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Comments on Draft Environment Impact Statement on Yucca Mountain, DOE/EIS-0250D

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Draft EIS does not analyze the potential impact of inundation of the repository zone by upwelling water

Draft EIS acknowledges that inundation of the repository zone by upwelling water, if happens, would have great impact on the long-term repository performance.(1) The possibility of such inundations was suggested by a number of scientists (Szymanski, 1989; Hill et al., 1995). Draft EIS explicitly states, however, that "*DOE does not agree with the inundation scenario*" (p. 5-15). This dismissal heavily rests on the findings of the 1992 NAS/NRC panel (National Research Council, 1992). The latter document is outdated, because much new data have became available since 1992. Below we summarize some of this evidence.

Fluid inclusion evidence

By rejecting "inundation scenario", DOE rejects new scientific information indicating the presence of waters with elevated temperature in what is now Yucca Mountain unsaturated zone in the past, obtained by studies of fluid inclusion in secondary minerals.(2) "Justification" of this rejection is given on pp. 3-49 - 3-50 of the Draft EIS as follows: "*DOE, given the opportunity to review a preliminary version of the report, arranged for review by a group of independent experts, including U.S. Geological Survey personnel and a university expert. This review group did not concur with the conclusion in the report by Dublyansky (1998 all)...*"

The quotation above reflects lack of objectivity in the DOE's handling of the controversy. First, experts who conducted the review for the DOE may hardly be called "independent", since all these scientists were promoting the "non-inundation" scenario for years.(3) Second, it is unfair and misleading not to mention written opinions of three truly independent experts from the Europe (selected for their outstanding scientific expertise in fluid inclusions and non-involvement in the Yucca Mountain studies)(4), attached to the report. All three reviewers concurred in the opinion that the fluid inclusion work is of high quality, and interpretations are reasonable.

Further, the U.S. NWTRB has agreed with the "thermal water" interpretation of the fluid inclusion data.(5)

Finally, a DOE-sponsored verification fluid inclusion research project presently underway at University of Nevada at Las Vegas, UNLV, has already (as of July, 1999) confirmed the presence of the two-phase fluid inclusions, yielding elevated homogenization temperatures in secondary calcite and quartz from ESF.

Other evidence

Besides fluid inclusions, the presence of hot waters in what is now unsaturated zone at Yucca Mountain is suggested by a host of other methods.

a). The USGS geologists inferred elevated, up to 120 ^{o}C, temperatures for paragenetically early secondary silica from ESF on the basis of stable isotopic studies.(6)

b). Based on yet another method, structural studies of calcite, Mary Beth Gray with co-authors (contractors to NRC) concluded that calcite in fault rock in the ESF were formed at elevated temperatures (probably, 150-200 ^{o}C), and there have been more than one event of calcite deposition (Gray et al 1998).

c). Terry Else with co-authors (1999) have found viable moderately thermophilic calcite-depositing bacteria (temperatures of habitat 40-60 ^{o}C) in calcite sample that yielded homogenization temperatures of 35-50 ^{o}C; adjacent bedrock tuffs did not contain such bacteria.

d). Preliminary data on stable isotopic gradients in surficial calcite at Yucca Mountain suggest the progressive evaporation, CO_2 degassing and perhaps cooling - features consistent with travertine origin and inconsistent with pedogenic origin of these deposits (Dublyansky & Szymanski 1996; Dublyansky et al 1998). Prof. John Valley, who evaluated this work for the U.S. NWTRB, concurred with this interpretation (with one reservation that the presence of these trends needs to be verified).(7)

Hydrothermal activity at Yucca Mountain - Summary

The status of the issue was best summarized by former consultant to U.S. NWTRB, Prof. Robert Bodnar, at the 1999 Spring Meeting of the American Geological Society in Boston, Massachusetts: "*Those scientists who have examined the recent data are in general agreement that waters of unknown but, presumably, deep origin have entered the repository horizon at some time during the geologic past. ... The problem as it relates to the suitability of Yucca Mountain as a nuclear waste repository concerns the timing of fluid infiltration*." (Bodnar 1999).

