UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Title: BRIEFING ON STATUS OF ACTIVITIES WITH THE CENTER FOR NUCLEAR WASTE REGULATORY ANALYSIS (CNWRA) - PUBLIC MEETING

Location: Rockville, Maryland

Date: Thursday, January 12, 1995

Pages: 1 - 60

ANN RILEY & ASSOCIATES, LTD.
1250 I St., N.W.,Suite 300
Washington, D.C. 20005
(202) 842-0034

DISCLAIMER

This is an unofficial transcript of a meeting of the United States Nuclear Regulatory Commission held on January 12, 1995 in the Commission's office at One White Flint North, Rockville, Maryland. The meeting was open to public attendance and observation. This transcript has not been reviewed, corrected or edited, and it may contain inaccuracies.

The transcript is intended solely for general informational purposes. As provided by 10 CFR 9.103, it is not part of the formal or informal record of decision of the matters discussed. Expressions of opinion in this transcript do not necessarily reflect final determination or beliefs. No pleading or other paper may be filed with the Commission in any proceeding as the result of, or addressed to, any statement or argument contained herein, except as the Commission may authorize.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

***

BRIEFING ON STATUS OF ACTIVITIES WITH THE CENTER FOR NUCLEAR WASTE REGULATORY ANALYSIS (CNWRA)

***

PUBLIC MEETING

***

U.S. Nuclear Regulatory Commission
One White Flint North
Rockville, Maryland

Thursday, January 12, 1995

The Commission met in open session, pursuant to notice, at 10:00 a.m., Ivan Selin, Chairman, presiding.

COMMISSIONERS PRESENT:

IVAN SELIN, Chairman of the Commission
KENNETH C. ROGERS, Commissioner
E. GAIL de PLANQUE, Commissioner

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

JOHN C. HOYLE, Acting Secretary

MARTIN MALSCH, Deputy General Counsel

JAMES TAYLOR, Executive Director for Operations

ROBERT BERNERO, Director, NMSS

MALCOLM KNAPP, Director, Division of Waste Management, NMSS

WESLEY PATRICK, President, CNWRA

BUDHI SAGAR, Technical Director, CNWRA

P R O C E E D I N G S

[10:00 a.m.]

CHAIRMAN SELIN: Good morning, ladies and gentlemen.

The Commission is pleased to welcome Dr. Wes Patrick and Dr. Budhi Sagar from the Center for Nuclear Waste Regulatory Analysis to provide their periodic Commission briefing on the status of activities at the Center.

The Center last briefed us in January 1994 and since that briefing several events have occurred. First, at the request of the Commission, our Advisory Committee on Nuclear Waste started a review of major research activities related to the high-level waste program and in their first report in August of last year the Committee reported that research being done at the center in the areas of volcanism, natural analogs and tectonics was generally relevant in support of the Commission's regulatory mission. I will leave the reader to fill in what they said about the rest of the research.

The second event was the Department of Energy's implementation of its new program approach which envisions making a suitability determination for the high level waste repository site at Yucca Mountain in fiscal year 1998. DOE's program approach is a major departure from the prior

approach that characterized the proposed repository site at Yucca Mountain and its implementation could affect all of our research activities, NMSS activities, the Center activities. In fact, I think it's fair to say it will have a significant impact on the work that we do in this area.

So, with this -- Commissioner Rogers?

COMMISSIONER ROGERS: No, nothing.

CHAIRMAN SELIN: Commissioner de Planque?

COMMISSIONER de PLANQUE: No.

CHAIRMAN SELIN: Mr. Taylor?

MR. TAYLOR: Good morning.

Consistent with the expression of the Commission, the briefing today will focus on technical areas and technical issues. I'll also note Bob Bernero and Mal Knapp are here at the table. You introduced the gentlemen from the Center.

I'll ask Wes Patrick to continue.

DR. PATRICK: Good morning, Mr. Chairman, Commissioners. We're pleased to be here with you this morning to have an opportunity to review for you just some of those matters that you noted in your opening remarks, Chairman Selin. In particular, as we progress through the briefing today, we want to focus on several technical areas, including the areas of volcanism and tectonics, to a limited degree the natural analogs work, as well as some other areas

which were noted by the ACNW.

Our focus today is to look at some specific advances that have been made in those areas and we'll be talking about five specific areas, and based on those advances to show you some of the ties that that research work and technical assistance work has to the licensing program.

If I could have the second slide, please.

[Slide.]

DR. PATRICK: We use a number of techniques to focus our attention on key technical uncertainties, technical concerns that are of interest to the Commission from the standpoint of fulfilling their regulatory responsibilities. We provided in the past briefings to you on a number of these areas, as has the NRC staff and management.

I would note on this second slide really just one key point and that's with regard to the last bullet, our participation in international programs. The Commission approved the Center for Nuclear Waste Regulatory Analyses to undertake work for others in critical areas in international programs based on the approval of the NRC staff. We have begun to do that and just this last month had completed a piece of work for SSI, the Swedish Radiation Protection Institute, where we developed for them a piece of software

with a graphical user interface which will aid them in their performance assessments. It's, we feel, been a very important contribution to their program.

We'll begin this month working for the United Kingdom on some of their performance assessment work related to both low and intermediate level waste storage facilities there.

In addition, as part of the NRC funded activities, we'll be beginning a review of the Canadian environmental assessment as part of an international peer review group for that work.

[Slide.]

DR. PATRICK: In slide 3, I would just note the five areas that we will cover this morning and we'll be discussing each of those as we progress through the presentation. I will address the first two, Dr. Sagar will proceed then to address the final three, and I'll have a few brief closing remarks. I'd encourage questions, as always, as we proceed through the briefing.

Slide 4, please.

[Slide.]

DR. PATRICK: One of the areas that is an area of great interest and concern to our staff and that of the NRC is the area of the potential for disruptive tectonic processes at the site. We're interested in this from both a

pre-closure and a post-closure performance perspective. When I refer to tectonic processes, we include here matters related to structural deformation, seismicity, earthquake recurrence and the like.

The basic situation that exists is that we need to understand the relationships between seismicity, structural geology, igneous activity and the like and to be able, based on those understandings, to make sound judgments with regard to the Department of Energy's submissions both in the pre-licensing period and eventually in the license application.

We show here in this particular chart the results of one of our analyses, a rather new and we feel interesting, informative and very useful approach to analyzing what we call slip tendency. In other words, as a first step to examine the geometries of the various faults that have been mapped by the Department of Energy and its contractors at the site and using considerations of the in situ state of stress, which are indicated here by the bars indicated, sigma 2 and sigma 3, and considering those in basic mechanical factors to make an assessment of which faults at the site are most likely to slip given those stress conditions that exist as the site at this time.

You'll notice a couple of things. Those highlighted in red are the ones which have high slip tendency. Those highlighted in green have low slip

tendency, which is to say that under existing conditions those are not likely to be areas of concern for the staff or for the Department of Energy with regard to seismic stability of that site. That's a key focusing mechanism for us. It helps us to zero in on those features which need the most attention by the staff with regard to tectonics. I'll note over here in summary fashion those which have a high slip tendency, three faults whose names you've probably heard in this conference room a number of times before, and then we highlight two here which, based on these preliminary analyses, do not have a particularly high tendency towards slip. Now, they may be important for other reasons and would have to be focused on, for instance, with regard to preferential flow and the like. They may be of interest from a construction standpoint and so forth. But with regard to tectonic processes, those are not faults that are of great concern to us.

COMMISSIONER ROGERS: Just before you leave that slide, where would the boundaries of the Yucca Mountain repository fall on this picture, if one were going to try to -- I know that's not exactly designed yet, but if you were roughly going to sketch it in, where is the region --

DR. PATRICK: We show here by the dark outline. That is the so-called geological repository operations area. So you see that we have moved far enough away, you can see

the scale down here of ten kilometers, that we can consider faults that are in the immediate vicinity that may be of interest to us from either a direct fault offset perspective or from a seismic risk perspective.

CHAIRMAN SELIN: First of all, what is the length of the red line?

DR. PATRICK: That is the surface fault trace as mapped by generally the U.S. Geological Survey.

CHAIRMAN SELIN: So there's nothing relative between the lines other than the trace of where they fall in terms of probability of risk or --

DR. PATRICK: That's correct. The red indicates high slip tendency, in this case green, low slip tendency.

CHAIRMAN SELIN: What do you conclude from this chart?

DR. PATRICK: Well, the main thing that we conclude is we now feel that we have a tool that will help us to zero in on those features which we need to pay attention to as we review the Department of Energy's study plans, their high-level findings related to tectonics and so forth. Otherwise, we really have to give equal attention to these faults. This is not the only technique we will use. Your point with regard to length of those faults is also very important to us. Those that are longer tend to be of greater interest because of their capability of generating

larger magnitude earthquake events than those that are small or disconnected. So, that is an additional focusing mechanism. The next step is to begin to analyze these on a more mechanistic basis.

CHAIRMAN SELIN: Will the Department of Energy use this information in doing their evaluation? In other words, are we providing a tool that we'll both use or is it just a regulatory tool?

DR. PATRICK: We've, of course, focused on satisfying regulatory requirements, but we've made a concerted effort to make this information available in a very timely way, both through presentations at meetings in the particular disciplines that are involved as well as in high-level waste conferences, and we also present this information in formal Center reports which are generally available to the public as well. The latter take a few months longer to get out. So, the papers and presentations and poster sessions give DOE immediate insight into the results of our work.

[Slide.]

DR. PATRICK: One of the things that we do is we examine new techniques such as this and I show in slide number 5 a first effort in this regard. Rather than assuming that the bright new idea is adequate, we test the idea against data that's available. We were given an

excellent opportunity to do so when in June of 1992 the Landers earthquake took place in Southern California.

I'd note a couple of things on this chart. The various symbols that are indicated there, the spheres, they are scaled according to magnitude of earthquake and aftershock. The red ones there are of particular interest. Those are the ones that are directly associated with the time at and immediately following that sequence of earthquakes.

The second thing that I would note is up in the repository area the sympathetic earthquake that occurred following the Landers event in the Little Skull Mountain area. This initial test, and that's what it is, an initial test, indicates that those faults which were shown by our model to have a high slip tendency were indeed the faults that moved, either with the initial event or in the collateral earthquake activity.

The other thing I would note, and it's noted in your slide there, is the last bullet. One of the interesting things that we found, and again it's very important from the standpoint of focusing the staff's attention on those fault structures that are of greatest interest and in understanding how seismicity occurs at the site, is that we found that some of the events which other authors would indicate were going to occur on one fault

surface, our slip tendency analysis would show that they would occur on a different fault surface. This is a way of breaking some of the ambiguities that we often see in a typical seismic analysis. I think that's going to be important to us as we continue with our evaluations and investigations of the Department of Energy's evaluations of the site. Important from two standpoints again, short-term seismic risk during pre-closure period, and then also in the post-closure period.

CHAIRMAN SELIN: Could you translate that last paragraph into English, slip tendency analysis suggests, et cetera?

DR. PATRICK: Let me, rather than translate, give you a completely different statement of it. That's even better probably. As long as he doesn't ask me to translate it in one of the other languages.

A typical seismic analysis following an earthquake goes through an analysis that's called based on the first moment. They're trying to look at the vector, the direction of movement based on the seismic signals that were recorded emanating from the earthquake structure. If we look at those, and those were published in the literature within the last year or so, we find that in doing that analysis there's ambiguity between which fault structure actually moved. Those ambiguities are broken based on expert judgments of

the seismologist who's doing the work. We have here a technique which says if you look at the state of stress in the facility, in the region surrounding the potential facility, you have a technique, a numerical technique other than expert judgment or to aid expert judgment.

