

# NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE & MATERIALS

December 17, 2007

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This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

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UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE AND MATERIALS

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185<sup>TH</sup> MEETING

+ + + + +

VOLUME I

+ + + + +

MONDAY,

DECEMBER 17, 2007

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The Advisory Committee met at the Nuclear  
Regulatory Commission, Two White Flint North, Room  
T2B3, 11545 Rockville Pike, Rockville, Maryland, at  
8:30 a.m., Dr. Michael T. Ryan, Chairman, presiding.

MEMBERS PRESENT:

- MICHAEL T. RYAN, Chair
- ALLEN G. CROFF, Vice Chair
- JAMES H. CLARKE, Member
- WILLIAM J. HINZE, Member
- RUTH F. WEINER, Member

1        NRC STAFF PRESENT:

2                    CHRISTOPHER BROWN

3                    LATIF HAMDAN

4                    ANTONIO DIAS

5                    NEIL COLEMAN

6                    DEREK WIDMAYER

7                    MYSORE NATARAJA

8                    GARY COMFORT

9                    MIKE FLIEGEL

10                   DENNIS RATHBUN

11                   BILL von TILL

12

13        ALSO PRESENT:

14                   JOHN KEMENY

15                   AMIT GHOSH (via telephone)

16                   ROMAN KAZBAN (via telephone)

17                   LUIS IBARRA (via telephone)

18                   ASA CHOWDHURY (via telephone)

19                   GOODLUCK OFOEGBU (via telephone)

20                   CHARLES PENNINGTON

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## P R O C E E D I N G S

(8:33 a.m.)

1  
2  
3 CHAIR RYAN: Okay. The meeting will come  
4 to order, please. This is the first day of the 185<sup>th</sup>  
5 Meeting of the Advisory Committee on Nuclear Waste and  
6 Materials. During today's meeting, the Committee will  
7 consider the following; the Electric Power Research  
8 Institute's report on drift degradation at Yucca  
9 Mountain, an update on NRC rulemaking on groundwater  
10 protection in in-situ leach Uranium mining facilities,  
11 and the NAC International views on transportation-  
12 aging disposal performance specifications. The  
13 Committee will also discuss ACNW letters and reports.

14 Neil Coleman is the Designated Federal  
15 Official for today's session. We have received no  
16 written comments or requests for time to make oral  
17 statements from members of the public regarding  
18 today's session. Should anyone wish to address the  
19 Committee, please make your wishes known to one of the  
20 Committee staff. It is requested that speakers use  
21 one of the microphones, identify themselves, and speak  
22 with sufficient clarity and volume so they can be  
23 readily heard. It's also requested that if you have  
24 cell phones or pagers, that you kindly turn them off.  
25 Feedback forms are available at the back of the room

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1 for anyone who would like to provide us with his or  
2 her comments about the meeting.

3 I'd like to begin the meeting with a  
4 couple of items of current interest. First, Professor  
5 Hinze, one of our members, is in the Indianapolis  
6 Airport due to weather, desperately trying to make his  
7 way here, so we'll look forward to his arrival. In  
8 lieu of Bill being the Cognizant Member for this  
9 morning's session, Professor Clarke has agreed to step  
10 in for him and cover those presentations.

11 Ms. Barbara Jo White, who has been with  
12 the ACRS ACNW Office for about 40 years and is off to  
13 my left - Barbara Jo, good morning - is retiring on  
14 January 3<sup>rd</sup>, 2008. All these years she has provided  
15 outstanding administrative support to the members.  
16 She's always insured that members have a good place to  
17 stay when they attend ACNW meetings in town, or out of  
18 town. She has been exceptional in insuring that the  
19 Federal Register notice to the Subcommittee and Full  
20 Committee meetings have been issued consistent with  
21 FACA requirements. Her outstanding administrative  
22 support for the members, hard work, dedication,  
23 professional attitude in dealing with not only members  
24 and staff, but also with members of the public are  
25 very much appreciated by both Committees and the staff

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1 of the ACNW&M and the ACRS.

2 We thank you, Barbara Jo, and look forward  
3 to wishing you every success and pleasure that life  
4 has to offer in the days and years ahead. And it's  
5 always a comfort to know I can call Barbara Jo, and I  
6 won't be out in the cold, and I'll be where I'm  
7 supposed to be. So thank you very much, and we  
8 appreciate all your service. Thank you.

9 (Applause.)

10 CHAIR RYAN: With that, I'll turn the  
11 session over to Professor Clarke.

12 MEMBER CLARKE: Thank you, Dr. Ryan. Is  
13 our speaker present?

14 VICE CHAIR CROFF: He is.

15 (Off the record comments.)

16 MEMBER CLARKE: Okay. Our first speaker  
17 is Professor John Kemeny of the University of Arizona,  
18 who will speak to us on the Electric Power Research  
19 Institute report on drift degradation at Yucca  
20 Mountain. John, it's all your's. Thank you.

21 MR. KEMENY: All right. Well, thank you  
22 very much. I'm from the University of Arizona, and  
23 also I work for EPRI, and I want to thank Nick Apted  
24 from Monitor Scientific also involved with this, and  
25 John Kessler from EPRI.

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1                   Today I'm going to talk about the problem  
2 of thermal spalling due to the heating of the nuclear  
3 waste in the underground repository at Yucca Mountain.  
4 I thought first I'd just mention that EPRI recently  
5 has been involved in a number of rock mechanics  
6 studies, and this one being the most recent. But also  
7 in 2007, we've been involved in looking at some rock  
8 mechanics issues associated with expanding the  
9 capacity of Yucca Mountain. And then if you look,  
10 you'll see that last year we did some studies on the  
11 effect of multiple seismic events, which is something  
12 quite important, and also long-term performance. We  
13 actually tried to look as far as a million years to  
14 see what we thought would happen to the repository.  
15 And then back in 2005, we were also looking at  
16 seismicity and rock fall.

17                   Okay. So I'll start sort of simple. What  
18 is rock spalling? It's, basically, a failure around  
19 a boundary of an excavation, and typically it could  
20 show up as some sort of bulging, as it does here.  
21 This is the test drift in Yucca Mountain, and you can  
22 see it sort of bulges here. But if there isn't any  
23 support, then the rock often will produce rock fall.  
24 And you can see here, this is from a paper, Rajmeny,  
25 and you can see this sort of initiation of some

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1 spalling, then some sort of minor amount of spalling.  
2 You can see a piece of rock on the ground. And then  
3 here you can see the drift is starting to get sort of  
4 oblong shape, because this quite severe rock spalling.

5 Okay. In terms of what causes rock  
6 spalling, basically, it's a high tangential stress  
7 combined with a low radial stress near the excavation  
8 boundary. I give this example from the Canadian URL,  
9 where basically they have very high horizontal stress,  
10 as high as 55 megaPascals, and so they end up with  
11 high tangential stresses on the boundary.

12 Now because the radial stress is  
13 essentially zero on the boundary, it's like a uniaxial  
14 test on the boundary. This is just an example of a  
15 uniaxial test that we might test in the lab, and  
16 you'll notice that you're getting these sort of --  
17 these high angle fractures, what we call these  
18 splitting fractures. Anyway, so that's the idea that  
19 the spalling will initiate on the boundary, because  
20 that's where the rock strength is the lowest. And as  
21 you go in towards the boundary into the rock, then, of  
22 course, first of all, the tangential stress goes down.  
23 And secondly, you develop a radial stress, and so it  
24 becomes stronger. So, typically, the extent of the  
25 spalling is limited, as you can see here for the URL

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1 case.

2 In terms of what spalling depends on, it  
3 depends on many factors, maybe the most important of  
4 which is the in-situ stresses, the magnitude, and the  
5 orientation of the in-situ stresses. Of course, the  
6 opening, the shape of the opening, the size of the  
7 opening, and the orientation if it has a particular  
8 shape. Also, the excavation method for --

9 CHAIR RYAN: John, I'm sorry to interrupt  
10 you.

11 MR. KEMENY: Yes.

12 CHAIR RYAN: I forgot one opening item,  
13 and that's, is there anybody on the bridge line? Is  
14 there anybody on the phone bridge line? Okay.  
15 They'll announce when they come in. We'll get a beep.  
16 I just wanted to make sure we got that on the record.  
17 Thank you.

18 MR. KEMENY: So will people be asking me  
19 questions while I give the talk? Is that --

20 CHAIR RYAN: No, I just wanted -- I had  
21 the obligation to make sure our record reflected the  
22 bridge lines.

23 MR. KEMENY: I'd be happy to answer  
24 questions during the talk.

25 CHAIR RYAN: If folks want to break in,

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1 I'm sure they will. Thanks.

2 MR. KEMENY: All right. Thanks.

3 All right. So, anyway, also the  
4 excavation method. TBM is probably the -- produces  
5 the most stable opening, so you probably see less  
6 spalling in that case, as opposed to fill and blast  
7 type. And, of course, the properties of the rocks, so  
8 the in-tact rock strength properties, as well as the  
9 joint properties are very important.

10 The underground environment can also have  
11 -- such as the temperature, the humidity, the rock  
12 saturation, these can also affect how much spalling  
13 you get. And the type and properties of the support.  
14 And I know this is an important issue, but support can  
15 reduce the amount of spalling. Typically, a lot of  
16 times, typical kinds of support will be rock bolt and  
17 shot-crete. A lot of times this will not affect the  
18 amount of spalling so much as it just supports the  
19 loose ground. It keeps it from falling. But in  
20 extreme cases where you have tunneling and very  
21 adverse conditions, actually, if you put enough  
22 support in, and you put it in soon enough, you can  
23 actually reduce the amount of spalling.

24 And then lastly, I talk about this thing  
25 called progressive spalling. And this is this issue

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1 that you get some spalling, and it sort of continues  
2 to -- rock fall continues to occur, and the spalling  
3 gets bigger and bigger. And this can occur, in  
4 particular, because of the time-dependent nature of  
5 the rock behavior. And, secondly, because of changing  
6 stress conditions. So, for instance, you might be  
7 driving drifts close by, and that caused a change in  
8 stress. Certainly, a seismic event would cause the  
9 change in stress, or the thermal loading that we're  
10 talking about at Yucca Mountain would also be a time-  
11 dependent effect, so we could see progressive spalling  
12 over tens or hundreds of thousands of years.

13 All right. Now I want to first talk about  
14 sort of the extreme cases. Now just in here is  
15 progressive spalling leading to total drift collapse,  
16 which basically occurs in very extreme conditions.  
17 It's certainly not the norm. And I list sort of two  
18 conditions where this could occur, and one is where  
19 the in-situ stresses are extremely high compared to  
20 the rock strength. And this is a graph from Everett  
21 Hoek, and he basically has a parameter down here which  
22 is the rock strength over the in-situ stress, and he's  
23 got different sort of categories. He's got a few  
24 support problems, minor, severe squeezing, very  
25 severe, extreme squeezing. And sort of the boundary

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1 between the minor and starting to get to severe sort  
2 of these spalling conditions would be at a value of  
3 .2, and that means the in-situ stress is five times  
4 the rock strength.

5 And if I go back to the previous figure,  
6 you can see that these are quite severe. Like here is  
7 a case where I have quite a high stress, 55  
8 megaPascals, but this is a granite. The strength of  
9 this rock over 100 megaPascals, so this stress is only  
10 half of the rock strength, so I'm talking about when  
11 the stress is five times the rock strength. So for  
12 this rock, this would mean that for this kind of  
13 stress, it would have to be a rock that's very weak,  
14 on the order of 10 megaPascal; or, conversely, for  
15 rock with 100 megaPascal strength, it would have to be  
16 a stress of 500 megaPascal, so, again, these are very  
17 severe conditions, that we get this sort of severe  
18 squeezing condition.

19 And you can also talk about in terms of  
20 the tangential stress, so it's the max tangential  
21 stress on the boundary of about 10 times greater than  
22 the rock mass strength, then you could get this severe  
23 squeezing.

24 These are famous cases where they tried to  
25 put in tunnels. The TBM gets stuck, or a mile of

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1 drift may take five years, with all sorts of kinds of  
2 support, and grouting and things like that, so these  
3 are very extreme conditions:

4           The other condition where we sometimes see  
5 a total collapse of the drifts is the opposite of  
6 that. It's a very low stress condition in a weak rock  
7 mass. And this would typically be very shallow, so  
8 maybe only 50 feet below the ground surface or  
9 something like that, very weak rock mass, maybe the  
10 joints have no strength, and you can get a collapse  
11 all the way to surface. So this is typically the two  
12 conditions that we see, this sort of total collapse.  
13 And we're not expecting these kind of conditions at  
14 Yucca Mountain, and I'll demonstrate that in a second.  
15 I'll go to the next slide, and I'll show you that  
16 we're not really near this Condition 1, and not  
17 Condition 2, either, because Condition 2 would involve  
18 a much shallower excavation than the drifts in Yucca  
19 Mountain.

20           So I think what we really have at Yucca  
21 Mountain is what I call slight to moderate over-stress  
22 conditions. And what I mean by that is that the depth  
23 of the spalling is less than one radius away from the  
24 boundary. So, for instance, let's say this is an  
25 excavation, has a radius R, and then I might have some

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1 spalling around it, and if that spalling is less than  
2 or equal to the radius, then I'd call it slight to  
3 moderate over-stress conditions. And these are very  
4 common in underground excavation. We see this all the  
5 time, almost every underground excavation has some  
6 kind of failure. It may be slight, or it may be  
7 moderate, and it's very typical that we can stabilize  
8 these excavations with very standard types of rock  
9 support, like shot-crete or rock bolt. And if it gets  
10 more severe, we can use concrete liners, and so on.

11                   And this is what I would expect at Yucca  
12 Mountain. Again, this is before I did any analysis,  
13 but just basically looking at the rock strength and  
14 the in-situ stresses, and the amount of stresses  
15 created by the thermal, this is what I would expect.  
16 So here is kind of the -- I guess we're going to focus  
17 today really on the non-lithophysal units. And I've  
18 done -- this is a similar categorization that DOE has  
19 done. They've separated their lithophysal into five  
20 types, five categories, the weakest being Category 1,  
21 and the strongest being Category 5. If you look at  
22 the strengths, the unconfined compressive strengths,  
23 they vary from let's say 10 for the weakest, up to  
24 let's say 30 for the strongest.

25                   The other thing that's very important here

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1 is the Young's modulus. Again, all these results come  
2 from the DOE's drift degradation analysis report of  
3 2004. Look at the Young's modulus in gigaPascals,  
4 you'll see that the Category 1 has very low Young's  
5 modulus, only 1.9. The Category 5 is very -- almost  
6 the same as the non-lith, with about 20 gigaPascal.  
7 And, of course, this has to do with the lithophysal  
8 porosity, which varies from 35 percent for the  
9 weakest, to maybe less than 7 percent for the  
10 strongest.

11 So what's going on at Yucca Mountain in  
12 terms of stresses? If we forget about the thermal,  
13 first of all.

14 CHAIR RYAN: I'm sorry. Is someone on the  
15 bridge line, please?

16 MR. CHOWDHURY: This is the Center.

17 CHAIR RYAN: Could you tell us who you  
18 are?

19 MR. CHOWDHURY: The Center.

20 CHAIR RYAN: Okay. And you are who,  
21 individually?

22 MR. CHOWDHURY: This is Asad.

23 CHAIR RYAN: Okay. Thank you. Anybody  
24 else with you?

25 MR. CHOWDHURY: I've got Roman, Luis, and

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1 Amit.

2 CHAIR RYAN: Okay. We'll have to get  
3 those names from you maybe after the session. Thank  
4 you.

5 MR. KEMENY: All right. So, again, back  
6 to this Young's modulus. So if we take the case where  
7 we don't have any thermal, so just basically what's  
8 going on now, there's a few drifts at the repository  
9 level now, and they're being subjected to the in-situ  
10 stresses. So we're getting maximum tangential  
11 stresses that vary from 3 to 18, and the 18 is coming  
12 on the walls, and the 3 is coming from the roof, so  
13 the walls have more stress right now than the roof.  
14 And if you look at these, and you compare these  
15 numbers to these, you can see that already we should  
16 be seeing some kind of spalling on the drifts for  
17 these Category 1 and 2 lith, which is the case. There  
18 has been some documentation of some wall spalling  
19 already in the drifts. And that's consistent with the  
20 in-situ stresses that would cause these kind of  
21 stresses.

22 Now when we add the thermal, and the  
23 thermal is very tricky because the amount of thermal  
24 stress depends on Young's modulus. If the rock is  
25 stiffer, you will create -- you will generate much

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1 more thermal stress. So what happens is, the reason  
2 the range is so great is because for this low Young's  
3 modulus, it's going to generate very -- just a few  
4 megaPascals of thermal stress, so the thermal won't  
5 really make much difference at all.

6 On the other hand, for the strongest  
7 lithophysal units, the Young's modulus is 20, and it  
8 will result in as much as maybe 45 megaPascals of  
9 increased tangential stress. And so what that means  
10 is it will exceed this value, so we can expect when we  
11 heat up the drifts that we're going to see some  
12 thermal spalling in maybe the last three categories,  
13 probably not in these first two because the Young's  
14 modulus is so low. And this would be both in the wall  
15 and the roof. Maybe the roof actually has a higher --  
16 -- ends up with a higher amount of stress than the  
17 walls.

18 Anyway, so if we compare these numbers to  
19 the previous, just to show you again, here I'm using  
20 this criterion that I get this extremely high stress  
21 when the tangential stress at the boundary is 10 times  
22 greater than the rock mass strength. Well, this never  
23 occurs for either the static stresses, or the thermal  
24 stresses. It would occur under seismic loading, but  
25 it does not occur under thermal.

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1           As you can see, if I took a value of 30,  
2 I would be -- if I took 10 times that, I would need a  
3 max tangential stress of 300 megaPascals, or the  
4 maximum of about 50, and so on. So, again, just to  
5 reiterate, we're not in this sort of what I consider  
6 these extreme conditions that would lead to total  
7 drift collapse. We're in what I consider this slight  
8 to moderate over-stress condition.

9           All right. So now the issue that really  
10 has come up with regard to this is what happens if  
11 there's no rock support? Because it's true that even  
12 though this is very common in mining, and also  
13 tunneling, almost in every case, if there's going to  
14 be some over-stress, then they'll put some rock bolts  
15 in, or they'll put some shot-crete in.

16           Now in this case we have something  
17 different. The Yucca Mountain drifts is going to  
18 remain under thermal loading for thousands of years.  
19 There will be rock support that will be installed as  
20 part of pre-closure, but it will deteriorate over  
21 time. And this is kind of a heavy statement, because  
22 we don't know ----- as far as I know, there hasn't  
23 been a lot of work on exactly how long rock bolts will  
24 last. Typically, rock bolts, for instance, are made  
25 of sort of low-grade carbon steel. They deteriorate

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1 very fast. It doesn't mean you couldn't make a rock  
2 bolt that would last longer. But overall, DOE is not  
3 taking any credit for the rock support, so similarly,  
4 we basically assume that there's no rock support left  
5 at the time of the maximum thermal loading.

6 So without rock support, there's kind of  
7 two possible scenarios, and this is where really the  
8 crux of the whole thing comes down to. The one  
9 scenario is that rock reaches the peak stress, which  
10 there will be some spalling. And if it immediately  
11 fails and falls, so I get some failure, and it falls  
12 out, of course, that means that that stress has to  
13 redistribute. The stress behind it will get loaded,  
14 and it can probably fail, and so we'll get sort of a  
15 progressive spalling. So the one is that the rock  
16 strength is exceeded. That rock falls out completely,  
17 and then the stress redistributes, and then I get this  
18 sort of progressive spalling. And in the end, I can  
19 get a much larger failure zone than the initial over-  
20 stressed region.

21 The second scenario is that the rock  
22 fails, but still remains -- still has some residual  
23 strength, which is typical for most rock. Most rocks,  
24 even when it reaches the peak stress, and a little bit  
25 after, the rock strength does not go to zero

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1 immediately. It goes gradually over strain, and so if  
2 that's the case, if it retains some residual strength,  
3 then the rock can remain in place. It will -- some  
4 stress will redistribute, but not as much, because the  
5 rock doesn't actually fall out. It remains in place,  
6 but it's damaged, so we end up with damaged rock that  
7 stays in place. So then the failure zone really  
8 doesn't grow. We don't get this progressive failure.  
9 So those are kind of the two extreme scenarios. And  
10 as it turns out, those are the two opinions, the first  
11 opinion by the CNWRA, the Center, and the second one  
12 by DOE. So that's kind of where we're left with.

13 And if I look at where they get these  
14 opinions, the DOE is basically based on modeling.  
15 They used some discontinued modeling, UDEC and PFC,  
16 and that gives them confidence that there in a sort of  
17 second category where the rock is damaged, remains in  
18 place; and, therefore, you don't see progressive  
19 spalling.

20 On the other hand, the Center has done an  
21 elastic analysis, and they get some slight to moderate  
22 over-stress. And they just make the assumption, they  
23 make the worst-case assumption that that rock will  
24 completely be removed, and so it's really an elastic  
25 analysis with what I call a worst-case assumption.

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1                   And just to sort of support both these  
2 ideas, that I think that if you go back in rock  
3 mechanics 20 years ago, we didn't have very powerful  
4 numerical models, so really the elastic analysis was  
5 kind of where we stopped. We would do an elastic  
6 analysis, and we'd say okay, we'd sort of have to wave  
7 our arms about what would happen after that.

8                   Now in the last, particularly in the last  
9 five or so years, there's been a lot of development in  
10 being able to model into the post-failure region with  
11 these underground excavations. But it's still  
12 relatively new, so I think what I'd say is the Center  
13 approach is the conservative approach, saying we don't  
14 feel confident going into that post-failure region, if  
15 we're going to make the worst-case assumption.  
16 Whereas, the DOE, I think, has done some very novel  
17 work in doing just that.

18                   All right. So let's talk about what I  
19 did, what EPRI has done. We did some modeling  
20 ourselves to try to also look into this. We did  
21 standard 5.5 meter diameter. There's a typo. You  
22 guys have -- it said radius in that. So 5.5 meter  
23 drift, separated by 81 meter pillars. I took all the  
24 material properties, basically the temperature, ground  
25 conditions, everything has come from the drift

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1 degradation analysis report. There's two kinds of  
2 analysis. I felt like one contribution that EPRI  
3 could make is to do something different than what DOE  
4 did, so that we could see another kind of analysis,  
5 and see what it gives.

6 So I did a continuum model, where I  
7 focused on the strength softening. Again, this goes  
8 back to this issue here on the previous slide of, if  
9 the failed region could retain some residual strength,  
10 so that all has to do with the strength softening  
11 properties of the materials, so I did some continuum  
12 modeling with a program called FLAC . And I varied  
13 these softening properties to sort of see the range of  
14 possible behaviors. And then also I did some  
15 discontinuum modeling very similar to what DOE did,  
16 but I also added a time-dependence. I added a time-  
17 dependent drift degradation and simulated stress  
18 corrosion cracking for 1,000 years, because that was  
19 another issue that was brought up by the NRC, or by  
20 the Center, was that you'd get a progressive time-  
21 dependent spalling over time, so I looked at that.

22 This was the mesh I used for the FLAC.  
23 It's only a quarter mesh, because for continuum  
24 analysis, it really is fine. All the other quarters  
25 are going to look about the same. But for the UDEC,

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1 I have what's called a block model. I'll explain more  
2 about this later, but it's a full mesh all the way  
3 around. You can see this is the big mesh, and this is  
4 just the -- focused on what's right around the drift.  
5 I focused on this block model. It's trying to  
6 simulate, realistic simulation of what actually occurs  
7 in the lithophysal properties.

8 So let's talk about the FLAC modeling.  
9 Again, it's what we call a strain softening model. So  
10 let me just explain what strain softening is. This is  
11 a typical stress strain curve for rock, and rock  
12 typically we get sort of an elastic region. We get a  
13 slight non-linear region near the peak, you get a peak  
14 strength, and then we get this what's called the  
15 strain softening region after the peak, and then we  
16 get some kind of residual strength at the large  
17 strains. And so that's the stress strain curve. And,  
18 in particular, we're interested again in this post-  
19 peak, because that's where this difference between  
20 being able to retain some residual strength. That's  
21 the key, because you can see that out to the peak, the  
22 strength goes down, but only after some amount of  
23 displacement, and so it doesn't go down immediately.

24 So what I did, I used -- this is the  
25 strain softening model in FLAC. Basically, I have

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1 three things, cohesion, friction angle, and tensile  
2 strength, and they all decrease as a function of  
3 plastic strain down to some minimum value. And the  
4 key parameter for the cohesion and the tensile  
5 strength, the minimum value is pretty much zero. So  
6 the key parameter for me is this  $\gamma_c$ , and that's  
7 the strain over -- that's the plastic strain over  
8 which these values decrease to their minimum value.  
9 And I'll just -- here's an example of a simulation of  
10 a uniaxial test using this strain softening model.  
11 We've got stress on this axis, I've got strain on this  
12 axis, so again I get this sort of linear region, and  
13 then I get the strain softening.

14 I just want to explain a little bit about  
15 the details of this, kind of waviness. The FLAC is  
16 actually a dynamic model, so when I applied the load  
17 initially, this actually creates a little bit of a  
18 wave, so that wave is what we see here. So that's why  
19 you see this little bit of a waviness rather than a  
20 straightness, is just because when I first apply the  
21 load, it's actually got this small amount of waving  
22 properties through there.

23 And, similarly, you see this kind of thing  
24 at the very end. And that's I get this instability,  
25 and then it sort of rebounds a little bit, because,

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1 again, it's a dynamic model, so that's why. So if you  
2 see that, I just want to explain about that.

3 All right. Well, this is kind of the core  
4 result that we get from the FLAC results. So I tried  
5 many different values of gammaC, and what I tried to  
6 do here was find a value that's on one side, and a  
7 value on the other side. So what ends up happening  
8 is, this is the Category 5 lithophysal tuff, so just  
9 remember it's the strongest. It's got a strength of  
10 about 30 megaPascal. It's got a high Young's modulus,  
11 and it's got a low lithophysal porosity, so it's got  
12 the highest thermal stress that's generated. And what  
13 happens is, I end up producing a large spalling when  
14 this gammaC is .002, which are these two left set of  
15 figures. And then I produce a very small spalling  
16 region for gammaC of .005. So there's sort of a  
17 transition in-between these two strain levels.

18 And just to explain this figure. The  
19 little Xs all represent places that have gone plastic  
20 in the FLAC model. And then there's also this kind of  
21 orange, and the orange just shows the most recent  
22 failures that are occurring there. And then there's  
23 actually some tensile failures that occur here. And  
24 you can see this is the uniaxial behavior for the  
25 gammaC equals .002. And this is the uniaxial behavior

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1 for the gammaC equals .005. So, again, a big  
2 difference.

3 I've created a scenario where I get the  
4 large spalling. I've created a scenario where I get  
5 the small, and the difference of these two strain  
6 levels. And the reason for this has got to do with  
7 the fact that when I look at the -- in the case that's  
8 unstable, what's happening is the cohesion, and the  
9 tensile strength are going to their minimum values,  
10 and so all the stress has to be redistributed. And  
11 it's that same effect that I talked about, so then  
12 that gets -- the load builds up there and fails again.  
13 So it's really very similar, these two are very  
14 similar to these two scenarios. So I've sort of  
15 created the case where I want to have the scenario  
16 where it does fail, and it's like it's being removed.  
17 And the other case, it retains some residual strength.

18 Now what I could -- just as a further  
19 explanation, here's the case, the stable case. And if  
20 I look at the cohesion values, you can see that the  
21 key here is the cohesion has not dropped to the  
22 minimum values. Initial cohesion 7.5 megaPascal, and  
23 then at most it's gone down by about 20 percent.  
24 Whereas, if I look at the unstable case, you can see  
25 here the cohesion goes all the way to zero, and that

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1 causes this advancement of the spalling. I really  
2 have captured the two scenarios, one a stable case,  
3 and one unstable.

4 So now the real key now is, let's figure  
5 out which one the actual Category 5 lithophysal tuff,  
6 which gammaC best fits that one, so here I do that.  
7 Now what I'm going to look at is the key parameter  
8 here is the strain it takes to go from here to here.  
9 So if I look at this axis of strain at the bottom, how  
10 much strain does it take me to get from the top to the  
11 bottom?

12 Now if I look at the unstable case, the  
13 peak to residual strain is less than .0001, and if I  
14 look at the stable case, the peak to residual strain  
15 is about .0004. Now here's some actual results for  
16 the Category 5 - well, this is actually Category 5  
17 lithophysal, so this is actually the non-lith, and you  
18 can see, first of all, these are very much more  
19 gradual. And, in particular, for the case with the  
20 lithophysal, actually very gradual. And if I measure  
21 the peak to residual, so for the non-lith, the peak to  
22 residual is about .001, and for the Category 5, the  
23 peak to residual is about .015, so you can see here  
24 that it's -- in this case, it's 15 times as much  
25 strain as the unstable case. So I make the conclusion

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1 from this only minor spalling is expected in Category  
2 5 because, certainly, the strain that you get is much  
3 greater than this minimum strain that you need in  
4 order to get this unstable.

5 Now you can make -- similar conclusions  
6 can be made for the other categories of lithophysal  
7 tuff. I'll just show you. This wasn't in the thing.  
8 I threw in the Category 3. This was in the report,  
9 but it wasn't in the handout. And very similar  
10 results for Category 3. Here's the uniaxial, here's  
11 again an unstable case, and a stable case. And, also,  
12 the Category 1, this is a Category 1, same idea, an  
13 unstable case and a stable case.

14 Again, the stable case you see still has  
15 wall spalling. And, again, as I talked about before,  
16 that's because that's a spalling that doesn't even --  
17 it occurred even without thermal loading. That's  
18 because it exceeded the strain. So that's an  
19 interesting case, so I'll repeat this last one.

20 I did a FLAC analysis for the Category 1  
21 without any thermal loading, because that's what's  
22 going on now in the drifts. And there's some drifts  
23 at Yucca Mountain that are under static stresses, but  
24 they're not under thermal loading. And you can see  
25 that for the Category 1, I predict spalling even

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1 without thermal loading. And if I look at the  
2 cohesion values, you'll see that they don't drop very  
3 much. Even though I get a spalling region, if I look  
4 at the loss of cohesion, you can see that it's at most  
5 around 10 percent. So what you'd expect to see, you  
6 wouldn't expect to see this big spall if you went  
7 underground at Yucca Mountain, because the cohesion  
8 values -- maybe you'd only see a little bit of  
9 spalling right at the center, and that's exactly what  
10 you see. So I think this matches very well with what  
11 you see. So, again, this supports the idea that the  
12 strain is significant enough, the strain softening of  
13 the actual Yucca Mountain rock, so that we're not  
14 seeing this large spall, we're only seeing a very  
15 small spalling region.

16 So then the question, just to say well, at  
17 least with Yucca Mountain, I haven't seen any case  
18 that would predict this large amount of spalling. Do  
19 rocks exist with a steep strain softening slope? And  
20 I make the statement here, in general, as the  
21 heterogeneity in the rock increases, the peak to  
22 residual strain would also increase. And so, for  
23 instance, if I take a granite, this is typical  
24 granite, and it's got very small scale micro cracks on  
25 the order of the grain of granite, which might be a

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1 10<sup>th</sup> of a millimeter, or might be a millimeter. And  
2 if I compare that to the lithophysal tuff, you can see  
3 there I'm getting heterogeneity on the order of  
4 inches. And so what I'm saying is that because of  
5 that, you can expect a lot more peak to residual  
6 straining post-peak, than you would in something like  
7 a granite. And I show some examples of stress strain  
8 curves. For instance, this is a basalt, and has very  
9 fine grain, volcanic rock, and also sometimes granite.  
10 And so there are rocks where you can expect to see  
11 maybe this kind of progressive spalling that wouldn't  
12 be in the Yucca Mountain rock, and I'd say that's  
13 because the heterogeneity is just too big, and so  
14 that's creating this large strain. And that kind of  
15 shows in the difference here.

16 You can see here's a case of the non-lith.  
17 Here's the lith. By putting all these voids in there,  
18 you can see how it's flattening out the post-peak.  
19 And that's exactly what should be causing stability in  
20 these cases. All right. That was the FLAC model.

21 Now I did another model with UDEC, and  
22 this model is trying to closely simulate what actually  
23 happens in the rock at Yucca Mountain. And, so, in  
24 the lithophysal. And if I take a look, here's an  
25 example of a picture of some of the lithophysal rock,

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1 and here's some of the numerical modeling. And what it  
2 shows is as I load this rock up, you essentially get  
3 cracks that connect the lithophysae, and that's the  
4 mechanism that you expect to get failure in the  
5 lithophysal zones, these cracks that connect the  
6 lithophysae. And so how would a block fall? If I'm  
7 going to get a block to fall in the lithophysal,  
8 what's going to happen is that all sides of that  
9 block, the cracks have to propagate, and it creates  
10 this free block that can fall. So I say here that  
11 rock failure occurs by cracks that connect individual  
12 lithophysae, and removable blocks, those are the ones  
13 that can create rock fall, are formed by cracks  
14 connecting all sides of a block.

15 So what that means is if I have cracks on  
16 three out of four sides of a block, that may not be  
17 enough. That block will stay in the roof, it won't  
18 actually fall out. It'll be damaged, the rock will be  
19 damaged, but I won't get, necessarily, a rock fall  
20 event. So a rock fall event means that I have to have  
21 creating a crack around all sides.

22 Now this is a lot in one slide, and this  
23 is a lot of work that went into this time-dependence,  
24 and I've written many papers on this, and I can give  
25 people some more references on this, but I thought I

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1 would be pretty brief about how I do the time-  
2 dependence.

3 Now I have this thing called a rock  
4 bridge. It starts with what I call a rock bridge, so  
5 what I'm calling the rock bridge is the in-tact rock  
6 between the lithophysae, so if you see a lithophysae  
7 here and here, then that little piece of in-tact rock  
8 is what I'm calling a rock bridge. So that what we're  
9 really doing is we're breaking the rock bridges, time-  
10 dependent degradation of these rock bridges. And it  
11 creates a cohesion guide, so what I have is a block  
12 model, and on all sides of the block I have cohesion.  
13 The cohesion is there because we have these rock  
14 bridges. And then as the rock bridges crack, then the  
15 cohesion drops to zero on the boundaries of the block.  
16 And if the cohesion drops to zero on all sides, then  
17 I have the potential for this rock to fall out.

18 Now based on the information in the drift  
19 degradation report, I've taken average rock bridge  
20 sizes of five, ten, and twenty centimeters for  
21 Categories 1, 3, and 5 tuff. And then I have a  
22 formula here, again, this comes from -- this has been  
23 derived in some papers that I've written. Basically,  
24 I have a cohesion that's based on the fracture  
25 toughness, the size of the bridge, and the size of the

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1 block. And what I end up getting, which is  
2 interesting, if I took all this information on the  
3 lithophysae, obviously, when I'm in the higher  
4 porosity lithophysae, like the Category 1, it's going  
5 to have a much higher concentration. And based on  
6 that, I calculated all the cohesion values, and when  
7 I go through the analysis, I get for the Categories 1,  
8 3, and 5, I get cohesion values of 3.8, 6.2, and  
9 11.25.

10 Now as it turns out, this is very similar  
11 to what DOE got in their UDEC model. They also put  
12 cohesion. They matched the cohesion by doing some  
13 kind of a matching procedure, but it's interesting.  
14 I went through calculating the cohesion based on the  
15 actual spacing of the lithophysae, and I got these  
16 cohesion values, which turns out to match the DOE  
17 quite well. And then I used power-law stress  
18 corrosion formula for the cracking of the rock  
19 bridges. And, again, I have material properties that  
20 we determined for all of these values. So that's  
21 basically how that works.

22 I'll show you some results now from the  
23 UDEC. Again, it's a block model, so you can see here  
24 I've got all these individual blocks. And on the  
25 sides of the block are basically the cracks that will

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1 connect the lithophysae. And, first of all, I've got  
2 the first plot is the number of rock bridges that  
3 failed versus time. And it's in seconds, so basically  
4 this goes to 1,000 years. And so what I did was in  
5 the modeling, is I loaded it up to the max thermal,  
6 and I held it there for 1,000 years just to see what  
7 the effect of having it at maximum temperature for  
8 1,000 years. So that was kind of -- that's how I did  
9 the thermal analysis.

10 And what you can see here is on this axis  
11 I've got number of rock bridges, and you can see the  
12 maximum is about 140. And what you can see is that  
13 most of the damage occurs in the first hundred years,  
14 fifty to a hundred years. And then it sort of  
15 flattens off, even though there's still a little bit  
16 of damage. This shows the actual damage around the  
17 excavation. This is Category 5 tuff. And you can  
18 see, if I look very closely, you can see blocks, and  
19 you can see, the green shows where the bridge, it's  
20 cracked. And what we see is, if I have a block where  
21 it's green on all sides, then that's a potential block  
22 that could fall out.

23 On the other hand, what I see mostly,  
24 though, I see some green, but in a lot of instances I  
25 still see some unbroken bridges. So in a lot of cases

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1 I get -- you can see I get a damage zone. I predict  
2 the damage zone, but you can see there's a few blocks  
3 that are actually falling. But, overall, the blocks  
4 are not falling out because -- there's two reasons why  
5 the blocks aren't really falling out. One is, because  
6 I haven't -- because the bridges have not broken on  
7 all sides, and so, therefore, they're still hanging  
8 on. And secondly, because there's still frictional  
9 forces, because the thing about friction is the  
10 cohesion in the post-peak region basically drops to  
11 zero, but the friction does not go to zero. Even when  
12 I fail, I create a crack, there's still frictional  
13 forces along that crack that's created, so the  
14 friction may be lower than its initial value, but it  
15 doesn't go to zero. And so because of that, I could  
16 have a big wedge like this that's still in held in  
17 place because I still have some stresses.

