we did not review that allowed him to be able to make that second statement would be my -- would be my observation. It would be my observation.
Q Have you ever interacted with the MDEQ in the course of your work at the White Pine Mine?
A Indirectly. I attended a number of the public hearings there and I interacted with some of the DEQ personnel that were involved. Steve Casey I think was one person. I called him up, talked to him about -- I was interested in White Pine Mine, I was -- I had a graduate student doing some of the work on the concrete bulkhead designs. I was very interested in -- the remediation plan there was some -- a lot of environmentalists use that -- I was asked to work on the Waddel pond which is a heavily contaminated copper -- they asked me to do a senior design project up there to do some -- to help them with their remedial action. The DEQ did, but in that through their consultant which was MG -- MFG asked us to do that.
Q Okay. Could you compare the MDEQ review at the White Pine

project with the MDEQ review of this project?

MR. REICHEL: Objection; foundation and relevance. I mean, I fail to understand -- I mean, first of all, it's not established that -- precisely what the nature of the issue that was being presented or the -- being presented at the White Pine Mine -- how that is all comparable to or relevant to any issue germane in this case. There's simply no foundation for that.

JUDGE PATTERSON: I agree. Can you attempt to lay a foundation for that?

MS. HALLEY: I'll rephrase the question.

JUDGE PATTERSON: Okay.

Q Was the MDEQ review of the White Pine project, to the extent that you were involved in it, done in a professional manner?

MR. REICHEL: It still doesn't -- objection; foundation. It still doesn't address the question of what this White Pine project was and how any of the issues presented here are germane to the permitting issues here.

JUDGE PATTERSON: I think it's vague; I don't understand -- if you could try to rephrase it again.

MS. HALLEY: I'll withdraw the question.

JUDGE PATTERSON: Okay. Thank you.

Q In your professional opinion has the DEQ conducted a thorough and complete review of the crown pillar stability for the proposed Eagle Mine?

MR. LEWIS: Objection; foundation.

MR. REICHEL: Join the objection.

JUDGE PATTERSON: There's been a lot of testimony about alleged deficiencies in the application and the Golder Studies, but I'm not sure there's been enough to lay a foundation for the DEQ's review here.

MS. HALLEY: I'll lay the foundation.

JUDGE PATTERSON: Okay.

Q Dr. Vitton, have you seen evidence in this application and in the responses of the DEQ to Kennecott that indicate an understanding of this particular mine and the mine plan?

MR. LEWIS: Objection; foundation, your Honor. I'm not sure what responses, if any, the DEQ has made to Kennecott that Mr. Vitton has reviewed; there's been no foundation or testimony about that of any kind that I know of.

MR. REICHEL: I would join in that objection and also note -- object to the form of the question; it's vague as to --

MS. HALLEY: I'll rephrase the question.

JUDGE PATTERSON: All right.

Q The DEQ sent a list of 91 questions to Kennecott after the initial application. Did you review that list, Dr. Vitton?

A Yes, I did.

Q What was your opinion of that list of questions?

A My opinion -- I was surprised that it wasn't -- they didn't ask more questions and raise more issues with a number of items, such as -- a number of issues. I was surprised that the number was low. My experience in dealing with regulatory agencies in Wyoming in dealing on my surface -- my permit application in Wyoming got volumes of questions, so I was surprised by 91, the number.
Q You were surprised by the number. Were you surprised by anything else?
A I was surprised that there were no more -- there were a lot of questions concerning things that were non-mining related, but the specific stability questions, the backfill questions, blasting next to cemented backfill -- those type of questions I thought were not asked that should have been asked.
Q Do you have an opinion about the quality of the questions that were asked?
A Again, I was surprised -- they asked a question, for example, about the finite element, the element that was used to evaluate the -- a subsidence question, not the plug -- there were no questions -- I can't remember if there were any questions on the plug type failure. But the other analysis that Kennecott did do in there using a finite element method was to simply if I have a crown pillar and it's got an open span there will be some slight settlement

of that. They did that analysis and they asked a number of questions about the type of element used in the finite element formulation, what the nodal -- type of nodal points were used and it was extraordinarily odd question. It just seemed to be probing, asking a question that was more or less irrelevant to the results they got from the program.

Q To your knowledge is that the only written communication in which the DEQ requested more information from Kennecott?

A I suspect there was -- I'm assuming there was a lot of communication between -- other than those 91 questions, but I don't know. I can't state that I know there was.

MS. HALLEY: I'd like to ask the question again, your Honor.

Q In your professional opinion has the DEQ conducted a thorough and complete review of the crown pillar stability?

MR. LEWIS: Objection; foundation.

JUDGE PATTERSON: Well, I think there's been a foundation of sort, so I'll allow him to answer the question based on that minimum foundation.

Q Go ahead, Mr. Vitton.

A Could you repeat the question?

Q Yes. In your professional opinion has the DEQ conducted a thorough and complete review of the crown pillar stability?

A My opinion would be no, it was not complete and not thorough enough.

Q Thank you. Even if the eight core holes you have reviewed are the worst quality cores, as Mr. Lewis has inferred, does that change your opinion about the stability of the crown pillar?

A No, not substantially; no.

Q Why not?