So, if the first moment analysis said the fault movement could have occurred here or here, our slip tendency analysis would say it has to be here given the state of stress. That difference of opinion occurred in 35 to 50 percent of the times, depending on which piece of literature we --

CHAIRMAN SELIN: Well, that helps you analyze some other earthquake, but does it help you predict what will happen on the site for earthquakes that we are concerned about if a --

DR. PATRICK: Not as a strict predictor, but it does again help us to focus our attention. There will be a whole family of faults that under the current stress conditions we don't need to pay much attention to with regard to slip. I'll talk in a little bit about dilation, which is another risk factor in this area.

CHAIRMAN SELIN: That you know from the analysis. What I'm groping for is what additional information did the earthquake give to you about your analytical techniques or your knowledge of the site that you didn't have before the

earthquake?

DR. PATRICK: They allowed us to make a comparison between what we would calculate should have slipped and those which actually slipped in this particular case. So, it's a measure of verifying the technique, if you will.

CHAIRMAN SELIN: Something happens. You use the technique to do the analysis of the different conditions that could have led to the observed data. This, ex-post facto, a posteriori, is more likely to have happened than that one. How can you use the same information to analyze and then to verify your own model? Do you see what I'm --

DR. PATRICK: I believe so. Let me try it this way. The a posteriori is simply to help us gain confidence in this technique that we're proposing. This slip tendency technique is not widely reported in the literature and we are always, as I noted earlier, concerned that when we come up with a new concept and a new technique that we first get it into the literature as soon as we can so it has an opportunity to be reviewed by the peers and, second, that we do adequate testing ourselves so that in the interim we can begin to gain some confidence in it. This just is one opportunity, the first opportunity, to do that kind of verification or confidence building in the new technique that we're proposing. If the technique were commonly used, I wouldn't be showing you that analysis. We'd have the

confidence already. Does that help?

CHAIRMAN SELIN: Yes.

COMMISSIONER ROGERS: Just on that, you had an example here because you had an earthquake at Landers and therefore you had some information on the direction of the shocks or whatever. How dependent on where the location of that source was would be the final conclusion as to what would be the slip fault lines that would be involved? In other words, suppose you considered an earthquake 180 degrees away from this one. Would you have had the same prediction or would that depend upon what the location of the specific earthquake would be?

DR. PATRICK: We should have had the same prediction in this sense, that faults which were shown by the slip tendency technique to have a high tendency to slip would have slipped. Now, if the earthquake were far from here, not all of the same faults would have slipped obviously. But the technique is robust against where the location of the earthquake is because the earthquake is serving as an additional source of stress. It's putting some more energy into the system and given that these particular faults have a high tendency to slip if sufficient energy is put into the slip system, then they will slip.

COMMISSIONER ROGERS: So the location of that source is not particularly important?

DR. PATRICK: That's correct.

COMMISSIONER ROGERS: But there is an additional energy introduced into the system --

DR. PATRICK: That's the key factor.

COMMISSIONER ROGERS: -- and that's where you'd look to see the effect of that.

DR. PATRICK: Exactly. And we would hope as additional earthquakes take place that we would do some additional testing, some additional confidence building so we can address the Chairman's question in that regard.

Any other questions on that one?

If we could move then to slide 6.

[Slide.]

DR. PATRICK: We show here another area, a second area, that is of considerable interest to the Center and to the staff from the standpoint of examining those conditions under which magma rising through the formations in the vicinity of Yucca Mountain might intersect a fault and in so intersecting a fault might either be diverted by that fault or that the rising magma might continue across that fault. That's important to us from a standpoint of examining the probability that an igneous intrusion would transect the repository directly or would be sufficiently close to the repository to affect its performance.

I'd point out just a couple of things on here.

The rising magma, what geologists would call a dike, is indicated here in the vertical red section. Again we do these calculations for a range of conditions, in situ stress conditions, depths of burial and so forth, for the particular case that we've chosen here. You can see that as that rising magma reaches another fault, and it's indicated in blue, under these particular stress conditions some of the magma continues to go across that fault structure, some of it is diverted by the fault structure.

Again, from a probability point of view, that's important to us should the repository be located in this vicinity. The vertical rising section would be included in a probability calculation. On the other hand, under conditions where the magma would be completely diverted, then perhaps dikes and those orientations under those stress conditions would not need to be considered by the staff in their evaluation of the safety of the site.

This is our first attempt to do what the Chairman had asked in a couple of briefings ago, "When are we going to move beyond mere probability modeling to begin to look at the mechanistic effects?" Here we're coupling together structural geology, the faults, a tectonic setting, including the in situ state of stress, and the potential for volcanic igneous activity in the area, namely the introduction of dikes in this case.

So, we have begun now to introduce mechanical properties into these calculations and it allows us to focus in better on the probability of occurrence of volcanic activity, particularly dike intrusions in the vicinity of the facility.

Slide 7, please.

[Slide.]

DR. PATRICK: Following along the same line, the detection of igneous features is particularly important to the staff. This is an area where the Department of Energy will be making findings with regard to the suitability of the site and the staff needs to determine whether there is evidence of igneous activity during the quaternary. This is a specific requirement of your regulation. We need to be certain that the Department of Energy has adequately characterized these kinds of processes and these kinds of probabilities.

What we show here in the figure are a couple of things. This is a parametric study where we've examined the potential to detect deeply buried igneous features in the vicinity of volcanos, indicated here by the little cones, red cone and black cone, that are just west of the site. We've superimposed two dikes intruding into this area. Using calculational techniques, we have done in effect an aeromagnetic survey in a mathematical sense for the site.

You can see here two things. One, in the areas of alluvium, indicated here by the brown, it's very easy to detect these igneous features. That's good to know. Underneath the volcanic cones where there's a high degree of electromagnetism already present, they are indistinguishable. That's important to us because at this particular site you have rock outcropping at the surface. Techniques such as aeromagnetics will find it very difficult to locate deeply buried igneous features which already exist at the site and which are of regulatory concern. Again, they're used in the probability calculations for the occurrence of such intrusions of this sort and those probabilities are in turn used in our total system performance assessments as they will be in the Department of Energy's assessments.

COMMISSIONER ROGERS: Well, it's a little detail, but the different colors here signify how deep the layer is. Is that it?

DR. PATRICK: The colors are measures of magnetic susceptibility and they're indicated in nano-teslas, units of nano-teslas. That's the color bar that's showing there a scale from roughly a minus 1000 up to zero.

COMMISSIONER ROGERS: Yes.

DR. PATRICK: So, the brown areas of the alluvium have very low magnetism and consequently a highly magnetic

dike that's intruded in that area stands out very boldly. Conversely, if the intrusion occurs beneath an area that is itself volcanic and highly magnetic as a consequence, the appearance of the dike, the location of the dike, is screened, is masked by the highly magnetic area that overlays it.

COMMISSIONER ROGERS: Well, it's a very minor -- you know, it's a little point, but the zero negative tesla region around that red area, the dike disappears in that. Why is that? That shouldn't be doing anything, should it?

DR. PATRICK: The overlying volcanics, red cone and black cone, completely mask.

COMMISSIONER ROGERS: Yes, but I'm talking about -- if I'm looking at this sort of yellow color, that's a zero negative tesla contribution, right?

DR. PATRICK: Correct.

COMMISSIONER ROGERS: And the dike disappears in that region, at least in this picture. It's not there. So, can you say anything about that? Am I misreading this thing or something? See what I'm looking at?

DR. PATRICK: Yes.

COMMISSIONER ROGERS: The lower dike going up 45 degrees. Just follow that right through the red area. I see that it disappears where there's a zero negative tesla.

DR. PATRICK: We're looking here at -- the key

feature is the contrast in the magnetism. You could see either a strong negative or a strong positive beneath a zero area, an absolute zero area.

COMMISSIONER ROGERS: Yes.

DR. PATRICK: Here we're just saying that this is an area of low contrast.

COMMISSIONER ROGERS: Okay.

DR. PATRICK: Yes, the magnetic anomaly above it are similar.

COMMISSIONER ROGERS: Well, I can talk to you about this later.

DR. PATRICK: Very good.

[Slide.]

DR. PATRICK: The next slide just really provides a summary of a large number of analyses of the sort that I just showed you in the color photograph, slide number 8. What we show here is a function of depth and magnetic anomaly magnitude, a series of curves. There are two shown for each one, five and ten meter wide dikes. These are for two different orientations at which a theoretical survey would be run. The key thing to look at, two things, one, look at the location between the two arrows here that are marked "Alluvium." If you were to progress upward from those you'll find that dikes as narrow as a meter wide can be detected within 100 meters of the surface. Wider

features can, of course, be detected deeper. Similarly, at the extreme right end of that, if the anomaly is greater, you can see the values here. But look what happens over here for the Tiva Canyon tuff. These again are the tuffs in the locale. If you move vertically upward from that you'll find that it is almost impossible to detect existing igneous features at the site that are more than anywhere from literally the surface to just a few tens of meters below the site.

Now, why do we care about that from a standpoint of a regulator? Department of Energy is going to need to come in with some evidence with regard to the igneous activity that current exists at the site. We want to be able to knowledgeably review the adequacy of that evaluation. It's important to us therefore to know how well their techniques can detect such crucial features as igneous intrusions that already exist at that site. We're finding here we have a very good model now to be able to determine the width and orientation of those features that they would be able to detect, be they under the alluvium to the west of the site or directly in the vicinity of the mountains beneath the tuffs.

COMMISSIONER ROGERS: These widths, are those in meters?

DR. PATRICK: Yes, that's in meters.

Any questions on the igneous activity at all?

COMMISSIONER de PLANQUE: What are the implications of not being able to detect them as you show on the right-hand side of the chart?

DR. PATRICK: Our sense is that below the limits of detectability the applicant will have to do one of a couple of things. One, they will either have to assume the presence of a certain number of these features being there or they will have to find other arguments, perhaps other geophysical techniques which will bolster their arguments that they are indeed not present at the site because of the important performance implications.

COMMISSIONER de PLANQUE: Thank you.

DR. PATRICK: I turn the discussion over to Dr. Sagar who will address the remaining three subjects in this area.

COMMISSIONER ROGERS: Could I just ask one question on that?

DR. PATRICK: Certainly.

COMMISSIONER ROGERS: Is there any difference in curves such as this, graphs such as this, taken say on the surface versus taken say underneath the surface at some depth? In other words, if you were actually say 100 meters below the surface, would the sensitivities be the same? Does it change, the fact that you're trying to detect these

things at the surface and whatever the magnetic environment tends to look like there? But if you get down into the material itself, does it get worse or better?

DR. PATRICK: It's unchanged. You just begin to shift your zero point, your data point. The key thing though with this technique, this is a surface based test. I personally don't know of any applications of it in this regard. Presumably one could apply it by going through the drifts and tunnels underground.

COMMISSIONER ROGERS: Well, that's what I was thinking.

DR. PATRICK: Something of that nature.

COMMISSIONER ROGERS: If you're down and you're in a tunnel, is it harder or the same or easier to detect nearby dikes?

DR. PATRICK: I would say it's not a matter of difficulty, it's a matter of closeness. But again, this particular technique is aeromagnetic. So, it in particular is not applicable. There are some other techniques which may be able to be applied and those are other ones that we're going to be studying of the next number of months, for instance to see if the seismic techniques, for instance, could detect some of these features.

