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Dan Dreyfus, Director
Office of Civilian Radioactive
Waste Management
U. S. Department of Energy
Washington, D.C. 20545

Dear Dr. Dreyfus:

The State of Nevada has reviewed the DOE Study Plan, "Natural Resource Assessment of Yucca Mountain, Nye County, Nevada" (Study Plan 8.3.1.9.2.1, Rev.0) and its cited references, and is providing its comments in this letter and attachment. The State's comments address the adequacy, completeness, and technical accuracy of the Study Plan to meet the purposes of site characterization.

The State's primary concerns regarding the subject Study Plan are summarized as follows:

1. The geochemical and geological activities of the Study Plan contain a fundamental conceptual oversight. The basic premise of the Study Plan is that the site area would present the same target to an explorationist in the future as it does today. Where, in fact, there will be residual thermal, radiation, and geochemical anomalies resulting from any long-term radioactive waste disposal that may be inherently attractive to future explorationists. Consideration of how the repository site might be disturbed in a hypothetical search for minerals could require major changes in how and when the study is carried out.

2. The Study Plan does not explicitly include any program for detailed geochemical, petrographic and related analysis of the rocks intersected by the exploratory tunnels and deep boreholes as they might relate to early site suitability determinations of natural resource potential.

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3. The authors of the Study Plan do not include consultation or participation of any U.S.G.S. geologists known for their work on the type of deposits most likely to be present in the Yucca Mountain site area.

4. The Study Plan, as outlined, is not an exploration plan based on industry practice of systematic sampling followed by more detailed studies of anomalous areas. The subdivision of the work into a "geochemical assessment" activity and a "geophysical/geological appraisal" activity is highly artificial and contrary to standard mineral potential surveys.

It should be noted that concerns and comments contained in this letter are applicable only to geochemical and mineral resource assessments. Concerns and comments relative to geothermal and hydrocarbon resource assessments will be transmitted later.

Should you have any questions, this office is available to meet with the Department and discuss the State's comments at any time.

Sincerely,

Robert R. Loux
Executive Director

ATTACHMENT
cc: R. Nelson, DOE-YMPO
J. Youngblood, NRC
M. Steindler, NRC-ACNW
J. Cantlon, NWTRB
S. Kraft, EEI
D. Weigel, GAO

ATTACHMENT

State of Nevada Comments on DOE Study Plan 8.3.1.9.2.1, Rev. 0 - "Natural Resource Assessment of Yucca Mountain, Nye County, Nevada."

GENERAL COMMENTS

The State believes that there exists a fundamental conceptual oversight in the formulation of the entire geochemical and geological program presented in this Study Plan. We believe that there are major fallacies in the ideas held by the Department and the authors as to how the repository site might come to be disturbed in a hypothetical future search for minerals. Recognition of these fallacies and consideration of their implications will require major changes in how and when the evaluation of the mineral potential of the Yucca Mountain repository site should be carried out.

The principal concern of DOE seems to be that future exploratory drilling of the Yucca Mountain site area could intersect radioactive waste and introduce it into the environment. We believe, however, that drilling should not be the principal and only concern. To drill an exploratory hole that would intersect the repository horizon clearly requires both a technological capability more or less equivalent to that presently available and a social and economic infrastructure that would favor high-risk investments for mineral investigation. Economic geologists, mining engineers, etc., of such a future society would clearly have knowledge and understanding similar to that of modern mineral explorationists and miners. Specifically, future explorationists would recognize that major tunneling had taken place on the eastern flank of Yucca Mountain, even if all historical records had been lost and considerable time had elapsed. In short, it will be impossible to hide the large amounts of excavated rock material.

