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Dr. Jared L. Cohon  
Chairman  
Nuclear Waste Technical Review Board  
2300 Clarendon Boulevard  
Arlington, Virginia 22201-3367

Dear Dr. Cohon

A number of factors, including a review of the literature and the presentations before the NWTRB on May 9, 2001, convince me that there are outstanding scientific and waste management issues that must be properly resolved before the proposed Yucca Mountain repository site can be declared suitable for high-level waste and spent fuel disposal. Most, but not all, relate to the question of possible hydrothermal incursions into the proposed Yucca Mountain repository. Before I discuss these issues, let me first say how pleased I am that there is now general agreement that fluid inclusions in many mineral samples show unequivocal evidence of the presence of hot water in the past. I take no small comfort in the role of the Institute for Energy and Environmental Research (IEER) in helping to bring about this scientific agreement on a difficult topic. As you probably know, IEER sponsored the first and, to date, the only research on fluid inclusions in Yucca Mountain, that has resulted in a peer-reviewed publication. What is at issue now, as the members of the Board put it so well during their questioning on May 9, is the origin of the hot fluids.

Here are the issues that concern me greatly. I request that the Nuclear Waste Technical Review Board (NWTRB) address them thoroughly.

### **1. Uranium-lead dating**

The use of the uranium-lead dating method is central to the conclusions of the Department of Energy and the United States Geological Survey that rainwater was the origin of the thermal fluid inclusions. The later conclusion relies greatly on the dating. The method, however, seems to contain circular reasoning. The U-Pb calculation method assumes implicitly that the common lead correction is constant. Since this assumption does not necessarily apply to hydrothermal fluids, but is characteristic of rainwater, it rules out the former on an *a priori* basis. The dating results are then used to conclude that rainwater was the origin of the thermal fluid inclusions.

For a process involving upwelling of the deep-seated reducing fluids and their subsequent mixing with the oxidizing near-surface fluids, as Dr. Dublyansky suggested in his presentation, the constant lead correction would not apply and it is no longer straightforward to use the uranium-lead dating method.

This implication of the assumption of a constant lead correction value was not made explicit by either the USGS, or Dr. Cline, or the NWTRB consultant on fluid inclusions, Dr. Bodnar. If the constant lead correction were thrown into doubt, then the dating results would no longer be valid, the dating problem become much more complex. Moreover, Dr. Dublyansky informs me that data from U-238-Pb-206 and Th-232-Pb-208 decay chains have been discarded. Apparently these data do not produce meaningful results for dating. They should have been put before the NWTRB for review. I recommend that you request this data from the USGS and Dr. Cline.

The NWTRB should ask the USGS for a clarification of the U-Pb common lead correction issue. The apparent rejection of hydrothermal upwelling in the U-Pb dating method should be explicitly discussed and justified, rather than taken as an implicit *a priori* assumption. The opinions of Drs. Bodnar and Cline would also be helpful, especially as neither of them have, to my knowledge, stated unequivocally that the thermal fluid inclusions were created by rainwater percolation.

## **2. Thermodynamic arguments against the rainwater hypothesis**

In his presentation, Dr. Dublyansky argued that the acceptance of the rainwater hypothesis for thermal inclusion implies a constant temperature during mineral formation to within much less than 0.1 degrees Celsius for millions of years. This, as he noted, is thermodynamically impossible. It is also geologically incredible. I have not checked the calculations that Dr. Dublyansky has made. But the argument appears plausible to me. As I recommended during the public comment period on May 9, it is essential for the NWTRB to address basic physics issues, including this one, and ensure that the DOE and USGS arguments do not have implications that are physically next to impossible. It should not be too difficult to resolve this issue, since it is one of physics. I understand that calculations along the lines discussed by Dr. Dublyansky are in the report presented to you as a public comment on May 9 by Jerry Szymanski.

Further, the thermal models of heating of the unsaturated zone at Yucca Mountain by an magma body developed by USGS and the State of Nevada scientists must be documented and presented for evaluation in the complete form. I think that the NWTRB as well as the public should have the opportunity to examine all analytical or numeric solutions, assumptions and boundary conditions that have been used to arrive at some rather surprising conclusions as regards the origin of the thermal fluid inclusions.

