ORIGINAL ACNWT-0082

OFFICIAL TRANSCRIPT OF PROCEEDINGS

Agency: Nuclear Regulatory Commission
Advisory Committee on Nuclear Waste

Title: 62nd ACNW Meeting

Docket No.

LOCATION: Bethesda, Maryland

DATE: Wednesday, March 23, 1994 PAGES: 1 - 303

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UNITED STATE NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON NUCLEAR WASTE

DATE: March 23, 1994

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UNITED STATES NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE

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62nd ACNW MEETING

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Nuclear Regulatory Commission
Conference Room P-110
7920 Norfolk Avenue
Bethesda, Maryland

Wednesday, March 23, 1994
8:32 a.m.

MEMBERS PRESENT:

MARTIN STEINDLER, CHAIRMAN
PAUL POMEROY, VICE-CHAIRMAN
WILLIAM HINZE, MEMBER
JOHN GARRICK, MEMBER
K. FOLAND, MEMBER

P R O C E E D I N G S

[8:32 a.m.]

MR. STEINDLER: The entire meeting today will be open to the public.

During today's meeting the committee will be briefed by the NRC Staff on high-level waste research related to natural analogs.

Ms. Lynn Deering is the designated federal official for the initial portion of this meeting.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act and has been announced at the Federal Register at 59-FR-11331.

Before we move on, let me make an announcement. The Advisory Committee is scheduled to move to the 2 White Flint building during the week of June 13 through 17.

The public is reminded to pay close attention to the meeting locations for the meetings from June until the logistics and support services are fully established at the new location on Rockville Pike. The 2 White Flint North building is conveniently served by the Metro Station centrally across the street, in case anyone is interested.

The committee may hold meetings at various hotels and conference centers until the conference room at 2 White Flint North are fully operational.

A word to the wise is sufficient.

We have received no written statements or requests to make oral statements from members of the public regarding today's session. It is requested that each speaker use one of the microphones, identify himself or herself, and speak with sufficient clarity and volume so that he or she can be readily heard.

Before proceeding with the first agenda item, I would like to cover some brief items of current interest.

I note that Bechtel Hanford is going to take over the environmental restoration work at the Hanford site, and a four-month transition to Bechtel Hanford from Westinghouse is going to start soon.

Westinghouse Hanford, the management and operating contractor at Hanford, has been responsible for the environmental restoration since the signing of an tripartheid agreement among DOE, EPA, and the State of Washington. The most recent version of that agreement was signed, I believe, either early this year or late last year.

Also, Massachusetts approved the search of an in-state, low-level, radioactive disposal site after significant amount of discussion among the various legislators. The Low-level Radioactive Waste Management Board of Massachusetts voted to begin immediately a three-year process to find the site.

We note as a matter of interest that four out of the five abstaining members, nation members, have agreed finally to the London dumping convention to ban "C" disposal of low and intermediate-level radioactive waste. The four nations that have agreed are Britain, France, Belgium and China. Russia announced its intent to continue "C" disposal until at least 1996 in order to deal with military waste, particularly old submarine reactors.

Recently, during a March 1st hearing, Senator Bennett Johnson asked Dan Dreyfus of DOE to estimate a timeline for various approaches to the Yucca Mountain project including the option of preparing to use the site perhaps as a monitored, retrievable storage facility.

I note that federal law prohibits the use of the Yucca Mountain site for an MRS. On the other hand, he also asked Dan Dreyfus if Yucca Mountain could be licensed. And I gather his reply was said to be, "Who knows?," which strikes me as not only not particularly informative, but is an unfortunate indication of the state of that program.

As another item, we have been invited to attend a workshop on the coupling of site characterization with performance assessment. In light of our yesterday's working group meeting, a timely invitation.

The meeting is going to be held in Sandia toward the end of May, and we will very likely have one or more Advisory Committee members and/or Advisory Committee staff members attend the meeting. It should be a very interesting meeting. It is fundamentally an international workshop that should be very useful.

The high-level waste management meeting in Las Vegas is going to be held at the end of May. One of our former members is presenting a paper at that meeting. Again, one or more of the members as well as the staff will attend that particular facility.

Finally, it looks as those DOE is proceeding with the development of the multi-purpose canister, the MPC to use in the event that they are unable to accept spent fuel by the 1998 contractual deadline.

The specific arrangements are not very clear, at least not to me, but it looks like movement towa.. the use of various sizes of MPCs is underway. There is no doubt, at least in my mind, that this would be subject to considerable amount of interaction between DOE and NRC when MPCs become an item to be considered for final disposal of spent fuel.

I think that is all the items that I want to mention at this point.

Does any one of us have any additional comments you want to make?

[No response.]

MR. STEINDLER: If not, let me turn the meeting over to the lead member on this topic, Bill Hinze.

It is your meeting at the moment, Bill.

MR. HINZE: Thank you, Marty.

The use of natural analogs to investigate the earth processes and products is really a tried and true methodology of geoscientists.

Field analogs are especially useful in many geologic studies because of an ability to define and parameterize analytical expressions for processes, and because of the complicating effects of the long time duration and large three-dimensional space of geologic events, which are difficult or impossible to reproduce in the laboratory.

For similar reason, natural analogs are of great interest in analyzing the processes and performance of high-level waste repositories. As a result, the NRC has and continues to have a program to use natural analogs in carrying out its responsibility in licensing of the high-level waste repository.

Today, we are meeting to review the natural analog research of the Nuclear Regulatory Commission with an emphasis on its use and performance assessment and the role of natural analogs in repository licensing.

Today, we are particularly interested in learning the anticipated role of the results of studying natural analogs to the pending licensing of the Yucca Mountain repository. This review by the committee is in response to a direct question from the commissioners as to the regulatory need for natural analog research.

A little over a year ago, the NRC research group and the center made a presentation on their natural analog research program to this committee. I want to make it clear that it is unnecessary to repeat the details that were presented at that briefing. Rather, we are seeking information bearing on the relevance of the research to the support of regulatory decisions. I understand that this has been made clear to all of us in discussions with the ACNW staff prior to this meeting.

We also understand that natural analogs are not a separate program unto themselves. Thus, one of the things that we would hope that we could achieve would be your help in integrating the disparate elements of the natural analog research.

Today we are pleased to have with us a cadre of staff from the NRC and the Center for Nuclear Waste Regulatory Analysis to brief us according to the agenda.

Linda will complete the day's agenda with a discussion of the future plans, and we will start his morning with Bill Ott, if I understand correctly, according to the agenda.

Bill, as I understand, you will give us an overview of the NRC research program and introduce other members of your team who will have specific aspects of the briefing for us.

We do have handouts for essentially all the briefings.

Bill, that is the question.

MR. OTT: Linda just brought her's with her.

[Discussion off the record.]

MR. OTT: I will make one minor correction. At the end we will sort of treat the conclusions and future directions as a group effort. I will introduce it.

We had a discussion when we were discussing our plans for this a week ago and reached, in general, conclusions about what we wanted the committee to come away. And what we will start off with are those, and then from that point on open it up for discussion at the end so that you can have an interaction with us on those future plans and conclusions with respect to today.

MR. STEINDLER: Sounds good.

MR. OTT: Okay.

I am going to begin very much the way I began the workshop on natural analogs which we had down at the center almost two years ago, which is by taking a look at the regulations.

In hindsight, there is actually a fairly interesting thread that runs through the regulations that takes into account, one, the difficulty of the problem we are faced with, and, two, the ways that we have to approach it and solve it.

The only quotation I used then was that proof was not to be had in the ordinary sense of the word. It was sort of a catch-all phrase to get some interest up. But that follows a section which discusses the general requirements that are in the regulations. The specific quote is 10 CFR 60.101(A)(2).

There is another section down in 10 CFR 60.21 which talks about the analyses and models and what will be needed to support those models and analyses in the licensing process. And it refers to an appropriate combination of field tests, in situ tests, laboratory test representative of field conditions, monitoring data, and natural analog studies.

[Slide.]

MR. OTT: Let's take a little look closer at the way the regulation is structured.

If you look at Part 60 you will find out that there are number of performance objectives which DOE must demonstrate compliance with.

There is a release performance objective which requires a release rate of no more than 10 to the minus 5 per year. There is a containment performance objective, substantially complete containment, on the waste package for 300 to 1000 years. There is groundwater performance objective of 1000 years, groundwater travel time. There is citing criteria which deal with favorable and adverse conditions of a geologic environment. And there is an overall EPA standard which is included in our regulations by reference.

[Slide.]

MR. OTT: If you look at little closer at those particular requirements, you will see timeframes in there of 300 to 1000 years on the waste package. You will see that the release to the accessible environment involves a 10,000-year time period the way the regulation is presently structured.

You'll see the groundwater travel time in reference to 1000 years. You will see that the spatial limits refer to the accessible environment, and here we are talking about distances measured in kilometers, not in meter or tens of meters or hundreds of meters, but in kilometers.

The siting criteria essentially reference factors in the geologic environment which should be considered if they are present. Things like the presence of potential volcanic or tectonic activity are specifically referenced in the regulations.

There are other things such as geochemistry and transport properties that all are included in the site characteristics that have to be considered, and, if you look at the EPA standard, things that you would have to know something about to make the calculations about cumulative releases to the accessible environment.

[Slide.]

MR. OTT: If we look at it in another way, this is a time-temperature curve that was done by some of the researchers out at Berkeley an number of years ago, and I believe this one is just based on center line temperatures from an individual canister. But you will notice that here very graphically we are talking about 250 degree temperatures, 100 degree temperatures. We are talking still about timeframes in thousands to ten thousands of years.

This does not in any way account for things like the hot repository concept, and it shows that we essentially have to worry about the performance of the site during conditions and over timeframes that we cannot measure. We just don't have direct experience to say exactly how that environment will act based on measurement of the environment itself.

Well, here is where we come to the concept that Dr. Hinze referred to as one which is traditionally used in the geologic sciences, and that is arguing by analogy for similar systems.

When you are looking at basic geologic systems, one has a certain advantage in that you are probably looking at systems that have enjoyed similar histories or other similarities. Here we have a system that is going to be driven beyond or away from what it has chosen to be its equilibrium state.

So we are going to take Yucca Mountain or whatever the final site is and emplace radioactive waste which will heat up the local environment. We will excavate and impose that particular insult on the system.

How can we use other analogous systems to try and understand that? We can use it to try to develop scenarios knowing what Yucca Mountain is and what it has been in the past. We can use that to say, well, there is some evidence of end-use activity in the area.

Are there other natural systems that have shown similar igneous activity, and can we get from that information on the consequences of such events, on the probabilities of such events? Can we use that to infer information that will allow us to quantify those risks for the repository system?

Sensitivity studies: perhaps we can find a series of systems where a parameter varies between systems, other parameters being held constant. And we can see how that parameter -- a parameter which perhaps may vary with time and Yucca Mountain -- has effected the performance of that system.

The effect of coupled processes: hydrothermal or geothermal systems where heat has driven other geologic systems beyond what would normally be the time history for that system could be studied to look at the effects of coupled processes and how chemicals and other constituents move in the environment.

In terms of model development, by being able to dissect some of these systems to much greater degree Yucca Mountain, perhaps we can understand what makes up the details of how the systems operate.

Confirmation of data: laboratory tests can be done on samples of Yucca Mountain. They can be confirmed by looking at natural data from other systems.

Insights for site characterization: later on Linda will talk some about the ARAP project which an ore body was taken apart in fairly great detail in terms of probably much more invasive investigation than you do at Yucca Mountain. What does that tell us about the degree of investigation? That we perhaps need to characterize a similar system at Yucca Mountain.

[Slide.]

MR. OTT: Let's go back to the time-temperature curve again for a moment.

If you look at where we can get conventional information, you could say that laboratory experiments -- we can get information on the order of days, months, weeks, years, from industrial experience. Since the Industrial Revolution, maybe 10, 20, 30, 50 years that we can get good information on some materials.

If you look at epithermal systems, hydrothermal systems, archeological systems, you can get information in these time ranges. You will find out when English talks about the Akrotiri set later on. They were taking about an archeological system that is fairly accurately dated with regard to a volcanic event which essentially covered the system.

We know the times very well. The rock formations are similar to those at Yucca Mountain. So again we found a system where we feel that we have taken care of a lot of the problems that people do raise with natural analogs.

I guess I should -- I should say something about those problems.

[Slide.]

MR. OTT: There is a natural analog working group that is sponsored by the CEC, Commission of the European Communities. This group has been in existence for about ten years, and one of the first things that they did -- first, their purpose is to oversee, to keep a general eye on what is going on in the international community with regard to natural analogs and their use in waste management problems and trying to address it and bringing insights into that problem.

One of the first things they did was try to come to grips with what you had to do to be able to get useful information from a natural analog. And they set forth a group of criteria which include things like being well-bounded in time, good chemical analogy. I don't know all of them off the top of my head, but there is a list of criteria. They don't necessarily have to all apply to all analogs. And this is another perspective that I want to bring forward.

Dr. Hinze mentioned we don't have a separate analog program. We have analog projects supporting data requirements and needs in various programs. That doesn't mean that we have not looked at natural analogs systematically to try to figure out how best to employ them in the program.

What it basically means is that the information needs are specific to the performance criteria and the objectives. We need information to support our ability to evaluate various problems.

And it is important that one not start thinking about analogs for the sake of analogs. That each one is studied only to the extent that it can yield something for the program or has promised of yielding something for the program.

On the other hand, one doesn't want to get hung up in semantics over what is or what isn't a natural analog. That the natural system can be used to gain insights in the sum critical performance aspect of a repository such as volcanic activity, the example I used before. It seems reasonable to go out and investigate it.

We have had at least one example where there was a disagreement between us and the Department of Energy over the definition of natural analog, and they essentially replied directly. I think John Bradbury recorded chis in a little more detail. The volcanic systems, they didn't consider to be analogs.

Well, whether they consider them to be analogs or not, if information is available from those systems that help you bound consequences or probabilities, it seems reasonable to go out and get that information.

MR. HINZE: Bill, while you are on the point of the CEC's work, I have an impression from looking at the literature and observing what is going on that the Europeans seem to have a much greater emphasis upon natural analogs than we do here in the U.S.

If that is true -- is that true? And if it is true, what's the reason for that?

MR. OTT: I don't know if it is true that they have a greater emphasis.

In the European community there is a much closer association between the developers and natural analogs than there is in this country.

MR. HINZE: Developers, you mean comparable to our DOE?

MR. OTT: Comparable to our DOE.

MR. HINZE: Okay.

MR. OTT: Because they essentially are charged with making their own demonstration as well.

Now, also in some of those countries, the relationship between the developers and the regulators isn't quite as distinct as it is here.

There is a video -- I guess it is going to be shown at the Las Vegas meeting -- on natural analogs which was sponsored by the Swiss, by NAGRA, and with contributions from a number of other countries.

We elected not to participate in that because it would have been viewed as promotional. Okay.

A number of other countries, including the operations -- including the Department of Energy did participate and produce in the video. That doesn't say that the video is promotion, just that for certain reasons we had to back off from becoming involved in it. There may be a much more active or proactive position in the European community with regard to pushing the value of the natural analogs.

That's the best I can do in terms of a guess as to why it is more public. I don't necessarily think they are putting a lot more effort into it. They are involved.

OKLO is being pushed by, primarily, the French, the CEA, with support from CEC. But other than the French, other natural participation, OKLO is very low.

SKB, being funded by the CEC and a little bit by themselves, participate in OKLO.

We fund a couple of very small projects in OKLO. DOE started to but then didn't.

Did you want to say something, Linda?

MS. KOVACH: There are -- Linda Kovach, Research.

I have a publication that just came out from the NAWG, the last NAWG proceedings, which I will make available for the ACNW. But there are actually quite a few analog programs that the various countries are involved in. Some of them do have -- are sponsoring several different analog studies at this present time, at this time. So I think that will give you a bit more overview.

MR. OTT: The document, right. I don't know necessarily that they are putting that much more emphasis on it that we are, are they?

MS. KOVACH: Some are.

MR. OTT: Some are?

MS. KOVACH: NAGRA is, for instance. But I think you hit on that point, that they are a small organization made up mainly of geoscientists and hydrologists. They are actually conducting the performance assessments, so while the program is very well integrated, and they are actively using analogs within their PA program.

It is a little bit more difficult for us, as Norm will talk about later, the reasons that we have more difficulty, and the DOE as well, integrating some of the data from analogs in performance assessments.

MR. OTT: NAGRA is the developer in Switzerland. They have to build and license and demonstrate compliance with the repository.

MR. HINZE: I was impressed by a conversation that was held around this table a couple of years ago by the Canadians and the fact that they were using the natural analog and finding that it was being very useful in terms of confidence-building with the people in the street, with the local government, and various interested groups.

And it seemed to me that a large part of their effort was focused on -- toward that end.

Is that also true in Europe?

MS. KOVACH: Yes. That is very true. Actually, I think the French and NAGRA have both had fairly good PR campaigns where they've used analog data to support the safety of the repository concept, the geologic disposal concept. As Bill mentioned, this natural analog video that will be shown or that has been produced and will be shown at the International High Level Waste Meeting in May is basically -- I think their aim was to use that in public relations to be able to show that to communities.

MR. HINZE: Thank you. Maybe we can come back to the international aspects later on. But since you brought up the CEC's program, I wanted to touch on that.

MR. OTT: The NAWG effort that Linda represents us on is one that we've been participating in since its beginning. Norm was actually our first representative to the initial NAWG meeting in Chicago almost ten years ago.

What I've shown here is a very simple diagram which essentially shows you a concept, which is suppose we only do a certain set of measurements at a site, Set A of measurements, and these are only hydrologic measurements. That set of hydrologic measurements says that there is a range of conceptual models that might pertain for this site.

Then we come along and we say, well, let's do some geochemical measurements and we take a set of measurements,

B. By doing the set of measurements B, we come up with a different set of conceptual models. But if we look at the intersection of these two sets, we see that there are, indeed, several of these conceptual models, I hope there are, which overlap, which both pertain to represent the same system.

One could observe, then, that by doing dual sets of measurements, we have, in fact, constrained the conceptual models of our site to a smaller set. Now, how you have done that, what it is in those conceptual models that you have constrained, maybe it's a parameter that your geochemical measurements allows you to establish more precisely than your hydrologic measurements did or perhaps a hydrologic parameter or measurement has allowed you to constrain some of the geochemical measurements.

Basically, the concept is that by doing multiple sets of information and comparing the conceptual models, you can reduce the range and the bounds on those sets which you feel are the actual conceptual models for your site. If you take it farther and look at geophysical models and geochemical models and hydrologic models and paleo-climatological models, if you go beyond this and think of collecting information from different systems, different temperature regimes over different timeframes, you essentially see that what we are trying to do by getting information that bound the problem is to reduce the domain that consists of consistent conceptual models.

Hopefully, if you do that, you put some constraint on the divergence of the system over time. You allow yourself to get some greater degree of confidence that you have bounded the system. One of the biggest conceptual problems I have, being a physicist at heart, I always see systems of time T-zero and I see them diverge from time T-zero because of basic uncertainties and parameters.

I very much like the concept of being able to somehow constrain that divergence so that at the end, I don't have an unhandleable problem. I think that through the use of natural analogs we have an opportunity to constrain that range of conceptual models.

This slide is, I believe, one you saw last year. It says "current" and I'm going to explain that a little bit. It says three of these projects are essentially ending. Two of them -- the Valles Caldera project has ended. You were given a copy of the final report for review before the meeting. It has not been published yet and Linda has some comments to go back to them that could probably make some minor modification before the project is actually finished.

The Valles Caldera is actually the most limited project. I'm debating between that and Akrotiri, because

Akrotiri also has very limited objectives. But the Valles Caldera was very limited in what we attempted to achieve there. So it's not what you'd call one of these global analogs.

Oklo is the one that everybody in the world considers as the classical example. Why? Because they've got 16 natural reactors buried there. Well, to a certain extent, the analog ends there because it's not the same kind of a system. However, there are still opportunities there because of those reactors that are unique and can't be found anywhere else in the world. It's also a target of opportunity that's disappearing because the system is being mined. So soon there will be nothing left of one of the most unique geologic systems in the world. The official Oklo project is supposed to end next year, I believe.

Pena Blanca is the analog site that English Pearcy will report on later today. It's down in Chihuahua, Mexico and is another uranium ore body. But this one is hosted in a tuff very similar to that at Yucca Mountain.

ARAP is the Alligator Rivers Analog Project. The NRC has funded work in the Alligator Rivers region for about ten years. The actual ARAP project was an international program, funded by five different nations, which investigated the Koongara ore body. Linda made a presentation at the Toledo meeting of the NAWG last year in which they summed up lessons learned from ARAP. I believe she'll give you some insights from that during her presentation today.

Akrotiri, as I mentioned earlier, essentially is a site on an island south of Greece where a volcanic event essentially destroyed the island and buried artifacts. The time history is fairly well known. The temperature history is fairly well known. English will tell you what we hope to learn from that.

I don't think I have --

MR. HINZE: Bill, before you remove that, if I might. Number one, I think it would be very helpful to the Committee, at least it would be to me, if sometime during the day, it doesn't have to be now, we could be briefed on what we have accomplished with the Valles Caldera study in terms of performance assessment, in terms of licensing, in terms of supportive regulations.

MR. OTT: I am hopeful that both Linda and English will go directly to the objectives we hope to achieve and those which we did achieve and how those can be included in the performance assessment.

MR. HINZE: Because you just finished Valles and not every research program works out. We understand that. But it's a splendid way to illustrate what is being done.

The second question that I have is I don't understand why I don't see a couple of additional items in that list of current studies. Number one, I wonder if Apache Leap isn't an analog study. If it isn't, I'd like to know what it is.

MR. OTT: Aspects of Apache Leap could be considered natural analog studies.

MR. HINZE: We have a program that's been going on for a decade and it would be -- it's supposed to be an analog of Yucca Mountain. It would be very helpful, I think, to the Committee to learn if it should be up there, what its role is and what we've achieved in the last decade.

The other aspect that I don't see up there that perhaps is appropriate is last month we heard from Dr. Hill that there is a study in basin and range volcanic studies. In my global view of natural analogs, I certainly would include that. I think that it's very appropriate that we're interested in the integration of these various research components. So it would be very helpful if we could learn where volcanism, per se, and the whole volcanogenic processes fit into the analog studies.

Have I missed any other analogs, any other programs that are underway in research that should fit in under that? Is this just focused on -- well, it isn't just focused on geochemistry. I guess the Valles was a thermal geochemical --

MR. OTT: Most of these are focused on things that were started primarily as analogs. Let me talk first about Apache Leap. Apache Leap is basically a hydrologic field site that began as a way of testing methods for measuring parameters in the unsaturated zone.

We began doing hydrologic research in unsaturated zone hydrology almost ten years ago, long before Yucca Mountain was selected as the site. There are certain aspects of Yucca Mountain that would indeed be considered analogs. As I mentioned earlier, we tend to think of analogs in terms of where we're trying to find out about large space scales, long time scales. A lot of the work being done at Alligator Rivers -- not Alligator -- at Apache Leap is very much modern day hydrology, what did the system do as you looked at it, scientific studies to understand it. You could consider that an analog.

As I said earlier, we don't really want to quibble about whether you consider it analog or not. Aspects of it, particularly the ones dealing with regional flow patterns, I would say, would definitely be considered by most people to be an analog for Yucca Mountain.

MR. HINZE: I was very much struck with your introductory material in which you referred to the subsystem requirements, particularly the groundwater travel time and the concern that I think all of us have in this room about whether we can really do something about groundwater travel time. Can we really define that?

It seems to me that the ten years of work at Apache Leap should start to tell us whether that's a good analog or at least that approaches. One could talk about the problems with it in terms of an analog to Yucca Mountain, but at least it approaches it.

One would hope that we would be learning something about whether, indeed, we can really define whether we can really come up with the site characterization that will help us to state what the groundwater travel time is in the volume of rocks such as we have at Yucca Mountain. I'm just really following your lead here in that one of the things that we should be ge ting at in terms of the analog studies is the subsystem requirements and whether we can really tie those down.

MR. OTT: Your observation is a very good one. In fact, as I said, certain aspects of that project we would, indeed, consider to be natural analogs, in a broad sense of looking at the project. From our perspective, the name is not as significant as the fact that we're actually getting the work done to look at the phenomenon. Maybe next time I use this slide, I'll put it on --

MR. HINZE: One thing that analogs should be doing is they should be telling us about phenomena. They should be telling about the process.

MR. OTT: No question.

MR. HINZE: That's why we're here.

MR. OTT: With regard to the second question you asked about volcanism -- the other slide, by the way, is sort of characterized around saturated and unsaturated environments and doesn't really go too much to the things like disruptive scenarios.

I might have found a place on that slide for Apache Leap, but I couldn't find one for volcanos. This slide is a little different. This one is a slide that has appeared in a number of different reports, publications, which talks about components of total system performance assessment. So we took the components and we put a title on top of that and said supporting analog studies for and made the blocks bigger and said, okay, where can I get information that will help me make contributions to these various components.

If you'll notice, down here under scenario analyses, we talk about volcanism and tectonism, hydrothermalism, climate change. If I had to list the analog sites that we're talking about in the volcanism project, we're probably talking three active volcanos and probably several inactive sites in the basin and range itself in terms of looking at analogous systems to try and get a handle, in one case, on the eruptive dynamics for active systems, and, in the other case, on frequencies for the probabilistic side of the calculation from the basin and range aspect of it.

So I would have to -- I'd have a much messier slide if I tried to list all of those particular sites. Let me leave it at, yes, we have got volcanism in there and we're talking about that in terms of scenario analyses, disruptive scenarios specifically.

In terms of consequence analysis, flow and transport geochemistry, we talked about Pena Blanca, Oklo and ARAP. They are all areas where we've been able to look at the migration of radionuclides of uranium daughter products.

In terms of the engineered barrier system, we talked about archeological analogs, possibly work from Akrotiri in terms of trace element analysis. In terms of the waste form itself, looking at urananites from Pena Blanca and Oklo and ARAP. In terms of the site, the Valles Caldera, which Linda will talk about more in terms of a thermal event, again, fairly well dated and a contact that's fairly well defined, Pena Blanca and Akrotiri.

MR. HINZE: Before you move that, excuse me, Bill, let me ask one quick question. In the scenario analysis, you have things going on in volcanism. Are there any of the studies that are going on at the center or elsewhere in NRC that deal with tectonism in terms of an analog and hydrothermalism and climate change?

MS. KOVACH: Yes. The Black Hills study in tectonics --

MR. HINZE: Black Hills?

MS. KOVACH: Yes. Black Hills in Nevada. That's being done by Gary Stirewalt and Steve Young in the tectonics project in Research.

MR. HINZE: And how about the other two there?

MR. OTT: The hydrothermalism and the climate change?

MR. HINZE: Yes. Just to set the record straight.

MS. KOVACH: Hydrothermalism would also be Valles Caldera. We don't actually have an analog site identified at the center at this point that we're working on, but that would certainly be one that we'd want to consider heat pipe effects, perhaps.

MR. OTT: In terms of the climate change, the only climate work we're doing at all right now is in terms of a very small program that follows the NOAA program on climate change, climates of the holocene. We've tried to start something else to look at climate models, but we have not looked at climatological analogs at all. Frankly, I don't think we have the resources to do that at the present time.

MR. HINZE: Thank you.

MR. OTT: That's where I want to end and turn it over to Bob Johnson. We have structured the program today so that I would give this brief overview and introduction. You all received copies of the center's natural analog workshop working group report. The last four sections of that report are the results of workshop meetings which occurred at the end of that workshop, in which there are a number of tables presented which indicate where various natural analogs might contribute to giving us information that would help in the PA process and understanding systems.

That's an interesting and fairly educational discussion of the range of possibilities that a lot of people who have been interested in the subject of natural analogs came up with as ways of doing that. Some of the things that were advanced in that workshop are, indeed, now being investigated. In fact, one of the ones that DOE participants reported on was a New Zealand analog in terms of hydrothermal effects, which is now being investigated by the Department of Energy. At the time, they didn't have funding, but they did manage to go back and get funding for that project.

The Black Hills was mentioned as a potential analog for the Yucca Mountain site. There were other suggestions in there of natural analogs. The suggestions far exceed the ability of ourselves to investigate or probably the Department of Energy to investigate.

We have to be selective and very careful in what we do to try and give us the best handle on what's going before us. The next three speakers are going to --

MR. HINZE: Before you introduce the next speaker, let me ask a few questions. Number one, I think I've read or at least looked at every page of the material that I had received and I've seen nothing about the Black Hills project. Is it possible for us to learn something about that? Is there some hard copy?

MR. OTT: The Black Hills are mentioned -- you mean what Linda said about Black Hills.

MR. HINZE: If there's a program, there's some kind of program plan. Is it accessible to the Committee?

MR. OTT: There should be something in Britt Hill's --

MS. KOVACH: No. It will be Steve Young. We can get you any information on that that we have.

MR. HINZE: Then I guess I'd like to come back to Apache Leap again. I don't want to dwell on this, but I would like to understand where we are. I look upon this as part of the analog program, that it really is an ingredient in terms of the framework you set up, Bill, as an analog. I would like to understand what is beirg accomplished at

Apache Leap in terms of the regulatory process, in terms of understanding how we're going to feed that into performance assessment. Could we have some information on that?

We are obligated to put some of this material together and we really need some help, because we've heard one report on Apache Leap, but it was a very focused report. We really need to have a broader view of that. Is it possible for us to obtain a synopsis of what has been accomplished over the last decade?

MR. OTT: That shouldn't be difficult. I don't know that I can provide it to you today. I can check with Tom Nicholson, he's the Project Manager, to see whether he has anything that fits that bill. Apache Leap we generally discuss under the terminology of hydrologic research.

MR. HINZE: This, Bill, is what I was getting at. When there's no analog program, there are all these disparate elements. We are trying to look at this in an integrated way and we can't do that without the assistance of you and your group.

MS. KOVACH: Bill, why don't I just comment for a minute. We've just done a program review of the complimentary Apache Leap work and CNWRA work in the hydrologic. Apache Leap, as we focus on it from the regulatory, we're looking at things in terms of key technical uncertainties, which I know you've heard about and

Bob Johnson will go into it in just a few moments.

Key at the Apache Leap is we're trying to understand some of the testing technologies, some of the unique methodologies that DOE is using to collect unsaturated zone data. So that's one of the key aspects that we're feeding back from the Apache Leap work.

The second is that we're looking at the spacial relationships as a basis for model validation. So much of the work that Schlomo Newman and his folks are doing there in spacial scales are assisting us in some of the work we're doing on model validation.

That's just a nutshell. We can certainly give -- we don't look at Apache Leap -- actually, we don't look at this work as segmented as a natural analog. We sort of feed all the work into our key technical uncertainties through the licensing process, and the performance assessment is part of that. So we may be looking at it packaged just a little bit differently, but we can certainly provide you the information.

MR. OTT: I guess there is one other aspect that I might mention. There's been something of a debate in the international community over the years of whether anything other than geochemical analogs should be considered analogs.

MR. HINZE: Does John have a feeling about that?

MR. OTT: Who?

MR. HINZE: John Bradbury.

MR. OTT: John has a very definite feeling about it. So do we. One of our objectives at the Toledo meeting last year -- maybe I shouldn't admit it, but we do send our representatives there with objectives -- was to stimulate discussion in the direction of getting more acceptance internationally for a broad interpretation of the term analog in the waste management community.

So as I said before, we're very interested in people not using as an excuse or as a reason for not investigating an analog that it doesn't fit some narrow definition. To us, that's not a reason for not doing a relevant investigation.

You wanted to make a comment about Apache Leap, Tim.

MR. McCARTIN: Tim McCartin with the Office of Research. One maybe quick example of the tie-in between performance assessment and Apache Leap is that through our IPA calculations, one of the big uncertainties that we've had is how does water actually enter into the mine cavity of, say, a Yucca Mountain repository.

We have had to make some assumptions about how water will go either through fractures or the matrix into that mine cavity. Very uncertain. At Apache Leap, we have the fortunate situation where there's Queen Creek or the never sweat tunnel. I had to think of the right terminology. But right there they have some situations where there's a lot of water going into the never sweat tunnel. The question is what conditions are causing that, how it's occurring.

The center and Arizona are working together to try and help the IPA effort to try and figure out exactly what kind of test can we look at, what kind of experiments can we conduct to see what is causing that situation to occur. So I think there is at least a tie-in where we hope to get a better idea of, say, water flow into a mine cavity, and Apache Leak offers a very nice situation there.

MR. STEINDLER: Bill, do you make a distinction between the application for the output from natural analog studies to key technical uncertainties in the application to what I call model validation?

MS. FEDERLINE: Model validation is a key technical uncertainty. That is one of the KTUs under the 112 performance objective for the total system. So when you say do we make a distinction between it, it is a key technical uncertainty. So we would identify sources of information that feed into it. I don't know whether that's different.

MR. OTT: I would not make a distinction, except that I would back off a little bit and I would say that we're not attempting to do any validation of models. We really consider the documentation and justification of the DOE's licensing case to be theirs. We're trying to understanding these systems well enough that we can analyze the data that's submitted to us and determine what the uncertainties in that system are.

We would hope that, say, by looking at an analogous volcanic system we can look at what DOE does with their site-specific investigations at Yucca Mountain and with their probabilistic models or whatever it is and have some confidence in whether they have or have not done the job that we feel is necessary to demonstrate their claims.

MR. STEINDLER: I recognize there is a usual confusion as to what I mean and what you mean by model validation. Maybe that's a discussion you and I can have off-line rather than waste everybody's time. But if you hold to your notion that you do not do analog studies for model validation, that might be something you might want to spend a few minutes on telling us at some point today.

If it's just a question of terminology, then --

MR. OTT: In terms of the model, there's going to be a conceptual model and a set of mathematical models advanced by the Department of Energy to license Yucca Mountain. We're not going to advance that model. We're going to review it and evaluate it. We're going to use every bit of information that we have to critique what they do.

The case to build confidence in that determination is one that has to be made by the Department of Energy. If you look on model validation in terms of how we've been talking about it in the last year, it's a process of building confidence. I know and everybody knows in the room that there's been a lot of debate over what does validation mean, what does verification mean.

If you look at those quotes that I gave in the first part of the presentation, they refer very specifically to an acknowledgement back when Part 60 was written that this is a different beast. It's not trying to figure out where a projectile fired from a gun goes within two millimeters or two-tenths of a millimeter. It's a case of projecting out the evolution of the system over 10,000 years when you perturb it with 70,000 metric tons of radioactively hot material.

It's not a simple project, not a simple job, nor is it one that I think you can hold to ordinary standards of proof. It's a case of investigating it enough to build confidence in your ability and DOE's ability to make estimates of what's going to happen and in our ability to evaluate those estimates. I don't know if I can be more specific than that.

MR. STEINDLER: No. But I think one of the issues that keeps cropping up in anything that you folks do is should you be doing it or should be DOE be doing it or why are you doing it in addition to or not in addition to DOE.

If model validation or the validation of scenarios is, in fact, the role that DOE plays, then someplace, I think, you folks have to address -- you ought to address to us at least why you're doing it rather than, say, somebody else, like DOE.

MR. OTT: There are times when DOE doesn't do things unless we do. If you look classically at the first estimates to look at hydrologic flow in Yucca Mountain, the assertions by the Department of Energy was that it was matrix flow and matrix flow only. It is only after considerable interaction and essentially a focused research program of our own at Apache Leap which says that, look, you really do need to look at fracture flow, as well as matrix flow.

But the DOE has accepted the situation that they have to look at matrix and fracture flow as a unit. It's not a single phenomenon that they have to worry about. There are a number of situations where we're probing the edges where there is a conceptual model or a concept that we feel needs to be investigated and perhaps the DOE isn't putting as much emphasis on it as we think is important.

Unless we can demonstrate that there is significant reason for looking at that phenomenon or including it in the model, it is oftentimes not possible to make the DOE do that independently. They do have constraints on their program, as well, in terms of costs and resources and they do have an obligation to investigate those things which they feel are most important.

If we feel that there is something else that's important and there's a disagreement, there are times when we have to do some work to prove our point.

MS. FEDERLINE: Let me just add, if I could, Dr. Steindler. This gets into the role of what is DOE's responsibility and what is NRC's. We've looked very hard at that lately as we've gone through the identification of our key technical uncertainties. Who should resolve the key technical uncertainties?

But we see a complimentary role here. As regulators, it's up to us to really probe the key -- the vulnerable aspects of these key technical uncertainties and make sure, as Bill says, that we have an understanding of the real critical aspect of the uncertainties, so that we can probe whether DOE is doing the correct thing. We have to have enough of an independent understanding to make sure that DOE is doing the right thing.

So in some senses, it could appear that we're overlapping and some people's judgment may be different than ours as to what really are the key aspects. But what we're really pursuing is focusing our efforts on the important vulnerabilities which we see are key for performance to make sure we understand and can feed back to DOE.

MR. STEINDLER: I think that is helpful, Margaret. Thank you.

MR. OTT: I can give one other example. This was many, many years ago, back when the basalt waste isolation project was still en vogue, at which time general corrosion was insisted by DOE as the primary failure mechanism for the waste packages and they did not want to worry about other failure modes, just localized corrosion. It was our research at Battelle Columbus that essentially demonstrated that pitting corrosion could lead to much more rapid container failure and that that had to be considered as one of the likely failure modes.

Again, there was a technical disagreement amongst those and we really couldn't get very far until we made a scientific demonstration that the phenomenon had to be considered.

MR. POMEROY: Bill, can I interject something here? First of all, I want to go back to something Margaret said. Margaret, the concept of important parts or key parts of key technical uncertainties is interesting to me. I've heard comments from the staff that say the KTUs, as defined, as so broad that they would justify any research.

Now I hear you saying that there are key parts of these key technical uncertainties. I would like a reference, if possible, to where I can find the listing of the key parts of each key technical uncertainty, if you could provide that

MS. FEDERLINE: It might be helpful to understand where we are in the process, and Bob Johnson can jump in if he prefers. We have just defined the compliance determination strategies for the first time, where we have been through the regulation and we've made our first pass at really identifying key technical uncertainties.

The job for us in this fiscal year is to do an integration analysis where we look at overlap among the uncertainties, how one uncertainty relates to another. There may be some shifting in terms of how we define the uncertainties, some differences in focus as opposed to the way we wrote them down the first time.

So as we evolve this systematic look at what we believe are the key technical vulnerabilities to the whole system, from our perspective, as we iterate this, as we get insight from performance assessment, the focus of those activities is going to become sharper and we're actually going to try to delineate what is NRC's responsibility in those KTUs and what is DOE's responsibility.

We're not quite there yet. We're working and as we refine the user needs each time we revise them, we're trying to put more emphasis on what we believe NRC's role is and what DOE's role in this is. But it's an evolving process and if you said could I give you a list today, I might be able to find an example in one or two areas where we've pushed the rim a little further and we're a little closer to defining what NRC's role is.

But if you'd like, we can try to find you one or two examples. It might be better to let us get through the integration review and then send you the integrated list of KTUs, whichever you'd prefer.

MR. POMEROY: No. I think that waiting until you're at a better point certainly is the appropriate move. I would just strongly encourage you to get to that point, because the key technical uncertainties blandness has bothered me in the past and it would be nice to see those issues come more sharply into focus so that we could concentrate in a better way.

MS. FEDERLINE: We agree.

MR. JOHNSON: I'd just like to add something. This is Robert Johnson. Actually, answering all these questions, we'll probably end up giving my whole talk in a few minutes. I appreciate that. So I will be getting into this a little bit more. But I would just like to add that very soon, when we publish the license application review plan Rev. 0 here probably in May, that will contain the current list of key technical uncertainties. As Margaret has said, we're going to be working on that list this year in the integration review. That will be refined.

As anybody can understand, I guess, when groups of people, different groups of people come together to identify some technical problems, you're going to have one-person splitters and some things are going to be a little narrower, some are a little broader, and that's one of the purposes of the integration review is to get a little more consistency and a little more focus after looking at the whole set, which we haven't had that opportunity to do yet.

MR. POMEROY: I strongly encourage that. Anything that can be done to sharpen those key technical uncertainties would be useful. I had one other thing I wanted to say.

I think you said at some point that the purpose of the natural analog studies was to enhance the understanding of the NRC to the point where we could review a license application. That gets me back to the same point again. One can justify any number of analog studies under that umbrella and you could certainly spend many millions of dollars doing that. We don't have that luxury.

I was hoping today that we would get an overview at some point that would tell us how each of these analogs that you are studying, that you have selected, how they were selected. What regulatory question are you answering? What is -- I can't say it better than an overall picture of where the focus of the research program is going.

I think you mentioned that there were three analog studies that were terminating, and correct me if I'm wrong on that. I wonder if you could just tell me what they were again, because I missed one of them, I think.

But I hope, to second Bill's earlier comment, that today, at some point, we will hear exactly what the results of these individual studies were and how they fit into a regulatory picture in a more focused way than simply enhancing our understanding of the regulatory process and the license application aspect.

MR. OTT: We will try to do that. The extent to which we're successful, we'll have to wait for the day to unfold. The three projects were the Valles Caldera. That project, actually, in terms of the research involved, ended a year and 18 months ago, but it's taken a while to get the final report and all the data analyzed and sifted through. Linda is just now finishing the final review on that. So a report should be out soon.

The ARAP project officially ended last year and the Toledo workshop was the -- there was a session there which was supposedly lessons learned and a report of what had been done at ARAP. There's a whole day's worth of proceedings. I believe that's the report you just got. The Toledo workshop report is the one that just came out. So there should be a major section in there on ARAP.

The actual final reports for ARAP have not all been issued. There's a series of 16 volumes, which include the data, the analyses, the whole smear of what has been done at ARAP over the years.

I say it's over, but I want to qualify that because there is an aspect of it that we won't be talking about here today because it's not high level waste related. We are actually funding some continuing work on some of the ARAP data, but in the low level waste program, because it's looking at transport in soils as opposed to transport in rock or that kind of thing.

So the actual five-nation ARAP project is over. There is some interest from Jaeri, our Japanese counterpart, to enter into another international agreement to share the results on the low level waste studies that we're doing. We're doing the low level waste project unilaterally. It's not part of an international effort right now. There is one proposed, but it will be much smaller than ARAP, just a very, very small project. We have specific objectives in mind for the very small low level waste effort we're doing there.

Another thing that is coming to an end is the Oklo project. It has, I believe, one year to run. Our two projects in there, one -- well, they have both officially ended. They were both funded under low level waste. We currently have under review a request for extension of one and a request from the other to do a different piece of work. The one project was looking at bitumen, which was a proposed solidification agent for low level waste. That's why that work was funded under low level waste.

But there's no longer any interest in bitumen as a solidification agent. So we're just not going to fund the bitumen work anymore. That particular investigator wants to continue, so he's proposed something else. That work is under review.

MR. STEINDLER: There is a big difference between the final report and assembling the scientific data that has been learned from an analog study. The thing that I think I hear my two colleagues over here looking for, and I certainly share that view, and that is the translation into a functional application to what your customer is needing. It is that translation, I think, that also needs to be included.

MR. OTT: When Linda speaks, she's going to talk a little bit about both the Toledo meeting and the NAWG meeting coming up this fall out in Albuquerque -- Santa Fe, excuse me. Same state -- in which, partially through our efforts and partially through an interest in the international community, there's been a movement in the natural analog working group to try and make a closer connection to the performance assessment.

We are also doing that independently within our own program. So there is general movement in the direction of trying to make all of this work be viewed as it contributes to the ultimate product, which is more confidence in the ultimate decisions that are made in the regulatory programs.

In terms of what gets funded and when, when you talk about large programs like Oklo and Alligator Rivers, it is quite often determined by external events which are beyond your control. For instance, when the Alligator Rivers project was first proposed to us, we had to look at it in terms of all of our other resources and, at that time, a time schedule in Australia which would have made that the next uranium mine which would be excavated and destroyed.

So when you have an opportunity with the right place to find the data that you're looking for and it won't be there in three or four years, it sort of elevates the priority in which you look at that work as opposed to other work. The same is true of Oklo. The French began the current phase of investigations at Oklo when it was determined to reopen the ore body and mine it. They decided that it was an opportunity that they could not forego in terms of doing further investigations.

The original investigations at Oklo did not collect the kind of data that would have resulted in good information for doing things like model validation studies. They were done ten years ago. They were largely qualitative. There was not good information on location. There was no hydrologic data. They were very, very cursory investigations that were done of the Oklo ore body when it was originally discovered.

This investigation by the CEA has been much more detailed and new ore zones -- not new ore zones -- new reactor zones that had been discovered since the project began at Okelobondo and Bagonde, which is actually about 25 kilometers south, have provided new opportunities for them to actually characterize zones before they go and mine them.

So both Oklo and ARAP were targets of opportunity. Now, it turns out that the politics in Australia resulted in the fact that they have a free mine policy or they did until the third mine closed. Now they have a two mine policy. So ARAP still hasn't been mined. But a the time, we were actually looking at the mining as a further opportunity, because the plan for the mining would have created a vertical face where they could have gotten extremely detailed measurements on one aspect of the ore body.

So there are pros and cons, but timing is sometimes critical in these projects. Valles Caldera, on the other hand, was a project which we initiated. Actually, it was originally called the Inuo Dome natural analog project. We were looking for something that would give us an insight into one of these contacts. It turned out that the original site was not suitable.

The investigator -- and Linda can talk about this later, if you'd like, and she'll explore it further with you -- came up with the Valles Caldera site as an alternative and we elected to go ahead with the project.

The other ones on there, Pena Blanca and Akrotiri, are probably the only two projects that I can name that were actually the result of a very wide and systematic search of potential natural analogs and their relevance to our particular site at Yucca Mountain. English can talk to you some more about that later. The first report out of that project was a literature search and, as part of the literature search, a site selection screening. They went through and they looked -- they investigated a number of sites.

I went with them on one of their investigations when they looked at sites up in northern Nevada at Virgin Valley and the McDermott Caldera. After all of these investigations, they selected Pena Blanca and Akrotiri as places to be looked at for feasibility studies. They went down and they did their feasibility studies, did preliminary analyses, came back and said, yes, the potential there is for -- there is good potential there for getting information that will be of value to the program.

Then we elected to go on further with the Pena Blanca and Akrotiri studies, and English will give you the detail on those later.

MS. KOVACH: Dr. Hinze, may I add one thing to address Dr. Steindler's question about transferability of the results? In the past, Research has done research summaries of the findings from our projects and I suppose that that should be done for the three projects that are ending. The Research summaries transmit the important information from these projects to Licensing.

So without committing myself to it, that has to be done. Secondly, we are planning a workshop, which we'll talk about later, between the NRC and the CNWRA staff that are working specifically on the analog project and our IPA. The purpose of that workshop will be direct -- we will be using data from the Pena Blanca site and modeling it in a performance assessment type of exercise.

So we will be explicitly integrating those results during that workshop, and that's planned for June of this year.

MR. HINZE: Thank you, Linda. I would like to go back, too, to one of Dr. Steindler's points, and that is the one regarding model validation, Bill. You referred to the document of the center and I would like to refer you to Page 27 of that document and an article by Budhi, Sagar & Wittmeyer on analogs and performance assessment.

I would like to ask if this is -- what, in your belief, is the sense of the NRC Research on this. This is a discussion that deals with whether one should have broad analog studies or focused analog studies, something that you already brought up. The report on McComby recommended that analog studies not remain focused on -- and this is the NAGRA group -- on narrow issues, but adopt a broader perspective.

Then the statement is made and I'd like to ask you what is the reaction of Research to this. "In the context of model validation, we believe that data from natural analog studies will have only low to moderate validation weight." Now, the way I interpret that is they don't think much of natural analog studies for model validation. That's a polite way of putting it.

This goes back to Dr. Steindler's question about the use of natural analogs in model validation. This is a document of the center, with the head of Performance Assessment making this statement about model validation. Is this also a policy of RES?

MR. OTT: A policy?

MR. HINZE: Is this also the belief of Research?

MR. OTT: Let me address the policy statement. The document is not a policy document of the Commission.

MR. HINZE: I understand.

MR. OTT: As long as you've got 20 people in a room who consider themselves to be experts on natural analogs, you'll have probably 20 views on what any individual analog will be worth in terms of model validation. Norm is going to address this specifically later. I see him sitting at the table wanting to get up now.

MR. POMEROY: Stop biting your hand, Norm.

MR. OTT: Let me make the observation that it depends on the system and what you're trying to get out of it. I listed up here before in one of my first viewgraphs possible uses of natural analogs. I think I avoided actually saying model validation in that particular list.

MR. POMEROY: Yes, you did.