18 So one way to see that, and let's go to  
19 the next slide. I'll show you some more. Now this  
20 shows some of those frictional forces, so this shows -  
21 - the green on this top plot shows open cracks. Now  
22 the open ones are the ones that certainly there's no  
23 stress on them, and they're ready to fall out. But  
24 you'll notice that on the sides here, I've got some  
25 ones in red, and red is the ones that have friction on

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1       them, forces on them.  So what I end up getting is a  
2       lot of these blocks are in place just because of  
3       frictional forces, even though the rock bridges might  
4       be broken.

5                       And one way to see that is to look at the  
6       stresses, because what happens is I get a damage zone,  
7       and the stress will move outside the damage zone.  And  
8       how much stress moves outside is a reflection of how  
9       weak, or what's the kind of cohesion of that damage  
10      zone.  So if I look at the bottom figure, different  
11      colors represent different stress, and you can see --  
12      the highest stresses, as you can see, have moved out,  
13      so right around the excavation, the stresses are  
14      lower.  And you can see that red kind of band around  
15      the outside.  That's where the stresses have moved, so  
16      there has been some damage, the stress has moved away.  
17      But what's interesting is the stress has not gone to  
18      zero by any means, and you can see that in a lot of  
19      places, I still have stresses on the order of 20  
20      megaPascal, so that's plenty enough to hold these  
21      blocks in place with friction.  So the only places I  
22      see where I'm really probably going to see rock fall  
23      are the stresses at the very bottom here, the very  
24      dark blue.  So if I look at these very dark blue ones,  
25      I think those are the ones I'd expect to see the rock

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1 fall.

2           And so what I'm saying then, is based on  
3 my UDEC analysis, we're predicting some rock fall  
4 within the damage zone, but not the whole damage zone.  
5 Overall, the damage zone seems to hold itself up,  
6 except for a few places where the stresses have gone  
7 to zero, or near zero, and they may fall out. So  
8 that's kind of my sort of conclusion for UDEC  
9 modeling.

10           Now Category 1 is a little different, so  
11 I thought I'd show that. Category 3 ends up the same  
12 as Category 5. Again, the Category 1 is the weakest  
13 one, and that one is interesting because, first of  
14 all, I get a bigger damage zone. You can see the  
15 damage zone here is quite a bit larger. Again, the  
16 rate is 2-1/2 meters, and I'm getting maybe up to 2  
17 meters of damage zone. But, again, if I look closely,  
18 you'll see that there's a lot of unbroken bridges in  
19 the damage zone. And, again, that's because there are  
20 still stresses there. Because of the orientations of  
21 those, they're not likely to break. And you can see  
22 there's some rock fall events occurring, but overall,  
23 I'm seeing some integrity of the damage zone. So,  
24 again, I don't expect that this whole thing will just  
25 collapse.

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1           Now what's also interesting about the  
2 Category 1 is I'm seeing some continued creep, even up  
3 to 1,000 years, so at least for the Category 1, it  
4 might be a case where given another 1,000 years or so,  
5 there could be some additional damage. I submitted up  
6 to 1,000 years, but certainly, even though most of the  
7 damage occurs in the first 50 years, there seems to be  
8 steady increase in damage over time in Category 1, so  
9 that's the weakest lithophysal unit. I expect any  
10 place that's going to see large amounts of rock fall  
11 are probably going to be -- it's going to be there.

12           And if I look at these other two figures,  
13 again, you can see there's a lot of this green  
14 represents open. But again, there's red zones that  
15 represent the friction. So, overall, again there's a  
16 mechanism for this rock to be damaged, but not falling  
17 into the excavation. And I can see that again here.  
18 Again, you see these big red zones on the side.  
19 That's where the stress is pushed out into these, but  
20 there's a small region with this very dark blue, where  
21 I expect to see some rock fall. And that's where some  
22 rock falls are interfering. And so, again, I would  
23 predict some isolated rock fall within the damage  
24 zone, but not the whole damage zone, for the reasons  
25 that I mentioned.

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1                   Now I did model the non-lith. This isn't  
2 in the thing. I had this in the report, but I didn't  
3 put it in the thing. I did model the non-lith. This  
4 is what I call regular. This is kind of this average  
5 properties of the non-lith, and it's very stable.  
6 This is very similar to the DOE results, basically  
7 predicting that almost no rock fall in the -- this  
8 actually increases the stability. I get the same  
9 results. The thermal stress actually causes to push  
10 on those joints, and actually increases the frictional  
11 effects, so it's very stable. If I look at the number  
12 of rock bridges, you can see it's very small. You can  
13 see there are still rock bridges that have failed, but  
14 overall, there's not really -- there's no open zones.  
15 You can see there's no green zones representing open  
16 zones. And if I look here, there's not much load  
17 stress even, so very stable, the standard, what I call  
18 the average non-lith.

19                   Now I also did, just for -- because I know  
20 when you go underground at Yucca Mountain in the non-  
21 lith, you do see zones that have a density of  
22 fractures, and they're referred to as these fractured  
23 zones, or I forget what I call them. It could be a  
24 fault zone, or it could be a highly fractured zone.  
25 And there, I modeled them, and that was the worst, of

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1 all the things I modeled that was the worst case, was  
2 that in this highly fractured zone in the non-lith.  
3 The reason is because the failure mechanism in the  
4 non-lith is different. These are actually joints, and  
5 there's hardly any cohesion on those joints. Whereas,  
6 in the lith, the lithophysal zones, you have to create  
7 those cracks between the lithophysae, and that gives  
8 it some cohesion that you don't have. And in these  
9 fault zones, I predict a lot of -- here it's got 800  
10 rock bridges broken. You can see it's a very -- and  
11 here's a case where a lot of the bridges are broken,  
12 so the only thing -- there's really no cohesion left  
13 in here. The only thing that's holding up is  
14 frictional effects. If you go to this one, you can  
15 see a lot of open, and this is a case where I would  
16 expect to get some rock failure. And, again, a lot of  
17 zones are very low stress near the boundary, so the  
18 only place where I really did find the condition where  
19 I might see a lot of rock fall is this highly  
20 fractured zone in the non-lith.

21 All right. So conclusion, again, I did  
22 two kinds of models. I did the FLAC and the UDEC.  
23 The FLAC results was a strain softening model, a  
24 continuum model. It was based on varying the  
25 steepness of the strain softening slope, and I show --

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1       it showed that if the slope is steep enough, sure  
2       enough, you will get a large spall. But for the  
3       material properties of the Yucca Mountain tuff, I  
4       never got a steep enough strain softening slope, so I  
5       come to the conclusion from the FLAC that I wouldn't  
6       see these large spall regions because there's always -  
7       - the strain softening slope is not steep enough in  
8       any of the rocks at Yucca Mountain.

9                The UDEC results I simulated by this crack  
10       growth around these lithophysae, creating free blocks  
11       that can fall out. And it showed that you will always  
12       -- you do create a damage zone, in every case there is  
13       a damage zone. It's bigger in the weaker rock, it's  
14       not as big in the stronger rock. Also, I did time-  
15       dependence, and it showed that there is time-  
16       dependence, but it generally stabilizes at about 150  
17       years. And the only kind of actual rock fall I saw  
18       was isolated blocks within the damage zone, not the  
19       whole damage zone, just isolated blocks.

20               There was a good correlation between the  
21       FLAC and UDEC. There was some little differences. I  
22       noticed that - this is a Category 1 tuff - but I  
23       didn't vary the -- I kind of made the standard  
24       orientation of block which consisted of sort of these  
25       three sets of joints. And because they were fixed, I

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1 think that sort of influenced the exact location where  
2 the weakest zone was. I noted that in the report.  
3 But, overall, other than that, I think there was good  
4 correlation between the FLAC and UDEC results. And  
5 the results I showed are in agreement with the DOE in  
6 the drift degradation analysis, and they're in partial  
7 agreement with the Center's results. And they're in  
8 partial agreement because it does predict damage,  
9 certainly. It does predict some failure, some  
10 spalling, but it doesn't predict total drift collapse.  
11 So for the last statement here, neither the FLAC, nor  
12 the UDEC predicted large amounts of spalling that  
13 would fill the drifts with rock blocks.

14 MEMBER CLARKE: Okay, John. Thank you.  
15 Dr. Ryan, I know you need to leave soon. Do you have  
16 any questions?

17 CHAIR RYAN: No, go ahead, Jim.

18 MEMBER CLARKE: Okay. Professor Hinze, as  
19 Dr. Ryan mentioned, is fighting his way to Rockville.  
20 He's had some serious travel difficulties, but he did  
21 send in some questions.

22 MR. KEMENY: Okay.

23 MEMBER CLARKE: And I want to make sure we  
24 have time for those, but let's take a couple from the  
25 Committee, first. So, Ruth, do you want to go?

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1                   MEMBER WEINER: First of all, thank you  
2 for a very, very thorough presentation. I have two  
3 questions that are not related to each other.

4                   The first is, are there natural analogs  
5 for this process? I mean, I know that we have done --  
6 Banolier National Monument, for example, is full of  
7 caves that people have lived in in volcanic tuff.  
8 Does that kind of situation afford you any sort of  
9 natural analog to what you're modeling?

10                  MR. KEMENY: I think so. I think the  
11 problem always come in the thermal. You know, the  
12 Center is very insistent that the difference --  
13 there's a lot of places that have high stresses, that  
14 don't show complete drift collapse, and the DOE said,  
15 well, look at that. And then the Center says well,  
16 those don't have thermal loading, so that's really --  
17 and, unfortunately, I can't think of a maybe an  
18 analog where you've got the same kind of thermal  
19 loading. I think that's probably the problem with the  
20 analog.

21                  MEMBER WEINER: Yes. I don't think you  
22 have the same kind of thermal loading. People did  
23 build fires in those openings.

24                  MR. KEMENY: Sure. True.

25                  MEMBER WEINER: And that gives you, more

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1 or less, a continuing thermal loading, but the  
2 temperatures, of course, aren't as high. There's no  
3 spike.

4 MR. KEMENY: Well, certainly, the best  
5 analog we have is the heater test. The heater test in  
6 the non-lith, which is good because according to my  
7 analysis, the non-liths would have steeper strengths  
8 off the slope, so if you didn't see runaway spalling  
9 in the non-lith, you would definitely not see it in  
10 the lith. And then the only -- the Center is  
11 basically saying well, that's not a good test because  
12 it's got rock bolts and mesh. And I would say again,  
13 you know, DOE said the same thing, if you look at the  
14 stresses, the kind of support stresses given by rock  
15 bolts, there is some. I mean, typically, I mean,  
16 think about the stresses at Yucca Mountain, you've got  
17 10, 20 type of megaPascal static, and then it could go  
18 up to like 50 megaPascals thermal. The support  
19 pressure of a rock bolt is probably half a megaPascal,  
20 10<sup>th</sup> of a megaPascal, it's very small. And, again,  
21 that assumes that you put it in before you get the  
22 deformation, which is the case at Yucca Mountain,  
23 probably. I assume they put the rock bolts in before  
24 they heated it up. I assume that, so if that's the  
25 case, then yes, you could get a slight amount of

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1 support stress from a rock bolt, but it would be so  
2 small that I wouldn't think it would change the  
3 dynamic of the spall region. So if you're getting a  
4 very small spall region in the heater test, I would  
5 think that's a pretty good indication that that would  
6 similar, even if you didn't have any rock spall.  
7 That's something you could analyze, because again,  
8 rock bolts just don't apply that support pressure,  
9 probably a 10<sup>th</sup> of a megaPascal, compared to the kind  
10 of 20 to 50 megaPascals that's running in there, so  
11 it's a very small amount of support pressure.

12 MEMBER WEINER: My other question really  
13 ought to be addressed to the Center, I guess. There's  
14 a big difference between your results, and the  
15 Center's results. And I remember that we discussed  
16 this some years ago in visits to the Center, and also  
17 in presentations to this Committee. What do you see  
18 is the resolution of that?

19 MR. KEMENY: First of all, I don't see it  
20 as a big difference.

21 MEMBER WEINER: Oh, that's interesting.

22 MR. KEMENY: You know, the differences are  
23 coming from -- it's coming from the conservatism, I  
24 would say, because they -- the Center ran an elastic  
25 analysis, which is fine, and the elastic analysis

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1 showed some failure, a small amount of failure. It's  
2 very similar to what I showed, and what DOE showed.  
3 They are just saying since we don't know what's going  
4 to happen in the post-peak, let's take the worst case  
5 scenario. So, again, it's not as if they modeled, and  
6 they created large spall from the model. It was  
7 really from an assumption. And, again, if I'm wrong  
8 on this, let me know. But I was assuming they did an  
9 elastic analysis, and then they made an assumption.  
10 And since they didn't want to make -- they just took  
11 the worst case assumption about what would happen in  
12 the post-peak. And what I tried to do is say okay,  
13 let's do better than that. Let's just see if we can  
14 model the post-peak, similar to what DOE did. And  
15 when you actually model the post-peak, it looks like  
16 it's stable. So, again, I would say it's not  
17 necessarily a huge difference in terms of the starting  
18 point. It's just this kind of sort of an assumption  
19 that's made.

20 MEMBER WEINER: So you would say that the  
21 differences, just to repeat what you just said so I  
22 have it straight, the differences are that the  
23 Center's assumptions were conservative. But within  
24 their assumptions, your models would yield basically  
25 the same or very similar results.

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1 MR. KEMENY: I think they would admit that  
2 their assumptions are - I think, I'm not positive -  
3 that they are conservative, because again, it's true,  
4 that modeling post-peak rock behavior is a relatively  
5 new thing in rock mechanics. I mean, we haven't been  
6 doing it for 20 years, we've been doing it for maybe  
7 less than 10 years, so it's not necessarily totally  
8 out of line to say, okay, well, we can't model post-  
9 peak; therefore, we just not going to. We're going to  
10 make a worst case assumption. But I think the Center  
11 would admit that they were making a worst case, a  
12 conservative assumption.

13 MEMBER WEINER: Okay. Thank you.

14 MEMBER CLARKE: Okay, Ruth. Thank you.  
15 Allen?

16 VICE CHAIR CROFF: A couple of things. If  
17 you get damage in the rock, as you project, and  
18 apparently DOE projects, and then a seismic event  
19 comes along, is the rock a lot more susceptible to  
20 spalling?

21 MR. KEMENY: Definitely. The real  
22 question then, if the rock is damaged, then when a  
23 seismic event comes along, it's more likely to -- the  
24 rock fall would be worse than if it wasn't damaged.

25 VICE CHAIR CROFF: Okay. And is the

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1 seismic event that would be required the magnitude of  
2 it, particularly large, without defining what large  
3 is?

4 MR. KEMENY: Yes. And it could be that  
5 the seismic event, it could create drift fill. It  
6 might be smaller than if the rock wasn't there, so  
7 that's right.

8 VICE CHAIR CROFF: Okay.

9 MR. KEMENY: But, again -- yes, that's  
10 probably true. And it goes back to how much damage  
11 there is. I'm not predicting like a meter to two  
12 meters of damage around that --

13 VICE CHAIR CROFF: Has anybody looked at  
14 superposition of these two, I mean, assuming the  
15 damage occurs, and then at some point well down the  
16 road you get a seismic event. Has anybody looked into  
17 that?

18 MR. KEMENY: That's a good question. We  
19 did not, because we did the seismic, but we didn't do  
20 the thermal. And, similarly, DOE did the seismic and  
21 thermal separately, if I remember right. I think we'd  
22 all agree that it would be -- I think it's reasonable  
23 to agree that a damaged rock is going to fare worse in  
24 a seismic event than an undamaged rock.

25 VICE CHAIR CROFF: Okay. Second, I'm a

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1 little intrigued by this mention of stress corrosion  
2 cracking. I don't think of rock as being susceptible  
3 to that kind of thing, but if I understand what you  
4 mean, the rock under ordinary conditions is fairly  
5 stable in the presence of the percolating water coming  
6 down from wherever. But what you're implying is that  
7 under stress, it becomes more susceptible to, I guess,  
8 corrosion or dissolution, if I can use that word. Is  
9 that what we're talking about here?

10 MR. KEMENY: Yes. It's a similar  
11 phenomenon that's very common. You guys speak that  
12 language with the metals, I know, but yes. I mean,  
13 the crack -- the way we talk about it is, we call it  
14 sub-critical crack growth. So what's happening is the  
15 rock is under stress, and so all the little cracks are  
16 under stress. And they're not enough stress to break,  
17 because if we take a sample in the lab, I have to --  
18 in order to reach the tensile strength, I have to  
19 pull a certain amount, and so it's under less than  
20 that. But given enough time, the crack will continue  
21 to grow, and it grows slowly but surely over time.

22 VICE CHAIR CROFF: And it's growing  
23 because corrosive --

24 MR. KEMENY: Well, the main mechanism for  
25 stress corrosion cracking in rocks is -- again, it's

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1 stress enhanced, so it's at the tip of the crack, and  
2 it's typically -- in quartz, you get it from the  
3 silica, the switch, you have a silica oxygen bond and  
4 it re-arranges and becomes a weaker bond, and then  
5 it's able to break. It probably a similar mechanism -  
6 - I don't really know much about the metal stress  
7 corrosion, but it's a chemical reaction that's  
8 essentially taking place at the tip of the crack.  
9 It's enhanced at the tip of the crack. And you need  
10 water to do it, you need some amount of humidity, at  
11 least, in order to drive it.

12 VICE CHAIR CROFF: Has that been studied  
13 very much in tuff?

14 MR. KEMENY: Oh, yes, it's been studied a  
15 lot. And I should say that DOE's model is the same.  
16 The DOE has a time-dependent model in their drift  
17 degradation, and it's also stress corrosion cracking  
18 model. It's a little different than the one I used.  
19 I used this what's called a power-law. They use an  
20 exponential function. But other than that, they're  
21 both -- they devote a lot -- there's a whole chapter  
22 devoted to this in the drift degradation analysis  
23 report about their model. Yes, and it's a stress  
24 corrosion model.

25 VICE CHAIR CROFF: Okay. And are the time

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1 constants on stress corrosion cracking - I mean,  
2 you've run through your models, and you basically  
3 conclude the tunnel is reasonably stable, some  
4 spalling but not much. Are the time constants on  
5 stress corrosion cracking such that it wouldn't have  
6 a lot of effect during the time you looked at it? It  
7 might be 100,000 years, or --

8 MR. KEMENY: Well, let me say first, it's  
9 not a standard type of test to determine these time-  
10 dependent parameters. I am a little uneasy on those  
11 properties, just because if you look at how I  
12 determined those, a little bit of back-calculation  
13 there, so I actually reduce the properties. I  
14 mentioned this in the report, I did the analysis where  
15 I just reduced the properties, just to see what would  
16 happen. Because let's say I'm off on this one  
17 parameter, so I reduced it much farther than I thought  
18 it would be, and just to see the difference. And it  
19 wasn't a huge difference, but there was a difference.  
20 But yes, I think what it's showing is, with the kind  
21 of stresses we're seeing there, 1,000 years isn't  
22 really enough. You're right. When you go to a  
23 million years, you start to see a lot more definition  
24 of that kind of mechanism. You can, it depends on the  
25 level of stress. I think everybody knows, for

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1 instance, that like -- let's say I have a rock, and  
2 it's got a strength of 100 megaPascal. If I sit it at  
3 80 megaPascal, let it sit there, probably after a few  
4 months it's going to fail. So if you're close to the  
5 failure strength, then you might only have to wait a  
6 few minutes, or a few months, or a few years. But  
7 let's say I only put a load of half the stress I need,  
8 well, then it may take 10,000, or may take 100,000  
9 years to fail. It will still fail, but it may take a  
10 lot longer, and it's sort of a logarithmic type of  
11 thing. So as the -- and these tests have been done in  
12 the lab. They can do the test where you put it at 90  
13 percent because it fails within a few hours. You can  
14 do the test at 80 percent of strength, maybe it takes  
15 a few days. But as soon as you get to like 70 or 60,  
16 you can't wait that long. It may take years, it takes  
17 tens of years, so, unfortunately, the test results  
18 don't go down the very low values because it would  
19 take too long to have them fail. So we're  
20 extrapolating all this, and they also do this in the  
21 DOE, they have to extrapolate to these lower values.

22 VICE CHAIR CROFF: Okay. Thanks.

23 MR. KEMENY: Yes.

24 MEMBER CLARKE: Okay. Thank you, Allen.

25 I want to get to Bill's questions, but one for you,

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1 John,

2 MR. KEMENY: Okay.

3 MEMBER CLARKE: I'm looking at the second  
4 bullet in your conclusions, and it says that the UDEC  
5 results indicate that damage would occur within 50 to  
6 150 years. Is that the case with the FLAC results, as  
7 well?

8 MR. KEMENY: Well, the FLAC was not time-  
9 dependent.

10 MEMBER CLARKE: It's a different kind of -  
11 -

12 MR. KEMENY: I didn't do a time-dependent  
13 FLAC result.

14 MEMBER CLARKE: Okay.

15 MR. KEMENY: The way I do time-dependence  
16 in UDEC is, it's actually the stress corrosion  
17 cracking, but there are really no cracks in the FLAC.  
18 FLAC is a continuum model, so, unfortunately, in a  
19 continuum model, you don't really have a crack, so I  
20 don't really know how to do the time-dependence in  
21 FLAC.

22 MEMBER CLARKE: I guess what struck me  
23 with that is that that would be during the period when  
24 the repository would still be open.

25 MR. KEMENY: That's true. And I feel that

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1 same way, that in some sense - and that's what these  
2 results show. We would be able to see -- let's say we  
3 were wrong. Scientists are not -- we're wrong  
4 sometimes, so let's say we were wrong, and you did get  
5 big spalling. Well, you'd see it, because it  
6 certainly would happen right away. If you look at  
7 those curves, I mean, all the damage, you get a very  
8 steep amount of increase in damage in just the first  
9 10 years, so you would see it.

10 MEMBER CLARKE: Okay. Thank you. Neil  
11 Coleman of the ACNW&M staff has been working very  
12 closely with Bill on these issues. He has Bill's  
13 questions, so Neil.

14 MR. COLEMAN: Okay. Could you comment on  
15 the in-tact rock strength versus rock mass strength,  
16 and the scaling relationship, and how that was  
17 addressed in the modeling that you did?

18 MR. KEMENY: Right. Now it's right at the  
19 beginning. I hope I'm not wrong in this, but the  
20 typical -- a lot of rock mechanics has been developed  
21 for the hard blocky rock containing joints, including  
22 your typical three-joint sets. In non-lith, there's  
23 this whole new thing, this is swiss cheese rock, and  
24 something that we were not used to. But, anyway, I  
25 think if I'm not wrong, these -- for these Categories

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1 of 1-5, these are rock mass properties, but it's a  
2 different kind of rock mass than you typically see for  
3 a hard blocky rock. Because what happens with hard  
4 rock is we test a little piece of granite in the lab,  
5 we get 200 megaPascals for the strength. Well, when  
6 we extrapolate that to the scale of a large slope or  
7 something like that, it can go down by a factor of  
8 100. The rock mass strength can be 100 times lower  
9 than the in-tact strength. In-tact strength is a  
10 little piece that we test in the lab. The rock mass  
11 is the big piece we see on a highway, or underneath an  
12 excavation, and it can be a difference by a factor of  
13 100. It depends on how many joints you have, the  
14 spacing of the joints. But this lithophysal rock is  
15 different, it doesn't have a lot what we consider  
16 these classical low-cohesion discontinuities, and so  
17 because of that, when you test a sample that's big,  
18 this big, it's a little bit weaker than a small  
19 sample, but it's not the factor of 100. So as far as  
20 I know, these are the rock mass, and there is no kind  
21 of equivalent in-tact, because - well, you can, but if  
22 you tested the material in-between the lithophysae, I  
23 mean, this is essentially -- the 30 is probably  
24 essentially the in-tact strength. And then by adding  
25 the lithophysae, reduced it to 10, but if you didn't

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1 have any lithophysae at all, you're probably just a  
2 little bit stronger than that one, so maybe 35 or 40  
3 megaPascal. So that's essentially the in-tact. And  
4 then as I add this heterogeneity, it keeps getting  
5 weaker and weaker, so these are what I would call for  
6 the lithophysae.

7 Now this bottom one I put, maybe that's  
8 what he's referring to. You can -- this is basically  
9 using one of these Hoek and Browne rock mass strength  
10 criteria, so based on R mar. R mar is something that  
11 he's calculated in the non-lith, you get R mar values  
12 of like 50 or 60, and based on that, you take in-tact  
13 rock, you can calculate it, and that's where that is  
14 coming from.

15 MR. COLEMAN: Actually, the staff are  
16 here, and I just wanted to confirm something by asking  
17 Raj, as I understand it, the current design, and you  
18 won't see the final design until an LA is submitted,  
19 but the current design involves stainless steel rock  
20 bolts, and a thin layer of a perforated stainless  
21 steel mesh. Is that still your current understanding?

22 MR. NATARAJA: Yes, but that's not being  
23 discussed here, because that support is only supposed  
24 to be helping you during the pre-closure period, and  
25 no credit is being taken for the performance of the

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1 support system during post-closure.

2 MR. COLEMAN: Right. But I'm just asking  
3 what the current design was.

4 MR. NATARAJA: Yes, what you just said is  
5 what we have seen in the current conceptual designs.

6 MR. COLEMAN: Certainly, stainless steel  
7 rock bolts would last much longer than the carbon  
8 steel that's typically used.

9 MR. NATARAJA: They could, but as the  
10 presenter said, I don't think there are too many  
11 studies documenting the life span of ground support  
12 system.

13 MR. KEMENY: The key is -- it's quite a  
14 corrosive environment for the rock bolt. It's in the  
15 rock, fluids are going to travel. Well, they can be  
16 grouted, I shouldn't say that. Well, they can't be  
17 grouted because you can't use cement. I don't know,  
18 so if you grouted them and protected the rock bolt  
19 from the environment, they would last longer, so I  
20 don't know if that's going to -- if they're going to  
21 be grouted or not.

22 MR. COLEMAN: Of course, there's also  
23 going to be a thermal period with extensive dry-out of  
24 the rock that would be keeping a lot of moisture away.

25 MR. KEMENY: That's true. So if the

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1 moisture is away, then yes, stainless steel rock bolt,  
2 I would think would last a long time. And I would  
3 think that -- I think there are some studies going on.  
4 When I just did some Google search, I found some  
5 various studies in the perforated sheet, and on the  
6 rock bolts. It looks like people are studying the  
7 long-term behavior of those things, but they haven't  
8 entered into any of these initial documents, the  
9 results, I guess. But it does appear there are some  
10 studies going on on this stuff.

11 MR. COLEMAN: Also, there's a question  
12 about the basic testing that the data are based on,  
13 the uniaxial compression testing. Now this, of  
14 course, is different from the actual conditions  
15 underground. Initially, you have a cylindrical tunnel  
16 that's unconfined on one side, and a lot of these  
17 conclusions about the rock strength are based on a  
18 completely unconfined test. Does this add to  
19 conservatism of the analysis in what one concludes  
20 about the strength?

21 MR. KEMENY: I don't know. I'm not sure.  
22 That's a typical -- if it's a typical, we just assume  
23 that's the uniaxial strength. I don't think that's  
24 necessarily that conservative.

25 MR. COLEMAN: In identifying the depth of

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1 spalling that takes place, I believe some of the  
2 materials you've written refer to a self-limiting  
3 process in this depth of spalling. And, although, I  
4 think you've addressed that at several points in your  
5 talk, could you just briefly summarize the things that  
6 limit the depth of spalling in the worst case.

7 MR. KEMENY: Here, these two figures -  
8 well, these two, so if I take a look at these two,  
9 here's a case where I do see a lot of spalling, here's  
10 a case where I don't. And the difference is -- the  
11 key difference, it's in the post-peak behavior of the  
12 material.

13 Now if I look at the stable case, what I  
14 see here is, I see, again, I see a very narrow region  
15 where I'm getting some softening. But if you look at  
16 these numbers right here, it starts at 7.5, only goes  
17 down to 6, only about a 20 percent decrease in the  
18 cohesion, and in the tensile strength. And because of  
19 that, it's basically -- it still maintains some  
20 residual stress. So the key is if I go -- maybe I  
21 didn't do that before - is start at the peak, and that  
22 material in the boundary is not down here, it's right  
23 here somewhere. It hasn't gotten all the way down.  
24 And the reason is because there hasn't been enough  
25 strain. Because this kind of -- it's all got to do

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1 with this kind of extra stuff right at the peak here,  
2 so it ends up sitting right there, instead of dropping  
3 down.

4 If I go to the unstable case, you can see  
5 it's a very sharp drop. It doesn't have any strain at  
6 the top there, so as soon as there's a little strain  
7 in the post-peak, it drops. So what happens is, you  
8 can see it started actually on the wall, but what  
9 happens is it completely reaches bottom, so all the  
10 stress has to go to the neighbor. That gets bottomed  
11 out, and so on. And the reason it sort of starts at  
12 the wall and sort of progresses toward the roof is  
13 because that what happens to the stress rate over  
14 time. As you heat up an underground excavation,  
15 initially you're just heating up right at the  
16 boundary, so the high stresses are equally around, all  
17 around the boundary. And it's going to fail first  
18 right here, because that in-situ stress is the highest  
19 in the wall. But then with time, what happens is  
20 there starts to be some interaction between the drift  
21 here and the drift that's 81 meters apart, and those  
22 temperatures start to expand that pillar. And that  
23 creates higher stresses in the roof. So you get sort  
24 of -- it starts here, and it kind of migrates over to  
25 the roof. And if you look at this figure here, you

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1 actually see -- this one, you can actually see the  
2 same thing, because what happened was, these are  
3 green, which represents yield in the past. And then  
4 the active yielding is in the roof, so what happens,  
5 again it started in the wall, and it migrated up to  
6 the roof, and that's sort of the process that we see  
7 there.

8 But anyway, so the big factor is that the  
9 fact that it's not very steep in the post-peak means  
10 that it can retain residual strength, and it doesn't  
11 have to fall out. It can just sit there with slightly  
12 -- it's a stable -- it turns out this is a stable  
13 equilibrium condition, with just a slightly yielded  
14 zone here, and it's like you said, it's self-limiting  
15 in this particular case. But if it was a steeper  
16 strain softening, it's not self-limiting, it causes  
17 that progressive spalling.

18 MR. COLEMAN: And here, you're talking  
19 about a case where there's no consideration of ground  
20 support at all, just the natural case.

21 MR. KEMENY: Right. Right. Sure. I  
22 mean, it makes sense. If you create a damage zone and  
23 the rock doesn't fall out, it retains a little  
24 residual strength, then that's the best support. It's  
25 like a natural support system, in a way, because the

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1 stress moves away from it a little bit, so there isn't  
2 much stress in it, but it doesn't fall out. That's  
3 right.

4 MR. COLEMAN: The NRC has recently  
5 published TPA 5.1, the User's Guide, and the current  
6 best estimates by the staff on collapse of the  
7 tunnels. And the current estimate in there is that  
8 full collapse of the tunnels would occur in less than  
9 2,000 years. And that certainly seems very different  
10 from what you're talking about here. It does not  
11 appear to take into account the variation in the rock  
12 properties, the lithophysal.

13 MR. KEMENY: You're right. Right. Well,  
14 that's another -- that's true. That's another thing  
15 that -- these are -- you would expect -- I mean,  
16 there's a significant change in the properties between  
17 this lithophysal 1 and 5, so you wouldn't expect  
18 everything to just happen the same across the board.  
19 You would expect there to be differences between the  
20 different materials.

21 And what I'm kind of showing, if there's  
22 any rock that's the most susceptible, it would be this  
23 lithophysal 1. It's got the highest porosity, it only  
24 represents 2.5 percent of the repository, but that's  
25 the one that, if anything, may show some more

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1 significant rock fall than the other one.

2 MR. COLEMAN: I'm trying to think of a  
3 very simple way to describe this. The liths that  
4 you're showing, the lower right in that figure shows  
5 this is the thermal phase, and you're showing a  
6 greater depth of spalling in the roof?

7 MR. KEMENY: Well, no. Actually, I should  
8 be careful, because this is what an elastic analysis  
9 would kind of show, because what an elastic analysis  
10 shows is that there's several phases of this  
11 temperature cycle. Initially, you're heating up right  
12 around the room, and then in the end, you're heating  
13 up the whole pillar and the whole rock mass is  
14 expanding. In the end, the elastic analysis, this is  
15 very similar to what -- maybe what the Center came up  
16 with. But what I kind of show sometimes, and that's  
17 very similar to the stable case, I get here. You can  
18 see I've got there's more cohesion lost in the roof  
19 than there is in the wall, so I also get that. But in  
20 this case, you'll notice it's a little bit different,  
21 because in this case, because I get failure of the  
22 wall first, it actually changes the stress state, so  
23 you end up with sort of a different kind of a failure  
24 in the end. And I mentioned this in the report, that  
25 in a true non-linear analysis, the stress path does

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1 matter. And you can see that here, the stress path  
2 results in a different failure than if you just did an  
3 elastic analysis. You might predict something like  
4 this, but because that's elastic, so there's no  
5 failure anywhere. But when you actually take into  
6 account the non-linear of the rock, you might get a  
7 different result.

8 MR. COLEMAN: One last point here. You  
9 describe how in the thermal period there's a  
10 transition in the maximum stress more to the overhead  
11 in the tunnel than in the walls; whereas, in the  
12 present day, there's a greater stress in the walls.  
13 Sort of a simple way to look at this, if you get  
14 initial spalling from the overhead in the drift, then  
15 more of it begins, from a stress point of view, to  
16 look like walls. Is that one of the things that in a  
17 simple way is limiting the overall spalling, where it  
18 eventually completely bridges over, and you don't get  
19 much additional failure?

20 MR. KEMENY: I don't know. Well, I mean,  
21 the -- initially, the stress is higher in the walls  
22 because this is a normal faulting regime. Normal  
23 faulting, you've got your highest stress is your  
24 vertical stress, so initially, the highest stress is  
25 in the wall, because this is your highest in-situ

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1 stress is the vertical stress, because it's a normal  
2 faulting type of thing. But the transition is really  
3 -- first of all, when you start to heat, if you look  
4 at solution for thermal stress due to putting a hot  
5 canister, it gives an equal thermal stress pretty much  
6 all the way around, and that's true. So then what  
7 you're doing is, you're still not creating this  
8 effect. But that final effect comes from the fact  
9 that you heat those pillars, 81 meter pillars up, and  
10 that expansion creates this sort of third phase which  
11 has got a high stress component in the roof. And  
12 that's got to do with -- because it's allowed to --  
13 the mountain basically moves up, but it can't really  
14 -- because you've got all these parallel drifts, it's  
15 kind of forced to not expand laterally, so it creates  
16 the stress. But that's when the full heating of that  
17 pillar -- I didn't bring any -- I should have brought  
18 some figures on that to show you, but that's really  
19 what's creating the high stress on the roof, is the  
20 heating of the pillar. It wants to expand, but  
21 because I have parallel drifts, it can't expand, so it  
22 creates a high horizontal stress. And that's kind of  
23 the third phase.

24 The first phase is before you heat, you  
25 have the highest stresses here. When I thermally

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1 heat, the thermal heating is kind of equal all the way  
2 around, but you'll end up with the higher stresses in  
3 the wall because you add the in-situ stress to the  
4 thermal. And then finally as the pillar starts to  
5 heat up, you'll start to see a little more -- maybe a  
6 little more stress in the roof. But you were giving  
7 some analogy which I couldn't quite --

8 MR. COLEMAN: Just as a final  
9 clarification here. Your first bullet there, "Depth  
10 of spalling less than 1 radius", it would predict less  
11 than 1 radius away from the boundary. And is that for  
12 the lithophysal Category 5?

13 MR. KEMENY: Well, I'm not -- I put this  
14 mainly -- I'm trying to just say well, what do I mean  
15 by slight to moderate over stress? I'm not really  
16 speaking of Yucca Mountain so much here. I'm just  
17 speaking about any place. I'm saying if the over-  
18 stress is greater than the radius, then we might -- it  
19 might start to get into this category here, what I  
20 consider to be -- we used the word here, we call it  
21 squeezing ground conditions. We have this super high  
22 stress, we refer to that as the squeezing ground  
23 condition, because the stress is so high. So what I'm  
24 saying is, once this D is greater than R, or maybe  
25 even 2R, then you've kind of -- now it's at the

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1 squeezing ground condition, as opposed to this, what  
2 I'd call slight to moderate over-stress condition.

3 MR. COLEMAN: Well, from your modeling,  
4 what insight would you have about -- not looking at  
5 the most highly fractured case, which is a severe  
6 case, but of the different categories of lithophysal  
7 versus non-lithophysal rock, what sort of radius depth  
8 of spalling --

9 MR. KEMENY: Well, the FLAC is predicting  
10 this to skip. I call it like a skin effect. So,  
11 again, you get sort of a different result between the  
12 FLAC and the -- the FLAC is predicting various thin  
13 skin of spalling, less than -- way less than a meter,  
14 less than a half a meter. And that's shown by  
15 basically this. So, again, we predict that you always  
16 get this sort of stable case. But you're getting some  
17 small region where you're over-stressing the rock, and  
18 it's just what we call a skin effect. Now that's what  
19 you get from the FLAC.

20 Now what you get from UDEC is a little bit  
21 different. UDEC kind of predicts this kind of result,  
22 where you've got a damage zone that could be quite  
23 thick, but you're only predicting very little isolated  
24 blocks to come down within that damage zone. So the  
25 who damage zone does not come down, and that's because

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1 the definition of damage zone is different than the  
2 definition of what the FLAC sees. The definition of  
3 damage zone means that at least one side of that block  
4 is cracked, but that doesn't mean all sides are  
5 cracked. So just because you have a damage zone,  
6 these blocks won't necessarily fail, because they're  
7 held up, and there's only some failure on certain  
8 sides of the blocks, and not all sides. That's why.  
9 Again, if you refer to the damage. So this is very  
10 similar to what DOE was getting, the damage zone was  
11 on the order of a meter, but again, it wasn't really  
12 showing that much rock fall within the damage zone.  
13 Just maybe isolated blocks here and there.