DR. SAGAR: If I might add, Wes, these are measured from an airplane where a meter sweeps over the

land. So, this is probably 100 meters aboveground.

COMMISSIONER ROGERS: Right.

DR. SAGAR: So the closer you come to the ground, you do get a better signal.

COMMISSIONER ROGERS: You get a better signal?

DR. SAGAR: Yes, but it's more difficult. It's more time consuming.

COMMISSIONER ROGERS: Yes, right.

DR. SAGAR: You can hold it in hand and walk over and get a better signal.

DR. PATRICK: With other devices.

COMMISSIONER ROGERS: Sure.

DR. SAGAR: Yes.

DR. PATRICK: Budhi?

[Slide.]

DR. SAGAR: I'll move on to the next topic, which is the study of sorption processes. There are a couple of reasons why NRC staff and the Center staff would be interested in studying the sorption processes. One of them is that we expect in DOE's waste isolation strategy that sorption processes are going to be depended upon. It's going to be one important process to retard the migration of radionuclides in the geology in the geosphere.

The second one is DOE's recent idea that they're going to bound everything. They're certainly going to bound

the sorption process. The way the sorption process are brought into calculations is through defining a coefficient known as the sorption coefficient. To those who are experts in this, they simply call it a Kd. The way the DOE would probably bound it is through batch experiments. They would have the water contaminated with radionuclides flow through a column of the rock and observe how much of the radionuclides or the material is taken up by the solid rock.

The NRC's interest is to try to decide whether that bound is indeed a bound or how good a bound is that. That's the reason why we're doing these kind of studies here. I'll show you two results here. One on chart 9 shows you laboratory experiments on a clay that's called Montmorillonite and the nuclide we are looking at is uranium in the sixth valence state. On the Y axis is the logarithm of Kd. The units are a little strange, milliliters per gram. This is to non-dimensionalize the equations in which this goes into. The X axis has the pH, which is one of the major definitions of chemistry of rock water.

What we show here, the solid line is the numerical model results and the triangles and rectangles are measured from experiment in the laboratory.

COMMISSIONER ROGERS: Now, that model, does that any adjustable parameters in it or is that -- are the results from that model purely come out of the input data?

DR. SAGAR: Unfortunately there are quite a few adjustable parameters in the model. There is just no models where we don't adjust something. But this one unfortunately has quite a few. It has seven, as a matter of fact.

COMMISSIONER ROGERS: I mean this looks awfully good.

DR. SAGAR: Yes. What we did though was that we fixed six of them based on some other experiments. There's one adjustable parameter that we did adjust to fit the data, which is not as bad as fitting seven.

COMMISSIONER ROGERS: Right.

DR. SAGAR: But the important conclusion we have to draw is that the Kd or the sorption coefficient, larger the Kd, larger is the sorption, that that heavily depends, strongly depends on the pH, on the chemistry of water. As you can see, close to 5 or 6, the neutral range of chemistry, you have a high value of Kd. As you go towards the alkaline range, toward 8, 9, as you go toward the acidic range to 1, 2, 3, 4, the same nuclide, the same rock would sorb less. The question then would be how do we determine a bound? What would be a bound in a short-term experiment?

That's why we did the numerical modeling. It was perceived that it could be thermodynamic basis that can be derived to give it bound for the Kd, not just depend upon the experimental value. Can we also verify it through the

experiment?

The studies are ongoing. I can't say at this moment what the conclusive answer would be to that, but that's an effort towards determining the bounds.

[Slide.]

DR. SAGAR: On slide 10 is the results of a study which we did on the natural analog project, Pena Blanca. Did I pronounce it right?

COMMISSIONER ROGERS: Yes.

DR. SAGAR: This is a site in Mexico where we have a natural uranium deposit which I show in the figure on the top here. Then there is a fracture that you see in the middle and we actually went and measured the uranium concentration. We don't know exactly the time span, which is one of the difficulties of studying natural analogs. The past history can only be guessed from what we see today. So, the original boundary conditions, the original source you have to guess. But this is the time you can think of in terms of about a million years. That's approximately the time span we are looking at.

The red color in this figure here close to the deposit shows you the concentration of -- a high concentration of uranium. As you go downstream in the fracture, the color becomes yellow and that shows smaller concentration. We cannot say how long it took,

unfortunately. We can say it took more than 20,000, but less than a million years. That's the kind of time scales we are talking about. The length here, as you can see, the transport plane is about 20 meters. That's marked on the Y axis here.

[Slide.]

DR. SAGAR: There are two things to be noted and I have put that on slide 11, two results. One is that we compared an experimental result that the DOE conducted -- this is on the right-hand side of the slide -- which thought of synthetic uranium oxide as an analog to spent fuel and they subjected it to dripping. They put it in a vessel and let the water drip over it and studied for four and a half years as to how the mineralization changed. From UO2 it went to Uranyl Oxyhydrate, which geologists call it schoepite, and then uranyl silicate. That's a four and a half year experiment.

We looked at the sequence of mineralization at the Pena Blanca site and the time scale, as I said, is about a million years. We see the same mineralization, same sequence in time which gives us some warm and fuzzy feeling that the four and a half year experiment is good enough to tell us how the dissolution of spent fuel would occur and what kind of secondary mineralization would occur.

The second conclusion that we draw from the Pena

Blanca experiment is that, if you go back to the previous slide, is that the lateral diffusion that is across the fracture of uranium is very small. That process is sometimes known as matrix diffusion. It's sometimes thought of as another delaying mechanism for the migration of radionuclides. At least at this particular site we don't see that. So, most of the migration is occurring through the fracture.

COMMISSIONER ROGERS: Excuse me. I'm still a little bit puzzled about how you connect these two time scale experiments. Could you go over that again? I mean there's something here that allows you to connect one with the other. I understand that what you're seeing in a four and a half year period is similar to what you saw over what took place over a million years. Now, how do you connect these two in time?

DR. SAGAR: One of the questions we often ask ourselves and the DOE is how can we project, how can we extrapolate short-term experimental data to large times?

COMMISSIONER ROGERS: Right.

DR. SAGAR: And this was one effort to try to see if indeed the solubility of the spent fuel, which depends on what minerals form, can that be determined, for example, from a four and a half year test? One of the utilities of the natural analog is to kind of tell us whether indeed the

same sequence of minerals are present in time. So, there's a history of mineralization present at the site, which we observe. So, we see that first from uraninite we have the oxyhydrate oxides formed. Well, we see the same thing forming in the laboratory.

COMMISSIONER ROGERS: Right. The sequence is the same, but how do you adjust the time scales?

DR. PATRICK: If I could interject on that. Here the key is not so much interjecting and interposing what the time scale is. One of the things that we're able to address in this experiment is a key question of whether it's dissolution from UO2 that is the governing, pacing time rate controlling process, or is it the oxyhydroxides, or is it the silicates? If we see this same sequence developing relatively rapidly that we see preserved in the analog at Pena Blanca, it gives us some indication that it may be the more complex secondary and tertiary minerals that are of interest and may be controlling factors rather than dissolution of primary UO2.

COMMISSIONER ROGERS: So you're not focusing on the time scales?

DR. PATRICK: We're really not focusing on the time -- the time is just a way of linking the application of the analog.

DR. SAGAR: I don't think we know yet,

Commissioner Rogers, as to how to scale up time. It just is a guesswork.

COMMISSIONER ROGERS: Okay. All right. Good.

DR. SAGAR: The next topic that I want to touch on is the long-term material performance. These studies are in the engineered barriers system. With the next concept that DOE has come up with, which is multipurpose container, and I'm sure the design would take some time to be finalized, again the issue of bounding the life of the waste package would become an issue. They would do a bounding calculation and the question is can we again look at some matter that would give us some confidence whether that bound is okay or not.

[Slide.]

DR. SAGAR: What I show you on slide 12 is a schematic of how corrosion would occur. You see that on the left-hand side is the dry period, assuming that there would be some heat load. We don't know yet what heat load you would eventually settle on. During the dry period we assume it's either a steam environment or it's totally dry and there's not much corrosion that would occur. But as a water film forms on the surface, you see two curves on this. The red curve here evolving with time is what we call the corrosion potential curve. The greater the corrosion potential the greater for corrosion to begin. The second

blue curve here is the repassivation potential. If the actual potential in the field falls below that or equal to that, then the pit or the gravis, the local corrosion repassivates and stops growing.

So, there are two phenomenon going on. As the chemistry of the water changes, as more corrosion occurs, the repassivation potential and the corrosion potential both are changing with time. The question is can we bound somehow this phenomena that would tell us that they would at least, the MPC or the waste package would last for 300 years or 1,000 years or however many years the life would be designed for.

In the next graph --

COMMISSIONER ROGERS: Excuse me. The repassivation potential, is that a property just of the material of the container itself? Well, the material of whatever is going to -- where the pits are going to grow. What determines that?

DR. SAGAR: It's the property of the material and the chemistry of the water.

COMMISSIONER ROGERS: And the corrosion potential is determined by the chemistry of the water?

DR. SAGAR: That's correct. In fact, both of them are functions of what material we are talking about and the chemistry they are subjected to. Since the chemistry can

change with time, so can the potentials.

[Slide.]

DR. SAGAR: Slide 13 shows you an experimental result that we conducted at the Center. In the top part of the picture, which is the red lines and you see the triangles here, is actual measurement of the repassivation potential. So, we took a metal piece, we put it in an electrolytic cell and we measured the potentials. On the X axis here is time in seconds. So, this is an experiment that lasted a little less than one year. You see that as the length of the experiment is increased, the repassivation potential -- I'm sorry, the initiation potential or the corrosion potential, which is the red line, decreases. What we are trying to show is that when you do measure these things in the lab, that the actual value depends on the time that you conducted the experiment. Again the main issue, how do we extrapolate small-scale experiments to larger times.

On the bottom part of this figure, which is in violet color here, is a measurement for the same sample, same chemistry of the repassivation potential. The conclusion we want to draw from this figure is that both the initial potential, initiation or corrosion -- I'm using the two names for the same -- and the repassivation potential converge to a single point. That a bounding value for that

potential at which local corrosion would start, it's either beating or crevice, could be taken to be the repassivation potential itself.

Now, in small time tests, I think there's a problem in determining what potential to look at in determining the life of the waste package. So, again, the stress here is to determine how good those bounds can be.

COMMISSIONER ROGERS: What is your last bullet, this comment on DOE's approach as non-conservative? Could you just enlarge on that?

DR. SAGAR: The best we know about DOE's approach is essentially using metal coupons and have them sit at a certain temperature and then pick them up and measure whether they have lost weight. If they have lost weight, they have corroded. If they have not lost weight, they have not corroded. We understand that the Lawrence Livermore Lab, they are probably thinking of testing something like 10,000 coupons in that way.

What we are suggesting is that that will not give you a bound, that you would see many samples that will not float at all. That doesn't mean they will not grow under the chemistry in the repository. So, we're suggesting two things. One that you have to take a mechanistic view if you want to extrapolate data, but you will have to go to electrochemistry to measure these electric potentials. Two,

that you will have to look at the bounding values at which such corrosion can be initiated. We believe that the approach as we know best, now that may have changed too, I can't say for sure, that that will not provide you a bound. In that sense it's not complete.

The last topic I want to talk about is volcanism. Again, volcanism is an important issue at the site. It's important for DOE to indicate that it will not impact the repository to safety. It's obviously important for NRC therefore to review and look at the alternate models and assure ourselves that the probability of volcanism, future volcanism at the site is reasonably bounded and also that the consequence of volcanism, since the probability of volcanism is obviously not zero at the site because of existing cones that we know are there, then also look at what the consequence would be if with some probability a volcano igneous event is going to happen in the future.