MR. OTT: That's what I call wisdom I guess. Let me clear it up again.

[Slide.]

MR. OTT: Confirmation of data. If you don't hear it model development, if you look at effects of a couple of processes, you're looking at there to a certain extent at things which can be quantified. I mean a lot of people, when you talk about validation, talk about quantification.

Does this tell me that I am plus or minus five percent? I'm not going to tell you that, yes, this model is going to tell you I'm plus or minus five percent. It may help me define the range of scenarios that I should or should not consider.

It may help me balance the probability envelope and say that I only need to consider volcanic events which are such and such a magnitude or less. It may tell me that the types of consequences from a particular volcanic event in this system are going to be less than a certain amount with a certain probability with some kind of uncertainty to it.

But I think you're talking about a matter of degree, not of can you or can't you. It is what you can get out of the systems and whether you have any other choice to get information on these systems. I think a lot of our problem lies not in whether I can or cannot, but how well I can and, in the final analysis, the determination is whether I have built a strong enough case that people have confidence that we have done the best job we can and the probability of safety is high.

Norm, you want to give us a better answer?

MR. EISENBERG: I'm Norman Eisenberg from NMSS. Let me start off by saying that I think there probably are more disagreements than these on validation than there are on religion.

[Laughter.]

MR. EISENBERG: In this particular case I am not sure that I would agree with Sagar and Wittmeyer entirely. I believe there point is for the natural analogs of limitation of the use of the information for validation is that you have a great deal of uncertainty about the boundary conditions, and for that matter, the initial conditions. Although, sometimes you have more information about the initial conditions than you do about the boundary conditions over the long periods of time.

The counterargument I would make to that is that if you use field data or field experiments, you are testing on time and space scales, which are very small compared to the ones of interests for geologic disposal of radioactive waste. So you're caught in a bind.

You can use natural analogs, get the appropriate time scales, but the boundary conditions are uncertain. You can use experiments over short periods of time where the boundary conditions are well known, but you're not at the time scale and special scale of interest. My person point of view is that we need both.

We need both types of information in order to build a case for confidence in the models and it will not be validation in the usual sense because -- I'm sorry Dr. Steindler -- I don't think we can do that. We cannot test date models in a definitive way over the time period of interest. We just cannot do experiments for 10,000 years.

MR. STEINDLER: I'm certainly not suggesting that you drag this process on for 10,000 years. It seems like that already as a matter of fact.

[Laughter.]

MR. EISENBERG: Yes, it does.

MR. STEINDLER: Let me simplify your discussion. The chap sitting in the second row of the licensing hearing is going to ask the question about the relationship between the real world and this model that you have put up and unless you are prepared in some fashion or another to give a fairly straightforward explanation to that chap in the second row you are going to have a great deal of difficulty getting the licensing process, you know, even sensibly accomplished.

If it isn't the guy in the second row, it may be the lady professor who has been asked to come and be an expert witness for the opposition who looks at the world in a more microscopic sense and ask the same question. And it is that sense that the analogs, you know in some fashion, have been counted as giving you an aid to satisfying a need.

It doesn't make any difference or not whether you do not know how to do accelerated testing. Everybody understands the problem of doing accelerated testing and that you cannot compress -- you have difficulty compressing one year into a reasonable laboratory study. By the way, Bill, the narrow scope of your lab test is a little too narrow. After all, we have been at it something like a decade about materials and not to be able to helping out on that.

We can argue about the discrepancies and difficulties in both time and space until hell freezes over but there is a basis need of convincing somebody that you understand the real world, and it seems to me, in that sense, I use the term validation and I read the science article that says that you guys cannot possibly, and frankly I had some sympathy with somebody saying it cannot be done.

But that is not the issue. I don't think that is the issue at this point. The five percent number that you are quoting -- you know you're in the wrong ballpark. What you want to know is whether or not you're in an order of magnitude range describing what is going on.

MR. HINZE: The analogs help us determine something about processes, what processes are in effect. But the details, as Norm has pointed out, the initial conditions, the boundary conditions as you proceed through time, we can say something about those but we don't have those pinned down and, therefore, we do have a problem. Yes, sir?

MR. MCNEIL: I'm Michael McNeil from the Office of Research. In defense of Bill, the only people that I know of that have actually had experiments and tests for periods ten years longer were the Corrosion Groups at the National Institutes for whatever they call it now. Now that group has been dissolved and that experimental program is dead.

[Laughter.]

MR. MCNEIL: I would say one think in defense of natural analogs. Twice since I've been in this program, in terms of waste package, the Department of Energy's contractors have begun to use models and when it was pointed out to them that the models predicted grossly wrong results when applied to the archaeological record, they went away and did something different. So there is a direct use for natural analogs in persuading potential licensees not to use certain models.

MR. STEINDLER: Well, Linda and Margaret made that point and I think it is a good point. If you want to sensitize the folks who are going to be license applicants to the fact that maybe they're not looking at the entire scope of what they should be looking at, that is fine. And that may be a fairly decent reason to pursue this kind of work. But, ultimately, in some fashion, you have to answer the question, are you describing the real world?

MR. OTT: I don't think anybody does not realize the scenarios that you mentioned a few minutes ago about the licensing hearing. All too real, and we can expect them. It is not a case of maybe it will happen. It is highly likely that it will happen.

MR. STEINDLER: As Bill Hinze pointed out, what we're looking for is some assurance or some evidence that at least that part of the activities of research are focused on that issue. There has got to be some mechanism of justifying the expenditure of time and effort and spending your time on this kind of thing that relates to the customer's need.

MR. OTT: I hope that what we do this morning gives you -- this kind discussion, the overall discussion of what we do this afternoon, gives you some of the detail to make you comfortable with what we have been doing.

MR. STEINDLER: I think we're looking forward to it.

MR. OTT: Thank you. We have tried to stay away from technical details of the project themselves and go to results and products and how it is used in PA as opposed to details about measurements and that kind of thing. So we hope that the focus is what you want. We did want to give you this forum in the morning to explore more general aspects of what is being proposed. I guess with that we will move on.

MR. HINZE: I think there are a couple of more that we would like to see. Linda?

MS. KOVACH: I would just like to throw out a question for thought. My thought is that we could use data from natural analogs to bound the order of magnitude of a process from process that occurs in nature and then use that order of magnitude as our limits within our performance assessment of what we expect.

In other words, if in nature we cannot narrow the range of a process done to less than several orders of magnitude, maybe we should not expect that we can do that, we can perform this assessment or that our models can do that.

MR. HINZE: That is an interesting concept.

MR. KEN: I think you've been trying to find a slot here.

MR. FOLAND: As an earth scientist who does, basically, laboratory research, all of which is almost always natural and long, have you thought about discarding the term, "natural analog," and identifying all of this research in terms of the objectives, be they geochemical or whatever? And it happens, in my perspective, that what you have put up there for a natural analogs project merely cites a study, which are analogous to a laboratories if we were doing corrosion studies of metal on a real time basis.

Perhaps if you might address that issue, it might help us to say what we might expect from natural analogs is really no greater than we would expect for a geochemical study that looks at the natural behavior of uranium over a large period of time.

MR. OTT: That is a good question and, yes, I have thought about it. I think about it programmatically. We do not fund any of these projects in the segment of our research program called Natural Analogs. The Valles Caldera was funded under geochemistry as if a geochemical analog project. Apache Leap is funded under Hydraulic Research, and Akrotiri is also under the Geochemical Analog Project.

I don't really have a good answer for you. The reason that the term "natural analog" came up originally in terms of waste and is probably almost 25 or 30 years ago when people first discovered Oklo and somebody said we have a natural reactor that is has been buried for 2 billion years. Isn't this the perfect analog of a nuclear waste repository and everybody said yes.

The term become a term of art or something like that, and over the years people thought about it and they thought, well, maybe other ore bodies would also be analogs for a repository because uranium has existed in these locations for years and has not gone away and damaged anyone. Maybe ore bodies ought to be, in general, considered to natural analogs.

Then the natural analog working grew, international interest became much more prevalent in trying to dispose of nuclear waste, and people became serious about looking at it. They realized the long time frames. They said, oh, this natural analog concept is something which could be broadened.

You're right. We could just as easily abandon the term "natural analogs" and just fund these as very specific directed oriented projects.

MR. HINZE: It is too late.

MR. OTT: You could say it's too late.

MR. FOLAND: But, in part, would it be beneficial to point out at the beginning that none of these are, in fact, true analogs for Yucca Mountain or any other site because they exist -- they're too many parameters. They are no true analogs.

MR. OTT: One of the things, a response that I wanted to make to Dr. Hinze earlier and I should have, again the NAWG criteria. NAWG is very serious about trying to determine those things which ought to be done to make certain that analogs are productive, things you should look at, like how well it is bounded in time and space to make sure you can extract some information from it.

You don't want to go into an open system and study it and then find out that you have gained nothing for all of the money that you invested in it. So we have tried to be very specific in terms of the analogs that we look at and trying to make certain that we have objectives that we can achieve and that they are limiting objectives.

The other thing that NAWG has said is that we ought to be looking at process-oriented analogs. We are looking at analogs processes and event, not looking at analogs or propositories. It is a very clear point. We are trying to understand things that might happen in Yucca Mountain, not because this is Yucca Mountain just translated to someplace else, but because the process that might occur at Yucca Mountain has occurred here, and by looking at this process where it has occurred, we may gain insights on what happens if it occurs at Yucca Mountain.

That is, essentially, the philosophy behind looking at analogs. From the point of view of it being too late, perhaps it is too late. Administratively, we can make a decision tomorrow that, no, we don't have a natural analog program. All we have is a process-oriented program. But people will come back and say do you have things that you would consider natural analogs and we tried out the list and said we consider all of these things to be natural analogs.

Whether you do one or the other, I don't know. You're point is well taken about them being process-oriented.

MR. FOLAND: If you take this one step further, there was some discussion about who has the responsibility for doing what. We certainly take one of these sites, Pena Blanca, for example, and let me ask the question because I really don't know the answer to this. What is the DOE doing that if I don't want to use the word "analogy" -- along the same vein of addressing the same issue as a geochemical transport of uranium, what research at DOE is being done at any locality that takes into account scale and time in a geologic context?

MR. OTT: I cannot tell you everything the DOE is doing. Linda stepped out of the room and she can address it a lot better. She would tell you in terms of Pena Blanca that she might or she might not -- we understand that DOE is preparing a proposal to undertake work at Pena Blanca as well.

In terms of ARAP, DOE was a participant in the ARAP Project for the last couple of years with that project. DOE attended the Oklo meetings a year ago. Dave Curtis made a presentation, a proposal to do work at Oklo, but the work was never funded.

They have done work at Cigar Lake up in Canada. They were part of the Pocos de Caldas Project. There is another one, Marysvale. So there are some of the areas in which DOE had been doing work. Most of those are ore bodies. They would be looking at transport processes.

MR. CLOKE: Let me introduce myself. I am Paul Cloke. You may remember, those of you who were here last year, that I came again at the request of DOE from Las Vegas to help our presenter answer questions regarding DOE programs. I would be glad to do that if the panel wishes to have me do so.

For example, yes, we have talked about wanting to get funding going to help with Pena Blanca, but I do not know of any proposal that is actually in the process of being developed. Another point of information that you may be interested in is I have, indeed, been involved with this natural analog video. I reviewed the video as it existed last November. I expect in about three weeks times to go back to Switzerland and review the final versions of that.

There will be two versions, a short version of about 22 minutes. That will be presented as part of the Natural Analog Plenary Session on Tuesday afternoon, May 25th I think it is. Immediately following the plenary, another session is being set up, which will show the longer version, which is a 15 minute version, which we'll have time for discussion and more introduction.

As I said, please feel free to call on me if you want any information on any of these matters.

MR. HINZE: Paul, could you briefly answer Ken Foland's question about Pena Blanca, what DOE is doing in comparable types of studies?

MR. CLOKE: I think that Bill actually covered that pretty well as to what is actually going on. Yes, there is work at Cigar Lake, which is active. We were involved, DOE was involved with Alligator's Rivers and the ARAP Program.

I don't know of any current natural analog study that DOE is doing aside from the Cigar Lake, which as I said, is active. Others have been done. The Maryvale one was done a long time ago and I believe that is totally finished at this point.

MR. HINZE: As is with Pocos de Caldas?

MR. CLOKE: Yes.

MR. HINZE: Thank you very much, Paul. With that, Bill, the agenda calls for a break at 10:00. We are 14 minutes behind schedule, but that is better than usual. With that I will turn it back to you, Margie.

MR. STEINDLER: I would be pleased to call a one minute break. Is that what you're asking?

[Laughter.]

MR. STEINDLER: Ten minute break.

[Brief recess.]

MR. STEINDLER: Let us reconvene. Dr. Hinze?

MR. HINZE: We will turn it over to Bob Johnson. Bob, as I understand it, you are going to be speaking about the SAR, KTUs, and all those good things, how they apply or how natural analogs apply to them.

MR. JOHNSON: Can you hear me with the microphone the way it is?

MR. HINZE: I can.

[Slide.]

MR. JOHNSON: I recall it was about last May that we spent about three hours discussing the systemic regulatory analysis, the SRA, and I was asked today not to repeat that but to focus it, maybe very briefly, just provide an overview of SRA, how we are using that process, the LARP process together with key technical uncertainties, and how that process leads to the development of users needs, and also give you a status of where we are with respect to developing the LARP KTUs and user needs.

I would like to recognize, though, with respect to natural analogs, you will hear probably -- we've talked about a little bit, but you will hear probably more this afternoon on key technical uncertainties and how they relate. I don't believe that you will find a key technical uncertainty about natural analogs.

However, people will say, as they already have, that results of these studies you might well contribute to how the Staff will prepare to review various key technical uncertainties. So I will imagine that the more specific discussions this afternoon will get into the results and how they relate specifically.

[Slide.]

MR. JOHNSON: Again, very briefly, I would like to just summarize what we mean by the systematic regulatory analysis, give an overview here, and what we are really talking about. I have tried to really boil it down a little bit and say that SRA is really kind of a management process. It is a systematic and controlled process that we are using as a Staff, together with a center's support, to develop our regulatory documents.

I said it is how we are using -- it is how we are managing our work. We are using it to identify our work, prioritize our work, help integrate it, control the development of our work, and, finally, how to document it.

That really amounts to how we are managing much of our work.

Last May, I think the focus of my talk was more on the license application review plan development using SRA. I just wanted to point out that there is more of our regulatory program that we are using in this process. This process, in particular back in 1990, the Center identified regulatory institutional uncertainties with respect to 10 CFR Part 60 using the process.

Then, of course, over the last two years or so, it will be ongoing, we are using the process to develop the license application review plan. But we are also, on the third bullet here, we're also planning on using the process to revise the Staff's draft format and content regulatory guide for the license application.

So I just wanted to point out in opening that it is a process for how we do our work and, although, a lot of it is focused on the license application review plan and how a lot of other technical work feeds into that, we have used it and will continue to use it in other areas of our programs as well.

[Slide.]

MR. JOHNSON: Now, I would like to look more specifically, just summarize for you some points about the development of our license application review plan. It is important here in this talk because the LARP, the license application review plan, helps focus and link our research work and our technical assistance work like an IPA in modeling helps link that work to our job, our eventual job in reviewing the license application in a more timely way, our reviews of our prelicensing reviews of what DOE is doing that will eventually form a basis for DOE's license applications.

So we are using it as a Staff to help integrate the programs work, the technical work, and research and technical assistance in order to prepare us to do our reviews. As you might remember, I said that LARP was made up of 97 individual review plans. Each of those 97 review plans as we are preparing them, we prepare them with two steps basically.

The first one is what we call the Compliance Determination Strategy. Compliance Determination Strategy is made up of two parts basically, the review strategy, which goes into the review plan, and that really simply describes the scope of the Staff's review for that particular part of the review plan, what type or level of detail the Staff will decide to use and the basic approach to the review.

In the type of review, there will be some identification or discussion about whether research is needed or whether some other technical assessment capability, like modeling, might be needed to support the Staff's review.

Now, the CDS also includes a rationale that supports the strategy. That rationale includes what we have called key technical uncertainties, which I will define again in a minute. Included in the rationale, though, for these key technical uncertainties, if the Staff has decided that research is important to address this key technical uncertainty, then a specific rationale is prepared for why NRC needs to do this research.

So we are trying to not only to identify and focus on those areas of key technical importance, but also what parts of them will need research and our reasons for that.

MR. HINZE: Bob, is the research strategy document then by both for identifying those elements which will involve research?

MR. JOHNSON: You mean the research program plan? That is linked to our strategy. We have developed an overall review strategy, which includes a strategy for research, and that research program plan is based upon that broad research strategy. That is linked into our program principally by way of these key technical uncertainties.

As I go through my next slides I will try -- that is what I was going to try trace and map out. If you have further questions after I get through those slides, we can try that.

MR. HINZE: Thank you.

MR. JOHNSON: The second part of developing the license application review plan would be, again, for each of the 97 review plans the Staff will develop what is called a compliance determination method. That document, basically, provides the remaining parts of a review plan, that is the review procedures and acceptance criteria, interfaces identified among various review plans, for example, evaluation findings, and last again, rationales for the Staff's choosing certain procedures or methods and acceptance criteria.

I don't want to go into this today because the CDM is in much more detail but it is not that relevant to the topic today except for the first part I think. In hearing the discussion this morning and trying to draw relevance, you know, for the result of research and how they fit into the Staff's needs, I thought it might be useful to say that part of the plan that gives procedures and acceptance criteria that is what we need input to.

I can imagine that various research projects, the results of research projects will, of course, vary. But they may provide a methodology for the Staff to use in doing its review, which will be documented here in the review procedure.

Another kind of research, that which had light, would help the Staff understand better so that they can come up with their own review criteria to review what DOE has done. So having a better understanding of the condition or process should help the Staff write criteria based on their own independent work, in addition, of course, to the work that DOE and the technical community is doing.

But taking all of that together, including our own independent research that should result in and should contribute to being able to write acceptance criteria in the review plan. So when people say what is the link you can say it helps us review better. It helps us have a better understanding and a better way to evaluate to what DOE is doing.

I'm trying to put it into tangible terms with respect to the license application review plan. That is the tool that Staff will use to guide us. Eventual license application review, but currently, today, it will help as we start getting parts of it written. It will help the Staff review and prelicense what DOE is doing today. So that is one way to generally describe how any research might be factored in.

Part of our strategy, overall strategy, as explained in our review plan and as explained in the research program plan is to better link the research projects to the key technical uncertainties which are a part of various review plans and LARP. So this is kind of a general summary of how we are trying to link the program pieces together so that we can have a better integrated program.

MR. STEINDLER: I think the last statement does not seem to be quite right. What you have described, I guess, could be termed as obvious. Clearly, you need to have, if you're going to have a research plan which is rationalized on the basis of some input to the customer and you being the customer, clearly, there has got to be some transfer of information and concepts.

But he said this is how we plan to do this. But you did not say how you plan to do that. I guess what I'm looking for is not just the obvious statement, namely, that you're going to be using research results. But I would like to see a little more explanation on how you intend to acquire the results, how you intend to provide for yourself some way to describe, to understand the impact of the research and the questions before you either as KTUs or the questions that are before you in some other fashion. What is the mechanism?

MR. JOHNSON: I will try to answer that a little bit here in a couple of ways. First, the results of research are documented in various reports from the Center from the research projects, and as I understand it, the semiannual reports. Now, to get a stronger feedback from research results tied to the key technical uncertainties we'll present results in a context of how those results are progressing to address these various key technical uncertainties.

MR. STEINDLER: That has not been done in the past?

MR. JOHNSON: We have just begun in the past year to identify key technical uncertainties within the framework that I am describing here. So, although, results have been documented before in setting up this program of linking research to the license application review plan by way of key technical uncertainties, now we have been revising the products so that the results are focused exclusively in that direction as well.

So it is just part of implementing the program. It was not done before because key technical uncertainties did not exist before. So we are in the process of implementing this program and trying to make the links and the feedback more explicit so that they can be used that way.

MR. STEINDLER: When would I be expecting to see a semiannual or quarterly report or monthly report from the Center that relates results to specifically the customer need? Coming up in the next month, coming up in the next six months?

MR. OTT: The next semiannual would be due after June I believe.

MR. STEINDLER: We get semiannual reports and topical reports at the completion of significant tasks. The next semiannual you would see July to August. It takes about 30 days to 45 days to process them.

MR. JOHNSON: I think I can -- the second answer to your question is as we develop compliance determinations strategies and as we plan on conducting or developing these compliance determination methods they are done oftentimes with a team of people from NMSS and the Center. Oftentimes the Center people that are doing research as well. So having that team group effort is a way that you are involving the people that are doing the research with the people -- they are the same people in some cases that are writing criteria and the review plan.

So their results are just direct because it is sometimes the same people who are doing the work. But, in fact, that is how we are anticipating writing the CDMs because that is how we wrote all of the CDS this past year. It was a combined effort of our research people, Center people, the particular technical disciplines that were needed.

So the results of their work were factored into, and in this case for CDSs, the key technical uncertainties that the group felt existed based on their experience. So it is another way when you talk about how do -- what is your process? How are you going to get the results of research actually into the LARP? People who are doing the research will be contributing to writing the LARP. Does that help?

MR. STEINDLER: Yes. Linda made a comment this morning before the break about the existence of research summaries that apparently transfer information from I assume the project manager of a particular research program to somebody. I assume it is targeted -- NMSS, you have mentioned that so far, and that strikes me as an interesting and useful way to do it. Where does that fit in?

MR. JOHNSON: I think you need documentation, whether it is called a research summary or whatever. It is output. Go ahead, Bill.

MR. OTT: The research summaries a vehicle that we had used in the past years. We have not done many in recent years because in the transition period over to the Center we did not have a lot of interim projects that were significant enough, in and of themselves, to generate them.

What we generally do is when a project had been completed or some major phase of a project had been completed with a significant result we would try to digest that material, assess its relevance to the licensing program, and send that research summary over to not only the NMSS Staff but the management.

It was a management information tool as well as a Staff information transfer tool because sometimes the volume of information that impugns on the licensing staff does not allow them to read everything to the detail that you would like. So we tried to focus on those aspects of the research that we felt were of significant impact.

I think the Center's program is maturing to the point where that would be a useful tool. On the other hand, the Center is so integrated into the licensing program that since the Staff works on both licensing and research it is probably not as important of a tool as it used to be because we had to have a transfer in the past because our contractors were not as closely integrated into the licensing programs.

MR. STEINDLER: That leads me quickly and appropriately into my other question. Your focus is based on the KTUs. Who determines those?

MR. JOHNSON: The process we have used this past year was a team was established that included the important technical disciplines for a particular review plan. Those people may have come from NMSS research -- our research staff and the Center. The technical group discussed not only the review of the particular requirement and the regulation, but what are the key technical problems with respect to demonstrating compliance with those particular requirements.

So the team came up with the key technical uncertainties, which then were reviewed by our management here and the Center management. So we went to the process of team development and then review by management.

Any key technical uncertainty, because of its implications, its importance and implications on the program was reviewed up through division management and the High Level Waste Division.

MR. OTT: I would like to add one thing to the general process discussion that we are having here. This diagram that Bob did not bring with him, but which was used the last time that we briefed the Committee, essentially showed the LARP process and the KTUs, the user need research program limitation, and the analysis methods in IPA, sort of a loop.

We've had comments from some people that did not like the loop because it did not have an output. But the important part of the loop was the fact that is organized, to a certain extent, on a budget process. Every year we have to go before committees to justify research in the

April/May time frame. So to a certain extent, the process for annual reviews and updating in the KTUs are built into the way that the budget process is done.

Now, we have the coordination document, which is Appendix C to NUREG 1406, which describes the coordination that we supposedly go through each year. As soon at the KTUs, the first iteration, is through, then we will begin doing this on an annual basis.

Now the question that begs is the fact the research needs do not occur on an annual basis. Information is constantly developed. We acknowledge that when we were putting this together and specifically made provisions for a recommendations to be floated up for new critical user needs as they occur and when a Staff member sees something of significance he brings it to the attention of whoever is in charge of that particular KTU development program and they meet on it and make a decision of whether something should be done immediately or whether it can wait for the revision of the KTUs so the review of the KTUs in the following budget cycle.

So we have got a coordination program designed for at least giving us an annual update. Research information sometimes doesn't even flow on an annual basis. Sometimes it comes a lot slower than that. At least on an annual basis, then if something comes up sooner than that, much more quickly, a mechanism for getting that into the user need process.

MR. GARRICK: I want to follow up Dr. Steindler's question on KTUs, where they come from. Am I to understand that they, basically, come out of a committee process?

MR. JOHNSON: They come out of a committee process, but the committee process is following procedure that uses criteria to help that committee makes its decisions, make its judgements. Those judgments are reviewed by management. Eventually, the judgments that people are making now will be further confirmed in the future as we get more results from iterative performance assessment.

What we have said before is that you have to understand that this is an iterative process. We are just beginning and we have our first attempt at identifying KTUs that will come out this year from this process. As Bill was alluding to, annually we will revisit those, based on information that we get, new information either from IPA or research or what we've learned from DOE's program.

So there is a lot of judgment in there, but what we have tried to do is set up procedures. We have set up procedures to guide the committee, the team's judgment.

MR. GARRICK: One of the things that occurs to me, and I am new at a lot of this -- and you finally mentioned it -- performance assessment is a natural vehicle, a natural mechanism for getting contacts to issues, and whether they are uncertain or not is not nearly so relevant as to whether they are key. So the process of establishing importance seems to be a process that does not lend itself too well to a committee process. I was just very curious about the mechanism.

[Slide.]

MR. HINZE: Before you remove that last one, I would like to ask a question if I might about that.

[Slide.]

MR. HINZE: That is, I did not understand the level of detail t[illegible] you get to in the CDM. Does that, for example, refer to any of the natural analog projects? Does this refer to Pena Blanca? Would this refer to Apache Leap for interfaces for procedures?

MR. JOHNSON: I may not be the best one to answer that specifically, but I think it can give the Staff insight on how to address certain technical problems, criteria on how to use natural analogs. I think that question -- it is a very specific question. You can ask some of the technical folks how they are planning to use the results.

MR. HINZE: Pardon me for interrupting, but before you left that, we don't have a field for what really is included in this other than these bullets and it makes it very difficult for us to evaluate it in terms of our mission.

MR. JOHNSON: I will be honest with you. When we are developing the LARP, it is exploratory for us too, and the first version that will come out in about a month here contains two CDMs. At least it will contain the results of the CDMs that will give the complete review plan.

One is in the area of quality assurance and the other is in the area of the evidence of volcanism Akrotiri. Volcanism -- that is potentially one of the adverse conditions. That is our first experience. That will give insight to those who will be reading it to get a feel for what a review plan, what a CDM with review procedures and acceptance criteria look like, at least for that example anyhow.

But in the course of developing that -- and I think that it will be true for every different topic that we work on -- it is exploratory. People are saying, now, how do I write acceptance criteria for evidence of Akrotiri activity or some other geochemistry potentially adverse condition? And then the question will be how can I use the relevant -- what is the relevance of natural analogs to this particular review plan?

If there is relevance, then what criteria can I use or develop or do I need to develop to review this particular area? So a lot of it is until we start working with some of these areas it is very difficult to predict ahead of time exactly what you're going to do.

MR. HINZE: The status of the CDMs? There are two that are coming out?

MR. JOHNSON: Rev. 0 will continue two CDMs as an example? It will contain 90 for our strategies for virtually the whole review plan. We'll have strategies developed and then a full review plan for two will continue all of this information. That will give us all an insight as to what this product -- what we are envisioning in this product, which helps, in turn, try to envision the output of research and modeling and how that should contribute.

MR. STEINDLER: I've got a different picture from what I think you're trying to convey. Let me write the picture for you and see where the problems are.

KTUs are set by a committee. It apparently includes NMSS, and I don't know much about the impact that NMSS folks have. It also includes research and the Center, and they identify the KTUs whose resolution is going to be done by research and the Center.

MR. JOHNSON: I will speak to that in a minute.

MR. STEINDLER: Some would view that description as incestuous and that poses both an administrative problem and I think a resource problem. Can you correct that?

MR. JOHNSON: I can say that the LARP development is a responsibility of NMSS, and when I say that the KTUs and the review plan for that matter -- but the KTUs are reviewed by NMSS management and approved by them. That, to me, is the control. Now, I think it makes sense to use the technical expertise of that is available to us at the Center or at research and/or on NMSS Staff.

Any of these meeting people sitting there on a lot of different views expressed and sometimes different views, and in the end if there is a different view and this is laid out in our procedure, the different views are discussed with the division management at the time of that approval with respect to the key technical uncertainties or not.

So I guess that is how we are controlling that process. We are the ones responsible for doing the reviews and developing our review plan. However, we are using the insight and the experience, the views of our technical people. However, the approval is in NMSS, at the division level.

MR. STEINDLER: If Bill will permit one other question, and that is -- one comment and then a question. The comment is that there is an enormous amount of work being done that eventually shows up in the literature, and if you track the literature on high level waste management in its entirety, there are some very interesting things that are coming that it strikes me that both the folks who are doing research on a particular topic as well as the NMSS people ought to be quite current on in order to use that. Who in NMSS does that tracking of the literature?

MR. JOHNSON: Each Staff member responsible for their part of the review is responsible for understanding the results in that technical area. They either have to understand that or they are also working with their contractor at the Center, their counterparts at the Center, to understand the current developments, whether it be DOE's developments or other parties in their particular technical areas.

MR. STEINDLER: So these folks read the abstracts for example?

MR. JOHNSON: I would assume. Part of the procedure that we have is that people need to come to the table and develop their part of the review plan with the appropriate, timely technical literature, understanding of technical literature.

MR. STEINDLER: One other quick point. The other point is there is a large agency whose headquarters is in Germantown that is working on a program somewhat similar to yours, only a bit larger. They clearly must have identified things similar to what you call KTUs. My question is what information does NMSS or anybody have on the relationship between the KTUS that you folks identified and the things that are important to the Department of Energy?

MR. JOHNSON: What list are you referring to?

MR. STEINDLER: I'm not referring to any particular list. If you want to know what they think is important, you just look at their program. What kind of relationship is there between the things that you have identified and what DOE thinks is important?

MR. JOHNSON: Our Staff for years has been involved with following DOE's program and reviewing their documents. Part of what they need to be aware of when they prepare this part of the review plan is DOE's ongoing program. So that is part of the process I guess.

I can say that our technical people need to be knowledgeable about what is going on in their field relative to that particular review plan.

MR. BRADLEY: I'm with NMSS. John Bradbury and I were both involved in developing the compliance determination strategies on the geochemical issues and we were involved in writing seven compliance determination strategies between the two of us. We coordinated with a gentleman at the Center and with research in doing that.

There was much discussion over the period of several months that went into not only organizing our thoughts about what the rules stated, but also in terms of what was really important and the Department of Energy coming to us with a license application, what we would be looking for.

We spent much time reading the site characterization plan to get a sense of what their thoughts were. To be important, we kept track of what is current in the literature, as well as spent much time in trying to think about where are the holes in our understanding, and then coming out in PA.

So it was not the sort of thing that was decided in an afternoon as to what a KTU was. It was over a period of several months that we spent writing in the individual KTU. There was much, much discussion that went into that. John, you might want to elaborate on that.

MR. BRADBURY: It was a relatively painful process because we were trained as scientists and we are learning, however, to be regulators. We had to go back and look at the actual words and dissect those words and try to interpret and understand what was intended when those words were written. It was an interesting process, very illustrative.

We came up the -- we approached the problem from a different viewpoint than what we normally do, and I think that we found some things that were surprising to us.

MR. STEINDLER: Thank you.

MR. HINZE: I think from where we are at this point, John Garrick asked a question, and you were about to answer it. Can we go back to the question again, moving off of this transparency, and I apologize again, John. Well, we still have this on.

[Slide.]

MR. GARRICK: It was all relevant. I am in my naive way trying to always look at these things in terms of the connection of what you are doing to the goal of offering -- providing a license for a repository. The activity that comes closest to correlating all of these inputs and knowledge basis and whatever, at least the activity that I have seen that comes closest to bringing order to some of the perceived chaos is the performance assessment activity.

So when anybody talks about key technical issues, I am looking for a couple of things. One is what does it have to do with the underlying requirements for getting a license and, two, how did it come about? What process was employed in establishing it and earmarking it as a key technical issue, especially given here we are talking here about technical issues as opposed to other issues, such as process or administrative or what have you?

So I will keep harping on that, I guess, until I get more educated and realize that it -- that everybody else has understood it all the way and I'm the only one who does not.

MR. JOHNSON: The reason I put this slide up and I was about to answer your question was it gets to the real brief summary. Granted, ask me what we mean by key technical uncertainties, I have tried to just paraphrase our meaning here, but we have procedures that define what key technical uncertainties are and give the Staff criteria to guide their identification of them.

But in simple terms, our technical issues that are most important are repository performance. One of our criteria is you can have lack of certitude in something technical. Maybe you don't know what kind of method is needed to test for something in the field or analyze it. Or maybe you just clearly do not understand a particular process. So you have a technical uncertainty.

But the criteria that test are asked to make it key as to whether it poses a high risk of noncompliance with one of the more Part 50 performance objectives. So we are doing two things by applying that criteria. One, we are tying it into the regulation so that it has relevance to demonstrating compliance with the regulation and, two, tying it to the performance objectives where we are tying it into repository performance.

That is the test as to whether a technical uncertainty is key or not. And let us be honest. The first cut we did this year is based on Staff's judgment. Some of that judgment may have been based on results of iterative performance assessments that DOE has done to date. However, it is still passed down to judgments based on people at this point and time, that the intent is to -- maybe Margaret or Norma want to enter this -- but the intent is to evaluate these key technical uncertainties using IPA in the future.

However, that is the future. Those are future iterations. We have to start somewhere. There was a real value, in my opinion, just to start making judgments, to get the Staff thinking in the perspective of the regulation, thinking in the perspective of what is important to performance just conceptually, and then you can go back and you can test that with IPA and see if you are more quantitative results will help support that initial judgment or not.

MS. FEDERLINE: I just wanted to add, we have to remember where we are in the process. We are just completing Phase II of our iterative performance assessment. The focus of the first two phases have been to develop the Staff capability and get the methodology to a point where we can actually use it and apply it in a regulatory program.

I think Norm and I are comfortable that we have reached a point so in Phase III we have identified a task that is actually going to review the KTUs. Probably not all the KTUs because of limitations and what we able to do, but beginning to look at the significance of the KTUs to try and validate our own judgement.

The SRA allowed us to organize and systematize our thinking from the perspective of regulators, and now we're going to bounce that judgment off the performance assessment analysis and see if our thinking agrees with what we are finding from performance assessment.

So a lot of this has been dictated to us from what tools were available at the time. But that is, at least, our thinking for the next phase.

MR. JOHNSON: It is not only what tools, but as John Bradbury was alluding to, this was a major piece of work this past year just to look at the whole regulation, the whole spectrum of what is covered in the license application review plan and go through it systematically. So by the sheer magnitude of that work, we are biting off pieces as we go and, hopefully, getting, refining, and improving as we go.

MR. GARRICK: Thank you. We will be looking in future meetings at your progress.

MR. EISENBERG: Could I just add one thing? Dr. Garrick said something that was a little bit surprising to me. He said that you want to look at the important issues for the system and not necessarily the uncertainties.

MR. GARRICK: Let me stop you right there because if there is anybody that would talk about uncertainty as being important, it would be me. All I am really saying by that is trying -- all I'm really suggesting is that I don't much care how uncertain we are about something that is not important and I would hate to see us implying a process that spent a lot of time fussing around with nonissues because we wanted to obtain purity with respect to the issue of uncertainty. That is the only point I was making.

MR. EISENBERG: The point I wanted to make is that, unfortunately, because site characterization is at an early stage still and because our modeling capability, both DOE's and ours, is at an early stage, we had a great deal of uncertainty about certain aspects of the system. The uncertainties are so great that we do not know how important the issue is.

Perhaps suitable example is the volcanism. It could be if we had all of the data in and had very robust models about the consequences of volcanism, that it might not be important. But at this stage I don't think we can say that it is unimportant because of the broad uncertainties we know to exist in both knowledge base and our treatment of it in the modeling. So we must carry it on, continue to carry it on as a key technical uncertainty.

So these are systems with I think much broader uncertainty bands in general than a lot of the engineering systems where it is a little bit easier to identify what is important and what is not.

MR. GARRICK: I understand that.

MR. JOHNSON: I wanted to point out on this slide the title of the talk of was also using the term "prioritization." The first bullet here just identifying key technical uncertainties that the intent of the Staff was to help prioritize our work and focus on the things most important to do. So I think we share your goal. That has been the attempt here.

The second way we are prioritizing once a key technical uncertainty is identified -- and I am just very briefly the two categories that we put these key technical uncertainties into, and again, they reflect the criteria that we're applying, but it is a difficult judgement.

The Staff has asked to determine for our key technical uncertainty whether it is just merely difficulty resolved or whether they would consider these as the most difficult ones, the ones that will result in a high residual amount of uncertainty even after all of the work people can do is done. So it is kind of just putting these key technical uncertainties into two parts, those that we think we can do something with and those that are going to be the most difficult to deal with.

So that is a very simple prioritization, but based on very difficult judgment criteria. You may hear people refer to these two categories as Type 4 from difficult to resolve to difficult to resolve in Type 5 for the most difficult to resolve, that is reflecting the kind of review that the Staff would do up at a Type 4 as difficult to resolve and 5 is most difficult.

So, obviously, the most difficult ones are the ones that we would consider highest priority. Those are the ones that we say if appropriate, research might be done for these. If appropriate, the Staff's technical assessment, like modeling, might be done for this. I will say a little bit more about that in a minute. But first I want to go to the third bullet.

Dr. Steindler, you were mentioning which ones we might resolve and which ones DOE might resolve. Our view is that it is DOE's job to provide adequate information to address all of the key technical uncertainties in their demonstration of compliance, just as part of a complete demonstration of compliance, and consistent with Staff's rules as a regulator and reviewer, we are not saying that we resolved them.

We are doing enough work, enough independent work, to be able to evaluate DOE's license application. So to turn that around, key technical uncertainties, we are doing enough work ourselves, independent research, modeling in some cases, detail review. Certainly, for all key technical uncertainties, we are doing enough work so that we can evaluate what DOE has done. That is consistent with our role as a regulator.

Yet, it is clearly DOE's job to address these technical problems along with all of the other information that they need to prepare for the license application.

The last bullet here is very important and it may tie back to a question earlier this morning about key technical uncertainties are very broad and you can justify any research for them. Not all key technical uncertainties require NRC research, or for that matter, our technical assessment modeling capability.

Part of the Staff's job in preparing a compliance determination strategy and writing a strategy to review key technical uncertainties, part of the Staff's job here was to say do I feel that I need research? Is it relevant to this particular problem? Can I justify research for this particular problem, given what DOE is doing? Do I need some independent modeling, some other kind of independent analysis, or development of our own conceptual models?

That was part of what the Staff did when they wrote a strategy to review a key technical uncertainty. So, conceivably -- and I'm talking hypothetically here -- you could have for a key technical uncertainty -- let's see. I'm saying the Staff will review, do a detailed review of all of them. But it may choose to do research just on a piece of one or maybe a large piece or maybe a small piece or none at all, whatever particularly is relevant and has been justified in this process. That is a judgment call, too.

But, in any case, what we're doing is we're trying to systematically follow a certain procedure, go through a thought process and evaluation of these problems and how we feel the Staff should address these problems or how the Staff should prepare to review these problems. That process and the results of it are reviewed by our management.

That is how we are systematically organizing our program, identifying the work, and prioritizing that work. Part of that CDS is to write the rationale for -- if we have identified where research is needed, part of our job is to write a rationale, provide that research is needed, given what DOE and other organizations are doing on this particular problem.

Now, I will be honest with you. Part of the reason for the integration review, and I'm getting ahead of myself a little bit, but it was said this morning that we still have work to do this year on key technical uncertainties. The integration consistency review that we are going to be doing this year, that we are beginning to do this year, is trying to deal with a number of things. One, Dr. Hinze, to address your question about the level of details, some of the key technical uncertainties are broader. Some are highly focused. We need to work on that kind of situation and possible focus them better.

Secondly, where rationales are written, we need to focus those rationales as well as we can to have a good justification for where research is needed. So we have the first cut this year and that is all we're saying it is. It is a good first cut. A lot of time was spent and I think the Staff gained a very good appreciation of the job and the nature of the role. But we still have more work to do to refine what we have done.

MR. POMEROY: Bob, I wanted to ask a quick question. At some point, would these rationales for research needed replace at some point in the future the user needs that are established?

MR. JOHNSON: I will just explain in this slide how we are using them. They are not replacing -- they are feeding into identifying user needs.

MR. HINZE: That was my question, too. When can we expect to see these reflected in the research plans?

MR. JOHNSON: I have a schedule here. Good question. I think I answered it and we will see how well that is.

[Slide.]

MR. JOHNSON: The next slide talks about Research NMSS coordination, coordination of research and technical assistance. Actually, when I look at these bullets again, talking it over with you, I want to start with the last bullet here because that as we have talked today I think it becomes a very important one even though we are saying it is an informal coordination.

But really what happens in the writing of the CDS and the writing of key technical uncertainties it is done, as we say, by a team or a committee effort made up of people from NMSS in all cases, sometimes supported by research members and then supported by our Center staff as well. They are working together as a team to prepare the CDS, to prepare the strategy that might include the need for research and the rationale for that research.

So there is, obviously, by working together there is a great deal of informal coordination that occurs right from the start. So that is an important aspect of coordination. Now, if we go to the first bullet here, we have established a more formal process to coordinate NRC sponsored research and our technical assistance program. As Bill mentioned early, we are looking for user's need update annually through the coordination of NMSS and research.

MR. STEINDLER: When you say you are looking for it, does that mean it is going to come in the future?

MR. JOHNSON: My schedule gives the schedule. December of this year is our schedule for updating the current users needs. The process, though, that we are talking about here is, again, NMSS, research and Center staff reviewing the key technical uncertainties, together with a rationale, looking at results from IPA that might be relevant, other research that might be relevant, and results of DOE's program.

Having a review of that material, and then based on that review, revise the existing user's needs. Based on those revised user needs, research would prepare Statements of Work consistent with that.

MR. STEINDLER: I guess I have a difficult time understanding why -- first off, I have a difficult time understanding why that process has not been implemented long ago. Why does it take until December to get this thing cranked out? This is an administrative structure I gather in which you simply change your way of doing business?

Not too long ago, we heard about user needs that were four years old for volcanism. I certainly would applaud the general direction in which you are going, but I have a difficulty believing that it takes in this case nine months or whatever it is to get this thing rolling.

MR. JOHNSON: I will answer that in the next slide, but I just should say that recently reviewing the Statement of Work that came in for a new project, the whole review process, coordinator review process, was focused on key technical uncertainties and writing justifications for them.

So as the need arises for a new project, we are applying this coordinator process as we go. We are not waiting. So in that sense, and then Bill can add to this, I am kind of reflecting a limited view here. But this is the way that I saw the process happening a couple of weeks ago. We have the need and we, basically, apply the logic that I am describing here to that particular instance. So it is not like we are waiting. We are applying it as we go.

MS. FEDERLINE: Could I just add, we've put in place a process. We've tried to thoroughly document our rationale. We've developed user need summaries, which you saw as an appendix to the research program plan. It identifies the user need. It identifies the approach for the research. It identifies the regulatory requirement. We're going to add the KTU to it.

So it is a very labor intensive process and actually writing down the information. And that has been the problem, having the resources to devote to it. We focused all our efforts during this past year in getting the

CDSs done, and there simply were not -- the meetings have occurred. The coordination meetings have occurred.

We can cite several cases in hydrology. We had a thorough review of the research down at the Center with the University of Arizona. In other words, the coordination is going on. What takes time is the actual sitting down and updating -- providing the thorough rationale and justification to update those summaries. So that is the place where we lag and it is simply a matter of resources that we've not been able to get to it.

MR. STEINDLER: Okay. Thank you.

MR. JOHNSON: To tie in the last point that Margaret said, the last point is joint program review, the ones that she mentioned in hydrology and I think there is one in design and tectonics as well.

MR. HINZE: Bob, while you are taking the slide off, let me ask you a point of information under the second bullet. You say review key technical uncertainties. Would that include, under your CDSs including, a rationale for including the key technical uncertainties, but it would also include a consideration of the rationale for research meeting in that process?

MR. JOHNSON: That's right. We're trying to build that rationale for researching to the CDSs, the beginning of the process. That can be used. You have a basis for writing your user need and putting the rationale right in. So, although, we have not gone through it yet, exactly, I think the one a few weeks ago we were directly preparing rationale for user's needs and research directly from the rationale's in the CDSs so that was a very recent experience that we used here, and that is how we used that.

It is working. It is just that when you start something new, you are trying to refine it as you go. That is where we are.

MR. POMEROY: Fine, thank you.

[Slide.]

MR. JOHNSON: We have gone over some of this slide here, but this slide I wanted to give you a status and a schedule of where we are with respect to key technical uncertainties identification and update of the user's need.

We have already said with respect to key technical uncertainties, we spend this past year, FY '93, identifying or developing I should say, first, 94 of the CDS, compliance determination strategies. That process this past year has resulted in the identification of 58 key technical uncertainties.

Those key technical uncertainties will be documented in the Rev. Zero license application review plan, which will be probably -- it is in press right now. We do not have an exact date for publication, but will probably be in the early May time frame. So that is where we are with respect to identifying them. As I've already mentioned though, this year and our plans our by September to have revised those key technical uncertainties, revoking from what I mentioned was the integration and consistency review.

Just very briefly, not to expend much more on it, but these key technical uncertainties were developed by groups over a years period of time and it is important for us, we feel, to lay out all 58 of these and look at them on the table, all at once to see their consistency, level of detail consistency, overlap, you know maybe some repetition, some more problems in different technical areas in a number of different ways that we want to analyze the whole group and possibly that may result in some refinement or changes on those key technical uncertainties.

Also, I have here to identify some additional ones related to performance objectives. These are in the areas of the "ologies," hydrology, geochemistry, with respect to future prediction, what may be needed to address some of the "ology" concerns with respect to each performance objective. So that is an additional task that we're going to be doing later this year. That, undoubtedly, will result in some additional key technical uncertainties.

MR. HINZE: Does this word additional mean that they have not been previously identified as user needs?

MR. JOHNSON: That's right. They have been identified at a very broad level with respect to the performance objectives. However, there is a need to look at a more detailed level as far as, for instance, probabilities of various geological processes happening. How do you determine probability of certain events?

MR. HINZE: Does this mean that the previous 58 are comparable with the current user needs?

MR. JOHNSON: Well, I was going to get to that. It is the last bullet down here. Currently, from what our Staff has looked, both in research and in NMSS, looking at the 58 they feel there is good general comparison between the key technical uncertainties and the user needs. I am not sure if you're going to see one-to-one correspondence in the wording of them, but there is coverage and there is comparison.

However, what I was trying to get at in here is that we have some work to do to refine our key technical uncertainties this year. That will be followed by the process I described earlier. By December of '94, we will be revising the 1990 research user needs based on these refined and updated key technical uncertainties, results of IPA, if we have the additional results from IPA Phase II, and any research from DOE work.

So the intent is to define our key technical uncertainties this summer up until December and then, based on that, revise the list, and then compare them systematically to the existing research user needs and update those needs and the rationales.

I mentioned earlier when currently when Statements of Work come up we are applying the process now. We are not waiting until later this year. It is important, I think, to express that coordination is ongoing and as new work needs to be identified and put into place, and it is done within the context of the key technical uncertainties. Unless there are additional questions, that is what I was going to conclude with.

MR. HINZE: Thank you Robert. That was much shorter than the three hours that we had several months ago. I would like to raise one question that is more directed towards Bill than to you.

Bill, would it be possible for us to have the research summaries that have been prepared on Apache Leap, and for that matter, any analog studies, but preferably, at least, on Apache Leap? Would that be possible?

MR. OTT: I will check to see what has been prepared on Apache Leap.

MR. HINZE: Can we have a yes or no on that?

MR. OTT: I will give you what we have.

MR. HINZE: When you find out you don't have anything, let us know that you don't have something.

MR. OTT: We will give you an answer one way or the other.

MR. HINZE: We would appreciate it. Any other questions then?

[No audible response.]

MR. HINZE: Then let us go to John Bradbury then.

[Pause.]

MR. BRADBURY: This morning I am going to talk about application of natural analog studies. This is a licensing perspective.

[Slide.]

