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Introduction

My name is Jerry S. Szymanski and I am commenting on the Draft Environmental Impact Statement (EIS) as a private citizen. Over the past 15 years, first as a DOE physical scientist and then as a science consultant to the Attorney General of the State of Nevada, I have been engaged in researching the issue of potential long-term releases of radioactivity from the proposed repository at Yucca Mountain. A realistic estimate of these releases is an essential prerequisite for estimating the potential environmental impacts and is, as it should be, a single most important factor in the eventual acceptance or rejection of Yucca Mountain as a host for this repository. I will restrict my comments solely to this topic.

Background and Focus

1 [Those scientists who are familiar with Yucca Mountain are in general agreement that a single most crucial question in estimating the future releases is that involving the long-term stability of the water table and the resulting potential for inundating the proposed facility. As noted in the Draft EIS, two contrasting viewpoints have been proposed in that regard. One is that the water table has been stable for the past several millions of years and that the inundation may safely be excluded from the release considerations. The other is that, at and in the vicinity of Yucca Mountain, the water table has risen repeatedly in the past and that it will do so in the future and, further, that the inundation is unavoidable and must be regarded as an essential aspect of the release considerations. Which one of these two viewpoints is correct?]

The answer lies inside minerals (crystalline calcite, quartz, opaline silica, and minor fluorite) which coat many fractures and cavities in rocks above the contemporary water table. Those scientists who have examined the USGS radiometric data are in general agreement that, as a whole assemblage, the minerals were precipitated over a time period spanning from several millions of years ago to as little as a few tens of thousands of years ago. However, at this point the agreement ends and the so-called rainwater vs. upwelling water controversy begins. This controversy revolves around processes that were responsible for formation of the minerals.

Some independent scientists endorse the upwelling water hypothesis in accordance with which the minerals were formed by hot waters which, in the past, were repeatedly welling up from a great depth underneath the mountain. That would mean geothermal waters have invaded the mountain in the past, in association with reoccurring seismic and/ or volcanic events, and might again at a time when the emplaced spent nuclear fuel and radioactive waste would still be extremely dangerous and when the temperature of the host rock would be at or above the critical point of water.

Other scientists, mainly those who are affiliated with the Yucca Mountain project, endorse the rainwater hypothesis and believe the minerals were formed when the volcanic rocks that make Yucca Mountain were laid down millions of years ago, and that some of the minerals continue to grow as rainwater was infiltrating through fractures in the rocks. In this view, the geothermal water would not pose a threat to the emplaced radioactive materials. This highly controversial view is essential, without it the Yucca Mountain site would not be considered and the project would have to be scraped.

Although the Draft EIS contains brief references to the rainwater vs. upwelling water controversy, it deals with this controversy in a grossly misleading and totally unacceptable manner. Particularly troublesome and regrettable are those statements in the Draft EIS which pertain to the radiological consequences of a breach of the proposed repository by geothermal waters and to the current status of resolving the corresponding controversy. As a result, the Draft EIS misinforms the public, the Congress, and the President about the actual attributes and potential pitfalls of Yucca Mountain as a long-term storage and disposal site for spent nuclear fuel and high-level radioactive waste.

Radiological Consequences

Referring to the potential consequences of an upwelling event, the Draft EIS states on pg. 3-49 as follows: "...it would affect the performance of the proposed repository". This is a hollow and grossly misleading account. Clearly, it is a disservice to the public and seems aimed at stifling public debate about hazards which may be associated with the proposed repository.

One does not have to be a rocket scientist to reckon that, by affecting "*the performance of the proposed repository*", the upwelling event could produce a disaster of unprecedented magnitudes. Such a disaster has been described in the popular press on more than one occasions. For example, in an article entitled "New Questions Plague Nuclear Waste Plan", published in the August 10, 1999 issue of the New York Times, Jon Christensen wrote: "*The results would be catastrophic. Hot water would rapidly corrode the canisters and dissolve the waste. Radioactive steam would vent from the mountain and contaminated water would spread underground*".