[Slide.]

DR. SAGAR: What you see on slide 14, and this slide by the way is slightly different on the TV than in front of you, shows a couple of things. One, that we recognize that at the Yucca Mountain region site and close to the site, there are only five known volcanoes which are less than 1 million years old. The cautionary period is about 2 million, we guess. So, there are only five and

those are too few to do any statistics. But you cannot really test your probability models, whether it's homogeneous, whether they cluster or not, whether it's a non-homogeneous Poisson process or it's a Markove process. If you are building those kind of models, the site has too few known volcanoes to be tested.

So, we moved to some other volcanic fields and the results shown here on the slide are from the Springerville Volcanic Field in Arizona. On the TV you see the numbered -- all these dots here are actually known volcanoes that are at least a million years old. So, there are sufficient number that we could do these statistics and see which of the probability predictive models seem to fit better. Again, there is no strict test of probability matters, that we know about. There's no real final test saying, "Well, this is the probability model that fits and this gives the right number."

What you see here on the spike is then using a non-homogenous Poisson model with clustering. The main theme is that the volcanoes cluster in space, that they kind of group together in certain points in space and that's the yellow spike here that shows you the greater number of volcanoes at this site, at this particular point, and that they move in time, that the centroid or the center of these volcanic faults change as time goes on.

The scale of the graph here, the yellow shows a larger frequency and this is at 1 million years. We can plot the same graph at 2 million years and 3 million years past and we see that the yellow spike moves in space. The question then again from bounding point of view is how do we figure these time and space dependence in projecting volcanism in the future, in the 10,000 year, 100,000 time span that we would be interested in in the repository?

COMMISSIONER ROGERS: Now, this movement in space, is that just simply an artifact of the fact that these different volcanoes are of different lifetimes, that are in your model, your overall analysis? So, you take a slice of 1 million years, you get the spike at one point. You take it at 2 million years and it moves. Is that all there is that's involved or is something else involved?

DR. SAGAR: Again, I'm not an expert in volcanism, but the people I talk to tell me that there's physical phenomenon that actually is responsible for the space and time dependence, just the planes of weakness or where the source of magma is and how they move in space, how the heat transfer occurs and so on.

COMMISSIONER ROGERS: Well, yes. Presumably there's some reason why these are erupting where they're erupting and when they're erupting, but if you just take the statistical approach that you've got a bunch of these with

different initiation times and different times in which they occur and you take a slice in time as to where the likelihood is of another one occuring, you get one result. Then if you do it at a different time, you get another result.

DR. PATRICK: Yes. I think that's true, but that reveals again as a first look. The statistics give you the first look.

COMMISSIONER ROGERS: There's something happening underneath this whole thing.

DR. PATRICK: Well, yes. They begin to point to two trends and two trends that are very important. One is the spatial trend and if you begin to see a spatial trend developing and then you can begin to examine the mechanism for that, you can begin to see whether the risk of volcanism is going to increase in the vicinity of the site or, stated another way, is going to get closer to the site or if it's going to tend to move away from the site. The other one is to try to get our arms around this really difficult question of is the field overall waxing or waning in its temporal occurrence? Both of those are extremely important from a standpoint of understanding both probability of occurrence of volcanism and also the consequences once we've sorted out the probability aspect.

So, it's not just an academic interest or a

mathematical curiosity. We really use those probability studies to begin to look at both of those trends.

COMMISSIONER de PLANQUE: Maybe I'm missing something here. I'm sure I'm missing something here, but I don't know if you said it. How do you know that your model is correct when you apply it in an area with a large number?

DR. SAGAR: We cannot say that the model is correct. I didn't mean to say that. All I'm saying is the model figured on some data predicts that there should be a greater number of volcanoes at this particular location.

COMMISSIONER de PLANQUE: Could you just tell me a little bit more about how you get the real data?

DR. SAGAR: The real data is from the Springerville Volcanic Field. There's actually a field and what they do is they go and take samples and measure the age, and they kind of figure out, "Well, this occurred a million years ago."

COMMISSIONER de PLANQUE: Yes. You've answered my question.

DR. SAGAR: Okay.

DR. PATRICK: Most of these data are from the open literature. These are not data that we took primarily ourselves.

[Slide.]

DR. SAGAR: Slide 15 shows you another effort at

trying to look at the possible consequences of volcanism. Again, the effort that NRC staff is interested in, we're interested as part of reviewing team for DOE's work is to look at what the DOE's models predict and see if they really indeed bound. There are two possible types of effects from volcanism. One of them is direct effects. That is if there's a volcanic event right in the repository and some of the waste comes out. The second type of effects are the indirect effects where because there is a heat source created by the volcano now, the chemistry changes, the hydrology changes and what that effect may have. That obviously depends on how far the volcanic event is from the repository.

One of the recent calculations that DOE has put out in public is their performance assessment, this is '93 or '94, and they essentially showed that the temperature from a dike will die out within a few meters of the dike within a few years, like two or three years. Therefore, there are no or negligible indirect effects.

The graph that you see on this chart indicates to you actually major temperatures in today's volcanic field in Russia, Tobajik. The zero on the X axis is totally arbitrary as we just put our instruments, some thermocouples to measure. But we anticipated that the middle of the dike is where you see the highest temperatures. This is after 19

years of eruption of the formation of dike. What you see is that at about two meters deep after 19 years, the temperatures are still 550 degrees C. So, they did not die out in couple of years and there could be indirect effects in case there's a volcanic eruption close to the repository.

Again, the idea is to check the calculations that are put out with some actual data if possible and see if we can gain some confidence in the predictability of models.

COMMISSIONER ROGERS: Can you actually see it at the surface?

DR. SAGAR: Yes.

COMMISSIONER ROGERS: There's still a temperature profile at the surface?

DR. SAGAR: Yes.

At this point I'll pass it on to Dr. Patrick.

DR. PATRICK: If there are no further questions about the particular aspects, I'd like to close with just a couple of remarks and give those in the context of the technical work that we've reported on today, our understanding of the Department of Energy's program approach as they've shown in their draft five year plan, and also indicate some of the responses that we feel are appropriate to be able to move forward based on the advances that we've reported to you here today, as well as others that have been made, consistent with what we see the Department of Energy

doing.

The first thing I would note is much of the volcanic and tectonic work that we reported here today, we're going to have to accelerate that. Even further given DOE's schedules for high-level findings, we're going to have to get and have a fairly high confidence in the models we have for both probability and consequences of those events. So, we're going to have to move forward smartly on those.

We're working with your staff at this point in the research area to reexamine the order in which we're conducting some of those studies and also to specifically look at whether some of those studies in light of the new pace of the program that's suggested can be done, should be done or if rather we should take a little more short-term focus on some of those studies to be able to prepare ourselves better to review the materials, the submittals associated with DOE's high-level findings.

A crucial aspect, in fact most of the graphics that you saw today, aside from being kind of pretty pictures, are extremely valuable research tools and extremely valuable review tools. A second bullet on that chart indicates that we need to continue to develop critical components of our geographical information system and that's a database that's available both to our staff and your staff, so that we're able to conduct focused reviews on a

rather large number of important documents that the Department of Energy is going to be submitting and to do those reviews in a very timely way, but also a high quality and conscientious way.

We also anticipate that there's going to be the need to augment some of our materials research. The charts that Dr. Sagar showed you dealt with one particular alloy which has been under consideration by the Department of Energy for their single shell container. It appears that that alloy is going to continue in their matrix, but the introduction of the multi-purpose canister is going to bring in some other materials and we're going to have to carefully examine our program and determine whether we need to add another class of materials to our evaluations, in addition to that not only adding different materials, different degradation modes and processes may become important with the multi-purpose container to worry about things as galvanic actions and the like.

We'll continue to incorporate our research and technical assistance results into the iterative performance assessments that the staff is doing and also to incorporate those results into our evaluations of the Department of Energy's iterative performance assessments. There's some indication, a very strong indication that the Department is going to be moving toward doing not only total system

performance assessments but also focusing more sharply on subsystem requirements and we'll be following and reviewing those works as well. By subsystem requirements, I'm referring to some of the waste package requirements, ground water travel time and so forth.

We have developed with your staff a technique, systematic regulatory analysis, that began with the identification of compliance determination strategies. We completed those. Those are recently reported in the license application review plan draft 0 or rev 0 that was released just in the last month.

The next step is to develop specific compliance determination methods. These are the methods and review plans that the staff will use together with criteria for acceptance of what the Department of Energy submits eventually in their license application. As a prudent management step, we want to prepare those review plans soon enough that we can use those very review plans, those compliance determination methods in evaluating the high-level findings in NRC's initial site suitability finding that will need to be addressed at the end of this century.

I'd also note that even with all of that, what we call our proactive work, we will continue to give high priority to the reactive part of the program, the reviews of what the Department of Energy is doing, including a new part

of that reactive program that began this year, namely to do in-field verifications of the work the Department of Energy is conducting including TBM operations. We've had staff, as your staff has, we've had staff members in the field, had an individual out there just last week again overseeing, evaluating, checking and providing advice back to your staff and ours with regard to how the Department of Energy's program of excavating, the exploratory studies facilities, mapping that facility, relating that data, making modifications to their designs and construction activities accordingly. That activity we anticipate will be a very strenuous one and quite a focus of our staff's activities.

And the final point I would note is that from the Center's perspective we need to continue to press to obtain a firm baseline repository and waste package design. These are so central to the performance of the site, but they're also central to understanding the suitability of that site, issues such as we've talked about here today with regard to materials being only some of those issues.

With that, Commissioners, I would conclude my remarks and, Chairman, turn it back over to you.

CHAIRMAN SELIN: You've talked some about it, but can you step back and talk about the program approach, sort of the general impression you have, both what it means for your work load but also if you have some light to shed on

this question of how we go about processing an application with one concept behind it even though it's likely to shift to the second concept of low temperature to high temperature?

DR. PATRICK: Our general sense is that the program approach is a much welcome one from the standpoint that it does make very strong attempts to focus the program on key issues related to site suitability and eventually to the ultimate licensing of the repository.

We have some particular concerns and we've worked with your staff and expressed them to them. Some of those concerns have been -- I should say essentially all of those concerns have been conveyed to the Department of Energy in recent correspondence with them and I think you're familiar with those.

We have concerns with regard to schedule, for example. There are additional budget monies provided there which we think will go a long way toward addressing that, but in some areas, and we've spoken here before about those, in some areas you just find yourself in a position as a researcher pushing the physics of the problem. It takes so long to run a thermal test. It takes so long to run an infiltration test and we don't know of any way that that can be rushed, so we're going to be looking very carefully at the revised study plans associated with those key long time

tests that we think are particularly important with regard to understanding both the performance of the site and also the suitability of the site, the basic characteristics of the site.

CHAIRMAN SELIN: What about the impact on the Center's research?

DR. PATRICK: Impact on our research is not going to be insignificant. We see it more --

CHAIRMAN SELIN: Not going to be insignificant?

DR. PATRICK: It will not be insignificant in the following manner.

COMMISSIONER ROGERS: How significant will it be?

DR. PATRICK: Let me tell you. Glad you asked that question. We're still working with your staff on sorting out the particular impacts that will be felt. I alluded earlier to the sense that we have that we're going to need to reexamine our research from the standpoint of perhaps even leaving out certain activities. Let me give you a specific example and it's one that we touched on here today and a very important one and one which takes quite a bit of additional discussion, dealing with our models for the probability of volcanism.