MR. BRADBURY: There is the title. This is what I intend to talk about.

[Slide.]

MR. BRADBURY: This is the outline of the presentation. First of all, I will give background. The background will start from the workshop that we had a couple of years ago and it will include interactions that the NRC and the DOE has had with regard to definitions of natural analog studies. There will be a description and analysis of how natural analog studies are used in 10 CFR 60.

A definition will be proposed in terms of what a natural analog is, what the study of a natural analog could be, and examples will be provided, and then why natural analogs are important.

[Slide.]

MR. BRADBURY: In July of 1991, we had this workshop, the Center and the NRC, on the role of natural analogs in geological disposal of high level waste -- and Linda will talk more about this. What was interesting was in that meeting, that workshop, we brought people from different walks of life, not just people involved in the high level waste program, to show how they used natural analogs in their work. Examples like an economic geology and petroleum exploration, and there are other ones that right now I cannot remember what they were.

But the main thing that -- one of the main results of that that I thought was somewhat interesting was at that workshop the DOE representatives expressed the view that natural analog studies should not be applied to volcanic and tectonic system and that studies addressing concerns in those areas are considered "geoscience as usual."

Following that, it looked like about a year later the natural analog review group, which was (a) group that was -- if I get this wrong Paul will help me out here -- it was a group that was established by DOE to make recommendations on concerning directions taken for DOE and how they would use natural analog studies in the U.S. and foreign countries. And this report recommends that natural analog studies be process oriented and address issues resulting from the perturbation of the natural system, that is, the geologic system, by the introduction of a technological system that is the repository.

And all investigations normally part of site characterization, even when considering comparisons with similar remote sites, such as paleo hydrology, et cetera, should not be considered as natural analog studies.

Well, what we did is we went back to the rule and looked for any indication -- both the rule and any background information. We looked for any indication whether this was the intent of what the words were in the rule.

We couldn't find that intent. That is, the NRC couldn't find that we were intending that natural analog studies were supposed to be restricted the way the NARG report said they should be. So we wrote a letter to John Roberts, recommending that there may be some discrepancy here with regard to this report and our view of what the rule says.

[Slide.]

MR. BRADBURY: The DOE responded to that letter by saying that they saw no inconsistency in the NARG report and 10 CFR 60. They said that the work that is being done will fall just under a different name. That is, it's normal geo sign, so there should be ro problem.

Subsequently the DOE -- we saw on Progress Report Number 8, in which it was stated that the DOE adopted the recommendations of the NARG report. So the NRC responded by saying that we recommend that DOE should adopt a broader definition of the studies to ensure the full benefit of this information in guiding site characterization, validating conceptual models and estimating repository performance.

And we were concerned that if a restricted definition of natural analog studies were used -- or was used, we were concerned that important work may not be done because of that restricted definition.

Now, this may be just a semantic situation. And if so, then we don't have any problem with it. What we're trying to do is play this conservatively and make sure that the DOE understands where the NRC is coming from. So, that's the way that is.

MR. STEINDLER: If you would just leave that on for just a second. The NRC staff comment on your last bullet -- comment on the DOE progress report, says, interestingly enough that analog studies are useful to validating conceptual models.

[Laughter.]

MR. STEINDLER: That's what the words say there. And that's in print; right? I mean, that's a letter that somebody sent out.

Just thought I'd bring that to your attention about those comments.

MR. BRADBURY: Oh, yes. It's hitting me square in the face right now.

MR. HINZE: Would you like some white-out?

MR. BRADBURY: If only I could.

MR. HINZE: Don, would you like me to comment? And then I'll talk about --

MR. BRADBURY: Please do.

MR. HINZE: Is this appropriate? Or after your presentation.

BRADBURY: Actually, I don't know exactly what Paul will say.

[Slide.]

MR BRADBURY: Now I'm going to get into the details of how the term is used in the rule. The words from 60.21, et cetera: An explanation of measures used to support the models, used to perform the performance required in Paragraphs A through D. And then there's more words, and then it comes down to saying that the models shall be supported by an appropriate combination of such methods as field tests, in situ tests, laboratory tests, monitoring data and natural analog studies.

Well, when applied to paragraphs A through D, Paragraph A talks about analysis of geology, geophysics, hydro-geology, geochemistry, et cetera. That's site characterization work. And likewise, Paragraph B is also site characterization work. These are site characteristics, siting criteria, favorably and potentially adverse conditions.

Paragraphs C and D definitely refer to performance assessment issues, and that I would view as might come from the perturbation of the natural system by a technological one. So, those are performance assessment related or they're more with regard to the actual perturbation of the site.

I'm seeing both site characterization and performance assessment issues as being -- possibly being addressed by -- well, no. Being addressed by a combination of methods in which natural analogs could be one of those methods.

[Slide.]

MR. BRADBURY: This is the second occurrence of the term natural analog studies and I'm not going to read these words. An analysis of these words, however, leads one to conclude that definitely natural analog studies could be used for performance assessment and very possibly site characterization also.

So the rule seems to indicate that site

characterization issues are to be or could be addressed by natural analog studies.

[Slide.]

MR. BRADBURY: Based on that, we've essentially developed a definition of a natural analog. The definition is: A natural analog is a condition, process or event or combination of these in nature that is similar to the same in another environment and/or time. And that is a rather stilted sentence, but it means essentially we're taking a very broad definition of what a natural analog is.

The term condition is meant to be very nonspecific. So it could refer to physical conditions like temperature, pressure, conditions like the presence of a phase or the composition of a phase. It could refer to structural, temporal, spatial conditions or conditions that we don't know whether they exist or whether they're important yet. That's as broad as the intent of that word is to mean.

Likewise, for process or event it can include things like dissolution, precipitation processes like erosion, groundwater flow, diffusion, faulting, volcanism, flocculation, respiration. You name it. Things that could happen in a geologic environment and with one in which a repository is placed.

[Slide.]

MR. BRADBURY: Now, if one adopts that very broad definition, then one leads to the conclusion that natural analogs need not be geochemical in nature, as was stated earlier today. That they need not be associated with a site. So again, we could look at something as constrained as a reaction, a process, a condition. We don't have to look at a large site and say -- and then, because of that, say, oh, that there are no natural analogs to Yucca Mountain.

We could be discussing actually analogs of specific processes that we think and that somebody thinks might go on at Yucca Mountain. And finally, it need not be uranium ore deposit.

Now, if you take the broad viewpoint of the definition of an actual analog that I just presented there, then you could look through the SEP and you could find a number of situations where the term -- where natural analog techniques have been used. Development of techniques for characterizing stream flow and dating techniques applied in different areas -- on and on.

Essentially it would be very broad and you'd find it in a number of places.

One of the problems that we see right now is that the term natural analog, if one did a word search on the SEP, you'd find that the term natural analog is only found in the geochemistry section. It's found nowhere else. That is in keeping with the definition that they adopted and is consistent with the NARG report.

Now, if one takes a broad definition of natural analog studies, then they can range from the full-blown international projects that we've seen like the ARAP and Poco de Caldas and Oklo or it could range all the way down to literature searches and literature reviews. So, very small scale. It could be large scale to small scale.

Now I'll provide an example of that. Several years ago there was a technical exchange, the NRC and Los Alamos, and there was a discussion about the use of -- or experiments that involved smectite, which is an expandable clay, in a steam environment.

What happened in this experiment is that this smectite -- at least this is what they say. They observed smectite to collapse irreversibly and they were concerned about this because at one time there was thought of backfilling the repository with bentonite clay, smectite being a component of bentonite clay.

Now if this occurred, then you'd have a system that would be full of fractures and possibly the way that system would perform would be different from the way you would have expected it to perform if you assumed that bentonite swells on contacting water and stays that way.

So, anyway -- so it's important to performance. Now, the question was posed to the people there: Has anybody done a literature search to see whether this particular phase exists in the natural environment? Has anybody ever seen this phase in, for example, fumaroles?

Now, that would be a natural analog study. It would be supporting the laboratory experiments. It would be important to performance of the site and it's only looking for actually a condition, the presence of a phase.

So it shouldn't be too expensive to do that. That's another thing about natural analogs.

Okay. Let's continue with the thought that natural analog studies can be literature reviews.

In developing key technical uncertainties and user needs, the NRC technical staff searched the general scientific and engineering literature for analogs to the high level waste repository project. So, what happens is a typical day in the technical staff's day is that documents and journals will come across our desk from various disciplines. We'll peruse them and we'll search through this literature and try and find situations which could apply to Yucca Mountain.

Now, if these studies, say, are of natural systems, then they could be considered natural analog studies. That is, for example, it's an analog once the technical staff says there's a connection here. And so this is the way I view this. That natural analog studies can be literature searches and that the technical staff is doing this kind of work every day.

I can give you examples, too, of the way this works.

For example, reading through the literature, come across a statement that zeolites are used to filter gas, different gas species. That is, the Japanese, for example, go and use big chunks of clinoptilolite or mordenite and through a cycling process they end up with a gas phase that is very enriched in oxygen.

Now the question becomes what about Yucca Mountain? One doesn't see the discussion about gas zeolite interactions at Yucca Mountain. Could it be that barometric pressure changes in which there are slight fluctuations in the temperature could result in compositional changes of the gas phase in Yucca Mountain? And what happens if in an extended dry scenario where there may be tremendous fluxes of gas through the mountain, whether gas compositions may change drastically due to interactions like this?

We don't know the answer to that, but that's kind of the way -- that's one example of the way that we might come up with questions which could be converted into user need. And those user needs might fit under certain criteria.

[Slide.]

MR. BRADBURY: Okay. Why are natural analogs important? Well, they are a unique approach to a unique problem. We haven't been faced with the task. We, man, hasn't been faced with the task of building structures to last 10,000 years. Possibly with the exception of the pyramids. And because of that, we're not sure exactly how to handle this.

Engineers haven't been trained specifically to do this, so -- and scientists don't have a much better handle on this either.

Thus, multiple approaches, alternative approaches are needed to minimize the uncertainties that result from trying to make such a structure. And as I described earlier, the natural analogs are important and can be used to compare laboratory and field tests.

Now, Bill showed how with regard to time, I guess, that many natural analogs occur over time periods maybe sometimes greatly in excess of the time period associated with the performance of the repository.

This is a guess, but uncertainties associated with interpolation may be less than those associated with extrapolation. To be able to constrain a certain process or a condition for a longer period of time might provide for better confidence in terms of applying laboratory tests to the repository.

The natural analogs are important because they act as testing grounds for geo-scientific techniques and analyses. And I'm glad that there was mention of Apache Leap because I consider that to be -- the work done at Apache Leap is natural analog work, natural analog studies. That is, for example, there are perched zones in Apache Leap. In the rule, one of the PAC's, potentially adverse conditions, talks about whether perched zones may exist.

So here's a very good example of where we're looking at a site. We can put holes in this site and find out whether perched zones exist; how one goes and characterizes a perched zone. And so this is -- I think Apache Leap is a very good example of a natural analog study.

Now, again, when you use the term in the broad sense, you can focus it down to a specific condition or a process, so it need not be associated with a site. So the fact that if one said that Apache Leap may not be a good analog for Yucca Mountain because there are many parameters and characteristics that are different from Yucca Mountain, that would definitely be true. But if one focused that and constrained the definition to something smaller than that, like the process of forming perched zones or fracture flow, the rates of interaction between fractures and matrix, one becomes more comfortable -- could become more comfortable with regard to the analogy between Yucca Mountain and this other environment; that is, Apache Leap.

In terms of testing grounds for geo-scientific techniques, well, Al Yang took core from Apache Leap and was squeezing that, developing the techniques for analyzing what the composition of water and gas is in the unsaturated zone, and now he's applying that technique to Yucca Mountain.

So, it's again used as a testing ground and we are learning as this program develops. And natural analogs are used in that way.

Natural analogs are used -- help us in recognizing biases, our own biases or others' biases. If anybody has ever stood in Trench 14 with a group of people from different walks of life and different disciplines, it's a real eye-opener to see how people see the same feature and they associate totally disparate origins to that material, to that feature.

And it's interesting and, again, we are learning as we go along because this is such a complicated problem. That we're learning that each one of us has certain biases and we should adjust as we learn.

Natural analogs provide another source of information. There was a field trip a couple of months ago on extreme erosion and on that field trip there were investigators from USGS and Los Alamos were describing what they saw at Yucca Mountain and what processes they thought had occurred to result in those features that we were looking at.

Well, the Center hired a desert geomorphologist who viewed the same processes, viewed the same features, and this person essentially said some very thought-provoking things concerning what we were viewing. He was making sense and giving us alternative views of these features that we saw at Yucca Mountain.

Now, this desert geomorphologist had never before gone west of the Mississippi. He had done all his work in Africa. All of that work was at analogous sites. And I as a regulator listened to him and factored his knowledge into the knowledge given by others who had only seen that site.

So, here's an example of analog information. Norm will say some more about this. In terms of PA, I was thinking about this. In terms of our iterative performance assessment work, we have auxiliary analyses and we have the system code.

The system code requires distribution curves for things such as -- oh, the Kd of uranium or the hydraulic conductivity of a certain unit.

The thought is that we may end up with sparse site-specific data and that natural analogs potentially could provide extra information to make those distribution curves more robust.

That's it.

MR. HINZE: Thank you very much, John.

Paul, would you like to make a few comments on the basis of his remarks?

MR. CLOKE: This, I guess, goes on the record, so let me say this is Paul Cloke, again. I should have said before I work for SAIC in Los Vegas under contract to DOE.

I should perhaps also comment that I was the principal author of the response to the NRC the last round in terms of the history that John was giving you there.

I think I want to start my comments, which I'll try to keep very brief, in reference to Dr. Hinze's citation earlier of this document that Sagar and Wittmeyer produced and expressing some doubt about the usefulness of natural analogs.

It's my understanding that that kind of perception is very largely responsible for in the first place the almost total lack of mention of natural analogs in the SEP. At the time the SEP was written there was a very strong perspective of DOE management: "No, no, natural analogs don't tell us very much. They're very poorly bounded. We can't use them."

Nevertheless, in this one spot or maybe two, natural analogs did get into the SEP.

This doesn't mean, however, that the DOE is not going to be doing all the appropriate and relevant work.

One of the comments that I had made before, I think last year, particularly to Linda Kovach, and refers to one of the things on one of the earlier viewgraphs on these bullets, about the NRC being concerned that if we don't call things natural analogs they won't get done.

I think the contrary is indeed more likely to be the case. Let me give you an example of that. Namely, the lack of DOE funding anywhere currently at Oklo. And it isn't because certain people within DOE or their contractors like myself think that that is not valuable work. It is, I think rather that there are those individuals who believe that Oklo has little to do with Yucca Mountain and therefore it cannot possibly be of any relevance.

So I think there's an example of where trying to call it a natural analog, let's say -- and I don't know any other way to call it in this particular case -- has ended up with the work not being funded.

On the other hand, standard geological work, and examples here -- let's see. I put one down in my notes here just a moment ago. Let me try to get back to it. Oh, yes. Some work of Al Yang that John just mentioned regarding

Apache Leap.

Well, Al Yang, of course, works under DOE contract. He was doing that for the DOE, not for the NRC. And so it was not called natural analog. The work was done.

I guess my only other comments here are to the effect that as I don't know the background information as to what went into the regulations in 10 CFR 60, but at least as I read that, not only does the regulation as written not restrict the definition of natural analogs, but also does not say that you have to include everything under natural analogs.

It does mention field work for using future studies and you seem to deal with volcanism and seismicity and whatever. Certainly, from my view of that, would be that falls under the categories of field studies, ordinary standard geological work.

Other aspects such as the disturbance of something, a natural system by an engineered system, we would classify under the category of natural analogs.

Our European colleagues on this natural analog review group had discovered that by not restricting the definition that you eventually end up calling almost everything an analog of one type or another. Indeed, I've even heard someone comment -- that was, I think, at a NWTRB meeting about two years ago -- to the effect that a large portion of all learning, all scientific learning, is by analogy.

And so our attempt there was to let's make this into a useful definition which, as our say, our European colleagues found that without a definition, they found that the usefulness of the term natural analog basically became very diffuse and was very hard to utilize.

I do agree with a lot of what John was just saying about the importance of these natural analogs and the kinds of things that are being done. I don't think I have any disagreement there.

So, I guess in conclusion I think that we are having a semantic difficulty here more than anything else.

MR. HINZE: Thank you, Paul.

Any questions, comment?

Dr. Steindler, it's 10 after 12:00. Should we proceed ahead with Dr. Eisenberg's presentation or --

MR. STEINDLER: Norm, how long is it likely to take, Norm?

MR. EISENBERG: It will be real short without questions.

[Laughter.]

MR. STEINDLER: Yes. Let's do it.

MR. HINZE: Please, Norm.

MR. STEINDLER: I don't guarantee that last caveat, however. I can't recall a time you talked to us that we didn't have significant questions.

MR. EISENBERG: Neither can I.

[Slide.]

MR. EISENBERG: This presentation is based largely on a short talk --

MR. STEINDLER: I don't think you've got your mike on.

MR. EISENBERG: This presentation is based on a short talk that was given as a lead into a panel discussion which I participated in that was held as part of the Fifth CEC Natural Analogs Working Group meeting in Toledo in October of '92. It was a different audience and a slightly different context, but I think a lot of the material and issues are relevant to the question that the ACNW is interested in.

Specifically, the topics of this panel discussions was: Why aren't natural analogs used more in performance assessment? So, if you'll allow me to just proceed, some of this, of course, is rather rudimentary about performance assessment. But for that group especially it was important to set the stage.

So I have this broad definition of performance assessment. That it's the process that quantitatively evaluates both the system and component behavior relative to the containment and isolation of waste.

[Slide.]

MR. EISENBERG: For a number of years I've been saying the following, the four bullets here, that performance assessment in my mind is always quantitative. It usually evaluates performance in terms of both magnitudes and likelihoods. That is, it's a probabalistic methodology

An inherent part of it is a comparison to a quantitative safety standard. The analysis is driven to a large part by the performance measures and limits that one is interested in. And this has profound implications on what we mean by model and how we use models especially in performance assessment.

It uses predictive models and the point of view is one of engineering, especially the systems approach.

Performance assessment, I believe, is comprised of two significant parts. There are the computer codes and the data that are used to produce quantitative estimates, but that is only part of the performance assessment. You also require the support for the estimates to help put them into perspective and to allow decisionmakers to judge the results of the performance assessment.

And this can consist of a wide range of information, other analyses, other computer codes, supporting models, natural analogs, laboratory studies, a whole range of information.

[Slide.]

MR. EISENBERG: This is at a place in the handout, I believe, but this might be a good time to talk about this pyramid. DOE I think originated this pyramid. It's kind of a nice picture. If you think of the end result of performance assessment as the estimates, then this is the peak of the pyramid.

This is supported by somewhat more detailed analyses and of course site specific data and studies on specific issues.

Underlying that level are the series and analyses for the repository systems, very general ones, and more general studies, including natural analogs, for system systems.

I would say those three levels all should be included in the performance assessment. I think you really can't just do the top. You must include all of this.

Underlying that is of course at least one or two other layers of knowledge and information. There's general scientific principles and general empirical data. And then of course all relevant human knowledge at some level feeds into this. So, this is a pyramid representing the different levels of information needed in performance assessment.

[Slide.]

MR. EISENBERG: Okay. Let me quickly go over this one. I agree with entirely with John Bradbury about the definition of natural analogs. It should be a very broad definition. It need not be limited to natural occurrences but archaeological analogs I think are also quite important.

And I can think of no reason to limit it, nor does the NRC definition I believe, limit the definition by time scale phenomena or discipline. It may be a problem in budgeting at DOE but I don't know that that's relevant to our discussions.

[Slide.]

MR. EISENBERG: This is similar, but not exactly what Bill Ott talked about. This is from a perspective of somebody that works in performance assessment. What might natural analogs provide to a performance assessment?

One of the first things is to provide information about the data and the uncertainties in the data. Generally, there are parameters used in performance assessment. And as many people understand, these parameters are not items or not data that are measured generally directly in the field.

These are often inferred parameters based on field test involving the use of models themselves.

Because of that, one must be careful -- I mean, that's one of the reasons one must be careful in defining both the ranges of the parameters and just probabalistic distributions of them. And this includes, of course, the means and the bounding values as well as the exact shape of the distributions.

We need that kind of information to be able to propagate parameter uncertainty in our performance assessments.

Natural analogs could also provide a qualitative conceptualization of the natural system. Yesterday, Scott Sinnock said something which I also agree with, which is that one can almost always turn the qualitative information about a concept into a value which one than then vary.

A good example might be coupling between the fractures in the matrix in flow at Yucca Mountain. One can have a coupling coefficient that talks about the communication between the fractures and the matrix.

If one puts it to zero, there is no coupling and that is one limits of the concept. If one makes it infinity, that's another limit. And of course, values in between represent intermediate results.

The problem is that some of the different concepts for natural systems -- what the geologic or hydro-geologic units are, what kind of coupling they have between them, what the boundary conditions are, whether you have or what is the correct dimensionality of a particular model to represent your hydrologic system -- these have such profound effects that you've really -- most people I think would be more comfortable talking about different conceptual models rather than talking about parameterizing the range with some parameter value.

There is, of course, quite a bit of overlap between -- or can be, between parameter uncertainty and conceptual model uncertainty.

Another aspect that natural analogs can help with performance assessment is qualitative and quantitative information about the processes that occur in the repository system, their interactions and their relative importance.

Natural analogs, one would hope, could also provide information about previous environments at the site if interest or similar sites as a guide to predicting the future states that the repository would operate in.

I believe natural analogs are quite useful for providing some information to help validate models, whatever definition of validation one wants to adopt. Certainly they should provide support, even if the support is negative. Even if analogs provide evidence that a particular approach or model is not appropriate, that is important information, especially for the regulator.

And it provides an arena for testing models that is not available that I know of by any other means because the time scales and spatial scales of interest are not available from any other data source.

And finally, natural analogs, because some of the same processes are used to study the site, can give insights into the limitations of site characterization.

A question that often comes up in site characterization is, "How many data points are necessary to represent this particular aspect of the repository whether it's the hydrologic system or the mineralogy or any other aspect?"

By looking at a system where one can get as much data as you want, you can determine what a limited set of data might due in terms of limiting your ability to predict performance.

And that's all I have to say.

MR. HINZE: Norm, in terms of those six items, viewing or understanding that IPA I and II were more towards developing expertise of the staff, can you give us any examples of how in IPA I or II natural analogs were of assistance in any of these items?

MR. EISENBERG: I can try. Maybe John is going to tell me that I'm wrong. But I thought that one of the things that we got for IPA II were distributions of certain geochemical parameters. And I believe John looked at the full scope of literature that was available, laboratory data. And I'm not sure whether there were any natural analog data or not, but since he certainly was cognizant of a lot of that literature, he certainly was able to use that information, especially in determining the ranges that were picked for these geochemical parameters.

That's an example. I believe that -- and McCartin is sitting in the back of the room. Believe that some of the hydrologic parameters, they used the Apache Leap data to again help determine what the ranges were and what the distributions were.

Maybe English wants to say something.

MR. PEARCY: I'm English Pearcy from the Center. One specific example of that. Dick Cadell made use of our maximum uraninite degradation rate of 10 to the minus 7 fraction of the original inventory per day in some of the IPA Phase II calculations.

MR. HINZE: Thank you very much.

Tim -- well, are you waving? There he is.

Tim, can you respond in any way to what Norm just said about the hydrologic parameters?

MR. McCARTIN: I think in a general sense what Norm said is true. That some of the hydrologic investigations at Apache Leap helped us assign some of the parametric values and ranges. Probably one of the biggest aids that we would look to in terms of infiltration rates at

Yucca Mountain, obviously when you're talking about a millimeter a year, it's very difficult to have any measurements that mean anything. But certainly looking at the Never Sweat Tunnel at Apache Leap where maybe a few months after it rains you see fractures start to trip, that's something that for us at least in terms of if we want to consider a wider range of infiltration, because there's certainly -- right now there could be a potential for fracture flow.

Also, Chlorine 36 at say Yucca Mountain that they see at large depths is another bit of information on the natural system that implies maybe there's a little more fracture flow than you could ever justify saying a 1 millimeter for year, however you would try to extrapolate that. So I think the infiltration parameter is one that we look at natural evidence to suggest should we -- are we sort of in the .01 millimeters per year or do we want to look more to the 1 to 10 millimeters per year. And we shy towards the high end because of that evidence.

MR. STEINDLER: What you're saying is what Linda referred to earlier this morning in terms of developing order of magnitude for PA analogous from the natural analogs.

MR. McCARTIN: Sure.

MR. STEINDLER: Thank you very much.

John, did you want to add anything? No. Okay. Fine.

Further questions?

MS. FEDERLINE: Just one question. I must say I'm a big confused as to why all the fuss about defining natural analogs? What difference does it make? What do we spend, with due deference?

In the discussion we went on and on and on about whether it is or it isn't. Whether it's a natural geologic process that the folks who are in that business go out and do ordinarily or not. What difference does it make?

MR. EISENBERG: Well, I think you have to understand that the NRC operates within the context we're a small agency with a small budget. We operate in the context of the international community, with DOE participating also with much larger resources. And for that community and for DOE it is an issue. So it becomes by transference an issue for us.

If we were operating just among ourselves, I don't think it's a problem for us.

MS. FEDERLINE: But I think if you look at the sense of our comment, it was that we wanted to make sure that the work was being done and we wanted to --

MR. STEINDLER: Yes. No matter how you define it.

MS. FEDERLINE: That's correct. And we wanted to be on record that we wanted to make sure that everyone understood what the broad interpretation of the work was that we wanted to see done.

MR. STEINDLER: But I have some sympathy to the folks who have to classify budgets. But beyond that, it seemed to me that it was not an issue that was a technical issue of any consequence, or did I miss something.

MR. CLOKE: I agree with you on that score.

MR. GARRICK: I have a topic that I will want to discuss off-line later and not take up time here, but I will just put it -- I will flag it. It has to do with your definition of performance assessment. I become concerned when I see definitions decoupled from end states that make sense. And the end state here that makes -- the only one that makes sense to me is consequences in terms of health and safety.

I fear these kind of definitions that provide a basis for performance assessment analysts doing analysis in geologic time or for geologic time. Forever, essentially. I don't think that is what performance assessment is. I think that -- I don't think that's an accountable and a responsible way to look at performance assessment.

And as I say, I'd like to explore that at a later time.

MR. EISENBERG: Okay. If I could just say just briefly that I think we are limited by the regulatory structure, and so our performance assessments are aimed at largely the performance measures and performance movements that currently exist in our regulations and in the EPA regulations.

However, let me hastily add that in Phase II we have done some things, as we did in Phase I, to be able to explore the effectiveness of the regulations in protecting public health and safety. That's always an issue for this agency, I believe, and something the staff is always keeping an eye on.

So we do have a somewhat broader scope but we can't depart too much from the current regulatory structure, else we'll be accused of doing analyses that are beyond our province, let's say.

MR. GARRICK: Yes. I'm not arguing with that as a philosophical issue. My problem is that I can't relate this definition to what I've been reading in the regulations. That's my problem.

MR. HINZE: I don't know if you can read that from there, Norm, but this is a sheet that I pulled off from a TRB presentation at a TRB meeting back in '91. And it states there must be effective communication between performance assessment and natural analog studies. This was in regard to natural analog studies. And I think that this is a very critical item some of what Bob Johnson talked to us about related to that. And I guess you're going to talk about that now?

MR. EISENBERG: I misled you. I got carried away. I thought I was finished but I wasn't.

MR. HINZE: I'm glad you're not finished because this is a very critical item in the whole process. And now that we have not only provided a definition of natural analogs, what don't you clarify the whole topic by telling us how to spell analog?

[Laughter.]

MR. EISENBERG: My dictionary says either one is okay. And I'm sorry. I forgot one final slide here.

There are challenges in using natural analogs in performance assessment which is what this slide is about.

[Slide.]

MR. EISENBERG: We have adopted methods for the NRC anyway to try and solve some of these problems or address these challenges.

One of them is that there tends to be a different focus for natural analogs and performance assessment. First of all, there's a different concept of model.

The people that do natural analogs use model usually in the sense that a scientist would use it as representing the behavior of the world or the behavior of a particular phenomenon or piece of the world.

I believe engineers have a -- and I hope I don't cause people to get made at me, but engineers have a more pragmatic approach to modeling.

A model only has to do enough to solve your problem. It doesn't have to be a real good representation of anything. It has to meet your end goal. And so if you can use a back of the enve alculation to solve your problem, that's a good model. It doesn't have to precisely say not only what's the exact trajectory but what color is the bullet when it gets there. You d need it. You can use a much simpler model.

For the natural analog studies, because it is more of a traditional scientific study, the investigators tend to want to look at all the data and match it all and have a model that's robust enough to handle l the data.

Performance assessment is much more pragmatic, I would say.

There's another difference. And let me say that this different perspective on what a model is translates into different views of model validation. And we have been conducting a dialogue within he staff and also with the Swedish Nuclear Power Inspectorate on validation and are hoping to try to get some consensus on what we mean, especially in terms of validation for performance assessment models.

Performance assessment, as I said before, is by and large probabalistic. The focus for natural analogs tends to be deterministic because you have the results of the study or you have the results of the analog.

Let me hastily add that our approach is to use natural analogs largely to support deterministic models, but natural analogs may help modeling probabilities, but it's unlikely, I think, that natural analogs would be used for comparison to the probabalistic results of performance assessments. You would have to start talking about ensembles of natural analogs. And although a long time ago I wrote a paper where I suggested that we do just that, I'm not sure that that's really going to happen.

Another difference is that the models used for natural analogs tend to be very precise and the models used for performance assessment, especially at the top of pyramid, are abstracted. And I think the appropriate use for natural analogs is to support the second and third tier models, not the highly abstracted models used in performance assessment.

There's another challenge in using natural analogs to support performance and there are organizational constraints. There are different departments and responsibilities and budgets. For larger programs I believe this is a larger problem. We attempt to address it by matrixing the staff for natural analogs and performance assessment projects.

I don't know if Linda talks about this a lot, but she participated in the Phase II work to a limited extent. So we do pull in people that are working in the natural analog area.

Also, to do this kind of work it's very intense work and requires full attention or a lot of attention and people often have limited time to communicate to other groups. And I believe the staff is planning a series of workshops to try to get the two groups together.

Finally, the results of natural analog studies are not always applicable directly to performance assessment. One point is that the natural analogs are anecdotal and performance assessment tends to proceed from general principles.

The resolution for this, I believe, is to use several natural analogs or a number of natural analogs to support the models used in performance assessment. Although there may be some limited use for natural analogs in terms of convincing the general public, I think you cannot base much of the licensing case solely on the results of natural analogs. I think there are just too many opportunities for differences between the particular analog and the repository and I'm afraid it would just fall apart in a hearing.

So I would advocate focusing the use of natural analogs primarily to support the models.

And finally, of course, natural analogs, it's difficult to determine the boundary conditions. And again, if we have a number of broad natural analog studies, they should hopefully provide support for the quantitative models.

MR. HINZE: That's a great answer to my question. Thank you.

Any questions, concerns?

MR. STEINDLER: Just one comment. I realize I'm surrounded in a sense by folks whose primary interest is geology, but I do want to remind you that there are natural analogs to systems that do not involve geology.

For example, the behavior of tectites and helping to identify the mechanism of glass reactions is an important one to some people, but it turns out not to DOE. That is neither here nor there.

But when you structure your commentary about the differences in the approaches, not to overlook the fact that not everybody goes out and looks at an ore deposit in order to learn something about how the world works.

Sometimes we simply look at tectites that have been sitting under water and ask the question: What is the long-term mechanism of the reaction of glass and how can we then dummy that up in the laboratory so that we can do tests that make sense in the long haul?

MR. FOLAND: It seems to me that there is perhaps -- following Dr. Steindler's comments there is an incongruity, some on this overhead and some of it John Bradbury told us. The definition of natural analog is almost entirely wide open, as I understand it. And if for example one needed to know at some relatively low temperature -- say 300 degrees -- what the diffusivity of xenon was through some particular metal that might be a cannister, we couldn't wait long enough to do it, and therefore we would do such an experimental high temperature and use some model to predict what it would be at low temperature.

In my book, that's a natural analog. Would that meet your definition of natural analog? And if so, it seems to me that that is not anecdotal evidence.

MR. BRADBURY: You're heating this up.

MR. FOLAND: I'm just doing an experiment at higher temperature and using temperature to make up for the time that I don't have in the laboratory. I would extrapolate it to low temperature. I think that would be a natural analog.

MR. EISENBERG: Why wouldn't it just be an accelerated test and you're going to do it in the laboratory?

You would not necessary have to go to some geologic system.

MR. FOLAND: Then does a natural analog -- that has to be done in the field that is not in the laboratory?

MR. BRADBURY: It has to involve nature is the way I interpret it. It gets fuzzy here. If you're talking about doing experiments with -- actually, anything that I consider you are doing an experiment yourself, then I consider that a test and not a natural analog. I consider when nature does the experiment that is the natural analog.

MR. FOLAND: So, it is a condition that cannot be perturbed by the observer that makes it a natural analog?

MR. EISENBERG: The thing you want from a natural analog is the long time scale and to do that you'd have to let nature do the experiment. You can't do it. If we could get -- I would say again from the point of view of performance assessment. If we can go in the lab and do the tests and get it over with in a year, let's do it. Don't have to mess around with going to the field.

The problem is that those data are not available in the laboratory.

MR. FOLAND: I thought the Apache Leap was directly perturbing the environment on a time scale and watching various tracers come through. Does that make it an unnatural analog?

[Laughter.]

MR. BRADBURY: I had some thoughts about this one. Earlier on I thought Apache Leap when they talk about, for example, pump tests. There's the word tests. And I think, oh, that's not an analog. Then I had the problem in saying, well, the normal thought of a natural analog is a site where a geochemist will go out and will collect data, parameters, and then ascribe some -- a process that had led to that, those end products of a reaction, say a geochemical reaction.

In terms of a pump test, although the hydrologists are perturbing the system, I think it depends upon their intent of the test. If they are perturbing the system to get a parameter, say the saturated hydraulic conductivity of the site, then I don't see any difference between that and what the geochemist does when he looks at a uranium ore deposits and looks at the phases there.

If, however, the hydrologist perturbs it in a way in which say for example he heats it up, a heater test, it's not a natural analog. That is a test. But if he perturbs it in a situation to represent what he anticipates will be a condition in the repository in the future, then I think that is not a natural analog.

Those are my own thoughts.

MR. HINZE: Thank you very much, John.

MR. STEINDLER: I guess after all of that I have concluded there are twelve angels that can dance on the head of a pin.

[Laughter.]

MR. STEINDLER: And with that, I will declare a one hour lunch break and we will get back here at a quarter of 2:00.

[Whereupon, at 12:45 p.m., the meeting was recessed to reconvene at 1:45 p.m., this same day.]

AFTERNOON SESSION

[1:45 p.m.]

MR. STEINDLER: Let's get going.

MR. HINZE: This afternoon we have a group of discussions that look very interesting. Linda Kovach will be making a presentation on research activities.

I think I see her around the corner.

Linda will be discussing with us analogue research activities.

Do we have a handout, Linda?

MS. KOVACH: You should.

MR. HINZE: Very well. Thank you.

[Pause.]

MR. HINZE: Go ahead, Linda.

MS. KOVACH: Good afternoon. I will be talking to you this afternoon about the research program on natural analogues in the Office of Research. Let me go through briefly the presentation outline.

As we heard this morning, we heard a fairly detailed rationale for our research program from Bill Ott this morning.

[Slide.]

MS. KOVACH: I will give one or two more slides on that and then we will jump into the Natural Analogue Workshop that we held in conjunction with the center in

1991. We will talk also about the results of the 1992 NAWG, National Analogue Working Group Workshop, that was held in Toledo, Spain, in 1992 and also about the objectives that we are planning for the 1994 workshop that will be held in September in Santa Fe.

I will talk a bit about the workshop that we are planning on having in June of this year. And, again, this is a workshop that will be restricted to the NRC and our contractors at the center.

And, finally, I will go through some lessons learned in the Alligator Rivers program, Oklo, and then just briefly on those two and then I will go into some more detail on the Valles Caldera study which, as Bill mentioned, finished about a year-and-a-half ago and we have now the final report. And finally we will talk about some future plans.

You notice I am not going to talk about Pena Blanca or Santorini because English will address that. And I think he will go into the rationale for doing that and, as well, how we plan to apply that information to performance assessment.

MR. HINZE: I see future plans on that. Will you be talking after English completes his discussion then?

MS. KOVACH: The future plans I have mentioned here are just very general.

MR. HINZE: I see that there is a portion of the agenda which has you for future plans at the end.

MS. KOVACH: I can pull that then and we can do it later.

MR. HINZE: It is not our agenda. I believe it was suggested by you people.

MR. OTT: I said I would be doing the conclusion part at the end and lead into that as a general discussion with some broad conclusions that we had come together with the team in developing the briefing for today.

In terms of plans, again, it is very general. We are actually talking more about conclusions than we are future plans. Future plans would probably be more in line with the workshops and things that we are trying to do to bring the PA and analogue work more closely together that Linda will talk about.

MR. HINZE: As we said earlier, it is important that we learn about the conclusions and what has been derived from the natural analogue studies. So if you will be finishing up with that?

MS. KOVACH: I will try to address that as I go along.

One of the questions that seems to be raised often is why is the NRC doing research on natural analogues. Why are we doing it and not DOE or why are we doing it and why is DOE doing it.

Well, as was alluded to or talked about earlier this morning, there really is a fundamental difference in the needs between the NRC and the DOE. We need to be able to understand a range of possibilities for processes that may occur in the repository for a range of data that may bound a particular problem. So, as I see it, the NRC needs really to take a very wide perspective, a wide view of analogues. And, as Norm had mentioned earlier, he said that we probably should be looking at a series of different analogues to bound the problem.

We need to be able to understand and to poke holes in what DOE will provide to us because that ultimately will be happening in a licensing hearing. So we need to make sure that we feel that we have covered areas where there are uncertainties. And I think Margaret talked about them as key, key uncertainties. So as far as that goes, we need to take a wide view of natural analogues.

DOE, on the other hand, needs to be doing analogue work, at least I guess from our perspective. But to support their demonstration of compliance. And in that sense they perhaps need to have a more focused view in analogue work. They need to find analogues that will support data or that will provide data to support their assumptions or their analyses.

So with this in mind, we think that the NRC should be doing analogue work and we have tried to focus -- we have tried to gear our research with that in mind, to take a broader look at potential analogues.

As I said before, and many other people have said this before me, John Bradberry and Norm Isenberg and Bill Ott, that these are some of the things that we feel analogues are useful for, for looking into site characterization, evaluating the range of models that they have for the site. Volcanism would fall into that category. It also falls into performance assessment.

We have to look at the data that they're collecting. Is it enough data to adequately characterize a site.

We also are concerned with the tests that they do. Are they actually testing -- is the data they are collecting the right data to test a particular conceptual model. So those areas where we feel that analogues -- and Alligator Rivers, for instance, was a very good example for testing site characterization techniques.

Then in performance assessment, again, we are looking at ranges of scenarios and parameters and would like to also with analogues bound uncertainties in conceptual models' parameters and the computer codes that are used. And there are --

MR. HINZE: Linda, while you have that up, may I ask a question?

MS. KOVACH: Sure.

MR. HINZE: I was very pleased to hear you speak about the use of natural analogues to determine the extent of data that are needed to solve an uncertainty, solve a problem. That is something that we constantly hear regarding the program. In other words, when is enough enough?

I am pleased to hear you say that natural analogues might be able to provide some kind of evidence for this. Can you give me some examples of how that can be done from work that has been done already? If you could, that would be helpful.

MS. KOVACH: The Alligator Rivers project is one that is a uranium ore body that we have been studying in the Northern Territory of Australia. As we have been conducting studies there in connection with ANSTO for the last 10 years, approximately, about six years ago the International Alligator Rivers ARA project started and it was completed a year ago in October.

There are 17 volumes, 16 volumes that came out of that and tremendous amounts of data. The one thing that -- let's see if I can find it. I was going to talk about it later, but as long as we are on it.

I don't have any specific examples of data in a V graph that I can pull out for you, but I will try to talk my way through this. This is back in your packet.

It is the series of reports that are involved in the Alligator Rivers that are part of the final report, so there are 16 of them. And it covers things like geologic setting, geomorphology, geophysics. There was a tremendous geophysics program that was involved that took place down there characterizing the site.

Hydrologic field studies, hydrologic modeling, groundwater chemistry, chemistry, the mineralogy geochemical databases, blah, blah, blah, uranium absorption, radionuclide transport -- it would be interesting to transpose "blah, blah, blah" -- and the chemistry of plutonium, iodine, technetium and chlorine and then scenarios.

Now, we have all this data and still we weren't really able to characterize the hydrologic site, to characterize the hydrology. And I shouldn't say that. Initially we had difficulties doing it, couldn't tell whether water was flowing across the fault that was present or whether it was not crossing the fault.

And we finally were able to more or less limit the conceptual models by using a combination of these approaches. The geophysics and the geochemistry were able to help us narrow the flow regime at Koongara.

I think that is an example of where -- oh, then we also had bore hole cameras, down-hole cameras, whatever, that looked at the fractures, the fracture mineralogy, the apertures and the fracture spacing. And that fed into the hydrologic model that we had as well.

So I think there is a case where, you know, the site, even with all the holes that we had, and there were a tremendous number of wells -- well, probably, what, 40 wells, 50 wells, Tim? Forty or 50 wells that were drilled. A lot of data that had been taken from the drill core. And yet we weren't able to adequately characterize that site from the core alone.

So I think in my mind that is saying that we really needed these other -- the geophysical studies. And even then it still is, I guess, you know, not completely pinned down. But we'll have a lot less holes at Yucca Mountain. And it's an equally heterogeneous system.

I think this is -- studies like this will be useful in helping us address that question.

MR. STEINDLER: I guess I am confused, if we can explore it. We were not trying to site a repository in Australia?

MS. KOVACH: Of course not.

MR. STARMER: The fact that you tried hard but failed to characterize the site at Alligator Rivers, I don't see how that translates to Yucca Mountain, except to point out that which pretty much common wisdom already tells you. It is going to be a tough job.

Am I overstating, understating the case?

MS. KOVACH: I think you are probably understating the case.

MR. STEINDLER: It's going to be a very tough job.

MS. KOVACH: We thought we would be able to characterize the Koongara site, especially the hydrology. It is a saturated region. It is saturated flow there, so it should not be that difficult to characterize. Yet it is a fractured site.

We have learned a tremendous amount about trying to characterize -- and correct me if I'm wrong, anybody. I see heads nodding. Yes. Okay.

We did learn a lot from that site, I think, that will be applicable to Yucca Mountain.

No, we were not trying to site a repository in Australia, but we will encounter the same problem.

MR. STEINDLER: This was a saturated site?

MS. KOVACH: Yes.

MR. STEINDLER: The site we're looking at at the moment is unsaturated?

MS. KOVACH: Yes.

MR. STEINDLER: Is there some reason to believe that you will encounter the same problem between those two sites?

MS. KOVACH: Sure. The heterogeneity of the site. I would say the same order of magnitude.

We looked at fracture flow, we did fracture flow modeling for the hydrology there. And we are encountering the same problems at Yucca Mountain in terms of trying to understand fracture flow, looking into the discontinuities and permeabilities.

MR. STEINDLER: One other question, then. The characterization of this site, even assuming that you are correct that there is a good translation of experience and skill between the Alligator Rivers and Yucca Mountain and the characterization of the site, it is not NRC's function to characterize the site; it is DOE's function.

MS. KOVACH: No, that's right. But I think what is of interest to us is not -- we are not trying to characterize the analogue site, but we are trying to understand difficulties in testing procedures.

In other words, I think without this exercise it may -- this may be fairly simplistic, but without this exercise it might be easy for the NRC to say, oh, well, sure, you have reams and reams of data, DOE, so we are sure that everything is fine.

But I think because of the difficulties we had here, it may alert us to studies that DOE might need to perform that otherwise may not have been done.

MR. STEINDLER: So is it correct to say that if you picked some other site that may not have been as relevant to Yucca Mountain but posed the same type of site characterization difficulties, you might have learned an equal amount from such a site?

MS. KOVACH: Yes. Yes.

MR. STEINDLER: Thank you.

MS. KOVACH: I don't think there is anything unique to Alligator Rivers. It is just the only natural analogue that we have been involved with that is now completed. That is why I am using that.

[Slide.]

MR. FOLAND: Was that undertaken as an analogue for Yucca Mountain?

MS. KOVACH: No. You have to realize that this was started 10 years ago. And at that time, we were considering three repositories, three different media for repositories. There was basalt, salt and tuff. And also the second repository where they were looking at crystalline rock was also being funded. And this was undertaken, I believe, because of the crystalline rock program. This is in crystalline rock. It continued for a variety of reasons, but there is also -- I should point out that there is an unsaturated zone at Koongara. It is variably saturated. The unsaturated zone during the dry season or the water table drops 15 meters during the dry season. So there are some processes of unsaturated flow that could be studied at that site.

And, as Bill mentioned, the site is continuing to be studied, but under low level waste funding from us. So, no, this was not meant to be a site for Yucca Mountain. In fact, the only one that we have that's specifically -- no, that's not true. Valles Caldera was designed to look specifically at problems at Yucca Mountain. But Pena Blanca and Akrotiri are the other two.

MR. OTT: There is one observation I might make about both Oklo and well all of the big international programs. And that is that to a certain extent many parties participate all with very individual objectives, depending on what their disposal programs are. And sometimes you look at a program like ARAP and look at the benefit with regard to the potential investment is a fraction of what your resources are and what the equivalent expenditure would be at a different location to get the information out.

And at ARAP, when we went into the program, we had the benefit of something like $5- to $10 million of industrial research in core that had been stored and accurately cataloged and we had the participation of the Australian government and net cost services from a number of local arms of the Australian government. So we had a cost beneficial way of embarking on the project, plus the cofunding from four other companies.

So there were a lot of advantages that accrue to it that make it cost beneficial as well as otherwise to go to a certain location rather than to another location.

MS. KOVACH: That is a good point. Did that kind of answer your question?

MR. HINZE: No, it did not, because it did not answer the question, when is enough data enough? What I learned is you don't have enough data no matter how much you collected.

Did you solve the problem?

MS. KOVACH: No, we did not solve the problem. But I think -- English, you're going to solve the problem for us?

MR. PEARCY: I will give you some examples of that.

MS. KOVACH: Okay.

As I mentioned, we held a workshop in San Antonio in 1981 and we invited people from the center, from DOE, academia and various industries to participate. The objectives were to examine the role of natural analogues and performance assessment, site characterization, and also to use this information for prioritization of research.

The workshop was -- the format, we had a plenary session in which the concept of natural analogues and reasoning by analogy was introduced. Then we had experts from various as John put it walks of life, but communities, academic communities, discuss their application of reasoning by analogy.

We had a discussion on the use of analogues in the petroleum industry, analogues in the economic, gold ore, specifically. We also looked at the use of analogues in seismicity, volcanism and various other areas. I think you all have a copy of that report. And it indicates the people that gave those discussions.

Then we broke down into four separate working groups, smaller groups that were made up of between 10 and 20 people. There was a moderator, two moderators for each group, and the purpose of those were to identify areas where analogues could be used in that particular subdiscipline. And those were waste package, near field processes, far afield processes, environment and volcanism and tectonics.

After -- during the working groups we compiled basically a summary of each working group and those conclusions were presented at the end in the final plenary session, which was -- we did end up with some quite heated debate regarding, again, the definition of analogues, which really is to us not that much of a concern. And then, secondly, the application of analogues.

And we heard from people that were involved in performance assessment and thought that analogues could not be used at all. Then, of course, we had the earth scientists that thought nothing else should be used. And it went on from there.

But I do think that it generated useful input for future studies. It did provide an exchange of ideas between the NRC and the DOE and got us talking, which was useful. And again, you have the proceedings in your hands and there will be a newer document but at this point we don't know exactly what number.

We are planning a workshop for June of this year and the purpose of this is specifically to get the performance assessment modelers from both the center and NRC, that's research and NMSS, to sit down and start talking with the analogue people and people that have data and keep touting this data as something wonderful but no one is using it yet.

So we thought, well, we'll just lock ourselves in the room until we figure out how to do this. Anyway, we are going to have this workshop. And then so two objectives, one to incorporate the data in RPA so this will be actively incorporating data, and secondly developing a strategy for bounding the range of conceptual models and parameters.

MR. GARRICK: Can you explain briefly what you mean by "bounding the range of conceptual models" in reference to performance assessment?