A It's troubling to see zones of that much fractured rock in this formation. There can't -- Dr. Bjornerud talked about the fact these drill holes, even though there's lots of them, maybe 120 or so, they still only penetrate a very, very small amount of this formation. And going through sections 55 meters of fractured material, that's 150 feet, something caused that. There's got to be some type of structural features in this formation that have caused those type of -- so being on the conservative side, it would make sense to me that -- to take those eight as being more realistic of the deposit and especially the crown pillar as a whole than assuming that the other hundred, if they're through the crown pillar, are somewhat better, which I'm assuming they are, but I don't see that that would change my opinion substantially.

Q Thank you. Even if the eight core holes you have reviewed are the worst, does that change your opinion of the application quality -- Kennecott's application -- does it change your opinion of the quality of Kennecott's application?

A No. My opinion, as I stated in my report, it came across to me as a rushed job. It was something that was put together without thorough review. There's a number of typographical errors in it. Two of the tables I showed you earlier has misquoted their top of crown pillar when they meant to say bottom of crown pillar. Those type of errors should have been caught. So my opinion is that it could have been done in a better manner or more thorough and had waited to understand what those discrete feature are and how those discrete features affect the mine as a whole over the stability of the mine. I would want to have understood that. An additional issue I would raise in this is they went with a very -- a very nonconservative mine plan. They went for a full extraction process using a new technique -- relatively new technique of primary-secondary backfill schemes which is being used in a number of mines but in different geology, different situations. They're taking operations at other mines and other situations that may not be relevant to the Eagle project. It was -- in my opinion they went with the most difficult mine plan to go with in terms of extraction and stability. And I would have gone with a more conservative mine plan as the first permit through the 632, I believe, regulations. I find that surprising, from my experience.

Q Have you read the permit issued by the DEQ --
A Yes, I have.
Q -- for the construction of this mine?
A Yes.
Q And does it allay your concerns?
A Not substantially. They do offer some -- some issues that -- for example, I believe it says that they're going to use cemented backfill in the top three layers if they're allowed to mine them. If the stability -- if the knowledge gained in mining the mine up to that level, which is the cutoff level for mining until they can prove they can go beyond that -- I think it's 357. I can't remember. 327 -- is good. They're trying to reduce the permeability into the mine by that. But I still have concerns, and it has to do with the backfill settlement, stacking up the cemented backfill on 218 PSI, cemented rockfill. I would have -- I have issues with those, with that. So I think there were some good points in there --
Q Issues that aren't addressed that aren't addressed by any --
A Pardon?
Q I'm sorry. Issues; are they addressed by the permit conditions?
A No, they're not. But I do think that there are me good points in there that they did ask Kennecott to abide by.
Q Thank you. Dr. Vitton, have you reviewed the what's called

the TDRSA, which stands for Temporary Development Rock Storage Area?
A Yes.
Q And what component of the TDRSA have you considered?
A I wrote -- in my review of it I had a number of comments concerning the application, the information put in the application, some of the data that was put in the application, some of the slopes that they had talked about, the height of water leachate that can be put into that. Some of those questions have been addressed in that, in the DEQ permit list.
Q Do you believe that that liner will leak?
A The statement says it will not leak, and that's not technically feasible. The regulations --
Q Is your opinion that it will leak?
A Yes, it will leak. That's a well-known idea, that there are diminimus levels in which you can't get beyond -- you can't get below a certain level of leachate going through your liner system no matter how well you construct it. You will always have some amount of leakage in any landfill that is built anywhere, because they're constructed facilities, and they cannot be made perfect. So the statements that they made in there that it will not leak is not technically correct. It will not leak much, but it will leak some.
Q Did you review the HELP model analysis?

A Yes, I did.
Q Did that analysis consider snow melt?
A The HELP model stands for Hydrologic Evaluation of Liner Performance. That issue and its problem with Northern Michigan is that the HELP model was developed by EPA at Vicksburg, Mississippi. But they acknowledge snow coming into the landfill, but it where it doesn't do a very good job is in the spring when you have sudden melt. If you have a very warm period and you get this dramatic runoff, that model doesn't handle that. And we looked at that. I had two students look at that issue, one at the Marquette landfill and one at the *Greenland landfill looking at how much leachate is generated during the springtime of the year, and it's fairly substantial in the Upper Penninsula of Michigan.
Q And did the application take that into account?
A No. It -- the model, again, takes the total amount but doesn't take the time element during the melting of it.
Q Thank you. Dr. Vitton, did you prepare a report dated October 17th, 2007, called "Stability Analysis of the Proposed Eagle Mine Crown Pillar Mining Permit Application Review" --
A Yes.
Q -- by Dr. Stan Vitton, Ph.D., P.E., and Jack Parker?
A Yes.

Q Have we discussed the points contained in this report during your testimony today?
A Not all of them; some of them.
Q Most?
A No; just one or two. Rephrase your question.
Q I'm asking you if we have discussed most of the things you've addressed in your report --
A Yes. We've done --
Q -- during your testimony?
A We've done most of them, yes; yes.
Q Thank you.

MS. HALLEY: I move to admit Petitioner's Exhibit Number 3, Appendix 9, his report.

MR. LEWIS: Ms. Halley, once again, I need to clarify since this exhibit is -- this large exhibit has now been broken down apparently into several new exhibits. What constitutes the document you're offering at this time? Could you tell me how many pages the document is?

MS. HALLEY: 158 pages.