14 MR. COLEMAN: Thank you very much. A very  
15 informative presentation.

16 MEMBER CLARKE: Thank you, Neil.

17 MR. COLEMAN: We have five minutes. You  
18 might want to invite any comments from the staff.

19 MEMBER CLARKE: I was going to do that,  
20 but Ruth has a quick one, and hope it's a quick one.  
21 And I want to invite the Center to participate, as  
22 well. We just have a few minutes, and we do need to -  
23 -

24 MEMBER WEINER: This is a very quick  
25 question. You're assuming that the effects that you

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1 see are uniform along the entire drift.

2 MR. KEMENY: Sure.

3 MEMBER WEINER: That's correct. Is that  
4 a good assumption?

5 MR. KEMENY: Well, I think, again, this is  
6 the same assumption that DOE makes, that the  
7 lithophysal makes for an okay, two-dimensional  
8 approximation, because it's kind of like the swiss  
9 cheese rock, so it's really okay.

10 Now when you go to the non-lith, you  
11 notice they did a full 3-D analysis, because really  
12 you run into problems there by making a two-  
13 dimensional assumption. But for the non-lith -- for  
14 the lithophysal, then I think it's a pretty good  
15 assumption, yes.

16 MEMBER WEINER: Okay. Thanks.

17 MEMBER CLARKE: Okay. Antonio has  
18 something.

19 MR. DIAS: Yes. Hi, this is Antonio Dias  
20 with the Center staff, and it's somewhat to follow-up  
21 from what Ruth was saying. In your model, UDEC model,  
22 you basically assumed at the start of your simulation  
23 that that was a pristine drift. What would be the  
24 consequence, and how difficult would it be to  
25 incorporate actually the effects of the drilling that

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1 cause on those walls, so instead of starting from a  
2 clean sheet, you actually have already some induced  
3 cracks.

4 MR. KEMENY: Okay. From the TBM, you  
5 mean?

6 MR. DIAS: Yes, the tunnel boring. How  
7 much of a penalty is that? And the other question I  
8 have would be, your thermal loading, you applied it  
9 for 1,000 years. Is it a constant load?

10 MR. KEMENY: Yes. I'm sorry. I didn't  
11 quite do -- I actually -- the way I did the thermal,  
12 I'll answer that question first, was I loaded up to  
13 the maximum thermal, and then I just kept it constant  
14 for 1,000 years.

15 MR. DIAS: Because it's --

16 MR. KEMENY: But I realize -- and I did  
17 some of the models where I did that, and it wasn't  
18 that much of a difference.

19 MR. DIAS: Really? That's very  
20 interesting.

21 MR. KEMENY: Yes. But, again, I didn't  
22 report on those, because I just did one run, I think,  
23 on that. Most of them I held it for constant for  
24 1,000.

25 MR. DIAS: Okay.

1 MR. KEMENY: But to answer your first  
2 question, yes, I think so. I think that TBM will do  
3 some damage, probably within -- maybe a half a meter  
4 or something, so that could be put into the model.

5 MR. DIAS: Yes. Okay. Thank you.

6 MEMBER CLARKE: Thanks, Antonio. Let me  
7 now invite the Center. Are you still on the bridge?

8 MR. IBARRA: Yes, this is the Center.

9 MEMBER CLARKE: Any questions?

10 MR. IBARRA: Okay. This is Luis Ibarra  
11 from the Center. I have a question about the FLAC  
12 model. Mr. Kemeny has mentioned several times that it  
13 was key behavior that made the key difference in the  
14 potential spallation of the rock. And he mentioned  
15 that a factor of gamma C, which is the strength after  
16 the -- the peak strength, it will be the key. I don't  
17 have the figures here, but in one of the figures on  
18 the report, he shows that you have a larger gamma C  
19 value, he has on ductility after the peak strength, so  
20 my question is there's no experiment, at least no  
21 available experiments showing what is the performance  
22 of this tuff material after the peak strength, and the  
23 question would be what are the reasons for believing  
24 that you shall have -- that shall be ductility or less  
25 ductility after the peak strength in the confinement

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1 area is reached?

2 MR. KEMENY: Okay. That's a good  
3 question. First of all, he brings up a very good  
4 point, which is mentioned in the report, that these  
5 are actually not laboratory test results. As it turns  
6 out, when do lab tests, it's been traditional to  
7 measure the peak, and to measure this slope so we know  
8 the modulus. But this is -- in all the reports that  
9 I have, I do not have the information from actual  
10 tests.

11 Now there were a couple of tests presented  
12 by DOE, I don't have them, that did show this  
13 International Lab test, but they're from some report  
14 that I don't have, or unpublished. But I think the  
15 key is, and I mentioned this in the conclusions, in  
16 the future we need to really start reporting the post-  
17 peak because it is so important in this problem of  
18 spalling. But I think the question that he asked is  
19 really the answer here, that why do we believe that in  
20 the real -- when we test the real rock, we're going to  
21 get those big strain softening slopes? And it's  
22 really got to do with the size of the heterogeneity,  
23 that when we tested granite, and it has a .1  
24 millimeter grain size, we sometimes get a very steep  
25 post peak. But in all cases, when you start to have

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1 this heterogeneous cracks, it's a very torturous path  
2 the crack has to take to get its way through there,  
3 and it always results in more strain. You can see  
4 that in the results.

5 This is without the lithophysae, this is  
6 with, and you can see that it produces a much bigger  
7 post peak. And I believe that in general, the larger  
8 the heterogeneity, the more strain, post-peak strain  
9 you're going to -- they're going to produce. And  
10 since this is the rock that we're dealing with --

11 MR. IBARRA: All right. That's all our  
12 follow-up questions.

13 MEMBER CLARKE: All right.

14 MR. OFOEGBU: John, this is Goodluck. I  
15 have the response to Luis' question, that in looking  
16 at the calculations you did, what we find is that the  
17 parameter, what it intends to control, actually, is  
18 not stress, often it is the amount of strain that your  
19 material can undergo without a significant change in  
20 the strength, which is the ductility that Luis is  
21 talking about. And you know that brittle rock, like  
22 basaltic, volcanic rock is typical brittle rock based  
23 on information that has been published in the  
24 literature, for it to have this kind of ductility, you  
25 have to increase the confining pressure to probably

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1       tens of megaPascals. The best thing, of course, would  
2       be to show whether the rock has this kind of  
3       ductility, that without a test, the question is what  
4       do we expect, based on studies of rocks that we have  
5       published in the literature. What kind of rock  
6       usually is the peak when you measure the ductility at  
7       the peak of the stress. Would we observe this kind of  
8       behavior from volcanic tuff?

9                   MR. KEMENY: I see what you're saying.  
10       I've seen some non-lithophysal tuff that's very fine  
11       grain, like you said. It could be quite brittle, but  
12       that's not what we're looking at, in general, in the  
13       lithophysal. It's very heterogeneous. But I would  
14       say, my biggest support, I think, would be the two  
15       test results that I -- the two kind of actual field  
16       results that you have. One is, that if I go to the  
17       Category 1, this is the Category 1, if it was very  
18       brittle. But this is not what we see in the drifts  
19       today. What we see in the drifts today, looks more  
20       like what we predict when it's not very brittle. So  
21       I guess this would be the one piece of evidence we  
22       have, is that this exists now in the tunnels. We can  
23       go look at this, and we do not see this massive type  
24       of wall spalling. What we see is something more  
25       consistent with this, where we see a region with just

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1 a little drop in cohesion, maybe a little bit of  
2 bulging right near the center.

3 The second case, I would say, would be the  
4 heater test in the non-lith, because again, there are  
5 rock bolts there. I don't believe the rock bolts are  
6 really adding much support; so, therefore, I would say  
7 that, again, that's another piece of evidence that  
8 it's behaving not like this basalt that has this super  
9 steep post peak, but rather like a more -- a rock  
10 that has a lot of heterogeneity to it on large scale.

11 MR. OFOEGBU: Can I see -- I don't know  
12 what the schedule is there, but this behavior of  
13 Category 1 material in the drifts that you mentioned,  
14 actually helps confine the strength of the material,  
15 that it doesn't really tell us what would happen if  
16 the stress were to -- if there is a constant sort of  
17 loading, like thermal load, that tends to increase the  
18 stress in the rock beyond the peak strength.

19 MR. KEMENY: The result I show, as I said  
20 before, because the modulus is so low, this has not  
21 got to do with thermal at all. The result I show for  
22 Category 1 is all based on in-situ stress, because the  
23 thermal - it's like one megaPascal increase due to  
24 thermal, and so this is the result of static loading  
25 only.

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1 MR. OFOEGBU: Yes, but I mean all the  
2 analyses come and do show that for Category 1 rock,  
3 you don't get -- you get failure on the side wall, but  
4 not in the roof, because of the low modulus on the  
5 thermal load. So what I'm wondering is how the  
6 behavior of Category 1 rock out in the field is  
7 evidence of ductility. It only gives you the -- what  
8 happens in an opening immediately after it's  
9 commissioned? That tells you how the stress, the in-  
10 situ stress, or the stress concentration around the  
11 opening relates to the strength of the material, but  
12 it doesn't really tell you how failure may progress,  
13 if it didn't occur. And the example you mentioned for  
14 the heater test, I thought that the heater test showed  
15 a lot of bulging in the wire mesh, indicating that  
16 there is a load of rubble weighing down on that  
17 material, and that it is possible that the existence  
18 of the material essentially removed the space  
19 available for more -- for rock to fall into, that's  
20 likely if the opening were to be filled with rubble.  
21 So why would you use that as an evidence of ductility  
22 for the non-lithophysal tuff?

23 MR. KEMENY: Well, again, I know how much  
24 force one of these -- this is a split-set, it looks  
25 like to me. If that's a split-set, it probably --

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1       when I said .1 megaPascal, that was for actually like  
2       a resin ball. There was a split-set, which that looks  
3       like it is, I have to calculate it, but it's probably  
4       100<sup>th</sup> of a megaPascal, is the amount of support force  
5       it's going to apply. So I can't imagine that the  
6       difference between massive rock fall and it's just a  
7       100<sup>th</sup> of a megaPascal of rock bolt support, so I would  
8       -- I think it -- I just think that compared to --  
9       again, this is the non-lith, so again, if anything is  
10      going to go, it would be the -- if anything is going  
11      to be brittle, it's going to be the non-lith. So the  
12      fact that you're seeing such a small zone of spalling,  
13      to me, would indicate that --

14                   MR. OFOEGBU: Well, the importance of the  
15      heater test, is that it's live evidence that we have  
16      of how the rock might behave on that thermal load.  
17      I'm surprised, though, that you're discounting the  
18      role of support. Support system does -- the role of  
19      support system is not really reduced related to the  
20      amount of pressure it applies in this particular case.  
21      What is critical is for something to -- the wire mesh,  
22      what it does is that as the rubble comes down, instead  
23      of falling off the surface, it is held by the wire  
24      mesh, and the wire mesh essentially creates -- limits  
25      the amount of space that is available. And once that

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1 space is filled up, then there isn't room for any more  
2 material to fall. This is speculation, of course.  
3 The right thing would have been to cut out the wire  
4 mesh, and let whatever is there fall off, and then we  
5 see how much it is, and then see whether there's any  
6 tendency, and this is why I think it's virtually  
7 incomplete in terms of the behavior of the rock under  
8 heated conditions.

9 MR. KEMENY: Well, let me just say that if  
10 I went into a deep underground excavation with this  
11 amount, same support rock bolts, mesh, and it was  
12 unstable in the sense of -- I would see this full of  
13 loose rock. I mean, it wouldn't just be in the  
14 middle, it would be all across, it would be sagging  
15 the mesh in-between the bolts, it would be popping the  
16 bolts out. I mean, there are many examples of  
17 underground excavations where this is a support, and  
18 it's just popping. It's just popping it out. So I  
19 would just -- if it really -- if you really thought  
20 that this was the kind of -- going back to this  
21 figure. If you really thought this was the kind of  
22 failure we're getting, then I would expect to see more  
23 evidence of that behind the wire mesh. We've seen  
24 that in deep underground excavations.

25 MR. OFOEGBU: We've spent a lot of time on

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1 non-lithophysal, but for the lithophysal rock, I think  
2 the main thing you present is that with some amount of  
3 ductility, that you can expect the rock -- the  
4 overloaded rock to simply fracture, and shed the load.  
5 But your analysis all show that even if you reduce  
6 this ductility, then you would expect the material to  
7 fracture and fall. One of the test results, you  
8 showed two tests by FLAC, one with .05 and the other  
9 one with -- okay, .002 and .005. So that small  
10 difference, and you also show that the difference is  
11 really in the ductility at the peak point or the  
12 stress break-off. In one case, there is measurable  
13 ductility. The other case, there is ductility, but  
14 not much.

15 MR. KEMENY: Right.

16 MR. OFOEGBU: Okay. So the first case  
17 showed what you interpreted to be spallation tended  
18 for the spallation to continue. Whereas the other one  
19 showed that in fact the ductility of the rock is  
20 enough to prevent it. So it boils down, really what  
21 needs to be determined, if we are going to -- if one  
22 would rely on this kind of behavior to predict what  
23 might happen in the drifts is to look at test results  
24 that will show whether this rock has sufficient  
25 ductility to change the behavior under thermal

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1 conditions.

2 MEMBER CLARKE: Mr. Chairman, I'm going to  
3 need to jump in here. We were scheduled to end at 10,  
4 and it's now past 10, after 10. Raj has one more  
5 question, then I'm going to have to call it. Thank  
6 you.

7 MR. NATARAJA: This is Nataraja, NRC  
8 staff. I don't have a question. We didn't intend to  
9 have any kind of a debate or anything like that on  
10 this presentation. All I can say is that it's an  
11 excellent presentation, and what we have learned today  
12 does not seem to change our approach to the review.  
13 If you remember what we said, we were looking at the  
14 various possibilities, the range of possibilities that  
15 might be predicted by various models, alternative  
16 conceptual models, and it looks like that this  
17 presentation confirms that we have a number of  
18 possibilities, as he showed the two extreme cases, and  
19 we are looking at all the things in-between in our  
20 performance assessment. So I think it actually  
21 strengthens our approach of review, and it's an other  
22 good data point for us. Thank you.

23 MEMBER CLARKE: Thank you. John, thank  
24 you very much.

25 MR. KEMENY: All right.

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1 MEMBER CLARKE: Thank you all. Allen?

2 VICE CHAIR CROFF: Thanks for an  
3 interesting presentation. At this point, we'll go off  
4 the record until 1:00, where we'll reconvene and hear  
5 about in-situ leach mining and TAD. Thank you.

6 (Whereupon, the proceedings went off the  
7 record at 10:14 a.m., and went back on the record at  
8 12:58 p.m.)

9 CHAIR RYAN: The meeting will come to  
10 order.

11 The cognizant member for this session, the  
12 session after the break, is Dr. Weiner on issues  
13 related to first in situ uranium mining facilities;  
14 and second, vendors' views on transportation, aging  
15 and disposal performance specifications.

16 So Dr. Weiner, have at it.

17 UPDATE ON NRC RULEMAKING ON GROUNDWATER PROTECTION  
18 AT IN-SITU LEACH URANIUM MINING FACILITIES

19 MR. RATHBUN: Thank you.

20 We are scheduled to have an update on the  
21 rulemaking on groundwater protection at in-situ leach  
22 facilities. And I take it our speakers are Gary  
23 Comfort and Mike Fliegel. Divide it up however you  
24 want to.

25 Gary, you're in charge, our lead speaker.

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1 MR. RATHBUN: Dr. Weiner, let me say -  
2 Dennis Rathbun from the Division of Intergovernmental  
3 Liaison and Rulemaking.

4 We are pleased to be here. We worked this  
5 up with Mike and Gary.

6 (Telephone interruption)

7 MEMBER WEINER: I think it's just us.

8 Dennis, if you want to continue. Sorry  
9 for the interruption.

10 MR. RATHBUN: Oh, sure. Thank you.

11 Anyway, we responded to ANCW's request.  
12 Talked to Mike Fliegel and Gary Comfort.

13 Gary will be - he has a set of slides that  
14 he's going to go through. But we've had a lot of  
15 interactions over the past several months with  
16 Environmental Protection Agency, and that's been kind  
17 of challenging I guess is a gentle way to put it.

18 And we had originally planned that e would  
19 have a draft proposed rule in late spring, April or so  
20 of next year in 2008. Whether or not we will actually  
21 make that date or not, given the current status and  
22 the complexity of the ongoing discussions that we had  
23 with the Environmental Protection Agency I think  
24 frankly is a little problematic at this point.

25 But ANCW wanted to have a status report on

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1 where we are with respect to the situation, and in  
2 particular the technical basis. And so Gary will go  
3 through what we're doing.

4 I'll turn it over to Gary and Mike.

5 MR. COMFORT: Good afternoon, everybody.  
6 My name is Gary Comfort. I'm a senior project manager  
7 in the rulemaking branch and division of inter-  
8 governmental liaison and rulemaking.

9 I'm here to update you on the status of  
10 our rulemaking for the groundwater protection at in  
11 situ leach facilities.

12 I plan on between Mike Fliegel who's to my  
13 right and I are going to basically plan to give you  
14 some information on the background of the rulemaking  
15 just to remind you of what it's about; the status of  
16 our current rulemaking effort; and then to respond to  
17 the comments that were sent to us last summer.

18 Just a reminder, we gave you a previous  
19 presentation on this on April 11<sup>th</sup>. During that  
20 presentation we discussed the technical basis of our  
21 rulemaking.

22 Included in that discussion was  
23 legislative and regulatory background, the efforts  
24 that we were - the commission's efforts and desire for  
25 us to try to eliminate dual regulation. Currently

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1 we're in a situation where the Environmental  
2 Protection Agency will provide permits to the  
3 underground injection - or the injection wells, and we  
4 provide licensing to the ISLs themselves for the  
5 uranium processing operations.

6 We discussed our rulemaking strategy at  
7 the time. And prior to the April 11<sup>th</sup> meeting we were  
8 having our discussions with the Environmental  
9 Protection Agency at that time also.

10 We were having some more high level policy  
11 issues about what the basis for our regulation was;  
12 whether - were the Uranium Mill Tailings Control Act,  
13 or if we could use the EPA's underground injection  
14 control for these ISL facilities.

15 We discussed our path forward, which as  
16 Dennis had mentioned we were hoping to get our  
17 proposed rule to the Commission by April of this year.

18 We had meetings shortly after we had  
19 resolved where our technical basis - or our basis for  
20 the rulemaking was for the UMTRCA, the Uranium Mill  
21 Tailings act, and we discussed that in final meetings  
22 with EPA, and also the National Mining Association to  
23 make sure they understood that the direction that the  
24 Commission had originally pointed us at was not going  
25 to work because of EPA's new discussion with us about

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1 what the actual statute required.

2 But we basically got agreement from both  
3 of those groups to move forward. Then we basically  
4 discussed what our next steps at that time were.

5 Just to remind you that our initial  
6 commission direction was given in March, 2006, where  
7 the Commission directed us to initiate rulemaking for  
8 groundwater protection at ISLs. The big thing on that  
9 was to focus on eliminating dual regulation of  
10 groundwater protection at those ISLs.

11 We were hoping that we could potentially  
12 get our regulation situated consistent with EPA's UIC  
13 program for Underground Injection Control program, to  
14 allow us to defer our regulation of certain aspects of  
15 our program to EPA; basically the day-to-day  
16 monitoring, that kind of thing, to either EPA or their  
17 state programs.

18 We were also directed to actively engage  
19 the stakeholders, and we were supposed to get a  
20 proposed rule at that time to the Commission in  
21 January of 2007.

22 That date wasn't met because of our  
23 difficulties with determining what the basis for the  
24 rule really should be.

25 In June of 2006, after we'd gotten the

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1 initial direction from the Commission, we sent out a  
2 letter to EPA which requested that they confirm with  
3 us that the Commission's intent that the UIC rules  
4 were the appropriate standards for which us to conform  
5 our NRC regulations; that was going to be correct.

6 We got back a letter in August of that  
7 year that basically said that they were very concerned  
8 with that proposal, and they suggested that we go  
9 ahead and meet with EPA to discuss that standard a  
10 little bit more intensively.

11 So we started going down the path of  
12 rulemaking because we had a very expedited schedule,  
13 but we were starting to meet with EPA at the same  
14 time.

15 In those meetings in August that we had  
16 with EPA, basically EPA stated that it had two major  
17 problems. The one first was that the groundwater  
18 standards in 40 CFR and 192 which basically were the  
19 UMTRCA standards are applicable to ISLs, and they were  
20 stating that the UIC standards were not applicable.

21 What this ran us into a difficulty is what  
22 our restoration requirements, that was where the  
23 biggest difficulty came out. UIC basically wasn't  
24 quite as conservative as what the restoration  
25 requirements were for UMTRCA. UMTRCA requires the

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1 first attempt for you to go back to background.

2           Additionally they pointed out that if we  
3 did want to defer, EPA didn't think they had  
4 sufficient resources to regulate the ISLs under an  
5 expanded UIC program to include what they thought NRC  
6 would need at the time, particularly in non-authorized  
7 states. The states themselves may have the resources,  
8 but EPA themselves at that point said they didn't.

9           So they were actually intending  
10 potentially maybe to even defer it to us, or rely on  
11 us for some of the work.

12           We continued those meetings all the way  
13 through late 2006, and finally EPA made it clear that  
14 they didn't believe that the use of the UIC standard  
15 as a basis for the ISL rulemaking was going to be the  
16 adequate standard. They said that the UMTRCA  
17 standards were the correct ones, and EPA however  
18 expressed a willingness to continue to work with us in  
19 this rulemaking process.

20           Now up to this point is basically things  
21 that you'd kind of seen in the previous presentation  
22 back in April. Now I'm moving up to things that  
23 happened after that date.

24           The first thing is, we updated the  
25 Commission on all this new information that we had

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1 gotten. Basically we told the Commission in COMSECY-  
2 07-0015 that we were resolving these issues with EPA;  
3 what the difficulties were; and what EPA had basically  
4 said should be the underlying standard.

5 And basically we said that we believed  
6 though that with that new information from EPA we  
7 could still go forth with a rule.

8 The staff requirements memorandum from  
9 that paper basically directed the staff to continue  
10 rulemaking; said they continued to remain diligent in  
11 working with EPA and the states also, and they wanted  
12 us to make sure we were establishing standards to  
13 protect the public and environment, as well as they  
14 still had an intent for us to reduce and eliminate  
15 dual regulation.

16 So that's where this rulemaking is going  
17 forth right now is to meet those goals.

18 In response to making sure that we worked  
19 sufficiently with the states and EPA, we added two  
20 working group members from the Environmental  
21 Protection Agency, one from their Office of Air and  
22 Radiation, and one from their Office of Water.

23 And we also added a person to help  
24 represent the states. We had already had an agreement  
25 state member from the Organization of Agreement

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1 States, so we added somebody from the CRCPD.

2 MEMBER WEINER: I am going to interrupt you  
3 just for a point of clarification. What now is EPA's  
4 role in regulating this?

5 MR. COMFORT: EPA set the original  
6 standard.

7 MEMBER WEINER: Yes, but they have said  
8 that they don't think the underground injection  
9 standard is applicable.

10 MR. COMFORT: Right.

11 MEMBER WEINER: So what now is their role?

12 MR. COMFORT: Well, they still have a role  
13 in providing us - basically we have to - they  
14 basically confirm that our regulations meet with  
15 UMTRCA says. They have a role in that.

16 MEMBER WEINER: Oh, okay.

17 MR. COMFORT: So making sure that it's  
18 consistent with UMTRCA. So we almost have to do a  
19 concurrence to them to a certain level that they say -  
20 and we've got that developed into our process, that  
21 they will basically put a statement at some point,  
22 probably in our statements of consideration, that they  
23 agree that the rule we are putting out is consistent  
24 with UMTRCA.

25 We are also using them in other ways to

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1 make sure that we are not - anything that we develop  
2 in regulation is not going to be in conflict with any  
3 of their regulations that they have to regulate the  
4 same facilities with, again, to help eliminate the  
5 dual regulation issues, and other complications that  
6 could cause.

7 So since that point we have these group  
8 members; we've also begun, or further developed our  
9 draft ruling, which the language is basically being  
10 pulled from our NUREG in 1569 which we currently use  
11 to help regulate the ISL facilities that we have.

12 We also did still grab a lot of language  
13 from EPA's UIC program, and you'll see in a few  
14 minutes that that caused a little bit of problems with  
15 EPA.

16 We are also adding focus on additional -  
17 or basically the rule we are writing is going to focus  
18 primarily on additional requirements that are specific  
19 to the groundwater protection at ISLs. The Commission  
20 was very clear that they don't want us to expand this  
21 rule outside of that role of developing it for  
22 groundwater protection only.

23 There'd been talk in the past of doing a  
24 bigger, broader role that would be specific to the  
25 conventional mills and ISLs, and the Commission

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1 basically decided they don't want to put the resources  
2 into that at this time, and just add this hole that  
3 they feel is missing in our regulations on how to  
4 better protect and regulate the ISLs.

5 Our recent interactions with EPA have been  
6 complicated to say the least. After we added the  
7 working group members, we provided this new version of  
8 draft language to all the working group members. And  
9 that was in September.

10 The EPA staff raised some concerns about  
11 that language, particularly our use of UIC. There  
12 were also some other difficulties that it felt that we  
13 were pointing more toward UIC instead of the UMTRCA  
14 regulations.

15 Part of it was because we'd provided them  
16 additional language to go into our existing  
17 regulations of the mills, in Appendix A of Part 40,  
18 and they didn't quite understand how it fit in there  
19 as well. So they were looking for an independent  
20 rule, and they saw no language related to UMTRCA  
21 rather tahn in the rule we were referring to the  
22 existing regulations, because they are still going to  
23 be applying to these facilities.

24 Again, our intent was just to add  
25 additional criteria that we thought were necessary to

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1 ensure the proper safety of these facilities.

2 EPA nad NRC have met a couple of times  
3 since that point after the working group meeting.  
4 They brought it up to their management, and brought  
5 their concerns related to the rule, particularly the  
6 use of the UIC, and the complications that they  
7 foresaw with using their language.

8 And we've been going through a process of  
9 trying to resolve those issues. We had a meeting in  
10 October, and our latest was in December.

11 Basically there are issues surrounding, as  
12 I said, the UIC being used as a standard. What they  
13 were concerned about is by us using some of their  
14 language, we were going to usurp their role in running  
15 their underground injection control program by  
16 basically taking away their ability to do permits, or  
17 doing something to impact how they were going to be  
18 writing these permits for these injection wells.

19 And they thought it would actually  
20 influence not just the ISLs but any that they did  
21 under this class of facilities.

22 They also thought that anything we  
23 interpreted by using their language would result in a  
24 difficulty that tehy would have to interpret the same  
25 way.

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1           So what they really preferred us to do was  
2 to change our language to do direct reference to their  
3 UIC program language.

4           While NRC saw that there were some  
5 problems with that direct reference - one, we didn't  
6 think anything such as the interpretation problem went  
7 away, it actually got worse; it would still be citing  
8 from our regulations. We have to interpret it, and  
9 now we are using their exact words.

10           Second of all their UIC program  
11 encompasses a lot more things than just ISLs, so  
12 trying to do a direct referral to aspects that would  
13 only regulate those - that was going to be specific to  
14 ISLs out of the larger scope was more difficult, and  
15 what we had done in our draft language was only taking  
16 that language that went specifically to the ISLs.

17           And then additionally we ran into a  
18 difficulty that the UIC program - lost my train of  
19 thought, apologize.

20           So they had a lot of difficulties though  
21 with us using UIC language, but we basically we were  
22 able to, in this December meeting, resolve that it  
23 would be our language; it was specific to our uses;  
24 and the other difficulty was that, or explanation that  
25 we had was, we were running under two different

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1 statutes that we are regulating under, so our use of  
2 their language was meant to basically make a  
3 consistent pathway forward to resolve similar  
4 problems, but because they were under different  
5 statutes there shouldn't be any difficulty if we had  
6 slight differences in interpretation, and we felt  
7 there was no reason to develop totally new language,  
8 and reinvent the wheel that could cause further  
9 conflict.

10 The other big difficulty they saw the  
11 current language was that despite us telling them that  
12 there were referrals back to the existing Appendix A,  
13 they didn't believe that the UMTRCA standard was  
14 represented in this language enough. And so we are  
15 trying to work on the rule language to better  
16 emphasize to make sure that people realize the UMTRCA  
17 is still the underlying standard.

18 Again, our last meeting was in December  
19 with EPA. We got it up to the management level of  
20 both EPA offices, as well as they got their lawyers,  
21 as well as our NRC lawyers, and managers were in the  
22 meeting.

23 As I stated we explained why the use of  
24 the UIC language, and why we wanted to use the UIC  
25 language, and what the problems with the direct

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1 referral were.

2 We did get most of the outstanding issues  
3 resolved that we believe we can move forward now with  
4 the rule. And this was only two weeks ago, so we're  
5 just at that point that we are reestablishing, making  
6 changes to the rule.

7 We are hoping to provide the working group  
8 a new version sometime in early 2008. Again, we will  
9 continue to work with EPA and provide those. They've  
10 got the working group numbers on the working group.

11 Our next steps are, we'll through the next  
12 couple of months continue drafting the rule package.  
13 There are a couple of other policy type issues that we  
14 have to deal with on handling some things in UMTRCA  
15 such as their use of the drinking water requirements  
16 and how that applies to the groundwater restoration,  
17 or Safe Drinking Water Act requirements.

18 The way it's been done in UMTRCA and  
19 Appendix A is that we've done basically a direct  
20 citation of what this Safe Drinking Water Act  
21 requirements were back when Appendix A was developed.  
22 That's now changed, and we're looking at a route that  
23 we can perhaps do a direct reference in this case,  
24 since they have to meet Safe Drinking Water Act.

25 But since UMTRCA itself and the EPA

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1 implementation doesn't have that, we've got to do some  
2 negotiating with EPA.

3 We hope to continue this, and as Dennis  
4 said, it's likely going to be delayed. We are  
5 expecting we probably won't be able to get a proposed  
6 rule to the Commission until sometime around fall.

7 Part of that is because we still have to  
8 do a few more meetings with EPA to make sure that they  
9 are okay with the path that we are going; they feel it  
10 will meet the requirements of UMTRCA. And also we do  
11 want to make sure that we can get further input from  
12 stakeholders.

13 We have been planning on trying to do some  
14 public meetings early in the process. And we're  
15 hoping to, once we get some draft rule language  
16 developed, and to a point that the working group  
17 agrees to it, then we can either get it, some of it  
18 put on the web for comment, or go out and do some  
19 meetings at the potentially impacted sites.

20 So that's really where we're at with the  
21 rulemaking. Mike will now go on and basically respond  
22 to the comments that you had provided back in your  
23 letter.

24 MEMBER WEINER: Let me interrupt briefly  
25 again. Do you have a slide that shows in some way

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1 what the language was that EPA objected to, and how  
2 you ahve resolved that? Or could you give us some  
3 more details?

4 It's a little difficult to follow just  
5 saying, they didn't like this. Do you have that in  
6 your presentation?

7 MR. COMFORT: That's really not in the  
8 slides. But I can talk to that.

9 What we had done is, as we laid out the  
10 rule, the first draft of the rule, we had sections in  
11 there about characterization of the aquifer, about  
12 requirements to ensure that wells are properly  
13 drilled; and that there is integrity testing for  
14 wells; things like that.

15 Well, in looking at what hte language  
16 ought to be, we borrowed some of that from rule  
17 language, EPA's rule language under the Underground  
18 Injection Control program. For example certain  
19 statements about well integrity testing.

20 And we only borrowed pieces because EPA  
21 had within their rule had requirements that didn't  
22 really apply. So we had pieces that came from the UIC  
23 program. We also had pieces that came from our  
24 guidance. And while EPA was upset about us  
25 essentially borrowing the language for certain aspects

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1 from their regulations.

2 As Gary stated, the concerns were, well,  
3 why don't you just point to our regulations? Well  
4 then we'd have to - every time we borrowed a piece,  
5 have to point to that specific location in the EPA  
6 regulations. It just would become very cumbersome,  
7 and it wouldn't resolve the problem that we  
8 interpreted something a little differently than they,  
9 whether we cite it in their regulations, or just write  
10 it in our own words, replacing EPA with NRC.

11 So that's basically what it was.

12 MEMBER WEINER: Thanks for the  
13 clarification. That's good. That's fine.

14 MR. FLIEGEL: I am Mike Fliegel. I'm  
15 senior project manager in the Uranium Recovery  
16 Licensing Branch in the Division of Waste Management  
17 and Environmental Protection.

18 I'm going to pick up on the ANCW's  
19 recommendations.

20 After the April meeting, the staff  
21 briefing, ANCW wrote to Chairman Klein on May 9<sup>th</sup>.  
22 The letter presented five recommendations.

23 The EDO wrote back to ANCW on June 10<sup>th</sup>  
24 and agreed with the recommendations. It was a very  
25 short letter basically saying they agree.

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1           The rest of my presentation will go  
2 through the recommendations and discuss how we plan to  
3 address them.

4           I'd like to say that we have already  
5 identified all the items in the recommendations. What  
6 I'll say is, we have identified most of them.

7           There are a couple of suggestions, they  
8 were all good, but there were a couple we hadn't  
9 thought of. Next slide.

10           The first recommendation was that the  
11 staff should proceed with developing the proposed  
12 rule, including codification of appropriate standards  
13 specified by EPA and we agree, and we are proceeding  
14 with the rulemaking as Gary as just discussed the  
15 recent activities.

16           The rule should provide specific guidance  
17 on the three-dimensional location of the point of  
18 compliance; groundwater monitoring requirements;  
19 methods of demonstrating compliance; and financial  
20 surety considerations.

21           I'll take them one at a time. The point  
22 of compliance: that's discussed in the present rule in  
23 the existing Appendix A with respect to conventional  
24 mills. It's location in the uppermost aquifer where  
25 the standards must be met.

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1           It's also used to identify how we identify  
2 leakings from an impoundment at conventional mills.  
3 For ISLs, well, first of all the mining zone we know  
4 will exceed standards during operation. The rule will  
5 define where the standard is to be met; that is, in  
6 the mining zone after restoration.

7           The rule will also require excursion  
8 monitoring to detect contamination moving away from  
9 the mining zone during operation.

10           It's not clear yet whether the rules will  
11 specifically use the term for that point of  
12 compliance, but we will have those requirements in the  
13 rule.

14           Groundwater monitoring requirements, both  
15 in the mining zone and outside, including aquifers  
16 above and below will be in the ruling.

17           Methods for demonstrating compliance, both  
18 for excursions and for restoration, will be in the  
19 ruling.

20           Financial surety, financial surety is  
21 already in the rule, in the existing Appendix A  
22 criterion 9. However the ISL rule will discuss  
23 additional surety requirements that are specific to  
24 ISLs.

25           For example currently our guidance

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1 discusses the situation if there is an excursion the  
2 licensee has to do certain things, and if he still  
3 doesn't contain the excursion and wants to continue  
4 operating, the guidance suggests that he's got to  
5 provide additional surety.

6 Well, things like that will go in the  
7 ruling. But again, surety in general, we feel is  
8 already in the rule.

9 The rule should establish guidance on  
10 measures to reduce the likelihood of contaminant  
11 excursions outside the mine zone and the site  
12 property, and for remediation outside the mine zone is  
13 excursion occurs.

14 To prevent excursions the rule will  
15 require a net inflow into the mining zone, and will  
16 require monitoring above and below the mining zone;  
17 and the rule will also address actions that must be  
18 taken if an excursion occurs.

19 Rules should be risk informed and should  
20 consider groundwater use, onsite effluent disposal,  
21 and deconditioning and license termination.

22 Restoration: requirements for restoration  
23 must be one of three standards. And these come from  
24 UMTRCA, EPA standards in 40 CFR 192, and are now in  
25 Appendix A, criterion 5. And the three standards are:

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1 first, premining background; second, essentially  
2 drinking water standards; and the third is an  
3 alternative concentration limit.

4 The third requirement, an alternate  
5 concentration limit, incorporates risk in groundwater  
6 use. And so that's how we believe that it will be  
7 risk informed, and consider groundwater use.

8 Onsite effluent disposal: a licensee  
9 basically uses one of two methods. They use  
10 evaporation ponds, and that is already addressed in  
11 Appendix A criterion 5. The rule will refer to that,  
12 will make it clear than an ISL an evaporation pond has  
13 to meet the requirements that already exist for  
14 impoundments in criterion 5.

15 And deep well injection, which really is  
16 a requirement by EPA or the state.

17 Decommissioning and license termination:  
18 the decommissioning of wells will be addressed in the  
19 rule. The decommissioning of the site and the license  
20 termination we believe are beyond the scope of the  
21 rulemaking, but those subjects are already in Appendix  
22 A.

23 An ISL site has to be decommissioned to  
24 cleanup criteria that already exist in criterion 6,  
25 and license termination is already in Appendix A.

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1                   Finally the rule should provide  
2 requirements for establishing premining background and  
3 baseline level quality. The rule will provide  
4 requirements for establishing premining background,  
5 baseline quality, for all aquifers potentially  
6 affected by the ISL activities.

7                   That includes the surfacial aquifer. We  
8 will in the rule point out that an ISL, you still have  
9 to look at the official aquifer, and the licensee is  
10 responsible for leakage from surface facilities into  
11 the surfacial aquifer in addition. And so it has to  
12 give some background for that, in addition to the  
13 aquifer that the mining zone is in and aquifers above  
14 and below it.

15                   That concludes my presentation.

16                   MEMBER WEINER: Thank you very much.

17                   Dr. Hinze, why don't you start off.

18                   MEMBER HINZE: Good afternoon, ma'am.

19                   MEMBER WEINER: Glad to see you made it.

20                   MEMBER HINZE: Thank you.

21                   It's really heartening to hear all of this  
22 response to the comments that the committee made in  
23 the letter.