Volcanism is sufficiently sparse at the site that it's difficult to develop a good probability model, but it's sufficiently present at the site that it is a potentially

adverse condition for that site, so we have to evaluate it. Our original plan approach was a very conscientious and deliberate step by step approach which would lead us to look at a number of other analog volcanic fields with regard to probability. We reported on one of those that we've examined, the Springerville field, today. We may not, in fact I believe will not have the luxury of examining many more or perhaps any more of those fields with regard to the probability models. We may have to complete our probability model studies very quickly using the data that we now have available and move on to the next area which is the consequences and focus our analog studies and other studies in that area. That is an impact that we anticipate seeing.

In the materials area, I would make similar remarks. We from the outset have, instead of trying to follow the Department of Energy's selection of materials and designs in very narrow explicit ways, we've tried to be a little clever and we're beginning to see it paying off. We selected classes of materials. For instance, we studied copper alloys as a class of materials and three specifics within that while the Department of Energy had that under consideration. We've looked at nickel alloys as a class of materials. So as long as they stay within that class, there's a great deal of information and a great deal in particular modeling work that we've done and developed,

predictive technique such as the repassivation potential technique that we're discussing here today. Those things we will be able to use and DOE's change of program should have relatively minor effects there.

Their MPC is going to introduce brand new materials, materials that would fall into a different class where different kinds of degradation processes are important and again that's an area where we will have to make a decision as to whether we need to set aside certain parts of the work that's currently underway and get enough understanding under our belts with regard to the new materials and the associated new degradation modes so that we'll be able to provide appropriate review of the MPC.

So while we see not insignificant impact, I would put it into English terms to mean, although we will see the core program continuing on, we see specific areas within each project that is currently underway that will have to have its emphasis increased or decreased perhaps to the point of that segment of the program being eliminated. We have not identified any of the ongoing 12 research projects which are invalidated or should be discarded or closed out as a result of the PPA.

CHAIRMAN SELIN: As long as you're speculating a little bit, why don't you go a little bit further and talk about what impact there would be on the program if we had to

look at a monitored retrievable storage site at Yucca as well, a surface site. Don't worry about a buried site.

DR. PATRICK: Specifically at Yucca Mountain?

CHAIRMAN SELIN: Yes.

DR. PATRICK: In terms of the Center's preparation to assist the staff, if the repository program continued along its current approach which is accelerated and larger and if the monitored retrievable storage program came in and it was accelerated and larger, if we were to support both of those our resources in gross magnitude would be inadequate.

Our resources in terms of basic staff capabilities, the correct disciplines and correct depths of experience and so forth are basically adequate. We've had a couple of staff additions in the area of nuclear criticality here in the last year which filled in some gaps that if you'd asked the question a year ago I would have said existed.

Stated another way, I feel that the Center is well prepared in terms of disciplines that we have to fully support you both in MRS and in the repository, but unless there is a juggling and changing of priorities, if resources remain the same, it would be somewhere between difficult and impossible to execute both programs from our staff perspective. Mr. Bernero would have to address that certainly from your staff perspective. We don't know the

extent to which they would request assistance in that area.

Our support in the monitored retrievable storage area to date has been quite small. This fiscal year there is no funding in that area. Historically it's been less than one full time equivalent on an annual basis.

CHAIRMAN SELIN: I assume if you had to look at a more generic MRS that would just further accentuate the remarks that you've made?

DR. PATRICK: To the extent that by "generic" we really mean a broad range of possible sites and designs and so forth, that's right, sir.

COMMISSIONER ROGERS: I've got just a couple of questions.

CHAIRMAN SELIN: I think Mr. Bernero wants to finish answering the question.

COMMISSIONER ROGERS: Oh, I'm sorry.

MR. BERNERO: I would like to volunteer a little bit of comment on the prospect of the MRS. There are a couple of fundamental questions that go with such an MRS at Yucca Mountain. If it's a parking lot MRS at Yucca Mountain, the MPC program will probably take care of virtually all of the technical aspects, you know, site suitability, seismicity, stability, things like that, because the MPC is simply parked there. It's quite uncoupled from the site and the review and licensing of such

an MRS would be dominated by the environmental impact of transportation and things like that.

In contrast, though, if that MRS was decided in the DOE program to go a lot more toward the original concept of the MRS which is a family of structures where fuel can be reconfigured or repackaged and possibly MPCs would only be dual purpose instead of triple purpose, you know, that there would be tailoring, that could have a very significant impact because it's a lot more complex facility. But it would have a very significant impact on the Yucca Mountain Repository Program from a system point of view, because right now we are pressing for repository and design analysis that is purportedly being built around these big MPCs. And if there was a programmatic decision to say, hey, wait a minute, let's get a little degree of freedom for the repository by being able to reconfigure or repackage, there are program interactions within the DOE program that would be very significant.

COMMISSIONER ROGERS: Well, just a little bit more on that point, early on one of the first projects that the Center took on was the analysis of our existing rules, regulations that would have to be addressed in a license application and where there might be some deficiencies in those and I remember you had a very fine approach there that I like very much and haven't heard much about it in recent

years. But I wonder whether the same sort of activity shouldn't be conducted for an MRS by the Center or whether we're entirely confident that there are no inconsistencies, there are no gaps that have to be closed over in our present regulations if they are to be applied to an MRS license.

MR. BERNERO: It's an interesting thing that Carl Paperiello and I have been discussing this over the past few days. The systematic analysis of the MRS right now, and this is especially as a parking lot MRS, is principally the systematic regulatory analysis of requirements for Part 71 certification for transport and Part 72 certification or review and licensing for storage. What we are doing is trying to develop an integrated set of performance requirements and specifications so that a multipurpose device has homogeneous -- a standard review plan, if you will, a homogeneous, carefully blended set.

We have been reviewing devices for dual purposes, but it's an iterative review. The 71 review gets it to look a certain way and satisfy certain analyses. Then you analyze it against Subpart 72 requirements and then you have to iterate back and forth. That has been a real difficulty. The only way we see to do the multipurpose canister, and it would pick up most of what you're looking for, I think, Mr. Rogers, is to have this homogeneous set of requirements. We're turning our attention that right now.

COMMISSIONER ROGERS: Well, good.

Well, now, coming back to the presentation, in the beginning you address selected key technical concerns. I'm just a little curious as to how those key technical concerns that you've been interested in relate to the key technical uncertainties that have been identified in the DOE program.

DR. PATRICK: Good question.

COMMISSIONER ROGERS: Do they overlap or is this just two totally different lists that happen to use the same word "key" in them?

DR. PATRICK: Well, they chose to use two of the three the same. The reason I switched to that viewgraph and used the term "concerns" instead of "uncertainties" is that each of the concerns identified here incorporate within them two or more of the key technical uncertainties which are documented in the license application review plan that was just given out. So, take the first one, for instance, the potential for disruptive tectonic processes. There's more than one what we've identified as a key technical uncertainty and we've tried to combine those enough here so that instead of going through four dozen key technical uncertainties we've recombined them and looked specifically at what NRC's responsibilities and the Center's progress toward fulfillment of those responsibilities have been.

COMMISSIONER ROGERS: Oh, good. Good. Well, I'm

glad to hear that.

I just want to say that I thought it was a very interesting presentation and I felt I got a great deal out of it, although before you began I wasn't sure what I'd get out of it because the slides themselves are pretty dry for the uninitiated to interpret. But with your assistance, they've taken on new life. I certainly enjoyed the presentation and what you had to say and your ability to connect this work with the existing program approach.

I would be very interested, and I'm sure other Commissioners would too, to at some point find out when you have matched your program up against what you think has to be done to address the new program approach and what you're going to cut out or defer, precisely what those things are and what the implications of them may be in adjusting to the needs to move ahead more rapidly with either a constant or declining budget as a possible situation to deal with in the future.

So, I think we'd like to hear about what they amount to once that work has been done, but I suspect you're not ready to do that yet.

MR. KNAPP: Well, as a matter of fact, we have an SRM from you to tell you our views on that I think in March. I right now don't think we can wait that long to make up our minds. We're reexamining the high-level program both among

my staff, Research staff and the Center and we're doing it as a group with all parties involved to answer some of these questions, exactly what is at the top of the list and what is it we're going to have to sacrifice. We anticipate that that will be done I would say probably late February or early March. We will have the best consensus we can get as to what we will actually do to respond to the program approach.

COMMISSIONER ROGERS: That's all I have.

COMMISSIONER de PLANQUE: I appreciate your mentioning some of the work you're doing in the international arena and I would turn the question around a little bit the other way. Is there much going on right now in other countries that's directly applicable to some of the questions that are being asked at the Yucca Mountain site and can be used rather than having to duplicate anything at the Center?

DR. SAGAR: If I may, we just finished reviewing the Canadian EIS. There is no Canadian site yet, but they're doing a pre-site selection environmental assessment to have a consensus in their nation to see if their concept would be accepted. There's a lot to learn for us. It's a huge document, of course there are thousands of pages. But the concepts certainly are useful for us. They have sensitivity uncertainty analysis that they have performed on

an actual database that they collected at the research site. There are techniques that they have used which certainly would be useful for us. Their regulations are quite different from ours. I think they have a health based standard, a single dose standard, a risk standard rather than the release plate like we have from the EPA rule. That does stress a lot more on calculation of dose and where the critical group is compared to I think what we do in our country.

But yes, I think quite a lot can be learned from what's happening in the other countries, Europe and Japan.

DR. PATRICK: The media are different, of course. The geological media are different. So, these specific problems are of some concern, not able to relate those directly, but the techniques, the methodologies as Budhi has emphasized. Those are where we really reap the benefit.

COMMISSIONER de PLANQUE: Okay. Correct me if I'm wrong, but are you going to produce a guidance document on expert judgment in the near future?

DR. SAGAR: Yes. We have actually two documents coming up, one to be completed in March and the other one to be completed in June. There are two main issues that they would focus on. The first issue is the technique itself as to what is acceptable in eliciting expert opinion and how to document it, what would be acceptable as a documentation of

that. The second one is looking at the areas in which it would be acceptable. Would it be acceptable in the definition of disruptive scenarios? Would it be, for example, acceptable to get the Kd values, option value from the experts?

The general feeling after looking at all the literature that we have, literature review we have done in the past, is that the expert opinion should not really substitute for measurement, that if there are scientific experiments that would give you that data, then those ought to be done. Certainly expert opinion would be acceptable in those cases where such data is either too difficult to get or is just not obtainable, the future prediction being one main area. You just cannot measure what's going to happen in the next 10,000 years. So, that's where expert opinion will play a role.

MR. KNAPP: I'm going to follow-up on that a little if I could. In the comments that the ACNW made on DOE's program approach, they raised the concerns about expert judgment. Among others, how would we resolve situations where a number of experts disagree? In the work the Center is doing, as they work with the staff, that's one of several issues that we're going to address and see exactly what sort of guidance we would need to put in place, what guidance that already exists from NRR that we might be

able to make use of. That'll be part of the process that will be following onto this March product they'll be bringing in to us.

COMMISSIONER de PLANQUE: Okay. Thank you. I too enjoyed the briefing this morning.

CHAIRMAN SELIN: Thank you very much, Dr. Patrick, Dr. Sagar.

DR. SAGAR: Thank you very much.

DR. PATRICK: Thank you.

[Whereupon, at 11:22 a.m., the above-entitled meeting was concluded.]