MR. LEWIS: The version that I have, Your Honor, which was provided with the so-called public comments earlier on to the DEQ, and that's the only version that I think myself or the Respondent had received prior to today because the Petitioners elected not to copy those and supply them to us as exhibits. And instead on this particular one listed an Exhibit Number 3 as part of their Part 632 exhibit list, which was entitled "Combined comments submitted by Petitioners." And then with the understanding that we already had those reports, they did not provide them. And that's perfectly fine. But as a consequence, again, we just had that big category of public reports. Now, what I have for Mr. -- or Dr. Vitton's report is actually some 40 pages, including the references at the end of his report. I think what may be going on here is that there were various additional appendices attached to Dr. Vitton's report in the public comments. So, for instance, on the document I have, there was Appendix A attached, which is actually Dr. Bjorerud's report. And there might be another 20 pages or so there. Based on what Ms. Halley has just represented, it sounds like there may be various other reports and attachments that I just don't know what they are at this time. So --

MS. HALLEY: Your Honor, may I explain what has gone on with this appendix?

JUDGE PATTERSON: Sure.

MS. HALLEY: We submitted the appendix all 158 pages completely to the DEQ on October 17th of 2007 electronically.

MR. LEWIS: Wait a minute, Ms. Halley. I have no issue with that. Mr. Haynes advised me I think this morning that there were these additional charts.

MS. HALLEY: No. You got Appendix C on Tuesday, and we -- when you and Mr. Haynes discussed this issue.

MR. LEWIS: So the exhibit you're offering now is Exhibit 3, Appendix 9?

MS. HALLEY: Correct.

MR. LEWIS: That does not include this?

MS. HALLEY: Yes, it does. If you look at the page number on the bottom --

MR. LEWIS: That's all I'm asking about.

MS. HALLEY: Okay.

MR. LEWIS: All right. So if you'll confirm for me that your Exhibit 3, Appendix 9 includes Mr. Vitton's report, which is 40 pages, plus this chart, that's pages 70 through 134, that Mr. Haynes delivered to me --

MR. HAYNES: That's correct.

MR. LEWIS: -- plus I think we have pages 67, 68 and 69, which are these summary charts --

MS. HALLEY: Which you were provided with this morning.

MR. LEWIS: I was also. If you'll confirm for me that that's your Exhibit 3, Appendix 9, I will have no objection to its entry. And if there are not other attached reports and so fort that I don't know about.

MS. HALLEY: I will confirm that.

MR. REICHEL: No objection, Your Honor.

JUDGE PATTERSON: Okay. No objection. They will be entered as confirmed.

MS. HALLEY: Thank you.

(Petitioner's Exhibit 632-3-9 received)

MS. HALLEY: Thank you, Dr. Vitton. No further questions.

MR. WALLACE: I have just a handful of questions, Your Honor.

JUDGE PATTERSON: Okay. Go ahead.

DIRECT EXAMINATION

BY MR. WALLACE:

Q Quickly, sir, you mentioned some specialization or participation in an organization having to do with explosives engineering; --

A Yes.

Q -- is that right? Do you have some expertise in explosives?

A Yes.

Q Do you have -- do you have an opinion, sir, as to how far potentially you could hear the blasting from this mine when they start blasting at Eagle Rock?

MR. LEWIS: Objection; foundation and form of the question. I've got no context here.

Q Let's say on a peaceful day. You know the terrain. You know it sits up high on a plateau, sir; correct?

A Yes.
Q Okay. And you know that Lake Superior is off in the distance?
A Yes.
Q And you know the land falls away in the other direction?
A Yes.
Q Okay. And you've heard blasting at many mines over the years, have you, sir?
A Yes.
Q Okay. Can you give us an idea of how far away you can hear the initial blasting when they began blasting on Eagle Rock?
MR. LEWIS: Objection; form of the question, Your Honor. Maybe I misunderstood. You say the initial blasting?
MR. WALLACE: Yes, the initial blasting at the surface.
MR. LEWIS: Okay. I have no problem. No objection.
JUDGE PATTERSON: Oh, okay.
Q Potentially, how far can you hear it in each direction?
A It depends on how well one hears.
Q I don't hear very well and you're wearing a device.
A I have hearing aids, so --
Q Just give us a sense.
A The initial blast will be in the rock. I mean, it'll be

potentially heard out ten miles, but not very loud. I mean, it's in the -- and the blast is not -- should not be that big if being a portal. I mean, it's not going to be like a surface mine production blast. CCI does large blasts, and I don't think people can hear that at any great distance. I would say maybe five or six miles you know something went off. It wouldn't be very loud liked you'd hear it.

Q And louder as you get closer; is that fair to say?

A Yes. As the blast goes off, you have geometric damping that occurs. And so the farther out it's going to decrease by one over the square root of -- square root or one over the third root, depending on which type of waves they are. So it'll damp out as it goes away rather quickly.

Q Does the altitude of the plateau above the surrounding terrain play a role in how far it can be heard?

A Well, it'll -- I believe -- and this is -- that it will shadow that sound somewhat. So it would act like a shadow so if the blast is on that east side where there -- no. They're going in on the west side, I believe. I can't remember now. But there would be louder away from it on that side. And then the rock would shadow it away from it.

Q I see. Louder in the direction of the headwaters of the Salmon Trout River, then, to the west?