24                   I do have a couple of questions at this  
25 time, and I'll ask a couple more afterwards.

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1           The matter of dual regulation is one that  
2 we've heard, and we have also heard some of the state  
3 people not be overly concerned about state regulation;  
4 about dual regulations; about NRC regulations  
5 overlapping from the state's.

6           The states certainly differ in their  
7 regulations on this issue, and one wonders if in the  
8 advance to eliminate dual regulation that there may be  
9 holes in this process.

10           What are you doing to assure us that there  
11 are no holes as a result of the varying state  
12 regulations and trying not to overlap them?

13           MR. FLIEGEL: Well, we are looking at - I  
14 view it as a two-step process. The first step is  
15 writing our regulations to cover what we conclude NRC  
16 has responsibility to regulate.

17           Once we have that in place, we can go to  
18 a state; we can look at what the state is regulating,  
19 and if they are amenable reach an agreement whereby  
20 one party regulates that aspect for the two of us.

21           For example, once our regulations are in  
22 place, and we have a regulation looking at, say, well  
23 integrity, and testing of new wells, if the state has  
24 a requirement under their UIC program for the same  
25 thing, we could write an MOU that essentially has the

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1 licensee meeting its NRC obligation by having the  
2 state approve the well integrity testing.

3 There may be, depending on what's in the  
4 state regulations, there could be a lot of areas where  
5 we could defer to the state, or if the state wants to  
6 defer to us and we are amenable to it.

7 MEMBER HINZE: Mike, I really appreciate  
8 that response, and it gives me assurance that there  
9 won't be holes.

10 But I guess the other thing, the other  
11 side of the coin is, I wonder how generic this  
12 regulation is. Is that every time you have to deal  
13 with a different state or a different licensee, that  
14 we will have to adjust the regulations; or adjust the  
15 license or the committee to accommodate the state's  
16 regulations.

17 MR. FLIEGEL: That's certainly possible,  
18 that once the regulations are in place, we may have to  
19 negotiate understandings with each individual state  
20 and with EPA if EPA is amenable, although in our  
21 earlier meetings they told us that they didn't have  
22 the staff to do it for states that are not EPA  
23 authorized.

24 But we may have to do it state by state,  
25 and depending on what the legal implications are, we

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1 may also have to do it licensee by licensee.

2 MEMBER HINZE: Well, that seems like a  
3 pretty cumbersome approach, but it may be necessary.  
4 I'll defer to Dr. Weiner on this, but we did hear the  
5 states not be overly concerned about dual regulation.  
6 They felt that the problem was more in the  
7 communication and understanding of where the states  
8 were going and where the NRC was going.

9 So I think this whole matter of dual  
10 regulation needs a very close look.

11 Let me ask you a question about this point  
12 of compliance, I forget now what slide it was in, 11A,  
13 something like that. In any event, the point of  
14 compliance. One of the concerns is, if that point of  
15 compliance is at the margin of the mining zone, and we  
16 have monitoring wells, we discover that indeed there  
17 may be some excursions, and some levels above that  
18 background; I'm concerned that the material that the  
19 contaminant would then be outside of the zone, because  
20 if you find it at the edge it's outside as well.

21 And I'm wondering if you have given any  
22 thought to buffer zones in terms of this point of  
23 compliance. I realize that they also impose a  
24 significant problem. But what's the thinking of the  
25 NRC on buffer zones?

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1 MR. FLIEGEL: Bill, do you want to -

2 MR. VON TILL: This is Bill Von Till. I'm  
3 the branch chief for Uranium Recovery. That's a good  
4 point. Appreciate your comment.

5 The existing regulations with plant  
6 compliant is set up for a surface impoundment whereby  
7 you are trying to detect a leakage from an  
8 impoundment.

9 The in situ situation is more analogous to  
10 underground storage tank, a circular RCRA groundwater  
11 remediate plume, where the entire plume as EPA or EPA  
12 authorized states would have point of compliance wells  
13 all within the plume itself; not outside the plume.

14 So we'll have to work this, but right now  
15 how we envision it more, you have a mine zone, you  
16 have like mine unit #1, for example. You have number  
17 of monitoring wells within the mining area.

18 And when they go to restore it, those  
19 wells will be the actual point of compliance wells to  
20 which they are measured by. As far as trying to get  
21 down to background MCLs or ACLs.

22 Now in addition to that you also have  
23 other wells that are outlying wells, horizontally and  
24 also vertically within other aquifers to look for,  
25 detect for excursion.

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1           So one of the things we are trying to do  
2 is put the point of compliance well strategy in this  
3 unique situation that is not really like a surface  
4 impoundment scenario.

5           So I think that kind of gets to your  
6 question more. The actual excursion monitoring well  
7 rings are about 500 feet or so, depending on the  
8 nature of the aquifer outside the mining area to  
9 detect excursions.

10           They are not really - I wouldn't say they  
11 are really point of compliance wells. They are almost  
12 more point of exposure wells.

13           I think the point of compliance wells,  
14 once they get into restoration, are really within the  
15 actual mining zone itself.

16           MEMBER HINZE: Is that in effect a buffer  
17 zone then?

18           MR. VON TILL: A buffer zone is in effect  
19 depending on how the aquifer exemption - we are seeing  
20 different scenarios with how that is done from state  
21 to state. For example in Nebraska -

22           MEMBER HINZE: And it depends on how you  
23 monitor it.

24           MR. VON TILL: Yes, sometimes in Nebraska,  
25 between Nebraska and Wyoming, some may have more

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1 buffer zones than other areas. But I think that's a  
2 good point, that it is important to have some kind of  
3 a buffer zone, so that by the time you get to the  
4 actual underground drinking water source, it's  
5 protected.

6 MEMBER HINZE: You used the term, in  
7 response to one of our concerns, net inflow. I think  
8 I know what net means, but what does net mean to you  
9 people? Does that mean that we can still have  
10 excursions, local excursions?

11 MR. VON TILL: I'm a hydrogeologist, too,  
12 so when it's a hydrogeology type of question, I'll  
13 kind of jump in.

14 There are different types of excursions.  
15 And the biggest one is losing control of the lixiviant  
16 and the mining solution horizontally. And the  
17 companies typically have a 1 percent, 2 percent what  
18 they call bleed. In other words they are pumping more  
19 than they are injecting, and that causes this net  
20 inflow.

21 And that in essence tries to prevent  
22 excursions. You still can have excursions even  
23 horizontally if they are not watching the ebb and flow  
24 of your injection. And we see that happening.

25 MEMBER HINZE: Not to belabor the point,

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1 but relying on net inflow is to me still opening up  
2 the box for having something go wrong.

3 MR. VON TILL: And that's a good point.  
4 There are really a number of contingencies here.  
5 There is the net inflow, and then there is the  
6 horizontal excursion monitoring well, and then there  
7 is also the monitoring wells that are located above  
8 and below the aquifers above and below. So there is  
9 a network of controls in place to make sure that the  
10 groundwater that is being used for drinking water  
11 purposes or other purposes is protected.

12 MEMBER HINZE: Mr. Chairman, can I have one  
13 -

14 CHAIR RYAN: I yield my two minutes to you,  
15 Bill. Go ahead.

16 (Laughter.)

17 MEMBER HINZE: Just a half a question.

18 MEMBER WEINER: Only half?

19 MEMBER HINZE: Just establishing the  
20 premining background, what kind of guidance are we  
21 talking about here in terms of coming to a premining  
22 background, and the length of time that is going to be  
23 - that monitoring is going to have to be in place, and  
24 what criteria are you going to use to determine what  
25 that length of time is going to be?

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1 MR. VON TILL: Well, we are looking at that  
2 in the rule. And you know, typically we like these  
3 licensees or these applicants to come in with at least  
4 a year of monitoring.

5 MEMBER HINZE: What is that based on?

6 MR. VON TILL: That's based on our Nureg  
7 1569.

8 MEMBER HINZE: What science?

9 MR. HAMDAN: Four seasons.

10 MR. VON TILL: Four seasons, yes, to  
11 capture the fluctuations of seasonal fluctuations.

12 MEMBER HINZE: We also have climatic  
13 change, and you know, and I think they are - I think  
14 one should take a very close look at the length of  
15 time that you require the mining companies to  
16 establish background, or down to some asymptote.

17 Because I would like to have a feeling  
18 that in the states involved, that even covering these  
19 four seasons over a period of several years would give  
20 a reasonably good value.

21 I understand where Latif is coming from,  
22 the four seasons. But we also know that the four  
23 seasons change quite a bit.

24 With that, I'll pass it.

25 MEMBER WEINER: Allen?

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1 VICE CHAIR CROSS: Bill, you got my  
2 question on excursions, so I'll give Mike back his two  
3 minutes.

4 CHAIR RYAN: Just a follow-on comment I  
5 think mainly to Mike. I applaud, and everybody I  
6 guess, I applaud the fact that you are working  
7 directly with states, particularly nonauthorized  
8 states. Because from a licensee's perspective, the  
9 fact that you are doing that means there will be a  
10 little more, hopefully, regularity state to state.

11 So even though, Bill, that is complicated,  
12 frankly I think that is preferred. I would hate to  
13 see all individual licensees having to go through that  
14 negotiation on their own.

15 So I think if you can get the bulk of it  
16 with the authorized states program, that's great. If  
17 you have a few other ones where you are working  
18 directly with them on collaborating or coordinating  
19 NRC regulations with states, working on behalf of  
20 whatever licensees might show up in that state, that's  
21 a real positive.

22 MEMBER HINZE: I think we are on the same  
23 team. We want to make certain that-

24 (Simultaneous voices)

25 MEMBER HINZE: So I thought I'd clarify my

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1 view.

2 CHAIR RYAN: Again, from a licensee's  
3 perspective I will tell you that is very positive to  
4 have the agencies working it out without using the  
5 licensees as lubricants in that process. So three  
6 cheers to that.

7 And again my other questions were covered  
8 well by Professor Hinze. So I'll pass it back to  
9 Ruth.

10 MEMBER CLARKE: Yes, thanks Ruth.

11 You mentioned a couple of regulatory  
12 programs explicitly, mill tailings, radiation control  
13 act, and the underground injection control which I  
14 think is under the Safe Drinking Water Act, is it?

15 And then indirectly the alternate  
16 concentration limits that I think come from RCRA; at  
17 least that was the first time I ran into them.

18 Are they part of UIC as well?

19 MR. FLIEGEL: Ultimate concentration  
20 limits?

21 MEMBER CLARKE: Yes.

22 MR. FLIEGEL: I don't believe they are.

23 MR. VON TILL: No, they are not. They  
24 originally came from RCRA as you were mentioning, then  
25 they were adopted at UMTRCA in our Appendix A

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1 criterion 5. But they originally came from RCRA  
2 sites.

3 MEMBER CLARKE: Yes, they could probably go  
4 in UIC as well. I mean it's all the same problem I  
5 think.

6 The other thing I wondered about, the  
7 evaporation ponds. Are they Clean Water Act, RCRA as  
8 well? Is that another, I guess -

9 MR. FLIEGEL: We would view the evaporation  
10 ponds as an impoundment with 11(e)(2) byproduct  
11 material. And so would be solely covered under UMTRCA  
12 and under - the basis for our regulation would be  
13 these UMTRCA regulations, 40 CFR 192, which envisions  
14 impoundments, impoundments in general, an evaporation  
15 pond. We feel that the existing regulations in  
16 criterion 5 are certainly adequate to address that.  
17 EPA has a separate responsibility for it.

18 MEMBER CLARKE: And EPA agrees with that?

19 MR. FLIEGEL: I don't know that it has been  
20 raised. But they haven't objected.

21 MR. VON TILL: No, they don't have a  
22 problem. I should mention that the industry where  
23 they can likes to use the deep well injection  
24 methodology for effluent disposal as opposed to  
25 evaporation ponds for economic reasons.

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1                   And even in our existing facilities, where  
2 they have evaporation ponds, like Crow Butte in  
3 Nebraska, they are trying to use more and more the  
4 deep well injection methodology.

5                   So with the incoming applications that we  
6 have, and I should mention we received our third  
7 application today; we have three now, three brand new  
8 applications; they are looking mainly at deep well  
9 injection is their preferred means for disposing  
10 liquid effluent.

11                   MEMBER CLARKE: Okay, that's helpful, thank  
12 you.

13                   MEMBER WEINER: I have a couple of  
14 questions to take off on some of Dr. Hinze's comments.

15                   First of all on the one-year monitoring,  
16 there are a number of EPA regulations and guidance  
17 that I am thinking specifically of power plants that  
18 require three years of atmospheric monitoring, three  
19 years of weather monitoring for example.

20                   And I would just simply encourage you to  
21 look at the question of whether one year is enough,  
22 whether you shouldn't expand that to a couple more  
23 years. That is just something for you to look at.  
24 And there may be very good reasons to stick with one  
25 year.

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1                   On the inflow question, don't you really  
2 mean inflow and not net inflow? I mean net inflow  
3 implies that you are controlling - that there is still  
4 outflow if you will.

5                   So I'm a little concerned about the  
6 language and how you intend to implement that.

7                   MR. VON TILL: that's a good point, and we  
8 should work with the terminology. But in essence an  
9 inward gradient, hydraulic gradient, is what we're  
10 really looking at there.

11                   We can work with the actual terminology  
12 and language.

13                   MEMBER WEINER: That's very helpful.

14                   Finally you did sort of slide past the  
15 question of financial surety. What are you doing if  
16 anything to prevent situations like the Atlas tailings  
17 pile from recurring? In other words where the company  
18 simply runs out of money, goes bankrupt. You have no  
19 financial surety, and you have to clean up the  
20 groundwater nonetheless.

21                   What is going to happen - what are you  
22 doing to prevent situations like that, or to address  
23 situations like that?

24                   MR. FLIEGEL: Well, we have to recognize  
25 why we ran into a problem with Atlas, and part of the

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1 reason that we ran into a problem with Atlas is that  
2 by the time the regulations were in place, the  
3 requirements for financial surety between the  
4 rulemaking and the challenges to the rulemaking, by  
5 the time we actually got to look at Atlas, Atlas  
6 Corporation didn't have the wherewithal to provide a  
7 larger surety.

8 So in the future, presumably, now that the  
9 regulations are in place, we are requiring the  
10 financial surety essentially up front, and what we do  
11 for all our licensees is, there is an annual review of  
12 surety. And the annual review is forward looking.

13 For example if we have a licensee, and  
14 they had a surety of \$10 million, and they have done  
15 \$2 million worth of remediation, they can come to us  
16 and say, well, our surety should now be \$8 million  
17 because we've done \$2 million; they have to come to us  
18 and show us, there's \$8 million of work left, and here  
19 is how we judge those costs.

20 So that's what we're doing now. We  
21 recognized that Atlas was under insured, but we didn't  
22 have the means, or Atlas didn't have the means to  
23 provide more financial assurance.

24 MEMBER WEINER: That's a very helpful  
25 clarification, that your surety requirements are now

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1 always forward looking and reviewed. I think that  
2 does resolve the question.

3 I have one more, and then I'll get back to  
4 you.

5 I was a little bit confused about your  
6 discussion about point of compliance. And it looks to  
7 me as if you are getting rid of the ACL concept, or  
8 not getting rid of the ACL concept.

9 Judging from what Bill von Till said, your  
10 point of compliance is now going to be in the mine  
11 zone. Maybe I'm just confused about this. Are you  
12 still looking at an ACL - at the possibility of an  
13 ACL, where a point of compliance is outside the mine  
14 zone, is somewhere close to the boundary?

15 MR. VON TILL: We are going to look at that  
16 in more detail. But to answer your question, the  
17 existing requirements for remediation and restoration,  
18 the background MCLs and ACLs, we are going to use that  
19 concept.

20 In other words, the way our guidance is  
21 right now, and the way we envision the rule, is that  
22 the licensee would have to first attempt to get down  
23 to the background in the mining zone itself.

24 And when you say, restore to those levels  
25 in the mining zone itself, you have to have compliance

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1 within the mining zone.

2 Now if they can't get down to that, and  
3 they can show that they have gotten as low as is  
4 reasonably achievable, after using practicable  
5 technologies and so forth, we will look at, like we do  
6 today, potentially alternate concentration scenarios,  
7 as long as they are protective of human health and the  
8 environment, basically outside the zone.

9 And so that is part of the risk, you know,  
10 informed risk based kind of approach that we utilize  
11 even today, and we plan to utilize that.

12 But luckily the criterion 5 already has  
13 that in there. We will have to expand on that in the  
14 rule to the unique nature of ISLs as opposed to  
15 tailings impoundment.

16 But we are going to use ACLs on  
17 background, MCLs and ACLs.

18 MEMBER WEINER: Thank you very much.

19 Jim, do you have another question?

20 MEMBER CLARKE: Thank you, just a quick I  
21 guess observation on monitoring, retains most of the  
22 monitoring, but one of the things that we are seeing  
23 a lot of in environmental restoration, especially when  
24 you put something into the subsurface, and then you  
25 try to get it out, is the mass transport dynamics in

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1 a subsurface with any complexity are such that stuff  
2 diffuses into zones where water doesn't move as fast  
3 as other zones.

4 This is going to be very basic to Bill.  
5 But when you stop pumping and you measure  
6 concentrations, there is something called a rebound  
7 effect. Concentrations will actually go back up if  
8 you turn the pumps back off.

9 So I was just wondering, does that have  
10 any role in deciding when you have met the -

11 MR. VON TILL: It does quite a bit, and  
12 licensees can use a number of pumping and groundwater  
13 restorations, bio restoration modeling. And we have  
14 been looking at this situation that you refer to for  
15 quite some time. We have been working with the Office  
16 of Research and looking at this aspect, and I've got  
17 right in front of me this NUREG/CR-6870, which is the  
18 consideration of geochemical issues in groundwater  
19 restoration of uranium in situ mining facilities.

20 So we continue to look at this research  
21 subject matter to try to get a handle on the actual  
22 geochemical conditions at one of these sites, and what  
23 happens when you stop extracting uranium, what happens  
24 to the actual uranium as it moves forward, and as you  
25 are trying to restore it.

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1                   And it is a research area that we are  
2                   looking at.

3                   I should also mention that we have the  
4                   SRM, the November 28<sup>th</sup> SRM that also tasks the staff  
5                   to work with the committee on looking at various  
6                   remedial technologies, you know, other types of  
7                   remedial technologies, and how they could be used at  
8                   these sites, too. And we want to start to meet with  
9                   the committee on that aspect.

10                  So this is kind of an ongoing research and  
11                  development kind of situation.

12                  MEMBER CLARKE: That's helpful, Bill. I  
13                  was referring to the false negative, if you will, when  
14                  you think your concentration is where you want it to  
15                  be, and then you turn the pumps off and it goes back  
16                  up again.

17                  So there are - there's been a lot of work  
18                  in this area. There are models now to handle this.

19                  MR. VON TILL: Stabilization is very much  
20                  on our mind, too. A lot of people can use  
21                  biorestoration, and bringing the concentrations down  
22                  temporarily, but how long would they stick is a big  
23                  question.

24                  And we want to make sure that we have done  
25                  an adequate job of monitoring that for an adequate

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1 period of time such that we have confidence that it's  
2 not going to be a problem in the future.

3 MEMBER CLARKE: Okay, for what it's worth  
4 I just throw it out. Thank you.

5 MR. FLIEGEL: The rule will address it.  
6 The rule will not define restoration completion as it  
7 meets the standards when you turn the pump off. There  
8 will be a period of time that the restored well field  
9 will have to be monitored.

10 MEMBER CLARKE: Thank you.

11 MEMBER WEINER: Bill, you had another  
12 question?

13 MEMBER HINZE: Well, it's an observation  
14 really.

15 In a study of what's going on in the West  
16 today where these ISL sites are, there is a lot of  
17 mineral resource development in the area, you drive  
18 out through there, and there are drill holes, a number  
19 of drill holes being put down by the petroleum  
20 companies. There are mining activities going on, coal  
21 deposits. All of these could have an impact on the  
22 gradient of the groundwater.

23 They could all have an impact on leakage  
24 from one aquifer to the other.

25 And I know there are state regulations

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1 that deal with a number of these things, but I think  
2 in developing new regulation, you should at least have  
3 in the back of your mind the possibility of mineral  
4 resource development, and making certain that the  
5 licensee really understands what's going on, and that  
6 there is some precautionary efforts made here to not  
7 have them interact with each other.

8 As we traveled to Grand Junction several  
9 months ago the number of wells going in was really  
10 outstanding. And they weren't far from many of these  
11 sites. And the same is true of the coal mines.

12 So this is something that you need to at  
13 least approach in the regulation in some sort of  
14 guidance to the licensee.

15 MR. VON TILL: I appreciate that. That's  
16 very timely. Some of the applications we have in  
17 Wyoming right now, we have a lot of coal bed methane  
18 production right in the area, and we are looking at  
19 that not only from a safety and groundwater aspect,  
20 but from a NEPA cumulative impact standpoint.

21 So we are looking at that, and we  
22 appreciate those comments.

23 MEMBER WEINER: Well, having touched on  
24 that, I will pick up on that. At the public hearings  
25 that were held on this rule, and I don't know what

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1 EPA's take is on this, but at the public hearings  
2 there was a great deal of concern expressed about  
3 doing a generic environmental impact statement, and  
4 that this would in some way obviate or limit what was  
5 done regarding site specific environmental issues.

6 And I wonder if any of you could comment  
7 on that?

8 MR. VON TILL: Well, the generic  
9 environmental impact statement was designed to look at  
10 the generic aspects of this. But in addition to that  
11 there is going to be site specific environmental  
12 analysis through at least an environmental assessment,  
13 along with public comment periods; so that there is  
14 adequate time for the public to comment on these site  
15 specific issues, and so that the issues that are not  
16 generic, like some of the groundwater issues in  
17 particular, some cultural resource type issues, will  
18 be looked at through the NEPA process, and we received  
19 a number of comments about that. Governor Richardson  
20 and members of Congress as well.

21 MEMBER WEINER: What I think we were  
22 looking for as a committee, and perhaps you want to do  
23 this at a future time, is to identify what issues you  
24 see that are generic as the state found those that are  
25 site specific.

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1           Because I think this is what the public is  
2 looking for. I recall at the public meeting, two  
3 public meetings that I knew about, it would have been  
4 - what people were looking for was a list. These  
5 issues are generic issues that affect all sites, and  
6 these other issues are ones that are clearly site  
7 specific.

8           And I would encourage you to look at that  
9 from that point of view.

10           And staff questions, I know that Latif  
11 will have some.

12           MR. HAMDAN: I want to first defend myself  
13 to Dr. Hinze the question was the basis for - I was  
14 not expressing an opinion. In Appendix A it mentions  
15 minimum of four seasons. 40 CFR 192 on the standards  
16 themselves, they say four seasons, at a minimum one  
17 year, and it goes back actually to RCRA, for CFR 264,  
18 same thing. So this is the absolute minimum.

19           And just if I could make another point,  
20 the point of compliance is actually in the case of  
21 mill tailings right at the mill tailings, and in this  
22 case it is in the aquifer.

23           The point that you were talking about away  
24 from the site is the point of exposure. So in other  
25 words you can have a higher standard, higher number so

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1 to speak, in the case of ACL, but you need the primary  
2 starter at a point of exposure, just to clarify for  
3 the record.

4 And I only have one question, Mike. Are  
5 you going to address in the rule the buffer zone for  
6 the ACL? Are you going to put a limit for how much  
7 area, or how much distance you will have between the  
8 point of compliance and the point of exposure?

9 MR. FLIEGEL: Yes, at this point in our  
10 address we don't have that in there. And there is a  
11 difference that there - at a conventional site what  
12 sometimes happens is that - especially because of past  
13 practices where impoundments were built before  
14 requirements for liners and the monitoring and the  
15 cleanup as soon as you see contamination; before that  
16 all happened there were some plumes at existing sites  
17 that have essentially migrated.

18 And one of the solutions that some of our  
19 licensees have taken is essentially to have a bigger  
20 piece of land that they could apply an ACL in and have  
21 their boundary as the point of exposure. And that's  
22 what is currently done in some situations, because the  
23 site goes to DOE in the end.

24 And an ISL it's not a site that is going  
25 to DOE, so what will have to happen is that if it's an

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1 underground source of drinking water, the licensee  
2 will have to make the argument that they are  
3 protecting the underground source of drinking water.

4 And I don't know that there is a mechanism  
5 to extend that out. Bill, is there?

6 MR. VON TILL: No, that's really somewhere,  
7 a lot of times, up to the licensee. We have to make  
8 sure that they adhere to the requirements of an ACL,  
9 or we cannot grant an ACL. And what they have done in  
10 some of the conventional sites is, they've purchased  
11 additional properties. They've used institutional  
12 controls sometimes.

13 That's up to them. What we have to prove  
14 is that it's going to be protective to human health  
15 and the environment where people will use that water.

16 And if there is not a buffer zone, that  
17 would steer more towards us not approving an ACL is  
18 the modeling doesn't demonstrate that it's going to be  
19 safe there.

20 But we can look at that, Latif. We'll  
21 have to work with EPA a little bit, because EPA  
22 actually a lot of times makes the aquifer exemption  
23 boundary. We don't do that here at NRC. And that in  
24 essence would set up the point of exposure, the  
25 aquifer exemption boundary, so we'll have to work with

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1 EPA on that a little bit.

2 MR. HAMDAN: I think you should, because  
3 this is really a major issue, in this case an ACL, the  
4 ACL guidance is clear, but I believe we are involved -  
5 in the ACL we are involved with - a certain area that  
6 the licensee cannot go beyond it.

7 This way, the licensee would not go and  
8 buy a lot of land, and could have a lot of area that  
9 otherwise would not be contaminated. This is  
10 something that needs to be looked at carefully I  
11 think. If you read the guidance in the ACL you would  
12 find this is the case that you cannot allow a free  
13 hand on how much land and how much area you can  
14 contaminate.

15 MR. VON TILL: That's a good point. From  
16 a research standpoint you don't want to contaminate a  
17 lot of the resource.

18 MEMBER HINZE: That's the buffer zone that  
19 we have to be concerned about.

20 Latif, how is this point of exposure  
21 position determined? What criteria are you using?

22 MR. HAMDAN: Okay, the main criteria is,  
23 the ACL is a standard that is larger than the primary  
24 standard. So the point of exposure technically is  
25 determined as the point at which this contamination in

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1 the point of exposure attenuates to the primary  
2 standard at the point of exposure.

3 In other words - are you with me?

4 MEMBER HINZE: I'm with you. I don't want  
5 to be with you but I am.

6 MR. HAMDAN: Actually you can think of it  
7 as - it is a point of compliance, but it is also a  
8 point of compliance location. So you meet the primary  
9 standard at a different location which is the point of  
10 exposure.

11 MEMBER HINZE: And that could lead to these  
12 very large buffer zones, which could take land out of  
13 place and use and so forth.

14 MR. HAMDAN: Yes, but to complete the  
15 answer to your question, that is the primary measure  
16 of where the building should be. However, the  
17 licensee land is not large enough. Then they cannot  
18 take full attention of that. They have to contain it.  
19 If the licensee land is too large, the question  
20 becomes -- that's where I was coming from.

21 But the idea is to have the point of  
22 exposure where the primary can be met. But that  
23 doesn't mean that you can, in my mind, I think the  
24 guidance for ACL, original guidance would say, that  
25 doesn't mean you go buy all the land you can and have

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1 a buffer zone that is five miles.

2 MEMBER WEINER: If there are no further  
3 questions, comments, I'll turn it back to the chair.

4 CHAIR RYAN: Okay, thank you. That was  
5 very interesting.

6 I agree with Professor Hinze, it's  
7 gratifying to see our advice been read and accepted.  
8 So thanks, we'll look forward to your updates on  
9 future visits. Thanks.

10 With that we're at a point where we should  
11 take a break. And based on the schedule, I don't want  
12 to get too far ahead, we will reconvene at 2:45.

13 Thank you.

14 (Whereupon at 2:06 p.m. the  
15 proceeding in the above-  
16 entitled matter went off the  
17 record to return on the record  
18 at 2:44 p.m.)

19 CHAIR RYAN: Our last session was also Dr.  
20 Weiner. So Dr. Weiner, without further ado, I'll turn  
21 the meeting over to you.

22 MEMBER WEINER: Thank you, Mr. Chairman.

23 We had a request from NAC International to  
24 make a presentation on their views on the  
25 transportation aging and disposal canister, and the

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1 presentation will be given by Charles Pennington, who  
2 is currently the director of NAC's marketing and  
3 business development for spent fuel storage and  
4 transportation businesses.

5 And just to go on the record, we have  
6 already advised Mr. Pennington as we did the other  
7 commercial vendors that came to us that we do not  
8 advise the Department of Energy. So we only advise  
9 the Nuclear Regulatory Commission.

10 So having said that, go ahead, Charley,  
11 with your presentation.

12 VENDOR'S VIEW ON THE TRANSPORTATION-AGING-DISPOSAL  
13 PERFORMANCE SPECIFICATIONS

14 MR. PENNINGTON: Thank you, Ruth.

15 Let me just follow that wonderful lead and  
16 assure the committee. I know it will be a  
17 disappointment, but this will not be a sales and  
18 marketing presentation. I will intend to address in  
19 a little bit of a unique way I think from what you've  
20 heard previously a technical issue.

21 This is primarily intended as a technical  
22 issue discussion, but is also intended to be a little  
23 more than that.

24 We all know that technical issues do not  
25 exist in a vacuum. Technical issues are

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1 contextualized by the framework in which we find them.  
2 In fact you can see that the context often defines the  
3 boundary conditions as it were to what technical  
4 solutions may be possible to technical issues.

5 I've heard in numerous discussions,  
6 especially in Miami recently at the PATRAM meeting a  
7 number of people expressing opinions about what the  
8 TAD system design was going to be or what it was not  
9 going to be.

10 And I was struck by how these people who  
11 are outside of the packaging industry felt about TAD  
12 systems, and how we, at least some of us, within the  
13 industry feel about the TAD system.

14 So I thought I would first of all try to  
15 take, and not be duplicative or redundant to other  
16 messages you have heard from previous suppliers, but  
17 rather try to take a few new issues that have some I  
18 believe resonance with TAD development; highlight  
19 those; then put those in a special context which I've  
20 called other issues and limitations.

21 Because I think from the committee's  
22 perspective you will see that those will play as great  
23 a role, if not a greater role, than the technical  
24 issues themselves.

25 So with that little bit of an

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1 introduction, let me proceed with the presentation  
2 itself. Please ask any questions at any time. I am  
3 not sensitive to interruption or whatever.

4 I am going to cover these topics. This  
5 will roughly serve as the framework for the technical  
6 issues that I will discuss, and then putting them in  
7 a context, contextualizing them, as it were, into the  
8 conditions that presently exist in TAD system  
9 development space.

10 I think we need to understand a little  
11 bit, so I've got one slide about NAC's qualifications  
12 for having input, providing input to this committee.

13 I want to give a brief overview of TAD  
14 system development, then talk about key TAD  
15 performance specification issues related to Part 71  
16 and Part 72. And let me further amplify, Part 71 and  
17 Part 72 is indeed all that I would be an expert on.

18 I do not claim expertise in Part 63. I  
19 understand some of the interactions at play here with  
20 Part 63, and the possible implications for Part 71 and  
21 72 design, but my discussion is limited to Part 71 and  
22 Part 72 issues.

23 Then I'll move into that contextual area  
24 that I've mentioned briefly about other issues and  
25 limitations that are of a potential concern. And then

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1 if there is desire at the end to have a discussion,  
2 I'll be happy to do whatever the committee wishes.

3 Quick background, and I have chosen to  
4 present a background in terms of the business  
5 organization.

6 (Telephone interruption)

7 MEMBER WEINER: Is anyone on the bridge?  
8 Excuse me, we have a bridge line, and we need to  
9 determine if there is someone on the bridge.

10 MR. IBARRA: This is the center from San  
11 Antonio.

12 CHAIR RYAN: And who are you?

13 MR. IBARRA: This is Luis Ibarra. I have  
14 with me Asa Chowdhury, Song Witt and Niko Shikan.  
15 RYAN: Thank you.

16 MR. IBARRA: Sure. No problem.

17 MR. PENNINGTON: Are we good? Okay.

18 The way to present the background I've  
19 chosen here is that we have three basic business areas  
20 at NAC.

21 One is for spent fuel, spent nuclear fuel  
22 dry storage systems development. We do that  
23 routinely.

24 We also fairly uniquely ship spent fuel.  
25 We have been shipping spent fuel since 1970. We move

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1 an awful lot of spent fuel. We've got currently more  
2 than 3,600 cask loads of spent fuel that's been  
3 shipped. And we have developed a lot of spent fuel  
4 systems and delivered them.

5 So this is our expertise that I want to  
6 simply mention for purposes of introduction of NAC to  
7 the committee.

8 TAD system development overview. For a  
9 year and a half the industry met very frequently with  
10 the DOE and others, and we worked very well together  
11 in working through - in fact, having been in this  
12 business for a few decades, it was the best  
13 interaction with DOE that we have experienced with  
14 respect to common objectives, and getting the  
15 performance specification contents into what I call  
16 the, quote, reasonable range.

17 I think thanks in no small measure to  
18 those activities NAC believes that the performance  
19 specification contents directed for Part 71 and Part  
20 72 can be met.

21 There are a number of things that were put  
22 into the performance specification rates with respect  
23 to the aging systems, and some of the criteria that  
24 they want met that will require additional discussion  
25 with the DOE. But uniquely I believe that right

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1 approach here is to take Part 72 systems and make them  
2 completely different from the aging systems.

3 Others have expressed a counter view, and  
4 I don't really see that right now. I think that that  
5 is not the right way to go.

6 Another point here is that I am going to  
7 be talking about issues. I am going to try not to be  
8 repetitive. You've heard from others. I'm going to  
9 bring up I think four issues that have either not been  
10 presented or not necessarily presented in the way I'm  
11 going to present them.

12 So I would move forward with the first one  
13 of those issues. The issue of borated stainless.  
14 Borated stainless steel is a material that has not  
15 been used widely in spent fuel casks for a number of  
16 years. Our good friends at Dominion Resources - it  
17 used to be Virginia Power - used borated stainless in  
18 a number of cask systems in the '90s. Not a lot of  
19 use of voided stainless steel currently.

20 There is - the next issue would be an  
21 increase of canister design life. The specification  
22 takes the design life of canister systems and more  
23 than doubles the industry average as they currently  
24 exist.

25 There is an interesting requirement for a

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1 PWR disposable control rod assembly in the spec. That  
2 is curious, because it's a DOE design, and it impacts  
3 our design and licensing of the canister.

4 And finally there are some flow through  
5 requirements for the geologic repository operating  
6 area and the aging system that as may have been  
7 highlighted earlier by a previous presented, may have  
8 some impacts on Part 71 and Part 72.

9 So I am going to touch on these issues  
10 straightforward.

11 Borated stainless, a function of borated  
12 stainless is as a neutron absorber of a poison  
13 material. The main function in the basket,  
14 particularly at the quantities that are listed in the  
15 performance specification, is for maintenance in a  
16 physical location and chemistry for the long term  
17 repository service.

18 However, Part 71 and Part 72  
19 really control how the borated stainless is to be  
20 deployed and fixed in the basket.

21 So the real duty of this material, the  
22 real challenge for the material, is from the  
23 repository, but the licensing, Part 71 and Part 72,  
24 control how it can physically be mounted and used in  
25 the basket.

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1                   Now there was a code case for the use of  
2                   borated stainless steel, Code Case -510-1, in the mid-  
3                   1990s. That issue has never really been tested with -  
4                   that code case has never really been tested with the  
5                   NRC.

6                   The code case is very restrictive with  
7                   respect to welding. Are there specific designs that  
8                   may need to do welding of the borated stainless for  
9                   their particular basket approach? Unknown, but it is  
10                  an uncertainty in the licensing process with respect  
11                  to borated stainless.

12                  Again, what load bearing properties would  
13                  the borated stainless be allowed to take with respect  
14                  to normal accident conditions in the canister?

15                  Again, uncertain issues.

16                  Finally, because of the severe duty of the  
17                  voided stainless in the repository, there is a very  
18                  large volume, a very heavy mass of borated stainless  
19                  required for the basket.

20                  This has a couple of factors. One, it  
21                  increases the weight substantially; two, with a very  
22                  limited canister diameter it restricts flux path and  
23                  it restricts moderation. So you are going to get -  
24                  you have a tendency toward under-moderation in the  
25                  canister design, which can be problematical, and may

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1 lead you in certain design directions with respect to  
2 the basket.

3 So that is a quick overview of some of the  
4 concerns with respect - some of the issues associated  
5 with borated stainless.

6 Canister design life: canister design life  
7 averages about 40 to 50 years in most industry  
8 applications. Performance spec calls for a canister  
9 design life of 60 years at the power reactors, and 50  
10 years at the aging facility; roughly a doubling, or a  
11 little more than doubling, of the design life.

12 There really is - the only real design  
13 life limitation that NAC has ever been able to  
14 identify would be in a highly corrosive environment in  
15 which the shell, or the welds on the shell, or the  
16 welds on the lid, might be compromised. And that  
17 literally is out many, many years.

18 How that is to be justified, defended,  
19 demonstrated, with that dramatic an increase in the  
20 canister design life is unclear. NAC does not  
21 consider it a problem. It only becomes an issue if  
22 there is far greater defense of that than has  
23 historically been necessary required.

24 The disposable control rod assembly, and  
25 this applies to PWRs only, and it's for fuels that

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1 fall outside the post-closure criticality loading  
2 curves, which are contained within the performance  
3 spec.

4 The design of that DCRA, how many are  
5 required per canister, all of these aspects of the  
6 DCRA are not only not final, they are not even  
7 identified.

8 The DCRA as you can appreciate fits into  
9 a spent fuel assembly very much like a control rod,  
10 either a CEA in a CE plant, or an RCC, rod control  
11 cluster, in a Westinghouse plant.