CERTIFICATE

This is to certify that the attached description of a meeting of the U.S. Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING ON STATUS OF ACTIVITIES WITH THE CENTER FOR NUCLEAR WASTE REGULATORY ANALYSIS (CNWRA) - PUBLIC MEETING

PLACE OF MEETING: Rockville, Maryland

DATE OF MEETING: Thursday, January 12, 1995

was held as herein appears, is a true and accurate record of the meeting, and that this is the original transcript thereof taken stenographically by me, thereafter reduced to typewriting by me or under the direction of the court reporting company

Transcriber: Carol Lynch

Reporter: Peter Lynch

BRIEFING TO THE COMMISSIONERS
CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

ADVANCES IN SITE AND REPOSITORY DESIGN EVALUATION

by
Wesley C. Patrick
and
Budhi Sagar

January 12, 1995

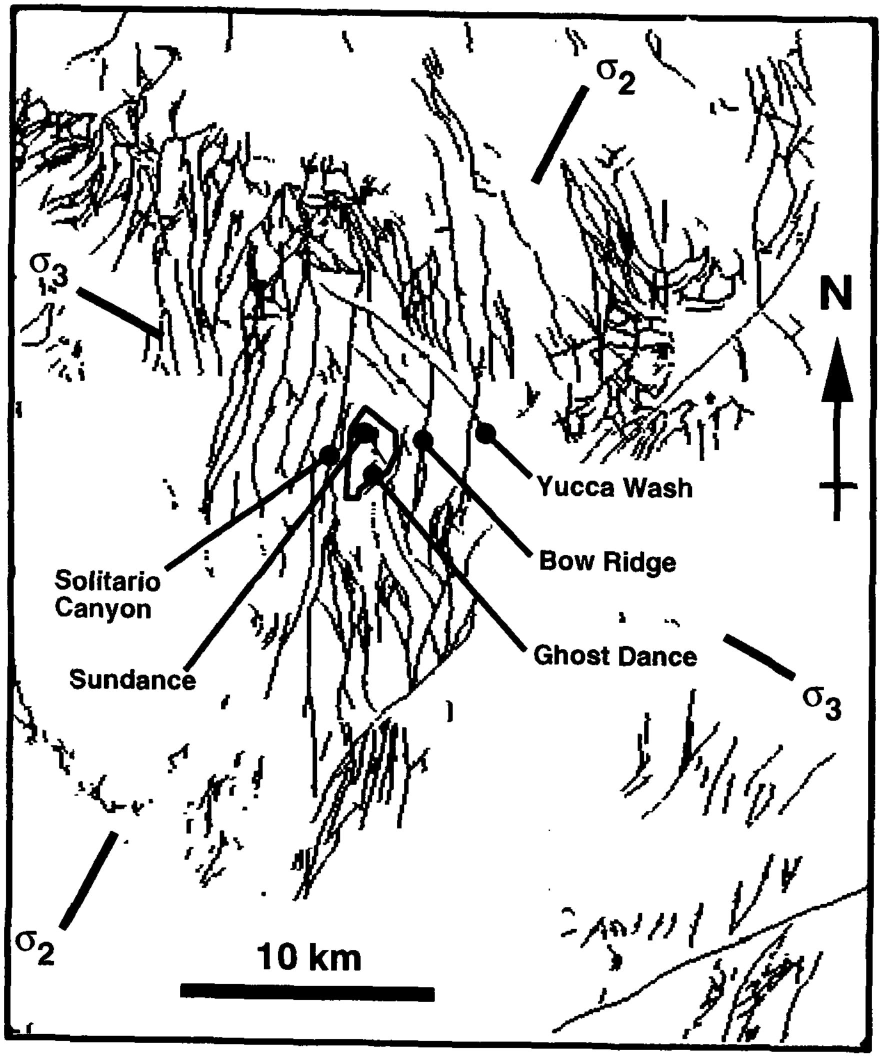
METHOD FOR FOCUSING ON KEY TECHNICAL CONCERNS

- Systematic Regulatory Analysis
- Iterative Performance Assessments
- Prelicensing Reviews and Interactions
- Results of On-Going Research
- Participation in International Programs

SELECTED KEY TECHNICAL CONCERNS

- Potential for Disruptive Tectonic Processes
- Detection of Igneous Features
- Effectiveness of Sorption Processes
- Long-Term Materials Performance
- Probability and Consequences of Volcanism

POTENTIAL FOR DISRUPTIVE TECTONIC PROCESSES

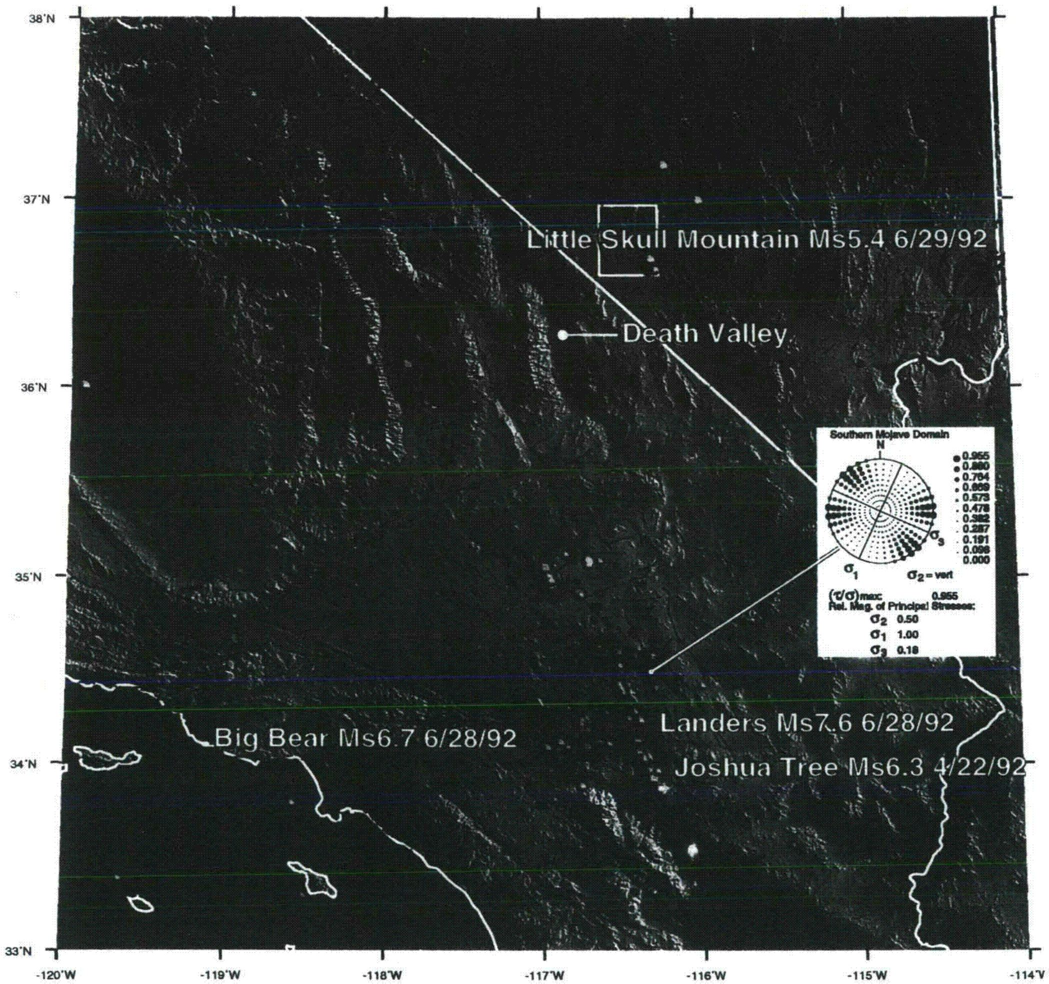


Solitario Canyon
Ghost Dance
Bow Ridge
] High Slip Tendency Faults

Yucca Wash
Sundance
] Low Slip Tendency Faults

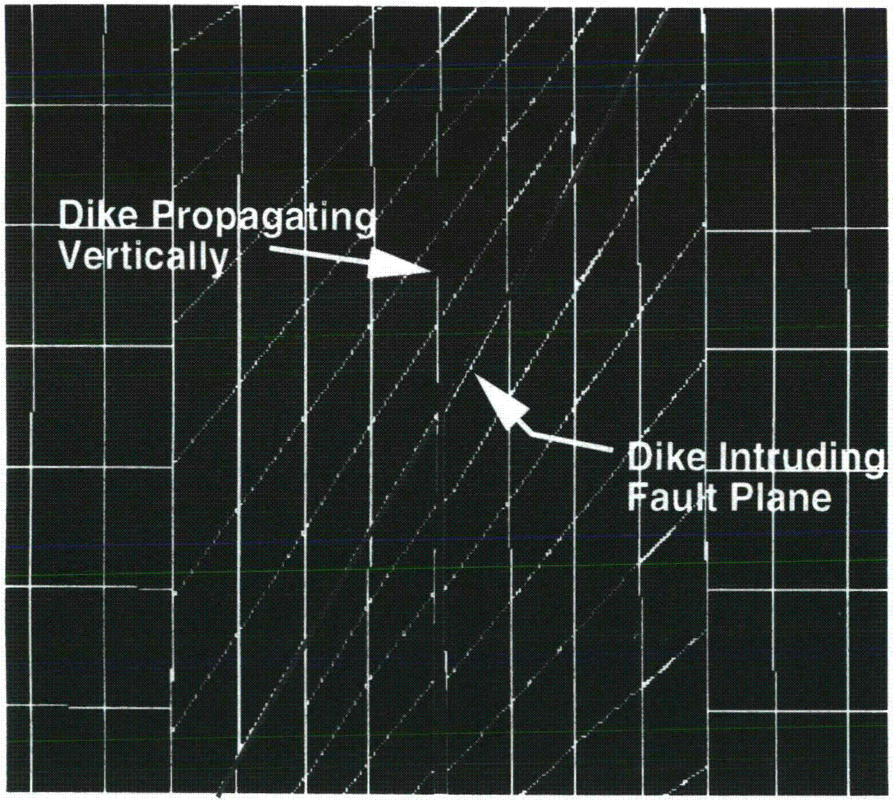
- Structural Deformation, Seismicity, and Related Effects Have Short– and Long–Term Effects on Performance
- Inability to Predict Likelihood of Earthquake Activity and Uncertainty in Fault–Plane Solutions are Key Technical Uncertainties
- Slip–Tendency Analysis Provides an Indicator of Seismic Risk and Fault Disruption Potential, and a Basis for Selection of Preferred Nodal Plane

POTENTIAL FOR DISRUPTIVE TECTONIC PROCESSES



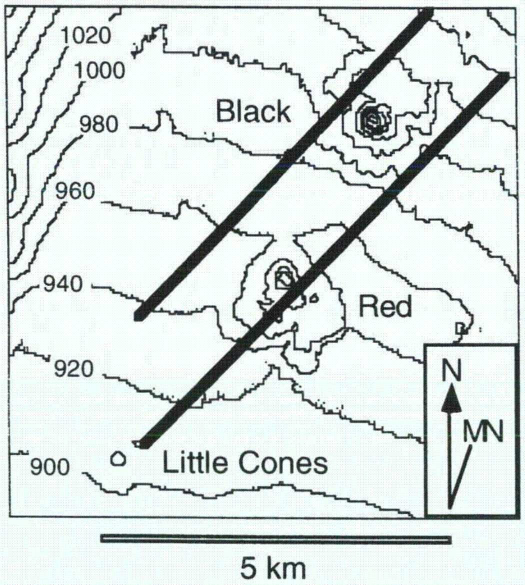
- Slip Tendency as an Indicator of Seismic Risk and Fault Disruption
- Initial Testing of Slip–Tendency Model Using Data from the Landers–Big Bear Earthquake Sequence
- Earthquake Hypocenter Data (March – September 1992) and Associated Fault Rupture Pattern Consistent with Results of Slip–Tendency Analysis
- Slip Tendency Analysis Suggests that 35–50% of Preferred Nodal Planes for Little Skull Mountain Aftershocks may not Correspond to Slipped Fault Planes