Moreover, future explorationists would clearly consider as one possibility that the tunneling had been undertaken for the extraction of minerals. This possibility would be reinforced by the clear presence of old mines (for example, the huge open pit of the Lac (formerly Bond) - Bullfrog mine in the Bare Mountain-Bullfrog Hills areas and the presence of a number of geophysical anomalies that would be created by the waste emplacement (e.g. thermal radioactive halos, gravity, magnetic, etc.). Undoubtedly, one of the first things that professionals of this hypothetical "new" society would do is to look at, and geochemically sample in a more or less systematic manner, the rock removed from the tunnels. This would unquestionably be done before any drill holes were placed into the repository area. It is clear that the principal indication to future generations of possible mineralization at Yucca Mountain would be the material removed from the exploration, haulage and repository tunnels. Irrespective of efforts to grade, smooth, cover, or otherwise conceal or obscure the waste removed from the repository tunnels, we feel that any society sufficiently advanced to carry out deep exploratory drilling would recognize and sample the rock waste dumps as a first step.

Following the above line of reasoning, we suggest that the most important rocks to sample will be those cut by the exploratory tunnels. The Study Plan for evaluation of mineral potential should, therefore, explicitly include a program of detailed geochemical, petrographic and related studies of the rocks intersected by the exploratory tunnels. Moreover, only when the exploratory tunnels are finished, and the geochemical, petrographic and other data that bear on mineral potential are available, can a reasoned assessment be made as to the degree to which the proposed repository would attract the attention of future mineral explorationists.

We do not believe that the logging, geochemical analysis, etc., of core from surface exploration holes can take the place of sampling the tunnels themselves. This is because the size of mineral deposits of the types that could be expected at Yucca Mountain is many times smaller than the average spacing of the existing and proposed drill holes. Indeed, even in areas of known mineralization, much more closely spaced drill holes commonly fail to intercept ore grade deposits.

The above line of reasoning can easily be extended further. For example, if the rock removed from the tunnels, etc., were to show signs of hydrothermal activity, mineralization, etc., future explorationists could be tempted to reopen the tunnels leading to the repository in search of the mineralized rock. It would be very difficult and probably impossible, to hide the location of the tunnels from professionals having the technology to drill deep exploratory holes. Detailed seismic, air photo, shallow drilling, or other methods could be used to search out and discover the tunnels, which then could be reopened and rehabilitated. Reopening would clearly involve a first-order breach of the integrity of the repository.

If rock with geochemical and/or mineralogical features suggestive of nearby mineralization were to be excavated, the repository tunnels could conceivably serve as a staging area for drilling, etc., to explore for nearby mineralization. Most likely, such hypothetical mineralization would be below, rather than above, the level of the proposed repository. If geochemical or other distal indications of possible mineralization are encountered in the tunnels and/or deep boreholes, consideration should be given to evaluating these possible deep targets by drilling or other means. If meaningful indications of potentially economic mineralization are found by such a program, then this would provide one more reason that the site should be disqualified.

A general impression from the review is that the sections on geochemical, geophysical and particularly, geological assessments relative to mineralization are weak and not as well thought out as are those sections for geothermal and hydrocarbon resources.

We are concerned that the authors of the Study Plan do not include any of the U.S. Geological Survey geologists who are known for their work on the types of mineral deposits, particularly low-grade bulk-mineable Au+/-Ag deposits, present in areas near Yucca Mountain or which might possibly be present beneath Yucca Mountain. Two of the authors are known to have worked for many years formulating trade-tonnage models of various types of mineral deposits. While such expertise is important, extensive field or laboratory experience with mineral deposits of the type known or possibly present in the vicinity of Yucca is more important. The discussion intimates that the research group does not include an analytical geochemist.

An illustrative example of the obvious lack of general and local expertise and knowledge in economic geology by the USGS authors of this Study Plan is provided by Plate 1 of Bergquist and McKee (1991) which, in a modified form, was also presented to the Advisory Committee on Nuclear Waste in Las Vegas on October, 1992. On this plate, the Sterling mine, a well-known, producing sedimentary rock-hosted disseminated gold deposit, is shown as a polymetallic vein type deposit. Vein type epithermal Au-Ag deposits of low total sulfide adularia-sericite type in the southeastern Bullfrog Hills, including the major producing Lac (formerly Bond) - Bullfrog mine, are shown as hot-spring type Au-Ag deposits. Similar adularia-sericite type Au-Ag vein deposits in the northeastern Bullfrog Hills (Mayflower and Pioneer mines) are classified as polymetallic vein deposits. These are errors that experienced economic geologists would not commit.