Elevated temperatures of secondary minerals deposition imply inundation of the Yucca Mountain unsaturated zone by upwelling water, provided two alternative sources of heat - residual heat of cooling bedrock tuffs and conductive heat transfer from deep-seated magmatic bodies - are ruled out. In the case of Yucca Mountain this requirement is met. Different researchers at different times have ruled out magmatic rocks as a potential source of

hydrothermal activity at Yucca Mountain.(8) Isotopic dating by USGS researchers have shown that the oldest secondary minerals at Yucca Mountain were deposited 2 to 3 million years after the emplacement of the tuffs (Neymark et al 1998; Whelan and Moscati, 1998), which means the latter have already cooled down.

Timing of hydrothermal inundation

Frequency of occurrence of the hydrothermal activity and, therefore, the probability of its occurrence in the future cannot presently be established with confidence due to lack of the data. The DOE-sponsored Project(9) which is presently underway at University of Nevada at Las Vegas, will, hopefully, substantially advance our knowledge on the timing of hydrothermal activity at Yucca Mountain.

Nevertheless, there is already enough evidence suggesting that thermal fluids were present in the repository zone, constantly or intermittently, during the extended time span of ~9-10 million years, with youngest occurrences being only few thousand years old. These young isotopic ages have been measured for calcite from the ESF by the USGS researchers (e.g., Paces, et al 1996).(10) Based on the preliminary data, the hydrothermal activity has probability of occurrence greater than the lower limit of 1×10^{-8} per year adopted by DOE as the level of concern (DOE 1998, p. 4-81).

Why it is important?

Water is the primary means by which radionuclides disposed of at Yucca Mountain could reach the accessible environment. The present repository concept critically relies upon the following factors: (a) small amounts of water (seepage in repository drifts) that may contact waste canisters; (b) small fraction of waste canisters that would contact with this water (because seepage is restricted to individual fractures); (c) high corrosion resistance of waste canisters in the predicted repository environment (moderate temperatures, oxidizing water, etc.); and (d) long pathway between the repository and accessible environment (including 175 to 365 m of the unsaturated zone beneath the drifts and about 20 km of saturated-zone flow to Amargosa Valley; with dispersal of radionuclides along the way).

However, if inundation scenario is considered, these factors are not the most important ones, for the following reasons:

Amount of water, contacting waste canisters. Instead of small amounts of seepage water contacting some waste canisters, <u>all</u> canisters will be completely submerged in water with composition totally different from today's meteoric water.

Corrosion resistance of waste canisters. Since the composition and the temperature of upwelling water will differ from meteoric water, the present assessment of waste package degradation rates cannot, therefore, be used for such dramatically different environment.(11) Preliminary data indicate that corrosion-resistant component of the base-case canister, alloy C-22, "*...is susceptible to localized corrosion ... when wet in a critical temperature range. If C-22 remains passive in this range, its anticipated life, prior to penetration, is thousands of years. If it is not*

passive, then its life, prior to penetration, is as little as a few tens of years" (Whipple et al., 1998).

Long radionuclide pathway. Long pathway of water, contaminated with radionuclides from repository zone through 175 to 365 m of the lower part of the unsaturated zone, and then through some 20 km of saturated zone to the extraction wells in Amargosa Valley, will be replaced by a 200 to 425 m-long "shortcut" right to the land surface, where these waters would discharge as springs.

"Hot repository" consequences. If inundation occurs during the period when the repository zone is still hot due to the radioactive decay (a period that may last several thousand years), the consequences may change dramatically. Much will depend on the temperature of rocks and waste canisters, with which water comes into contact. This temperature will depend on time elapsed since emplacement, as well as the chosen thermal load. A set of scenarios may be constructed for water invasion in the repository zone when: (1) the temperature is well above water boiling point; and (2) when it is below boiling, but still higher than the temperature of upwelling fluids. Vigorous boiling and steam venting may be envisaged for the first scenario and enhanced convection of water for the second. Both these scenarios envisage faster failure of the canisters, thereby enhancing the ability of radionuclides to migrate.

Summary on inundation scenario

We have demonstrated that:

a. There presently exists significant body of evidence, indicating that inundation of the repository zone by upwelling hot waters.
b. The ages of these events are presently not known with certainty; extensive preliminary data indicate, however, that they occurred intermittently between 9 million years and 8 thousand years ago.
c. Based on the present evidence, it is reasonable to conclude that the probability of occurrence of inundation is greater than the 1×10^{-8} per year DOE level of concern, which means that the hydrothermal hazard probabilistic analysis must be carried out.
d. Potential consequences of inundation of the repository filled with high-level nuclear waste may be disastrous for the environment and people.
e. Draft EIS does not consider the inundation scenario.