A Yes. They go in on the west side. It would certainly be louder on the --

Q Did you understand from the submissions by Golder and by Kennecott how they went from suggesting a horizontal stress of 2.0, which I think they drew from the Canadian shield, --
A Yes.
Q -- to a horizontal stress of 1.0, which they used later in their calculations?
A What was their thinking or reasoning?
Q Yes, sir.
A I don't know. Be from an engineering perspective they were attempting to be more conservative. In soil mechanics, typically as you go down the horizontal stresses are only a third of the vertical stresses in soils. So that's an issue that if that's very, very fractured rock, although I don't believe that fractured represents soils, but those horizontal stresses in soils are considerably lower than in rock. A lot of that rock horizontal stresses develops from continental stresses, tectonic-type stresses.
Q Could you tell from what you read where they got the 1.0 horizontal stress?
A No. I don't have -- I think it was just assumed value.
Q Is it an assumption?
A Assumption.
Q You made a comment to the effect or some statements to the effect that it would be preferable to be at the drilling side or talk to the drillers or have some more direct

knowledge of the extraction of the core samples as they came out, did you not, sir?

A Yes. When I have done RQDs on drilling, I'm right there when it came out. We made a determination as to what -- I mean, we recently did the Jacobsville sandstone, which is very layered. And it would come out -- the drill core would come out of the hole. We'd turn it on its side and we'd start bringing the core out and it'd break. You'd see it break. And that did not count in the RQD. We'd have a five foot drill run and we would get five feet up. By the time I got it to the box, it was broken into three or four pieces. So that did not -- it was still -- the RQD was still 100 of that core. So you need to be there to see it and make -- know that it did it break when someone tapped it on the side of the drill core barrel or did it not.

Q And the part I'm interested in that you testified about was if you're there at the drilling site, water's involved in the drilling operation; right?

A Yes.

Q Okay. And I believe you've testified that, if you lose water while you're drilling, that tells you something? You recall that testimony?

A Yes.

Q Okay. And what did you mean by that?

A What I meant is that when you're drilling in rock and somewhat in soils you need to -- you're cutting the material with typically a diamond core bit or it could be a button bit. In either case, you're breaking and fragmenting the rock, and that rock has to be taken out of the hole. In some cases you can use air, but many times you use drilling -- you use water to blow the -- as well as cool the tip. And so if you're drilling down and it's very competent rock then all of a sudden you hit a zone that is fractured, the pressure won't go up. It'll go into the formation and it'll be called losing your water. And you can have lots of problems. You lose your drill bit, you can do -- but it's telling you something about the formation.

Q That the water's disappearing into fissures or something?

A Yes; yes. It's going somewhere. It's --

Q And typically do drilling logs record when you lose water?

A Yes.

Q Did you get to see the drilling logs here, sir?

A No, I did not. We asked for them, but we did not see them.

Q You testified about 143 discrete features, and I think you pointed out --

A We did not go to that section that discussed the numbers of features of discrete features there are. There's -- it's discussed in the C3 permit application that I believe that number -- I'm going on my memory. You might want to check it to see in the C3 under subsidence.

Q My question is simply this: Were any aspects of these discrete features which were handled in a different section taken into account quantitatively in either the crown pillar analysis or the scaled scan analysis?
A My opinion is that it was not, because they were not included in the GoCAD analysis that modeled me those figures. Because according to that permit, they used those figures to come up with their 75, 85 RMR values. So it appears that they did not include those.
Q Okay. Were they included in any quantitative analysis in any of the materials you reviewed from Golder or from Kennecott, these discrete features?
A Not that -- not that I can tell.
Q Are these discrete features, as they listed them in the narrative but did not quantify, are they relevant to an analysis of crown pillar stability?
A Yes.
Q Are they significant? Are they minor?
A Very significant. The -- what those features will do to the overall rock mass rating, which is quantitatively we refer to or identify as the RMR, how is that rock mass going to behave, the more discrete features there are, the lower that number is going to be. Instead of 75 it could be 65 or 45. If that's what we attempted to do by taking that information in the eight -- by taking those eight cores, we did those

eight and came up with an estimate of that and it lowered it. It lowered the RMR by including them in. That was our assessment.

Q At the Athens Mine, the 1800 foot thick plug that fell to the bottom, was that in essence the crown pillar of the Athens Mine?

A Yes. And in a crown pillar analysis, the -- if it's a plug failure, the thickness of it is -- I mean, as it gets thicker it gets heavier. So if the strength of holding it up is the same all the way down, at some point it's going to fail because the strength's -- I mean, it's -- do you see what I mean? It's --

Q And that's exactly what I'm asking. Is the risk of a plug failure, is it alleviated by making the plug even thicker?

A No.

MR. WALLACE: That's all I have. Thank you.

MS. HALLEY: Your Honor, I neglected to move to admit two exhibits. They were Petitioners Exhibit 51 and 55. They were papers, one the Time Dependancy Analysis by Trevor Carter. And Exhibit 55 was the backfill paper by David Stone. We discussed them at some length. Dr. Vitton testified about them. I move to admit them now.

MR. LEWIS: No objection, Your Honor.

MR. REICHEL: No objection.

JUDGE PATTERSON: Okay. Thank you, Counsel. No objection. They'll be entered.

MS. HALLEY: Thank you.

(Petitioners Exhibits 632-51 and 632-55 received)

MR. LEWIS: We need a couple minutes again to switch over.

JUDGE PATTERSON: Okay. Just a couple.