A similar account was given in an article "A Nuclear Graveyard" which was published in the March 18, 1991 issue of the US News and World Report. In it, the author, Betsy Carpenter painted the following picture: "*The apocalyptic scenario begins with an earthquake near Yucca Mountain.... The temblor is minor; it does not even rupture the tunnels and chambers honeycombing the mountain. But fresh movement in the earth's crust causes ground water to well up suddenly, flooding the repository. Soon lethal brew of nuclear poisons seeps into the water that flows underground to nearby Death Valley. Insects, birds and animals drink at the valley's contaminated springs, and slowly the radioactivity spreads into the biosphere. It would be a terrible disaster*".

Perhaps the most appropriate account was given by William Broad in an article entitled "A Mountain of Trouble" and published in the November 18, 1990 issue of the New York Time Magazine. According to the author, some experts regard the rapid incursion of hot water as possibly "*the beginning of the ultimate end*". Further, the author cited Dr. C.B. Archambeau, a professor of geophysics at the University of Colorado, who said: "*You flood that thing and you could blow the top off the mountain.... At the very least, the radioactive material would go into the ground water and spread to Death Valley, where there are hot springs all over the place, constantly bringing water up from great depth. It would be picked up by the birds, the animals, the plant life. It would start creeping out of Death Valley. You couldn't stop it. That's the nightmare. It could slowly spread to the whole biosphere. If you want to envision the end of the world, that's it*".

In light of the popular press accounts, the DOE's portrayal of the potential consequences appears as ridiculous and foolish. This portrayal seems to be aimed at maintaining the pretense of an unassailable site and at preventing a recognition, by the public, of the potential shortcomings of Yucca Mountain and the resulting pitfalls. It adds nothing to the

public understanding and further damages the DOE's credibility.

Rather than insisting on the presently unacceptable portrayal, the DOE should address the potential radiological consequences in a forthright manner. In this regard, however, there are only two alarming possibilities. First, if the water table would gently rise and gradually inundate the repository, the expected result would be a complete breakdown of the critically important natural barrier as well as some (undeterminable) deterioration of the integrity of all the engineered barriers. The releases of radioactivity could reasonably be expected to be potentially large and unacceptable; in particular, if the rise would occur at a time when the facility is "hot" (i.e., during the initial thousands of years, when the temperature exceeds the critical point of water) and if this rise would be maintained for a few tens of years. At the very least, it would be impossible for the DOE to give, under these circumstances, reasonable assurances in regard to satisfactory performance of the proposed repository. This is because, regardless of how complex and ingenious the performance assessment models are, all analytical and computer-based calculations are incapable of yielding realistic simulations and estimates of releases of radioactivity from a flooded but hot and previously dry repository.

Second, if the water table would violently rise, such as in association with the ascent and eruption of a gas-charged hydrothermal plume which would be triggered by a tectonic event (either an earthquake, a volcanic intrusion, or both), the reasonably expected result would be a complete and catastrophically rapid breakdown of the natural barrier as well as a total deterioration of all the engineered barriers. The releases of radioactivity, directly into the atmosphere and hydrosphere, could reasonably be expected to yield catastrophic, perhaps life-threatening, doses of nuclear radiation. The resulting environmental catastrophe would dwarf the Chernobyl event and would reach well beyond the borders of Nevada. One can hardly imagine a sane individual who would disagree that, if such would indeed be the case, the uncertainties would be sufficiently high to warrant disqualification of the Yucca Mountain site.

The preceding considerations imply that depending upon a likelihood of the occurrence, which at present is a disputed and highly uncertain matter, the repository flooding entails a hazard that neither can be estimated nor can it be mitigated and reduced to prudent and acceptable levels. In view of this, the Final EIS should assure the public that, if a likelihood of the flooding, which will be determined in the course of investigations presently underway at the UNLV, would exceed some vanishingly small level (say 1 chance in 10 or 100 over the future 10 000 years), the DOE would be prepared to act swiftly by disqualifying the Yucca Mountain site.

Current Status of the Controversy

Another shortcoming of the Draft EIS is that it misrepresents the current status of resolving the controversy which surrounds an origin of the minerals at Yucca Mountain and a likelihood of the catastrophic breach of the proposed repository. Description of this status on pg. 3-49 and 3-50 of the Draft EIS seems to be aimed at creating a perception that the controversy is almost resolved in favor of the rainwater hypothesis and, further, that a likelihood of occurrence of the upwelling event, in the future tens of thousands of years, is practically nonexistent. However, this perception is very far from the truth.