MS. KOVACH: Well, yes. I will try.

In thermal hydrology, for instance, there currently is a model put forth, the heat pipe model by Proos and Buscheck. And that is one -- one model, conceptual model of how heat may be transferred in the repository.

There are other conceptual models that exist that have been put forth. And the idea here would be to look at several analogues to try to identify conditions under which those conceptual models operate. Those are valid conceptual models. And that would be bounding the range of temperatures or pressures, hydraulic properties, you know, rock type, that sort of thing.

MR. GARRICK: And this is for a specific application or in general? In other words, are we talking about Yucca Mountain?

MS. KOVACH: We are talking about Yucca Mountain. This would be for a specific -- yes, it would be.

For instance, when -- this would be for what we classify as the subsystem modeling. What I am talking about, because the codes that Buscheck has developed and other people, those will not be directly applied to the large PA models.

But we need to validate. We need to validate the use of that model to make sure that it is within reason or within range based on models that we have of the natural system.

MR. GARRICK: You are coming around to what was behind the question then that was precipitated by the discussion this morning on the use of analogues to verify models. It sounds like that is kind of what you are saying?

MS. KOVACH: Right.

MR. GARRICK: Okay.

MR. STEINDLER: We mentioned this morning we got an invitation to a workshop on the coupling of site characterization and performance assessment. But this one is May 18 and 20. Is that the one you're talking about? You said it was in June.

MS. KOVACH: No, ours is in June, June 13 through the 18th.

MR. STEINDLER: We have two back-to-back workshops then, separate. Okay.

What we propose to do is have a test problem that modelers would work on, and I've just given an example here, of trying to predict the uranium distributions that one would expect in the Nopal tuff at Pena Blanca given the hydrologic data and initial conditions and initial concentrations of uranium.

And we would like to see them predict the distribution afterward. We pull out the data, that actual data -- the field data that we have to see how well they did in terms of predicting.

From that point, then discuss where there were shortcomings in the models or where we didn't have the -- hadn't collected the right data, what data then we would need to go out and collect so that we could assist the performance assessment modelers in their task.

So, you know, basically this is a first step. Again, I have gave this as one example.

We might also use data from the various Valles Caldera for testing some of the hydrothermal models that are out there. We haven't yet figured out exactly what we are going to test at this point.

And as was mentioned before the reason for doing this is that we do not feel that we have successfully incorporated, or to a large extent incorporated results of the natural analog in our PA at this point, and that modelers and data gathers or people that investigate natural analogs must work closely together to assure that the data is useful to the modelers.

Conversely, earth scientists must interact with modelers at an early stage to assure that the appropriate choice of conceptual models in data are collected.

An example of that we found in the Valles Caldera study where they were looking at a -- looking at the alteration of a tuff, analytic tuff, in response to a thermal pulse. And they went out and looked at this area and saw basically that there was this red-baked zone close to the contact, within a few meters of the contact, and proceeded to sample. And sampled within the first three, at maximum, ten meters from the contact.

Well, they found out later that with the hydrothermal model that Buschek has been working on that alternation of boiling may occur as far as, say, 50 meters form the contact. And they, at that point, through the work that they'd done realized that they hadn't sampled far enough out to get unperturbed, thermally unperturbed, host rock.

So there is an example where there needs to be close interaction or iterative work between the modelers and the people that gather the data.

I think their initial assumption of collecting only the first couple of meters was valid at the time based on the models that they were using, but in the last four or five years the models have developed -- that they have been fine-tuned, basically.

MR. HINZE: Linda, may I ask you again -- and this may be in the discussion with English Pearcy -- but do I understand correctly that the Pena Blanca is the key to this workshop that you intend to have in June? That you will be testing that? Does that mean that you are bringing to a conclusion the Pena Blanca study?

MS. KOVACH: No. No, not at all. No.

MR. HINZE: And is there any attempt -- will there be an attempt to use the performance assessment to define what kinds of information are needed?

MS. KOVACH: Yes. Yes, there is already. English will address that.

MR. HINZE: How long do you anticipate that this Pena Blanca project will carry on? Will this be an interim process then with a performance assessment? Is this a year-by-year basis?

MS. KOVACH: No. Currently plans are to 1997.

MR. HINZE: 1997. Okay. Thank you.

[Slide.]

MS. KOVACH: As was mentioned before, there is a natural analog working group that is sponsored or supported by the Commission of European Communities. The purpose of the working group is to provide a forum for discussing the various international analog projects. There are currently quite a few different analog programs among the various 13 or 14 nations that are involved in nuclear waste disposal.

Every two years the NAWG convenes a meeting to present results of analog studies and also to discuss various problems that they are having. So the fifth meeting was in conjunction with the final Alligator Rivers workshop that was held in Toledo in 1992.

The objectives were to present the final results of the Alligator Rivers project, to present state-of-the art modeling of -- state-of-the-art of the major national and international programs on analog studies, and they were supposed to specifically address relevance to performance assessment.

Then we had two sessions on expanding the concept of natural analog to include other processes, other fields other than geochemistry. In the past the NAWG group had been focusing mainly on geochemical analogs. And so we had sessions on paleohydrology, gaseous release, thermal alternation, and neotectonics.

Finally, there was a panel debate, basically, on the respective role of analogs and performance assessment and why we are not seeing analogs used more in PA.

MR. STEINDLER: Do you mean debate?

MS. KOVACH: Yes. It was a debate.

MR. STEINDLER: Are you going to tell us the outcome?

MS. KOVACH: Actually, you can read about it. I will give you some -- the proceedings just came out. There are papers from all of the people that presented stuff, as well as statements from the core group and statements by the people that were on the final panel.

This is actually a pretty nice volume. It has summaries of all of the work that was done in the Alligator Rivers project as well as the papers from the presenters of this workshop.

[Slide.]

MS. KOVACH: So the results were that there was consensus that natural analog are essential, or should be essential components of performance assessment and that the importance of analogs in performance assessment will be increased as more focused studies are documented.

Pena Blanca was cited as an example of a well-balanced, more-focused study. It was recognized by the international group as being that.

"Natural analog workers" -- and this is a direct quote -- "and performance assessment modelers should keep working closer together to avoid communication difficulties."

Finally, discussions regarding the evaluation and application of geochemical models. This is a paper that Dr. Kirk Nordstrom wrote or volunteered after sitting and listening to a lot of the sessions there. He went around and was stirring up -- he was very concerned about the choice of validation and verification and whether analogs could be used indeed to validate or verify geochemical models in particular. So there was a lot of discussion about that in and around the meeting.

Norm, I don't have a bullet on the slide here for what the results of the final panel discussion were, but there were four people who presented their views on analogs and performance assessment. Norm is suggesting that we just don't -- really, we see things differently. Some of the others were saying that there was not a problem; that they are using analogs extensively in their programs so that there was a range of discussions.

[Slide.]

MS. KOVACH: The next working group workshop will be held in Sante Fe in September of this year. We are in the process of putting together the agenda for that. The objectives, again, are for information exchange on analogs, but this particular meeting will not be in conjunction with the end of any large international project. So the focus is strictly on how analogs will be used in performance assessment.

To that end, there will be four working group sessions again on selected topics. And within these working groups there will only be three, basically, presentations by experts who will sum up the knowledge in that particular area and then the -- it will be thrown up for discussion with the rest of the audience. We will have experts in the audience as well who have definite opinions and we have selected these people as invitees to try to cover the various views that exist regarding analog. So it will be sort of a provoked discussion that will, hopefully, ensure within each working group session.

[Slide.]

MS. KOVACH: So that is basically where that stands at this point. Are there any questions on that before I go on?

MR. STEINDLER: I have one. Very early on you indicated that one of the reasons that NRC does research on natural analogs in the area of site characterization is to obtain high-temperature thermal dynamic data. I find that I don't understand that.

High-temperature, thermal dynamic data are obtainable in the laboratory, and the thought is that the thermal dynamics were valid 10 million years ago as well as they will be in the future.

MS. KOVACH: We are finding that the thermal dynamic data is sparse and in some cases, especially at high temperatures, and that in running different databases we can come up with an order of say, seven, an order of magnitude difference -- seven order of magnitude difference in results using different people's data or using different databases.

So it is not clear, at this point. And it certainly is a point of contention among the people using reaction path model, equilibrium models, at this point in time.

We had very good discussions about that at the Toledo meeting, and I think that continues. Is that your understanding John or English?

MR. BRADBURY: Laboratory experiments can be very clean and controlled, but then when you try to model the site for a natural system in which solid solutions are probably a rule as opposed to the exception -- in natural systems where solid solutions may be the rule rather than the exception, there is definite need to essentially develop databases that will be able to handle impure and complex situations.

MR. STEINDLER: And you are going to extract those out of natural analog is what you are saying?

MS. KOVACH: We can test them.

MR. BRADBURY: By comparing what you see, by comparing your results, say, from an EQ36 simulation, which has certain subroutines concerning how solid solutions work, are supposed to work.

MR. STEINDLER: I understand what you are saying. My only comment is let's not confuse ignorance and stupidity with lousy thermal dynamic data. Those are two quite different things.

MR. HINZE: While we are at this point let me ask a question that relates to the same transparency. One of the uses of the analog studies that you have given is the prioritization of research. And I am wondering if the studies that have been conducted to this point have led to any examples of that within the NRC program.

MS. KOVACH: Well, I think that currently with the Pena Blanca study we are using results from that to focus future research. The same has been done with the Alligator Rivers in terms of focusing some of our work on sorption and complexation models.

So, yes. I would say that this information is being used to prioritize research.

MR. HINZE: In that geochemistration area?

MS. KOVACH: Yes.

MR. HINZE: And retardation and so forth?

MS. KOVACH: Right.

MR. HINZE: In your results from the Toledo workshop, you point out there are most focused analog studies. The most focused would be relating it to Alligator Rivers?

MS. KOVACH: No.

MR. HINZE: What is more?

MS. KOVACH: What they mean by more focused, they are delineating between studies like Alligator Rivers and Pena Blanca. Where Pena Blanca is specifically focused for our repository, whereas Alligator Rivers and Pocos De Caldas --

MR. HINZE: To a specific repository then, not to a specific process objective?

MS. KOVACH: No. And also to a specific process objective. Ours was designed to look at geochemical transport on unsaturated fractured rock. So it is very -- a fairly focused study. But some of these others were not.

MR. HINZE: And the results of this workshop, I gather that a number of countries presented their results?

MS. KOVACH: Yes.

MR. HINZE: Did any of them report on natural analog studies that were not geochemical in nature?

MS. KOVACH: No.

MR. HINZE: They were all geochemical?

MS. KOVACH: Except us.

MR. HINZE: What did you report on? You reported on Valles?

MS. KOVACH: Yes, volcanism.

MR. HINZE: Valles and Pena Blanca?

MR. JC..NSON: Right. And the purpose of the workshop was to -- one of the purposes was to explore other analogs, other potential analogs. As I said we talked about paleohydrology. But the international community made the decision that, for the most part, these should not be considered analogs, natural analogs. Okay?

MR. HINZE: Proceed ahead then, if you would, unless there are further questions.

[Slide.]

MS. KOVACH: I would like to discuss some points about the Valles Caldera natural analog studies.

This study first was initiated in 1987, and the purpose was to evaluate modeling capabilities for the chemical and physical changes to host rock as in response to local and site-wide heating.

We have down here for 10,000 years but realizing that the heating would basically occur within the first thousand years. The rationale is that there are two significant heat sources at high-level waste repository, potentially at Yucca Mountain: the heat source generated from the waste itself and heat that may be generated from volcanic activity.

The concern, basically, was that volcanic tuff is meta-stable and there may be mechanical instabilities and chemical or chemical instabilities that may arise due to the thermal pertibation.

Since then there has been focus on -- well, not focus but suggestions of a driver repository where the thermal loading would be such that anticipated temperatures would be on the order of 250 degrees centigrade within the host rock.

Initially, the repository was -- the design was to keep the temperature below 100 degrees centigrade with the realization that zeolites and glass, some of the meta-stable phases, could alter above that temperature.

One of the other reasons for doing this study was that there are uncertainties that arise due to extrapolation of equilibrium conditions specifically from small-scale experiments to large kilometer-scale processes. Two of those examples would be zeolite stability and the mechanical stability of tuff.

The specific goals were to search for evidence of chemical and mineralogic changes in the tuff in response to a heating event to provide well-characterized example to test the chemical migration models and to provide guidance for co-development and future analog studies.

[Slide.]

MS. KOVACH: The approach was initially to identify a site where there was thermal pertibation. They looked for various areas where there would ge an igneous body, a dike or a silt or a flow emplaced against a tuff, a cool tuff, in order to determine -- well, in order to look at the changes. They followed the NAWG criteria, which was to find a site where they felt they could bound the ages and the time of the thermal pertibation, also bound the chemistry. And they wanted to look for a site where there was no hydrothermal alternation prior to this heating event.

So we went through a couple of iterations initially looking at the Inyo site, Inyo Domes in California, but we found that the host rock there was too altered to be able to determine what migration, if there was migration, as a result of the heating event from the dike emplacement.

Finally, we ended up with the Valles Caldera site which is in New Mexico. I will explain that a bit later, the geometrics of that.

The second task was to collect data and to collect multiple data sets -- to test hypotheses. And again this is the same sort of thing at Alligator Rivers that if they collect data from various types of data that will help narrow the final conceptual model that they are dealing with and when they try to model the system.

We also asked that they do laboratory experiments to help to bound the uncertainty in field data. Then there was to be thermal and chemical modeling that would be iterative with the data collection and the lab experiments.

[Slide.]

MS. KOVACH: I believe you all have a copy of this report that has come in in draft form. It was done at the Sandia National Laboratories by Dr. Harlan Stockman, Dr. James Krumhansel, Clifford Ho, and other staff there.

[Slide.]

MS. KOVACH: This is the table of contents just to give you an idea of the range of studies that were done. I am not going to go into detail on this because you have it in front of you, but they looked at -- characterized the rock samples both from drill core and out-crop samples.

They performed leaching studies, did neutron activation analysis, XRF analyses for chlorine, sulfur, and fluorine; looked at water analysis pyrograms, did micro-probe studies; did age determination, heavy mineral separates, XRD, SEM. So quite a range of your typical analytical techniques when looking at volcanic rocks and trying to determine if there was any alternation.

Then, as I mentioned before, thermal modeling, gas transport experiments and discussion of vapor phase transport, chemical variations induced by capillarity and evaporation and discussions on the overview of the project.

MR. STEINDLER: Is there any uranium in the sub-strait?

MS. KOVACH: Yes, there is.

MR. STEINDLER: How much?

MS. KOVACH: And they saw no evidence of -- they weren't able to conclusively show that there was any transported uranium, but they did check for that. That is also in the handout, the results from that.

[Slide.]

MS. KOVACH: This is a simplified geologic map of the Valles Caldera. It is a situated -- Los Alamos is situated to the east or right on the edge of the Caldera. And they were looking at two flows, the Banco Bonito obsidian and the Battleship Rock tuff.

[Slide.]

MS. KOVACH: The Battleship Rock tuff -- here is a schematic diagram was it was extruded first and eroded. Actually, fairly deeply eroded. There were channels that had been cut into it.

At some later period of time the Banco Bonito obsidian was extruded over top of the Battleship Rock tuff. This indicates there is a breccia zone at the base of the Banco Bonito, which is fairly typical of these kinds of flows.

So what they did is they took -- they looked at this contact between the Battleship Rock tuff and the Banco Bonito and identified three sites that they felt were good for sampling and study.

You notice that this -- the contact between the two is dipping to the east and they ended up sampling a horizontal site where the contact was horizontal and a site where the contact was vertical, and actually found that the vertical site was better for studying major and trace element variations within the tuff because there was no soil that had formed -- paleo-soil that was left in that area.

As an example of some of the data that they collected, they looked at volatiles. These are taken from -- this is the volatile content that is in the Battleship Rock tuff taken at various distances from the contact. The contact being right here.

You can see that, basically, the two elements that showed the most response to the thermal pulse were fluorine and chlorine, fluorine being increasing toward the contact, decreasing away from it and chlorine decreasing away from the contact.

When they found this, this was something they hadn't anticipated, so they went in and did some experiments on crushed tuff to look at the liberation of the volatiles from the tuff in a steam environment.

[Slide.]

MS. KOVACH: This is just some of the data that they performed studies on the water content of the tuffs.

This is a pyrogram for the Battleship Rock Tuff compared to the Panum Crater in California.

The Panum Crater is typical of young obsidians. It has a signal of two peaks, basically, where the molecular water is released at higher temperatures, generally, above 400 degrees. The bound water is then -- the loosely bound water is released at 200 and the molecular water at higher temperatures.

They found for the Battleship Rock Tuff that it didn't follow this classic example. So they won't make any claims, but it may indicate that this has been reheated. The Panum Crater is an example of an obsidian that has not seen any reheating.

They did some thermal modeling. This was the basic model that they started with. They had a wet but unsaturated tuff which is analogous to the Battleship Rock Tuff. The obsidian flow over top of it was heated. They were assuming infiltration of apparation, heat loss through radiation and convection.

They found also a model of the boiling front that developed within the Battleship Rock Tuff below it. This basically gives a basic temperature profile and the thermoconductivities that were used for this.

It started out -- one of the things that was interesting they started with a simple diffusion model and found that they didn't feel that that applied because they actually saw within half a meter of the tuff that within half a meter of the obsidian, so within this zone of boiling, that the Battleship Rock Tuff had been plastically deformed which indicates that it had seen temperatures on the order of perhaps 500 to 600 degrees Centigrade.

That didn't fit with their initial model of diffusion. So they went back and tried different models. They ended up putting their model for the Battleship Rock Tuff. They looked at basically diffusion but with a stefan solution where they modeled the moving boiling front change as it went down into the rock.

This is an example of the depth of the boiling front and time for various degrees of saturation within the tuff. That is the movement of the boiling front.

They modeled, in addition to that, to the temperature profiles, the cooling profiles within the obsidian flow. That was based on a convective model, although it looks to me like it is diffusion. They did this for one year. This is the curve for 500 years.

Finally, the thermal profiles for the tuff itself. You can see after 600 years, the tuff is still at an elevated temperature on the order of 100 degrees, close to 150 meters from the contact.

[Slide.]

MS. KOVACH: So they feel that this is a more realistic thermal model than the one they initially proposed. This thermal model is based on iterations of looking at the data, doing some lab experiments, and going back and readjusting their thermal models to be more realistic.

You can see in there the apparatus that they used to look at their steam experiments. They did some experiments to determine the amount of chlorine and fluorine in the steam as the result of temperatures. They went up to 800 degrees Centigrade. It started at 200.

But they found that these volatiles were liberated from the tuff at temperatures as low as 100 degrees Centigrade.

This has implications for the repository in that this stuff is boiling off it will be possible to have higher concentrations of hydrochloric acid in the water once the repository cooled down and fresh water reentered -- well, not fresh water but cooler water entered the region.

They also did some reaction path modeling and looked at two cases -- one, when the modeler assumed the formation of quartz was suppressed and secondly when quartz was allowed to form.

In the case where quartz is suppressed in the modeling, various zeolites, such as clinoptilolite and mordenite form. In the case where quartz was not suppressed, we don't see that. Instead, albite and quartz formed.

These are less open to phases. This is not something that -- one of the reasons that the study was undertaken in the first place was to try to see if we would have a problem with the formation of zeolites under conditions of higher temperatures.

So let me kind of skip to the results. There was evidence of mechanical heating of the tuff because there was plastic deformation within a half meter of the heat source. That has implications for the mechanical stability of the tuff in the vicinity of the waste package. This may be especially critical in the case of a dry repository, or within the new waste packages that DOE is proposing that are quite massive.

They also found that there was migration of halogen-rich fluids. They felt that these most likely would be in the form of Hf or Hcl. This again has implications for the composition of the water that may contact the waste package and the canister.

They also, in this particular study, found no evidence of formation of the zeolites -- clinoptilolite or mordenite -- but instead widespread alternation to albite and silica polymorphs were formed.

Again this just cautions one in terms of the reaction path calculations that could be done for a system such as Yucca Mountain. Basically assumptions need to be carefully assessed when looking at calculations of that type.

[Slide.]

MS. KOVACH: Applications to performance assessment -- again, the interactive process. This, I think, was a very good example of how models were fine-tuned in response to data collection. This is something that we should be implementing in our Pena Blanca study and in any future analog studies.

We really need to have the modelers working hand-in-hand. The thermal modeling -- it would have benefitted us had they done that very early on because they would have taken samples much further away. They have seen more migration than what they saw. In other words, they may not have gotten outside the envelope of thermal alternation.

Identification and alteration scenarios and basically alteration of less sorptive minerals, migration of radionuclides in the vapor phase. They investigated this but didn't see any effects of that at the Valles Caldera site. And then again, testing of the reaction path models.

[Slide.]

MS. KOVACH: I have included a slide on how these address some of which key technical uncertainties may be addressed by a study of this type. I think you can probably take a look at it. There are quite a few that could be addressed by this to varying degrees.

The KTUs, of course, were developed after this project was completed. The project was originally based on user needs that were identified in 1984 through 1986. Basically those were, as I mentioned before, what happens when you heat a metastable rock unit. There were also questions about vapor-phrase transport.

But this addresses equal or increased capacity of alteration mineral assemblages to inhibit radionuclide migration, geochemical processes that reduce radionuclide retardation volatility, stability, and chemical species of radionuclides to some extent.

Okay. That is all I am going to say on the Valles Caldera at this point. I would like to go briefly through some of the --

MR. HINZE: Before you leave this, let's make certain that there are no questions.

Does anyone have any questions? Ken?

MR. FOLAND: Yes, Linda, could you, or maybe someone else, just give us an example of one of these things that has come out of this, like the geochemical processes that reduce radionuclide retardation.

What would be an example of one of these processes that you have learned about from this study that address that, a specific example? Just a category of processes that sort of addresses that?

But can you point to one specific process that you learned about its role at this study?

MS. KOVACH: Well, I wouldn't say that we learned about its role, but one of the questions we had was, for instance, the heating of clays or heating of zeolites and collapse on heating of these minerals and is that irreversible?

Again, I think what we saw here was nothing that we had not anticipated. I mean, this is something that was talked about in the literature. Yet, there was concern at the time that the DOE was not looking at the possibility of the different phases forming in response to a heat source. Now, that we are looking at higher temperatures, it is much more critical.

One of the other things -- and again this release of volatiles was something that now the DOE is beginning to look at. Yet, initially they were not.

So are these things that we have learned about? No. I mean, we had an idea that this would happen anyway. But you can see them in short-term laboratory experiments. But what happens kinentically over the long haul?

MR. FOLAND: So is then fair to say that basically this study confirmed what would have been a prejudice before going in, to basically confirm that things that one had evidence of from other things were more or less as expected or as refined in a setting very similar to what might apply to Yucca Mountain?

MS. KOVACH: Right.

MR. FOLAND: Thanks.

MR. POMEROY: Linda, let me pose a question to you in a form that I hope you can provide me the answer to. If you were thinking in terms of the regulatory process that the NRC is going through, what are the three most important items that this study produced that had a direct effect on the way the regulatory process works?

While you are thinking of that, what three things do you think are the most valuable results in terms of the NRC's program?

MS. KOVACH: In terms of how licensing will use it?

MR. POMEROY: Yes, how your customer would use this information.

MS. KOVACH: Where's John? He should probably answer this. But I would think that the fact that this would alert them to uncertainties in conceptual models about how the repository will respond to a thermal pulse, both chemically and mechanically.

I think that it also may provide data for them to model. For instance, they could utilize the data that has been produced to use the V-tuff code as a test case. They could test that against the data that was provided here.

MR. POMEROY: While you are working on the third one, could you tell me: Is this the only place that they could have gotten a data set like this for the test case? Is this so unique?

MS. KOVACH: No.

MR. POMEROY: Is there a third one?

MS. KOVACH: Do I have to provide a third one?

MR. POMEROY: No, you certainly do not.

MR. GARRICK: Maybe it is a corollary question and equally unfair --

MS. KOVACH: Thank you.

[Laughter.]

MR. GARRICK: But I would like to ask it this way. Have these studies convinced you that analogs are very helpful in enhancing the credibility of performance assessments? If they have, why were you and others not able to convince the skeptics at your recent symposia?

MS. KOVACH: Because we speak a different language.

MR. GARRICK: But do you really see analogs as playing an important role in the quality --

MS. KOVACH: In the quality? Yes.

MR. GARRICK: In the quality of the performance assessments?

MS. KOVACH: Yes.

MR. GARRICK: Is this a step change? Is this a qualitative effect or is it a quanitative effect in your judgement, as a researcher?

MS. KOVACH: I think it is both. The Valles Caldera study, the people that were doing it, were actually involved in WIPP performance assessment at the time, and found that some of the models that were -- some of the work that was being done used contradictory data within an individual run.

That is mainly because it was used by people who were familiar with the model, with the computer codes, but not familiar with the data that was being in. Neither -- the people that were running those codes are not stupid people. They are just not informed in your sciences, or in a particular discipline. So, yes, this information is definitely useful.

MR. GARRICK: Now since you mentioned the WIPP performance assessment -- and they are somewhat ahead of most others -- can you see the difference, the before and after difference, with respect -- at the CCDF level?

MS. KOVACH: I don't know the answer to that.

MR. HINZE: Let me ask the question a little differently. Are the results of this study primarily in terms of assistance and site characterization, or in performance assessment or in prioritization of research?

MS. KOVACH: I would say in performance assessment.

MR. HINZE: That is interesting because I would not have said that. From my own very simplistic look at this, it seems to me that one of the things that this project really has shown is the need to perform performance assessment on a small segment of the TPA, of the Total Performance Assessment, to better characterize the site so that they you know better about the acquisition of data.

It seems to me that that is the thing that you really learn from this project is that we shouldn't wait for these large total performance assessments, but they should be carried out really iteratively in the same characterization process.

Maybe that is performance assessment. Maybe it is site characterization. But to me it is site characterization because it really is leading to the acquisition of better data.

MS. KOVACH: Yes, I would agree with that. But I think it also speaks to future analog studies, the importance of having the PA, the modeling incorporated very early in the project.

This is something that is always -- it is nothing new. This is something that was brought up 10 years ago. But it doesn't always seem to be incorporated or followed.

MR. HINZE: But when you mentioned that its greatest results, or the most significant results are in performance assessment, what were you thinking of?

MS. KOVACH: Well, I was thinking in terms of looking at the difficulties that one may have with the reaction path modeling.

Again where that fits in -- does that fit into -- is that part of site characterization or is that part of PA? I think that is a kind of diffuse boundary there.

MR. HINZE: Are there further questions at this point?

MR. STEINDLER: This is just an observation from somebody that doesn't know anything about geology. It strikes me that two things that you keep coming back to is that studies of this kind lend credibility to your statements to DOE, that those guys ought to be looking in an area that they have already decided they aren't going to look at.

MS. KOVACH: Right.

MR. STEINDLER: I find that interesting if for no other reason than it is maybe an expensive way to enforce what otherwise becomes an enforced issue at the time of licensing.

Unfortunately the expense is on the back of the NRC rather than to simply say, "All right, guys. You don't pay attention to us. Let's wait until licensing. Then we will tell you that you have to go back and look at it."

The second thing that strikes me is that the geosciences people who are participating in this kind of work are using the analog studies as a classroom to learn what they apparently don't know about how to evaluate systems rather than providing input to a process that is already well defined but simply has missing information.

You know, when somebody says, "We can't seem to make a model in a particular area work. Why? Because we diun't understand the phenomenon. Now we have a field laboratory in which we are learning about the phenomenon."

That is the same as Geology 305 where the field portion of it gets you smarter and then to go back into the classroom and learn what you have learned.

It seems to me that those are the items that seem to be more important, as I hear you talking. That may be a bias of my listening, than the directed input into a higher quality performance assessment.

That is a comment. That doesn't require anything else. But my bias leads me to think that the geoscience folks are getting smarter, which is a good thing.

[Laughter.]

MR. GARRICK: It is about time.

MR. STEINDLER: It is way overdue.

[Laughter.]

MR. STEINDLER: It belies the undercurrent of concern that I have about how smart they really are.

[Laughter.]

MR. POMEROY: Since I am not very smart, let me ask one last question, Linda. On your last slide dealing with this particular example, you say -- there is one bullet basically. It says, "Provides means to bound uncertainties in natural analogs which will aid in bounding uncertainties in future repository systems."

Could you just elaborate a little bit on what you mean by "provide means"? What are the means to bound the uncertainties that you have learned? How will they aid in bounding the uncertainties in the future repository system?

MS. KOVACH: Well, maybe that is poorly stated, but it is basically the point that I had brought up earlier today that we could use analog studies to bound the value of processes or the magnitude of processes that occur in nature.

If we can't bound them looking at natural systems, can we really bound them -- can we expect to provide bounds to performance assessment modelers for their assessments. Th.t was the thought behind it.

You know, certainly this study provides perhaps one data point, if you will, on a curve, not necessarily -- it doesn't provide the whole range.

MR. POMEROY: Are you then saying that the range then would be transferrable in some way?

MS. KOVACH: Yes.

MR. POMEROY: Directly between this and Yucca Mountain?

MS. KOVACH: I think that is a trick question.

MR. POMEROY: It certainly is.

[Laughter.]

MR. POMEROY: You don't have to answer it.

MS. KOVACH: Thank you.

MR. POMEROY: Thank you.

MR. OTT: I would like to make a couple of observations, if I could. With regard to the earlier question, Dr. Pomeroy asked for three examples of applications. There is a slide in here which deals with implications of results of the project which probably is transferrable in this particular context into how things might be used.

An aspect that I might personally bring up is that from our point of view this is probably the first time we tried to examine a process that was not traditionally considered to be an analog in the sense of geochemical analogs, or ore bodies, or that kind of thing.

We actually had recognized this problem with the thermal heating and tried to figure out an approach to get some answer to what that effect would be.

From that point of view I think we learned a lot about going out and doing this kind of a project, one of the first ones being that the initial site wasn't the right place to go. That was the very first lesson that we learned in this project. Hopefully it didn't cost us a lot. It cost us a little bit.

That, I think, is the lesson we have learned in all of the research. I don't think there is anything else I really want to say right now, but that is primarily the two things I wanted to bring out -- on that I think we learned something just from trying to look at, to use this approach to attack something which wasn't traditionally used.

MR. POMEROY: Thank you, Bill.

MS. KOVACH: If I could just add one thing, I was concerned -- maybe I am just mishearing what is being said, but an important part of performance assessment for us is understanding processes and understanding the vulnerabilities of the process. Performance assessment provides us a framework for our thinking at this point in time to help us. We would say that any direct implications for understanding processes are a direct benefit to performance assessment.

Now maybe, you know, maybe we have a broader view of performance assessment than others, but the way we talk about these things sometimes we may be passing each other in the night in terms of terminology and that's at least my view of performance assessment.

MR. OTT: I finally remembered my other observation. With regard to what Dr. Garrick said, Dr. Garrick's remark as to how this fit into the performance assessment.

If you remember the pyramid of analyses that Norm put up there with that very small systems model at the top and subset of models under that, we're probably talking about process models that are fairly far down that pyramid in terms of trying to aid in the auxiliary analysis and provide input to the systems models at the top.

MR. HINZE: Linda, as we move to these next items, because of the obvious interest that there is in asking you questions about the topics you are covering, I think you are going to have to focus your discussion on these items to a considerable degree and focus them on results, anticipated results and how they might impact with the regulatory process.

As you discuss, the Alligator Rivers I believe and Oklo --

MS. KOVACH: Yes, I think what I am going to do with Oklo is basically just -- it is a project that is currently ongoing, nearing completion, the first three years of study, and we presented information to you on Oklo last year so I am not going to go over that again.

Basically, what we have learned from that study is that we found or have been able to show that the clay layer was effective. The clay layer and the organic layer, the bitumen, were both effective barriers to radionuclide migration from the natural reactors.

There is an increase of U-235 toward the periphery of the reactor zones and immediately surrounding the reactor zones is the clay layer. There was no evidence of plutonium or any of the radionuclides having gone beyond the clay.

There is evidence the plutonium had moved through the site. It's indirect evidence. They are currently doing extensive investigations on the alternation of the uraninite and the purpose of that is specifically to validate the laboratory experiments that we have on corrosion of the uraninite or corrosion of spent fuel.

We're trying to understand the mechanisms by which the uraninite corrodes.

There is evidence that radiolysis has occurred and that it is important and may be important in altering the redox state of the system.

The Oklo site is also being used to test and to construct and test to the ground water flow models. We are also using it to test some hydrothermal models that we have. There's a 20 meter dolerite dike that was intruded between two of the reactor zones. We have done some cursory modelling of that to determine what the temperature profiles may have been.

Why are we concerned about that? We're concerned about that for two reasons, that we would like to see if there an effect on the migration of the radionuclides in response to this thermal pulse, the intrusion, the dike intrusion. It's a similar composition to what we would see or expect to see at Yucca Mountain if a basaltic dike were to intrude that area. Those are the -- we are also investigating colloids, the role of colloids, organics, and microbes in either retarding or enhancing the migration of radionuclides at that site, so it is inconclusive at this point. The study is not finished but those are the type of things that we are looking at.

MR. HINZE: This is the University of New Mexico or University of Arizona studies?

MS. KOVACH: This is the whole.

MR. HINZE: The whole?

MS. KOVACH: The whole project because we have access to all of that information through our involvement.

MR. HINZE: But the NRC is independently supporting this?

MS. KOVACH: Yes.

MR. HINZE: Plus your work on the dikes?

MS. KOVACH: Yes. Okay.

MR. STEINDLER: If we relate these results to an impact on Yucca Mountain, the clay and bitumen information is interesting, but is it relevant?

MS. KOVACH: It is not relevant to us. It is relevant in low-level waste and this was funded through low-level waste.

The uraninite -- I gave you areas that are of concern to the greater waste management community, the international community. Bill, you were going to say something?

MR. McNEIL: I would like to say a word to the geologists present, that we use the word "corrosion" for uraninite and for spent fuel. That is deliberately used instead of alteration because it is an electrical-chemical process because of high electrical conductivity of uraninite and really the experimental tools, as the Canadians have found, is the experimental tools of corrosion science that you want in order to answer the questions. It is a corrosion process.

One doesn't ordinarily think of corrosion of minerals in a purely electric-chemical sense, but this happens to be one.

MR. STEINDLER: And the notion is because you are going eventually alter it from UO-2 to uraninite that it is important?

MR. McNEIL: No, the point is that all of these uranium minerals have high electrical conductivity so when you start trying to model it, it is just like a metal surface. You can have separate cathodic and anodic processes.

MR. STEINDLER: How do you get the uraninite in the first place?

MR. McNEIL: Spent fuel. UO-2 alteration. Even starting with the UO-2 pellets you are dealing throughout this with compounds that have a high electrical conductivity until you can have separate cathodic and anodic processes, which you usually can't in minerals.

Talk to Dave Shoesmith if you don't believe me. They have done that work quite carefully up there.

MR. STEINDLER: I believe you.

MR. McNEIL: It happens to be an important point when it comes to experimental techniques. It sounds like --

I did not want to let it pass and have everybody think it was merely a question of our borrowing somebody out of, the geologists' borrowing somebody else's terminology.

This actually affects the experimental technology.

MS. KOVACH: In terms of the Alligator Rivers, we have been through that as well, last year.

Lessons Learned, I would say that, as I mentioned before, in site characterization the example that we found, that it provides an example of multiple data sets that may be necessary to characterize the site and also found that there was a good deal of difficulty in determining the site hydrology.

In terms of performance assessment, these various points, the uranium tends to absorb or was retarded by the iron oxyhydroxides in the system almost exclusively.

We used this to test and develop reaction path models to test the uranium thermodynamic database. We found in testing this that the database was inadequate for -- it was uranyl phosphates and uranyl silicates, which had not been known before.

As I mentioned before, there was difficulty in modelling the hydrology. We tried several different models from porous media to equivalent porous media, fractured Trackman programs that were used to model the site, none of which doing a very adequate job.

Los Alamos used this, is using this, and this is a really good example of where they are looking at multiple analog sites to try to bound or to test the idea that uranium minerals could be analogs to nuclear reaction products. Los Alamos National Lab was part of this project. They were looking specifically at Koongara but also Cigar Lake, Oklo, Pocos de Caldas and have produced a nice report dealing directly with that.

MR. STEINDLER: What is the bottom line to that?

MS. KOVACH: To their report?

MR. STEINDLER: Yes.

MS. KOVACH: I am not the person to ask.

[Slide.]

MR. STEINDLER: When you say nuclear reaction products, do you mean fission products?

MS. KOVACH: Yes. I think I am going to stop here.

MR. HINZE: Does that mean that you want to come back?

MS. KOVACH: The slide I have is just -- I will throw it up and you can decide whether you want to talk about it now or talk about it later.

MR. HINZE: Why don't we talk about it now? You are up there. Let's talk about it.

MS. KOVACH: Future plans.

[Slide.]

MS. KOVACH: I have outlined here a few things. We are actively getting research and center staff who are working on the analog projects involved in IPA. We plan to continue with the Pena Blanca and Santorini studies through 1997.

We are initiating work in volcanic fuel studies which we consider as analogs for a site characterization and also performance assessment but in the area of volcanism and tectonism, identification of natural analog projects is ongoing and additional ones that may be studied.

We have the workshop coming up in June that we plan to hold. There is a second Alligator River study that is being initiated this year but that is primarily for low-level waste and we will continue participation in the working group.

MR. STEINDLER: What do you plan to get out of the Pena Blanca and the Santorini studies? Why are you interested in them? Where do you think the information is going to be useful?

MS. KOVACH: They were designed to look at contaminant transport and unsaturated, fractured rock. The reason that we were looking at that, it's not well understood and very difficult to model. We wanted to see if we could identify a site and study that, study what the major mode of transport is, whether it is via the fracture or the matrix. This was a question.

In performance assessment, we have been using matrix flow for the most part. I guess we are involved, we are doing work with fracture flow but we wanted something to see if we could identify what the major mechanism was so that was one of the objectives of the project.

MR. STEINDLER: And both of those are sufficiently analogous to Yucca Mountain, so that the data will be applicable?

MS. KOVACH: Yes, this is a site where the data will be very transferable, applicable.

MR. HINZE: I think English is going to cover most of this. Further questions? Ken?

MR. FOLAND: Linda, do you want to say anything about Pocos de Caldas?

MS. KOVACH: No.

[Laughter.]

MR. FOLAND: I don't know how much it costs you people but somebody spent a lot of money up there.

MS. KOVACH: We were not involved in it at all.

MR. FOLAND: But you get to share all of the benefits of this presumably. If that is not the case, just say so. Presumably this is all public information.

MS. KOVACH: It is now, yes.

MR. FOLAND: Then presumably it was done under some QA and you can have confidence in it. Did we learn something from that? Can you name specific things?

MS. KOVACH: One of the major things that came out of that was the importance of the redox, for instance in retarding radionuclides and they looked at colloids, the importance of colloids. Anything else? Microbes.

MR. OTT: The observation I was going to make I believe back when Pocos got started we had an opportunity to participate and I don't know exactly what the reason was. My recollection is we chose not to. It could have been that somebody chose not to for us. I believe that we chose not to because this was a case where we were skeptical that the system was well-bounded enough to give us good results in the end.

When the final reports came out, we tended to agree with everybody else that the study did provide useful results, even if only qualitative, and that it was worth doing but again it was a case where we made the call and actually called the other way, so from your perspective it is the one that we did not elect to study.

MR. STEINDLER: You know, it is interesting. The comment was that you learned that redox potential is important in transport.

MS. KOVACH: Well, we didn't learn that. We knew that.

MR. STEINDLER: That is a subject well-known for the last decade. I am confused.

MS. KOVACH: I'm sorry, but that was understated. The question really --

MR. STEINDLER: Geology 305. No? Okay.

MS. KOVACH: They found in that study that coprecipitation was an important mechanism for trapping all sorts of non-redox sensitive elements at a redox front. That is what was found in that study, not that redox reactions occur in nature.

MR. HINZE: If my notes are correct, Bill promised that you would say a few words about the Black Hills or Black Mountains?

MS. KOVACH: Yes. It is the Black Mountains. The only thing I can point you to at this point because I am not very familiar with that is there is a small write-up on page 120 in the back of the workshop proceedings that described the Black Mountains.

It is a rotated detachment fault and provides an opportunity to look at the plumbing system of a volcanic, plumbing system of a cinder cone volcanic system.

MR. HINZE: And this is being done under tectonics?

MS. KOVACH: Yes, but I think that -- do you know anything about this, English?

MR. PEARCY: English Pearcy from the center. At the risk of trying to explain what Steve Young is doing, and it is considerable for me to take that risk, my understanding is that the interest in the Black Mountains is that they have been identified as a likely example of what lies beneath Yucca Mountain as it has been uplifted in the exposed fashion and can be better studied there so that you have an accessible view of otherwise inaccessible or only very limited access through deep bore-holes.

MR. HINZE: Don't say any more. Sounds good. Sit down while you have a chance.

Let me ask Bill if it would be possible for us, since this is an analog, for us to get a copy of the project proposal, the project plan on that.

MR. OTT: For the tectonics project.

MR. HINZE: For Black Mountains, if that would be possible, that would be appreciated; the volcanism project -- this is Chuck Connors?

MS. KOVACH: Right. You heard about last month's.

MR. HINZE: And I don't know exactly where that is going from where he is at this point but we will pick that up at another time.

Dr. Steindler, I would suggest that we take a very brief break and then we will hear from English Pearcy, no more than 10 minutes.

MR. STEINDLER: Sounds good.

[Recess.]

MR. HINZE: English, please feel free to begin, at your convenience.

[Slide.]

MR. PEARCY: This is actually the third time I would have spoken to the ACNW. The first time was in our laboratory, about three years ago. The second time was in this venue almost a year ago, just a little over a year ago, and I am oddly enough perhaps looking forward to the opportunity to --

[Laughter.]

MR. PEARCY: -- to talk about our work.

MR. HINZE: We are looking forward to hearing what you have to say.

[Slide.]

MR. PEARCY: The outline that I will be following is intended to address many of the concerns that have come up repeatedly during today's discussions. I will deviate even a bit from my plan and further deemphasize the technical aspects of the talk, even beyond what I had already planned.

Nevertheless, if someone develops an interest in a technical question, please do not hesitate to ask. I will be glad to go into it further and provide you with whatever information you may be interested in.

Generally I want to move from reiteration of the regulatory bases through an overview of the project objectives and what we see as some of the important results from the project and we will go ahead and talk about those directly, and then to the project structure, and give you a sense of the schedule that we have been following and what we anticipate for the future, and then talk rather more quickly than I might have otherwise about the task objectives and results, and then go on to the project perspective, the integration with performance assessment, site characterization, and the use of the results with this project with respect to key technical uncertainties.

You have seen longer versions of these regulatory citations earlier today. As noted, the regulation does not require the use of natural analogs, nor does it preclude it. It simply holds them out as one method by which information can be usefully gained.

[Slide.]

MR. PEARCY: This is a list of six, one of them slightly faded, key technical uncertainties. When I call them selected key technical uncertainties I mean exactly that. I selected them from a list of 58 that Robert Johnson mentioned earlier today.

These are the six that this project is speaking most clearly to. I want to list them for you in advance of the talk so that they can be in your mind and then we will come back to these and we will talk specifically how some of the results will be used in performance assessment and towards these key technical uncertainties.

[Slide.]

MR. PEARCY: These are the project objectives taken from our project plan, beginning with obtaining a state-of-the-art knowledge of natural analog studies to undertake a natural analog study both to obtain fundamental data and to demonstrate a methodology in which you might use natural analog data, in site characterization activities and in demonstration of compliance with performance objectives.

[Slide.]

MR. PEARCY: Project results, again very broadly stated, are that we have obtained a state-of-the-art knowledge of natural analog studies and that we are continuing to maintain that knowledge. We have had many interactions with DOE scientists and with scientists from the international community.

We have identified two outstanding analogs for the proposed repository at Yucca Mountain. We have obtained a great many fundamental data in a variety of areas and we are examining transport and retardation processes and developing conceptual models.

[Slide.]

MR. PEARCY: The project structure is really quite straightforward. We began with a literature review and a workshop that has been discussed already today. That was complete in June of 1990. That was also the month when I first addressed the ACNW.

The site selection was our Task 2. It was completed in June, '91. Data acquisition is continuing through the present, data interpretation continuing to present and our reporting has been active throughout. You will not hear me talk about Task 5 anymore but what that consists of is our monthly -- what we call our periodic reports, our semiannual reports and topical reports on an as appropriate basis. It usually works out to something like once a year.

MR. HINZE: That is really site selection, is that correct?

MR. PEARCY: The title of the task was Site Selection but the objective was to select a site or sites.

MR. HINZE: Thank you.

MR. STEINDLER: In your reporting task, have you published anything in the open literature?

MR. PEARCY: Yes, sir. If you would like, we can provide you with a bibliography of that information.

MR. FOLAND: Can I interrupt to ask a question? I am back about two or three slides.

You listed half a dozen KTUs and you said you selected these among 58?

MR. PEARCY: That's right.

MR. FOLAND: How did you select these?

MR. PEARCY: I helped to write them when I helped to write the CDSs and natural analogs are mentioned within the CDSs as one means of moving toward developing methodologies to reduce uncertainties in those cases.

MR. FOLAND: Okay. Were there other KTUs you could have sited here?

MR. PEARCY: Sure.

MR. FOLAND: Is your project tied to particular user needs?

MR. PEARCY: Originally, when this project was conceived in 1988 and 1989, there were no KTUs. There were no CDSs. There was no SRA. What was available was user needs and that is exactly what it was directed towards and at present, as Robert Johnson described, the user needs and the KTUs are being used to reinforce one another. The KTUs are being developed to expand on what had been originally presented as user needs.

MR. GARRICK: I think I missed it. I still don't understand why you selected the ones you have listed here.

MR. PEARC": Those are the ones for which I am best able to provide the evidence that we are moving towards some -- not resolution of the KTUs because that is not our job, but toward which we are improving the understanding to reduce those uncertainties and toward which we can develop a methodology by which one might demonstrate compliance with performance objectives tied to each of those KTUs.

MR. GARRICK: Let me understand. Are you talking about a difference between KTUs that you can do something about with respect to an analog or are you talking about KTUs that are ranked in terms of importance based on all of the evidence including the performance assessment?

MR. PEARCY: KTUs that are addressable by analog study.

MR. GARRICK: So these may not be -- in the limit, these could be irrelevant to the bottom line results of the repository?

MR. PEARCY: As Robert Johnson mentioned this morning, of the 58 KTUs, one of the exercises that is presently ongoing is a prioritization of those. That is exactly right.

That has not been done at present. But I think, as we move through this, that it will become apparent that some of these will be critical to radionuclide release and you will see something tracked through to your CCDS.

MR. GARRICK: Thank you.

MR. POMEROY: You talked in your project objective slide about four objectives and I think I understand them all except the second one, which is design and undertake natural analogue study of contaminant transport relevant to the high level waste depository at Yucca Mountain.

Can you tell me why that should be an objective of an NRC study rather than an objective of a DOE-supported study?

MR. PEARCY: Something that was mentioned earlier today is that the work that the NRC chose to undertake at Valles Caldera and then in this project placed with the center is a new approach to natural analogue studies which hadn't been practiced in the international community or in the United States previously, which was to focus the selection of a site toward a specific proposed or candidate repository site. That had not been the way things had been done for 20 or 30 years in natural analogue studies.

Natural analogues began with Oklo. And it was such a great place that couldn't be done otherwise that if it was a stretch between what you were thinking about in some other place, well, it was necessary because it was Oklo.

The idea that Linda Kovach, George Bushard and others at the NRC developed with the restriction of the U.S.

program to only looking at Yucca Mountain as the candidate repository was -- the choice was made to go forth and look for analogues which are the best representations that one could find of processes or conditions anticipated to be likely at Yucca Mountain.

Now, Dr. Foland's comments earlier today are well taken that no analogues are -- analogues are analogues. Analogues are not the same, they aren't identical. So you'll see similarities. We looked for a high degree of similitude, but not identity. But that was a new idea that the NRC research group promulgated and which we executed in searching for these two sites.

That was not being followed by anyone previously because no one had focused them before that site. So I think that was a big contribution.

MR. POMEROY: That may well be. I don't think you have quite answered my problem, though. And that is, there is another way to solve that.

What you are saying here, looking at here, is contaminant transport. That is clearly something that DOE has to investigate and has to look at. It is not clear to me that we have to look at it, unless there is something about it that is so unusual that DOE is not going to look at it that we have to -- and I guess another approach to it would be for the Staff simply, one way or another, to say to

DOE, this is something that you should really look at and then wait and see whether they do.