(Off the record)

JUDGE PATTERSON: Mr. Lewis?

MR. LEWIS: Thank you, Your Honor. Is it "Vitten" or "Vitton"?

THE WITNESS: Vitton.

MR. LEWIS: Dr. Vitton, I'm Rob Lewis. I represent Kennecott Eagle Minerals Company in this matter.

CROSS-EXAMINATION

BY MR. LEWIS:

Q I'd like to start reviewing a couple things. I think you told us about some information that you would have liked to have had but did not have. Actually, I think it was in the context of a question as to, if you were doing a workup on this question of characterizing the crown pillar, what would you have done. And you indicated first of all you would have -- I guess if you were Kennecott, you would have talked to a geologist regarding the geology at the site. Do you recall that?

A Yes.

Q Now, you're not implying, are you, Dr. Vitton, that Kennecott did not in fact do some geological investigation?
A No, not at all.
Q And you're aware of the report by Mr. Coombes, and I forget the other gentleman's name, that was reflected in the Appendix C1? You reviewed that; right?
A Yes; yes.
Q Is it -- and you indicated that you would have liked to work with the drillers to get as much information as you could from them I think again in response to Mr. Wallace's question about the water and so forth. And again, something you were not able to do that would have been relevant to this analysis; is that correct?
A That's correct.
Q You would have liked to talk to somebody at the site about fractures from the drill cores as to whether they were manmade, artificially induced fractures from the drilling or whether they were in fact natural fractures existing in the earth, and you were not able to do that either?
A Yes; that's correct.
Q You would have liked to look at the cores themselves; correct?
A That's correct.
Q But all you had was photographs?
A That's correct.

Q You would have liked to look at more cores than the eight, I assume, as well?
A Yes.
Q Now, do you, Dr. Vitton, in addition to your academic duties, do work as a paid consultant for industry from time to time?
A Yes.
Q And I recall you indicated that you had met Mr. Jon Cherry at some point and in fact offered him some data or information concerning the White Pine, which you thought might be relevant for them to have?
A That's correct.
Q I take it from what you said apparently your understanding was the information was not needed or was not asked for by Kennecott?
A I think in the context of him giving a presentation and then me simply going up unknown to him and asking him for, you know -- "Do you want this information," I think it has to be taken in that context.
Q You were not, I take it, asked by Kennecott to serve as a paid consultant relating to this mining operation?
A No.
Q I wanted to go back to this question about the scale span analysis, if I could, Dr. Vitton. I believe we looked at a table in there. And while we're waiting for that to come

up, Dr. Vitton, you testified earlier as to your recalculations of the RMR numbers. And you also testified concerning the Golder Report, specifically Appendices C2 and C3 as to the correlation between a particular RMR number and a factor of safety as stated in those Golder Reports; do you recall that?

A Yes.

Q At any rate, Dr. Vitton, we looked at those tables. And do you recall that those tables reported various elevations for bottom or top of the crown pillar?

A Yes.

Q And do you recall I think you testified earlier that it was your view that there were actually three progressive, I think, elevations for the crown pillar set forth in the Golder Report?

A Yes, there were. There was one in C1, one in C2 and then I think attachment seven of the DEQ site that made the third elevation.

Q Here's the table six that I referred to earlier, page 13 of Intervenor Exhibit Number 2, which was Appendix C3, Dr. Vitton.

A Yes.

Q And there, for instance, it showed a bottom of crown pillar elevation of 357.5; correct?

A That's correct.

Q And you understand the permit elevation now to be 327.5?
A That's correct.
Q And in your testimony you talked about what if the RMR was in fact a number different than Golder had reported, in that case, what would the corresponding factor of safety be. Do you recall that testimony?
A Yes.
Q And it's true, is it not, Dr. Vitton, that you, like Dr. Bjorerud, in your reporting and statements about the corresponding factors of safety with your own versions of the RMR failed to take into account the current permit conditions for the crown pillar?
A I'm not sure what you mean by that. You mean taking the permit conditions, is that -- are you referring to top three levels being cemented back filled? Is that --
Q The fact that the current level for --
A Oh, I see what -- I'm sorry. I'm sorry. You meant because they're restricting the mining to that 327?
Q Yes, sir.
A And did I take that into my consideration? Indirectly, yes.
Q Well, you did not in your computations as to what the factor of safety would be if your RMR values were correct?
A No. The one stated in my report, the 51, included down to the 327 value.
Q Well, as I recall your earlier testimony, in fact, you were

referred back to the tables in the Golder Report, and specifically this table, table six, and --

A Yes.

Q -- you were asked to refer to those crown pillar elevations. Do you recall that testimony?

A Yes.

Q I don't recall that you were ever asked to nor did you testify as to what the factor of safety would be with the current crown pillar elevation of 327.5 meters; --

A That's correct.

Q -- isn't that correct?

A That is correct.

Q And in addition, Dr. Vitton, you were here, I think, for Dr. Bjorerud's testimony yesterday, were you not?

A That's correct.

Q And you recall I went through these same two appendices in these Golder Reports with Dr. Bjorerud, and we discussed the statements in the reports to the effect that Golder had assumed in these two initial reports that they would be an open void below the crown pillar; do you recall that?

A That's correct.

Q And you understand that to be true, do you not?

A That is true.