In this regard, for the past several years the State of Nevada has retained Dr. Y.V. Dublyansky, a mineral expert at the Siberian Branch of the Russian Academy of Sciences, to collect and study the mineral samples from Yucca Mountain. The results of this research

were summarized in a number of scientific papers, which were written by Dr. Dublyansky in cooperation with a number of his co-workers and, published in the peer reviewed literature. The overall theme in these papers was that the rainwater hypothesis could not be confirmed, that this hypothesis does not appear to be uniquely valid, that the minerals exhibit a number of characteristics which are not compatible with the postulated by the DOE rainwater origin, and that most likely the competing upwelling water hypothesis is valid.

In the summer of 1998, the Institute for Energy and Environmental Research (IEER) retained Dr. Dublyansky to study the mineral samples which he collected in June, 1998, from the Exploratory Studies Facility, after the USGS workers refused to conduct joint studies with him. The aim of this study was to confirm the previous findings of the Dublyansky's et al. research. The report "Fluid Inclusion Studies of Samples from the Exploratory Studies Facility, Yucca Mountain, Nevada" was publicly released by the IEER on December 1, 1998. This report presented a number of convincing lines of evidence which demonstrated that the ESF minerals were indeed formed in association with past upwellings of geothermal waters and that, most certainly, they were not produced by an infiltrating rainwater, which contradicted the DOE-USGS assertions.

Referring to the Dublyansky's 1998 report, the Draft EIS states on pg. 3-50: "*DOE, given the opportunity to review a preliminary version of the report, arranged for review by a group of independent experts, including US Geological Survey personnel and a university expert. This group did not concur with the conclusion in the report by Dublyansky (1998)...*". This is an outrageously misleading account. Clearly, it distorts the truth and is aimed at allowing the DOE to maintain the traditional no-upwelling, and no-catastrophic release of radioactivity, image of the Yucca Mountain repository.

As a matter of fact, the draft version of the report released on December 1, 1998 was subjected by the IEER to a wide-ranging and exhaustive review. The review was performed by experts unaffiliated with the Yucca Mountain Project from the United Kingdom (Dr. B. Yardley of the University of Leeds), from France (Dr. J. Dubessi of the CNRS), and from Austria (Dr. L. Diamond of the University of Leoben). One of the experts, Dr. Diamond, even conducted an independent examination of some of the samples. In addition, the draft version was reviewed by individuals selected by Dr. Lake Barrett, Acting Director of the DOE's Office of Civilian Radioactive Waste Management. This group included those of the USGS researchers who were affiliated with the Yucca Mountain Project as well as a truly independent expert (Dr. J. Cline of the University of Nevada, Las Vegas).

Dr. Dublyansky devoted a great deal of effort to ensure that all comments, including those made by the DOE-selected reviewers, have been carefully addressed on their merits. Where warranted, he has made changes to the draft report. In other cases he has provided clarifications and additional explanations. However, most of the USGS comments were judged by Dr. Dublyansky to be inappropriate and without merits. In all such cases, he has provided a reply on a point-by-point basis.

Without a single exception, the independent reviewers were favorably impressed by the Dublyansky's work. All three of the experts concurred in their assessment of the high quality of the report and the research on which it is based. In this regard, Dr. Diamond wrote: "*I find the report prepared by Dr. Dublyansky to be of very high quality*". Similar sentiments were voiced by Dr. Yardley: "*I consider that the procedures followed accord with best practice...*" and by Dr. Dubessi who noted: "*...the report...contains high quality data, their interpretation is reasonable...*".