And I am curious as to whether -- why this particular -- I understand the other objectives and I think they are fine. I am just curious why that objective to look at contaminant transport specifically as though that is an end in itself, why that is there.

MR. PEARCY: The reason that is there is that in executing a regulatory function, it is required to have an adequate understanding of the processes involved to be able to evaluate compliance with performance objectives.

Performance objectives are partly defined in terms of contaminant to the accessible boundary. The boundary of the accessible environment. Those processes are not well understood for a Yucca Mountain environment, which is quite different than any other repository site being considered around the world.

Without that understanding, were the DOE to come forward with a license application claiming compliance with the performance objective, basing part of the support on that claim on natural analogue data, the absence of that understanding and of the means to use analogue data, the transferability of data from one site to another that Dr. Steindler has raised earlier, an understanding that the realistic utility of that, the limitations that you can reasonably expect of that, and the absence of that understanding precludes acting to evaluate the license application. That makes it an NRC responsibility.

MR. POMEROY: So you would make this actually a sub-bullet under Item 3? Obtain fundamental due data to understand -- to improve the understanding of processes? In other words --

MR. PEARCY: That would be for part of it. The other part would be the use of analogues, information to support information from one site to speak to a process that occurs at another site. How one might do that in a regulatory setting is also very poorly understood.

It seemed to us and it still does that that is best done when the two sides are as similar as they can be.

MR. OTT: I would like to add one more thing to what English has said. Part of what we are discussing here goes back to several reasons that have been presented to the Committee many times before about why NRC does research at all.

Part of that is to maintain an independent capability to review that DOE application. Some of it is to do confirmatory tests.

When you look at where we are allowed to do research, we don't do work at Yucca Mountain. DOE has very specific reasons for doing all of that work itself. And they are placed under very high standards by us. And if we are going to do work that is not at Yucca Mountain, I think it behooves us to do work that is at least at a site that we can make some analogy to the processes at Yucca Mountain.

MR. POMEROY: Bill, I don't have any problem with that; I honestly don't. And I understand completely the rationale for the other three items in the objectives of this project. It just seemed to me that that one is really -- if it is really a sub-bullet under the improving the understanding of the processes, that is very clear.

Please.

MR. PEARCY: Task one, as I noted, has been complete for some time now. It is our literature review.

[Slide.]

MR. PEARCY: It had several objectives including both a compilation -- conduct and compilation of literature review, the initial sorting through of potential sites, and hosting of the workshop that has been mentioned a couple of times.

We did conduct a comprehensive review of the literature. Comprehensive means looking at the entire literature that we could identify. This is a copy of that report. There is an annotated bibliography of 248 technical papers in here. There are, of course, about 200 publications just on Oklo alone.

Those are not all in there. Only a few of those are in there. It was not relevant to this work to summarize all available work but to try to seek out all of the different sites that had been considered.

We looked at 40 different analogue sites, considering things from archaeologic glass, archeological materials through large uranium ore bodies. The intent was to survey what had been done.

We identified contaminant transport processes likely to be important in Yucca Mountain. We established a set of criteria based substantially on the NAWG criteria but modified somewhat for the successful use of selection and successful use of natural analogues. We identified four sites, Pena Blanca, Akrotiri, Virgin Valley and McDermitt Caldera for further study in our site selection task. We hosted the technical workshop and published the results of that workshop, the results of which you already have.

[Slide.]

MR. PEARCY: Following through on that systematic approach to choosing a site, in task two, as discussed, the idea was to find something as similar to Yucca Mountain or aspects of Yucca Mountain as we could find.

We evaluated the four sites I mentioned, building on the literature studies with personal contacts, with field study, sampling and laboratory analyses. And, using that criteria we developed in task one with those direct observations, we decided that Pena Blanca, Mexico, and Akrotiri, Greece, were the sites most likely to produce results relevant for Yucca Mountain studies.

Just to remind those who may have forgotten, Pena Blanca is located in Chihuahua just north of Chihuahua City in the same trend of tertiary volcanic rock as is Yucca Mountain. Akrotiri is not in that same trend of tertiary volcanic rocks; it's in tertiary volcanic rocks -- or actually much more recent than tertiary, 3,600 year old volcanic rocks in Greece on an island group of Santorini. The large island here is Thera. That Akrotiri archaeologic site is on the southern end of that large island.

Among other things, I am not going to reiterate to you the similarities between those sites and Yucca Mountain unless you care to have me go over those again.

In our task three data acquisition, the objective was quite broad. And we have implemented it in a variety of ways. I'll first present a list of results of data acquisitions for Pena Blanca and then a similar list for Akrotiri.

We have now produced everything from basic air photography, topographic geologic maps, geologic cross sections. We have mapped the uranium concentrations. We have collected 1,649 rock samples described and studied them and are tracking them in a QA sample custody control.

We have conducted a variety of chemical, mineralogical, petrographic analyses and are in the process of extending that.

Just very quickly to remind you what the site looks like, this is a digital elevation model of the site. This is important to give you a point of reference for some of the locations we will be discussing when we talk about some of the results that are useful for performance assessment.

Most important is this broad, flat surface. It is a mine surface that I will refer to as "level 10." The smaller flat subpart, sub-horizontal surface is "level zero." These are mined surfaces on the side of a basin and range horst, just as Yucca Mountain is a basin and range horst.

MR. HINZE: Is the tip of that feature such that you get some three dimensionality?

MR. PEARCY: The rocks dip about 15 degrees to the west. The third dimension is provided essentially by these mined faces. The boundary between the two rock formations in which the ore body is hosted sits about here, dipping back at 15 degrees. But we have about 60 meters vertical exposure and about 2,000 meters, square meters, potential horizontal surface exposure.

MR. HINZE: The uranium minerals are still in sufficient abundance in those faces in order for you to carry out a three dimensional view?

MR. PEARCY: That's true.

[Slide.]

MR. PEARCY: Not to give you too much technical detail.

We have conducted -- I will show you a gamma survey of this level surface 10 and level surface zero. We have also conducted a gamma survey of this 10 meter high vertical face. No mean feat to do a gamma survey on a vertical face. But that gives us -- it is only 10 meters, but it is across that vertical face that the ore body is actually exposed and in vertical dimension as well as the two horizontal dimensions. There is no exposure of the ore body on this large vertical face.

MR. HINZE: The reason I am asking this is to get to the point of whether you can do three dimensional modeling.

MR. PEARCY: We can do limited three dimensional modeling at a relatively small scale. There are some historical drill core from the Mexican mining agency, Euromex, who did the exploration at the site. The Mexican drill core from the 1970s is less than current standards.

We have discussed the possibility of drilling in the future, but that is quite an expensive proposition outside of our current budget.

[Slide.]

MR. FOLAND: Could I ask you -- I am having trouble keeping up.

One viewgraph back, the objective of this project, data acquisition is to develop methodologies. I am not sure what you mean, develop methodologies. You are not developing methodologies for TEM measurements of your uraninite, are you? Those methodologies are --

MR. PEARCY: So far, no.

MR. FOLAND: And so, I am not sure what the objective is.

MR. PEARCY: By the developed part of that?

MR. FOLAND: I guess I am not sure what the objectives are. Before I acquire data, I know what my objective is in terms of a scientific product and then I figure out the data I need to address that objective.

MR. PEARCY: That's right. And then what that actually means in practice is that, say, for instance, three weeks ago I was at the site. We wanted to use electromagnetic or electroconductivity measurements to try to discern the limits of the postulated perched water horizon that may have reacted on a seasonal basis with the ore body.

So we know what we want to do, we get the equipment, we arrange to have the equipment at the site. It remains to develop a means for actually executing those measurements. It's not textbook. Textbook assumes lots of perfect geometries, lack of complicating factors such as colichi horizons, locally present conductors which form locally present conductors, other things that you have to work out ways to accommodate.

That's what in practice is meant by "develop methodologies," that kind of accommodation to what -- how do you apply a standard technique to this circumstance. We are not creating new electrical techniques.

[Slide.]

MR. STEINDLER: Is it reasonable to say that once you have developed the methodologies and you are able to obtain data that you find satisfactory, you now have established a base from which you can judge whether or not the Department of Energy is doing a decent job in getting its data? Is that the purpose?

MR. PEARCY: It certainly provides us with better understanding of that. But that is really a corollary of the project. To the extent that we become better informed, that is always helpful. But I cannot say that that is a specific regulatory, if you will, goal of the project. I accept, as that information might inform one of those KTUs that we addressed.

I am going to show you a photograph next.

[Slide.]

MR. PEARCY: Taken from up here looking down at this flat surface.

[Slide.]

MR. PEARCY: This is level plus 10 looking west to east. The ore body -- the exposure of the ore body on level plus 10 is about here.

[Indicating.]

MR. PEARCY: Our activities relevant for performance assessment KTU, work focused on three principal aspects that are illustrated in part here.

What we have done here is to sweep the outcrop clear for the folks who may not have seen these kind of photographs before.

The mine surface was covered with debris and we have simply swept it clear here. Swept with wheelbarrows and shovels and finally brooms.

We have looked at the margin of the ore body here. Later on I will show you the uranium profiles and uranium series disequilibrium measurements taken at about this location across the edge of the ore body. I will show you data pertaining to uranium transport along this through-going east-west fracture at this location. And I will show you a gamma map of uranium concentration showing a plume of uranium out to the north through generally fractured and then discrete fractured rock to the north.

The other aspect of the ore body not illustrated on here but to which we have spoken underneath this surface, entered from the level zero surface are a set of tunnels, underneath that surface, providing access within the ore body. There is about 80 meters liner sum of tunnels beneath this surface, and they are completely bounded by the covered area, the cleared area that you see here. Those provided access to the uraninite which provided the original source term for uranium transport at this site and which was such a good comparison to spent fuel.

[Slide.]

MR. PEARCY: This is a geologic map showing the fractures on that cleared area. You were looking before from a position up here down onto this surface. This light yellow-green line is the perimeter of the visible uranium mineralization which is present in most of this area, though there is an area of its absence near the center.

This is a computer compilation from within Arc-info database, base the original mapping has allowed us to enter and track within this database. And represented, though not discernable on this figure are 11,374 fractures mapped on about 1,200 square meters of cleared surface.

That area has now been expanded and includes about another 250 square meters down here. That is to give you some idea of the level of detail at which we are working.

MR. HINZE: What have you learned from that? Is that getting ahead of your story?

MR. PEARCY: I would be glad to speak to that while I am looking at this.

One of the things that had been mentioned earlier was to what level of detail do you have to do something. The scale at which this mapping was done is a scale of one to 25. I chose that scale based on practical considerations of time and money. That was not a scientific consideration. It was a pragmatic, I think Dr. Foland -- Dr. Garrick who said earlier today -- I'm sorry, it was Norm Isenberg who said that engineers in performance assessment have a different approach. It is pure pragmatism.

Well, this was a scientist operating on a pragmatic mode, getting the job done.

There are, of course, many, many fractures, many more than 11,000 that occur on the surface which are not mappable at that scale. And we have chosen to address that through a set of smaller area studies that I'll show you later.

And what I can say as far as what we have learned is that this map, though it is very detailed by most studies, certainly I would consider any presentation from a mine or from any repository site that was mapped to this level of detail, I would say that it was highly detailed, to be inadequate to show all of the features relevant to important modes of contaminant transport. And I will show you some data to support that.

MR. HINZE: Will you show us how they have controlled the contaminant transport? Is there an anisotropy that is commensurate with the fractures?

MR. PEARCY: There are six fracture sets. Three pairs of -- three conjugate pairs here that do not support the kind of anisotropy that I think you are alluding to. But there is a relationship between the large fractures, what I will call the MESO fractures, those with apertures measured on a scale of millimeters and have links measured on the scale of tens of meters, between those fractures, between what I will call microfractures, that is those with fractures less than a millimeter, and pure matrix transport, the absence of any discrete discontinuity in the rock fabric. And I will speak to that. That is important for retardation.

MR. STEINDLER: The fracture that was shown in the photograph does not seem to show up on that map. It does not extend to the level?

MR. PEARCY: No, it's right here. The reason you don't see it as clearly is it is one of a set of fractures which is stained by iron oxides and oxyhydroxides. And what you are actually seeing is the reds and oranges from those iron oxides.

There are lots of fractures in here which you see as slight irregularities or not at all, because there is no color difference or shadow to show you from a photograph but which, when you look at the rock from a distance of maybe tens of centimeters, put your face down and look at it, are readily apparent.

[Slide.]

MR. PEARCY: We have looked at many scales. The other extreme of our scale is by transmission electron microscopy. We have just gone from a scale of tens of meters to a scale of 50 angstroms. So depending on how you want to think about it, that's 10 or 12 orders of magnitude variability in scale.

Again, I am leaving out lots of detail I could provide if you're interested.

MR. FOLAND: You might tell us what that last detail is.

MR. PEARCY: I'm sorry, I didn't tell you what the image was. This is uraninite. That is the uranium crystal lattice. You are effectively looking at an electron pattern produced by the uranium atoms themselves. You can measure the unit cell parameter directly by measuring perpendicular distance between these two rows and find that it is indeed about 5.4 angstroms.

Data acquisition at Akrotiri has progressed in a number of directions, including a fair amount of hydrologic work, which has been facilitated at Akrotiri by the excavations in the archaeologic site and by the unwelded nature of the overlying Minoan tuff, which allows us to use standard, unsaturated soil infiltration techniques which are not useful at Pena Blanca.

We have selected a specific area within the site for study and have gone through a variety of chemical, hydrologic measurements and we are presently continuing with analysis of lechates from the tuff collected from the bronze sites as our major activity at present.

The specific location within the site is a room that I will refer to as Delta 3. That is the designation given it by the archaeologists. It is a very small part of a relatively large excavation which has been undergoing archaeologic study since the late 1960s and is still being studied at present on a seasonal basis.

Delta 3 is the basement of a former three-story house with indoor plumbing, 3,600 years old. This is Delta 3. The photograph looks old because it's black and white, but this was taken in September of this past year on our last visit to the site.

There are several features I'd like to point out here. This information was not available the last time I addressed this group.

We have used photographs taken at the time of the excavation of the bronze artifacts in 1970, September of 1970, to work out definitively the precise locations, a set of photographs taken from many different angles, to work out precise locations of the artifacts, six of which were in a pile at this location.

This is bedrock tuff, this is the Cape Riva tuff. The artifacts sat here. And in that location, they were buried by a mixture of Minoan tuff, the eruption that buried the city and destroyed it, some alluvium that was formed at the time, intermixed with the early stages of the eruption itself, and by building debris from the three-story house above.

The circular features you see here and here are pad sites from infiltration tests where they measured the saturated and unsaturated hydraulic conductivity of the Cape Riva, just a meter or so from the site where it collected vertical samples of the tuff by hammer and chisel down into the tuff above which the bronzes were located. And this hole was augured into the Cape Riva tuff for a different type of saturated hydraulic infiltration test.

[Slide.]

MR. PEARCY: As a reminder, this is one of the bronzes from that location. It rested at that location and this is how it appeared in the National Archaeologic Museum in Athens a year-and-a-half ago.

[Slide.]

MR. PEARCY: This is a schematic map of the Delta 3 area showing the locations where those artifacts were unearthed. Over here were the locations for those hydraulic infiltration tests and beneath that is where we have taken these tuff profiles.

[Slide.]

MR. PEARCY: In task four is our interpretation of data and our modeling activities. And the objectives are essentially that. In addition to collecting the data, we want to interpret it, develop transport models, and evaluate the use of data from actual analogues for support of performance assessment, specifically of Yucca Mountain.

Our results are considerable, for Pena Blanca somewhat more limited. I'll show you a list in a minute for Akrotiri. But some of them are of considerable significance for a performance assessment. And I have a slide that calls that out in just a bit. Again, I would be glad to tell you more about any of those in which you take an interest.

I will give you a few examples of some of particular interest for performance assessment now.

One of the most useful results that we see is a set of alteration sequence from the uraninite preserved at Pena Blanca. The alteration sequence from that uraninite through a set of oxyhydroxides to uranyl silicates.

This sequence turns out to be quite similar to a laboratory sequence developed in experiments which are long by laboratory standards. These results were from four-and-a-half years of continuous experiments. They have now gone on for about seven years but they don't have the money to put together all of their results.

Working at Argonne, they took J-13 water, let it react with tuff for a few weeks, drifted on to Synthetic U-02 at 90 degrees Centigrade for four-and-a-half years, and then not only studied the rate of uranium leaching into the solution, but also actually looked at the morphologies, habits and sequences of the secondary products formed allowing us this kind of comparison. That sort of study is not commonly done.

In most fuel alteration studies, they are interested in the leaching rates of the radionuclides, and if they report anything about the secondary phases, it is because they happen to notice them on their filter paper and said, oh well, we had better do an SEM and see what it is. This study was designed to look at that sequence.

So their intent -- these are two things done independently. Our intent was to find a site similar to Yucca Mountain. Their intent was to conduct a relatively long-term laboratory study similar to Yucca Mountain and we find some confidence in the extrapolation of relatively short-term laboratory results to relatively long-term field data, natural analog data, in the similarities between those two sequences. There are differences, but it is remarkable that they are as similar as they are.

[Slide.]

MR. PEARCY: Another example is this east-west vein that I mentioned that you were asking why you couldn't see it on the photograph. Here it is viewed west to east, looking down the line of it, so that is somewhat foreshortened.

We sampled the filling of that fracture, scrapping it out with a steel knife, that measured the uranium contents of the fracture filling itself. We have taken transects perpendicular north and south of the fracture at five different locations as varying distances from the edge of the ore body, which is about here.

[Slide.]

MR. PEARCY: Those concentrations along the fracture and perpendicular to the fracture are illustrated here, taking those measured values and fitting a surface to those to, as Dr. Eisenberg was saying earlier, generalize and try to leave behind some of the "unnecessary detail" and trying to be useful, there are a number of things which are apparent here that we think are of significance for performance assessment.

Along a discrete fracture with an aperture varying from 2 millimeters to 7 millimeters, we see a maximum distance of uranium transport of about 25 meters. These are distances from the edge of the ore body. I apologize, uranium concentration here is in ppm of uranium.

Perpendicular to the fracture, to the major fracture, through rock with the microfractures, that is rock fractures with apertures less than 1 millimeter, frequently on the order of 100 microns to 200 microns, and with a fracture density too great to be mapped at the scale of 1 to 25 that I showed you on the high resolution map of the entire area, the fracture densities measured perpendicular here exceed one fracture per centimeter, and that is of fractures visible to my eyes as I sat and looked at the swept off rock. When you look at them under a microscope, the number of fractures per linear centimeter goes up by a factor of ten or 100.

You only see uranium transport a very short distance into the host rock, but that is where you find most of the uranium to be residing. You have the greatest distance along a through-going fracture, about 25 meters, but a relatively small proportion of the uranium, of the inventory of the uranium. There is about six times more uranium sitting just outside that fracture than there is within it.

Only about 2 percent of the uranium got out of the big fracture by pure matrix diffusion in the absence of any fracture at all. The bulk of the uranium that was retarded along this path was retarded as it moved into the generally fractured but mircofracture scale tuff on either side of a through-going fracture.

Note also, this graph is for presentation purposes somewhat distorted. This scale from here to here is one meter. From here to here it is 25 meters. If you stretch this out to true portions, you will have a better sense of just how little there is outside the fracture relative to its length.

[Slide.]

MR. PEARCY: Across that two meter transect I pointed out on the earlier photograph, on the western margin of the deposit, we collected on a two meter transect, we collected samples every 20 centimeters, measured the U-234/U-238 ratio, find that within the area of visible uranium mineralization samples are more or less in equilibrium indicating a relative closed system behavior for at least the last million years, whereas the three samples that occur beyond that limit have exhibited open system behavior during the last million years.

If you look at the uranium concentrations along that same profile, you find a remarkably systematic set of concentration variation along that path. When I say remarkably systematic, remember this is field data of bulk rock samples through generally fractured tuff. This is not a laboratory experiment. But many times lab data doesn't look this good.

Field data decreases quite dramatically and, again, in the absence of a through-going fracture, there is very little uranium transport outside into the generally fractured tuff dying to background values in just over a meter -- I am sorry, just over half a meter.

[Slide.]

MR. PEARCY: The entire area was surveyed by contact gamma survey, and this is the plume of anomalous uranium. Anomalous meaning above the background concentration natively present in the tuff at the site, which is around ten ppm uranium.

We do not yet have disequilibrium measurements from this area. One of the goals that we have are to try to place rate and time constraints on the migration across that two meter transect which I showed you along the east-west fracture, which interestingly does not show here -- this is where the east-west fracture is. We measured these contact gamma measurements every meter across the entire area on a one-meter-by-one-meter grid, and the fracture is located about 13.5 meters north. So it fell in-between all of our grid points even though that was a highly detailed survey.

In any event, by the time you are more than five or eight meters away from the ore body, the concentration of uranium drops to near the detection limits of a field meter, in any event.

We are collecting samples and conducting measurements to try to place time constraints on these transport paths. We do have several dates on the system which give us a framework that we are working within now, but we can't say that it took so many years to go this far yet. We may never be able to say that.

We have measurements on an opal sample collected from about this location, which is paragenetically one of the latest uranium bearing phases. It is dated by uranium series disequilibrium at about 54,000 years. We have an isochron date on -- uranium series isochron date from a caliche sample collected about this location on the premining surface, a caliche sample, which is very high in uranium and which also has a date of 54,000 years.

We take the high uranium caliche with 54,000 date and a high uranium opal late stage paragenetically at 54,000 years as an indication that there has been uranium mobility at the site at that time during the most recent time. That is during the time in which the ore body has been uplifted as a horst and in a position well above the water table and chemical oxidizing zone similar to the proposed repository horizon.

We are presently focusing our activities on things that have happened most recently rather than trying to work out the evolution of the ore deposit which has been dated by chemical uranium lead techniques at about 8 million years, so the error on that measurement is quite large. We are not focusing, we are trying not to focus on things on the scale of millions of years, but to focus our measurements and interpretations on things that have happened on a scale of tens of thousands of years so that we are not reaching so very far out.

MR. HINZE: English, is the tip of the mineralization vertical?

MR. PEARCY: It is a subvertical near cylindrical body. It is undulating in space. If you would like, I can show you some cross-sections.

MR. HINZE: That is fine, but it is basically vertical?

MR. PEARCY: It is basically vertical.

MR. HINZE: Thank you.

MR. PEARCY: For Akrotiri, we have much more limited results of data interpretation. As I say, we are still in the early phases of making many of the measurements. Nevertheless, we have developed some conceptual models for transport. We have interpreted some magnetometry data from the site; beginning interpretations of the metal leachates from the tuff. This formation of alluvium at the site is important because there is the chance that the amount of water and the timing of the interaction and the duration of the interaction of water with the artifacts has been a function of local drainage, and we have tried to interpret that, as well as interpretation of the field hydrologic data that I mentioned.

Our project perspective is to continue, as I mentioned, the uranium series measurements to look for open system behavior and to try to place dates on the transport distances. We are interested in making measurements of rare earth element concentrations so that we can speak to, at least from a chemical analog point of view, elements other than uranium. We can use some of the light rare earths as analog elements.

Continue structural analysis of uraninite oxidation, that is the TEM and micro-EDS work using ten angstrom spot size measurements. Perhaps the most important bullet on here is this last one for the perspective for Pena Blanca is that we are planning to conduct field hydrologic infiltration tests at the site taking advantage of the special geometry afforded by the clear level plus ten surface with the adducts present beneath it, providing from the back of the adduct to the surface eight to ten meters distance through this tuff.

We have, on our most recent trip, identified four different kinds of locations at the site for planning purposes. They would involve constant head, falling head, and a variety of tracer tests, partly over discrete fractures such as the east-west fracture that I pointed out, partly through generally fractured rock, and using test locations chosen at differing distances from the ore body, you vary greatly the kaolonite content of the altered tuff and, thereby, can assess the integrated, the effective fracture plus matrix flow through variably altered tuff. That will provide both parameter values potentially useful for performance assessment as well as some rates that will allow us to make more complete interpretations of the past transport that we observed at Pena Blanca.

MR. HINZE: You feel that the analogy is close enough that these will be able to .pply the absolutely?

MR. PEARCY: I don't think applying them

absolutely in the sense that you have a unique value that you believe is, in some sense, the right value, I think that would be inappropriate, but I think by looking at rock from essentially fresh unaltered tuff to the very high altered tuff, you will have two nice boundary values that will give you a sense of whether the numbers that McCartin and Krew are using are in the right ballpark.

MR. HINZE: What is the limit of the precision of your work?

MR. PEARCY: Which part?

MR. HINZE: Both parts, in terms of the hydrologic parameter in the altered and nonaltered?

MR. PEARCY: To the hydrologic, I can't speak to it because we are just in the design stages of those experiments, and I can't tell you right now whether we would expect breakthrough curves or breakthrough times on a scale of days, weeks, or months. I don't know the answer to that. So it is hard for me to speak to anything else about that.

MR. HINZE: How are you going to do the design, will you do some modeling?

MR. PEARCY: The first thing we will do is essentially do a very low tech test and see what kind of a scale that we will be working at, and then using those measurements, we will do modeling. Once we have some kind of a ballpark number, we will take results, for instance, from STRIPA tests. STRIPA is actually the most similar to the kind of results or kind of tests that we are interested in here.

Using those results and our initial shot test, try to make some calculations of what we can reasonably expect for different distances and different levels of alteration. What we believe will be the useful result of that will be both direct input, as I mentioned, constraining performance assessment calculations and, as was mentioned earlier, some practical experience in how one might actually conduct these things for site characterization, as well as providing information on the scale of eight to ten meters in a direct line path.

That is intermediate to the sorts of things you can do in a laboratory where you do things at a scale of millimeters, or centimeters, or perhaps as much as a meter, and the sorts of things that are done at STRIPA and at Apache Leap, where you are on a scale of hundreds of meters. What is going on between the surface at Apache Leap and the Never Sweat Tunnel, there are some drill holes that give you some idea of what is going on, but there is a great mystery in the intervening space. This will provide an intermediate scale which is really much better constrained just because the distance involved is much less.

MR. POMEROY: Can I go back to Bill's question for a minute regarding the closeness of the analogy between Pena Blanca and Yucca Mountain, did I understand you to say that you thought that the range of value that you established at Pena Blanca would be applicable in Yucca Mountain, would provide a constraint on the performance assessment?

MR. PEARCY: That's right.

MR. POMEROY: So, if you were a regulator and the Department of Energy came in with a performance assessment that said, I use these values, these range of values, that I determined at Pena Blanca for Yucca Mountain, you would find that an acceptable range of values to have used at Yucca Mountain, independent of any measurements that might have taken place at Yucca Mountain?

MR. PEARCY: What I would find acceptable is if they said, in our performance assessment modeling, we considered scenarios in which the tuff remains pure and pristine and much as it is today when we mine into it.

We consider other scenarios in which a hydrothermal system develops, either as a result of natural processes and causes alteration of the tuff, or as a result of a hot repository which causes some vapor movement around there altering the glass and the tuff to a variety of clay minerals which are not present currently in the system.

In our evaluation of those performance scenarios, we based our choice of parameters on some real world values that we measured at Pena Blanca. I would find that preferable to saying, gosh, we think it is like this, and we used these values, and we really don't have a reason for having used these values except that we figure as there is more clay, the value changes in this way, and we have laboratory experiments which suggest that. I would find that useful.

MR. POMEROY: I don't think anybody would say "gosh" to me. That is fine, thank you.

MR. HINZE: It would be interesting to apply some heater tests on top of that.

MR. PEARCY: There are many interesting things. We tried to remain focused.

[Slide.]

MR. PEARCY: Interpretation of data and modeling perspective consists of exactly that. Continued development of conceptual models, particularly of matrix and fracture flow. Also for Akrotiri, and then finally moving into numerical models of transport for both Pena Blanca and Akrotiri with the final result of a report which will discuss use or evaluation of models and development of guidance for the use of analogs and analog data for support of performance assessment, and site characterization, and their use in license application review. Again, current project plans call for completion in FY97.

[Slide.]

MR. PEARCY: The next slide calls out specific results in terms -- this slide is things that we have done, and I can't put this off on anybody else, what I believe their use is for performance assessment.

I mentioned earlier in response to a question somebody asked, it may have been Dr. Hinze, who said, has anybody used any results from Pena Blanca in IPA-II, and I mentioned the ten to the minus seven fraction of the original inventory per day as our conservative, that is, maximum rate of uraninite alteration that we have estimated from the site based on geochemical, mineralogic and geologic constraints. That is what I am talking about here. That rate provides a constraint for source term release rates. That is that ten to the minus seven rate.

The second item here is the alteration sequence that I showed you in comparison to the laboratory results. It provides specific mechanisms for waste form alteration models. What I mean there is, if you have a waste form alteration model which says when you alter fuel in a Yucca Mountain groundwater, if you don't make a sequence of alteration minerals at least roughly similar to what we have seen in an environment which we believe to be comparable in many regards to Yucca Mountain, and which is very similar to that scene in laboratory experiments designed to be similar to Yucca Mountain, I would have great concerns about that calculation.

The third item here is that the very fact is that Pena Blanca, virtually everything there is altered now to a uranyl silicate. It has all gone to the bottom of that time sequence with only a few kilograms of uraninite remaining, probably not more than 10 or 20 kilograms of uraninite left in the entire 300 ton ore body.

The secondary uranyl silicates are therefore going to be at Pena Blanca and very likely to be in a Yucca Mountain environment the long-term major factor controlling long-term release of uranium for transport. Those phases, again, if they are not predicted in a performance model, I would have considerable concerns about that.

It turns out, you can even generalize taking the argument that Norm Eisenberg made earlier that you can draw on many different analogs, and that Bill Ott mentioned in his first slide, drawn on data from many different analogs to look for generalizations or things which are mutually supportive and consistent.

If you look at analog sites, that is uranium ore bodies, some of which have been studied as analogs, many of which have not but have been studied in the context of economic geology, the most popular secondary uranium mineral on the plant is uranophane in a wide variety of environments, particularly in a Yucca Mountain like environment. At Pena Blanca, uranophane is far and away the most abundant. It is 80 percent of everything that is there or better. Most of what you find that is yellow on the ground there is uranophane.

At Shinkolobwe, in a very different environment, most of what you find is uranophane. In many different environments, when it oxidizes and there is free silica available, as there surely will be at Yucca Mountain, you make uranyl silicates. If there is calcium around, as there surely is abundant activity of calcium in the Yucca Mountain environment, you make uranophane.

That is what I am talking about here.

This last item is the relative importance of the meso fracture, the micro fracture and matrix transport for uranium transport or retardation, if you want to think of it the other way around.

The relative importance of those, again, that is something else that Norm Eisenberg and John Bradbury mentioned in ranking processes. Even though you might not be able to place a specific value, a number that you would say, gosh, let's tote this number over and use it for Yucca Mountain, you can certainly say by relative importance how they ought to be taken account of in a performance assessment model.

Some of them taking a pragmatic engineering approach could be neglected or lumped together in some appropriately conservative way, not having to take account of how things actually behave in the real world, as Dr. Eisenberg pointed out, but that is the use for that kind of relative ranking.

[Slide.]

MR. PEARCY: This next slide --

MR. POMEROY: Can I ask you a question before you leave that?

MR. PEARCY: Sure.

MR. POMEROY: Can you just expand, this is one of the times that you can expand a little bit on the technical aspects of what you have done? Could you just expand on that last one and tell us what is the ranking that you would apply to these, and anything else you would like to say?

MR. PEARCY: Based on these observations which are preliminary, I would not publish them, but I will say, because you ask me, I will give you my best answer today, it appears, based on the measurements that we have made at Pena Blanca, that retardation of uranium by inhibition into the matrix is not an important mode for uranium retardation. Rather, movement of the uranium bearing solutions and consequent retardation of the uranium by microfractured rock is much more important than that. That the greatest distances are achieved through these through-going larger aperture fractures, but the amount, the portion of the inventory of uranium which is transported to those greater distances, is relatively small, and that in any event we see in this system that greater distance was only about 25 meters, but I can't tell you the distance under which that occurred.

MR. POMEROY: Twenty-five meters, and I have forgotten the date, can you just remind me of the date of emplacement?

MR. PEARCY: We have a chemical uranium lead date of about 8 million years plus or minus about 5 million years.

MR. POMEROY: Thank you.

MR. STEINDLER: This is a breccia pipe, right?

MR. PEARCY: It has been described as a breccia pipe. I prefer to call it a highly fractured subvertical zone. It is not a breccia. If I handed you a sample, you would not, as a petrologist, you wouldn't call it a breccia. There are portions of it which are true breccias. The bulk of it is simply highly fractured tuff.

MR. HINZE: Is that what is controlling the 25 meter movement?

MR. PEARCY: We have made some calculations which I could show you on the fractured density over that entire area. Depending on how you calculate fracture density, whether by length or by number of fractures as the mining engineers usually do, the fracture density is greater as you go toward the ore body or not.

If you walked across it, your intuition would say, yes, it is more fractured as you go toward the ore body. Therefore, as you move away, it is somewhat less. What we see along that fracture, that through-going fracture, is not a function of that general density variation. That through-going east-west fracture, one of the reasons that you could see it so well in that photograph is that not only is it highlighted by iron oxide, but it is structurally late. It crosscuts everything. The east-west fractures occurred well after the formation of the ore body, just because they cut across every feature in the ore body, so I don't have a date on it, but it is the latest fracture there, or the latest set. So it takes no account of that variation except as it affects the fracturing outside of itself. The fracture itself cuts through all of that.

[Slide.]

MR. PEARCY: The next slide describes results which I anticipate may become available from this project, but which we did not have available at present. So I have not listed them the way I did on the previous slide. But just to give you some idea of additional results which may become available toward which we are working from this project, including putting some rates, as I mentioned, on the transport, further evaluation of the relative importance of retardation mechanisms, specifically taking into account differential sorption on to various mineral substraights, precipitation of different secondary minerals and matrix inhibition.

The effective fracture and fracture plus matrix flow measurements, this is what I -- and talking about the infiltration tests, the elements that you see listed in the next two bullets are the elements that we have measured to be present in bronze corrosion products from the artifacts at Akrotiri.

Again, development of conceptual and numerical models. Finally, evaluation of the limitations and utility of natural analog data in support of evaluation of a license application.

MR. STEINDLER: What do you expect or estimate the maximum temperature to be during which you get rare earth and uranium transport?

MR. PEARCY: Temperature information from this site is tenuous and we don't have good control on that. There is some French data from a thesis done on the site which suggests that maximum temperatures achieved during emplacement of the ore body were around 250 to 300 degrees

Centigrade.

It has been proposed that another way to view this analog, rather than looking at things that have happened most recently, as I mentioned, is to look at things that have happened further back in the past, that is, when it was an active hydrothermal system depositing this uranium, producing the alteration that we observed around it, and perhaps inducing the kind of transport that you are questioning.

At present we are focusing our attention on recent things we assume to be at ambient temperatures.

MR. STEINDLER: When and if you do get data on the rates of uranium transport over the long time, you will also have to, in order to be able to use it usefully, you will have to make some kind of an estimate of the temperature profile over that same period of time.

Are you planning to use, say, oxygen isotope measurements for example to try to get at it?

MR. PEARCY: We have considered that. There are problems with using oxygen isotopes at these very low temperatures. If we have evidence that we really are at 250 or 300 degrees when that transport occurs, then you could use them with some confidence. If you go below 150 or 100 degrees, I wouldn't believe in an oxygen isotope temperature.

MR. HINZE: What was the basis of the French thesis?

MR. PEARCY: Fluid inclusion measurements. The documentation for the measurements is very limited.

MR. FOLAND: What about the relative rates of fluid influx? How are you going to control that when you start talking about rates of transport, talking about fluid transport? How do you estimate the flux of ground water?

MR. PEARCY: If we can show that the rate that we are trying to measure, the distance, the transport that we are trying to measure, if it occurred recently within the last tens of thousands of years, it is very likely that it occurred when the ore body was in a similar geometry to its present position.

The mining that has proceeded has removed over a portion of the ore body only a few meters of material so the point where I indicated that we sampled the opal I estimate to have been about two meters, not more than five, perhaps as little as two beneath the pre-mining surface. The ore body actually was exposed at the surface. It was found by aerial reconnaissance, aerial gamma survey. It was just parked on the side of the hill, sticking out there. They have mined in that area relatively little.

One of the points of making this detailed fracture map of the 11,000 fractures, we have also conducted similarly-detailed, equally-detailed fracture mapping of all of those vertical faces. We hope to be able to synthesize a three-dimensional fracture network to allow us to make infiltration measurements, since we are only having to reach a relatively short distance, a few meters, into the rock that we won't have too large of an uncertainty on that.

We will have to infer things like rainfall rates and durations, pre-slope conditions we can reconstruct from photographs taken prior to the mining and of course the three-dimensional fracture network itself will actually be a calculation but it will be constrained by these highly-detailed maps in three-dimensions all around it so we think that we can make some pretty good estimates but they will be just estimates and inferences but as these things go, pretty well constrained, especially if we have those field infiltration measurements to go with it.

[Slide.]

MR. PEARCY: Coming back to the six key technical uncertainties that I showed you at the beginning of the presentation, these are the same six listed in the same order. Again, what we are -- our role in support of the NRC's mission is to help the NRC move toward the KTUs by improving the understanding and developing methodologies to determine compliance with performance objectives represented by each of the KTUs.

This first one is extrapolation of short-term laboratory results to long-term predicted models, and as I pointed out, I think that we have made some progress toward that. I think that that is a useful step.

The uncertainty regarding equal or increased capacity of alteration mineral assemblages to inhibit radionuclide migration is something specifically that I mentioned we are addressing by looking at differential sorption onto different phases and precipitation of different secondary minerals.

Uncertainty in identifying geochemical processes that reduce radionuclide retardation, when I say we are evaluating that, what was in my mind when I wrote that was the matrix, microfracture, misofracture, all work that I have described.

The other three we're also moving toward -- uncertainty in conceptual model representations of the natural system. You'll notice that nowhere in my slides is the word "validation." That does not occur and I don't care to reopen that debate but what I would like to say is a contribution of what I mean when I talk about this is that choices of model components, which processes are included and what relative importance and how they are linked, is a form of model uncertainty that can be reduced by looking at natural systems.

These last two are partly addressed by the field infiltration, this last one and the penultimate one partly by the field infiltration data and partly by the relative transport measurements that I just described.

[Slide.]

MR. PEARCY: In conclusion, we have obtained a state-of-the-art knowledge of natural analogs and are maintaining that. We have followed a systematic process in our site selection and in developing the analog studies we have found two very strong sites and we are producing data which are useful for performance assessment and these results are helping to improve understanding of the key technical uncertainties and in so doing allow some measure of improvement in the methodologies by which one might determine compliance with those performance objectives.

MR. HINZE: Thank you very much, Dr. Pearcy.

Are there any questions? Let me start off with a question, if I might.

As I understand it, this program is going through '97.

MR. PEARCY. That is the current project plan.

MR. HINZE: Does that include both Akrotiri --

MR. PEARCY: That's correct.

MR. HINZE: And Pena Blanca. At what time will you start to reach some conclusions about some of these points that you have made in the latter transparencies?

You have some anticipated results?

MR. PEARCY: That's right.

MR. HINZE: And when do you anticipate those or do you plan to do those shortly or is it '97?

MR. PEARCY: As was mentioned, we have since the development of the KTUs in the last year, we have been changing the format for semi-annual research reports so that every six months when a portion of those reports for each research project expresses progress toward addressing those KTUs.

MR. HINZE: Do you have any plans for additional field work at these sites, and what might that be?

MR. PEARCY: I was there three weeks ago. The additional --

MR. HINZE: Set up a Hilton hotel on Pena Blanca for one thing?

MR. PEARCY: Plumbing would be a big thing if you were there for a week.

[Discussion off the record.]

MR. PEARCY: Our field work for Pena Blanca, the biggest outstanding component of that is the uranium series disequilibrium measurements, refinement of the clay mineralogy at the site. We just took our first samples from an altered vitrofer, which is immediately juxtaposed with a high-grade ore body on level zero, exposing the first opportunity to sample zeolites. Hulanite has been reported by one researcher there but we have not yet, in the last three weeks we haven't been able to confirm that and the field infiltration tests, those are the large remaining field activities at that site.

The infiltration tests, if it is determined to go ahead with that, or enlarge activity, that will take extensive collaboration from associates at the Mexican University in Chihuahua. It's not something you can conduct remotely very well.

At Akrotiri, we are still doing the leachates on those tough profiles that we collected from the holes we built beneath the resting places for the bronzes. Pending the results of those experiments and some of the model calculations we are trying to use pour-flow to model some of the hydrologic data that we collected, pending the results of those measurements and the pour-flow calculations, we may have to make additional hydrologic measurements and/or take additional samples at that site.

They also unearthed, as we were leaving at the end of this past September, a newly-unearthed bronze artifact. I was allowed to collect one modest set of samples adjacent to it. They are -- when I say "they" I mean the archaeologists -- are understandably sensitive about having one of these geologists come and poke around too close to an artifact and they have been most gracious in giving us access to the site. They even let us mine holes in the floor of their room, which I was kind of surprised about.

Their attitude with regard to that actually was, into the rock? Beneath the anthropogenic horizon? Well, sure -- and they have let us climb all over the site, but I am hoping to be able to collect additional traverse samples around this in situ artifact. Of course, the place we're working in Delta 3 the artifacts were removed in 1970 and we didn't examine them in place. We have had to infer the enclosing material and we had to reconstruct the geometries involved. It would be a good bit easier to qualify the situation, the geometry of the situation in particular, if we were there at the time of discovery.

MR. HINZE: Thank you. I also want to speak for myself in that I think you have done a very good job of hitting the target that we set out for you, so with that I will ask my colleagues if they have any questions or concerns.

MR. STEINDLER: Yes. I have got essentially one.

You have identified for us both anticipated results and some actual results. Of that suite of results, what part of those are parallel to or similar to work that DOE is doing elsewhere?

MR. PEARCY: DOE work, which is presently ongoing or envisioned, under the Yucca Mountain Project, is relatively limited and I am sure Dr. Cloke can expand on this a bit.

What is presently underway is actually under their waste package environment, work break-down structure item. They are studying a hydrothermal system and silicic tuff in New Zealand. Specifically they are trying to -- they have used the word "validation" with respect to EQ36, trying to resolve problems with kinetic parameters for silica, of various forms of silica precipitation.

There is another items also involving hydrothermal systems and tuff -- that's its title in the work "Breakdown Structure," called "A Natural Analog of Hydrothermal Systems in Tuff," which is not funded at present. They have requested limited funding to develop a study plan from the project officer and that assumes that so far as I know it has no activity.

MR. POMEROY: No one would question after your presentation and knowing you in any case that you have the state-of-the-art knowledge suggested in the first item of your conclusions back here somewhere. In one of your slides you mentioned the development of guidance to the DOE, I presume for the use of analog data in support of a licence application, which is an important item, and I just wondered if I could address a question perhaps both to you and to Bill Ott with regard to the timeframe that you might envision for that kind of guidance and given what you have just said, perhaps how necessary is that in any timeframe?

MR. OTT: I will take the first shot at it.

In terms of official regulatory guidance, meaning something produced by the Office of Research, there is nothing in the wings.

We have no requests to do regulatory guides, no branch technical positions or anything like that. There may be guidance that the licensing office would give as the result of the review of DOE's study plans which we would participate in and so would the center, but that would be part of the ongoing review process with DOE, so I would presume that English is probably talking more about that, in the ongoing interactive process, than he is about formal guidance.

MR. PEARCY: The form of that kind of guidance is something best decided by people better versed in that than I am.

MR. POMEROY: I understand that.

MR. PEARCY: I would be glad to have input to it.

MR. POMEROY: But there is no formal plan for anything like -- just to clarify for me -- a regulatory guide, a BTP or anything like that with regard --

MR. OTT: Nothing that I am aware of.

MR. POMEROY: Okay, thank you.

MR. FOLAND: If I could just dwell on one technical point as an illustration of what one might expect ultimately out of this study, let's take Pena Blanca. You had a slide that had the dimensionless time parameter DT equals 0.3 meters squared. If one converts that to an ordinary diffusivity, do you know, and you assume some reasonable time, what sort of magnitude value one gets for that?

MR. PEARCY: Yes.

MR. FOLAND: And the follow-up is would you expect --

MR. PEARCY: 5.6 times 10 to the minus 6 meters squared per year. That is using the 54,000 number that I said we had measured. Whether that is the appropriate number to use, I am not sure, but if you plug it in, that is what you get.

MR. FOLAND: What is in centimeters squared per second?

[Laughter.]

MR. FOLAND: Squared meters per year, sorry. Okay, I will calculate that later.

[Laughter.]

MR. FOLAND: If one comes back, do you expect to take that number and feed that literal number into any other similar sort of quantities as a numeric value into some PA code?

MR. PEARCY: I would be very surprised if it were used that way.

To be perfectly straightforward, what happened was we made the measurements. We said gosh, it looks like a diffusion curve and we took a standard diffusion model and, sure enough, you could fit it pretty well, and that is what we did and there are a lot of problems with interpreting that because of course what we measured here is on bulk fractured rock. There is no liquid phase present. It is on residual uranium within and on these bulk fractured tuff.

Interpreting that in terms of a diffusion and extrapolating that as a value -- you know, not a limit because I can't say that is some sort of limit -- it's just one value, if I could say it was some sort of maximum or minimum then you might have some use as a constraint for performance assessment calculations but I am not prepared to argue that that is such a limit, and so right now I would have to look for additional information to speak to that.

MR. HINZE: Further questions?

[No response.]

MR. HINZE: Again, we thank you very much. Bill, is this the time that I throw it back to you or to Linda?

MR. OTT: You throw it back to me for the moment.

[Pause.]

MR. OTT: Tim and English will stay close to the microphones. Linda will be up to the table to help me out in case there is trouble.

MR. HINZE: There is an overhead.

MR. OTT: You have a set of overheads. I have also been making some notes over here. I wanted to go over a couple of observations which you do not have and I just drew these over heads up while I was sitting over there on the side, sometimes not paying attention as I should have, but still -- I want to go back to a point that Ken Foland raised earlier in the morning where he said why do we call these things analogs? Why don't we just call them field projects and be done with it.

So I sat down and I looked at a research program off the top of my head and I said what have we got? If you look at what we have gotten and divide them instead of calling things analogs or not analogs, call them laboratory and theory studies and field studies, you have got these projects, two synergy of chemistry projects, one called unsaturated mass transport, and I forget what the other one is called -- Bobby Pavalon's work and Bill Murphy's project, and then we've got the synergy of chemistry analog project, which English Pearcy just reported to you on.

We have got two center hydrology projects, neither of which are field programs.

We have the Apache Leap project, which we don't call an analog but which certain aspects of I think anybody would call analogs.

We have a center materials project. We really have no materials analogy project. There was some thought at one time at the Akrotiri site we might find a material that was analogous to DOE container material. If they go with stainless steel as was last reported by Michael McNeil, we are not going to find anything anywhere that is going to help us in that area.

In thermal hydrologics, we could say that the Valles Caldera gives us a handle on some of those coupled thermal hydrologic processes in terms of modelling that contact over the extended period of time of the thermal pulse. If you look at the center seismic rock mechanics project, that actual project has a component which was measurement at Lucky Friday Mine. You know, it's a field operation where we are looking -- we don't call that an analog project. Other people might. We are looking at a field measurement and trying to establish the effects of seismic events on underground openings.

We are actually doing an extension of that work in Garner Valley with the French with cooperative funding, looking at larger seismic events.

In the tectonics area, the only field program that we actually have doing measurements is the work at Cal Tech, which is actually looking at spreading rates in the Death Valley - Yucca Mountain region. This would definitely not be called an analog project because that is information that is directly relevant to the Yucca Mountain site itself.

In the volcanism in the Basin Range, we have a companion field volcanism program. This actual volcanism of the Basin Range probably has components of analogs in it because they are probably looking at data from systems in the basin and range, which would be considered analogs.

If you look at that, yes, we could call everything on this list analogs except for this one Cal Tech measurement. It is a term of art and for the time being, as some people observed earlier, we're stuck with it to a certain extent.

I just wanted to sort of put that in perspective because of what Ken said earlier and we could try and get rid of the term "natural analog" and just say these are field projects with specific objectives. This is another way of breaking it down.

MR. STEINDLER: What function of the field studies are methodology development?

MR. OTT: Of the field studies?

MR. STEINDLER: Yes.