Q And when you went back to these tables in response to questions from Counsel and were asked what would the factor

of safety be with your re-computed RMR values, you also did not take into account or adjust for the fact that the entire void beneath the crown pillar would not in fact be open; isn't that also true?
A My assumption was that the only way the plug analysis makes any sense was to have a void underneath it. So my assumption was there was a void underneath it.
Q And that would be the situation in the Athens Mine; is that correct?
A That is correct.
Q Where there was no backfill; correct?
A There was no backfill.
Q And in fact, if we look at this Table Six, for instance, which is one of the tables you were referred to in questioning by counsel for Petitioners, you described these various parameters going across the top of that table, one of them but T as the crown pillar thickness. We've already talked about that; instead of 57 ½ it's now 87 ½. And you understand that, I think. But you also talked about S&L. Do you recall that?
A Yes.
Q And that represents what? The span and the length of the void?
A Yes.
Q And in fact, you understand now, do you not, that it's going

to be a stope sequence of mining?
A Yes. I know it's going to be a stope sequence of mining.
Q And do you know, do you not, that the dimension of the stope, the width of the stope, will be ten meters?
A Yes, although it's stated 15 and 20 in various parts of the permit.
Q And do you recall also, Dr. Vitton, my discussion with Mr. Parker yesterday as to the distinction between the word "development" of a mine and actual mining?
A Yes.
Q And do you recall that the permit condition that I looked at with Mr. Parker requires that before actual mining begins that Kennecott is in fact required to collect in situ stress information?
A That is correct.
Q In addition to other drilling and data gathering for additional characterization of what would ultimately be the crown pillar?
A Yes.
Q I recall you talked about the Athens Mine earlier, Dr. Vitton. I believe you indicated -- tell me if I'm wrong -- that there was no collapse of the roof of that mine for several years after mining commenced; is that correct?
A That's correct.
Q Do you know whether or not in that mine that the owner was

required to in the development phase and prior to mining stop and do diamond drill -- diamond drilling into the roof of the mine, do in situ stress testing and gather additional geotechnical data as Kennecott will be required to do in this case?
A They did not do that at the Athens Mine in 1931 when it opened.
Q Have you perhaps recently reviewed a report titled "Underground Hard-Rock Mining: Subsidence and Hydrologic Environmental Impacts" by Messieurs Blodgett and Kuipers?
A The one I reviewed was Carter and -- Carter and Blodgett, I thought.
Q I'm asking about this one in the context of the Athens Mine. It's got a review of the Athens Mine.
A I'm sorry. I was confused when you asked. Could you re-do that one? Sorry.
Q It's a technical report on "Underground Hard-Rock Mining: Subsidence and Hydrologic Environmental Impact" by Steve Blodgett and James Kuipers. Do you recall that article?
A I remember it, but I'm not sure I read it.
Q The authors have some discussion here about the Athens Mine. And I want to see if some of these things fit with your understanding about the Athens Mine. Okay?
A Okay.
Q First of all, they indicate that --

MS. HALLEY: Objection. Are you offering this as an exhibit?

MR. LEWIS: Not at this point.

MS. HALLEY: Your Honor, we have no reason to believe that this is relevant at this point. We have no understanding of what this document is. And the witness just testified that he's not familiar with it.

MR. LEWIS: I'm asking him if some of these things fit with his understanding about the Athens Mine. Of course, as you know, Your Honor, I have objected to the use of evidence as to other mines in these proceedings. That testimony has been allowed. So I do want to examine the witness a bit as to information about the Athens Mine. I can for Counsel's reference indicate that this article is listed as Petitioner's Part 632 Exhibit 23 and again is listed in that -- in Part 632 Petitioner's as Exhibit 64.

MS. HALLEY: It hasn't been offered as an exhibit by Petitioners, Your Honor, but I'll withdraw my objection.

JUDGE PATTERSON: All right. Thank you.

Q Are you -- do you have an understanding that this mine is in the area of Lake Superior, Dr. Vitton?

A Yes.

Q Which is one of the oldest hard rock mining districts in the United States with numerous underground iron and copper mines that date to the early 1800's and Native American workings of native copper deposit mines that date to the -- or that are several hundred years old?

A Yes.

Q And does it fit with your understanding that the Athens Mine was opened in 1913 and began shipping ore in 1918?

A It would fit my general understanding of the Marquette iron range.

Q Before both your time and my time?

A I hope so.

Q And are you aware that the type of mining utilized in the Athens Mine was a special system developed for that mine that combined what's called top slicing and sub-level caving of an orebody that was 500 feet wide, 300 feet thick and 2,000 feet long?

A Yes, I'm aware of that.

Q And I take it since you've testified earlier that you were familiar with the geology of the Athens Mine that you would be aware that the geology of the Athens Mine consists of 150 feet of Pleistocene sand and gravel that overlies 1900 feet of jasper, which the author here indicates is iron oxide or gossans cap and that this gossans cap overlies the 300 foot thick orebody of soft hematite which in turn overlies a foot wall of slate and that a vertical diorite dike forms the north boundary to the orebody while a near vertical fault bounds the orebody on the south?

A In general. I think my testimony was that a very general understanding of the geology, but that sounds very detailed. But in general the picture that I had up there had those features in it in general.