Also unanimously, the independent experts concurred with the Dublyansky's conclusion in regard to the main question addressed by his research, namely: whether the mineral samples from the ESF represent products of descending rainwater or, conversely, whether they are products of ascending geothermal waters. In this regard, Dr. Diamond wrote: *"I am still of the opinion that, viewed collectively, the remaining compelling evidence is good support of the report's conclusion that the calcite+opal+fluorite fracture coatings precipitated from warm, upwelling fluids, and not from descending meteoric water ..."* and Dr. Dubessy that: *"...it is clear that the data given in this report validate the hypothesis of ascending hot fluids"*. In addition, Dr. Yardley emphasized: *"The report marshals a number of other arguments in support of a hydrothermal, rather than pedogenic, origin for the calcite: presence of fluorite and especially quartz, homogeneous stable isotope composition and presence of hydrocarbons. These interpretations are soundly based by comparison with results from geothermal systems in my opinion"*.

It is noteworthy that the expert on fluid inclusions of the Nuclear Waste Technical Review Board (NWTRB), Dr. R. Bodnar of the Virginia Polytechnic Institute and State University, reassessed some of his previous opinions of the subject after he worked with Dr. Dublyansky and had a chance to study some of the Yucca Mountain samples. In a letter to the NWTRB dated July 8, 1998, Dr. Bodnar now agreed that elevated temperature fluid inclusions were present in the samples and that they were not artifacts of the preparation of the samples. In addition, he reported evidence for the presence of aromatic hydrocarbons entrapped in the inclusions which, if confirmed by the further research, would independently preclude a rainwater origin of the samples.

Only one of the reviews, by a panel composed of those of the USGS researchers who were associated with the Yucca Mountain Project for the past decade and half and who were original authors of the disputed rainwater hypothesis, disagreed with some of the main conclusions in the Dublyansky's report. Nevertheless, by agreeing with the report's main recommendation that the further research was needed, even this review implicitly acknowledged that there may be problems with the rainwater hypothesis.

According to a forward to the Dublyansky's report written by Dr. A. Makhijani, President of the IEER, the USGS review contains serious misrepresentations of some of the reviewers own data and displays evidence for gross misreading, by the reviewers, of data and analyses clearly presented in the report. In a letter dated November 30, 1998 to Dr. L. Barrett, Dr. Makhijani lamented: *"We were dismayed by the personal remarks, derogatory tone, and factual inaccuracies and misrepresentations in the Whelan et al. review. Furthermore, we found many of the charges made in the review to be illogical and unfounded"*.

To enable the public and other interested parties to see all the evidence, the IEER went to the extraordinary length of publishing all of the review reports, including the Dublyansky's point-by-point reply to the USGS review, as an appendix to the final report. This appendix reveals the shallow and divisive approach taken by the USGS reviewers in this matter. In light of the material provided in the appendix, their review appears as a shameful display of a total disregard of scientific integrity and honesty. It is impossible to concur and justify the DOE decision to regard this review as a contribution which would warrant the exclusion of an upwelling event from considerations of the potential releases of radioactivity and of the resulting environmental impacts.

To disclose the risks which may be associated with the proposed repository, the DOE

must fairly state what is the current status of resolving the rainwater vs. upwelling water controversy. In this regard, there is already a broad consensus developed among the scientific community. As of this writing, this consensus is not challenged anymore even by the USGS researchers. A paper by R. Bodnar "Paleohydrothermal Activity at Yucca Mountain: An Assessment of the Problem, the Politics, and the Solution", which was read at the Spring 1999 Meeting of the American Geophysical Union, provided the following account of this consensus: *"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 in the geologic past. Samples of these waters have been trapped as fluid inclusions in minerals precipitated from these waters. The problem as it relates to the suitability of Yucca Mountain as a nuclear waste repository concerns the timing of fluid infiltration. If the waters entered the horizon at some time shortly after the Timber Mountain event (10-13 Ma), and if no heated waters have subsequently entered the site, then the fluids have little relationship to assessing the possibility of future incursions of hot water at Yucca Mountain. If, on the other hand, the heated waters and their host minerals are recent (a few 100 Ka), then Yucca Mountain may not be the best possible location for long-term storage of nuclear waste"*.