MR. OTT: Very few of those are methodology development. The University of Arizona was related to measurement technique development, site characterization process development.

MR. STEINDLER: I include that in methodology development.

MR. OTT: If you include that then even English's project would fall in that category. Valles Caldera I am not certain would because that is more of an anticipatory type. It is an intrusive event type of a project.

Lucky Friday Mine, there again we are looking at measurement techniques and we are just actually measuring processes as opposed to developing -- no, that's not true, too, because there is some methodologies being developed for analysis of those results.

There is definitely work in the field of volcanism in terms of methodologies for addressing the probabilities so in most of these there is a component of methodology development, learning from the field experience.

The other point I wanted to make is we don't generally do work -- I may have made this observation earlier -- we have to go through a great deal of pain to even get on the Yucca Mountain site in terms of calling ahead and getting approvals and signing up and getting escorts and all the rest of it. We had a number of calls from the last field visit from Cal Tech because we didn't dot all the i's and cross all the t's and we got into trouble. That was just to make a couple of GPS measurements, so if we are going to do field research, and many people have argued that our research program and our technical support program is not really going to be complete without a field component to it, we almost have to work at sites and those sites should have some relevance and probably be construed as analogs by someone.

[Slide.]

MR. POMEROY: Before you leave that completely, can I ask you a complete question? Can you just give me an idea of what the Pena Blanca effort is in terms of FTEs or something like that?

MR. PEARCY: A little more than two FTEs.

MR. OTT: I will come back to that in a second.

MR. HINZE: Is that for Pena Blanca or Akrotiri?

MR. PEARCY: Pena Blanca and Akrotiri are lumped for budgeting. That's total.

[Slide.]

MR. OTT: I think the proportion is much higher on Pena Blanca, though, correct?

MR. PEARCY: That's true.

MR. OTT: This is a series of disrelated thoughts that I had as we were coming through this afternoon.

There is an observation. You are all aware of INTERCOIN, HYDROCOIN, INTERVAL and the possibility that there may be even a follow-on to INTERVAL.

One of the objectives when they went to HYDROCOIN was to search out the data sets available throughout the world and find the best ones and use them to validate hydrologic models. The conclusion at the end of the project was there weren't any and the reason was that none had been collected for the purpose of doing it. Every project that had ever been done to collect hydrologic data had had some specific goal in mind and that specific goal generally resulted in the collection of a limited data set which didn't include all the parameters that someone else needed to run a performance assessment model or to run a full hydrologic model.

The logical conclusion that one comes to and that they came to in HYDROCOIN is that there has to be, and again the same point that has been made here time and time again today, a much closer cooperation between the designer's field experiments and the people who have to do PA modelling.

It hasn't happened yet. We hope it is beginning to happen but its conclusion is not new but maybe five years ago it was new. People kept thinking oh, yeah, there have been some really big hydrologic studies out there, good data, and they looked at them and they came up wanting. The information wasn't there. Hopefully, and it takes a long time to collect this data, that situation is gradually changing, but the need for interaction is the important thing, between the modelers and the geoscientists that are conducting these programs.

I owe Linda an apology here. The package that she gave you on the Valles Caldera, had they kept the KTUs that we thought were addressed by the project listed up-front, and I said, Linda, don't talk about those up-front, put them in the back, because we didn't have them when we started the project. We started it for specific objectives.

I think that if she focused on those first and tried to carry the thread through the talk, things probably would have gone a little easier through the presentation. That was my faux pas, not hers.

I wanted to give a dollar perspective on that project as well. If you talk about two and a half FTEs on the Pena Blanca, Akrotiri project, the Valles Caldera project through its entire inception cost less than one year's, probably less than two-thirds of a year's effort at the Pena Blanca, Akrotiri program, so when you compare the two projects or think about those two projects you need to look at a project that was conceived with a very limited goal and very limited resources to try to address a very small issue.

As we said before, it was our first attempt to try and do a fairly focused attack on this thermal heating problem.

People have touched on pragmatism, levels of abstraction, Norm's pyramid of abstraction and I am not going to get into that right now. I will go to the prepared slides and if we have time, I will give you a couple more that I brought back up.

[Slide.]

MR. OTT: As I said when we were going over the plans for the briefing and it was decided that we ought to have a little session at the end and see what our conclusions were, essentially what they said is what would we like the committee to come away with, with what our feelings were about natural analogs.

These first four bullets, this and the next slide, are the licensing perspective -- I'm not from the licensing office but they have looked a these.

I think this is pretty much a consensus with the Licensing Office, and the Office of Research that analogs can be an important tool for gaining insight for the development of conceptual models and for holding the margins of possible system performance.

This is almost a motherhood statement. It is something that few people can disagree with. What they disagree with is the degree to which it is going to be useful. Okay.

Unfortunately, before we had done the work difficult to quantify how useful something is going to be, if I get back to the question of levels of abstraction, it is what we are dealing with from the very beginning to the very end.

If you think of the pyramid that Norm showed earlier, it is a variant on a diagram that shows up in a DOE document which shows the system performance or the system model at the very top, and this base of good solid knowledge.

That pyramid, when I first looked at it, gave me an illusion of a good solid structure. But the first time I heard about it was over the telephone. I thought, "Well, I don't have the diagram, so I will make one up."

What I came up with was different because when I viewed the process, I didn't view it from the perspective of a good solid basis of knowledge.

I viewed it from a perspective of a whole bunch of subprocesses combining into sub-system models, combining into a system model at the top -- successive levels of abstraction, all of which reduced the information in the actual model, and all based on incomplete information at the bottom.

We are dealing with levels of abstraction and successive approximation. Exactly were and how we evaluate the individual contribution of these analogs, I don't know. I know what level they come in. They come in primarily at the bottom level. We are talking about the subsystem and the process models at the bottom. That is where we getting the most information, and how those can be combined conceptually to form subsystem models and how those can be combined in the system models.

So that is the level that we are talking about for most of these.

From the Licensing Office's perspective, analogs should be an integral part of the DOE program from What Paul Cloke said. They may not call them analogs. The last slide will speak to that.

From our perspective, and perhaps from everyone's perspective, they need to be more integrally linked to performance assessment programs.

There is no question in any of our minds that the initiative that Linda and English are undertaking in June, that the initiative that is being undertaken by the NAWG in September, that perhaps the workshop that the ACNW has been invited to -- all of these things are necessary.

There has to be a linking between these programs, whether they are called analogs or whether they are called just process research. There has to be a linkage which does a better connection.

This goes back to the argument that we had this morning. It merely states that whatever you call them, not calling them something is no reason for not doing work that is relevant to answering questions that are key to making the models and systems work.

I am going to go from licensing perspectives to a few perspectives which I call research perspectives. Since I am in the Research Office in a regulatory operation, it is difficult to tell whether these are entirely research and don't have a licensing component to them. So bear with me.

From our Office's point of view in terms of providing research support to NMSS, natural analogs must be a part of any effort to provide credible support for evaluation of DOE's estimates of long-term performance. We don't know of another way to get a handle on some of the processes. If someone does, I wish they would show me and show me very clearly how to do it.

Care has been, at least as far as I think the Valles Caldera program, the Pena Blanca, and the Akrotiri program, there has been a lot of care taken in the selection of the analog sites. Before that, as English pointed out with Oklo and has happened with Cigar Lake, a lot of these things were studied because they were there and people said, "Aha, it is an analog."

Well, the other sites -- with Valles Caldera, with Pena Blanca, with Akrotiri -- they were not selected that way. They were selected looking towards specific objectives, not just because they happened to be there.

We also took more care in the specification of the objectives in the work plan, particularly in the Pena Blanca project. More involvement is needed from the PA staff. This is just a carry-over from the licensing perspective side.

PA and phenomenological research is needed to focus on integrated efforts to expand the boundaries and the time and space of the domaine where there is confidence in the applicability of the PA models. Again, it says the same thing. We want the cooperation between the researchers and the PA.

It has to be the central theme of where we are moving from now on. If I have anything to say about future direction, it is that we want to force a closer coupling between the PA program and the analog, or if you want to call it that, the phenomenological research program, to make those things more closely coupled.

This bottom paren is something that I think

Margaret alluded to earlier and wanted me to mention in our conclusions. We have sort of sidestepped to a large extent, the validation question today, although Marty invited me to get into it on the side earlier.

NRC is currently working with the Swedish Nuclear Power Inspector, the SKI, on a joint validation strategy document. All right. There are two schools of thought.

One school is: Let's get rid of the work validation and work on the concept of confidence building. Another is: Let's define validation as being the process of confidence building.

Whatever the final answer is, the Agency has a responsibility. The DOE has a responsibility. They have waste to dispose of. They have to do it and make decisions in some kind of a credible manner.

We have to build confidence in that decision-making process, whether we call it validation, whether we call it confidence building, or whatever it is.

This SKI effort is trying to put some kind of a framework on that process. How successful it will be, I don't know. It may just generate another round of debate. The literature is full of debate.

My last official conclusion -- no, two of them. I didn't realize I had two on this page -- is the same as one of Linda's observations.

NAWG is the primary international forum where people get together and try to work on these problems. There is a common thread at NAWG that this PA and phenomenological research connection needs to be made -- whether you call it analogs or something else.

We have been working fairly actively over the last couple of years to try to point NAWG in directions that we feel are best not only for our program, but for the international program. This focus on PA this fall is one of those efforts that we, I think, have been instrumental in.

From that point of vie the planned internal workshop that we are going to have here in June -- actually in San Antonio -- the planned internal workshop for us -- at least in the Office of Research -- will be a high priority, I think, from what Margaret has seen today and what we have heard from her before.

It is going to be a high priority for her as well. It goes back to the old argument of putting your own house in order before you tell somebody else to put their house in order.

Perhaps the workshop that you have been invited to is going to do the same thing on the DOE side. Hopefully we are all moving towards convergence in a direction that will lead to better decisions and better acceptance of those decisions in the long-run.

I have no more in terms of formal remarks. We are open to anything that you would like to question us about. Margaret is not here, but she said I could speak for her.

[Laughter.]

MR. HINZE: Bill, on behalf of the Committee, and certainly myself, I do want to thank you and your colleagues -- Linda, Pearcy, John, Norm, and Bob Johnson. It has been an intriguing interesting day. Certainly I am much more knowledgeable as a result of all of this massive effort that you and your colleagues have put on.

Do you want to touch on that one?

[Slide.]

MR. OTT: That is just my pyramid of abstraction. In other words, when I put it together, I saw gaps. I think when the DOE pyramid was put together, it was a good solid information base. I didn't see it that way. I see the world a little differently. My models represent small discrete portions.

MR. HINZE: What I would like to do is to, first of all, ask my colleagues if they have any further questions for the presenters.

If not, at this point, what I would like to do is ask Paul if he would, as we have discussed earlier, if he would give us two and half minutes on the DOE analog in the broad sense program.

If you could do that, Paul, I would appreciate it.

MR. STEINDLER: One quick question before you start. What state would you peg as the start of the KTU process?

MR. OTT: As the start of the KTU process?

MR. STEINDLER: When were KTUs sufficiently well-developed so that they became somewhat used in target selection for projects? Are we talking six months ago or a year ago or two years ago?

MR. OTT: The first time that KTUs were actively used by us in the planning process would have been about this time last year.

MR. STEINDLER: Good enough. Thank you.

MR. OTT: It might have been plus or minus a couple of months. But that is the first time that the process became well enough defined that we could actually use them.

MR. HINZE: Since Dr. Steindler has brought up that point, I do want to register a complaint. There is precedent for the KTU acronym. KTU is the official name of the German drill out in Bohemia. Those of us who are more geoscience-oriented, whenever you say "KTU" we think about the German deep bore hole. There is precedence. That has been around for at least eight years.

MR. OTT: I am not guilty.

MR. STEINDLER: You are not guilty.

MR. OTT: It is a NMSS product.

MR. HINZE: One is German and one is NRC.

Paul.

MR. CLOKE: Yes, thank you.

Since you asked me some time ago to get prepared for this, I put together a few little notes here which I will try to keep very brief.

The on-going actual analog studies that DOE is doing, there is one at Cigar Lake which involves some extremely high level uraninite concentrations, and in fact, sufficiently high that it is possible to detect a little plutonium in regard to that.

The main purpose of that, as I see it, of that natural analog is to look at the migration of plutonium to understand the process. We recognize that its deposit is, in fact, greatly different in almost all other respects from what would happen at Yucca Mountain.

I should also mention in passing that in the Alligator Rivers project, and also some migration of uranium is looked at is also at Oklo. We both have oxidizing and reducing environments, those concepts of the processes in those areas.

In terms of what DOE is calling the natural analog, the only other one I thought of in the last hour or so is the one that is going on basically in the system in Wairakei system in New Zealand.

I think I should make a little comment about how that site was selected. I don't know the exact date, but at least three years ago, in my recollections, when I first heard a presentation from Bill Glassey from Lawrence Livermore National Laboratory, telling me why this site should be looked at, the Livermore people had on the order of some 12 criteria to look at in conjunction with selecting a site which they thought would be suitable for looking at hydrothermal systems.

One of those was they wanted to have an active system. Another one was that it should be in volcanic rocks. A third one is that it should have a similar temperature range of what would be anticipated for Yucca Mountain. A fourth was that it should have some unsaturated zone characteristics.

There were some others. I don't remember the rest of them at the moment. I guess I got about half of the ones that they talked about.

So, there was indeed a logical rationale for selecting that. Analogous to what English was telling about the NRC has done. It was somewhat different, but nevertheless focused on that particular aspect of things.

The activity which is actually going on actively at the moment is looking at the behavior of some of the concretes that have been in place for a long time there. There is indeed significant biological degradation. I have been assured that the microbiology -- the microbes there bring the pH down to about 3.

This is, I am assured, not because of oxidation of hydrogen and sulphite, which is so small an amount of sulfuric acid, but because of microbiological effects. Apparently that can be demonstrated that it is microbiological and not inorganic. Yet, of course, as one might imagine, it does have a significant corrosive effect upon the concretes.

It is also going to be looked at in conjunction with the corrosion of steels and other materials there. So part of the DOE natural analog system, if you like, in regard to that, is to look at analogs for engineered systems, not just for the rocks and things of that sort as well.

English did mention that, yes, an objective here is to look at this as a hydrothermal system, an analog for a hydrothermal system. And as Livermore is putting it, for validation of some of the work with EQ 36. I have as much trouble with the term "validation" as all of the rest of you do, I believe, but nevertheless, that is the terminology that is being used currently.

I should update you, by the way -- English and the rest of you -- that since apparently your last information, that that work has been shifted. All of the near field environment work at Livermore has been transferred under geochemistry on the work break-down structure.

That is currently under the administration or overview of Ardyth Simmons. Hopefully, therefore, this will lead to a little bit better way of getting some of these things accomplished.

Those are the ones that I can think of off-hand that DOE calls natural analogs. However, there are some other ones which the NRC would call natural analogs. This includes some volcanic-types of things, looking at other volcanos and their similarity to the volcanic activity, especially out in the crater flat, in the vicinity of Yucca Mountain. The PIs, by the way, do call it natural analogs in spite of the project position on that.

Similarly, this happens with seismic studies. There are some of that going on. I think we might put in there some of the regional hydrology studies, which look at some of the area well-around, including the springs, lakes, and that kind of stuff.

I think it would be fair to put erosion studies in there. There has been some recent discussion in conjunction with CHEMVAL. DOE has joined the CHEMVAL effort. One of the PIs that we have has indeed directly expressed an interest in doing some investigation, some natural analog studies in order to help this CHEMVAL process.

I don't know quite whether to call the cooperative work that the U.S. has with the Underground Research Laboratory -- excuse me, the Hydrox Laboratory in Sweden. But that would deal primarily with hydrology -- hydrology in saturated zones and fractured rocks. It probably would qualify under NRC's thinking about natural analogs.

There is also a cooperative effort with NAGRA. I think that deals primarily with generation and transport.

Finally, perhaps, in that regard, there are the on-going climate studies. It looks like I am going to be involved in an audit of some of that here in the near future through the National Center for Atmospheric Research and other aspects of that.

Some of the hydrology work actually gets closely related to that as well -- past climate conditions.

There is some potential for some other natural analogs. For example -- in fact, part of this has been already been done -- using basalt glass, the degradation of basalted glass as an analog for degradation of vitric nuclear waste.

I am quite sure that I remember a publication from Livermore which did do a comparison of that sort of thing in terms of modeling the degradation of vitric waste. That might also include some work on tektites. I can't remember for sure if that was viewed as part of that.

We recently have had some uiscussions with the Japanese who were clearly interested in getting a cooperative project -- programs going with the DOE. That would definitely involve some natural analogs from their perspective. They are interested in that, if we are not.

One of those, by the way, involves a dike intrusion across some bentonite. So they are concerned about the bentonite stability question there.

There was discussion earlier about DOE wanting to be involved with Pena Blanca. Some of us think that that would be a good idea. The difficulty is we don't know how to achieve that. The NRC obviously is still there. We can't simply come in and become a partner with the NRC.

Conceivably this could be arranged through some multi-national arrangement. The French would probably be the most interested in regard to that.

But it is not entirely clear whether any other country really is interested in using that as a natural analog. After all, nobody else is looking at the unsaturated zone or at tuffs as a repository. We just don't know whether that is actually feasible or not.

I will continue to pursue looking into that, but I don't know whether indeed anything will ever develop out of that aspect of things.

Let me mention finally that this report of the Natural Review Analog Review Group, which I basically acted as Chairman, did come up with at least a preliminary list of criteria by which we thought that natural analogs should be chosen. That has not been acted upon by the DOE at this point. Perhaps it will be, but I can't predict what is going to happen in conjunction with that.

That Group did make some recommendations including -- let me say some suggestions suggesting that places like Pena Blanca, Akrotiri, McDermitt, Caldera -- were worth looking further at in terms of doing some additional work in those areas. Again, I cannot tell what is going to happen there.

Let me finally say that I have found this meeting particularly helpful in terms of giving me a better perspective as to what we may expect -- what we anticipate NRC's expectations of DOE when it comes to licensing questions Indeed, it may even help to get some of these things going in a bit better basis that they presently see them.

MR. HINZE: Thank you very much, Paul. That was very helpful and very informative. It is not 6:00 yet. There is no point in trying to close this off.

[Laughter.]

MR. HINZE: At this point I would like to ask my colleagues if they would like to make a few off-the-cuff remarks about what they have heard today and what they think is important, and how they see this program being undertaken by the NRC and Research.

Jim, can I ask you to go first? How many pages of notes do you have?

[Laughter.]

MR. FOLAND: I stopped counting after five. I have about a half a dozen comments here that I have written down, if that is not too many. I promise to finish before my two minutes is up.

We have heard a lot of fascinating presentations and discussions today about what, in my opinion, were a number of high-quality state-of-the-art research efforts on stimulating issues.

I would characterize the information that has been produced by these as being relatively fundamental information. If I can respond to Dr. Steindler's rhetorical question about whatever Course 305 was, is yes, we should have, in fact, learned in 305, but were never really known. Some of the processes that are very complicated I think we are learning a great deal about.

If the processes are not new and we are not learning new things, then we are certainly confirming much more realistic our conclusions about concepts that now exist or prejudices.

In my opinion, this is essential, and a very valuable part of the sort of research that we have heard about today and that is we really need to understand the processes before one can take any meaningful account of the process into an evaluation of some scenario or assessment of performance.

Now, from what I understand of the research miscion as it is described in terms of independent research capability, et cetera, it seems to me appropriate that the Agency undertake studies of this sort.

When I say "this sort," I am not sure what I mean because it is not clear to me what the term "natural analogs" means. As I mentioned before, this creates a great deal of confusion which I think is unfortunate.

The term has different meanings to different people and, in part, looks like some groups use the same term to mean different things, namely, one might be to investigate natural processes in the natural domaine, and the other is to have it be a literal analogy to Yucca Mountain,, or part of the Yucca Mountain system.

It seems to me that as a result the projects of this sort that deal with natural systems have to have objectives and a relationship to these objectives to things like KTUs and user needs.

I think, from what I can discern from the description of the project is that this dilemma about the meaning of natural analogs and what one is trying to study, namely an analog or a process, that dilemma is reflected in the relationship or non-relationship between objectives and critical needs.

Now, if I can discern that the committee here is seeking specific results of the research that satisfy some discreet needs, for example, for PA, it seems to me that the basic results is that the learning results of the studies are rather generally much broader at this stage than providing discreet values or even discreet models to be used in assessment. I don't mean to say that the value is less because I don't think that is the case.

To look at some of the problems when one says, if there is a specific study, does this satisfy a specific need that we have at the present or in the near-term future, I think we must remember that there is -- the programs have evolved over time and many of the programs, the ones that are active now, have time lines on the order of ten years, and that the programs, the high-level waste program over ten years, has changed dramatically.

My estimation is that there needs to be much more input to the KTUs -- that is apparent from the brief discussions that we've had -- to define the aims of the natural analogs.

I guess I would suggest that the studies are going to be much more valuable and much more appropriate if the objectives are very carefully defined and focused in a fashion which studies the process rather than studies an analogy.

Finally, I think we need to ask some questions. Namely, how much can one expect realistically of a given natural analog study? What can one do in terms of -- I use a forbidden or sometimes forbidden word -- validation, and it seems to me that we are doing sometimes the same thing. And it is whether or not we call it validation.

Again, it seems to me most important that these research projects serve a function of isolating, identifying, and quantifying in terms of process -- not the analogy but the process -- that can be used in defining the scenarios that one might develop for performance ultimately.

That's all I have now, Bill. Thank you.

MR. HINZE: Thank you. Thank you very much.

John?

MR. GARRICK: Thanks, Bill.

As a person trained in physics and engineering, I have heard more geoscience than I have in any of the other previous times. It was very interesting and I learned a great deal. Of course, I've probably learned the most because of where I was coming from.

I really only have three general comments and they all are kind of interrelated. One thing I would very much like -- and I think they may all have been addressed and they may all have been done but let me comment on them anyhow.

Number one, I would really like to see a before and after analog dose calculation with uncertainty for a specific scenario or a specific case. For example, if it turns out that what we are talking about here is over the 90 percent interval dose calculation that varies between .01 milligram per year and 1 milligram per year, and then after it may decrease its uncertainty by a factor of 10 or whatever, that is one.

So the thing that would be most revealing here would be the magnitude and the uncertainty of the parameter, and the parameter that I am most interested in is a dose calculation and how it varies between before and after.

I think a good analysis like that would be very valuable in beginning to focus the connection between phenomenological transport and actual consequences.

Two, I think that performance assessment needs to be -- as you recognized in your wrap-up slide, Bill -- more visible as an input to prioritizing research. It almost seems to be the other way around. It seems that -- and this may be just an impressions, but I kind of get an impression that the tail is wagging the dog here as far as the role of performance assessment. I think much more benefit would accrue to the research program and to the knowledge of the NRC about regulating this business if we tried to switch that around a bit.

The third thing I guess I would like very much to see -- and I suspect this is going on either by DOE or NRC or I hope somebody -- and that is to avoid confusing the flow of technical and scientific information to bottom line results of repository performance with labels and licensing and regulatory jargon.

I think Margaret was right earlier today when she said after all what we really are talking about here is learning what we can from analogs, enhancing our state of knowledge about the repository and its performance.

In some circles they call this doing the safety analysis as opposed to the compliance analysis. I surely hope that is being done because frankly I don't have that much confidence in the regulations, and we have a lot of history where once we learn how to do quantitative analysis of critical safety parameters we were able to improve the regulations greatly. I am sure that where we are in this arena will find that the same will be true.

So I think simultaneous consideration of compliance and safety would yield some very valuable results about regulation as well as safety.

MR. HINZE: Thank you.

Paul?

MR. POMEROY: Well, I just want to second the last point that John -- the next to the last point that John made with regard to what we are doing here, which was really a statement by Margaret -- stated by Margaret very well, and that is that we are trying to understand with analogs, gain a better understanding of the processes involved. To that extent, I think that these projects go a very long way toward that.

I am concerned a little bit about KTUs. I realize that they are very new. I would, as I indicated earlier, I am very much interested in seeing a sharper focus on the KTUs in terms of what each one of them is intended to delineate.

Margaret mentioned the key elements, the soft spots, within each key technical uncertainty, and I think that's really what I would like to see more effort put into and I understand that that is going to take place over the next year or two. But I think as the Staff identifies those soft spots in each key technical uncertainty that we should try to publicize, if you will -- it is a bad word -- what those soft spots are so that we can continue to have a good idea of what the KTUs really represent.

KTUs, as I said, are really, at this point, very broad. One could encompass almost any activity under 58 independent variables, the way I look at it.

Finally, I wanted to say that Bill Ott's wrap-up presentation was very useful to me. I really appreciated it and I want to emphasize two things that you were emphasizing, Bill, because I think they are important.

One is that in selection of analog sites, and we should be very careful to specify the objectives and the workplans, to quote from you, very carefully in what we want to find out. I think that has been done, and certainly in the latest cases.

And I want to emphasize even more strongly a point that this committee has made several times in the past. I am really enthused to see this point having emphasis from the research perspective and that is that PA in the phenomological researchers, as you point out, need to focus on integrated efforts to expand those boundaries in time and space where there is confidence in the applicability of PA models. It is really excellent to see that there, and I encourage you to push as hard as you can to achieve that goal.

That's all I have, Bill.

MR. HINZE: Thank you.

Marty?

MR. STEINDLER: Yes. Let me start out by making a comment to Paul. If he is convinced that this meeting might give DOE a better idea of what the NRC expects, my strong urging is by all means tell DOE that in loud, clear, emphatic tones to whoever has to be told, and I would recommend you tell it to more than one person because turnover is pretty high.

[Laughter.]

EVENING SESSION

[6:04 p.m.]

MR. STEINDLER: We have had a number of directors of the program that keep shifting. They need to hear that a little more often. I think that we could reduce the amount of apparent conflict between the Agency -- that is, between the NRC and DOE, by having them listen a little more carefully.

My conclusion, this was indeed a fascinating meeting. I must say that I was impressed by the willingness of the Staff to spend what has to be an enormous amount of effort getting ready for this thing and I think we need to at least convey that message to somebody with our thanks.

It is not easy standing up in front of a bunch of people who have no accountability for what they say within limits and have to take all of this nonsense that we occasionally dish out, for which I guess I also need to apologize on occasion.

My conclusion is that as Bill pointed out, if the KTUs really have not become an important part of the planning process any more than perhaps a year ago, then the existing analogue projects were initiated and cranked down a path that didn't have the benefit of that kind of very sharply or more sharply focused planning.

Some of the concerns that have been raised both by this Committee in the past as well as by others to whom we occasionally listen to really need to be cast in that light. I think it is incumbent on the Committee to make that point as cleanly as possible.

I sense very clearly that that situation is changing and while it may not be clear that it's changing absolutely the way I would have it change, they're certainly moving -- that is, the Staff is certainly moving in the direction of using a more systematic planning process that's oriented to the customer. Licensing-related issues are being brought up.

What still is not completely clear and, I think, is simply a matter of working through it since I sense that the NRC staff is moving in that direction, is the direct application of whatever the results are and, particularly, at the planning stage to performance assessment. That's often a bit vague and unclear and sometimes it needs to be vague and unclear.

I think we need to reinforce the opportunity for the Staff, to the extent that we can, for the Staff to feel free to say we are about to embark on a program whose methodology is not totally clear to us and we have got to learn that process before we can tell you how good our answer is going to be.

There is methodology development and I don't see any reason why that should not become an explicit target for a particular natural analogue, or whatever you want to call those things, program. But I think in the planning stage, KTUs ought to be written, rewritten, so that they have the methodology implicit in the words that make it clear how the results from resolving those or at least addressing them are going to be applied, particularly to performance assessment.

If that means we have to go from 58 to 158 because we've got to subdivide them, so be it. Nonetheless, I think they should be -- I am sensitive to Paul's point that they are so vaguely written that they can be used as a justification for a very large host of things. They ought to be at least subdivided in some fashion or another.

I think research is moving in the right direction and I think that building confidence in the ability to direct their programs toward an improved PA output, I am frankly pleased that the past noises that this Committee and its predecessor has made about pushing folks to become sensitive to the customer needs are being -- in the past years are being followed and I think we need to be suitably appreciative of that.

I don't think I have anything else of any consequence. But my view is that the direction in which the folks are moving, that is research and NMSS, together I might add rather than individually, is I think in the direction that will allow easy justification for tackling natural analogue programs and justifying them as a necessary part of the program.

MR. HINZE: Thank you, Marty.

I want to again thank the NRC Staff for their excellent briefings. They have been extremely helpful and they have accomplished everything that I think we set out to do. I think I should also add the Committee's thanks to the ACNW Staff and particularly to Lynn Deering for the massive effort that she, too, has put in on focusing us in on this.

There has been a lot said and I can't add much to it. I would say, in my own evaluation, though, that it seems to me that we are seeing the very early stages of the interaction of natural analogues with the regulatory process. I think part of that problem is because of the fact that we are moving from the user needs which were less distinct to the KTUs, which we still have problems with but are still vague to us and the CDS and the CDM.

I, too, think that we are only starting to develop the communication lines between the scientists working on natural analogues and those working on performance assessment. Those communication lines are not very easy and I think that Norm in his chart of the challenges in applying natural analogue studies to performance assessment hit on a number of these different viewpoints really which are not easy to overcome in the communication process.

One has to say that, at least in my view, that there are some real encouraging things on the horizon. I think that this meeting has shown a sensitivity on the part of the analogue scientists as well as the PA to listen to each other and to be interested in each other's work.

With that, I come back to the future plans and I, for one, want to strongly support what the research staff is doing in setting up this June meeting between PA and natural analogues. I like it for a number of reasons. I think it is timely, I like the fact that you're getting into the trench, you are actually doing some operating, you're not just talking to each other because we don't listen to each other. We really need to get in there and work together.

I also like the idea that you are keeping this to the workers without a lot of people sitting on the sidelines that may be kibitzing. I think that's excellent.

I would hope that we would hear a report on this effort shortly after it is completed. I think you will know the results -- I think you will know the results within the first half day, despite the fact that it's a five-day meeting.

I guess my -- is it a five-day meeting?

MS. KOVACH: Two days.

MR. HINZE: You may need more than two days. I would keep an open end on the airplane tickets.

The only suggestion that I would have to you is if you could broaden it beyond Pena Blanca where you could look at some additional PA problems other than the geochemical modeling, which I think will probably be the particular emphasis. I would encourage you to, within the time and the financial constraints, to open that up somewhat.

I guess I have to say I am looking forward to receiving some of the things we have requested because I think it will help us to understand what you're doing and to put it into the broad term perspective of regulatory analysis.

With that, Mr. Chairman, I have had my say and I will pass it back to you.

MR. STEINDLER: It's only a quarter after 6:00. We have at least two more hours.

[Laughter.]

MR. STEINDLER: Are there any other comments that we need to make? If not -- Bill, you are certainly entitled to a comment.

MR. OTT: I just wanted to second my thanks to Lynn. She was helpful in trying to convey to us what you guys were expecting to see and to a few of the people in the audience, Paul Cloke and Ken Foland as well as four or five of the Staff here, a belated two-year-old thank you for participating in that workshop which we finally got the proceedings out on. We think it's a significant document.

That's all.

MR. STEINDLER: With that, I will thank the reporter for her patience.

We will close the meeting for the day.

[Whereupon, at 6:16 p.m., the meeting was adjourned.]

REPORTER'S CERTIFICATE

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

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DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, 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.

Barbara Whitlock

Official Reporter
Ann Riley & Associates, Ltd.

Geochemical Natural Analogs Research Project

FIN B-6673
NRC Project Manager: Linda Kovach

Presented by:
English C. Pearcy

Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute
6220 Culebra Road
San Antonio, Texas 78238-5166
(210)522-5540

Principal Investigators:
English C. Pearcy, William M. Murphy,
James D. Prikryl, and Ronald T. Green

CNWRA Project Manager:
H. Lawrence McKague

Geochemical Natural Analogs Research Project

Presentation Outline:

I Regulatory Bases
II Project Objectives and Results
III Project Structure
IV Task Objectives and Results
V Project Prospective
VI Integration of Project with Performance Assessment and Site Characterization
VII Use of Results to Develop Methodologies to Determine Compliance with Performance Objectives for Which There Are Key Technical Uncertainties
VIII Conclusions

Geochemical Natural Analogs Research Project

Regulatory Bases:

10 CFR 60.21(c)(1)(ii)(F)

°Specifies that Analyses and Predictive Models Given in the License Applicant's Safety Analysis Report Shall Be Supported by Appropriate Use Of Such Methods as Field Tests, in Situ Tests, and Natural Analog Studies.

10 CFR 60.101(a)(2)

°Stipulates that Demonstration of Compliance with Objectives and Criteria For Repository Performance Over Long Times in the Future Will Involve the Use of Performance Models that are Supported by Such Measures as Natural Analog Studies.

Geochemical Natural Analogs Research Project

Selected Key Technical Uncertainties:

- °Uncertainty in Extrapolation of Short-Term Laboratory and Prototype Test Results to Predict Long-Term Performance of Waste packages and Engineered Barrier Systems
- °Uncertainty Regarding Equal or Increased Capacity of Alteration Mineral Assemblages to Inhibit Radionuclide Migration
- °Uncertainty in Identifying Geochemical Processes that Reduce Radionuclide "Retardation"
- °Uncertainty in Conceptual Model Representations of the Natural System
- °Uncertainty in Modeling Groundwater Flow through Unsaturated Fractured Rock Caused by the Lack of Codes Tested Against Field Data
- °Uncertainty Regarding Experimental Confirmation of the Basic Physical Concepts of Groundwater Flow through Unsaturated Fractured Rock

Geochemical Natural Analogs Research Project

Project Objectives:

- °Obtain knowledge of the state of the art in natural analog studies applied to contaminant transport.
- °Design and undertake natural analog study of contaminant transport relevant to the proposed HLW repository at Yucca Mountain, Nevada.
- °Obtain fundamental new data to improve the understanding of processes affecting contaminant transport in unsaturated media.
- °Demonstrate a methodology in which data from nature are used to inform site characterization activities and to evaluate performance assessment transport models at time and space scales generally inaccessible in laboratory studies.

Geochemical Natural Analogs Research Project

Project Results:

°State of the art knowledge of natural analog studies applied to contaminant transport and practical experience has been obtained and maintained.

°Numerous interactions with international and DOE scientists have been conducted.

°Two strong Yucca Mountain analog sites have been identified.

°A variety of fundamental data have been obtained to improve the understanding of processes affecting contaminant transport in unsaturated media.

°Transport and retardation processes have been evaluated for relative importance to performance assessment models.

°Conceptual models of contaminant transport have been developed.

Geochemical Natural Analogs Research Project

Project Structure:

Task 1	-	Literature Review and Workshop	(complete, 2/90 to 6/90)
Task 2	-	Site Selection	(complete, 6/90 to 6/91)
Task 3	-	Data Acquisition	(continuing, 6/90 to present)
Task 4	-	Data Interpretation and Modeling	(continuing, 6/90 to present)
Task 5	-	Reporting	(continuing, 2/90 to present)

Project anticipated to be complete in FY97.

Geochemical Natural Analogs Research Project

Task 1 - Literature Review and Workshop

Objectives:

- °Compile and Evaluate Research Conducted on Natural Analogs Relevant to HLW Contaminant Transport at Yucca Mountain
- °Identify Potential Sites at which to Undertake a Natural Analog Study
- °Organize and Host a Technical Workshop on the Use of Natural Analogs

Results:

- °Conducted a Comprehensive Review of the Natural Analog Literature (CNWRA 90-008).
- °Identified Contaminant Transport Processes Likely to be Important at Yucca Mountain.
- °Developed Criteria for the Successful Use of Natural Analogs.
- °Peña Blanca, Mexico; Akrotiri, Greece; Virgin Valley, Nevada; and McDermitt Caldera, Nevada-Oregon; Identified as Potential Analog Sites.
- °Conducted a Technical Workshop on the Use of Natural Analogs.
- °Workshop Results Published (CNWRA 93-020).

Task Complete

Geochemical Natural Analogs Research Project

Task 2 - Site Selection

Objective:

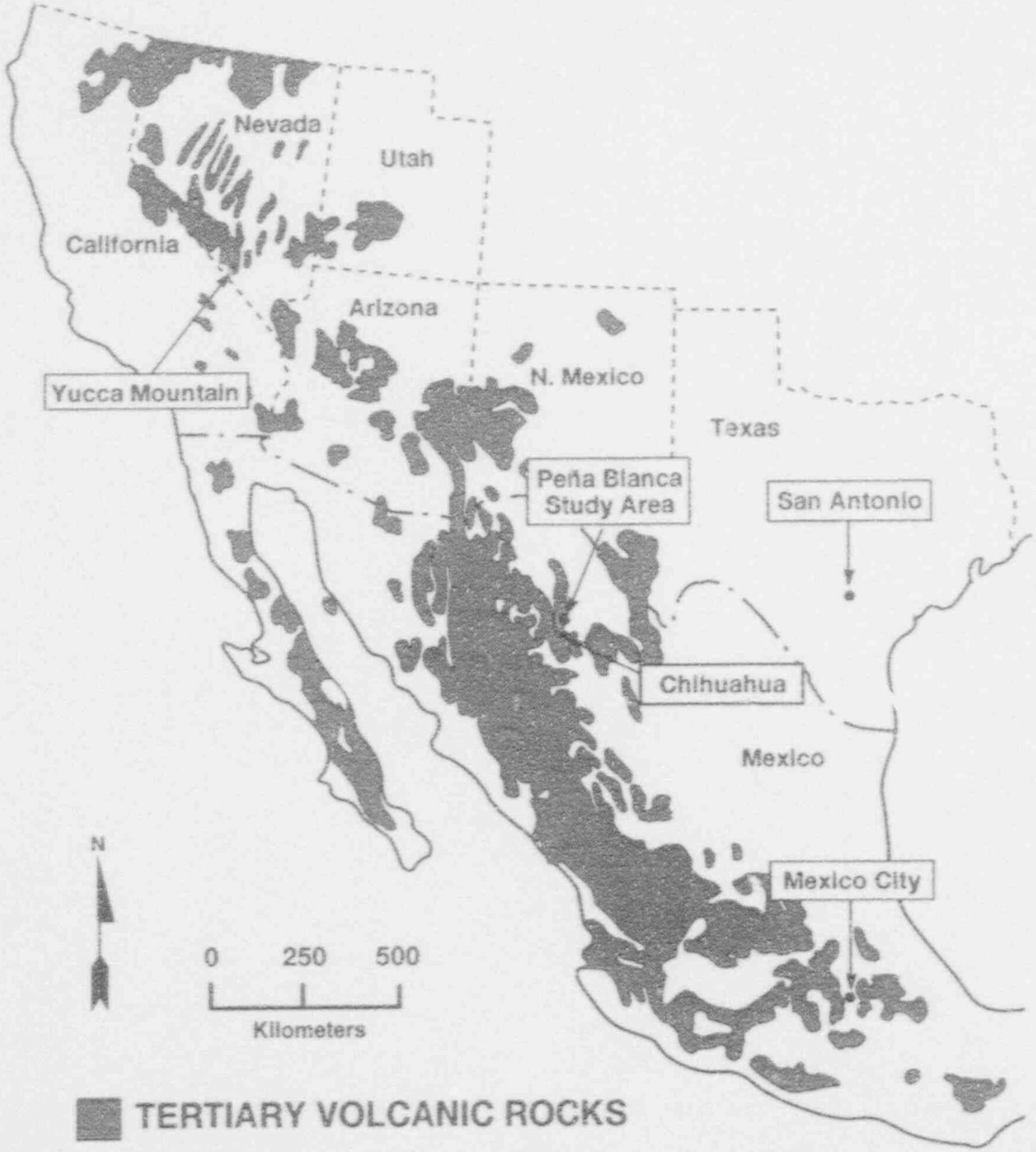
°Select a Site or Sites with a High Likelihood of Yielding Information on Processes and Events Controlling Contaminant Transport in a Yucca Mountain Repository

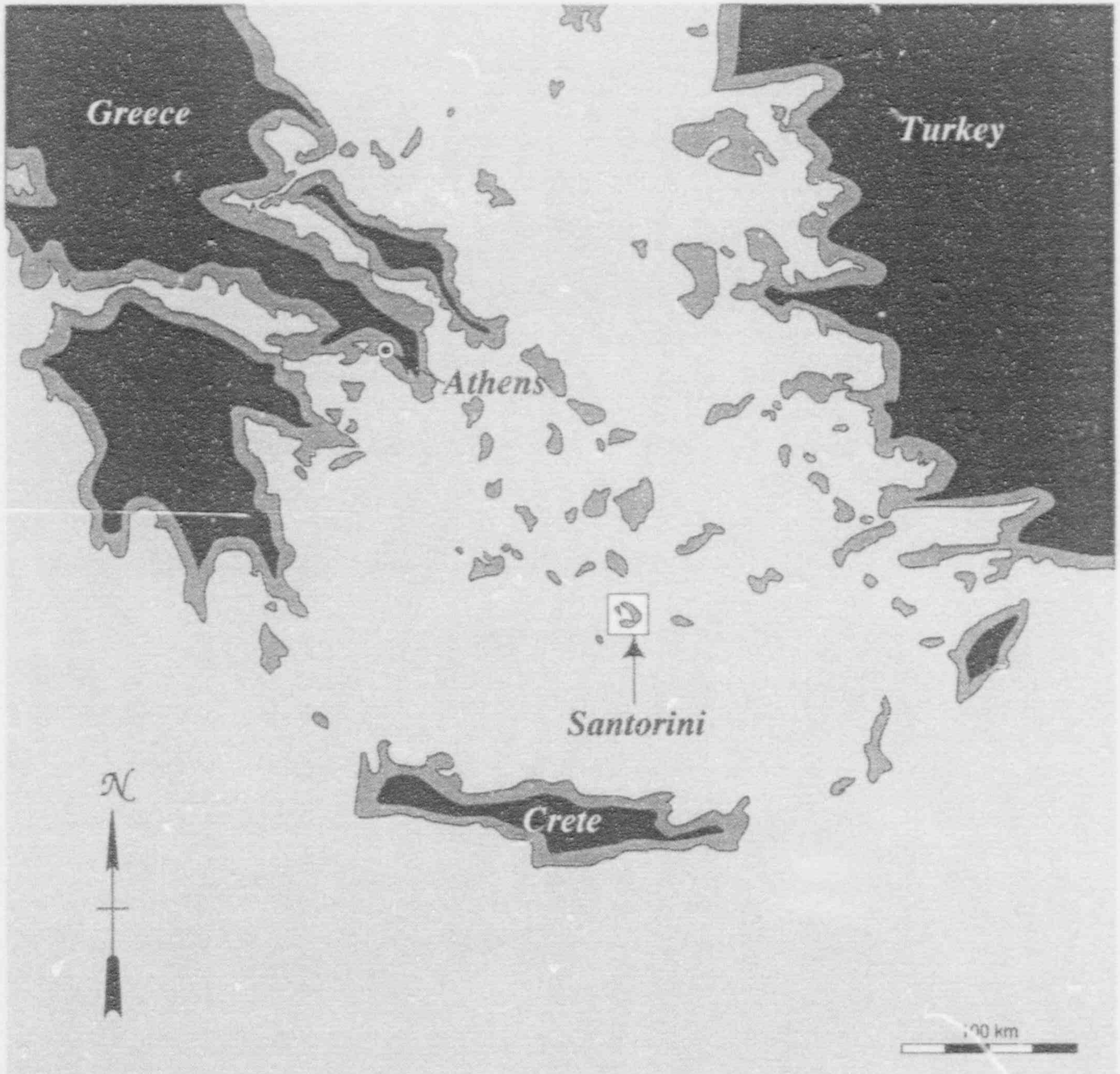
Results:

°Peña Blanca, Mexico; Akrotiri, Greece; Virgin Valley, Nevada; and McDermitt Caldera, Nevada-Oregon; Evaluated for Potential Analog Study through Field and Laboratory Research.

°Using Criteria Developed in Task 1, Accompanied by Field and Laboratory Research, the Nopal I Uranium Deposit at Peña Blanca, Mexico, and Archaeologic Site at Akrotiri, Greece Were Selected for Analog Study.