Q And at least this article indicates that production started at the western and lowest end of the mine in 1918. A considerable amount of water was encountered. Mining proceeded through the method of top slicing and sub-level caving over the next ten years with efficient recovery of the orebody after initial problems with water in the deeper parts of the mine, little additional water was encountered and the dry weight iron content of the soft hematite ore increased each year until finally at 5:00 a.m. on June 19, 1932, block two, which was 250 feet thick, 350 feet wide and 600 feet long caved to the surface. That fits with your recollection, does it not?

A My recollection was that the dimensions you quoted earlier of the large rooms underneath are correct. The thickness to the collapsed structure was 1800 feet to the surface, which would have included 150 feet of the sediments that you're talking about would be my understanding of that collapse.

Q Okay. And does it fit with your understanding, Dr. Vitton, or would you agree with the author of this article when he states that local geologic factors were responsible for the unexpected caving at the Athens Mine?

A Yes, I would.
Q Now, I wanted to ask you also, sir, about your testimony concerning your review of David Sainsbury's reports. And specifically I think I wrote down here that you testified that you felt that his report supported the opinions you offered in this case as to the stability of the crown pillar; is that fair?
A In general, yes, I think that's fair.
Q Now, while you indicated that you had reviewed I think you said two reports by Dr. Sainsbury and that you felt they supported your opinions, I wanted to ask you, and you probably heard this yesterday as well when I -- maybe you did -- I can't recall -- when I talked to Dr. Bjorerud, but at any rate, are you aware that Dr. Sainsbury's deposition was taken some time after he authored those reports?
A Yes. I think you -- the statement you made said there were two reports. I think there was one report by Sainsbury and two reports by Dr. Wilson Blake. I think that's --
Q All right. Thank you. I stand corrected if that's the case. So you were aware that Mr. Sainsbury's deposition was taken after the report -- after he had prepared the report that you had reviewed?
A Yes.
Q And did you review the transcript of that deposition?
A I did not review it.

Q Did you ask for it?
A It was submitted, I believe, in the exhibits I received, but I did not -- I did not read it. I did not review it.
Q Were you asked to read it?
A No, I was -- I don't technically think I was asked to read that specific one.
MR. LEWIS: I want to read -- and this is from Sainsbury's deposition, Intervenor Number 217, but I believe it's also listed in Petitioner's Exhibits as well as perhaps the DEQ's exhibits. And I'm going to start at page 141, Counsel.
Q I'd like to read to you a few excerpts from Mr. Sainsbury's deposition. And --
MR. WALLACE: What page, Counsel? I'm sorry.
MR. LEWIS: 141.
Q And ask whether you would also rely on what Mr. Sainsbury had to say at the time of his deposition, Dr. Vitton.
A Yes.
Q On page 141 -- and this is in response to questions by counsel for Petitioners -- Mr. Sainsbury said at line four, "We have a basic understanding that a 57.5 meter crown pillar is marginally unstable." Do you recall, Dr. Vitton, that's the --
A Yes.
Q -- crown pillar that you talked about in the earlier Golder

Report?

A Yes.

Q And Mr. Sainsbury goes on to say, "And we know that an 87.5 crown pillar is definitely going to be stable. That's all we know." Do you see that?

A Yes.

MR. LEWIS: And again page 150, Counsel, line 14.

Q In reference, Dr. Vitton, by a question from Petitioner's counsel as to the serviceable life calculation for a scale span analysis, Mr. Sainsbury said, "The author of all this literature, this Carter" -- and that would in all likelihood be the Trevor Carter from Golder that you talked about earlier, Dr. Vitton?

A Yes; yes.

Q "This Carter who has come up with these criterion for scale, he came up with the scale span analysis, he's an author on the Golder's response, and so I -- this Carter is well respected within rock mechanics community. I have full confidence in his analysis with the methodology that he developed and the criterion on serviceable life that he developed that the analysis that Golder has conducted would be sufficient, yes."

MR. WALLACE: I'm sorry, Counsel. Are you asking this witness questions or just reading from somebody's deposition?

MR. LEWIS: I indicated I prefaced my reading with that I was going to be asking him questions as to whether he also relied on what Mr. Sainsbury had to say at his deposition for his opinions. Now I'm reading the questions and I will ask him that question in a moment again. Page 198 -- or excuse me. That's enough.

Q Dr. Vitton, you indicated earlier, I believe, in your testimony that you had read Mr. Wilson Blake's report as well. And I think you testified to the effect that -- and tell me if I'm wrong. I know it wasn't these words -- that you thought maybe he had some information that you didn't have or something to that effect?

A The statement was that he agreed with the report we had written in general, but then said -- made the statement that the -- that the permit -- that the mine was stable. The permit should be approved I think was what he had said. And I -- that was a disconnect. I don't know what information that was -- he was allowed to review or see that we did not review in this application.

Q And you have that same feeling now about Mr. Sainsbury?

A Well, I think the problem -- or as I see it, my opinion hasn't changed. What I would ask -- or I guess I can't do that. But I don't think Dr. Sainsbury saw the information that we saw in terms of the eight cores in terms of the missing RMRs. I would think that if he understood or saw the information that we had seen that his opinion might not be that.

Q Now, are you aware, sir, that between the time Mr. Sainsbury authored his report that you indicated that you relied on and felt supported your opinion and the time his deposition was taken that Golder had also issued its July 7, 2006, technical memorandum?

A Yes. That's the one I believe that reduced the crown pillar to 327.