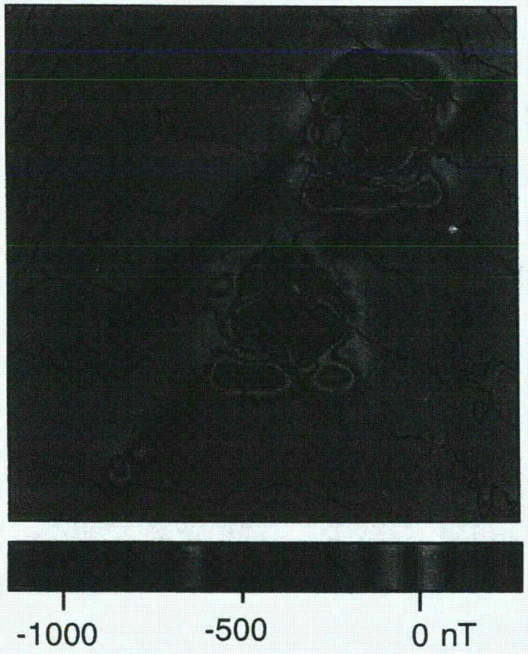
TECTONIC EFFECTS ON IGNEOUS INTRUSION



- Dilation Tendency Model Used to Assess Potential for Magma Capture by Faults
- Initial Testing of Model Using Data from the San Francisco Volcanic Field, Arizona
- Mechanistic Modeling of Fault–Dike Interaction Indicates that Magma Capture Dependent on State of Stress (Depth) and Fault Orientation
- Probability of Volcanic Disruption Altered by Fault Orientation and Distribution

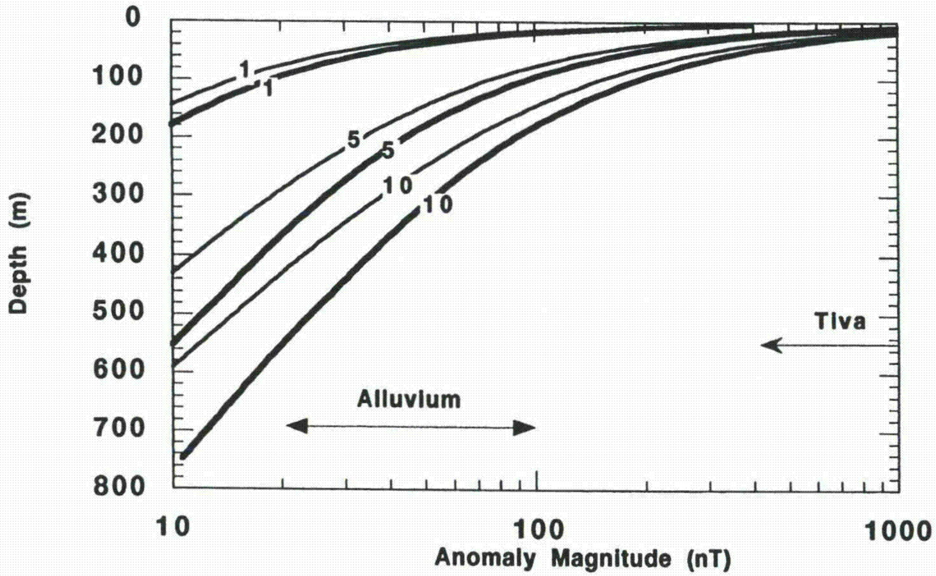
DETECTION OF IGNEOUS FEATURES





- **Low Resolution of Exploration Techniques is a Key Technical Uncertainty Related to Site Characterization**
- **Limits of Detectability can be Studied Analytically**
- **Even Wide (5 m), Shallow Dikes in Alluvium are Difficult to Detect Beneath Magnetized Topography**

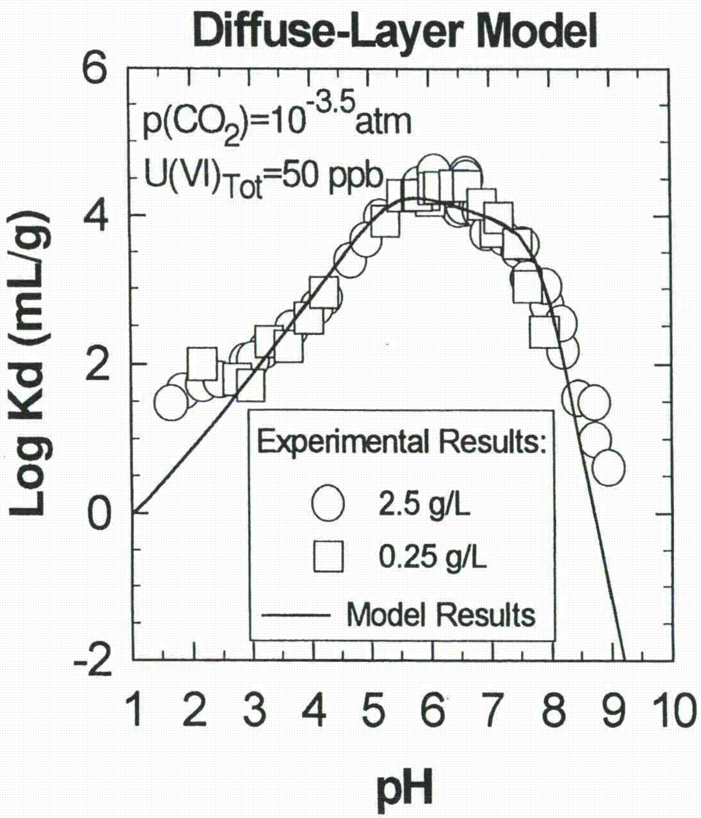
DETECTION OF IGNEOUS FEATURES



- **Parametric Study Quantified the Limits of Detectability**
- **Large Igneous Features Easily Detected in Alluvium; 5 Such Features Detected in Amargosa Valley**
- **Even Wide Dikes Must Be within 10's of meters of the Surface to be Detected where Tuffs Crop Out or Alluvium is Shallow**
- **Large Potential for Intrusive or Buried Extrusive Features to be Present but Undetected**

EFFECTIVENESS OF SORPTION PROCESSES

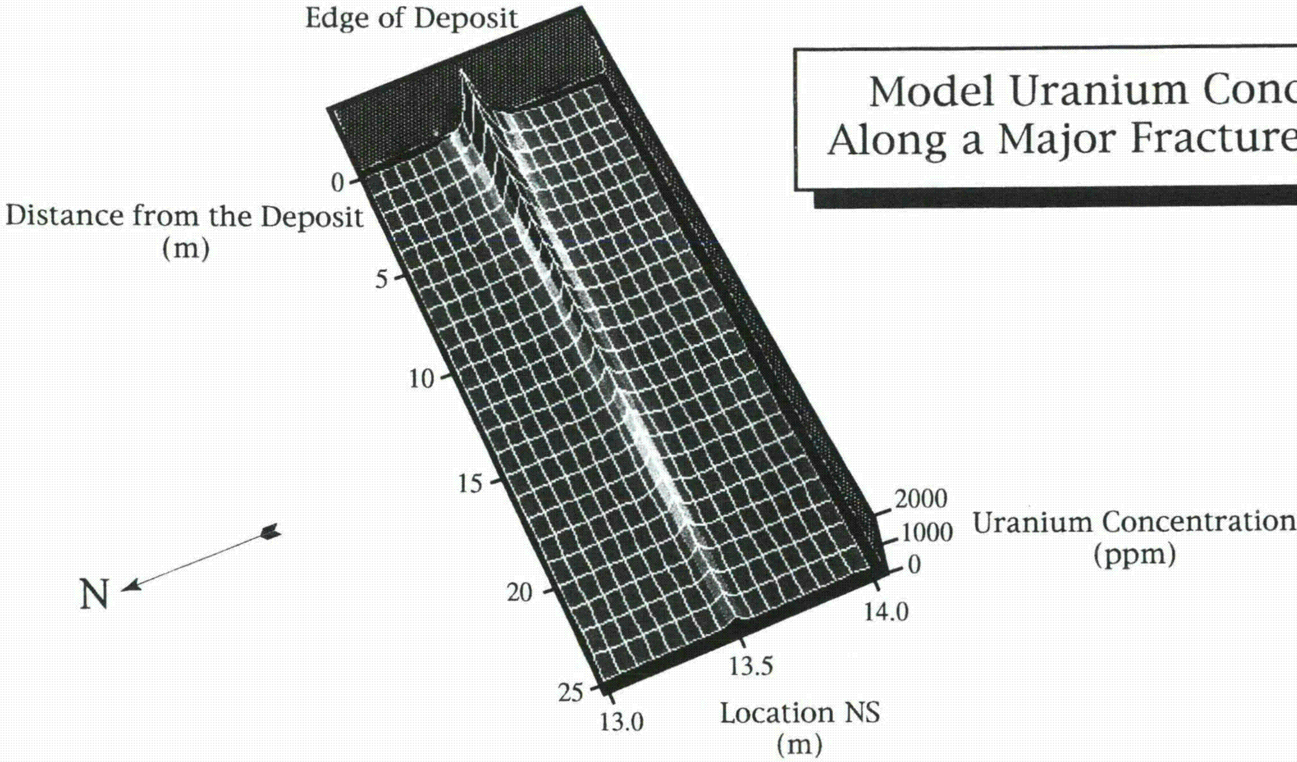
U(VI) Sorption on Montmorillonite



- Sorption is a Strong Function of Physical-Chemical Conditions (e.g. pH, Mass/Volume Ratio, Total Carbon)
- Mechanistic Models Based on Thermodynamic Principles Can Predict Effects of Chemistry on Sorption
- Experimental Data Needed to Develop Mechanistic Models
- Surface Complexation Models Support Simplified Approaches Used in Performance Assessment
- Use to Evaluate DOE Bounds on Sorption Parameters

FRACTURE AND MATRIX TRANSPORT OF URANIUM

- **Extrapolation from Laboratory to Field Scale is Essential**
- **Natural Analogs Support Evaluation of Conceptual Models**
- **Studies at Peña Blanca Demonstrate Dominance of Fracture Transport and Retention of Nuclides in Microfractures**
- **Studies at Peña Blanca Indicate Matrix Diffusion is Unimportant**