12 That means it's displacing water. That  
13 means that you are again being driven towards under-  
14 moderation. And depending on how many of these DCRAS  
15 you're required to have, and what some of these  
16 special unique characteristics such as an extra thick  
17 Zirc cladding, extended poison coverage, a special  
18 spider design, all of this is in DOE's design core.  
19 We need that for input. We need that very quickly  
20 when we move into contract execution in order to  
21 decide what fuels we indeed can license. Because  
22 that's our decision.

23 So this is an issue really of, hopefully  
24 timing is okay, hopefully DOE's understanding of the  
25 DCRAS is sufficiently detailed. But the use fo these

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1 DCRAs may drive basket designs toward either larger  
2 flux traps, or flux traps in general whether they have  
3 them or not.

4           Again, the licensing schedule makes  
5 finalization critical.

6           The GROA, aging system flow through  
7 requirements from the performance specification, there  
8 are a number of system drops, and system handling  
9 events, due either to seismic or mishandling at the  
10 GROA that are required by the performance  
11 specification.

12           Interestingly the acceptance criteria is  
13 specified and stated in terms of leakage rates. Now  
14 I think everyone would understand that when you start  
15 talking about leakage rates you by definition have to  
16 have a hole size or a crack size or a leak size in  
17 order to begin to make that determination; and the  
18 analysis methods that are used with the code, design  
19 codes allowed, do not give you anyway to do that.

20           So there are some discussions that need to  
21 go on amongst the vendors and the DOE on exactly what  
22 this means. We have a strategy on how this is to be  
23 done. We have a way to look at this we think that  
24 will work.

25           But this is, as mentioned I believe by one

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1 of my predecessors here, this could have some impacts  
2 on the canister designs for the storage and transport.  
3 I personally don't think it will, but it could.

4 At any rate it's one of the things that I  
5 think can be resolved with discussion, but it needs to  
6 be resolved, and it needs to be resolved very clearly,  
7 because this will be an issue that might come up in  
8 licensing space even under Part 71 and Part 72.

9 Now I mentioned earlier that technical  
10 issues don't stand by themselves. Technical issues  
11 are indeed rarely the control and technical  
12 organizations that do not understand the context in  
13 which they are developing technical solutions are in  
14 great peril of failure.

15 So I want to talk a little bit now about  
16 some of the context that surrounds us with TAD system  
17 development, because there are some significant  
18 boundary conditions I would call them that will impose  
19 types of technical solutions upon us.

20 First of all we have a number of  
21 unresolved transport certification issues, and the  
22 committee has heard about these issues. NEI and  
23 others have made a number of presentations on these  
24 issues. I won't bother to dwell on them. But high  
25 burnup fuel cladding properties, burnup credit,

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1 moderator exclusion, all are issues that weigh in  
2 right now.

3 And the key point is that while making  
4 progress on these issues, they are still works in  
5 process. So we are not at closure on these issues.

6 Now DOE intends to proceed in the near  
7 term on TAD development, which it would be hopeful  
8 that they would. Time has really expired for applying  
9 any new resolutions. Because once the flag drops,  
10 there is a very crisp schedule, and a number of  
11 deliverables that have to be met, and time for working  
12 on resolution and new approaches just won't be there.

13 So in my view, I think industry must  
14 proceed with the current situation with respect to any  
15 of these issues in resolving licensing issues for  
16 transportation. And by the way I'm going to get to  
17 some ideas in the end to suggest how industry might go  
18 about doing this.

19 Another big issue is what we call  
20 confirmatory testing that is needed for transport  
21 certification with the NRC. Confirmatory testing is  
22 not testing for licensing; it is simply testing that  
23 confirms the analysis methodologies that you have used  
24 with the system designs that you are trying to  
25 license.

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1           This testing of cask systems is time  
2 consuming and costly. Testing facilities, how many of  
3 them are really out there? Well, right now I would  
4 only be willing to say that Sandia National Labs is  
5 available. There is not a lot of testing that goes  
6 on; therefore there is not a big business in testing;  
7 therefore there is very little incentive for people  
8 that have testing to maintain their testing  
9 capabilities.

10           And make no mistake about it, drop testing  
11 is a craft. And it's an important craft, and it's  
12 very difficult, and even more importantly, and I  
13 mention this in the next bullet, they need to be  
14 audited and fully approved supplies under vendors -  
15 approved vendors.

16           In other words they have to be a quality  
17 supplier with an appropriate QA program. I would dare  
18 say there is no supplier of casks out there that right  
19 now has an approved vendor for cask drop testing on  
20 its approved vendors list. Just my guess, but I would  
21 be willing to hazard that guess.

22           Next, those of us that have done extended  
23 testing and a lot of testing over the last seven years  
24 are aware of the expanded nature of NRC requirements  
25 for cask drop testing. In the 1990s cask drop testing

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1 was really limited pretty much to assuring that peak  
2 G loads in the analysis were matched by peak G loads  
3 in the testing.

4 Today that is not the case. Today it's a  
5 matter of a time-history G loading in the actual drop  
6 test that matches a similar time history analysis  
7 curve from your own codes that you are applying to  
8 this.

9 It's a very rigorous approach to  
10 confirmatory drop testing.

11 What this says is that phantom work cask  
12 confirmatory drop testing for certification will be a  
13 time consuming process, especially if there were,  
14 let's say, only one supplier offering that service,  
15 one supplier that has a QA program, one supplier that  
16 have been approved.

17 And another issue that provides the  
18 context here for our technical issues, the DOE  
19 licensing requirements and their licensing schedule,  
20 and the current delays that we seem to be experiencing  
21 in deciding to proceed with the TAD development.

22 Under the current DOE procurement  
23 documents, vendors bear all risks of NRC licensing  
24 including schedule. We all know that new designs, new  
25 system designs, are most challenging both for vendors

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1 and for the NRC review staff with respect to  
2 schedules. Anything new and novel requires a very  
3 thorough review. And so from a schedule perspective,  
4 that is challenging.

5 One doesn't have to think too hard about  
6 this to see that if there were four suppliers of TAD  
7 systems, each providing at approximately the same  
8 time, within weeks of each other, an application for  
9 transport certification, and an application for dry  
10 storage certification, all of those on top of  
11 everything else could end up taxing the system. That  
12 is a very likely scenario with respect to what we see  
13 the DOE approach to be.

14 And finally we are now about approaching  
15 three months behind the schedule that we anticipated,  
16 and it's getting to be a critical proportion, even  
17 vendors have to do something with resources. So the  
18 resource availability becomes a concern the longer  
19 this carries forward.

20 All right, so now let me try to put a  
21 little bit finer point on the context issues I've  
22 raised here that surround the technical issues.

23 First of all all these context issues I'm  
24 sure have been looked at as carefully by the other  
25 supplies as they have by NAC. Our reviews and reviews

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1 in general lead you to consider the following things.

2 Well, let's get rid of as much originality  
3 as we can. Let's make this TAD canister just about as  
4 much a duplicate as anything we've ever done.

5 Storage and transport: the next  
6 consideration that might come up is, let's really  
7 limit our spent fuel. Let's make sure that we are  
8 not doing anything challenging with respect to  
9 licensing space. High burnup fuel and burnup credit  
10 issues being the way they are, if licensing is going  
11 to be an issue, licensing schedule, then let's be very  
12 careful about what we select to license.

13 Consistent with the abilities of outside  
14 contractors to provide testing services, one could  
15 say, okay, let's make sure that not only our canister  
16 but that our transport cask is bounded by recent  
17 testing that we have already done.

18 Let's get as much - let's get as close on  
19 a transport cask design impact, limit our design to  
20 current designs as possible, so that we restrict the  
21 need for this testing with respect to schedules.

22 And finally even one might consider that,  
23 let's make the TAD system a simple amendment to  
24 current designs that we have already certified.

25 So those are some of the implications that

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1 vendors might consider in looking at all of the  
2 context of the technical issues that we face.

3 So real quickly, I believe that the  
4 performance specification issues for Part 71 and Part  
5 72 can certainly be solved.

6 We are looking at them, even the flow  
7 through requirements, we've looked at approaches that  
8 will address some of the grow up pass through  
9 requirements; believe those can be done. But again  
10 you are never certain until you've talked with the DOE  
11 and then met with the NRC.

12 So it's really from NAC's perspective  
13 these other issues and limitations that are more  
14 troubling. How shall we view those? And how shall we  
15 use those to bound and restrict our TAD development  
16 so that it is likely - not only likely but highly  
17 likely to be successful in the time frame that DOE  
18 expects?

19 And finally with the schedule delays that  
20 we are experiencing with the DOE, I would say that  
21 most importantly time is of the essence. The  
22 schedules that DOE had laid out originally are  
23 aggressive. With the delays we've got right now they  
24 become even more aggressive.

25 So we believe that it's time to make our

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1 moves, and make them very quickly; start resolving not  
2 only the contextual issues but the technical issues.

3 Lady and gentlemen, that's my quick and  
4 very - I would apologize, it's not superficial, but it  
5 did not have a lot of technical detail. But at least  
6 it highlighted some of the issues that we in the  
7 industry think are important.

8 MEMBER WEINER: Thank you very much,  
9 Charley.

10 Jim? Mr. Chairman?

11 CHAIR RYAN: No, I didn't have any, thanks.

12 MEMBER WEINER: Allen?

13 VICE CHAIR CROSS: No, thank you.

14 MEMBER HINZE: Well, I won't leave you  
15 hanging.

16 How do you change the canister to achieve  
17 this doubling of the lifetime? You mentioned the  
18 corrosive environment, particularly on the welds.  
19 What needs to be done?

20 MR. PENNINGTON: Nothing. There is so much  
21 reserve margin in canister design as it exists. We  
22 have never really been able to find anything that  
23 limits the canister design from a lifetime  
24 perspective.

25 In fact we've only really taken any

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1 analysis out for a very long time, and that would be  
2 a canister in a very aggressive marine environment.  
3 And even at that point you'd get, and you are clearly  
4 looking at thinning, thinning of welds, thinning of  
5 shelves and things of that nature, you are still  
6 looking at canister design lives of around 200 years  
7 before you would compromise your accident analysis and  
8 lose confinement containment of the materials inside.

9 So the real question is not what we have  
10 to do to the canister, but what we would be required  
11 to do for licensing space to demonstrate a rough  
12 doubling of the design life.

13 That's the uncertainty. It hasn't been  
14 done this way before.

15 MEMBER HINZE: Is there anything that could  
16 be done with the welds to improve their quality and  
17 their lifetime? Is there - is there any robustness  
18 that one can add to the welds?

19 MR. PENNINGTON: This is an opinion, and  
20 I'll express it that way: I believe the welds are  
21 actually as high quality as anything else, because you  
22 are using materials in the welds that are actually  
23 better than the canister itself.

24 MEMBER HINZE: It isn't the material. It's  
25 the weld.

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1 MR. PENNINGTON: Well, the weld itself is  
2 so redundant and so I would like to say it is well  
3 tested. Now it is not as well tested of course as if  
4 it were a code weld. And this is just a lid weld.  
5 The other welds on the canister are code welds.

6 But it is so well tested and so  
7 progressively tested and since we've never really had  
8 a failure of one of those welds, I think the  
9 experience is that it's a good weld.

10 Now if you wanted, the way to make it  
11 fully high quality would be to use either a UT or an  
12 RT method of inspecting that at the plant. That  
13 becomes horrendously expensive, and I could virtually  
14 - I don't want to speak for the utility community, but  
15 that would be very difficult for the utility company  
16 to take.

17 MEMBER HINZE: How can you improve the  
18 testing or calibrate the testing so that one can  
19 achieve a validity out to 100, 110 years? How do you  
20 improve the likelihood of extrapolation? And what  
21 happens to the uncertainties as you extrapolate out?

22 MR. PENNINGTON: Well, let me just walk you  
23 through what I consider to be the life of a canister.  
24 You've got a canister that is closed, and it's been  
25 placed into service. And everyday that passes from a

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1 thermal and a radiation perspective, its life gets  
2 better and better. If the heat load goes down, source  
3 term goes down. So the threat diminishes, any threat  
4 from either temperature or radiation decreases with  
5 time.

6 The historical analysis work on canisters  
7 shows such high margins for anything like fatigue,  
8 thermal cycling, anything like that, such high margins  
9 that you really - there really is not a need to try to  
10 say, okay, instead of a 3/4 inch or 1/2 inch canister,  
11 I'm going to double the fitness. I'm going to up the  
12 weld thickness by this amount.

13 There really isn't - you are already  
14 talking about margins that are sufficient, so that you  
15 are not going to really threaten them very much by  
16 essentially doubling the life.

17 But again the very questions you are  
18 asking might be the questions that the review staff  
19 asks, and says, okay, do something different. I don't  
20 know what they will ask, but that is an uncertainty  
21 that presents itself to any vendor going in with a new  
22 design requirement.

23 MEMBER HINZE: Going to your slide #10,  
24 referring to the 3 g seismic peak acceleration design  
25 requirements, Kennedy from DOE was in last month and

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1 discussed some of the recent work that the DOE has  
2 done on preclosure. And it struck me in reading the  
3 transcript on that, I missed it at the time, but he  
4 was talking about the 3 g being important because they  
5 didn't want the aging casks to tip over, because the  
6 ends of the canisters were not as adequately protected  
7 from radiation as the cylinder.

8 Can you help me with that?

9 MR. PENNINGTON: Yes, I think what he was  
10 saying loosely was that the lid thickness of the cask  
11 is not historically as much as the shell thickness,  
12 skyshine is such a small component dose. I think  
13 that's what he must have been trying to say. But  
14 again you can make it as thick as you want. You can -

15

16 MEMBER HINZE: So one can solve this 3 g by  
17 doing something to the lids? Could you?

18 MR. PENNINGTON: No, I think what - at  
19 least as I understood what you said to me, he was  
20 saying, well, we don't want them to tip over because  
21 we are going to get higher shine out of the -

22 MEMBER HINZE: Yes, right.

23 MR. PENNINGTON: Well, I can fix that.

24 MEMBER HINZE: Well, the top and the  
25 bottom.

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1 MR. PENNINGTON: if that is all you are  
2 worried about, I'll put 10 feet of concrete up there.

3 MEMBER HINZE: That can be fixed.

4 MR. PENNINGTON: That can be fixed. So I  
5 think, and I don't want to put words in his mouth -

6 MEMBER HINZE: No, I'm just trying to -  
7 because you have obviously looked at the 3 g sites -

8 MR. PENNINGTON: Yes, and 3 gs is not a  
9 problem. And keeping it from tipping over at 3 gs is  
10 not really a problem. It can be done. It's going to  
11 be a hellatiously, horrifically expensive cask, but it  
12 can be done. It certainly can be done.

13 I think, and I don't want to speak for  
14 everybody else in the industry, but I think we would  
15 prefer to see tie-downs. They don't want to go  
16 through the inspection of tie-downs. Okay.

17 But this is certainly a kind of dialogue  
18 that we need to have with the site people in coming up  
19 with, okay, what's really important here? Can we  
20 combine a new design idea with perhaps a performance  
21 specification modification? There are certainly ways  
22 to go about this to solve these issues.

23 The g loading in 3 gs is nothing for these  
24 canisters. It's not a threat on that. It's only a  
25 threat on tip over, and you don't want it to walk off

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1 the pad. So you are going to avoid cylindrical bottom  
2 plates. You are going to do something else.

3 But you will be able to solve these  
4 issues, expensively, but you can sure solve them.

5 Now your point is well made. Okay, if all  
6 you are worried about is a tip over, we'll put you a  
7 real thick lid on there and there won't be any shine  
8 off the top.

9 MEMBER HINZE: Thank you very much, Mr.  
10 Pennington.

11 MEMBER WEINER: I just have a couple of  
12 questions. Normally, or recently, in recent  
13 environmental impact statements, no credit has been  
14 taken for the TAD in looking at the risks of  
15 transporting spent nuclear fuel.

16 Could you comment on what the influence of  
17 the TAD would be on those risk assessments, if credit  
18 were taken for the TAD, or if the TAD were included in  
19 the risk assessment; any TAD.

20 MR. PENNINGTON: Well, I would certainly be  
21 happy to do that.

22 The TAD provides in essence double  
23 containment. The transport cask will be licensed as  
24 a containment boundary. We can assure by both  
25 analysis and test that the canister will not leak. It

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1 won't leak; it won't let water in either. So that's  
2 a different issue.

3 But the point is that you have double  
4 containment system. I don't believe that there really  
5 is no event that I can conceive of in the regulatory  
6 framework, present regulatory framework, that would  
7 cause failure of either containment system, let alone  
8 both.

9 So the risk assessment has to come down to  
10 your beyond-design basis assessment, and I'm not sure  
11 which environmental assessment you're talking about,  
12 and whether they took into account beyond-design basis  
13 events or not.

14 But beyond-design basis events, there  
15 really isn't, if you shift - if you were to use an  
16 beyond-design basis event analysis for instance, if  
17 you were to shift away from code allowable to shift to  
18 really an ultimate strain or ultimate stress or  
19 ultimate strain criterion, you can do almost anything  
20 to these casks and they won't fail.

21 If you look at a simple stress vein curve  
22 for simple stainless steel, and you look at the amount  
23 of that area under that curve that the regulations  
24 allow you to use, you are going to see that you have  
25 a factor of 10 safety just to ultimate on any of the

**NEAL R. GROSS**

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1 materials you are using, including the weld material.

2 So I think that the presence of the TAD  
3 canister, if properly assessed, increased - decreases  
4 the risk order of magnitude, more, something like  
5 that, for releases, for releases or radioactive  
6 material.

7 MEMBER WEINER: Thank you.

8 Other questions or comments from the  
9 audience? Hearing none, I turn it back to you, Mr.  
10 Chairman.

11 CHAIR RYAN: All right. Well, thanks very  
12 much. We appreciate your time and presentation.

13 With that, we are at the point where we  
14 are going to take up a discussion of our letter  
15 writing activities, and I guess we can probably take  
16 a five-minute break before we initiate that session  
17 and get ready for that.

18 So thank you all very much. And we will  
19 close the formal part of the record today here, and we  
20 can be in five minutes or so.

21 (Whereupon at 3:19 p.m. the proceeding in  
22 the above-entitled matter was adjourned.)

23

24

25

**CERTIFICATE**

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on  
Nuclear Waste & Materials  
185<sup>th</sup> Meeting  
Docket Number: n/a  
Location: Rockville, MD -

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

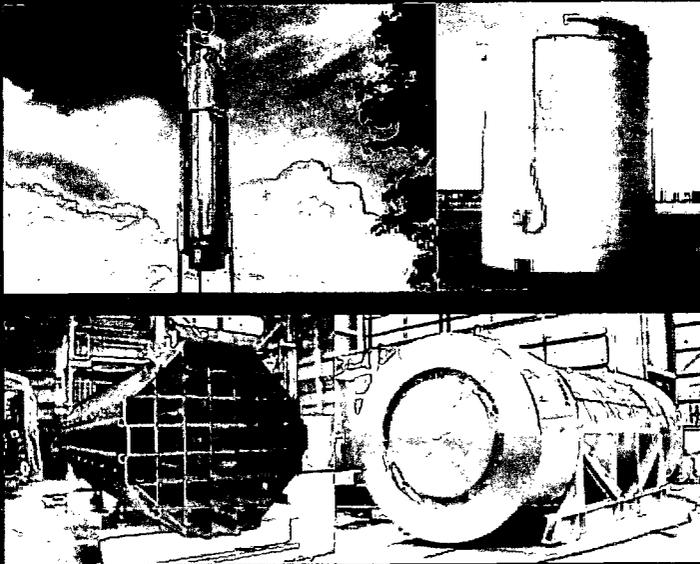


Charles Morrison  
Official Reporter  
Neal R. Gross & Co., Inc.

# NAC International's Views on the TAD Performance Specification (PS) and Licensing of TAD Systems

Charles W. Pennington  
Vice President  
NAC International  
Norcross, Georgia, USA

December 17, 2007



 **NAC  
INTERNATIONAL**

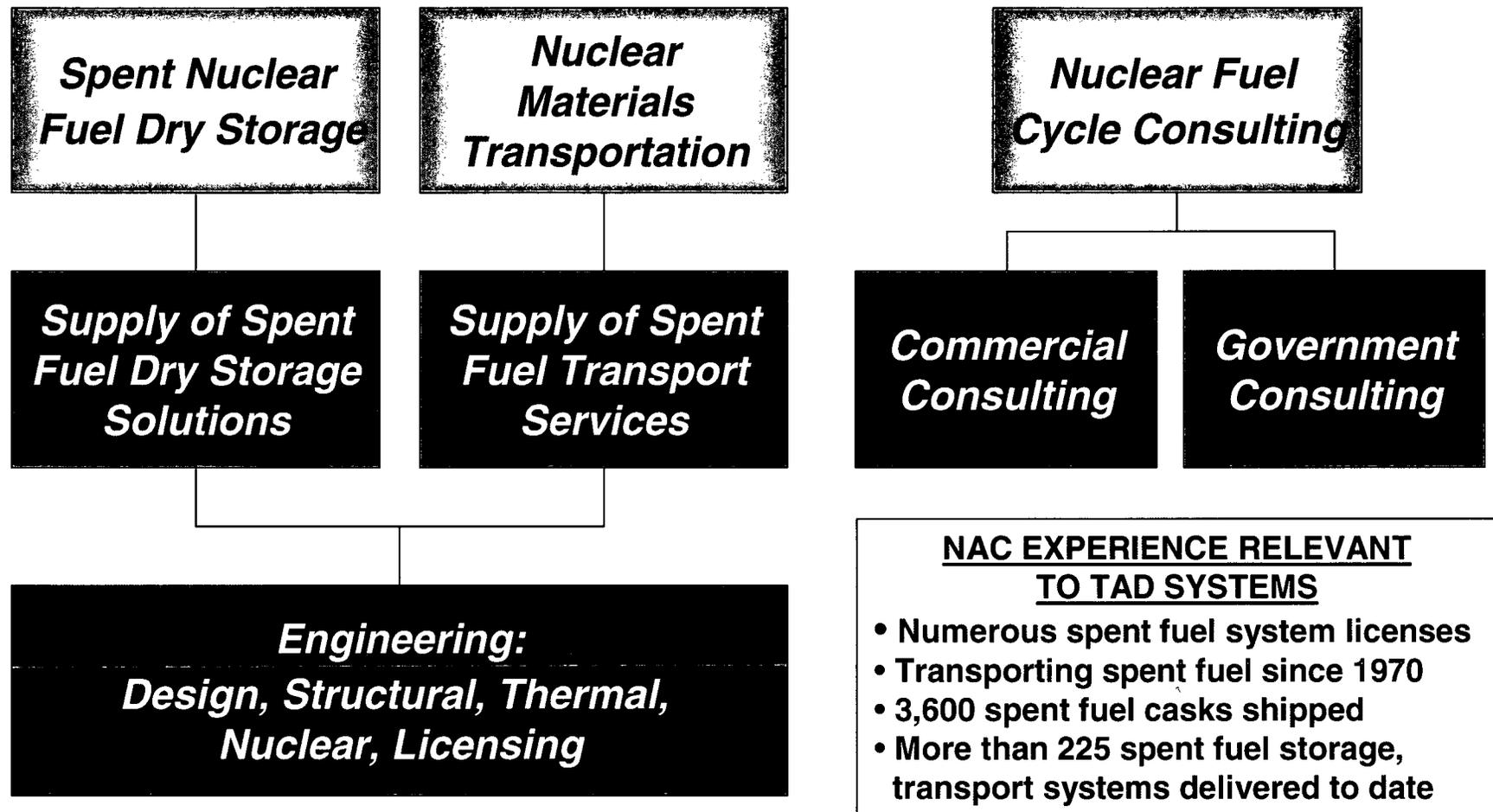
NAC International Is a Wholly Owned Subsidiary of USEC Inc.,  
a Leading Supplier of Enriched Uranium Fuel for Commercial Nuclear Power Plants

# **NAC International's Views on the TAD Performance Specification (PS) and Licensing of TAD Systems**

## **Topics**

- **NAC Background Relevant to TAD Systems**
- **TAD System Development Overview**
- **Key TAD PS Issues for Parts 71 and 72**
- **Other Issues/Limitations of Potential Concern**
- **Discussion**

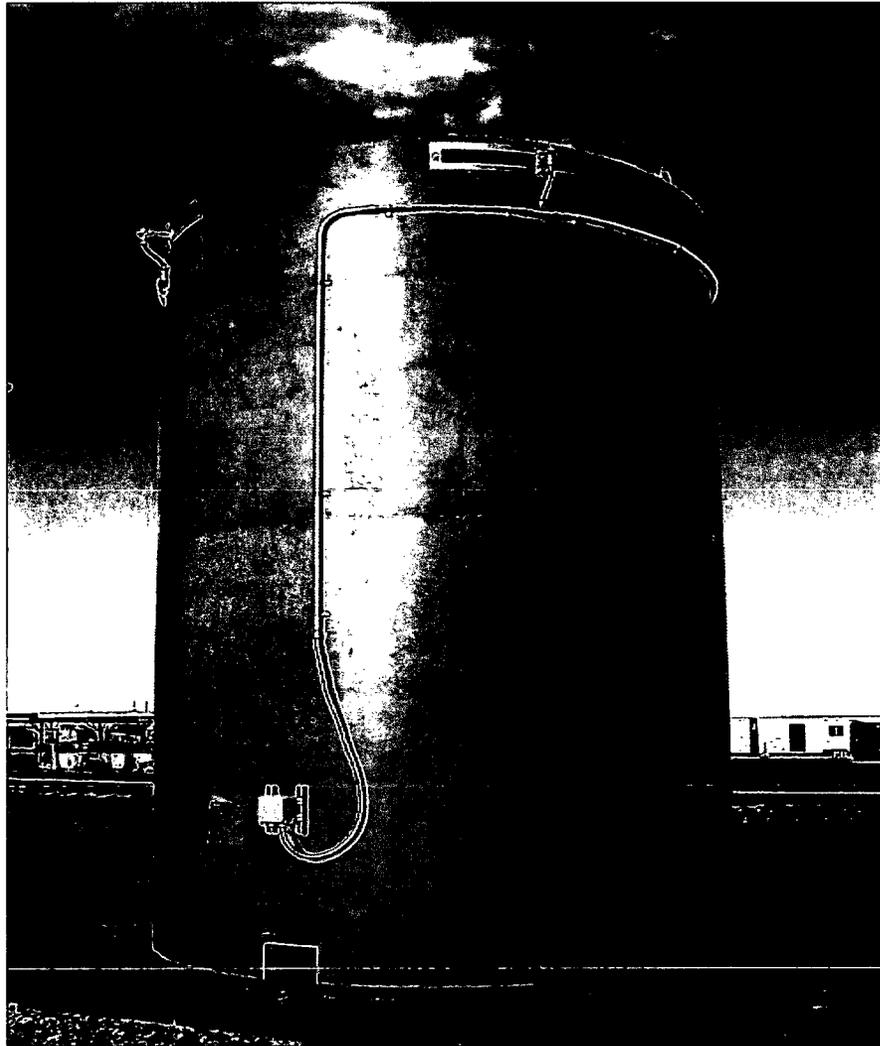
# NAC Background: Business Organization



# TAD System Development Overview

- DOE has worked well with industry to get PS contents into reasonable range
- TAD PS for Parts 71 and 72 can be met
- TAD PS for Aging Systems requires more discussion with the DOE
- The Committee has heard from others about their issues: try not to be repetitive here
- The following summarizes Parts 71 and 72 issues that may not previously have been covered

# TAD System Discussion



Slide 5

# Key Part 71 and 72 TAD PS Issues

- Borated stainless steel in TAD baskets, NRC approval
- Increase of canister design life to 110 years
- Requirements for PWR disposable control rod assembly (DCRA)
- GROA/Aging System flow-through requirements on canister for Parts 71 and 72

# Borated Stainless (BoSS) in Basket

- Neutron absorption (poisoning) function
- Maintenance of physical location and chemistry necessary for long term repository service
- Parts 71 and 72 control BoSS in basket design
- NRC approval of ASME Code Case N-510-1?
  - Does design need welding of BoSS?
  - Acceptable BoSS load bearing properties?
- Large BoSS volume, limited PS canister diameter restrict flux traps

# Increase in Canister Design Life

- Current designs for storage/transport canisters use 40 to 50 year design life
- PS calls for canister design life of 60 years at plants, 50 years at aging facility
- Foresee no limitations on design life, but requirements to justify, defend, and demonstrate such a change for Parts 71 and 72 unclear

# PWR DCRA Requirements

- DCRA necessary for PWR fuel that falls outside post-closure criticality loading curves
- DCRA design and required extent of use not final
- DCRA must be installed at reactor facilities
- Need more DCRA design information on thick Zirc cladding, extended poison coverage, and spider than is offered in PS for Part 71 and 72 licensing
- Water displacement by DCRA's may make flux traps more important
- Licensing schedule makes finalization critical

# GROA/Aging System Flow-Throughs From PS

- PS requires analysis of system drops at GROA from seismic or handling events
- Acceptance criteria at GROA stated as leakage rates
  - 3 g seismic peak acceleration design requirement suspends need for meeting design code allowables
  - normal 1 foot drop and 10,000 year seismic event require meeting design code allowables
- There may be impacts on canister design for storage and transport as a result

# Other Issues/Limitations of Potential Concern

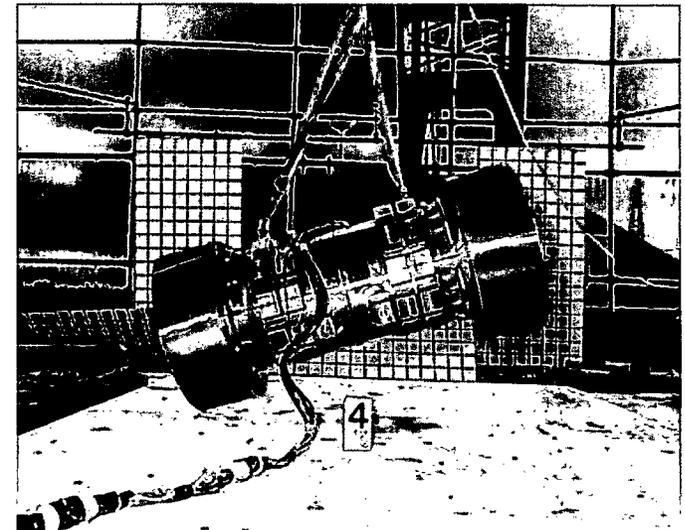
## Unresolved transport certification issues

- High Burnup Fuel (HiBuF) cladding properties
- Burnup Credit (BuC)
- Moderator Exclusion (ModEx)
- Resolutions of these issues are still works in progress
- For near-term DOE award of TAD development, time has expired for applying resolutions to TADs
- Industry must proceed with current situation

# Other Issues/Limitations of Potential Concern, continued

## Transport cask confirmatory drop testing for certification

- Testing of cask system designs: time consuming and costly
- Testing facilities' concurrent availability for all vendors?
- Testing facility audits required to make them approved suppliers
- NRC has expanded testing requirements over last 7 years
  - dynamic analysis time history: g load vs time predictions must agree with test measurements



Drop testing the NAC-STC cask (with impact limiters) containing UMS™ type fuel basket.

# Other Issues/Limitations of Potential Concern, continued

## DOE licensing schedule requirements, DOE delays

- Vendors bear risk of NRC licensing schedule
- New designs are most challenging for vendors and NRC with respect to schedules
- Numerous concurrent TAD licensing submittals may tax system
- DOE award delay now of critical proportion
  - planned resource availability a concern

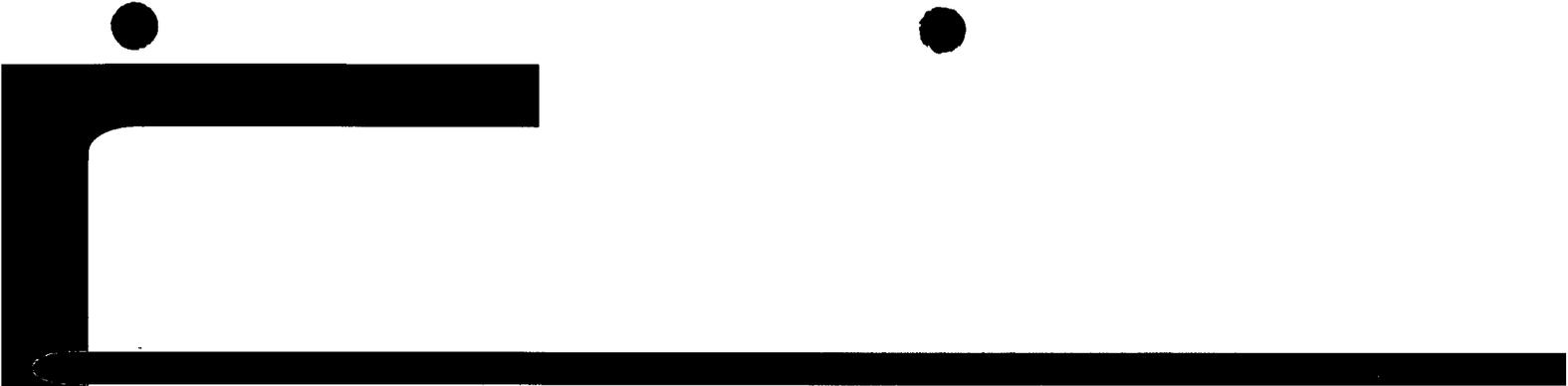
# Other Issues/Limitations of Potential Concern, continued

## Implications of Other Issues/Limitations

- They require careful review for TAD development under DOE's procurement requirements
- Vendor reviews may lead to following considerations:
  - make TAD canister design very similar to current storage/transport canister design
  - restrict fuel coverage with respect to HiBuF and BuC for ease and speed of licensing
  - assure TAD transport system design bounded by recently approved transport system testing
  - amend currently certified designs to include TAD system components

# Summary and Conclusions

- NAC believes PS issues can be solved for Parts 71 and 72
- Other issues/limitations (resources, unresolved issues, schedule, DOE delays) are more troubling
- Time is now of the essence of TAD System development



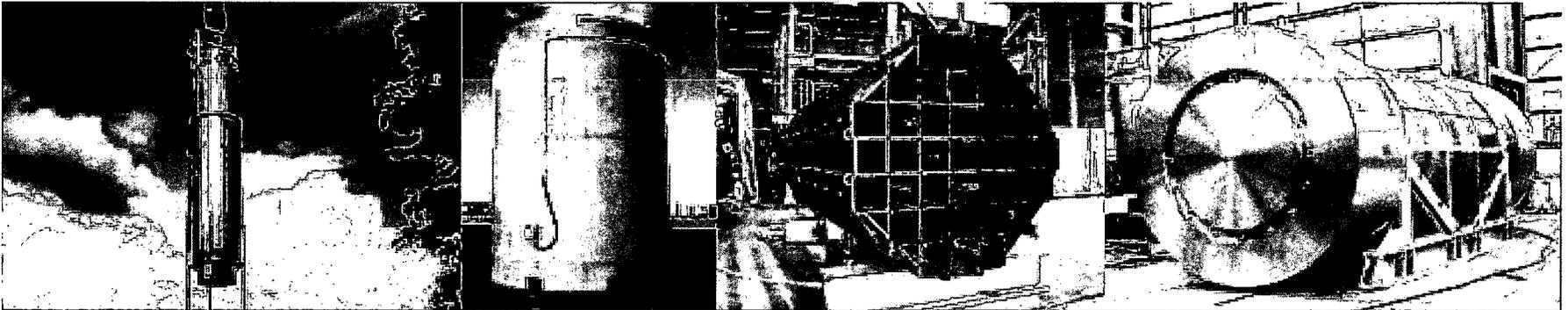
# **QUESTIONS and DISCUSSION**

Slide 16



**NAC  
INTERNATIONAL**

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 **U.S.NRC** *Protecting People and the Environment*  
UNITED STATES NUCLEAR REGULATORY COMMISSION

## Update on NRC ISL Rulemaking

ACNW Briefing  
Gary Comfort  
Division of Intergovernmental Liaison  
and Rulemaking, FSME  
December 17, 2007

## Purpose

- Brief ACNW
  - Background of Rulemaking
  - Status of ISL rulemaking effort
  - Respond to past ACNW recommendations

2

## April 11, 2007 Briefing Discussed Technical Basis of Rulemaking

- Legislative and Regulatory Background
- Efforts to Eliminate Dual Regulation
- Staff's Rulemaking Strategy
- EPA Interactions
- Path Forward
- Meetings with EPA and NMA
- Next Steps

3

## Initial Commission Direction March 2006

- Commission directed staff to initiate rulemaking for groundwater protection at ISLs
  - Focus on eliminating dual regulation of groundwater protection at ISLs
  - Defer regulation to EPA/States through UIC program
  - Actively engage stakeholders
  - Proposed rule to Commission - January 2007

4

## 2006 Interactions with EPA

- June 20, 2006 letter to EPA requests confirmation - UIC rules appropriate standards to which to conform NRC regulations
- August 3, 2006 EPA letter - EPA concerned with NRC proposal - suggests discussions before NRC rulemaking effort proceeds. However, because of expedited schedule, staff continued rulemaking effort, while discussing with EPA

5

## 2006 Interactions with EPA (cont)

- August 3 and August 15, 2006 meetings with EPA - 2 major concerns of EPA staff
  - Groundwater standards in 40 CFR 192 are applicable to ISLs and UIC standards are additional requirements
  - EPA does not have sufficient resources to regulate ISLs under expanded UIC program in non-authorized States - had intended to rely on NRC regulatory program for monitoring
- Meetings and discussions with EPA – late 2006
  - EPA does not agree to use of UIC standards as basis for ISL groundwater protection
  - EPA - UMTRCA-based standards are appropriate requirements
  - EPA expressed willingness to work closely with NRC in rulemaking process

6

## Updated Commission Direction

- Provided Commission Rule Update to Commission in April, 2007 (COMSECY-07-0015)
  - Updated status of rulemaking and resolution of issues brought up by EPA
  - Requested direction to go forth with rule
- SRM directed staff to continue rulemaking
  - Remain diligent in working with EPA/States
  - Establish standards to protect public and environment
  - Reduce/eliminate dual regulation

7

## Rule Development

- Added working group members from EPA (Office of Air and Radiation, Office of Water) and CRCPD
- Developed draft rule language
  - Pulled language from NUREG-1569 and EPA UIC program
  - Focuses primarily on additional requirements specific to groundwater protection at ISLs

8

## Recent Interactions with EPA

- Provided draft rule language to working group members in September 2007
- EPA staff raised concerns about language at September working group meeting
- EPA/NRC staff met in October to try to resolve issues

9

## EPA Issues

- Concerns with use of UIC language
  - NRC using UIC as standard
  - NRC usurping EPA UIC program
  - Precedence of interpretations
  - Preferred NRC to do direct referral to UIC language
- Believed approach did not represent UMTRCA standard strongly enough

10

## December Meeting with EPA

- Meeting included managers from EPA and NRC
- NRC explained why use of UIC language and problems with direct referral of UIC language
- Resolved most outstanding issues
- Plan to provide working group with new version in early 2008

11

## Rulemaking Next Steps

- Continue drafting rule package
- Currently assessing new schedule
  - EPA interactions will result in proposed rule to Commission likely in Fall 2008
  - Schedule needs to include additional meetings with EPA and stakeholders

12

## Update on NRC ISL Rulemaking

ACNW Briefing  
Myron Fliegel  
Uranium Recovery Licensing Branch  
DWMEP, FSME  
December 17, 2007

### May 9, 2007 ACNW Letter to Chairman Klein

- Based on April 11, 2007 briefing by NRC staff to ACNW
- Presented five recommendations
- Staff is addressing those recommendations in the rulemaking

The FSME staff should proceed with developing the proposed rule, including codification of the appropriate standards specified by the EPA.