Task Complete


Nevada
Utah
California
Arizona
N. Mexico
Texas
Yucca Mountain
Peña Blanca Study Area
San Antonio
Chihuahua
Mexico
Mexico City
N
0
250
500
Kilometers
TERTIARY VOLCANIC ROCKS


Greece
Turkey
Athens
Santorini
Crete
N

Geochemical Natural Analogs Research Project

Task 3 - Data Acquisition

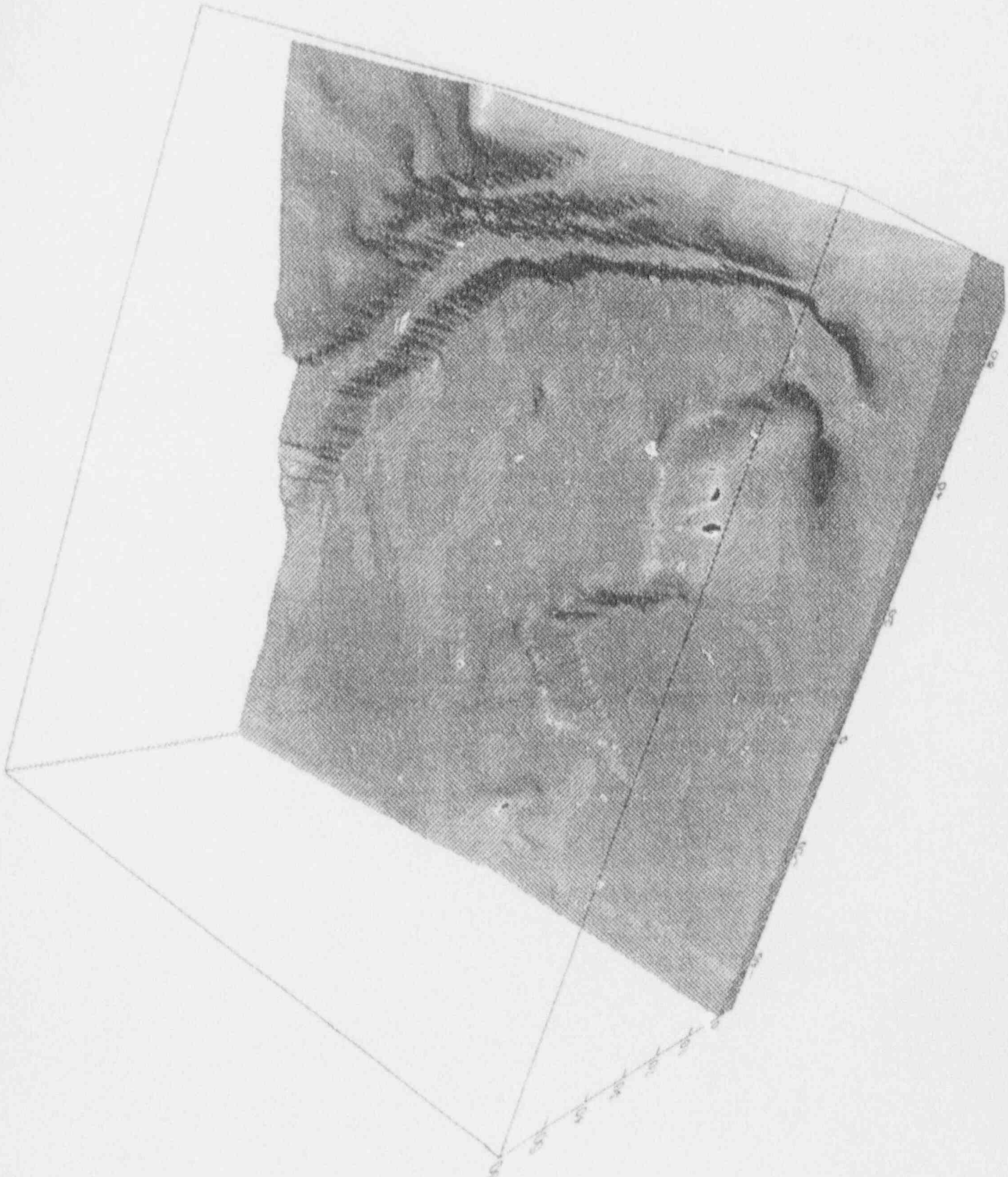
Objectives:

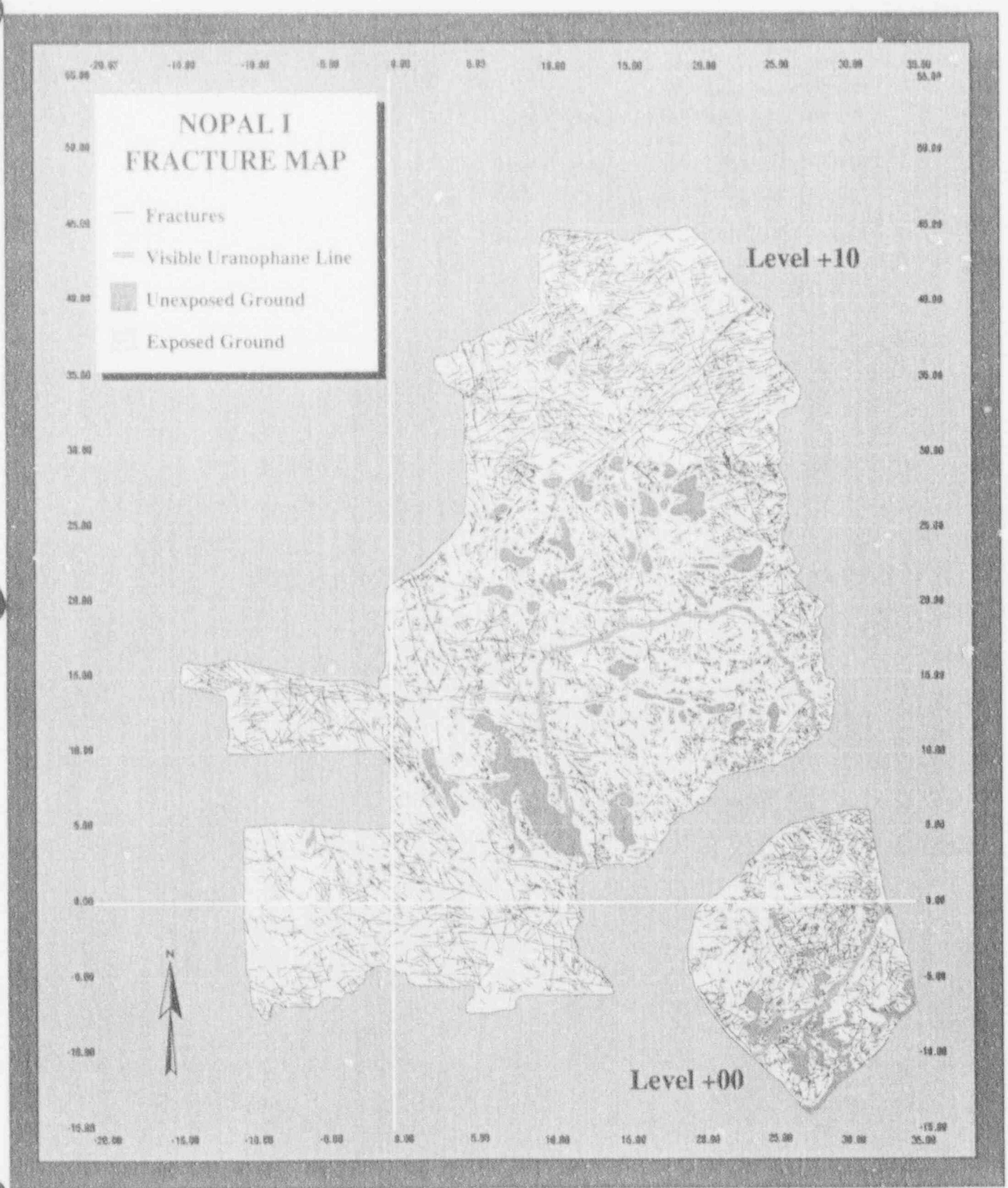
°Develop Methodologies for Data Acquisition and Implement Those Methodologies for the Analog Sites

Results:

Peña Blanca

°Geologic and Topographic Mapping of the Nopal I Site
°Major and Minor Secondary Uranium Phases Identified
°Compositions of Uranium Minerals Determined
°Mineralogy and U Concentrations Measured in Transects Across the Margin of the Deposit and in Vein Filling Materials
°Uranium Distributions Mapped
°Composition of Water at Nopal I Measured
°Hydrologic Setting of Nopal I Defined
°Collection, Description, and Study of 1,649 Samples
°TEM Measurements of Uraninite Structures
°U Series Dating of a Post Ore-Formation Caliche
°U Series Disequilibria Documented in Bulk Rock
°Matrix Hydraulic Properties of Nopal Tuff Measured




NOPAL I
FRACTURE MAP
Fractures
Visible Uranophane Line
Unexposed Ground
Exposed Ground
Level +10
Level +00
N

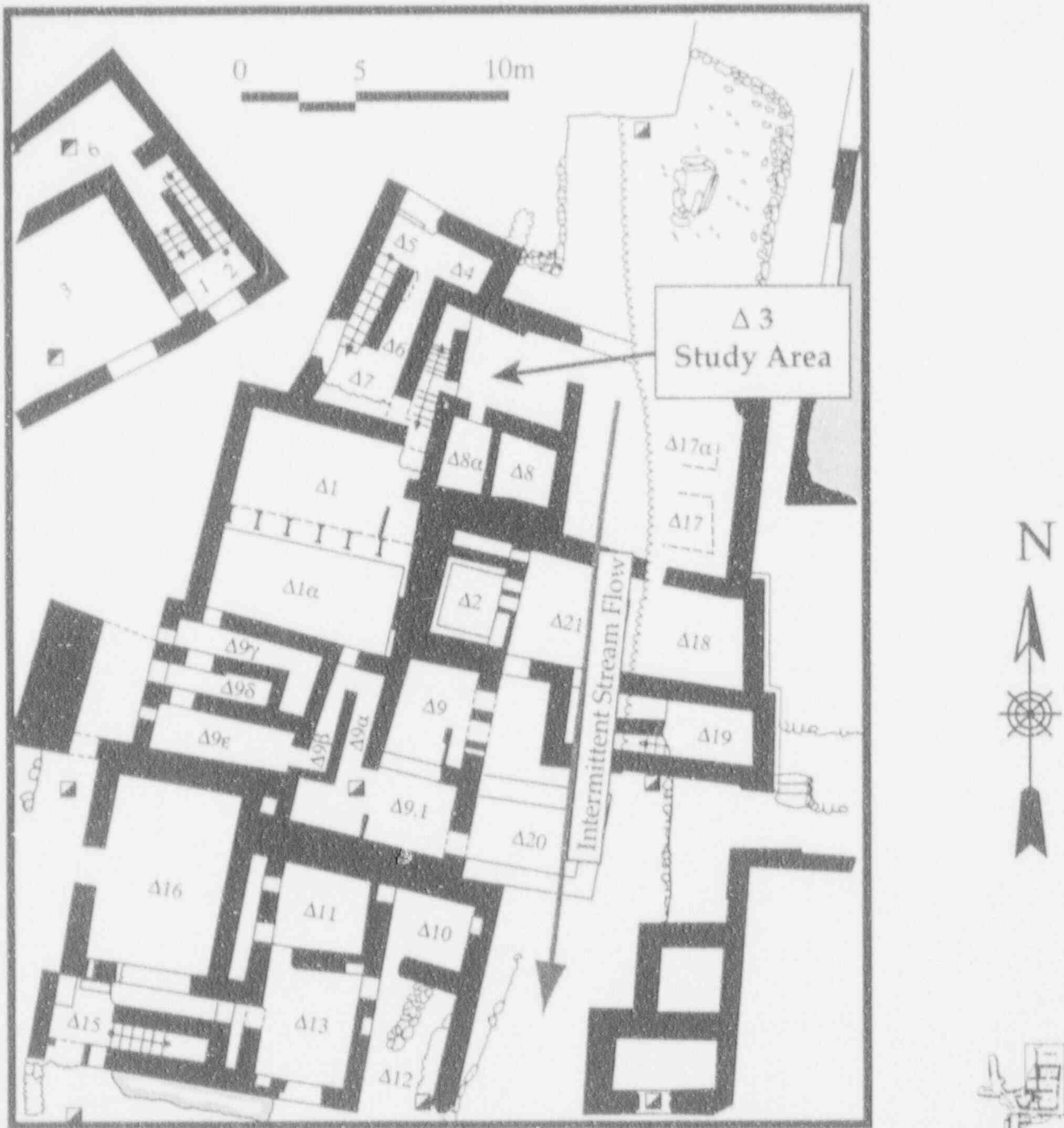
Geochemical Natural Analogs Research Project

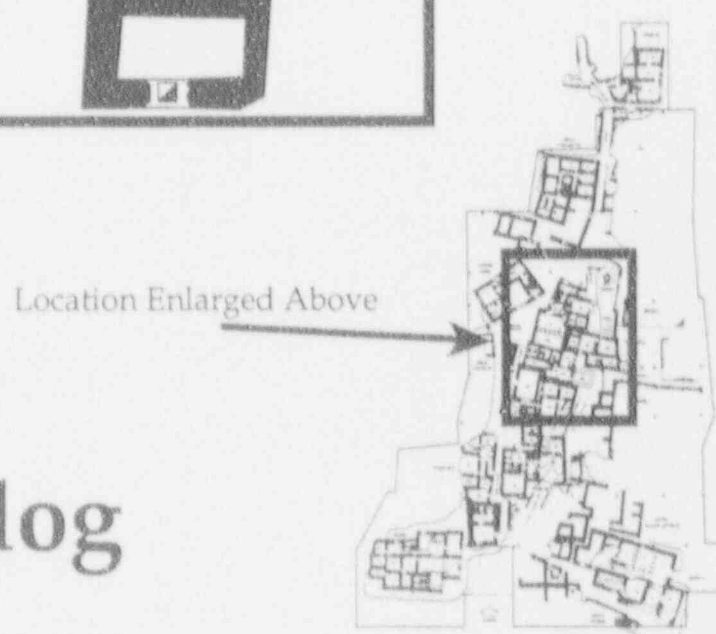
Task 3 - Data Acquisition

Results:

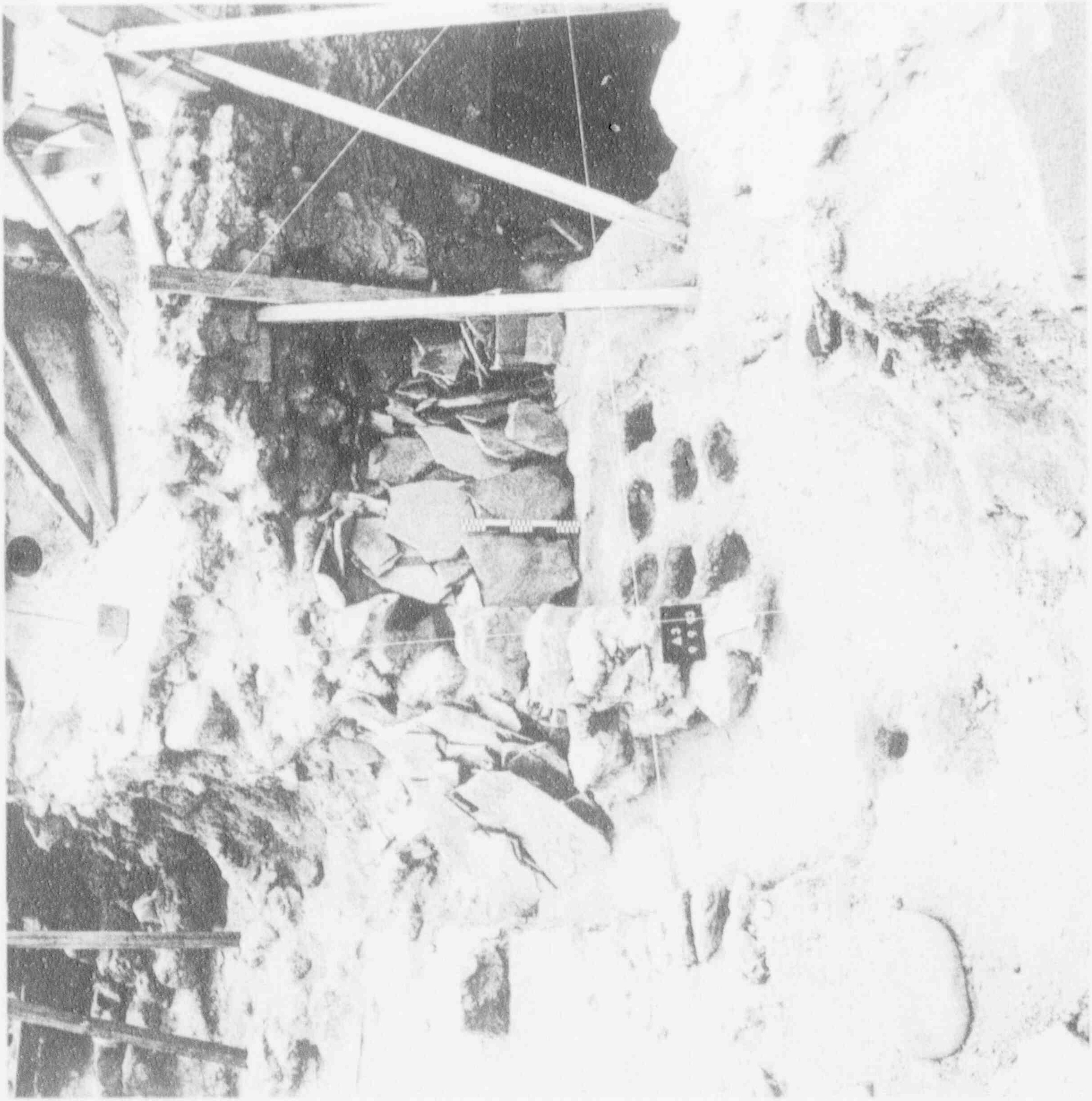
Akrotiri

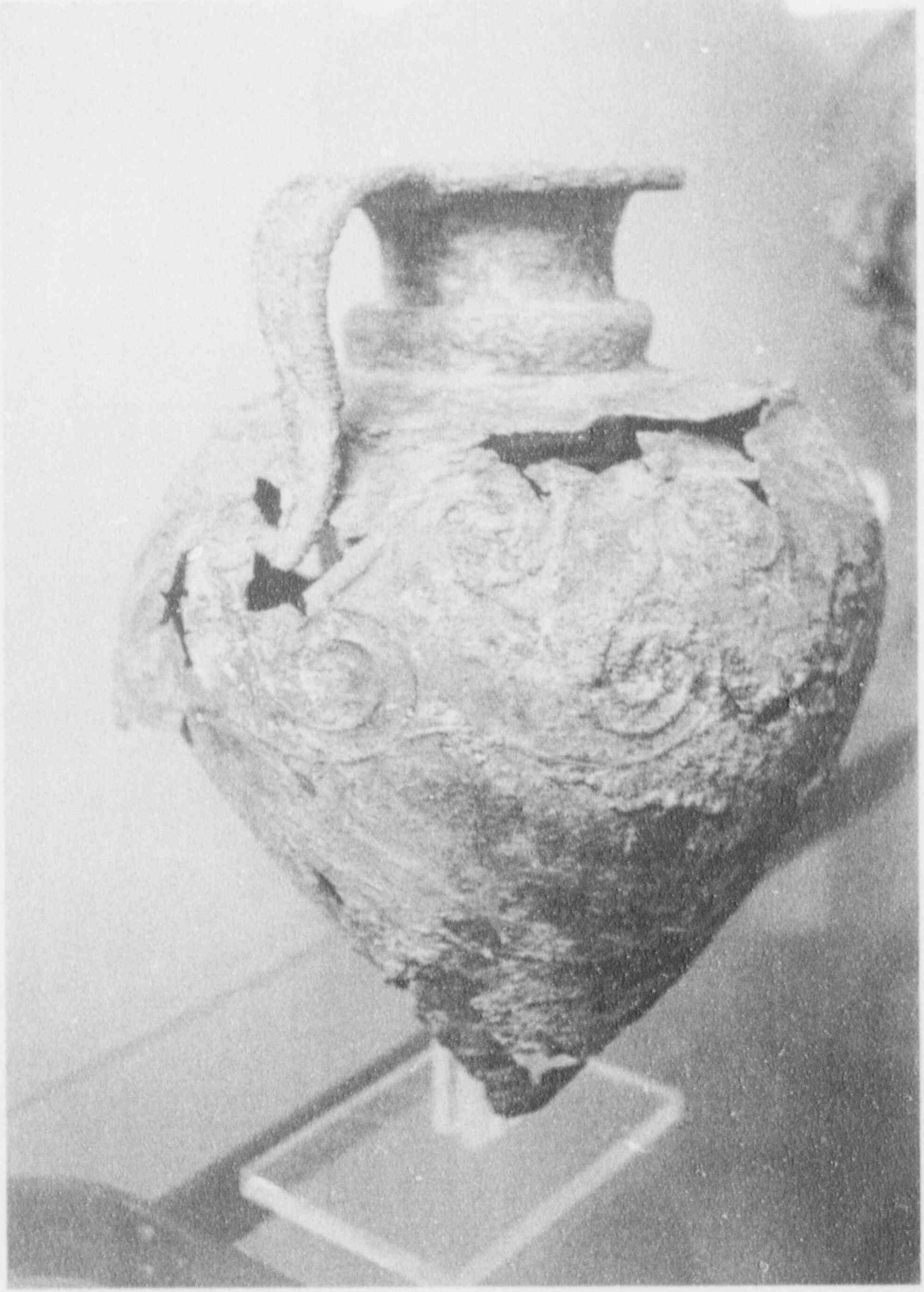
°Locations Within the Site Identified for Transport Study
°Collection, Description, and Study of Rock Samples
°Characterization of "Packed Earth" Materials
°Major and Trace Element Compositions of Rock Samples Determined
°Chemical Analyses of Leachates from Rock and Earth Samples
°Tuff Collected at Site of Unexcavated Bronze Artifact
°Field Hydrologic Data Collected
°Field Hydrologic Measurements
°Delta 3 Site Mapped and Bronze Locations Constrained
°Tuff Profiles Collected from Bronze Sites
°Minoan Tuff Samples Collected for Hydraulic Characterization
°Bronze Corrosion Products Collected and Characterized

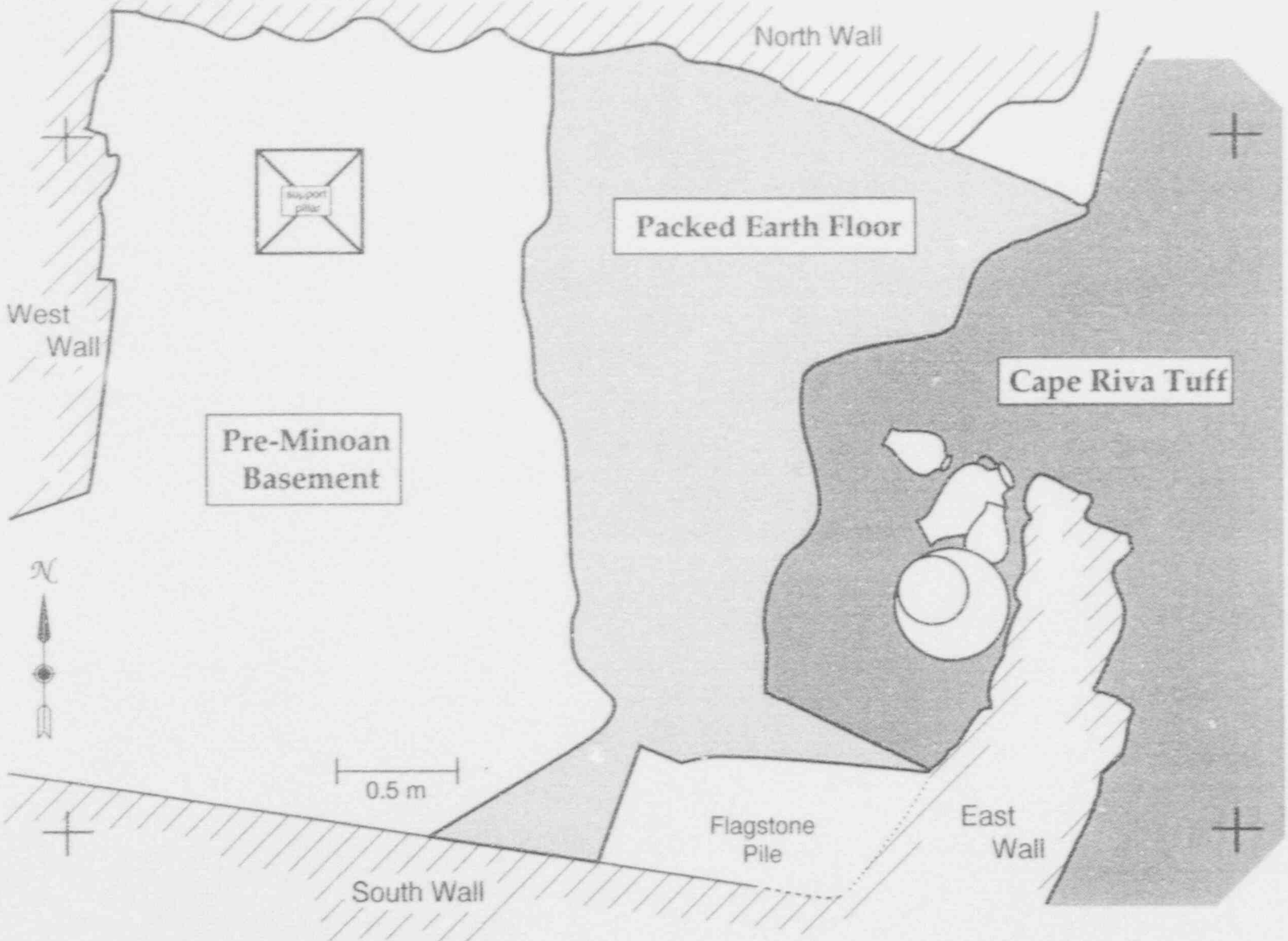




Site Map
Akrotiri Analog






North Wall
Packed Earth Floor
West
Wall
Cape Riva Tuff
Pre-Minoan
Basement
N
0.5 m
Flagstone
Pile
East
Wall
South Wall

Geochemical Natural Analogs Research Project

Task 4 - Interpretation of Data and Modeling

Objectives:

- °Interpretation of Data Collected for the Analog Sites
- °Development of Transport Models for the Sites to Identify and Interpret Important Processes
- °Evaluation of the use of Data from Natural Analogs for Support of Performance Assessment Modeling of a Yucca Mountain Repository

Results:

Peña Blanca

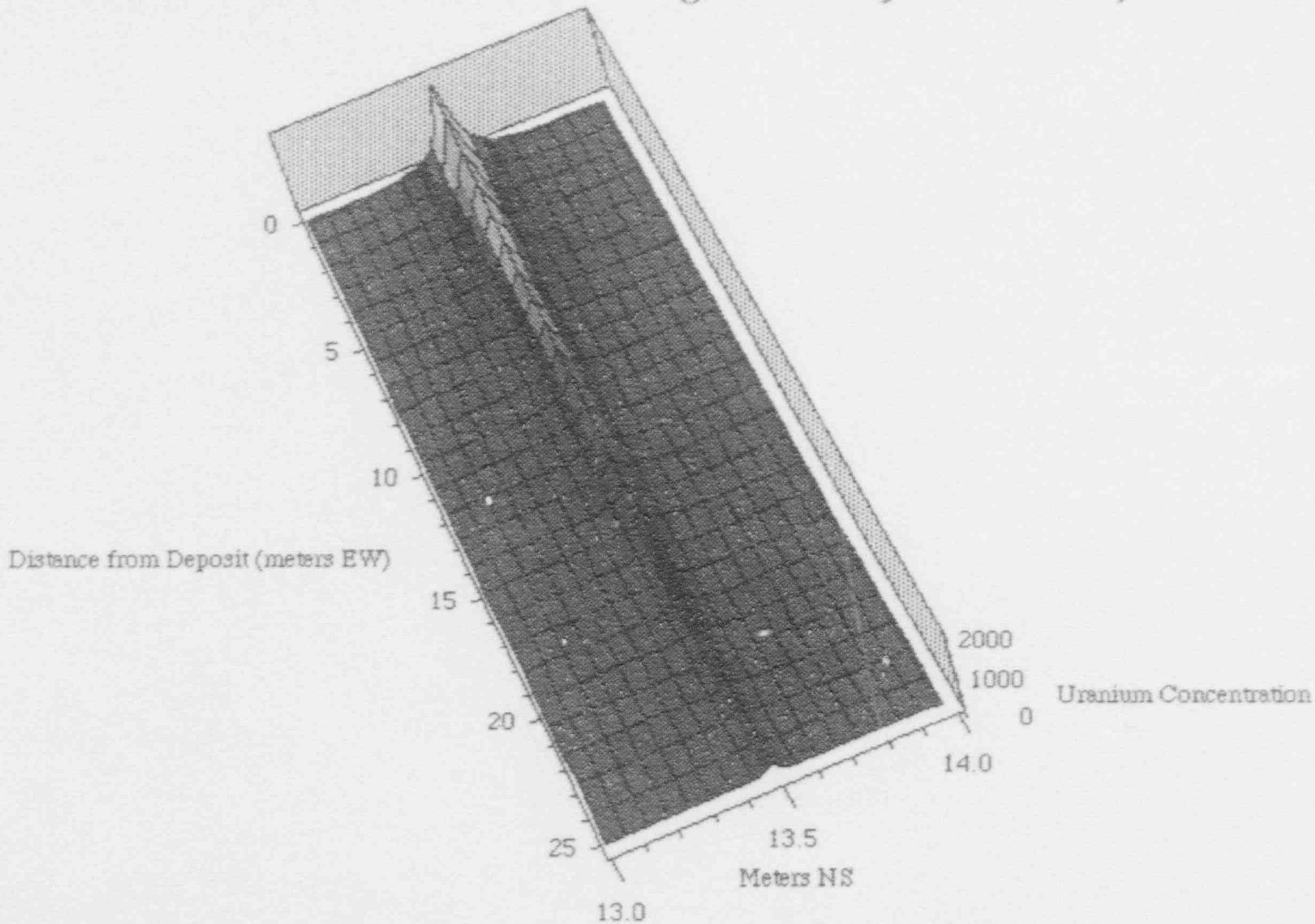
- °Paragenetic Sequence of Uranium Phases at Nopal I Established
- °Maximum Limit on Uraninite Alteration Rate Established
- °Conceptual Models of Fracture vs. Matrix Transport of Uranium Developed
- °Fracture Characteristics of Level +10 and Level +00 Modeled
- °Uranium Distributions of Level +10 and Level +00 Modeled
- °Uranium Series Measurements Along a 2 m Transect Interpreted in Terms of Transport
- °Uranium Series Measurements of Opal and Calcite Interpreted as Dates of Formation
- °Laboratory Hydraulic Measurements on Nopal Tuff Interpreted

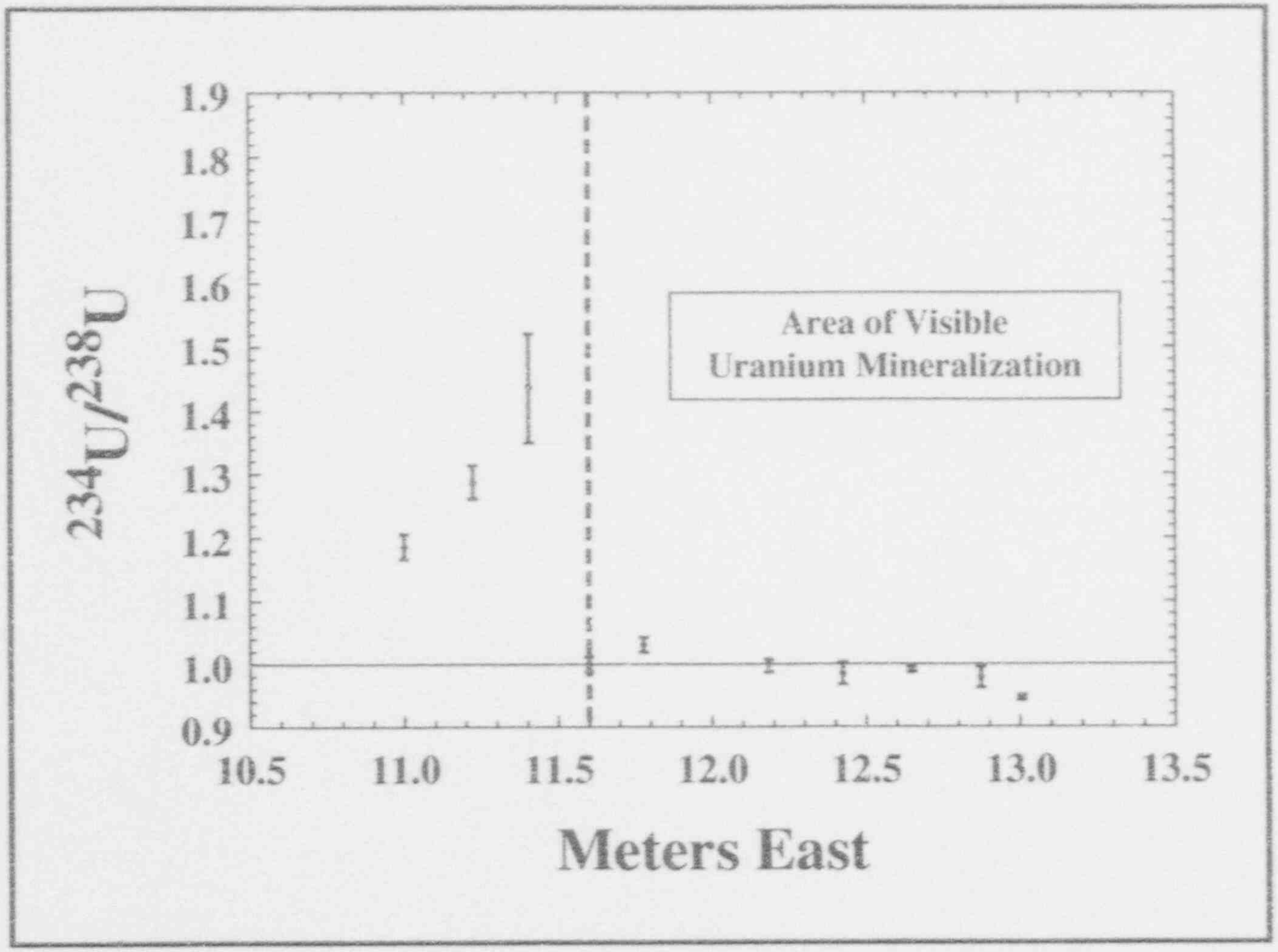
Comparison of Nopal I Uraninite Alteration Sequence to Laboratory Experiments of UO_2 Alteration

	Nopal I Sequence	Laboratory Sequence*
oxides	Uraninite	Synthetic UO_2
oxyhydroxides	Ianthinite Schoepite/ Dehydrated Schoepite Becquerelite Billietite (?)/Abernathyite (?)	Dehydrated Schoepite
silicates	Soddyite Weeksite/Boltwoodite Uranophane	Soddyite Uranophane/Boltwoodite

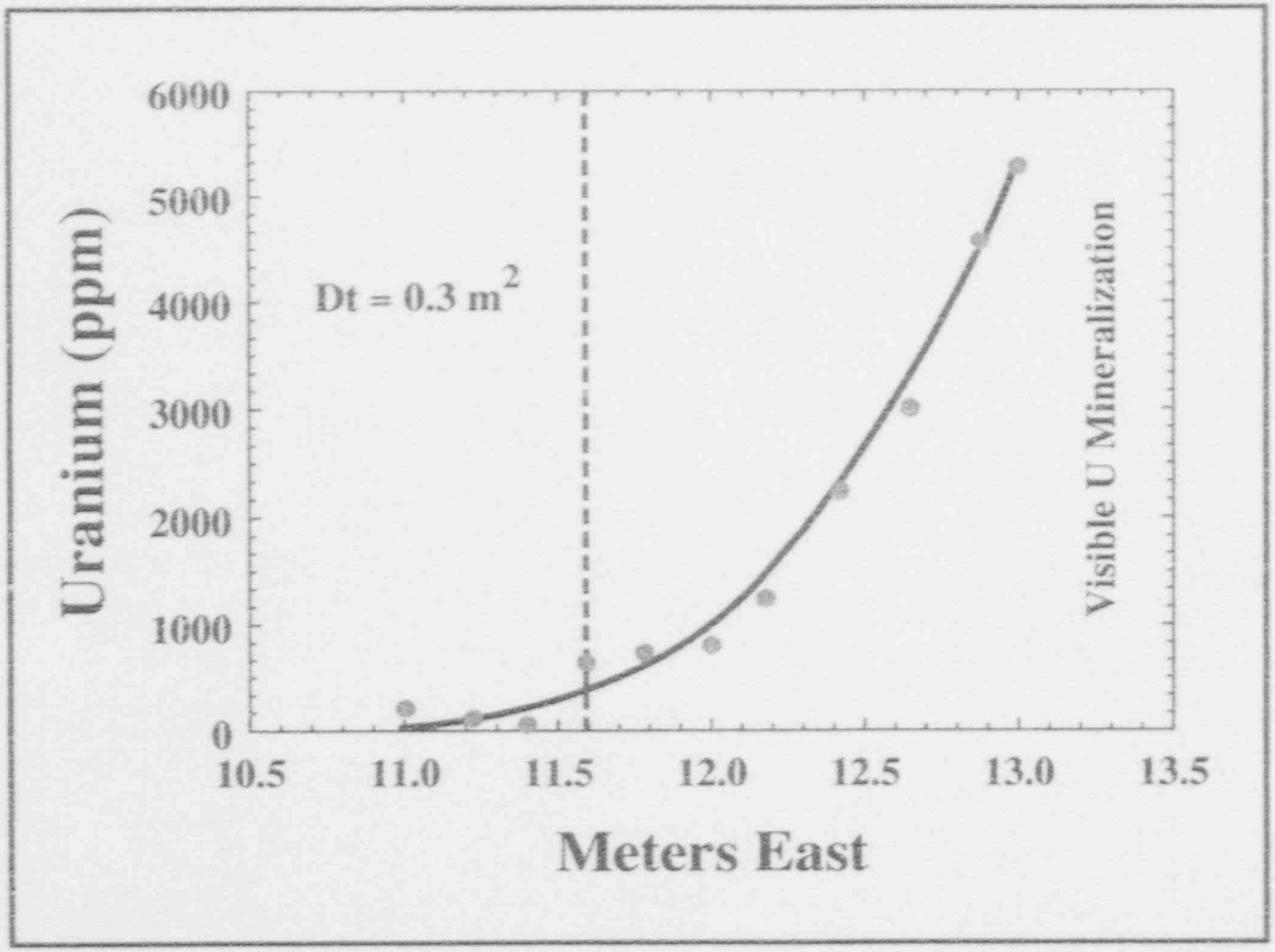
Time ↓

Uranium Concentration Gradients Along and Away from a Major Fracture

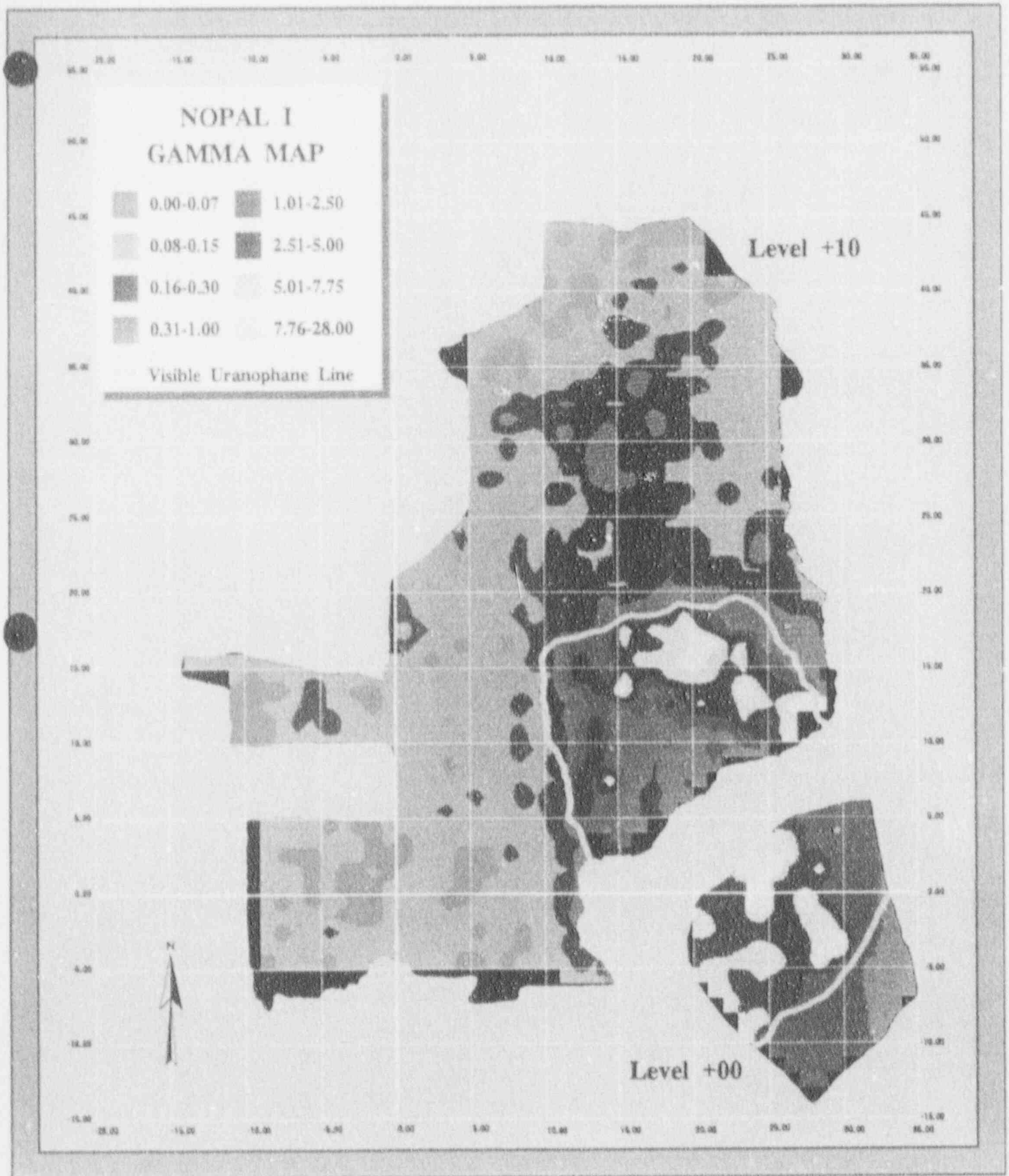




Area of Visible
Uranium Mineralization
$^{234}U/^{238}U$
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
10.5
11.0
11.5
12.0
12.5
13.0
13.5
Meters East



Uranium (ppm)
6000
5000
4000
3000
2000
1000
0
10.5
11.0
11.5
12.0
12.5
13.0
13.5
Meters East
Dt = 0.3 m2
Visible U Mineralization


NOPAL I
GAMMA MAP
0.00-0.07
1.01-2.50
0.08-0.15
2.51-5.00
0.16-0.30
5.01-7.75
0.31-1.00
7.76-28.00
Visible Uranophane Line
Level +10
Level +00
N

Geochemical Natural Analogs Research Project

Task 4 - Interpretation of Data and Modeling

Results:

Akrotiri

- °Developed Conceptual Models of Elemental Transport
- °Magnetometry Data from Unexcavated Area Interpreted
- °Chemical Compositions of Initial Metal Leachates Interpreted
- °Formation of Alluvium at the Akrotiri Site Interpreted
- °Field Hydrologic Data Interpreted

Geochemical Natural Analogs Research Project

Project Prospective:

Task 3 – Data Acquisition

Peña Blanca

- °Continue U-Series Measurements
- °Conduct Measurements of REE Concentrations
- °Continue Structural Analysis of Uraninite Oxidation
- °Continue Mineralogic Analyses of Fracture Minerals
- °Continue Laboratory Hydraulic Characterization of Nopal Tuff
- °Conduct Field Hydrologic Tests of Fracture and Matrix Flow through the Nopal Tuff

Akrotiri

- °Conduct Chemical Analyses of Delta 3 Bronzes
- °Continue Leachate Analyses of Delta 3 Tuff Profiles
- °Collect Materials From and Adjacent to Newly Discovered Artifacts

Geochemical Natural Analogs Research Project

Project Prospective:

Task 4 – Interpretation of Data and Modeling

°Continued Development of Conceptual Models of Peña Blanca
°Continued Assessment of Relative Importance of Matrix vs. Fracture Flow in Controlling Secondary Uranium Transport
°Continued Development of Conceptual Models of Akrotiri
°Development of Numerical Models for Transport at Peña Blanca
°Development of Numerical Models for Transport at Akrotiri

Final Results:

Evaluation of Models and Development of Guidance for the use of Analog Data for Support of Performance Assessment and Site Characterization, and Use in License Application Review.

°Expected Peña Blanca Project Completion: FY97
°Expected Akrotiri Project Completion. FY97

Geochemical Natural Analogs Research Project

Results To Date Useful for Performance Assessment and Site Characterization:

Result:	Use:
Long-Term Degradation Rate of UO_2 in a Yucca Mountain-like Environment Conservatively Bounded.	Provides Constraint for Source-Term Release Rates.
Identities, Compositions, Morphologies, and Sequence of Long-Term UO_2 Alteration Products in a Yucca Mountain-like Environment Determined.	Provides Mechanisms for Waste Form Alteration Models.
Secondary Uranyl Silicates Determined to Be a Major Factor Controlling Long-Term Release of Uranium for Transport.	Identifies Controlling Phases for Long-Term Release Models.
Relative Importance of Meso-Fracture (i.e., apertures 1-10 mm), Micro-Fracture (i.e., apertures <1mm), and Matrix Transport Evaluated.	Provides a Ranking of Long-Term Effectiveness of Different Transport Paths.

Geochemical Natural Analogs Research Project

Anticipated Results Useful for Performance Assessment and Site Characterization:

°Rates of U and REE Transport Over Long Time Scales.

°Evaluation of the Relative Importance of Retardation Mechanisms (e.g., sorption onto iron oxides, clays, and zeolites; precipitation; matrix imbibition).

°Effective Fracture and Fracture+Matrix Flow Measurements (e.g., breakthrough curves and flow paths).

°Rates of Cu, Sn, Co, Ag, Pb, Fe, Mn, and Zn Transport over 3,600 years in a Yucca Mountain-like Environment.

°Evaluation of the Relative Importance of Retardation Mechanisms for Cu, Sn, Co, Ag, Pb, Fe, Mn, and Zn in a Yucca Mountain-like Environment.

°Conceptual and Numerical Models of Contaminant Transport in Two Yucca Mountain-like Environments.

°Evaluation of the Limitations and Utility of Natural Analog Data and Models in Support of a License Application.

Geochemical Natural Analogs Research Project

Use of Results to Improve Understanding of Key Technical Uncertainties and to Develop Methodologies to Determine Compliance with Performance Objectives for Which there are Key Technical Uncertainties:

°Uncertainty in Extrapolation of Short-Term Laboratory and Prototype Test Results to Predict Long-Term Performance of Waste packages and Engineered Barrier Systems

- Long-term Rates of UO_2 Alteration and Formation of Secondary U Phases Have Been Studied and Compared to Laboratory Experiments.

°Uncertainty Regarding Equal or Increased Capacity of Alteration Mineral Assemblages to Inhibit Radionuclide Migration

- The Relative Importance of Alteration Mineral Assemblages to Inhibit Radionuclide Migration is Being Assessed.

°Uncertainty in Identifying Geochemical Processes that Reduce Radionuclide "Retardation"

- The Relative Importance of Geochemical Processes for Radionuclide Retardation is Being Evaluated.

Geochemical Natural Analogs Research Project

Use of Results to Improve Understanding of Key Technical Uncertainties and to Develop Methodologies to Determine Compliance with Performance Objectives for Which there are Key Technical Uncertainties (continued):

°Uncertainty in Conceptual Model Representations of the Natural System

- Difficulties Fncountered in Developing Conceptual Models of The Peña Blanca and Akrotiri Systems Allow Informed Evaluation of Likely Sources of Uncertainty in Developing Conceptual Models of the Yucca Mountain System.

°Uncertainty in Modeling Groundwater Flow through Unsaturated Fractured Rock Caused by the Lack of Codes Tested Against Field Data

- Results Are Providing Well-Constrained Field Data for Code Te ting (including evaluation of the basic conceptualization of the codes).

°Uncertainty Regarding Experimental Confirmation of the Basic Physical Concepts of Groundwater Flow through Unsaturated Fractured Rock

- Results of Field Infiltration Tests Are Anticipated to Provide Well-Constrained Experimental Data on Basic Physical Concepts of Groundwater Flow through Unsaturated Fractured Rock.

Geochemical Natural Analogs Research Project

Conclusions

°A State of the Art Knowledge of the Applications of Natural Analogs Has been Obtained and Maintained.

°Systematic Literature, Field, and Laboratory Investigations Have Resulted in Identification of Two Strong Yucca Mountain Analog Sites.

°Complementary Studies of the Peña Blanca and Akrotiri Sites Are Producing Understanding, Data, and Models Which Provide Support for Performance Assessment and Site Characterization.

°Results Are Helping to Improve Understanding of Key Technical Uncertainties and to Develop Methodologies to Determine Compliance with Performance Objectives for Which there are Key Technical Uncertainties.

Application of Natural Analog Studies

Presentation to the Advisory Committee on Nuclear Waste

March 23, 1994

John W. Bradbury (301-504-2535)
Division of High-Level Waste Management
Office of Nuclear Material Safety and Safeguards

Outline of Presentation

I. Background information
   A. CNWRA/NRC Workshop on Natural Analogs
   B. Natural Analogue Review Group (NARG) Report

II. Use of "natural analog studies" in 10 CFR Part 60
   A. Supporting performance assessment
   B. Supporting site characterization

III. Definition - broad range of applications
   A. Conditions
   B. Processes and events

IV. Examples of natural analog studies

V. Why natural analog studies are important
   A. Unique approach to unique problem
   B. Testing ground for geoscientific techniques and analyses
   C. Another source of information

Background Information

- CNWRA/NRC Workshop on the Role of Natural Analogs in Geologic Disposal of High-Level Nuclear Waste - July 23-25, 1991

  (At this workshop, DOE representatives expressed view that natural analog studies should not be applied to volcanic and tectonic systems. Studies addressing concerns in those areas are considered "geoscience as usual.")

- Natural Analogue Review Group (NARG) report - June 1, 1992

  (This report recommends that natural analogues be process-oriented and address issues resulting from the perturbation of a natural system (the geologic site) by the introduction of a technological system (the repository). All investigations normally part of site characterization, even when considering comparisons with similar remote sites, such as (paleo)hydrology, etc., should not be considered as natural analog studies.)

- NRC Response to NARG Report - October 6, 1992

  (This letter to J. Roberts states that the NARG report's recommendation concerning the range of topics to which natural analog studies can apply is too restrictive as compared to those in 10 CFR Part 60.)

Background (continued)

- o DOE Response to NRC Letter on NARG Report - January 26, 1993

  (The DOE sees no inconsistency between the NARG report and 10 CFR Part 60.)

- o DOE Progress Report #8 - September 22, 1993

  (The DOE adopts the recommendations of the NARG report.)

- o NRC Staff Comments on DOE Progress Report #8 - February 6, 1994

  (The NRC recommends that the DOE adopt a broader definition of natural analog studies to ensure the full benefit of this information, in guiding site characterization, validating conceptual models, and estimating repository performance. The NRC is concerned that a restricted definition of natural analog studies might be used as a reason for not doing important work.)

Use of "Natural Analog Studies" in 10 CFR Part 60

§60.21(c)(1)(ii)(F) An explanation of measures used to support the models used to perform the assessments required in paragraphs (A) through (D). Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests which are representative of field conditions, monitoring data, and natural analog studies.

(A) An analysis of the geology, geophysics, hydrogeology, geochemistry, climatology, and meteorology of the site,

(B) Analyses to determine the degree to which each of the favorable and potentially adverse conditions, if present, has been characterized....

(C) An evaluation of the performance of the proposed geologic repository for the period of permanent closure....

(D) The effectiveness of engineered and natural barriers...against the release of radioactive material to the environment.

Paragraphs (A) and (B) involve site characterization; paragraphs (C) and (D) involve performance assessment.