Q And that's Intervenor Exhibit Number 24, again also included as Exhibit 79 inadvertently. Had you prior to the time you prepared your report, Dr. Vitton, that you talked about earlier reviewed this July 7, 2006, memorandum by Golder Associates?

A Yes. I refer to it as trying to shoot at a moving target. The information kept changing. But, yes, I did review that.

Q I recall -- my recollection is that in your report you based your opinions as to the RMR calculations and what it meant as to the stability of the crown pillar based solely on the earlier Golder Reports, the Appendices C2 and C3; isn't that true?

A That is correct. I had not seen the -- the report you're referring to, the July 7, 2006, only made -- if you read that, the Carter statements in there are not direct. They're contradictory in a sense that it's not clear that he's recommending at one point it's a recommendation. There was no statement that we are in fact going to 327 at that point in time. So there was no basis for me to go to that crown -- that elevation in my analysis.

Q That document I believe has been admitted, Dr. Vitton. Now, you just testified that in fact you had read that document prior to the time you prepared your report. Now we have it on the screen. And I believe you just testified that in your view Golder was equivocal as to whether it was in fact recommending a final -- or a design elevation of 327.5 meters?

A I think there's two statements in this document. The last one makes a recommendation for it. I'm not sure that the statement and my reading of it at the time I read it stated they are in fact going to that elevation. But, I mean, it's clear that they were discussing going to that elevation of 327.

Q Page eight of that report, Dr. Vitton, again, Intervenor Exhibit 24 says, does it not,

"On the basis of these results and in order to ensure a factor of safety greater than two and a corresponding probability of failure of less than 5 percent for the initial mining layout arrangements for the worst case geometry conditions (full width, unsupported crown) the phase three mining limit is recommended to be set at an elevation of 327.5 meter corresponding with a crown pillar thickness of 87.5 meter."

That's what it says there, doesn't it, Dr. Vitton?

A Yes, it does.

Q And if we could go to page 13, please? And on page 13 of that same report in the summary section it says, does it not, in the bullet point number two, Dr. Vitton,

"Based on the updated results, the phase two design allows mine development to begin and further information to be collected before the crown pillar is actually constructed (i.e., before the upper levels of the mine are completed)." And in the fourth bullet point it says, does it not, "As described in the preceding sections," which we just read, "the phase three mining limit is recommended to be established at an elevation of 327.5 meters corresponding with the bottom of production level one." And finally, the last bullet point which says, "The proposed mine schedule will allow approximately 69 months to complete the data collection and phase three crown pillar design prior to commencing production of this mining above this mining limit."

That's what it says, does it, Dr. Vitton?

A Yes, it does.

Q Now, Dr. Vitton, I also wanted to talk to you a little bit
about your experience, I think, or your discussion and
testimony about the White Pine mine and perhaps also in
reference to testimony by Mr. Parker about his more direct,
I take it, experience with the White Pine Mine; that again,
I think you heard that testimony yesterday, did you not?
A Yes. Well, I could not hear Mr. Parker very well, so I did
not hear his responses.
Q I understand that.
A I basically could hear you, but I had a hard time hearing
Mr. Parker.
Q You recall or at least you heard from me probably that I
asked him some questions about his testimony in a federal
penalty case as to the use of a technique I believe is
called roof bolting?
A Yes.
Q And I wanted to ask you, Dr. Vitton, you're aware, are you
not, that there are various mine engineering techniques to
stabilize the roofs of mines and rooms in mines in the event
it's appropriate to do so?
A Yes.
Q And some of those mitigation -- or not mitigation, but
stabilizing methods, as I understand them, include the roof
bolting that I talked about yesterday with Mr. Parker.
Would it also include a technique called roof bolts with

screen?
A Yes. Screen?
Q Screen.
A Okay.
Q Are you familiar with that?
A Yes; yes.
Q Another technique that can be used is steel beam support?
A Yes.
Q You can use steel screen with shock crete over the screen? Are you familiar with that technique?
A Yes. You're saying steel beams?
Q No. Steel screen with shock crete over the screen.
A Oh, yes; yes.
Q And in fact, I assume that there are other mine engineering techniques which can be used and have been used to stabilize the roofs and sidewalls of underground mines with which you're familiar?
A Yes.
Q In addition to those techniques for additional stabilization if needed, I would assume that during the mining process if the additional information is gathered once underground, as Mr. Parker put it, looking at it, kicking it, putting sticks in the cracks and so forth, or as we're talking about here in our mine permit application, actual diamond drilling, taking additional cores from the rock, in situ stress

testing and so forth, that if further adjustments might need to be made, if stability problems are encountered beyond these techniques for stabilizing the roofs and walls of mines, that other adjustments in the mining plan can be made, such as adjusting the size of the stopes or the openings for the mining process?

A That's correct.

JUDGE PATTERSON: It's a little bit after 5:00.

MR. LEWIS: I'm --

MR. REICHEL: I have some questions.

MR. LEWIS: I'm willing to stop there if you want to try to let Mr. Reichel finish. Or if not --

MR. REICHEL: Whatever your preference is.

JUDGE PATTERSON: I prefer to stop right now.

MR. LEWIS: Okay. Well, I'll look it over. And if I have any questions in the morning, I'll --

JUDGE PATTERSON: Okay. I'll give you a chance.

MR. LEWIS: Okay.

(Proceedings adjourned at 5:03 p.m.)

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