In our judgement, the failure to consider this important scenario makes the present Environmental Impact Statement completely inadequate and cannot be used for evaluating real environmental impact of the planed facility. "Inundation" issue must be explicitly resolved prior to any decision regarding the fate of the Yucca Mountain site.

Closing remark - A fiasco rehearsal

Draft EIS (as well as released earlier Viability Assessment) is a model illustrating how critical decisions regarding the fate of nuclear waste will be made, and on what sort of science these decisions will be based. Having spent more than 15 years and several billion dollars to

characterize the Yucca Mountain site, DOE and its contractors have produced tremendous amount of highly technical information. It is contained in millions of pages of reports and publications. Final Environmental Impact Statement, as well as all other documents that will provide basis for legal decisions must be based on careful evaluation of all pertinent information contained there. It is exceedingly important not to leave any information that has bearing on the performance of the repository beyond the scope of the analysis.

Decisions regarding what is important and what is less important and may, therefore, be omitted, can only be made by highly qualified professionals. We find it incredible that among 30 members of the Draft EIS preparation team only one has a degree in geology.(12) We do not believe that one Bachelor of Science, however brilliant he may be, may be put in position of being responsible for evaluation and compilation of 15 year-worth work of several organizations and tens of researchers that cover substantial number of very specific and intricate fields of Earth Sciences.

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Endnotes

1. "*There has been no analysis to determine the effect; however, if such an event occurred, the long term impacts would probably increase greatly.*" (p. 5-11)

2. Dublyansky and Reutsky 1995 & 1998; Dublyansky et al 1996; Dublyansky 1998-a & -b.

3. Authors of the review, arranged by DOE are: J.Whelan, J.Paces, B.Marshall, Z.Peterman, J.Stuckless, L.Neymark of USGS and E.Roedder of Harvard University.

4. Independent experts who evaluated Dublyansky 1998 report are: Dr. Larryn Diamond, University of Leoben, Austria; Dr. Bruce Yardley, University of Leeds, UK; and Dr. Jean Dubessy, CNRS, France.

5. "*... fluid inclusions found in mineral deposits at Yucca Mountain do provide direct evidence of the past presence of fluids at elevated temperatures ... in the vicinity of the proposed repository*" (letter of the Chairman of the U.S. NWTRB Jared Cohon to Acting Director of the U.S. DOE Office of Civilian Radioactive Waste Management Lake Barrett; July 24, 1998, p. 2)

6. "*Delta-^{18}O values of the silica phases quartz, chalcedony, and opal indicate that some of the early massive-silica-stage phases must have formed from heated water...*" Whelan et al. 1998, p.21.

7. "*These trends deserve close examination. If such trends are reproducible and are in fact different from local elevation effects, this would be strong evidence favoring progressive evaporation and CO_2 out-gassing (and perhaps cooling) as fluids move down slope.*" Letter from Prof. J.Valley to L.Reiter of NWTRB; Dec. 18, 1997. p.4.

8. "*Silicic volcanism located close enough to Yucca Mountain to have provided heat to the local hydrologic regime ended more than 11 Ma. Magma bodies below larger calderas (>10 km diameter) cool slowly and may be heat source for up to 2 Ma (Wohlentz and Heiken, 1992). Calculations based on theoretical cooling model (Smith and Shaw, 1978) indicate that magma chambers associated with calderas of the central zone of the Southwestern Nevada Volcanic field would have completely crystallized and cooled to ambient temperature several million years ago.*" Flynn et al., 1995, p. 27.

9. The project' term begun in April, 1999 and is scheduled to end by April, 2001.

10. The authors interpret this calcite as being deposited from rain waters percolating downwards through interconnected fractures. Recent results of Dublyansky (1999) and UNLV Committee have shown that 40 to 70 % of calcite from the ESF (including calcite from some occurrences dated by USGS), as well as some quartz, contain two-phase fluid inclusions indicating elevated, up to 60-80 ^{o}C, depositional temperatures.

11. "*No rational materials selection can be made without knowledge of the characteristics of the waters in contact with the waste packages. These characteristics include: temperature, pH, Eh and ionic concentrations (Cl, SO_4, NO_3, CO_3, Fe^{+++}, Ca, etc.)"* Third Interim Report of the Peer Review Panel on the TSPA 1998.

12. Jeffrey McCann; B.S., Geological Sciences, 1980. US DOE 1999, pp. 13-1 - 13-7.