Use of "Natural Analog Studies" in 10 CFR Part 60
(continued)

§60.101(a)(2) While these performance objectives and criteria are generally stated in unqualified terms, it is not expected that complete assurance that they will be met can be presented. A reasonable assurance, on the basis of the record before the Commission, that the objectives and criteria will be met is the general standard that is required. For §60.112, and other portions of this subpart that impose objectives and criteria for repository performance over long times into the future, there will inevitably be greater uncertainties. Proof of the future performance of engineered barrier systems and the geologic setting over time periods of many hundreds or many thousands of years is not to had in the ordinary sense of the word. For such long-term objectives and criteria, what is required is reasonable assurance, making allowance for the time period, hazards, and uncertainties involved, that the outcome will be in conformance with such objectives and criteria. Demonstration of compliance will involve the use of data from accelerated tests and predictive models that are supported by such measures as field and laboratory test, monitoring data and natural analog studies.

This paragraph involves performance assessment and possibly site characterization. The paragraph preceding §60.101(a)(2) discusses "performance objectives and site and design criteria..."

Definition of Natural Analog

A natural analog is a condition, process, or event, or a combination of these in nature, that is similar to the same in another environment and/or time.

The term "condition" is meant to be nonspecific. It can refer to a physical condition, like temperature or pressure, or a chemical condition, like the presence of a phase assemblage or phase composition, or a structural, temporal, or spatial condition, or conditions not yet considered or known.

The term "process or event" likewise is meant to encompass a wide range of possibilities. It can refer to reactions like dissolution, precipitation, or processes such as erosion, groundwater flow, diffusion, faulting, volcanism, flocculation, or respiration.

Examples of Natural Analog Studies

Natural analog studies need not be:

1) geochemical in nature
2) associated with a specific site
3) a uranium ore deposit

The scope of natural analog studies can range from:

1) full-blown international projects, to
2) literature searches

Examples of natural analog studies as literature searches

Laboratory experiments involving smectite (an expandable clay) in a steam environment produced a phase which irreversibly collapsed. Has this phase been identified in fumaroles?

In developing Key Technical Uncertainties and User Needs, the NRC technical staff search the general scientific and engineering literature for analogs to the high-level waste repository project.

Why Natural Analogs are Important

- o Unique approach to a unique problem
  - Man-made structures are not built to last 10,000 years.
  - Multiple alternative approaches are needed to minimize uncertainties.
- o Comparison to laboratory and field tests
  - Uncertainties associated with interpolation may be less than those associated with extrapolation.
- o Testing ground for geoscientific techniques and analyses
- o Recognize biases
- o Provide another source of information
  - Parameter distribution curves from sparse site-specific data can be made more robust.

SYSTEMATIC REGULATORY ANALYSIS (SRA) AND

PRIORITIZATION OF KEY TECHNICAL UNCERTAINTIES AND USER NEEDS

PRESENTATION TO THE ADVISORY COMMITTEE ON NUCLEAR WASTE

MARCH 23, 1994

ROBERT LANE JOHNSON (301-504-2409)
DIVISION OF HIGH-LEVEL WASTE MANAGEMENT
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

SYSTEMATIC REGULATORY ANALYSIS (SRA) OVERVIEW

- Systematic and Controlled Process to Develop the Staff's Regulatory Documents

  - Identification of 10 CRF Part 60 Regulatory/Institutional Uncertainties and Reduction Methods

  - Development of License Application Review Plan

  - Revision of License Application Format and Content Regulatory Guide

DEVELOPMENT OF LICENSE APPLICATION REVIEW PLAN (LARP)

- o Compliance Determination Strategy (CDS)
  - Review Strategy Includes Review Scope, Type, and Approach
  - Rationale Includes Key Technical Uncertainties and Rationale for Research Needed
- o Compliance Determination Method (CDM)
  - Review Procedures and Acceptance Criteria
  - Interfaces
  - Example Evaluation Findings
  - Rationales for Procedures and Acceptance Criteria

KEY TECHNICAL UNCERTAINTIES

- o Technical Issues Most Important to Repository Performance (i.e., Pose a Risk of Non-Compliance with 10 CFR Part 60 Performance Objectives)

- o Prioritized into:

  - Difficult to Resolve

  - Most Difficult to Resolve, High Residual Uncertainty

- o DOE's Job to Provide Adequate Information to Address Key Technical Uncertainties

- o NRC Will Conduct Detailed Reviews for All Key Technical Uncertainties

- o Not All Key Technical Uncertainties Require NRC Research to Support Detailed Reviews

RES/NMSS RESEARCH AND TECHNICAL ASSISTANCE COORDINATION

- o Formal Process Initiated to Coordinate NRC-Sponsored Research and Technical Assistance Program

  - User Needs Updated Annually Through Coordination Between NMSS and RES

  - NMSS, RES and CNWRA Review Key Technical Uncertainties, IPA, Research, and DOE Program Results

  - NMSS Revises Existing User Needs Based on Coordinated Review

  - RES Prepares Statements of Work Consistent with the NMSS User Needs

- o Joint Program Reviews Also Used for Research and Technical Assistance Coordination

- o Informal Coordination Occurs Regularly by NMSS, RES, and CNWRA Staff Working Together on IPA and LARP/Key Technical Uncertainty Development

STATUS AND SCHEDULE OF KEY TECHNICAL UNCERTAINTY AND NEEDS DEVELOPMENT

- o Key Technical Uncertainties

  - FY93: Identified 58 Key Technical Uncertainties to be Documented in LARP Revision 0

  - Sept 94: Revise 58 Key Technical Uncertainties Resulting from Integration/Consistency Review

  - Identify Additional Key Technical Uncertainties Related to Performance Objectives

- o Needs

  - Dec 94: Revise Existing 1990 Research User Needs Based on Key Technical Uncertainties, IPA, Research, and DOE Work

  - Currently, New Research Statements of Work Are Being Prepared with Justifications Based on CDS Key Technical Uncertainties and Rationales

  - Preliminary Conclusion: Good General Comparison between Key Technical Uncertainties and Research User Needs

PERFORMANCE ASSESSMENT AND NATURAL ANALOGS

PRESENTED TO THE ACNW ON MARCH 23, 1994

BY NORMAN A. EISENBERG (301-504-2324)
HYDROLOGY AND SYSTEMS PERFORMANCE BRANCH
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
US NUCLEAR REGULATORY COMMISSION

PERFORMANCE ASSESSMENT

PA IS A PROCESS TO QUANTITATIVELY EVALUATE COMPONENT AND SYSTEM BEHAVIOR RELATIVE TO THE CONTAINMENT AND ISOLATION OF RADIOACTIVE WASTE

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

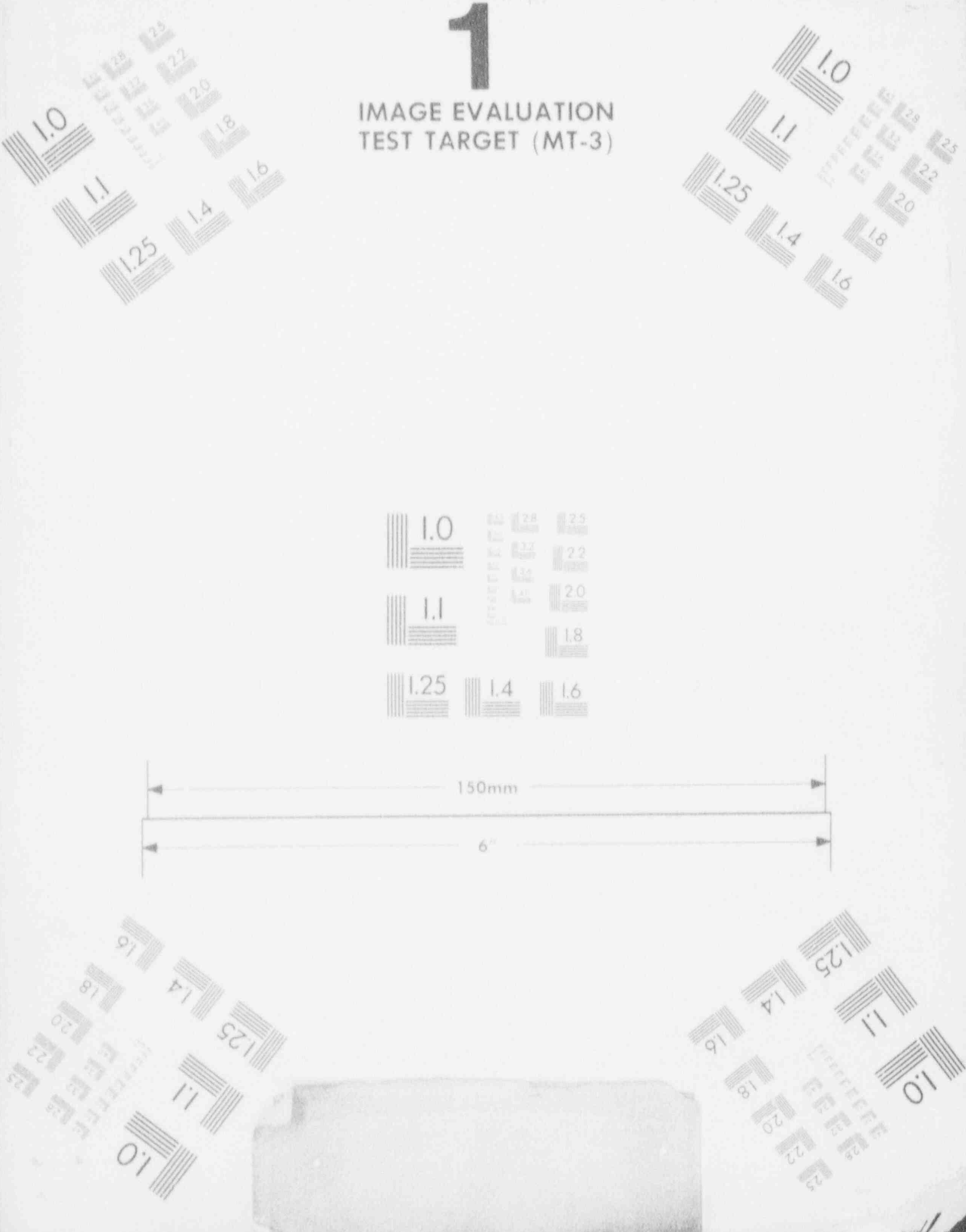
IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)



1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

PA IS:

(1) QUANTITATIVE

(2) USUALLY EVALUATES PERFORMANCE IN TERMS OF MAGNITUDES AND LIKELIHOODS, I.E., PROBABILISTIC

(3) REQUIRES COMPARISON TO A QUANTITATIVE SAFETY STANDARD

(4) GENERALLY USES PREDICTIVE MODELS

(5) UTILIZES THE POINT OF VIEW OF THE SYSTEMS APPROACH, DERIVED LARGELY FROM ENGINEERING

PA IS COMPRISED OF:

(1) MODELS, COMPUTER CODES, AND DATA USED TO PRODUCE THE QUANTITATIVE ESTIMATES OF PERFORMANCE

(2) SUPPORTING MODELS, COMPUTER CODES, ANALYSES, STUDIES, EXPERIMENTS, FIELD STUDIES, NATURAL ANALOGUES, LABORATORY STUDIES, ETC., TO HELP EVALUATE THE QUANTITATIVE PERFORMANCE STUDIES AND THE ESTIMATES THEY PRODUCE

NATURAL ANALOGUES (NA)

ANY NATURAL OCCURRENCE WHICH, BY ANALOGY OR BY SOME DEGREE OF SIMILITUDE, CAN SUPPORT THE ASSESSMENT OF REPOSITORY SAFETY

<u>BUT</u> HUMAN INDUCED ANALOGUES, BOTH ARCHAEOLOGICAL AND MORE RECENT, ARE ALSO IMPORTANT

<u>FURTHER</u> THERE APPEARS TO BE NO REASON TO LIMIT, NOR DOES THE NRC LIMIT, THE DEFINITION OF NATURAL ANALOGUES BY TIME SCALE, PHENOMENA, DISCIPLINE, ETC.

WHAT MIGHT NA'S PROVIDE TO PA'S

1. DATA AND DATA UNCERTAINTIES

   - PARAMETERS USED IN PA
   - RANGES OR PROBABILISTIC DISTRIBUTIONS OF PARAMETERS

     - MEAN VALUES
     - BOUNDING VALUES

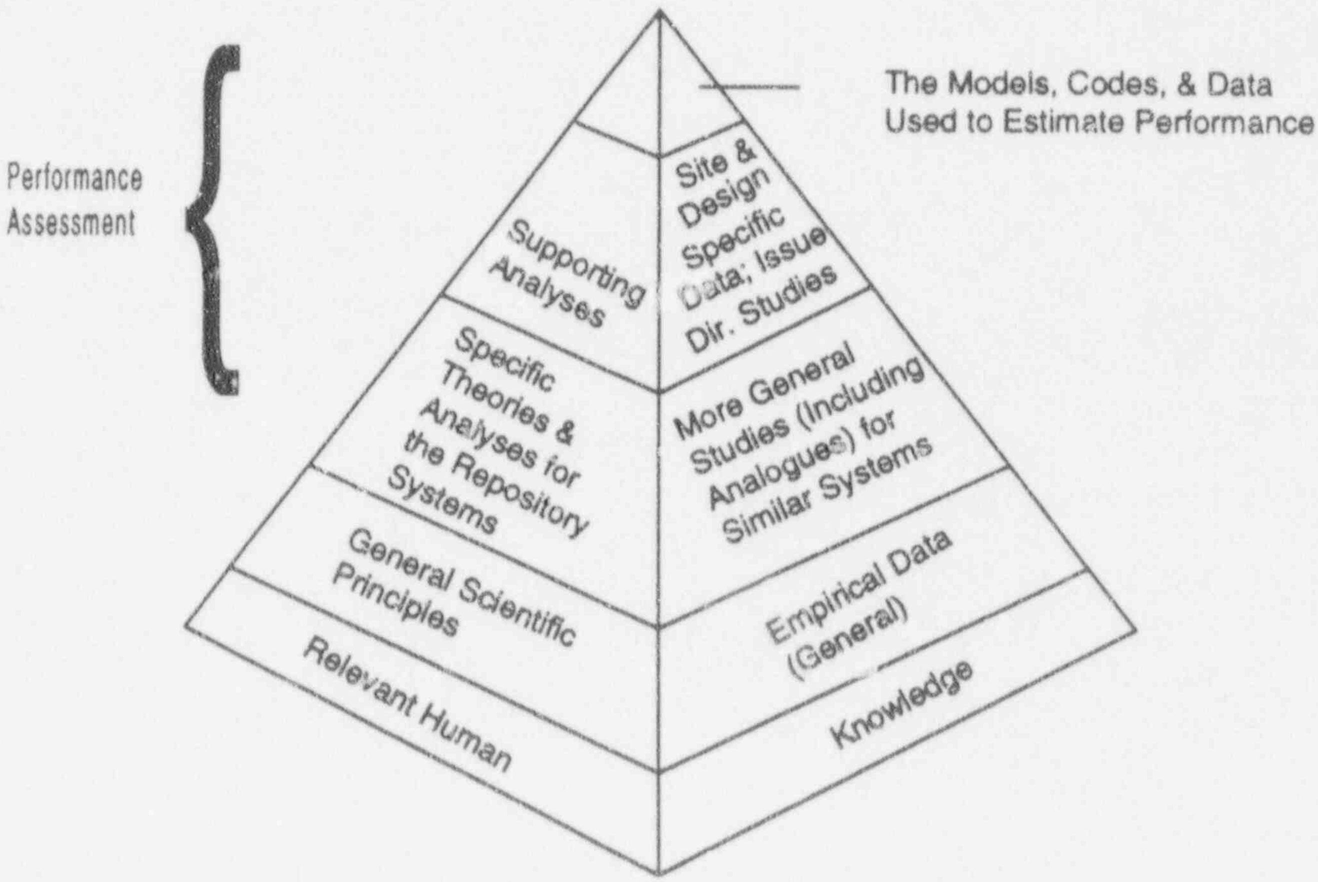
2. QUALITATIVE CONCEPTUALIZATION OF NATURAL SYSTEMS

3. QUANTITATIVE AND QUALITATIVE DETERMINATION OF PHYSICOCHEMICAL PROCESSES, THEIR INTERACTIONS, AND IMPORTANCE

4. DETERMINATIONS OF PREVIOUS ENVIRONMENTS AS A GUIDE TO FUTURE STATES

5. SUPPORT FOR PARTIAL VALIDATION OF MODELS, E.G., ARENA FOR TESTING MODELS

6. INSIGHT INTO LIMITATIONS OF SITE CHARACTERIZATION



Performance Assessment
The Models, Codes, & Data Used to Estimate Performance
Supporting Analyses
Site & Design Specific Data; Issue Dir. Studies
Specific Theories & Analyses for the Repository Systems
More General Studies (Including Analogues) for Similar Systems
General Scientific Principles
Empirical Data (General)
Relevant Human
Knowledge

SOME CHALLENGES IN APPLYING NATURAL ANALOGUE STUDIES TO PERFORMANCE ASSESSMENT

CHALLENGES	APPROACH
1. **DIFFERENT FOCUS FOR NA & PA**	
- Different Concept of "Model"	- Dialogue on Model Validation
- Deterministic vs. Probabilistic	- Use NA to Support Deterministic Models
- Precise vs. Abstracted	- Use NA to Support Detailed, Not Abstracted Models
2. **ORGANIZATIONAL CONSTRAINTS**	
- Different Departments, Responsibilities, Budgets	- Matrix Staff for NA & PA Projects
- Complete Activities Require Extensive Resources for Exchanges Across Disciplines and Coordination	- Workshops to Coordinate NA & PA
3. **RESULTS OF NA STUDIES NOT ALWAYS DIRECTLY APPLICABLE TO PA**	
- NA'S Anecdotal, PA Needs General Principles	- Use Several NA's to Support Models - Do Not Base Licensing Case Solely on Results of Natural Analogues
- Difficult to Determine Boundary Conditions	- Broadly Scoped Studies Focused on Support of Quantitative Models

T-10,11,12,13

NRC HLW RESEARCH ON NATURAL ANALOGS

PRESENTED TO THE ACNW ON MARCH 23, 1994
BY LINDA A. KOVACH (301-492-3869)
WASTE MANAGEMENT BRANCH
OFFICE OF NUCLEAR REGULATORY RESEARCH
US NUCLEAR REGULATORY COMMISSION

Natural Analogue Research Program

Presentation Outline

I. Rationale for NRC Natural Analogue Research Studies

II. NRC Natural Analogue Workshop 1991: Objectives and Results

III. NAWG: Results of Workshop 1992, Objectives for 1994 Workshop

IV. NRC Natural Analogue and Performance Assessment Workshop, June 1994: Objectives

V. NRC Research Natural Analogue Program: Lessons Learned in ARAP, Oklo and Valles Caldera Studies

VI. Future Plans

WHY NRC RESEARCH ON NATURAL ANALOGUES?

Fundamental Difference in Needs Between NRC & DOE

1. DOE - Technical Support of Demonstrations
2. NRC - understanding RANGE OF POSSIBILITIES

Evaluation of DOE License Application

A. SITE CHARACTERIZATION

1. Evaluate range of models, and data for systems or processes where data do not exist: i.e. unsaturated fractured rock, high temperature thermodynamic data

B. PERFORMANCE ASSESSMENTS

1. Identify range of possible scenarios
2. Identify parameters for PA
3. Bound uncertainty of conceptual models, parameters, and codes

Workshop on the Role of Natural Analogues in Geologic Disposal of High-Level Nuclear Waste

Objectives:

Examine the Role of Natural Analogue studies in Performance Assessment, Site Characterization, and Prioritization of Research related to Geologic Disposal of HLW

Implementation:

Plenary Session:
Expert Opinion solicited from HLW community, Academia and Industry regarding use of Reasoning by Analogy in Earth Science Applications

Working Groups:
Four separate working groups addressed the use of Natural Analogues in four technical areas of HLW: Waste Package, Near-Field Processes and Environment, Far-Field Processes and

Workshop on the Role of Natural Analogues in Geologic Disposal of High-Level Nuclear Waste

Environment, and Volcanism and Tectonics

Final Plenary Session:
Working group Conclusions Reviewed

Results:

- Generated lively debate regarding:
  1. definition of natural analogues
  2. applications
- Generated useful input for future natural analogue investigations
- Provided forum for the exchange of ideas between the NRC and DOE regarding the use of natural analogues
- Proceedings CNWRA 93-020 and NUREG XXX

NRC-CNWRA Workshop on Implementation of Natural Analogue Data in Performance Assessment

Objectives:

- Incorporate data from the Pena Blanca NA into Performance Assessment calculations
- Develop strategy for bounding the range of conceptual models, and quantifying the range of parameters

Proposed Format:

- Test problem: e.g. Blind model predicitions of Uranium distribution within Nopal I tuff, given hydrologic data and initial concentrations of uranium. Provide actual U distribution data as check against model predictions.
- Discussions among modelers and earth scientists regarding problems encountered, data needs for modeling efforts, quantification of data for IPA Monte Carlo or Latin Hypercube simulations

NRC-CNWRA Workshop on Implementation of Natural Analogue Data in Performance Assessment

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Rationale:

Data from NRC Natural Analogue Studies has not yet been incorporated into our IPA exercises. Modelers and data gatherers must work closely to assure that data useful to PA modeler can be obtained. Conversely, earth scientists must interact with PA modelers at an early stage to assure choice of appropriate conceptual models and data.

Attendees:

NRC and CNWRA Staff

CEC Natural Analogue Working Group

Fifth NAWG Meeting and ARAP Final Workshop, Toledo, 1992

Objectives:

- Present Final Results of ARAP Project concerning Site Characterization Studies and Experimental Measurements for Testing of Geochemical and Radionuclide Transport Models

- Present State-of-the-Art of Major National and International Natural Analogue Studies and Relevance to Repository Performance Assessments

- Expand concept of Natural Analogues in reflecting Geochemical Processes to include further Natural Processes of relevance to Repository Performance Assessment (e.g. Paleohydrology, gaseous release, thermal alteration, neotectonics, etc.)

- Debate Respective Role of Performance Assessor and the Analogue Worker in Performance Assessment.

CEC Natural Analogue Working Group

Fifth NAWG Meeting and ARAP Final Workshop, Toledo, 1992

Results:

- Consensus that Natural Analogues are Essential Component of Performance Assessment

- Importance of Natural Analogue Studies to Performance Assessments will Increase as more Focused Analogue Studies are Documented

- "Natural Analogue workers and Performance Assessment Modellers should keep working closer together to avoid communications difficulties"

- Discussions regarding the Evaluation and Application of Geochemical Models (e.g. "Validation and Verification", see Nordstrom, 1994, EUR 15176)

CEC Natural Analogue Working Group

Sixth NAWG Workshop, Sante Fe, NM, September 1994:

Objectives:

- **Provide Forum for Exchange of Information on Natural Analogue Studies**
- **Investigate the Role of Natural Analogues in Performance Assessments**

Format:

- **Initial Plenary Session Presenting 13 National Programs and Relevance to Performance Assessment**
- **Four "Working Group" Sessions on Selected Topics (Waste Package Performance, Near-Field Processes, etc.). These sessions include Three Presentations by "Experts", and moderated discussions focused specifically on questions relevant to Performance Assessment.**

Valles Caldera Natural Analogue Study

Key Technical Uncertainties Addressed

- **Identifying conceptual models to adequately represent isothermal and nonisothermal liquid and vapor phase movement of water through unsaturated fractured rock at Yucca Mountain**
- **Equal or increased capacity of alteration mineral assemblages to inhibit radionuclide migration**
- **Geochemical processes that reduce radionuclide "retardation"**
- **Geochemical processes that adversely affect the EBS**
- **Magnitude of the effect of the geochemical processes that reduce radionuclide "retardation"**
- **Uncertainty in determining the magnitude of the effect of the geochemical processes that adversely affect the EBS**
- **Volatility and stability of chemical species of radionuclides**
- **Gas flow and gaseous radionuclide transport**

Valles Caldera Natural Analogue Study

Additional Key Technical Uncertainties Addressed

- Determination of characterization parameters
- Nature and rates of Quaternary geochemical processes
- Effect of Groundwater Conditions on Mode and Rate of Waste Package Corrosion
- Understanding / predicting the effect of Groundwater Conditions on Dissolution of Waste Form
- Evolution of Groundwater Conditions near and within the Engineered Barrier System

Valles Caldera Natural Analogue Study

Goals:

I. Search for Evidence of Chemical and Mineralogic Changes in Tuff which occurred in response to Heating Event

II. Provide well-characterized example to Test Chemical Migration Models

III. Provide Guidance for Code Development and Future NA Studies

Valles Caldera Natural Analogue Study

Objectives:

To evaluate modeling capabilities to predict chemical and physical response of host rock to local and site-wide heating for 10,000 years.

Rationale:

Two significant heat sources at HLW repository
- Waste generated heat through radioactive decay
- Volcanic activity

"Dry Repository" - Anticipated temperature of 250 C in host rock

Uncertainty arises due to extrapolation from equilibrium conditions, small-scale experiments to kilometer-scale processes, e.g.:
- Zeolite Stability
- Tuff Stability

Valles Caldera Natural Analogue Study

Approach:

- Identification of Appropriate Analogue Site: Valles Caldera, NM
- Data Collection : Multiple Tests of Hypotheses
- Laboratory Experiments : Bound Uncertainty in Field Data
- Modelling Exercises : Iterative Process

Valles Caldera Natural Analogue Study

Results:

- **Evidence of Mechanical Effects of Heating : Plastic Deformation of Tuff within 0.5 meter of Heat Source**

- **Migration of Halogen-Rich Fluids (most likely in form of HF and HCl)**

- **No evidence of formation of Zeolites Clinoptilolite or Mordenite, rather widespread alteration to Albite and Silica Polymorphs :**

NUREG-☹☎☹⌚☺ ☺

The Valles Natural Analogue Project

Manuscript Completed: February 1994
Date Published: March 1994

Prepared by
Harlan W. Stockman, James L. Krumhansl, Clifford Ho, Sandia National Laboratories
Vicki S. McConnell, University of Alaska, Fairbanks

Sandia National Laboratories
Albuquerque, NM 87185

Prepared for
Division of Engineering
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

CONTENTS

Valles Caldera Natural Analogue Study

Implications:

Mechanical Stability of Tuff in vicinty of Waste Package

Composition and phase of water interacting with waste package and cannister

Concern regarding the validity of Reaction-Path Calculations for Yucca Mountain

Basic assumptions regarding suppression of mineral phases needs to be carefully investigated. Small variation in thermodynamic data may yield large differences in predictions of radionuclide retardation.

Valles Caldera Natural Analogue Study

Application to Performance Assessment:

- Example of the Iterative Process involved in IPA
  - Fine-tuning of Thermal Models to include more 'Realistic' interactions between tuff and aqueous solutions

- Identification of Alternative Scenarios
  - Migration of Halogens
  - Migration of Radionuclides in Vapor Phase
  - Alteration of Host Rock to Less Sorptive Minerals

- Testing of reaction-path models and thermodynamic data base for critical minerals
  - Maintenance of QA'd Thermodynamic Database
  - Example: Different generations of Database = 10^7 variation in predicted solubility of U

Valles Caldera Natural Analogue Study

- Provides means to Bound Uncertainties in Natural Analogue which will aid in Bounding Uncertainties in Future Repository System

A BRIEF HISTORY OF OKLO

- In the 50's and 60's considerable speculation over the possibility of natural sustained criticality.

- Calculations were carried out to estimate concentrations of fissionable uranium and plutonium at various times in the geologic past.

- First calculations found that concentrations might have approached 30% of those necessary.

- Later calculations introduced larger amounts of water to act as a moderator and demonstrated that under the right conditions a sustained fission reaction could have occurred.

SCIENTIFIC INVESTIGATIONS AT THE OKLO NATURAL REACTORS

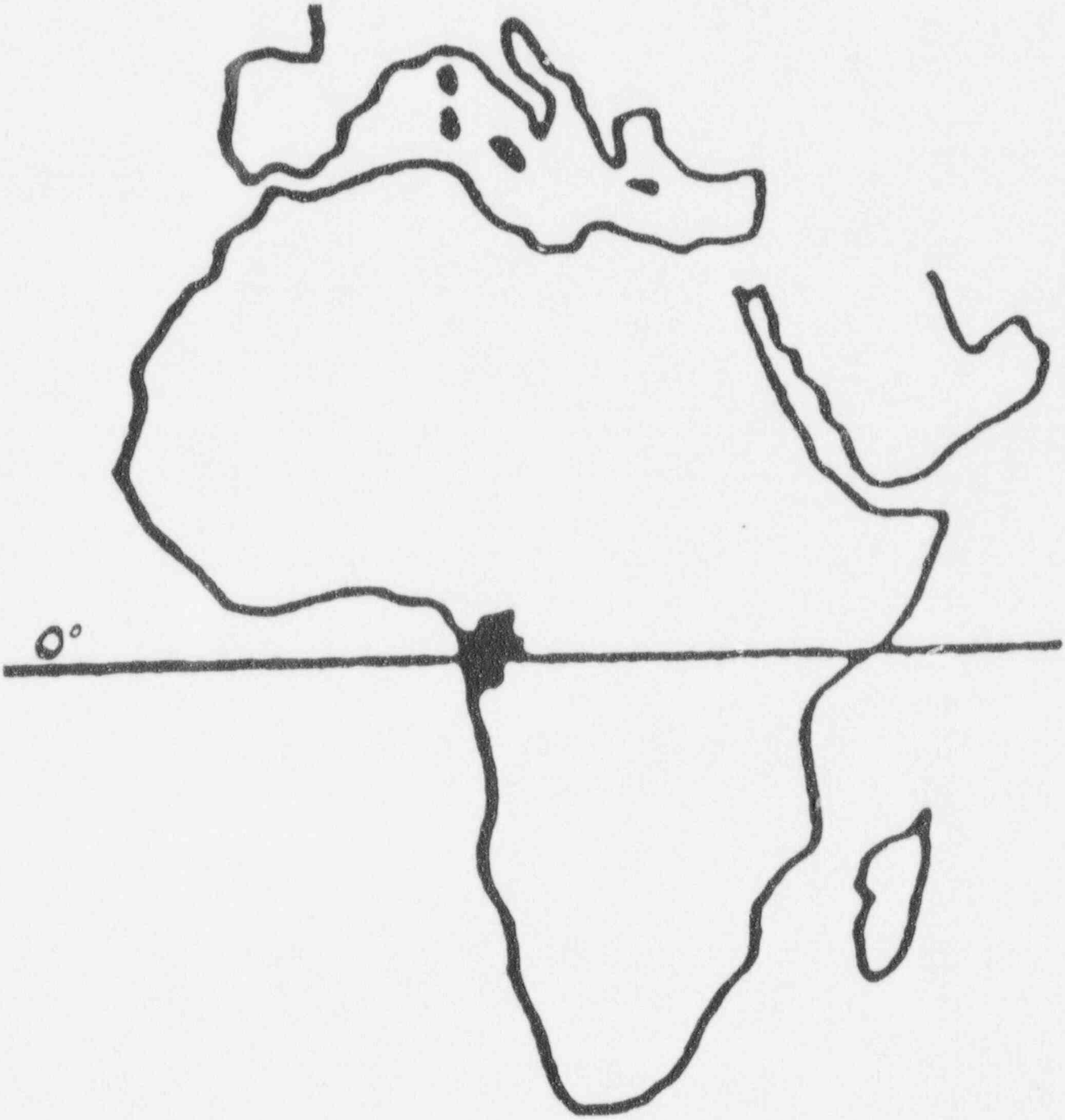
- Oklo, in Gabon, Africa, is the only known location where natural uranium ores have been concentrated to the point where a sustained fission reaction took place.

- Since 1972 16 reactor zones have been identified.

- An open pit mining operation has consumed reactors 1 to 9 and 15 - reactors 11, 12 and 14 may have been identified in error.

- Extensive sampling of the mined reactor zones was undertaken before and during excavation so that extensive mineral samples and basic hydrogeologic data are available.

AFRICA SHOWING GABON



OKLO AS A NATURAL ANALOG: THE CLASSIC EXAMPLE

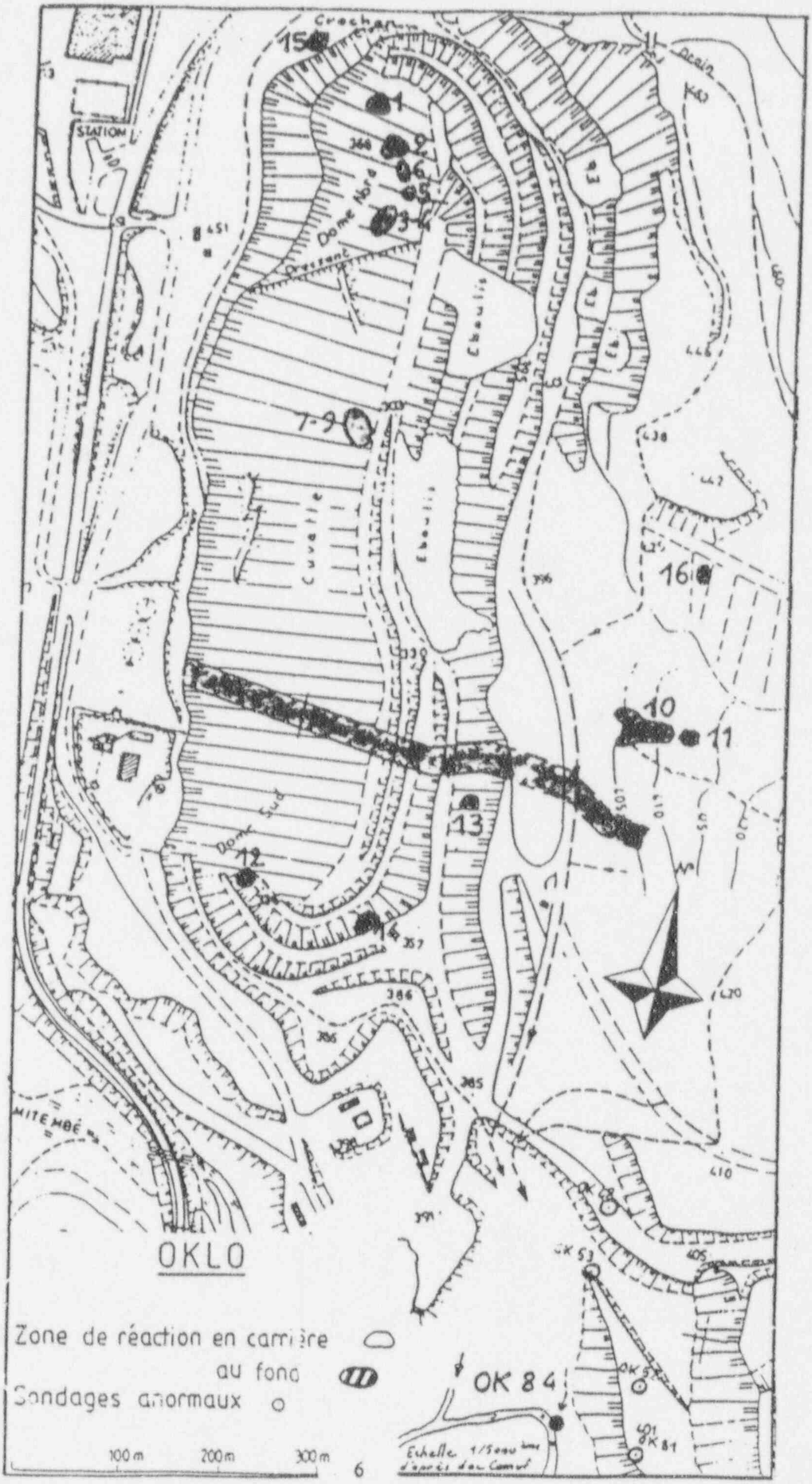
- Access to system and availability of data.

  - Information from investigation of ore body.
  - Data and samples collected during mining operation.
  - Current agreement for continued access.
  - Availability of reactor zones which have been minimally disturbed.

- Presence of fission products and depleted uranium ore so that degradation, mobilization and transport processes can be studied.

- Opportunity for systematic site characterization in vicinity of remaining reactor zones.

OKLO URANIUM ORE BODY AND REACTOR ZONES



CURRENT INVESTIGATIONS (CEC/CEA)

- CEC/CEA Project centers around reactor zones 10, 13, 16, OK-84 and Bangombe.
- Extensive work has been undertaken to assess migration around 10 and 13. Focus is analogue for source term and transport processes.
- Dolerite dike offers opportunity to study effects of igneous intrusion.
- OK-84 is the center of efforts to characterize hydrogeology - Parallel effort being undertaken at Bangombe.
- Opportunity exists for adequate hydrologic characterization until mining consumes remaining reactor zones.

NRC FUNDED RESEARCH (LLW)

- Uraninite from Oklo, Gabon: A Natural Analog for the Corrosion and Alteration of Spent Fuel - Dr. Rodney Ewing, University of New Mexico
  - Objective: Characterization of chemistry and structure of uraninite from reactor zones 10 and 13 to assess causes of degradation. Most past work assumed compositional stability of uraninite.
- The Oklo Analog: A Guide for Radionuclide Containment - Dr. Bartholomew Nagy, University of Arizona
  - Objective: Understand the long-term radionuclide containment mechanisms at Oklo with specific attention to the role of organic materials in this process.

URANINITE FROM OKLO, GABON: A NATURAL ANALOG FOR THE CORROSION AND ALTERATION OF SPENT FUEL

- **Determination of mechanisms of alteration by which certain elements such as U, Pb, REE, are released from uraninite.**

- **Determination of mass balance reactions of major and minor elements during alteration.**

- **Determination of relative timing and temperature of the alteration.**

- **Development of a model to explain the behavior of uraninite in a geologic disposal system under reducing conditions but in the presence of hydrothermal fluids or silica rich solutions.**

STATUS (U OF NM)

- Project initiated January 30, 1992.
- Electron microprobe analyses completed on eight samples from reactor zone 9 obtained from LANL. Petrographic analysis by transmitted light microscopy completed on 26 samples from reactor zones 9, 10, 13 and 16.
- Preliminary results:
  - No significant difference in chemical composition between uraninites enclosed in clays and organic matter.
  - All uraninites are homogeneously depleted in Pb which subsequently precipitated in situ to form galena, present in abundance in all samples.

THE OKLO ANALOG:
A GUIDE FOR RADIONUCLIDE CONTAINMENT

- **Characterization of organic components.**
- **Characterization of the time-dependent interrelationships of the organic and inorganic phases.**
- **Characterization of radionuclide mobilization and retardation.**
- **Assessment of role played by organics in radionuclide mobilization or retardation.**

STATUS (U of Az)

- Project initiated March 31, 1992.
- Reflectance studies of samples of organic matter in reactor zones 7 and 9 and environmental samples at various distances from the reactor zones completed.
- Preliminary results:
  - Variability of bitumens greatest in area of natural reactors.
  - At least three generations of bituminous material occur with one associated with the period of heating due to criticality and one with the dolerite dike swarm.

SUMMARY

- Recently encountered reactor zones at Oklo and Bangombe have rekindled interest in Oklo as a source of analogue data relevant to the disposal of both high-level and low-level waste.

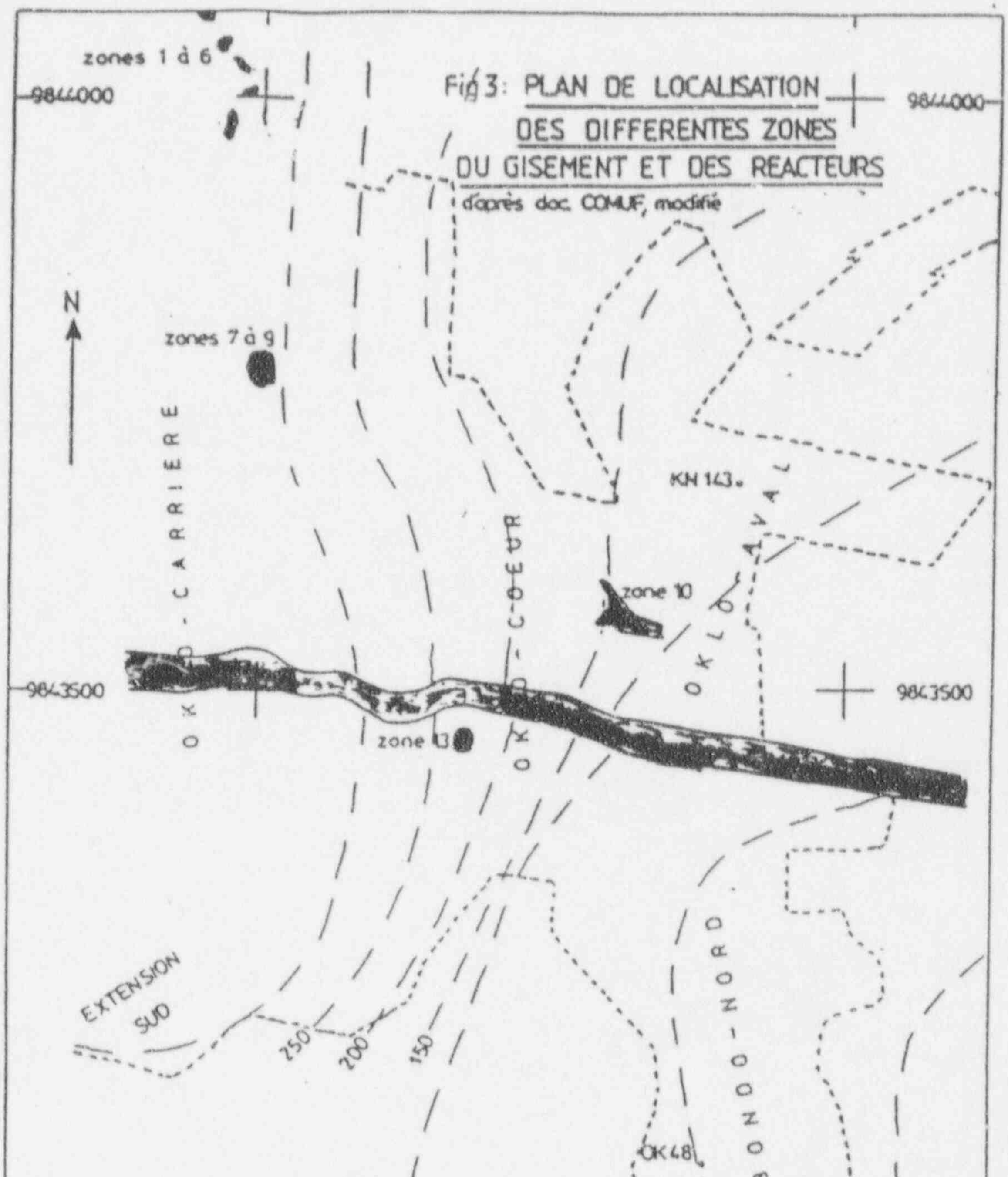
- The CEC and CEA have established a multi-laboratory team to systematically investigate the remaining reactor zones. A steering group of the participants meets annually to review and guide the project.

- Other participants include SKB, US NRC, US DOE, and AECL. Each participant funds work within its country and sits on the steering group.

- NRC is funding two LLW research projects studying Oklo samples.

- Significant potential value also exists for use of data from the Oklo project in building confidence in HLW performance assessment models and analyses for source term and transport processes.

EXPANDED VIEW OF REACTOR ZONES 10 AND 13 AND DOLERITE DIKE



The Oklo Natural Analogue

Status of Project:

- **Completion of Three Year Project**
  Product: Final Report ISPN and EUR Documentation of Research, in print

- **Two year Continuation Planned**

Summary of Results to Date:

- **Corrosion of Uraninite: Analogue to Spent Fuel Degradation**

- **Role of Clays and Organics in Retarding Migration of Radionuclides**

- **Identification of Migration of Fission Products**

- **Presence of Dolerite Dikes Provides Opportunity to Model Migration of Fission Products in response to Thermal Perturbation, Analogue to Igneous Intrusion**

PREFACE

The Koongarra uranium ore deposit is located in the Alligator Rivers Region of the Northern Territory of Australia. Many of the processes that have controlled the development of this natural system are relevant to the performance assessment of radioactive waste repositories. An Agreement was reached in 1987 by a number of agencies concerned with radioactive waste disposal, to set up the International Alligator Rivers Analogue Project (ARAP) to study relevant aspects of the hydrological and geochemical evolution of the site. The Project ran for five years.

The work was undertaken by ARAP through an Agreement sponsored by the OECD Nuclear Energy Agency (NEA). The Agreement was signed by the following organisations: the Australian Nuclear Science and Technology Organisation (ANSTO); the Japan Atomic Energy Research Institute (JAERI); the Power Reactor and Nuclear Fuel Development Corporation of Japan (PNC); the Swedish Nuclear Power Inspectorate (SKI); the UK Department of the Environment (UKDoE); and the US Nuclear Regulatory Commission (USNRC). ANSTO was the managing participant.

This report is one of a series of 16 describing the work of the Project; these are listed below:

No.	Title	Lead Author(s)
1	Summary of Findings	P Duerden, D A Lever, D A Sverjensky and L R Townley
2	Geologic Setting	A A Snelling
3	Geomorphology and Paleoclimatic History	K-H Wyrwoll
4	Geophysics, Petrophysics and Structure	D W Emerson
5	Hydrogeological Field Studies	S N Davis
6	Hydrogeological Modelling	L R Townley
7	Groundwater Chemistry	T E Payne
8	Chemistry and Mineralogy of Rocks and Soils	R Edis
9	Weathering and its Effects on Uranium Redistribution	T Murakami
10	Geochemical Data Bases	D G Bennett and D Read
11	Geochemical Modelling of Secondary Uranium Ore Formation	D A Sverjensky
12	Geochemical Modelling of Present-day Groundwaters	D A Sverjensky
13	Uranium Sorption	T D Waite
14	Radionuclide Transport	C Golian and D A Lever,
15	Geochemistry of ^{239}Pu, ^{129}I, ^{99}Tc and ^{36}Cl	J T Fabryka-Martin
16	Scenarios	K Skagius and S Wingefors

Alligator Rivers Analogue Project

Lessions Learned:

- **Site Characterization:**

    - **Example of mutliple data sets necessary to characterize site**
    - **Difficulty in determining site hydrology**
    - **Applicability of Down-hole Camera**

- **Performance Assessment:**

    - **Importance of Fe-oxyhydroxides in radionuclide retardation**
    - **Testing of Geochemical Reaction-path models**
    - **Testing of uranium thermodynamic database, i.e. identification of inconsistencies in data**
    - **Difficulty in modelling site hydrology**
    - **Testing of uranium minerals as analogues to Nuclear Reaction Products, in-situ measurements of NRP**

NRC Natural Analogue Research Future Plans

- Participation in IPA by RES and CNWRA staff
- Continue with Pena Blanca, Santorini Studies Fy 1994-1997
- Continue with Volcanism Field Study Analogues FY 1993-1997
- Identification of additional Natural Analogue Projects : KTU's
- Bi-annual NRC-CNWRA Natural Analogue Workshop to report progress and ensure applicability to PA
- ASARR FY 1994-1996
- Continued Participation in NAWG

Natural Analogue Research Program

Summary

I. Rationale for NRC Natural Analogue Research Studies

II. NRC Natural Analogue Workshop 1991: Objectives and Results

III. NAWG: Results of Workshop 1992, Objectives for 1994 Workshop

IV. NRC Natural Analogue and Performance Assessment Workshop, June 1994: Objectives

V. NRC Research Natural Analogue Program: Lessons Learned in ARAP, Oklo and Valles Caldera Studies

VI. Future Plans

T-16,17

CONCLUSIONS - FUTURE PLANS

- **Licensing Perspective**

  - Can be an important tool for gaining insight for the development of conceptual models and for probing the margins of possible system performance.

  - Should be an integral part of DOE program.

  - Need to be more integrally linked to performance assessment programs.

- **Limited definitions should not be used as reasons to avoid studying systems that may yield important information about processes important to repository performance (e.g. don't study analogous volcanic systems because they don't fit a specific definition of natural analogs).**

- Research Perspective

  - Natural analogs must be a part of any effort to provide credible support for evaluation of DOE estimates of long-term performance.

  - Care has been and must continue to be exercised in the selection of analog sites and the specification of objectives and work plans. More involvement is needed from PA staff.

  - PA and phenomenological researchers need to focus on integrated efforts to expand the boundaries in time and space of the domain where there is confidence in the applicability of PA models. (NRC is currently working with SKI to develop an approach for this confidence building process.)

- Continued interaction with the NAWG is desirable if this focus can become a central thread of its efforts. The fall meeting may be an important milestone.

- The planned internal workshop should be a high priority effort.