- We agree

15

The rule should provide specific guidance on the three-dimensional location of the point of compliance, groundwater monitoring requirements, methods of demonstrating compliance, and financial surety considerations.

- Point of compliance
  - Standards currently define POC in relation to surface impoundment
  - For ISLs, rule will define where restoration standard applies
- Groundwater monitoring requirements – will be in the rule
- Methods of demonstrating compliance – will be in the rule
- Financial surety – already in Appendix A – criterion 9

16

The rule should establish guidance on measures to reduce the likelihood of contaminant excursions outside the mined zone (the exempted aquifer unit that contains the uranium ore deposit) and the site property (the land that is under control of the licensee), and for remediation outside of the mined zone if excursion occurs.

- Excursions – the rule will require a net inflow into mining zone
- Remediation – will be in the rule

17

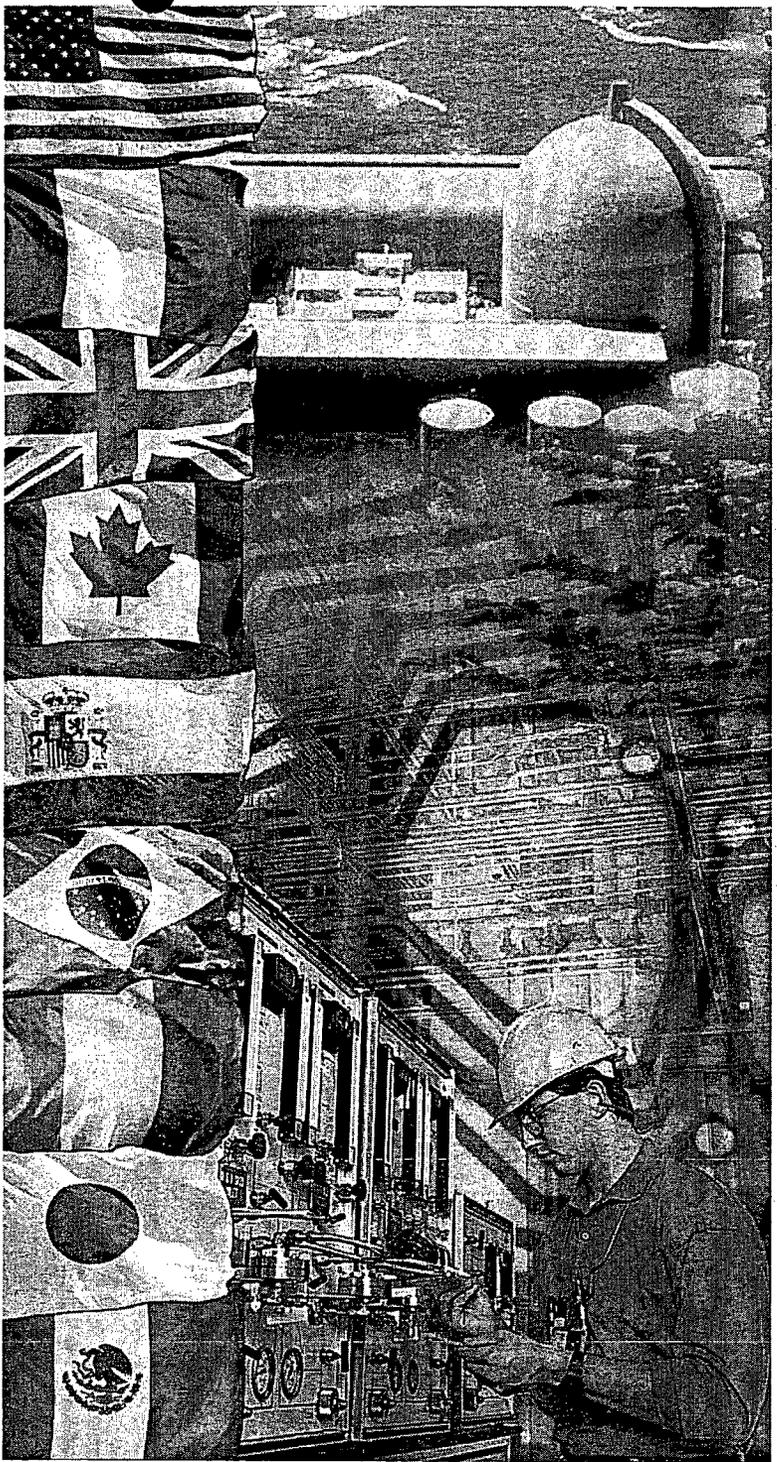
The rule should be risk-informed and should consider groundwater use, onsite effluent disposal, and decommissioning and license termination.

- Risk informed, consider groundwater use – ACLs address this
- Onsite effluent disposal
  - evaporation ponds covered by criterion 5
  - deep well injection permitted by EPA or State
- Decommissioning and license termination
  - Decommissioning of wells – will be in the rule
  - Decommissioning of site and license termination – beyond the scope of rulemaking but already in Appendix A

18

The rule should provide requirements for establishing pre-mining background or baseline groundwater quality.

- Will be in the rule



**EPRI** | ELECTRIC POWER  
RESEARCH INSTITUTE

# Analysis of Thermal Spalling of Tuff Host Rock for the Yucca Mountain Repository

John Kemeny  
University of Arizona

Mick Apted  
Monitor Scientific

John Kessler  
EPRI

# Recent EPRI Yucca Mountain Studies Containing Rock Mechanics Analyses

- EPRI. 2007. Program on Technology Innovation: Analysis of Thermal Spalling of Tuff Host Rock for the Yucca Mountain Repository, Report 1015390, Electric Power Research Institute, Palo Alto, CA.
- EPRI. 2007. Program on Technology Innovation: Room at the Mountain, Analysis of the Maximum Disposal Capacity for Commercial Spent Nuclear Fuel in a Yucca Mountain Repository, Report 1015046, Electric Power Research Institute, Palo Alto, CA.
- EPRI, 2006. Program on Technology Innovation: Effects of Multiple Seismic Events and Rockfall on Long-Term Performance of the Yucca Mountain Repository, Report 1013444, Electric Power Research Institute, Palo Alto, CA.
- EPRI. 2006. Program on Technology Innovation: Room at the Mountain, Analysis of the Maximum Disposal Capacity for Commercial Spent Nuclear Fuel in a Yucca Mountain Repository, Report 1013523, Electric Power Research Institute, Palo Alto, CA.
- EPRI. 2005. Program on Technology Innovation: Effects of Seismicity and Rockfall on Long-Term Performance of the Yucca Mountain Repository, 2005 Progress Report 1011812, Electric Power Research Institute, Palo Alto, CA.

# What is Rock Spalling?

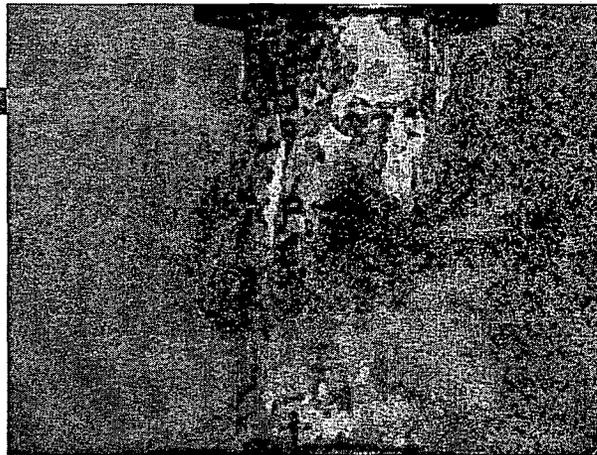
- Rock failure at the boundary of a rock mass, usually forming slabs that bulge from the rock and may eventually detach (rockfall)



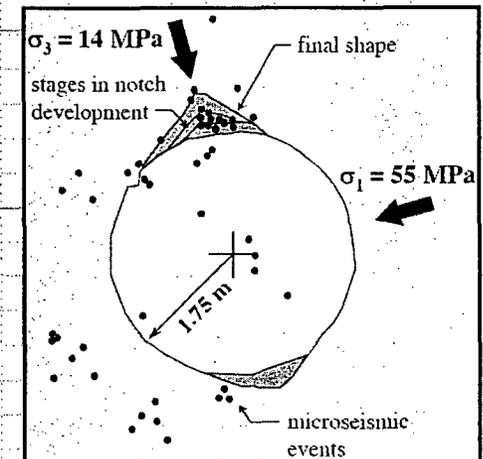
From BSC (2004)

From Rajmeny et al. (2002)

# Causes of Rock Spalling



Rock sample under uniaxial loading

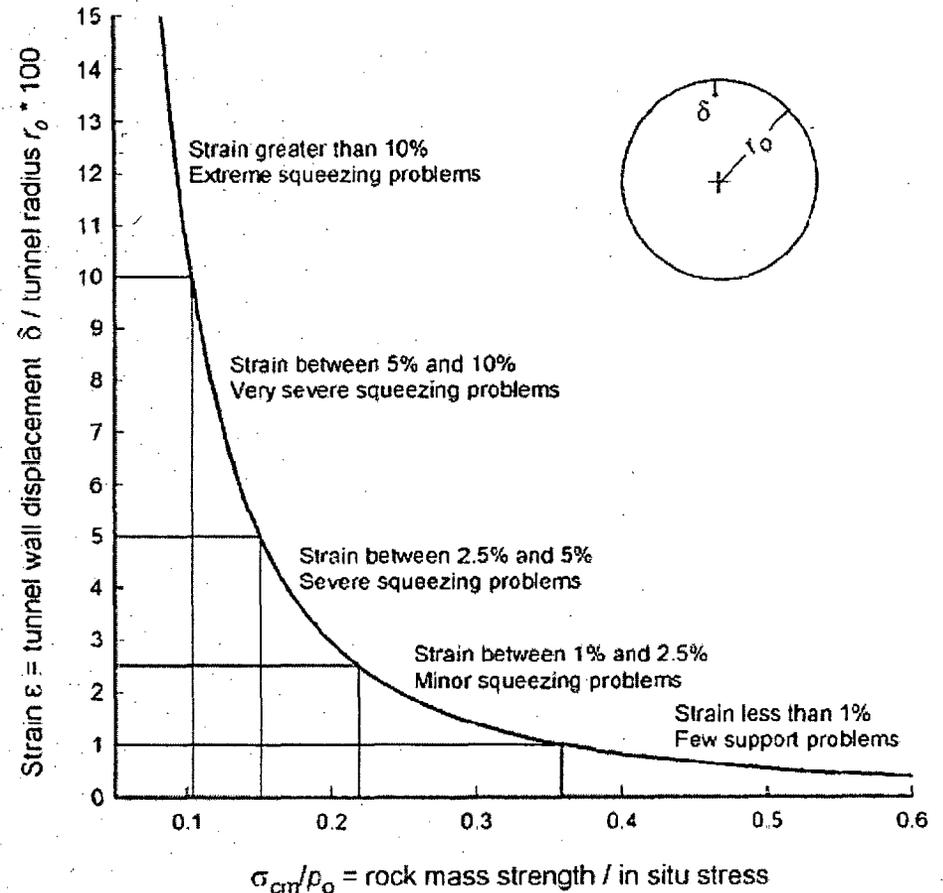


From Martin et al. (1996)

- High tangential stress, low radial stress near an excavation boundary
- The extent and depth of spalling depend on:
  - Magnitude and orientation of the in-situ stresses,
  - Size, shape and orientation of the excavation,
  - The excavation method and sequence (blasting vs. tunnel boring machine (tbm), single vs. multiple headings),
  - Intact rock strength and deformation properties,
  - Rock discontinuity strength and deformation properties,
  - Underground environment (humidity, temperature, rock saturation, water inflow, etc.),
  - The type and properties of the support, if support is applied,
- Progressive spalling can occur due to changing stress conditions (seismic, thermal, continued mining) and time-dependent rock behavior

# Progressive Spalling Leading to Total Drift Collapse

- This only occurs in extreme conditions:
  - Condition 1: Extremely high stresses relative to the strength of the rock (in-situ stresses > 5 times rock mass strength; max tangential stress at boundary > 10 times rock mass strength)
  - Condition 2: Very low stresses (i.e., very shallow) and a very weak rock mass
- These conditions are not expected to occur for the static stresses and thermal loading at Yucca Mountain

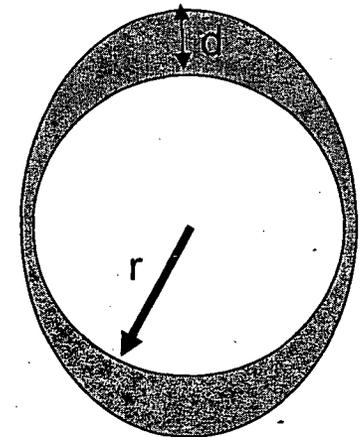


From Hoek (2001)

# Slight to Moderate Overstress Conditions

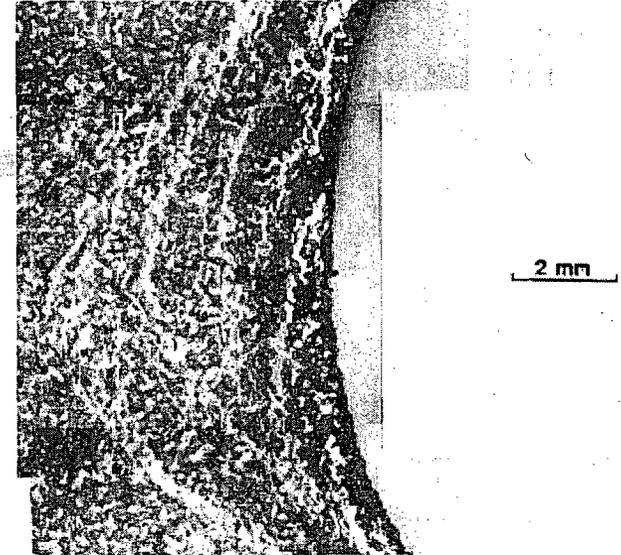
- Depth of spalling ( $d$ ) less than one radius ( $r$ ) away from boundary
- This is common in many underground excavations (civil and mining)
- Standard rock support such as rock bolts and shotcrete are able to support the loose rock associated with these conditions
- Slight to moderate overstress conditions expected at Yucca Mountain due to static+thermal stresses => max tangential stress due to in-situ stresses varies from 3-18 MPa, max tangential stress due to thermal varies from 1-50 MPa (thermal variation due to variation in rock mass Young's modulus)

Rock Type	UCS (MPa)		Young's Modulus (GPa)	Percent of Repository	Lithophysal Porosity (%)
	Mean	Lower Bound			
Lithophysal 1	10	2.0	1.9	2.5	35
Lithophysal 2	15	5.6	6.4	6.0	28
Lithophysal 3	20	9.2	10.8	22.0	21
Lithophysal 4	25	12.8	15.3	29.0	13
Lithophysal 5	30	16.3	19.7	25.5	7
Non-lith	30*	20*	20-30*	15.0	<5



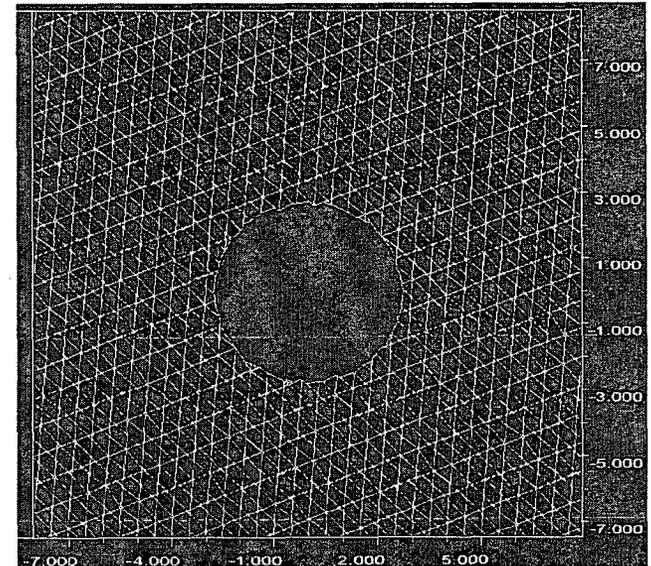
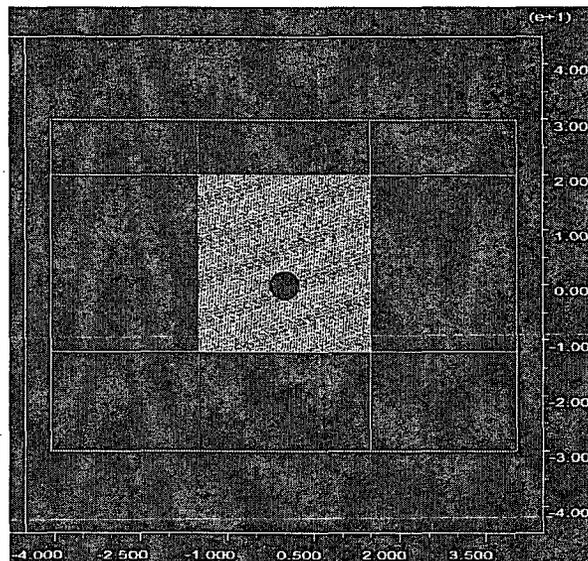
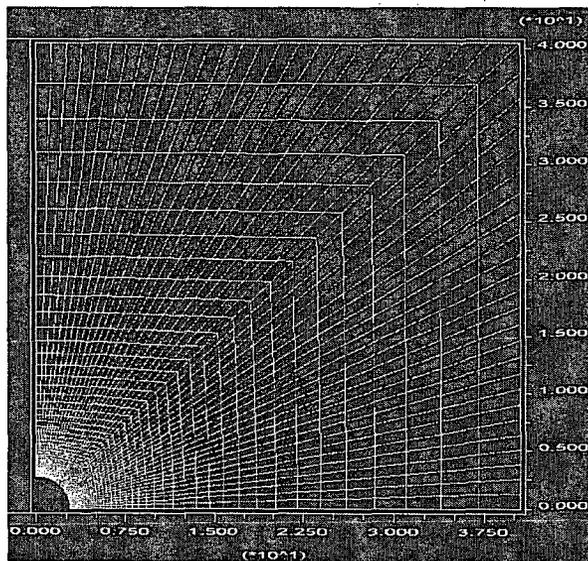
# What Happens If There Is No Rock Support

- Yucca Mountain drifts will remain under thermal loading for thousands of years.
- Rock support will be installed as part of pre-closure, but it will deteriorate over time.
- Without rock support, there are two possible scenarios:
  1. If rock that reaches the peak stress fails and is immediately removed from the roof or wall of the excavation, all stress originally in the failed rock will be redistributed to unfailed rock, possibly resulting in additional failure and a much larger failure zone than the initial overstressed region.
  2. If the failed rock could retain some residual strength, then the rock could remain in place (i.e., no rockfall) and transfer much less stress, resulting in no additional failure or a failure zone only slightly bigger than the original overstressed zone.
- These two scenarios are reflected in the differing CNWRA (1) and DOE (2) opinions on thermal spalling at Yucca Mountain.
- DOE opinion based on discontinuum modeling (UDEC and PFC), CNWRA opinion based on an elastic analysis with a worst-case assumption about post-peak rock behavior in the failed zones.



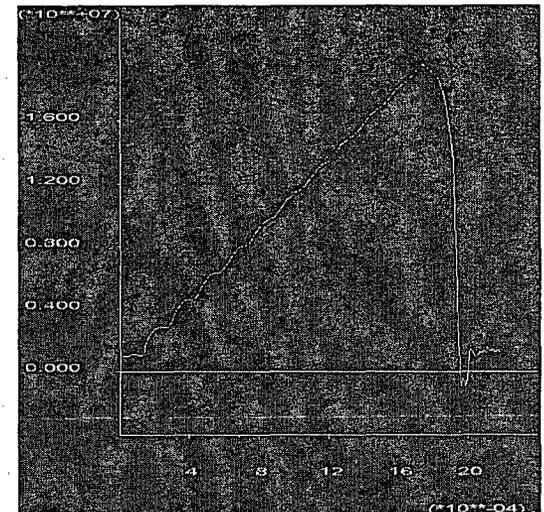
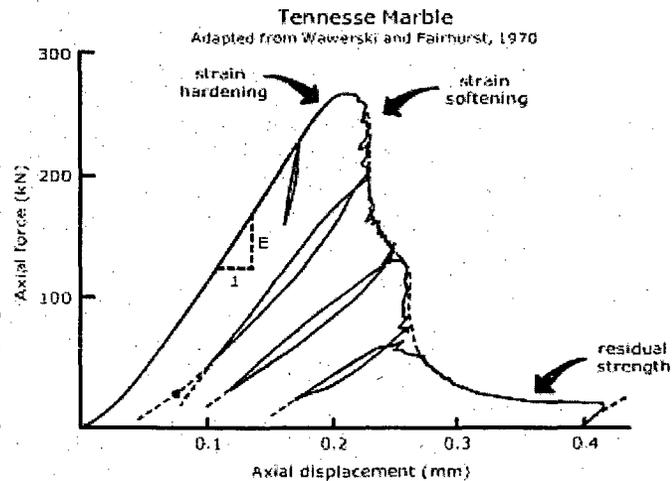
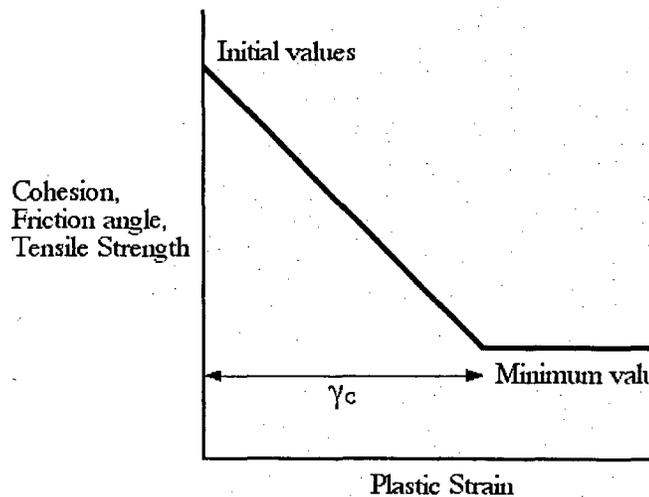
# EPRI Modeling

- 5.5 meter diameter drifts separated by 81 meter pillars
- Material properties, in-situ stresses and temperature boundary conditions from the Drift Degradation Analysis report (BSC, 2004)
- Continuum modeling using FLAC (Itasca). Strain softening properties varied to simulate the range of possible post-peak behavior.
- Discontinuum modeling using UDEC (Itasca). Block model to simulate the actual failure mechanism in the lithophysal tuff. Time dependent drift degradation due to stress corrosion cracking is simulated for 1000 years of thermal loading.



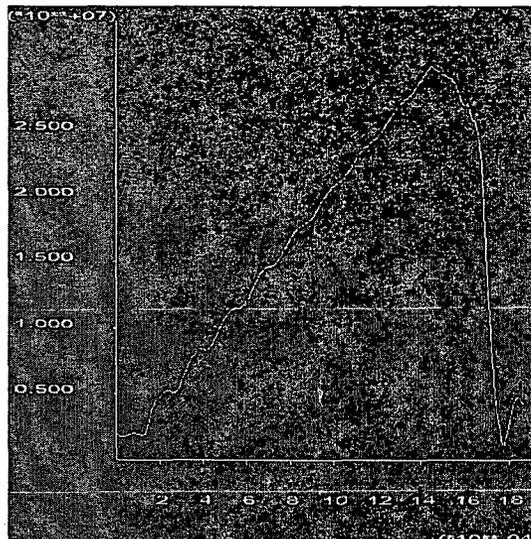
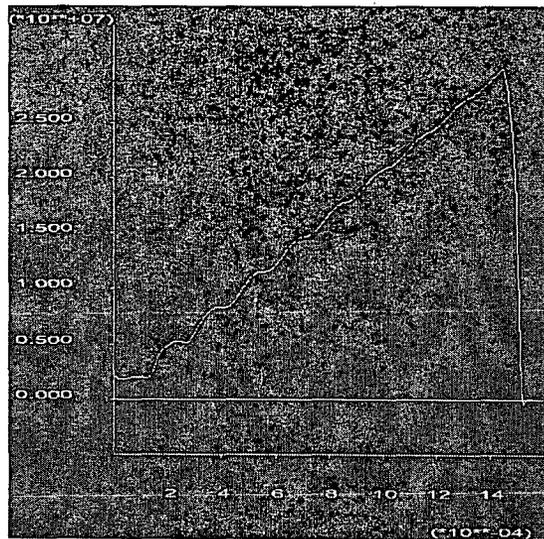
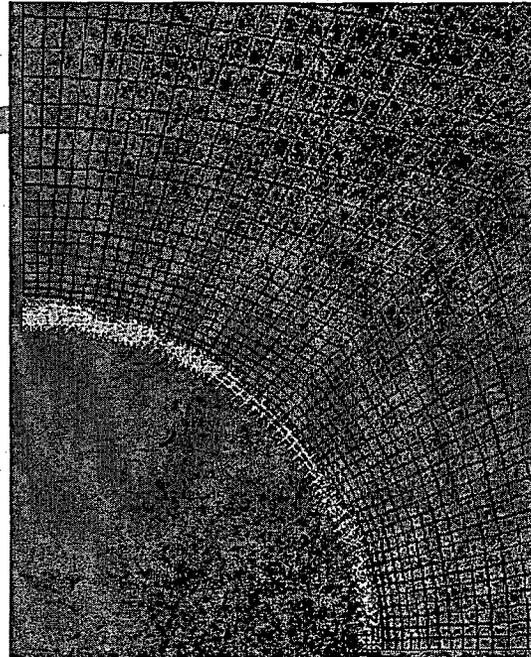
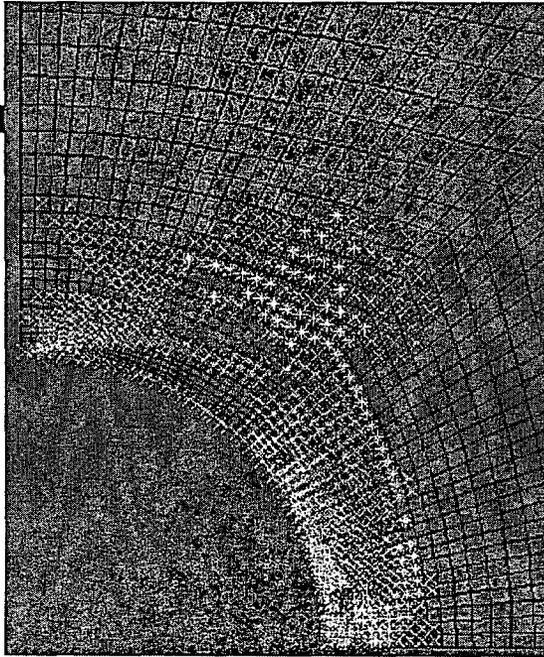
# FLAC Modeling

- Strain softening parameter  $\gamma_c$  used to simulate the brittleness of the post peak behavior (smaller  $\gamma_c$  = more brittle)
- Strength and elastic moduli known, however in general the post peak properties not reported (so  $\gamma_c$  varied over a range of values)
- FLAC simulation of the uniaxial test can be compared with reported results



FLAC simulation of uniaxial test

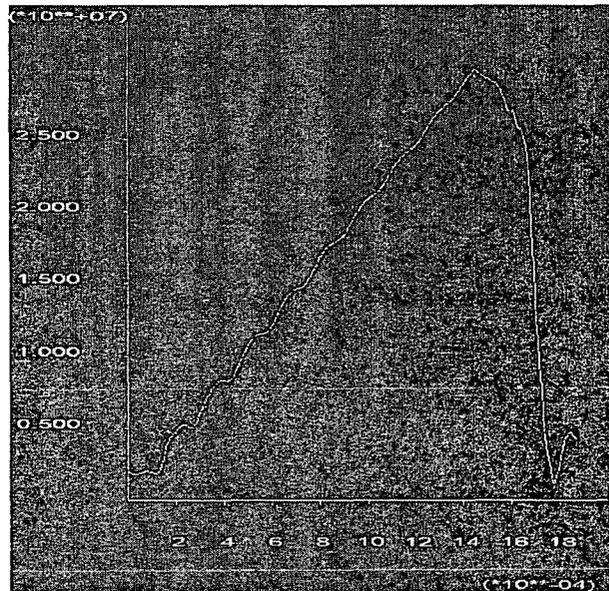
# FLAC Results for Category 5 Lithophysal Tuff



- Category 5 tuff: strongest (30 MPa), highest modulus (19.7 GPa), lowest lithophysal porosity (7%)
- Large spalling region for  $\gamma_c = 0.002$  (left set of figures)
- Small spalling region for  $\gamma_c = 0.005$  (right set of figures)
- (green: at yield in past; pink: yield in shear; purple: yield in tension)

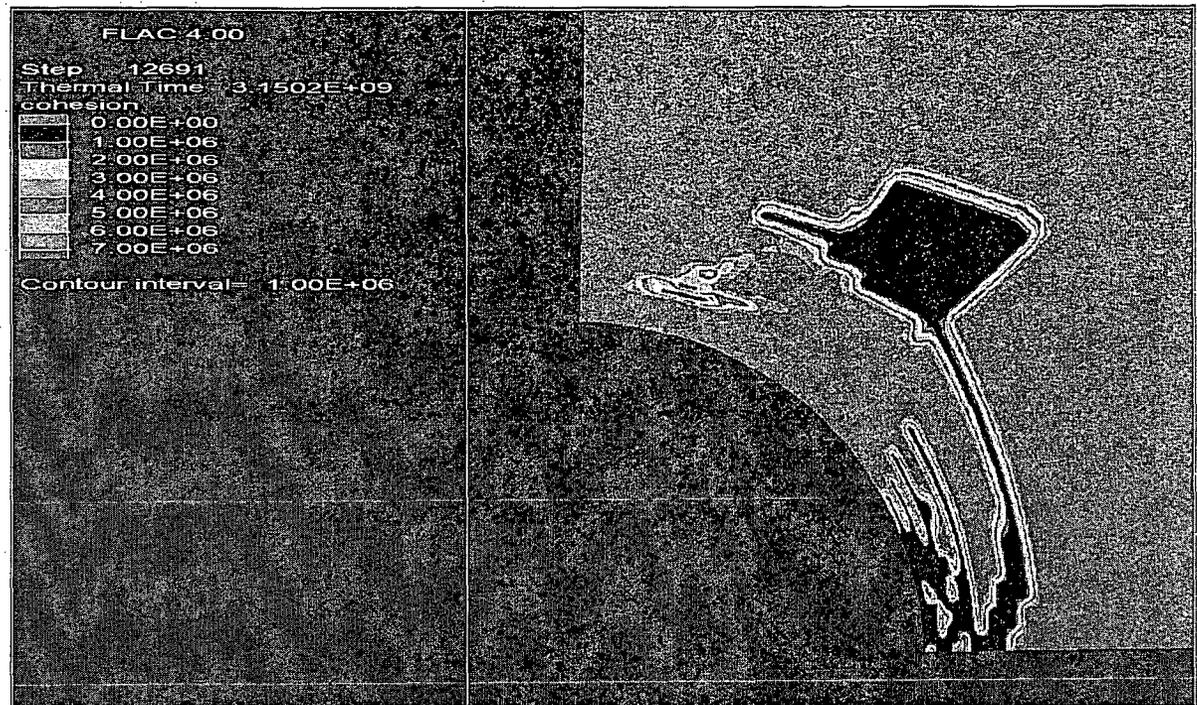
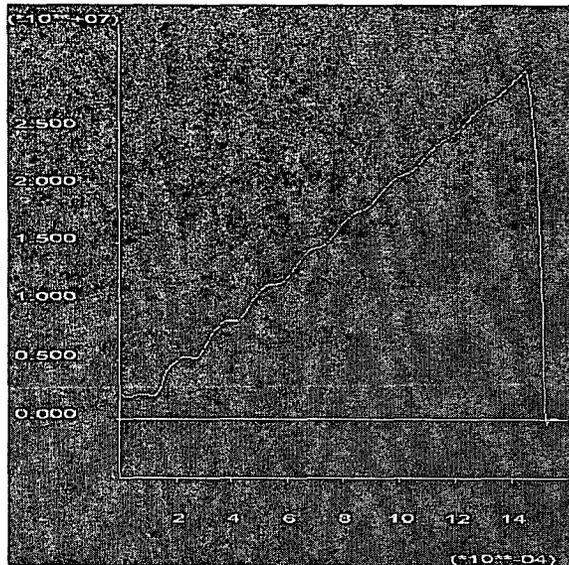
# FLAC Results for Category 5 Lithophysal Tuff

- The reason for the stable behavior in the second case is that the cohesion only drops slightly in the spall region, thus only a small transfer of stress occurs
- Compare FLAC uniaxial results with actual test results to estimate likely  $\gamma_c$  value for Category 5 lithophysal tuff



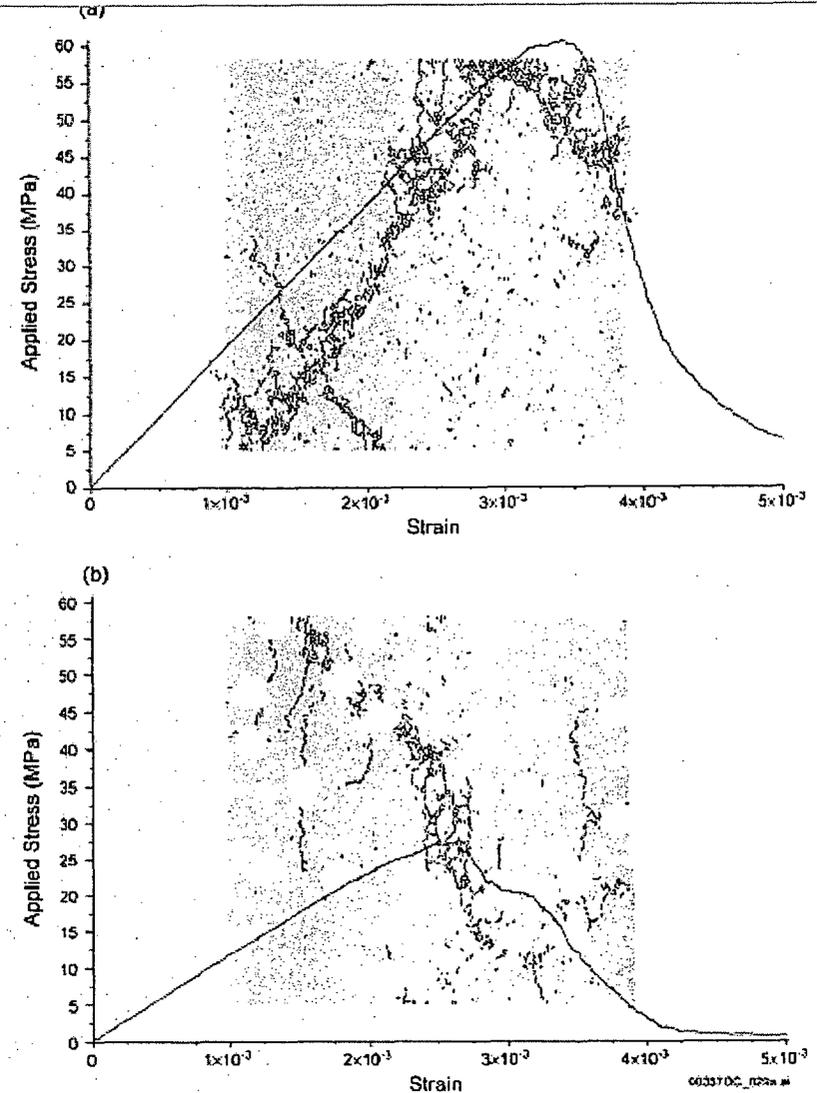
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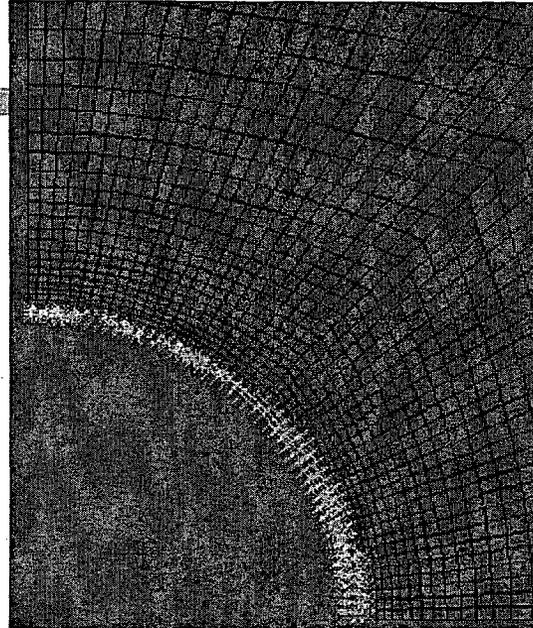
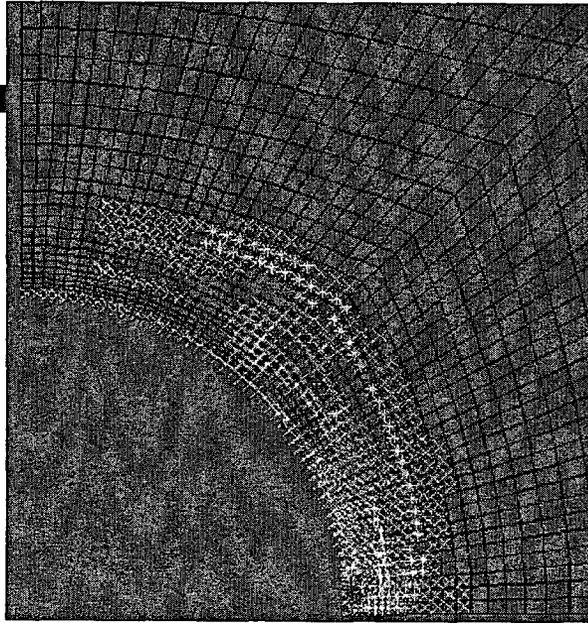
# FLAC Results for Category 5 Lithophysal Tuff

- For  $\gamma_c = 0.002$  (FLAC), peak to residual strain less than 0.0001
- For  $\gamma_c = 0.005$  (FLAC), peak to residual strain about 0.0004
- For nonlithophysal tuff (test), peak to residual strain about 0.001
- For Category 5 lith (test), peak to residual strain about 0.015
- Can conclude that only minor spalling is expected in Category 5 lithophysal tuff under thermal loading
- Similar conclusions can be made for the other categories of lithophysal tuff



Source: BSC 2004j, Section 6.5.6, Figure 6.5-2D.

