

## **Brief Report to Nuclear Waste Technical Review Board**

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The purpose of this brief report is to present my general observation of issues associated with the Panel on Natural Systems held in Las Vegas March 9-10. These written comments are a review of oral comments that I presented to the Board on March 10.

(1) Progress in the Safety Case: All of the talks continued to reinforce the inherent safety benefits of the non-engineered barrier system. Even with an admittedly conservative bias to the analyses, both the unsaturated and the saturated zones are helpful to the safety case for the proposed repository. For me, the presentation of Dr. Murphy was fascinating in the sense that with mineralogical sequestration of contaminants there is substantial potential to impact the mobility of different contaminants. However, additional more research is required to develop these concepts.

(2) Conservatism as a Philosophy: Contaminant transport analyses have for years embraced a philosophy of conservatism, which essentially leads to (a) the elimination or diminishment of attenuation mechanisms that never were well understood, and (b) the exaggeration of primary transport processes like advection. Operationally, this philosophy was not critically examined because the geosphere barriers were typically considered a minor part of the safety case. In other words, a robust engineered barrier system, made it possible to de-emphasize consideration of transport processes in the saturated and unsaturated zones.

There are several examples in this respect that came up during several of the presentations. In terms of matrix diffusion, the saturated rock system is assumed to be largely intact rock blocks separated by rare zones where flow is occurring (concept of flowing intervals). Testing at the C-well complex finds these intervals that are not well correlated between holes. This model minimizes the possibilities of matrix diffusion. These same rocks are called upon to carry relatively large quantities of flow and function effectively as an aquifer. The conservative assumption for flow provides a much more active flow system that Dr. Patterson sees with the geochemical data. The concept of conservatism in this case provides what in my opinion are likely inconsistent models of the rock system.

There are other examples of how conservatism has delayed understanding of how the unsaturated and saturated zones are likely to perform. The merits of a conservative approach are being balanced by important limitations.

(3) Little New Work: My impressions from the talks are that the science programs have diminished as work continues on issues related to the license application. I don't know the reason for this perhaps other than the work force is fully engaged. I heard little about

prospects for new more long-term efforts, except the analog work at Pena Blanca and the Nye County wells. Although it should be possible for the safety case for the geosphere to be made, important issues remain that warrant continuing, long-term studies to reduce uncertainty.

(4) Analog Studies not well Integrated: Before this panel meeting, I was not aware of the possibilities for analog studies in Mexico. While these studies, as reported by Drs. Murphy and Simons, are quite interesting, the approaches for fitting this and similar studies into the Yucca Mountain project were not clear, at least at the meeting. For example, important lessons, data, and processes understanding don't transfer well because the physical settings are different in many ways. I think that as these studies go forward, a more concrete strategy needs to be developed a how these studies can be organized to benefit the Yucca Mountain Project more concretely. Perhaps the Pena Blanca site could be modeled to develop confidence in the ability to analyze the geochemical complexity. This site also might be examined to assess the possible role of colloids in nuclide transport. Differences in geological, climatological and hydrogeologic settings keep coming back as impediments to simply transferring data back to Yucca Mountain.

(5) Evidence still Conflicting in Some Areas: It is apparent that inconsistencies in the conceptual model still remain, especially with work from the USGS. For example, Dr. Patterson in questioning reinforced my feeling that the saturated flow system is much more sluggish than PA modeling would suggest. The isotopic data and geochemical modeling of C-14 between wells along Forty Mile Wash suggest flow velocities less than other estimates using different approaches. Dr. Flint has a somewhat different conceptualization about the role and extent of lateral diversions.

There are other examples besides these two. The point here is not so much about the importance of the science issues but the perception that after years of study, quite visible uncertainty remains with respect to ground water .

(6) Discovering Complexity and the Third Dimension: Dr. Winterle's presentation was important because it began to show explicitly how uncertainty in the three-dimensional geometry of the system influenced transport. These are themes touched on by Dr. Layman in the past and others. That issue and the issue of structural complexity appear to have some prospects for continuing uncertainty. Dr. Nelson of the Board had similar sentiments specifically concerned with unexpected fast flow paths due to fault zones.

These ideas of complexity and dimensionality are coupled in a sense because they convey uncertainty of actual system behavior as opposed to that predicted for models of simplified versions of these systems. My feeling is that complexity will provide attenuation possibilities rather than fast flow. I think the possibilities for dispersion and matrix diffusion will be enhanced relative to current thinking.

(7) Learning from the Field Trip: Field trips are also important to understanding issues. I took away a number of impressions of this trip. First, is the size of the area relative to the

drilling that has been done. Looking only at maps and computer models, one forgets how large the spacings are between wells and other measurement points. For the saturated zone, the study effort has been rather limited, although one would need to acknowledge the costs and difficulties in doing this work. Second is the complexity of the media. By crawling over the rocks you see the diversity in fracturing, abrupt lithological changes, and the occurrence of large holes in the rocks. Finally, I was impressed by the difficulties in sampling alluvial materials. The new core was held up as a very significant advance over previous coring methods. Yet, understanding of the sediments from this new core is still incomplete relative to what one sees in outcrop.