## **3. Hydrocarbons**

Dr. Dublyansky's research showed that some all-gas inclusions in calcite minerals contained hydrocarbons. This provided an important part of the evidence leading him to conclude with a high degree of confidence that hydrothermal upwelling were the origin of the thermal fluid

inclusions. Research by the USGS and by Dr. Cline has not addressed this issue. The NWTRB needs to examine the issue of hydrocarbons in some inclusions and its relevance for the hydrothermal upwelling hypothesis. Such an examination should include a review of Dr. Dublyansky's work.

#### **4. Dr. Cline's database on fluid inclusions**

All parties agree that Dr. Cline has compiled an extensive and scientifically worthy database. However, this database has not been reviewed, nor have the detailed calculations upon which Dr. Cline's conclusions are based. I recommend that the NWTRB ask for the full database and make it public so that it is available for independent review. Given the centrality of the issues, I think that a review by the NWTRB itself is important.

#### **5. Minerals from nearby faults**

Dr. Dublyansky has postulated that an examination of minerals from nearby faults would yield clues as to whether the upwelling model he presented to the NWTRB is valid. Given the crucial nature of this issue, I believe that it is imperative that the DOE and USGS carry out these investigations and that they do so in an open and transparent manner, prior to making a conclusion about site suitability.

#### **6. Jerry Szymanski's submission to the Board**

Jerry Szymanski submitted a report to you during the public comment period as his last comment on the NWTRB on the subject of Yucca Mountain. Given his central role in the entire issue of hydrothermal upwelling, his expertise on many other areas relating to Yucca Mountain, and his standing as a long-term consultant to the State of Nevada, I recommend that the Board review that report thoroughly and commission independent reviews of it as well. These reviews should be made available to the public before the Board makes any findings on DOE's site suitability recommendation.

#### **7. Defense waste canisters and repository loading**

The DOE is now projecting that it will produce about 90,000 canisters containing vitrified high-level waste from its defense programs section, mainly Hanford and Savannah River Site. These numbers may increase upward yet again, given the uncertainties surrounding waste processing at both these sites. The implications for repository space of such a large number of waste canisters need to be studied very carefully. The uncertainties arising from future waste canister increases also need to be addressed. This issue not only relates to repository space but also to repository loading. The pressure to accommodate more canisters may result in inappropriate decisions to increase repository loading to the detriment both of performance and predictability. The NWTRB should ask the DOE to produce repository-loading scenarios that take into account present and possible future estimates of the number of glass canisters from its high-level wastes.

## Conclusion

In sum, the evidence so far leads me to conclude that the issue regarding the presence or absence of hydrothermal upwelling at Yucca Mountain is a very serious one and is far from resolved. Moreover, the issue of repository loading has now become more complex due to the uncertainties created by repeated failure of the DOE and its contractors to put in place a sound program for processing and vitrifying all defense high level wastes. Indeed, the failure is so complete that even an estimate of the number of canisters cannot be said to be moderately reliable.

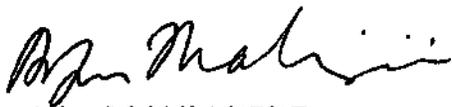
I know that the NWTRB takes its role as the scientific guardian of the public policy process regarding site suitability most seriously. I believe that it is essential that the NWTRB insist that the DOE resolve these issues fully before making its site suitability recommendation. Given the depth of the scientific controversy and the complexity of the issues, I cannot see how these issues can be reasonably resolved in the next eight to twelve months, DOE's timetable for a site suitability recommendation.

I recommend that the NWTRB immediately send a letter to the DOE that it should satisfactorily address all these questions and that it take the time needed to do so. This would give the DOE notice of the seriousness with which you intend to examine the site suitability recommendation in regard to these issues. Such a letter would create some public trust and confidence that the process will be guided by sound science rather than political expediency. A letter from you is especially needed since the Board's prior recommendation ("Review of Materials on Hydrothermal Activity" of July 24, 1998) does not allow an unambiguous reading as to whether the Board considers the issue of hydrothermal upwelling to have resolved.

Mr. Chairman, in closing let me congratulate you on the wonderful way in which you conducted the May 9 meeting. The presentations, questions and answers, the opportunities for public comment, the solicitation of clarification from the presenters on issues that were raised during the public comment were done in an exemplary way. I truly appreciate the way that you chaired the public process and I learned a great deal from it. Thank you very much.

I look forward to hearing from you.

Yours sincerely,



Aijun Makhijani, Ph.D.  
President