# FLAC Results for Category 3 Lithophysal Tuff

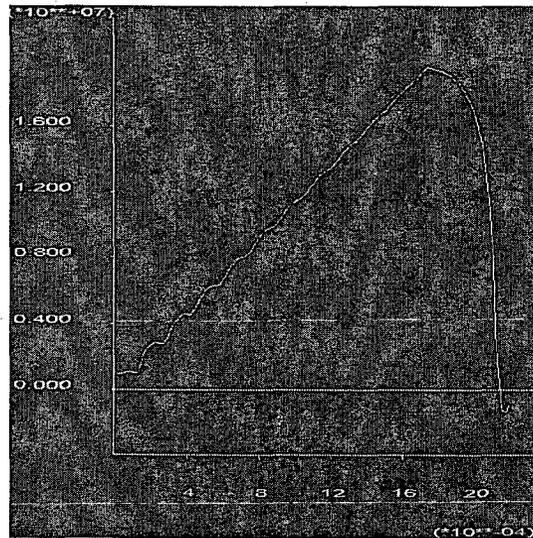
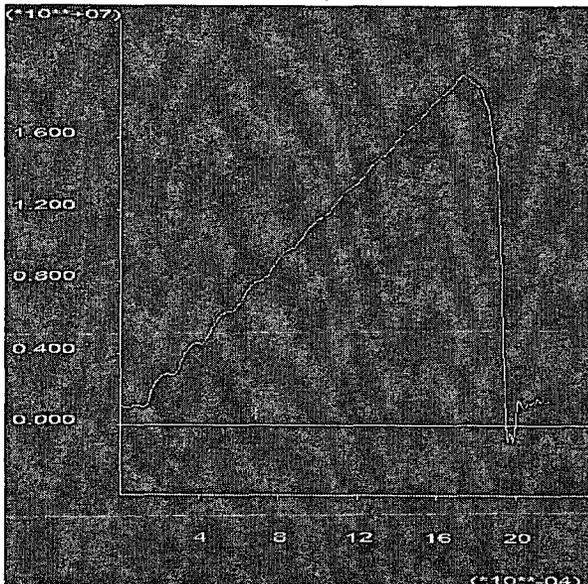


Category 3 tuff: strength (20 MPa), modulus (10.8 GPa), lithophysal porosity (21%)

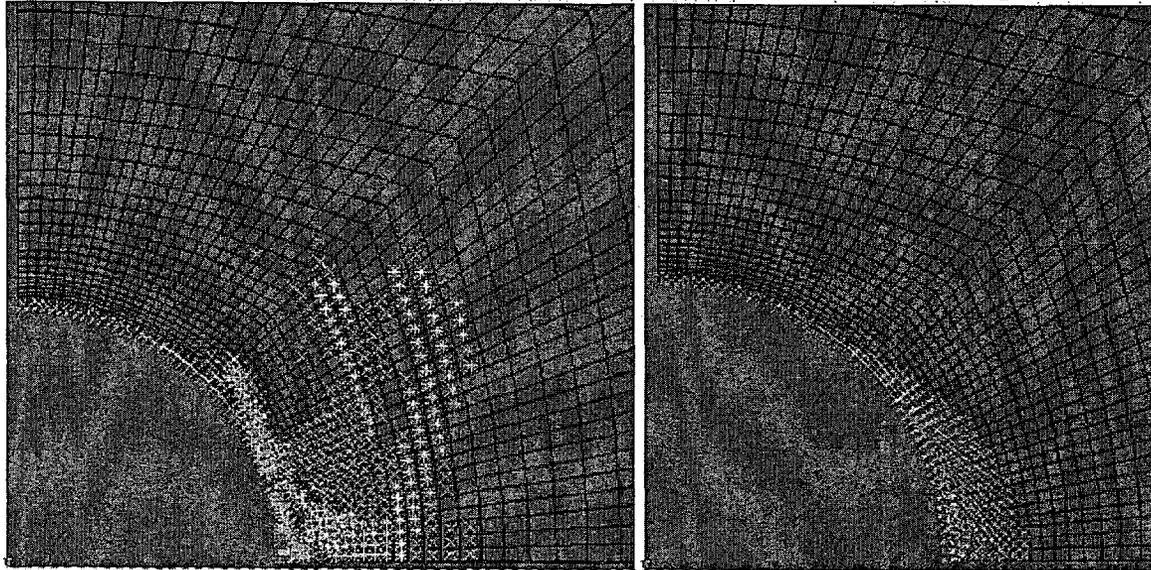
Large spalling region for  $\gamma_c = 0.005$  (left set of figures)

Small spalling region for  $\gamma_c = 0.01$  (right set of figures)

(green: at yield in past; pink: yield in shear; purple: yield in tension)



# FLAC Results for Category 1 Lithophysal Tuff

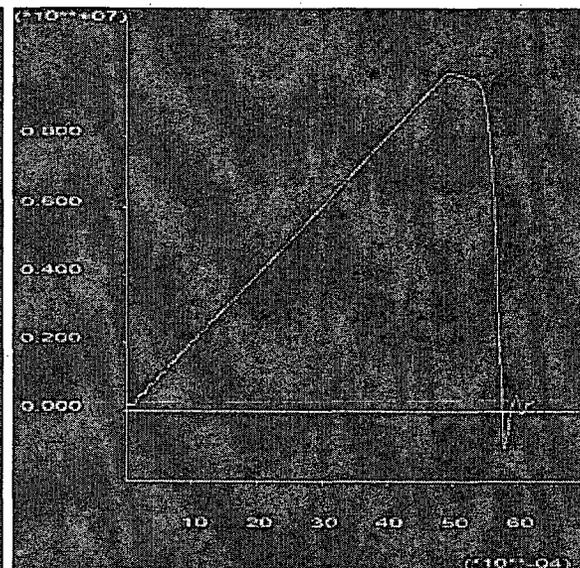
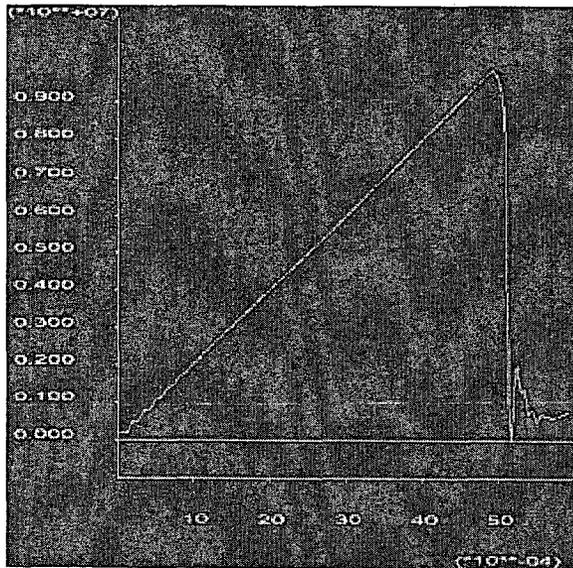


Category 1 tuff: strength (10 MPa), modulus (1.9 GPa), lithophysal porosity (35%)

Large spalling region for  $\gamma_c = 0.01$  (left set of figures)

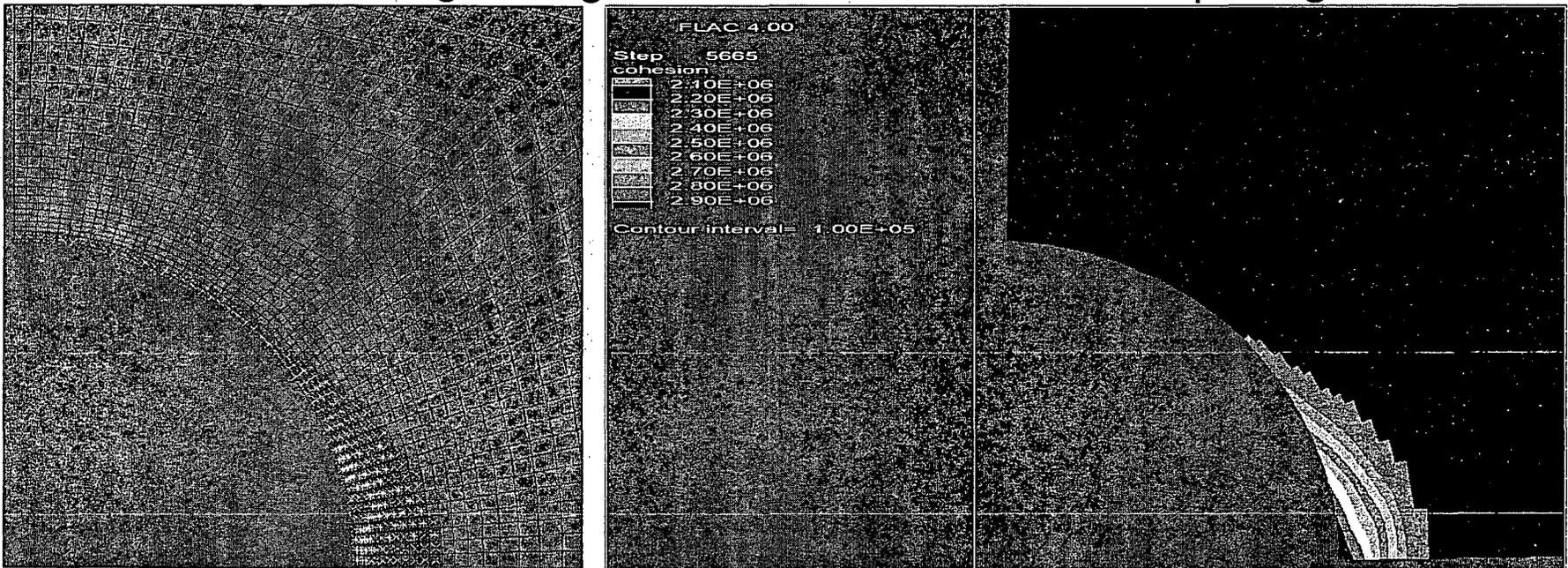
Small spalling region for  $\gamma_c = 0.05$  (right set of figures)

(green: at yield in past; pink: yield in shear; purple: yield in tension)



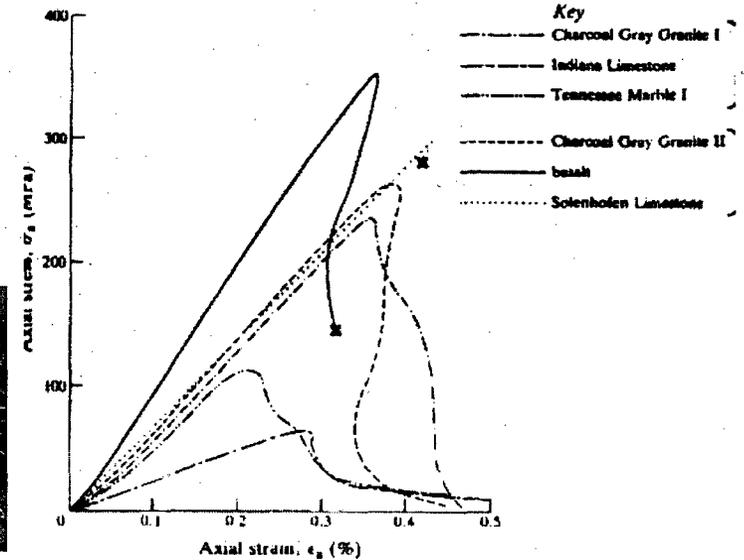
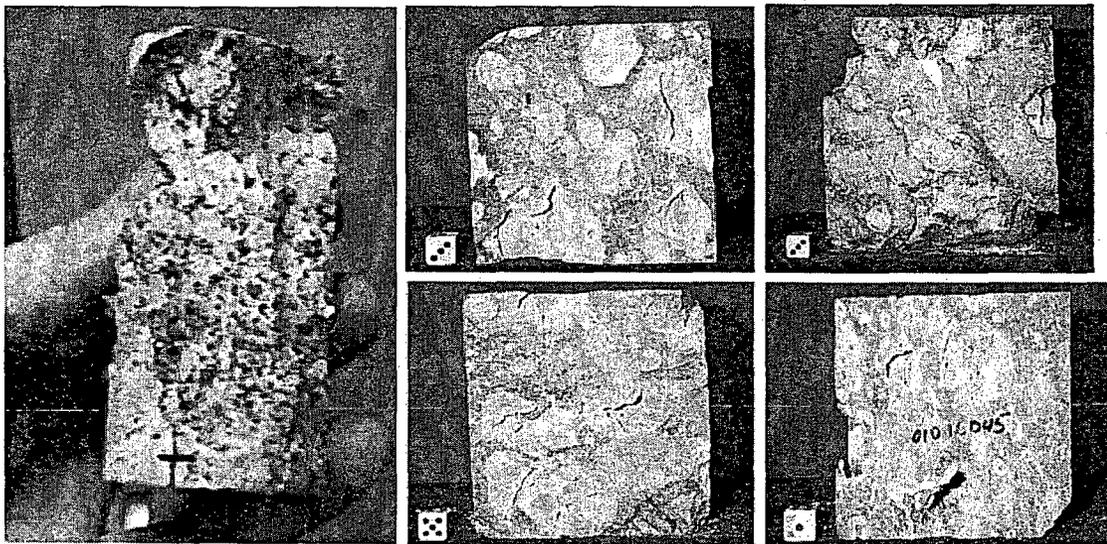
# FLAC Results for Category 1 Lithophysal Tuff Without Thermal Loading

- Category 1 tuff: weakest (10 MPa), lowest modulus (1.9 GPa), highest lithophysal porosity (35%)
- Some wall spalling is currently observed in the Category 1 lithophysal tuff. FLAC was used to simulate Category 1 tuff without thermal loading
- The results indicate a zone of spalling, with only a minor loss of cohesion in the spall region (no additional damage due to thermal)
- The results are in good agreement with the observed spalling



# Do Rocks With Steep Strain Softening Exist?

- In general, as heterogeneity concentration and heterogeneity size increase, peak to residual strain increases
- Fine-grained granites can have initial microcrack sizes on the order of 0.1 mm. The nonlithophysal tuff has heterogeneities on the order of cm. The lithophysal tuff has heterogeneities with sizes of 10 cm or more.



# UDEC Modeling

- A block model was developed to simulate the crack growth mechanism that occurs in the lithophysal tuff
- Rock failure occurs by cracks that connect the individual lithophysae
- Removable blocks are formed by cracks connecting all sides of a block

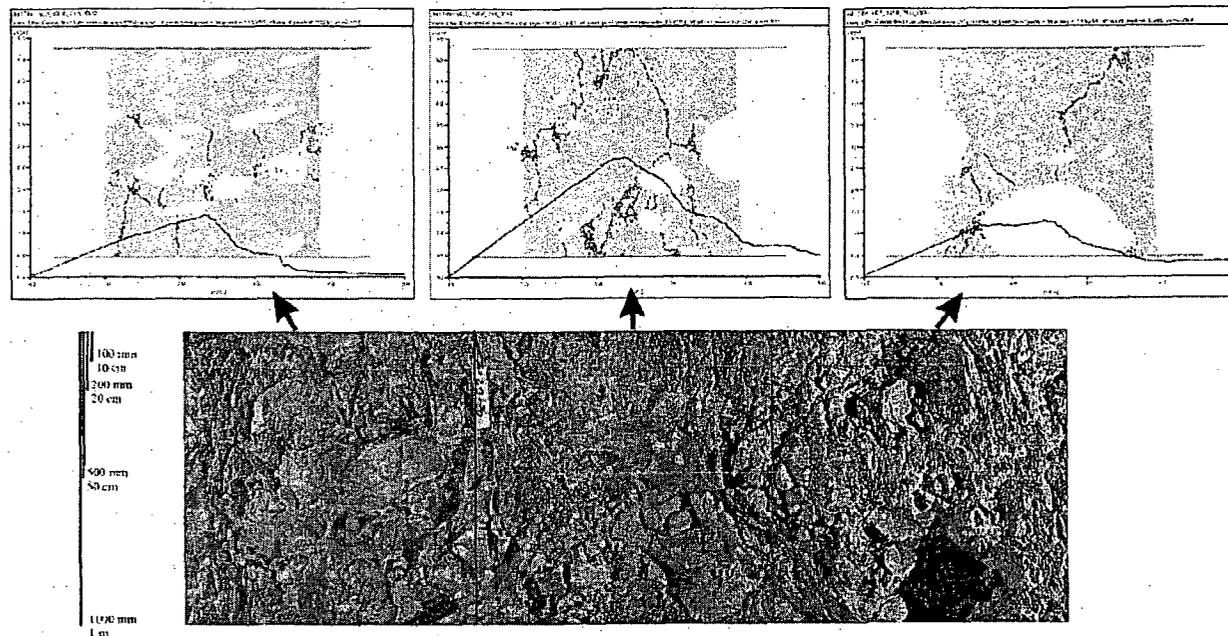


Figure B-14. Damage in PFC2D Stenciled-lithophysae Specimens (blue is pre-peak, red is post-peak) at an Axial Strain of 0.5% Generated from Lithophysal Cavities of Panel Map at ECRB Station 20+18 to 20+21 (Left Wall)

# Time Dependent Rock Bridge Failure

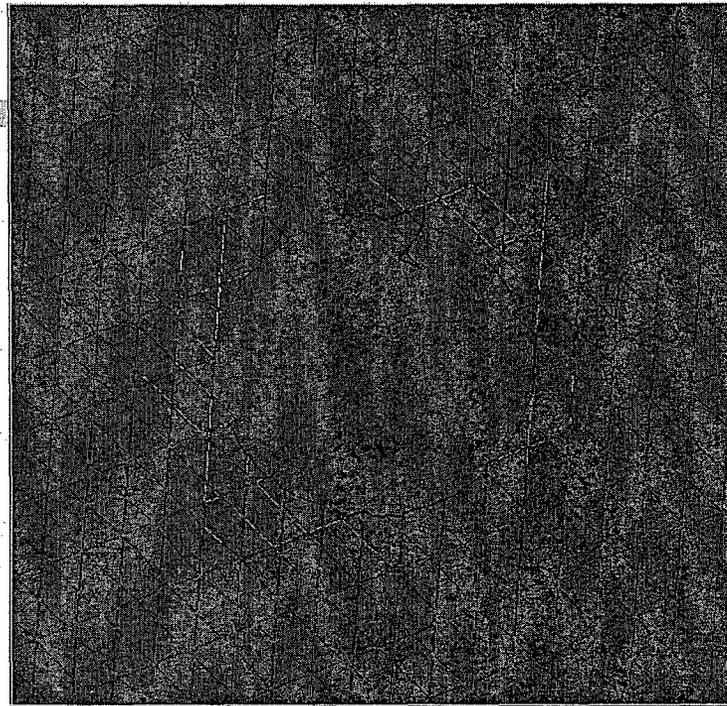
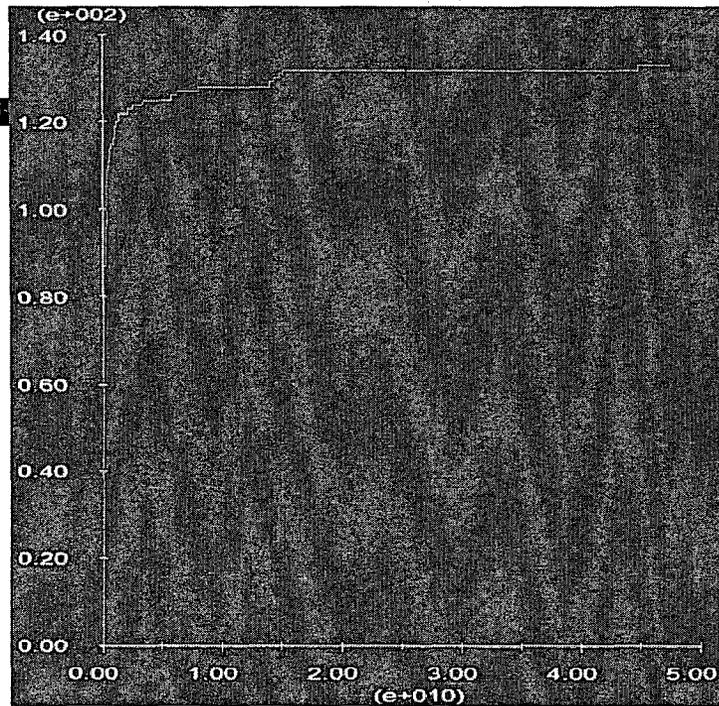
- The segments of rock separating the lithophysae are referred to as rock bridges
- The initial cohesion values for the boundaries of each block are determined based on the size and properties of the rock bridges
- Average rock bridge sizes of 5, 10 and 20 cm have been assumed for Categories 1, 3 and 5 tuff (based on information in BSC, 2004)
- The rock bridge cohesion is calculated as follows:

$$C_o = \frac{K_{IIC} \sqrt{a}}{2w}$$

- This gives initial cohesion values of 3.8, 6.2 and 11.25 MPa for Categories 1, 3 and 5 tuff, which are surprisingly close to the cohesions used in BSC (2004). These cohesion values will decrease with time due to stress corrosion cracking.
- A power-law formulation for crack growth due to stress corrosion cracking is utilized:

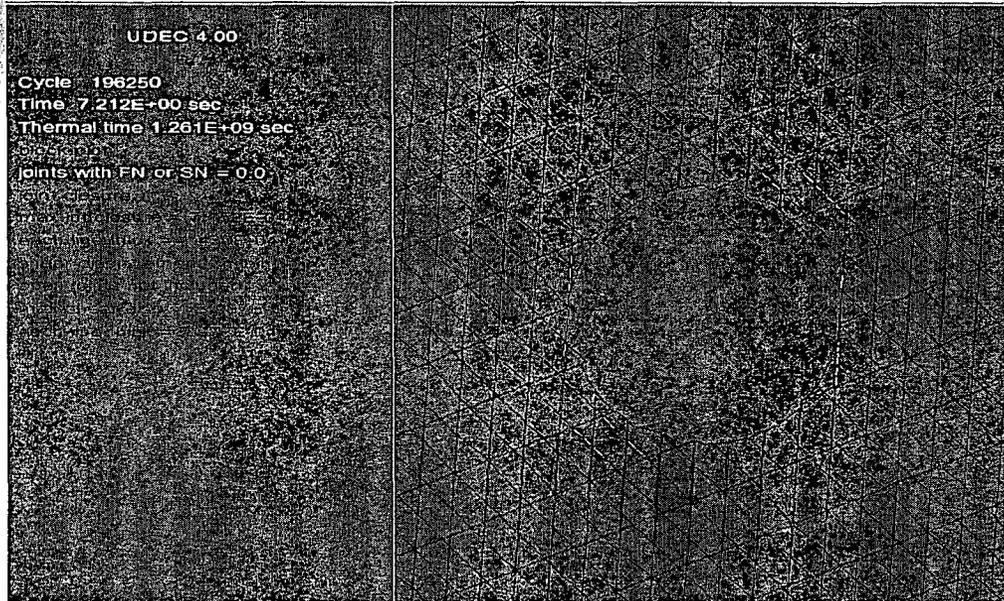
$$\text{Crack Velocity} = A \left[ \frac{K_{II}}{K_{IIC}} \right]^n$$

# UDEC Results for Category 5 Tuff

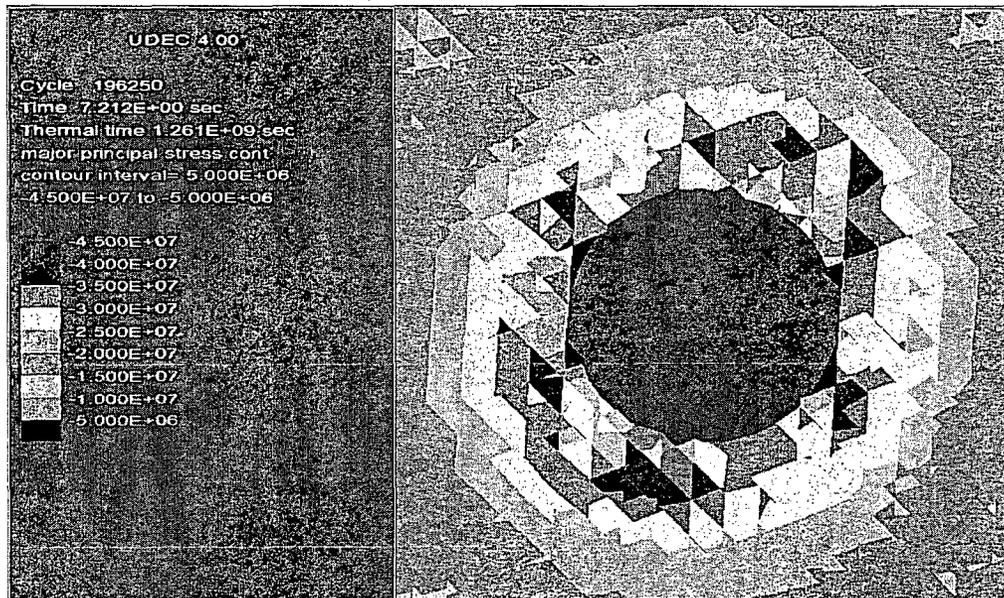


- [left] Number of rock bridges where the cohesion has reduced to zero with time, showing most damage in the first 150 years.
- [right] Location of these bridges after 1000 years of thermal loading (damage zone)
- In order for rockfall to occur, the cohesion on all sides of the block must be zero. Even then, friction can stabilize the block.

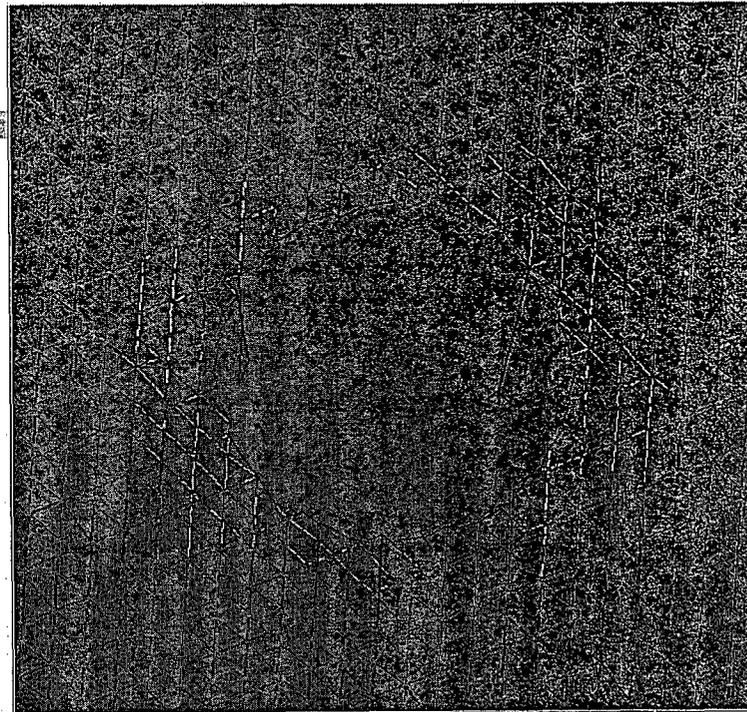
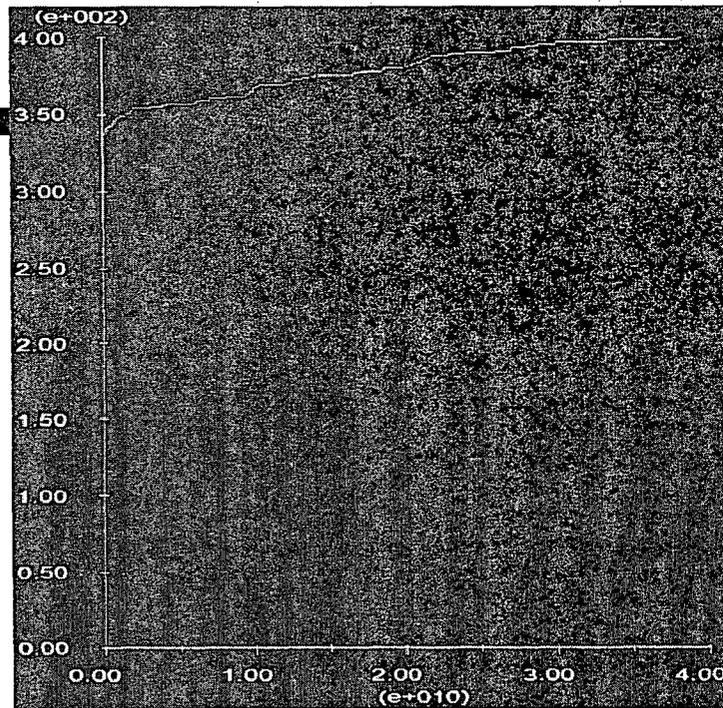
# UDEC Results for Category 5 Tuff



- The stress remaining in the damage zone is a measure of its integrity (similar to cohesion in FLAC)
- Low stress (dark blue in lower figure) areas are likely to see rockfall
- Overall, UDEC predicts isolated rockfall within the first meter of the damage zone, stable overall
- Similar results for Category 3

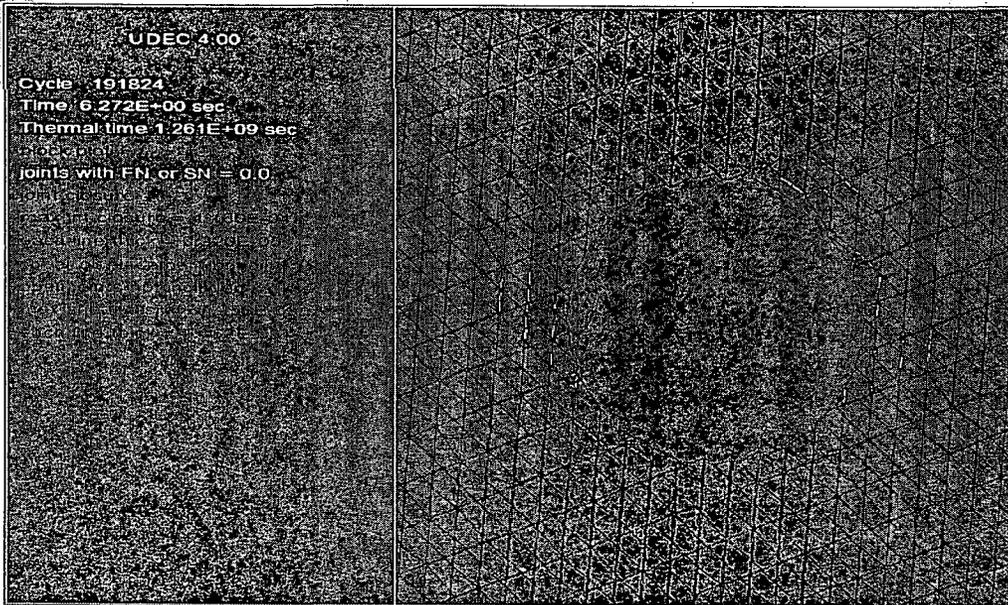


# UDEC Results for Category 1 Tuff

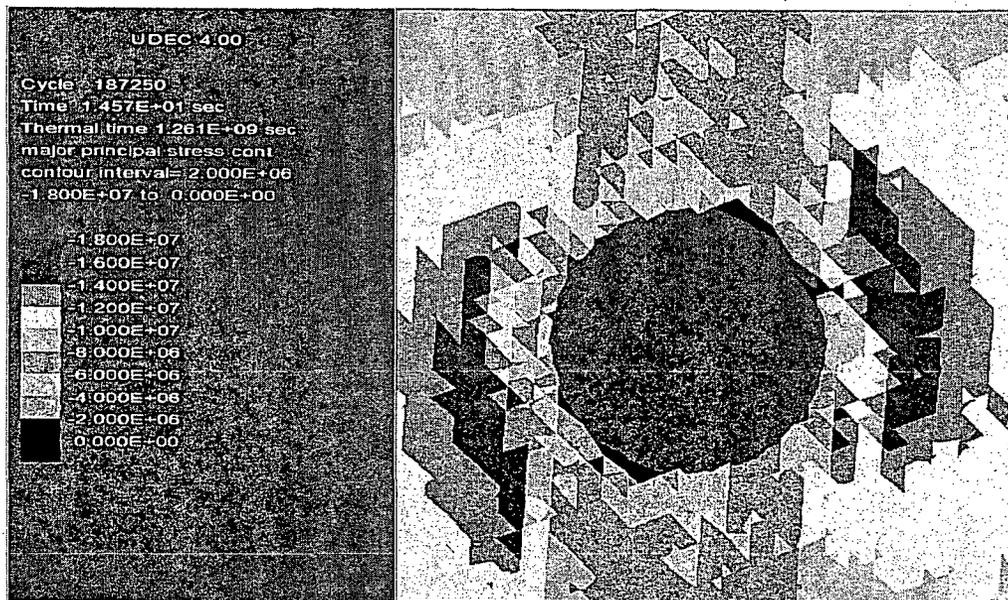


- Number of broken rock bridges has increased in Category 1 tuff, and also there is an increase with time, even at 1000 years
- Damage zone is larger in Category 1 tuff, however most of the blocks still remain in place due to 1) not all sides of the blocks fractured, and 2) friction still holding blocks in place

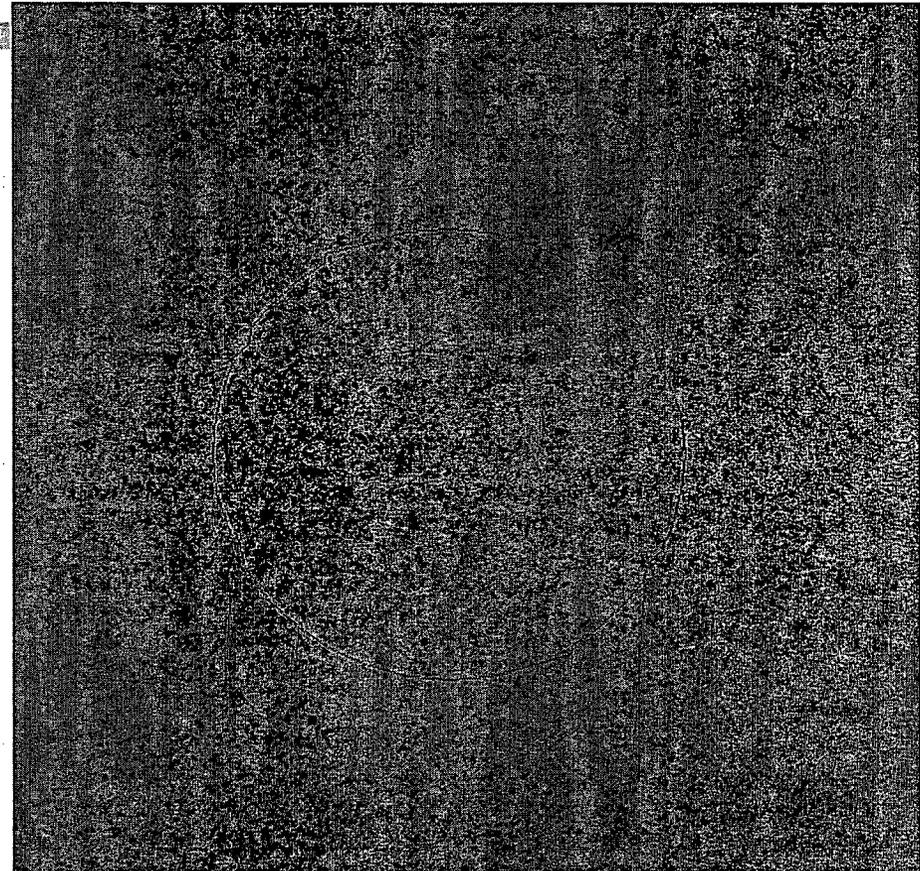
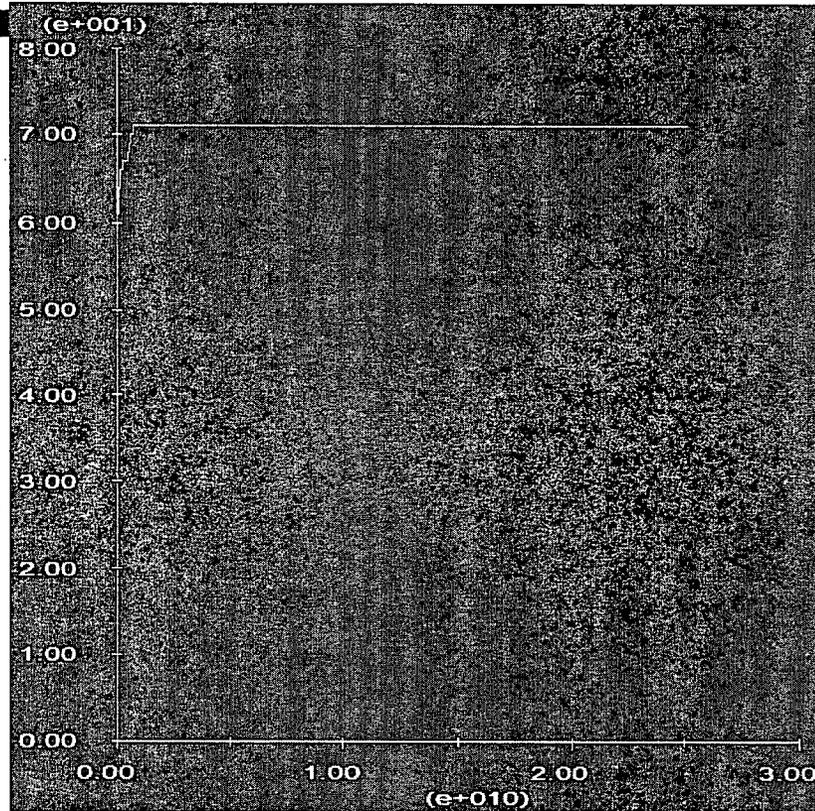
# UDEC Results for Category 1 Tuff