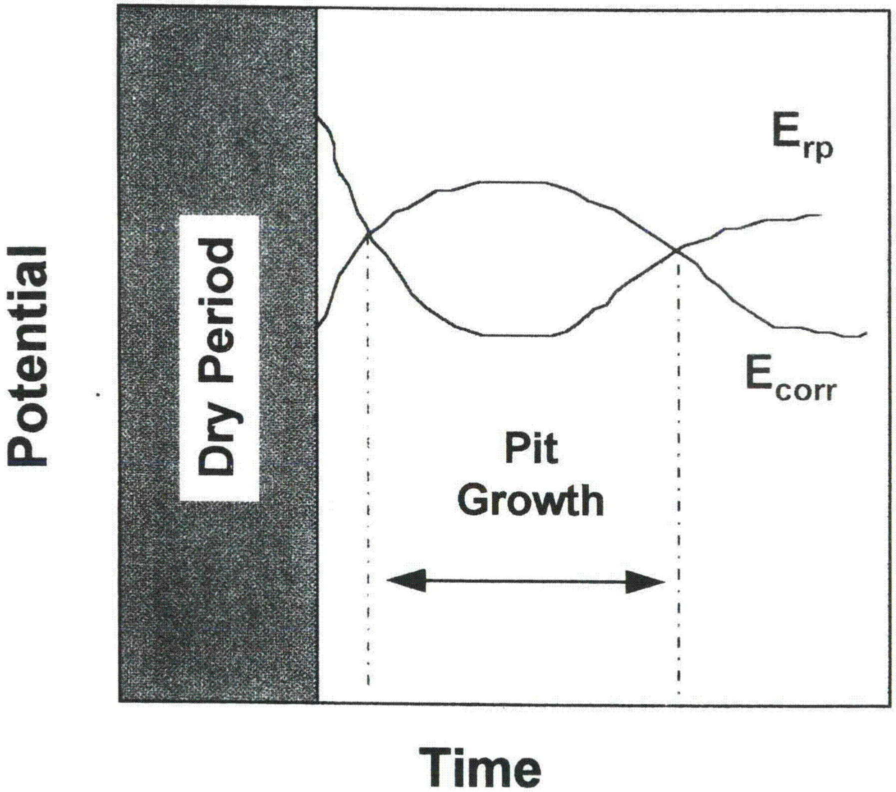
Model Uranium Concentrations
Along a Major Fracture at 13.5 m N

MINERALOGIC ALTERATION OF URANIUM

- **Extrapolation of Short-term Tests to Repository Time Scales is Required**
- **Studies at Peña Blanca Indicate that Short-term DOE Laboratory UO_2 Alteration Tests Produce Results Similar to Long-term Natural UO_2 Alteration**

Field Data from Peña Blanca		Laboratory Data from Wronkiewicz et al. (1992)
Uraninite		Synthetic UO_2
Uranyl Oxyhydroxides (Schoepite)	T I M E ↓	Uranyl Oxyhydroxides (Schoepite)
Uranyl Silicates (Uranophane, Soddyite, Boltwoodite)		Uranyl Silicates (Uranophane, Boltwoodite)
~10^6 yr		~4.5 yr

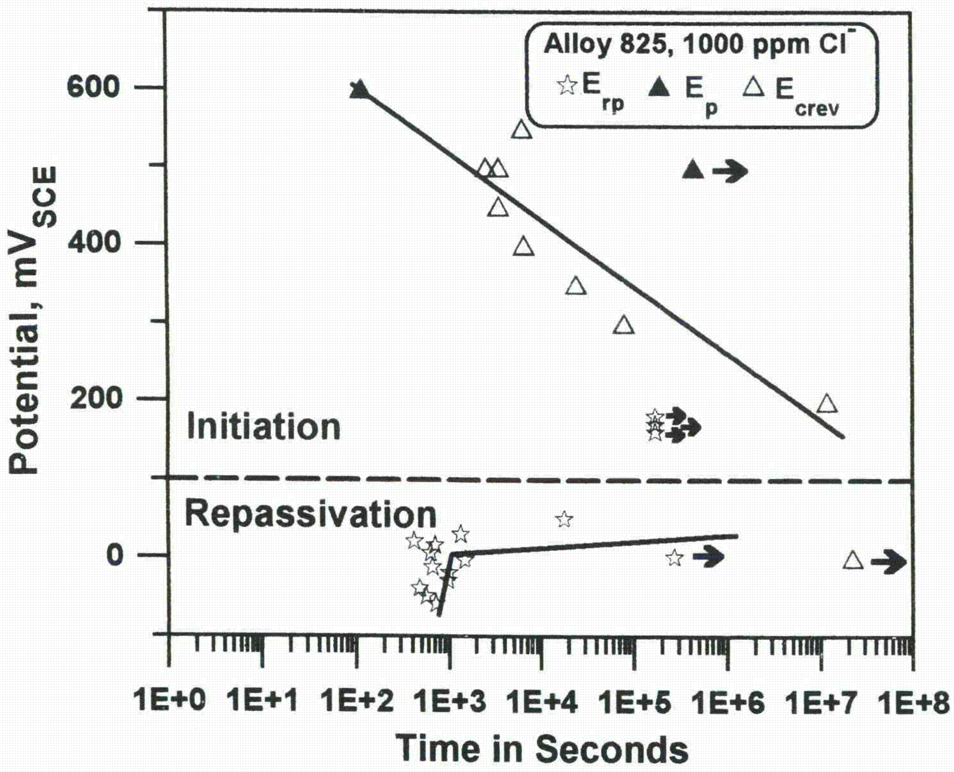
LONG-TERM MATERIALS PERFORMANCE



- **Repository Design (Thermal Load) and Waste Package Design are Important Factors**
- **Repository-Scale Drying and Rewetting are Complex and not Well-Known Phenomena**
- **Container Time-to-Wetting is a Crucial Parameter**
- **Localized Corrosion in an Aqueous Environment, if Initiated, Can Occur at Relatively High Rate**

- **Localized Corrosion Can Occur When the Corrosion Potential (E_{corr}) Is Greater Than the Repassivation Potential (E_{rp})**

LONG-TERM MATERIALS PERFORMANCE

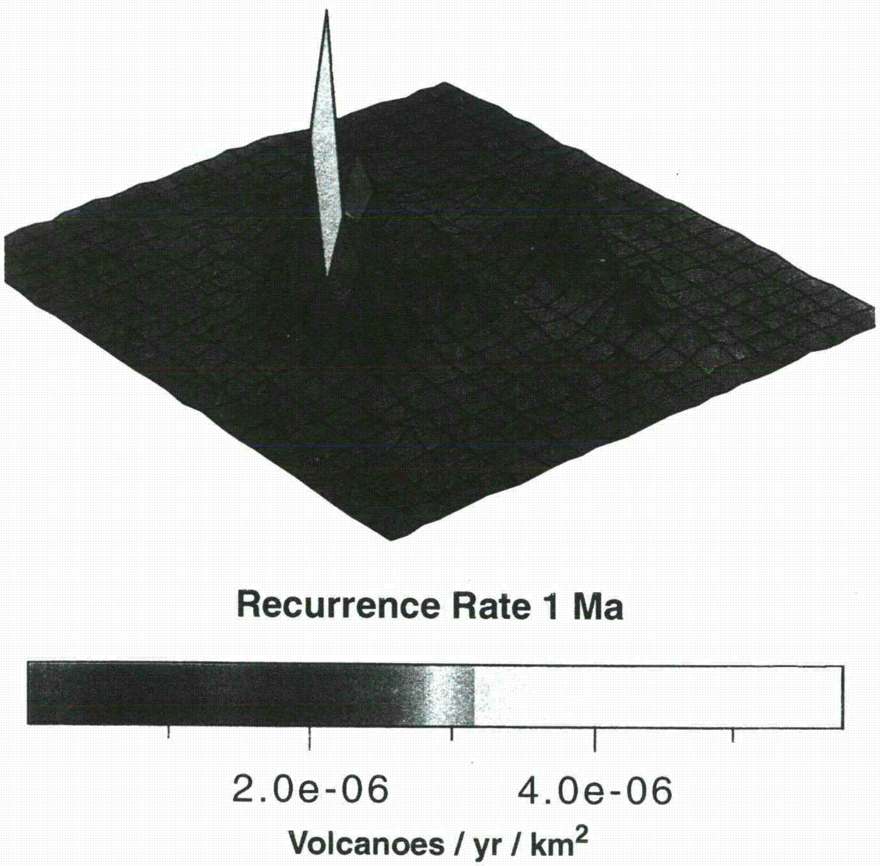


- **Extrapolation of Short-Term Data to Long-Term Performance is Difficult, But Can Be Approached Systematically**
- **Corrosion Processes, including Localized Corrosion and Stress Corrosion Cracking, Can Be Bounded using Appropriate Parameters**
- **Current DOE Approach Based on Initiation Potential for Localized Corrosion is Nonconservative**

- **Repassivation Potential for Localized Corrosion (E_{rp}) Can Be Used as a Conservative Parameter for Predicting the Long-Term Performance of Multiple Barrier Disposal Packages**

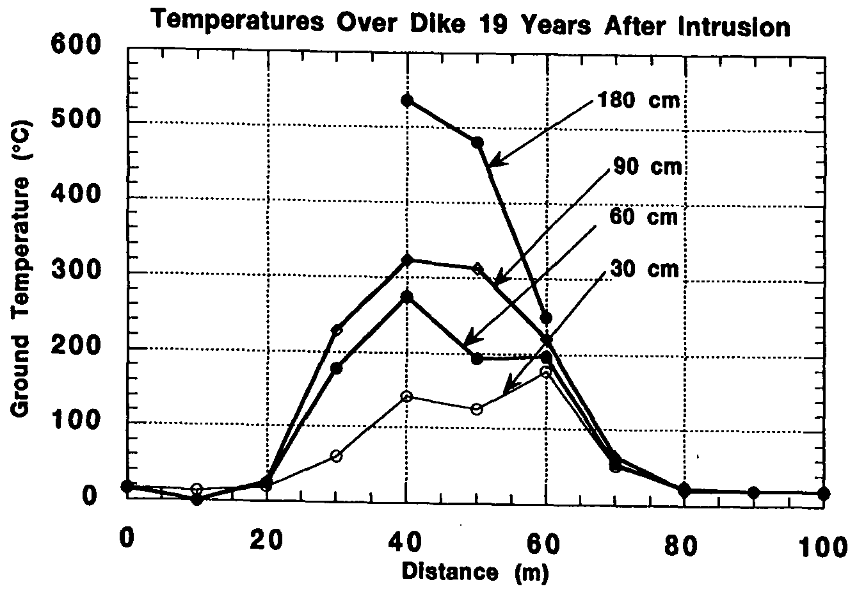
PROBABILITY AND CONSEQUENCES OF VOLCANISM

Springerville Volcanic Field, AZ



- 5 Volcanoes Younger than 1 Million Years within 20 km of Yucca Mountain Site
- Small Number of Volcanoes Makes it Difficult to Estimate Recurrence Rate and Probability
- Analog Sites Used to Test Recurrence Rate Models, and Hypotheses of Structural and Topographic Control
- Locus of Volcanism Shifts In Time, Volcanoes Form Spatial Clusters, Vent Alignments are Common: Probability Model Must Capture these Characteristics

PROBABILITY AND CONSEQUENCES OF VOLCANISM



- **Thermal Effects on Transport of Radionuclides**
- **Indirect Effects of Volcanism Generally Underestimated, Benign**
- **Alternative Consequence Models Being Developed**
- **Analog Volcanoes Show Extended Period of Heating Near Dikes and Cinder Cones; Influences Groundwater and Chemistry**

FOCUS OF FUTURE ACTIONS

- Accelerate Volcanic and Tectonic Field Investigations to Provide Basis for Critique of Probability and Consequence Models
- Expedite Completion of Critical Components of Geographical Information System for Use in Focused Reviews
- Augment Materials Research Effort to Include MPC Materials and Degradation Processes
- Continue to Incorporate Research and Technical Assistance Results into Iterative Performance Assessments and Subsystem Evaluations
- Reschedule Compliance Determination Method Development to Parallel DOE High-Level Findings
- Continue to Give Priority to Reactive Work, Including In-Field Verifications
- Press for Baseline Repository and Waste Package Design