Thus, a likelihood of occurrence of an upwelling event at Yucca Mountain and, based upon it, the pertinence of such an event to the Environmental Impact Statement are both dependent upon the eventual outcome of discovering the reliable answer to the question of timing of the past hydrothermal activity at Yucca Mountain. However, this topic is presently open to various interpretations and is a subject of conjecture and considerable controversy. Emergence of the broad-based consensus is hindered by the fact that the USGS geochronological data base consists of a great number of ages on those ESF minerals for which an origin is not constrained by fluid inclusion measurements. Thus, strictly speaking, ages of those specimens for which a hydrothermal origin has been conclusively shown are not known with the absolute certainty.

Nevertheless, the combined fluid inclusion and geochronological data only allows for considering two possibilities: either 1) the entire ESF mineral assemblage is monogenetic, i.e., it has been precipitated intermittently, over a time period spanning from about 8 millions of years ago to as recently as a few tens of thousands of years ago, in a hot-aqueous environment; or 2) this assemblage is polygenetic and consists of two sets of genetically distinct minerals, one set consisting of the rainwater produced minerals and the other of minerals formed in a hot-aqueous environment. Although theoretically it is possible that the ESF minerals are polygenetic, chances for this interpretation of being correct are remote at best. This is because those specimens for which a hydrothermal origin cannot be denied are identical (in terms of crystallographic habits, mineralogy, and isotope compositions) to those specimens for which it is possible to assert the rainwater origin but which carry the youngest radiometric ages.

It is also noteworthy that one sample (SS#39-40), which was shown by Dublyansky to be of a hydrothermal origin, yielded an average uranium/ thorium age of about 160 000 years before the present. However, because the sample was fairly large, weighting 4.5945 grams, this result was considered by Dublyansky as preliminary and one which should be reproduced and verified in the course of subsequent analyses. Most probably, the 160 000 age represents an average age of the sample; ages of the innermost parts of this sample may be older and the outermost younger than the average. It is unlikely, however, that ages of the innermost parts, those which contained the elevated temperature fluid inclusions, are significantly greater than about 1 million years. If they were such, the average age would have been much greater than 160 000 years.

Although the SS#39-40 age may possibly be regarded by some as problematic, this age represents the first geochronological datum on a sample for which a hydrothermal origin has been firmly established. At the very least, this age should be regarded as a red flag of caution that warrants the most conservative stance in regard to ages of the hydrothermal minerals in the ESF, to a likelihood of the catastrophic breach of the proposed repository, and to the resulting environmental consequences. After all, the burden of proof rests squarely on the shoulders of DOE and not on critics of the proposed repository.

Concluding Remarks

It is evident from the preceding discussions that the Draft EIS is not a credible document. Particularly condemnable is the fact that this document gives the grossly deficient account in regard two critically important matters. On the one hand, it trivially understates the radiological consequences of a catastrophic breach of the proposed repository by geothermal waters, upwelling of which would be triggered by the expected at Yucca Mountain occurrence of a seismic and/ or volcanic event. On the other, it seriously misrepresents the current status of resolving the controversy which surrounds a likelihood of occurrence of such a breach in the future tens of thousands of years.

It is essential for the DOE to recognize at last that it owes electricity rate payers, taxpayers, nuclear industry, and future generations the benefit of scientific disclosure that would do justice to the gravity of the problem at hand. Providing truthful accounts in regard first to the radiological consequences and then to the current status of resolving the corresponding controversy is essential for the fulfillment of this obligation. Both of these topics are critically important and deserve an open, honest, and forthcoming disclosure in the Final EIS.

The DOE must prepare the Final EIS keeping in mind that this document is a part of the foundation for decisions, by the President and the Congress, in regard to the ultimate fate of Yucca Mountain. Needless to say, these decision may impact the entire humanity, and life in general, in an unprecedentedly adverse manner. However, without knowing ages of hydrothermal minerals from the ESF and without knowing whether the paleo-inundations of the repository horizon were violent or not, the DOE is not in a position to give, in the Final EIS, any credible assurances in regard to the satisfactory performance of the proposed repository. Thus, the Final EIS should forthrightly state that all final decisions regarding the disposal and storage of radioactive waste and spent nuclear fuel at Yucca Mountain will await a satisfactory resolution of the rainwater vs. upwelling water controversy. To issue a final judgment about the site environmental acceptability first and then to engage in the scientific studies that are critical to the most crucial questions that affect this acceptability would be at variance with sound scientific practice.