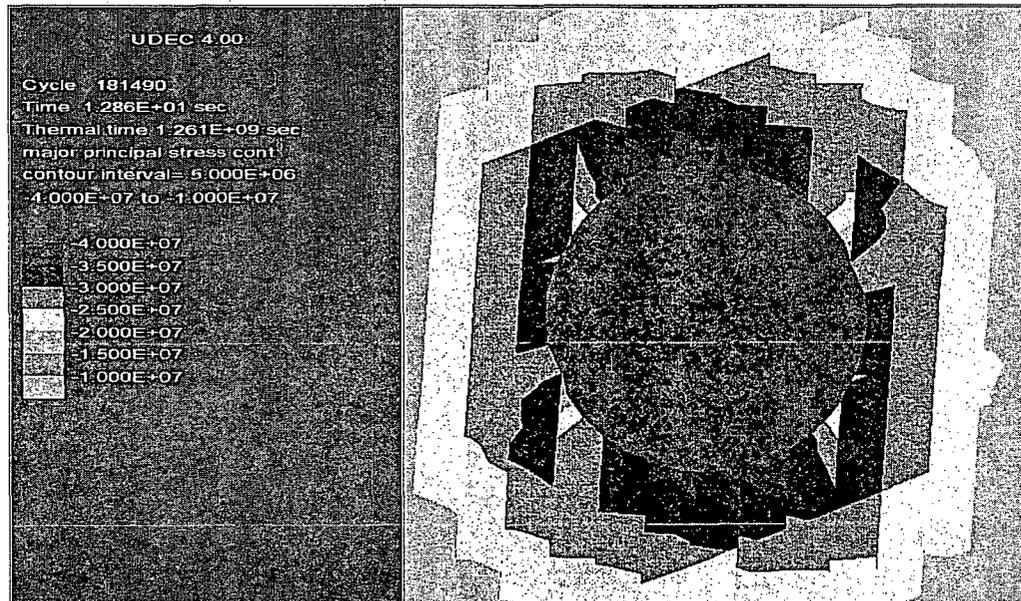
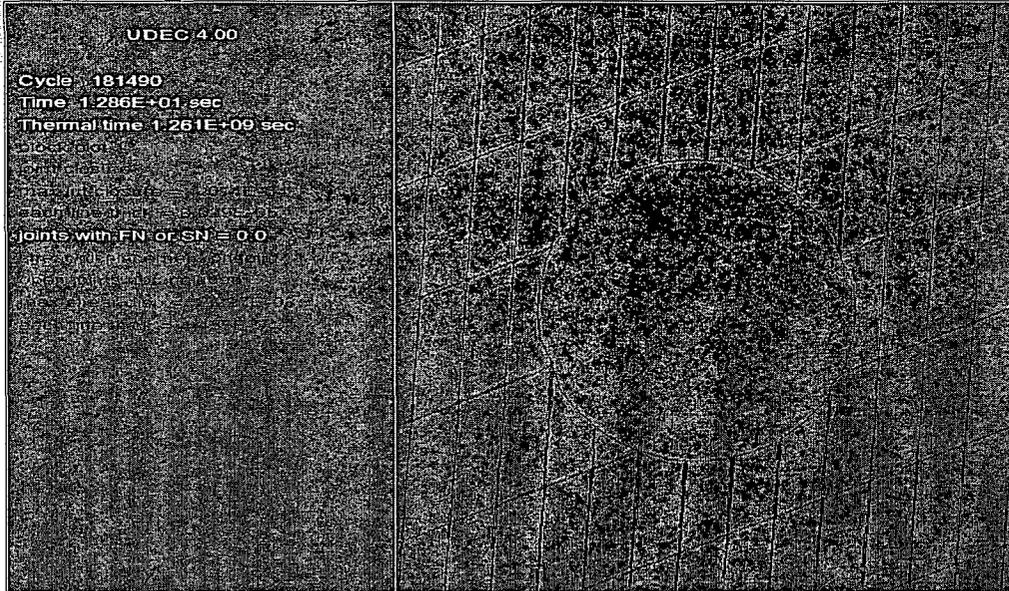
- Low stress (dark blue in lower figure) areas are likely to see rockfall
- Overall, UDEC predicts isolated rockfall within the first 1.5 meters of the damage zone, stable overall



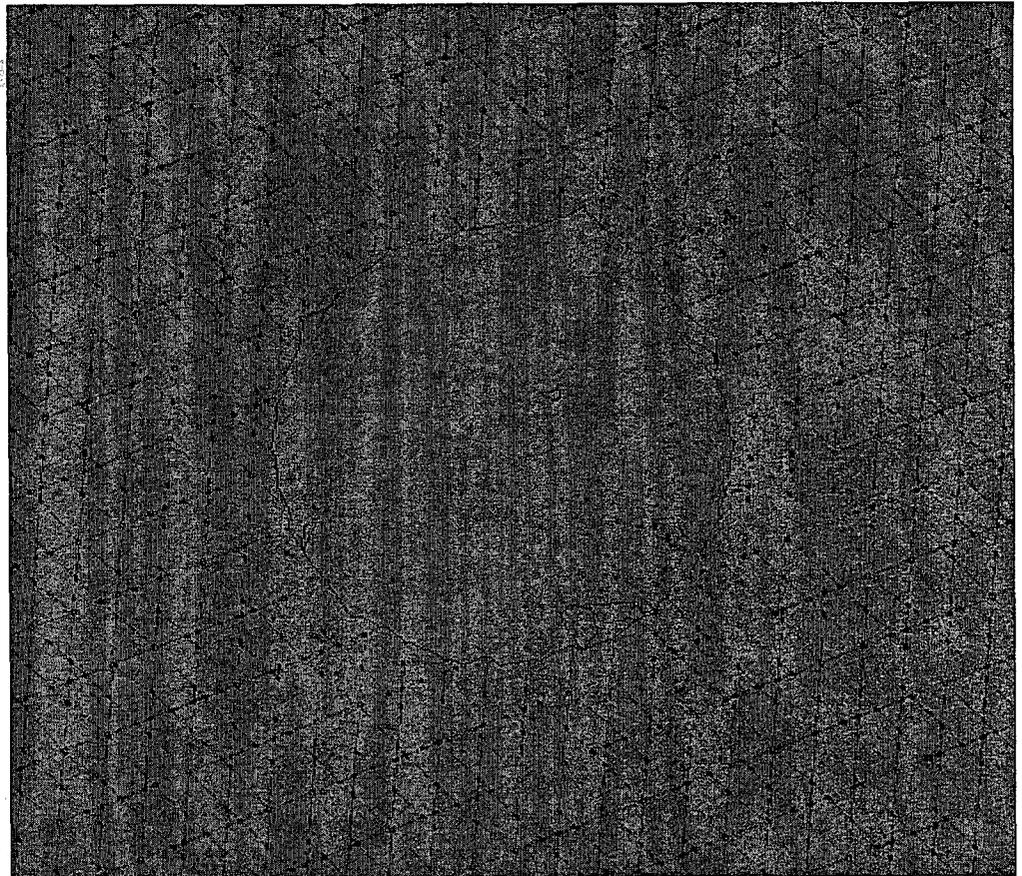
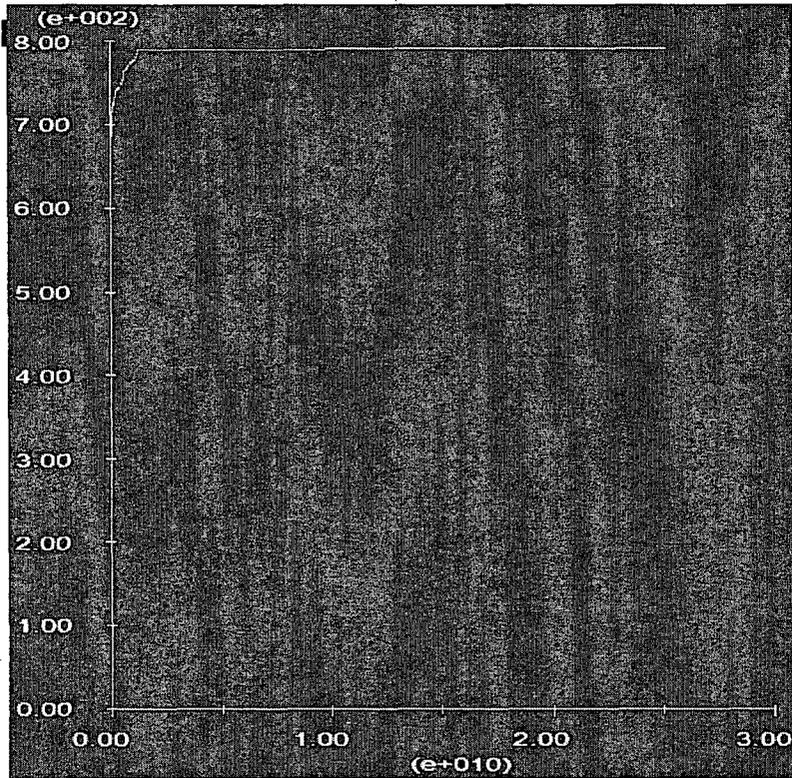
# UDEEC Results for Non-Lithophysal Tuff (regular)



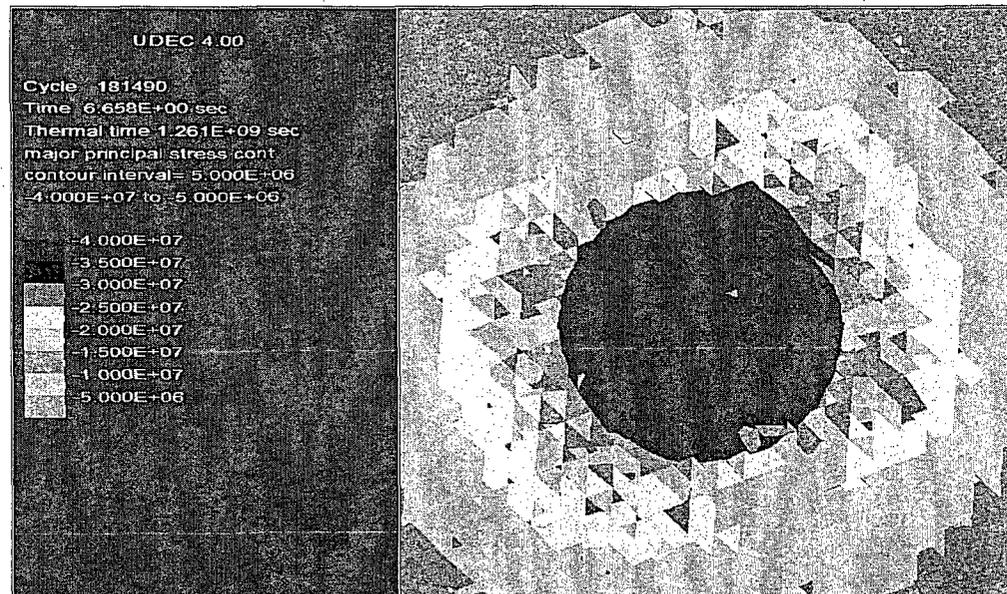
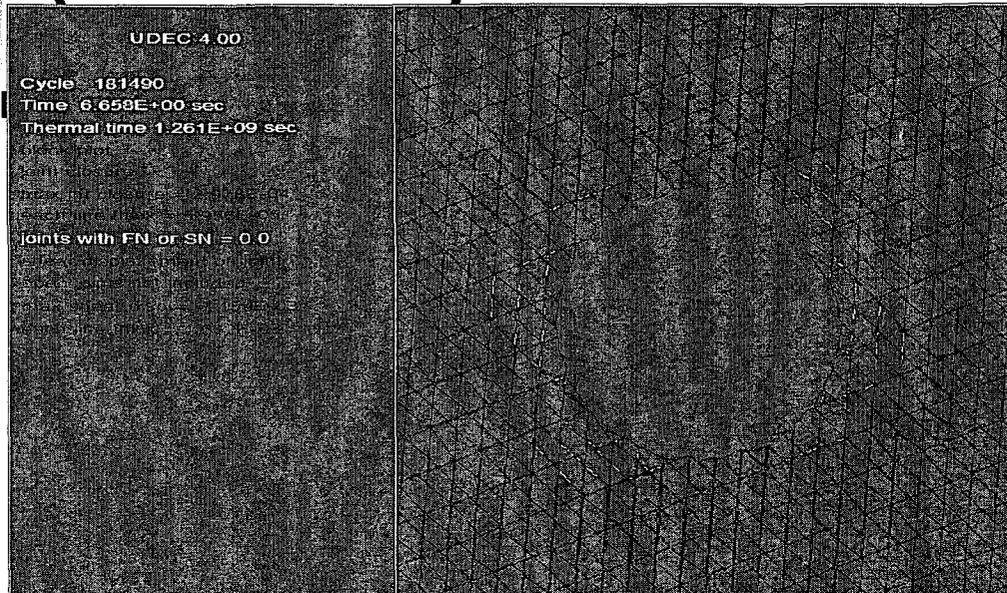
# UDEC Results for Non-Lithophysal Tuff (regular)



# UDEC Results for Non-Lithophysal Tuff (fault zone)



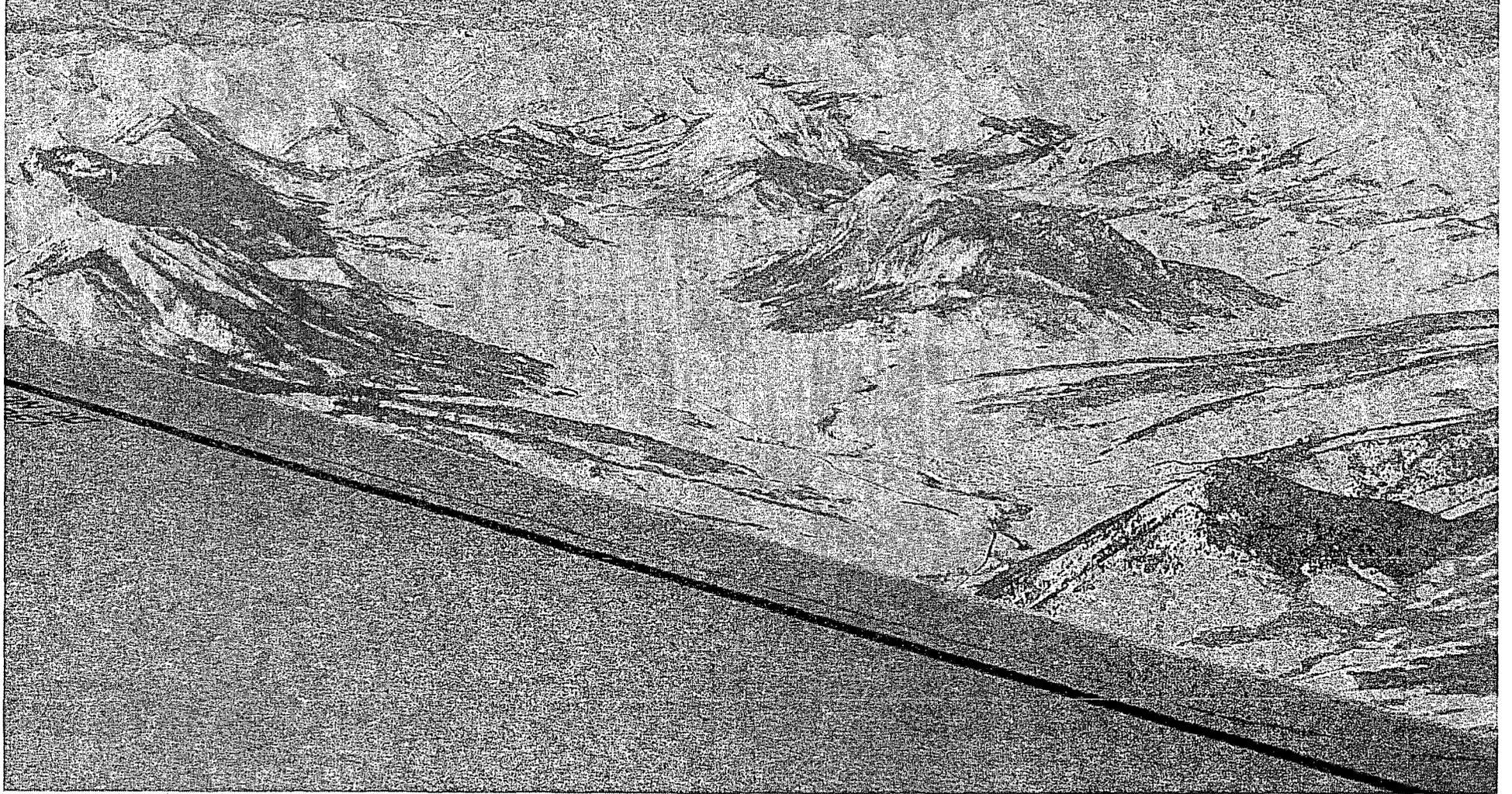
# UDEC Results for Non-Lithophysal Tuff (fault zone)



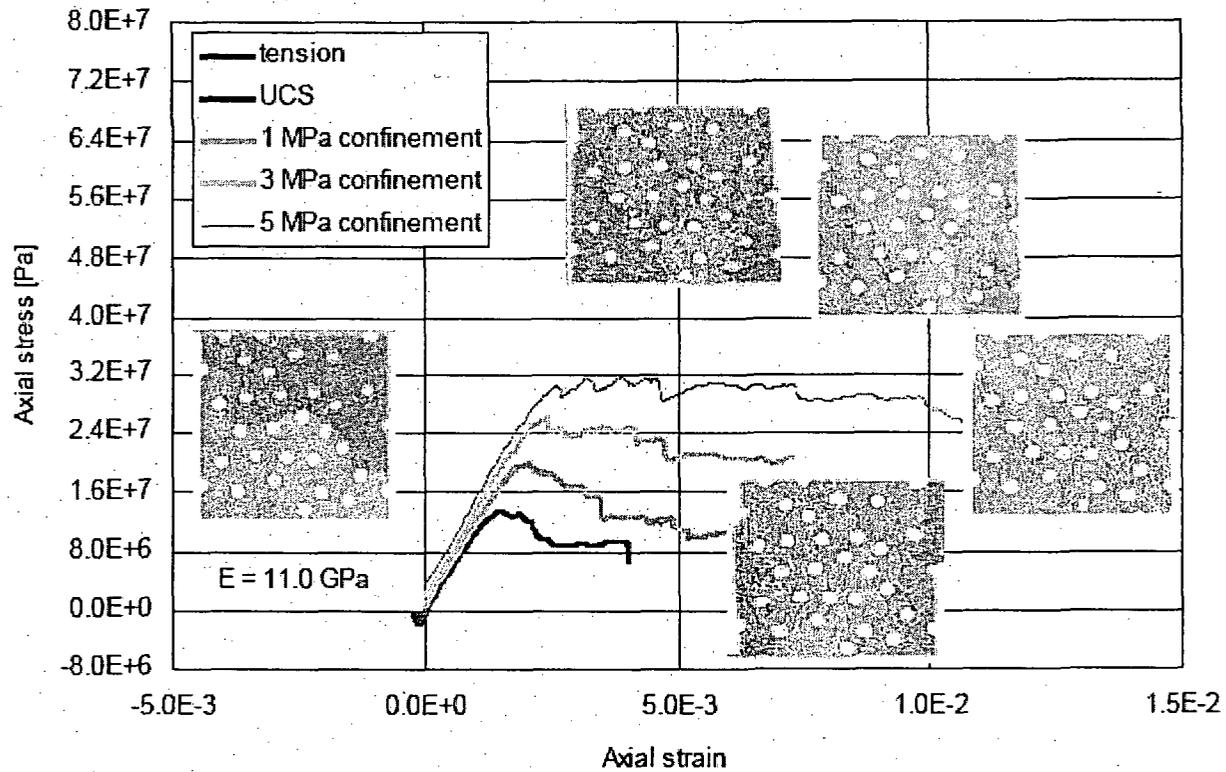
# Conclusions

- The FLAC results indicated that if the strain softening slope is steep enough ( $\gamma_c$  is small enough), large spalling could occur. However, for all categories of lithophysal tuff, it was found that actual values of  $\gamma_c$  were significantly greater than the critical value necessary for large spalling. Thus stable drifts were predicted with isolated rockfall within the initial overstressed region.
- The UDEC results indicated that a damage zone with a size on the order of 0.5-2.5 meters is created around the drifts due to thermal loading. However, only isolated blocks within the damage zone are expected to produce rockfall. UDEC results also indicated that most of the damage occurs within the first 50-150 years.
- There is good correlation between the FLAC and UDEC results.
- These results are in agreement with DOE results in BSC (2004) and in partial agreement with CNWRA results.
- Neither the FLAC nor the UDEC results predict large amounts of spalling under thermal loading that would fill the drifts with rock blocks

**Questions?**

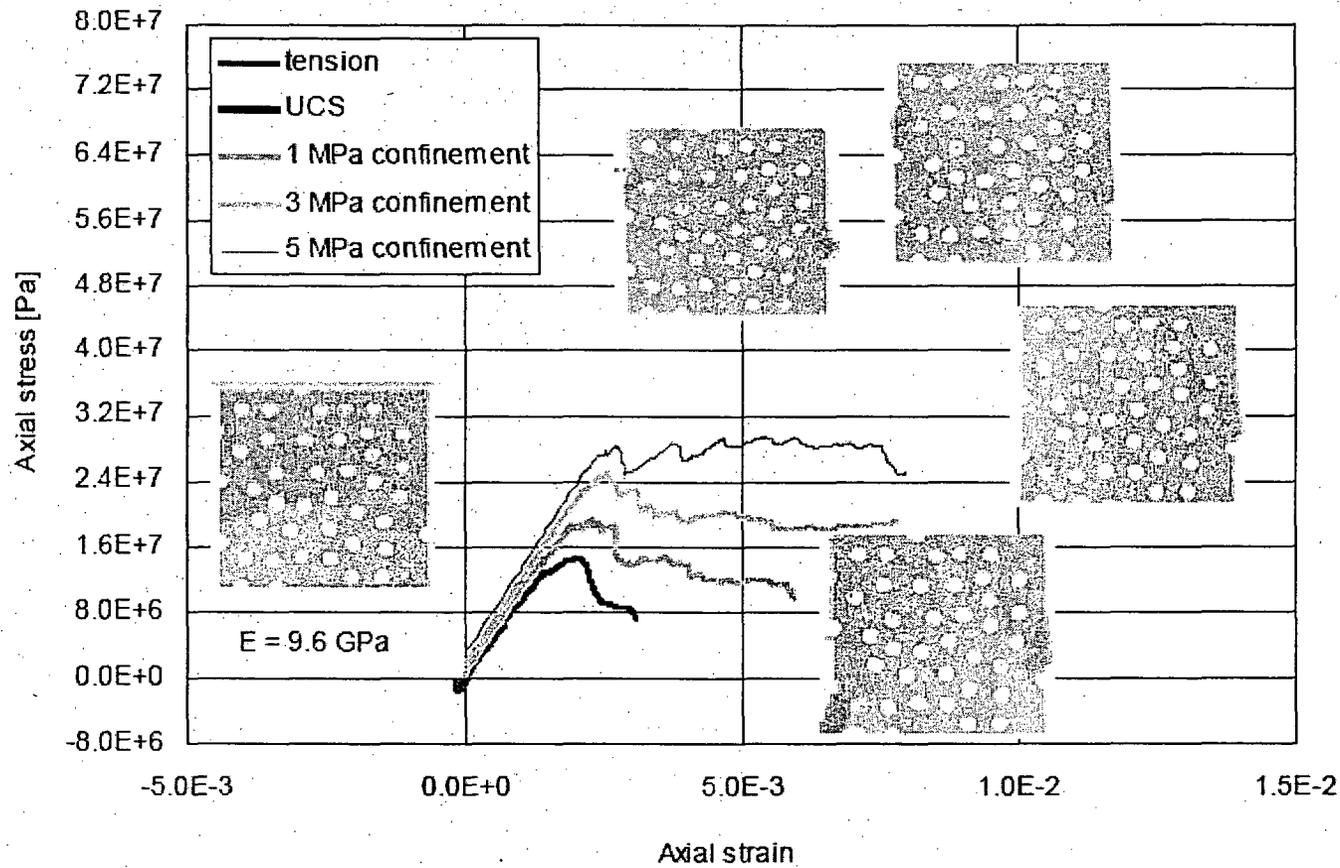


# FLAC Results for Category 3 Lithophysal Tuff



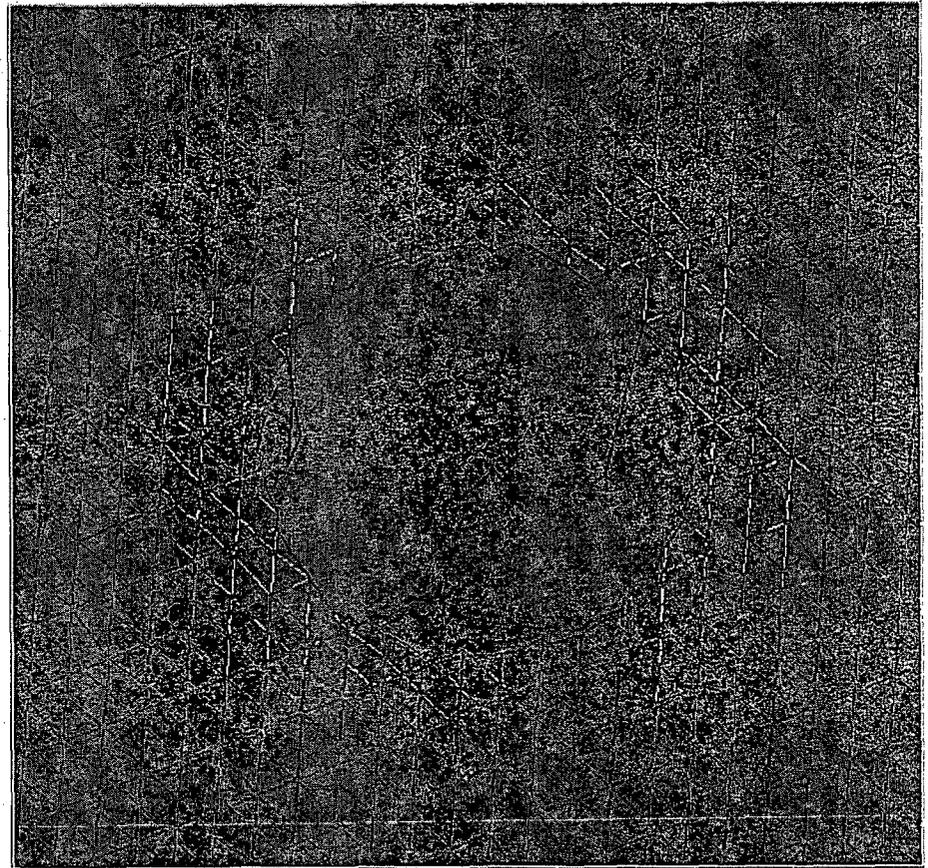
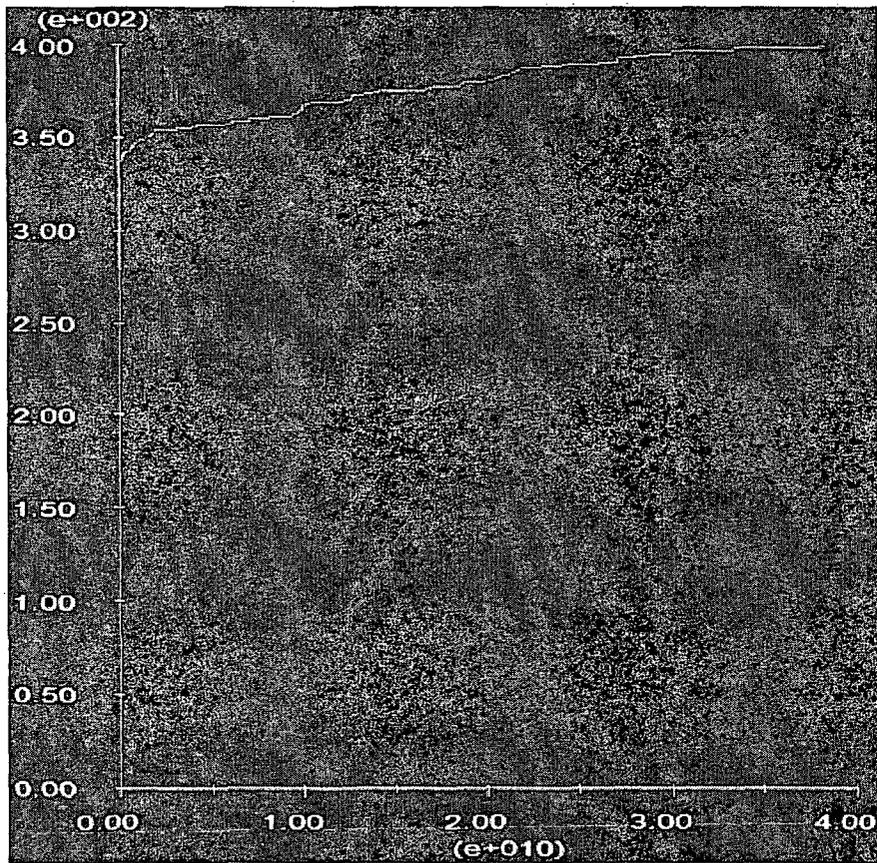
Lithophysal Porosity = 17.8% (Category 3+)

# FLAC Results for Category 1 Lithophysal Tuff

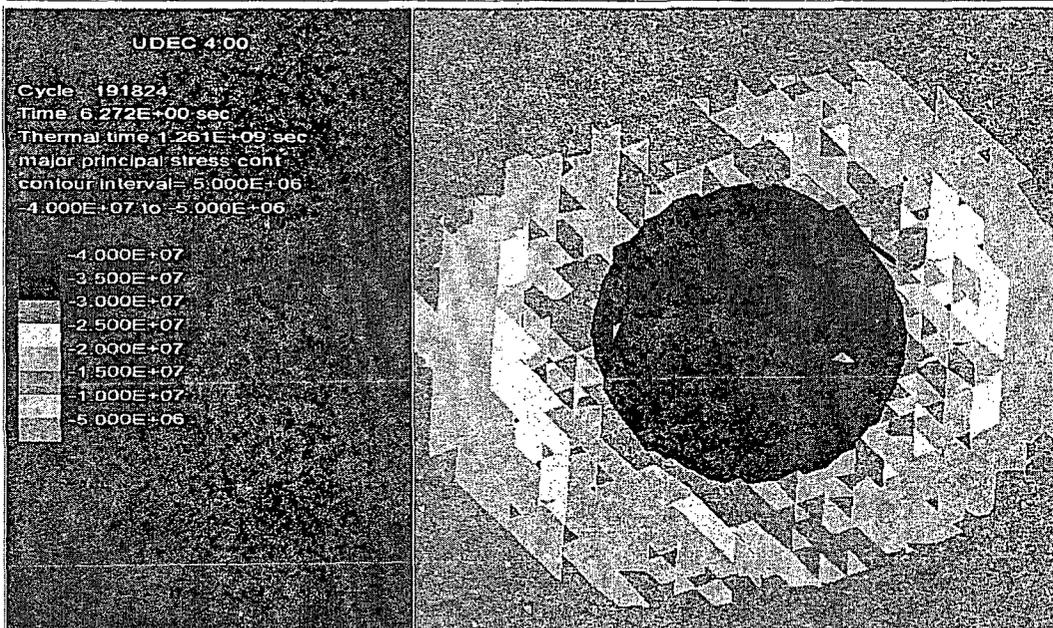
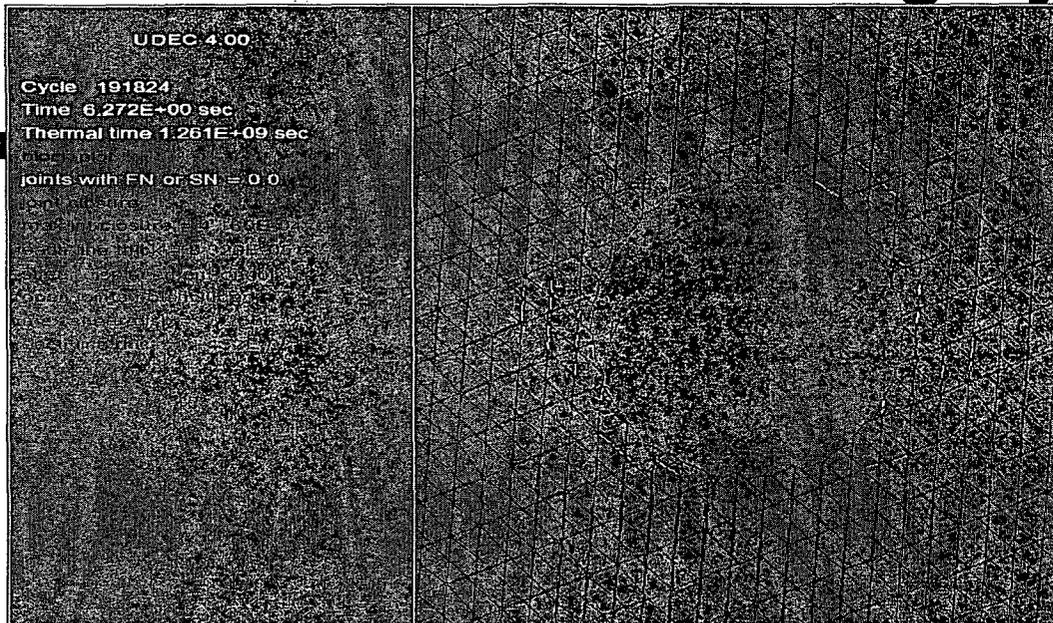


Lithophysal Porosity = 23.8% (Category 3-)

# UDEC Results for Category 3 Tuff



# UDEC Results for Category 3 Tuff



# FLAC and UDEC Properties

Rock Type	Elastic Props		Rock Mass Strength Props			Strain Softening Props		Temperature Props		
	G	K	Co	$\phi$	To	Min values	$\gamma_c$	k	s	$\alpha$
	GPa	GPa	MPa	deg	MPa	Co, $\phi$ , To		W/m <sup>2</sup> K	J/kg <sup>2</sup> K	/°C
Cat1 lith	0.8	1.07	2.9	29	1.5	1e4, 25, 1e4	.01, .05	2.0	920	**
Cat3 lith	4.51	6.01	5.1	35	1.8	1e4, 29, 1e4	.005, .01	2.0	920	**
Cat 5 lith	8.21	10.95	7.6	36	2.5	1e4, 29, 1e4	.002, .005	2.0	920	**

FLAC Properties (\*\*  $\alpha=7.46e-6$  for temps < 100 °C,  $\alpha=9.1e-6$  for 100<temp<125,  $\alpha=9.98e-6$  for temp>125.)

	Intact Rock		Discontinuity					Rock Mass	
	K	G	Co	$\phi$	Kn	Ks	To	K	G
	GPa	GPa	MPa	Deg	GPa/m	GPa/m	MPa	GPa	GPa
Cat 1 Lith	9.03	6.8	3.8	35	9.34	4.67	1.53	1.07	0.8
Cat 3 Lith	51.37	38.6	6.2	35	53.08	26.57	3.18	6.01	4.51
Cat 5 Lith	93.6	70.5	11.25	35	97.0	48.4	4.92	10.95	8.21

## UDEC Properties

	Intact Rock		Discontinuity					Rock Mass	
	K	G	Co	$\phi$	Kn	Ks	To	K	G
	GPa	GPa	MPa	Deg	GPa/m	GPa/m	MPa	GPa	GPa
Non-lith average	18.93	13.61	0.1	41	50.0	50.0	0.05	12.04	8.7
Non-lith frac zone	18.93	13.61	0.1	35	50.0	50.0	0.05	9.2	6.3

## Non-lith (UDEC) Properties