The subdivision of work to assess the potential for mineralization and mineral resources into two parts "geochemical assessment" and "geophysical/geological appraisal" (p.2-1 - 2-5) is highly artificial and is contrary to the way that appraisals of the mineral potential of an area are normally carried out in the private sector. Geochemical data and geophysical/geological information clearly should not be segregated and evaluated independently of one another but rather must be closely integrated to arrive at a proper evaluation. Although the Study Plan clearly states that information will be closely shared between groups/tasks, this does not take the place of having a single group working with both geochemical and geological data. This artificial subdivision of efforts is underscored on page 3-2, where the various types of geochemical data that are to be obtained are listed. Many of these data, for example the petrographic, potassium-argon, argon-argon, and stable isotopic data are fundamentally geological in nature, and require a person with geological insight to both obtain the samples and interpret the data.

In addition proposed program of geochemical assessment is significantly outmoded relative to sampling methodology, analytical techniques, and interpretation. This appears to reflect: 1) an unfamiliarity, or at least a lack of practical experience, on the part of the authors with standard private-sector exploration geochemical methods and practice and 2) the fact that apparently none of the authors are practicing analytical geochemists.

The general design of the geochemical program as outlined in the Study Plan is focused on detailed surface sampling of rocks, soils, vegetation, etc. combined with the study of drill core and groundwater. As discussed above, we feel that the Study Plan is seriously flawed by the omission of any program of sampling of the exploratory tunnels. In addition, the program as outlined is not a cohesive plan to address the problem. A large percentage of the possible techniques that one can use for geochemical exploration, ranging from the use of panned concentrates to the sampling of certain plant species have been listed. No coherent plan for general systematic sampling followed by more detailed study in geochemically anomalous areas has been elucidated. Everything is going to be done using almost every possible technique that could be thought of. Finally, the discussion of the analysis of the data is typical of a research study and not a standard analysis of mineral exploration data collected and analyzed by an industry exploration team.

Perhaps more importantly, the program does not appear to explicitly take into account present geological knowledge. Although geochemical studies of the rocks exposed in the immediate area of the repository are far from systematic or comprehensive, many geologists have studied and sampled the area. From these observations it is reasonably clear that there is no evidence of hydrothermal alteration or other signs of hydrothermal activity visible at the surface. On the other hand, there is evidence for hydrothermal activity and mineralization in older rocks exposed in various areas both east and west of Yucca Mountain (e.g., Castor and Weiss, 1992). Also, a thin unit of siliceous sinter has recently been recognized on the northwest slope of Yucca Mountain between the Tram and Bullfrog Members of the Crater Flat Tuff (C. Fridrich, personal commun., 1993). For these reasons, we suggest that the surface studies focus on ash-flow and other units below the Topopah Springs Member of the Paintbrush Tuff.

The Study Plan appears to confuse the determination of initial or original geochemical features of the various units with estimation of background values. The determination of initial values requires careful sampling of the various units and various parts of compositionally zones units in areas where they have undergone the least post-depositional modification. On the other hand, estimation of background values, for the purpose of evaluating mineral potential, requires more systematic areal sampling, because the concentration data sought will include any and all post-depositional changes unrelated to hydrothermal activity and mineralization.

The amount of discussion devoted to geological studies is extremely modest compared to that for the geochemical and geophysical studies. We consider that geological considerations are of equal, or even greater, importance than are geochemistry and geophysics.

The Study Plan fails to include any maps showing the location of mines, mineral deposits, prospects, etc., in the vicinity of Yucca Mountain. Nor is there a map showing other mines in the southern Great Basin equivalent to the ones given, for example, in the section on hydrocarbon potential.

The Study Plan lacks an appropriate summary discussion of the mineral deposits present in the surrounding areas. A recent summary paper by Castor and Weiss (1992) appears to have been ignored, as are previous publications of the University of Nevada Reno that bear directly on geology and mineral deposits, for example, Noble et al(1992). Moreover, other types of mineral deposits such as non-metallic or aggregates that might be present at or near the repository site need to be discussed more completely.

In the Study Plan it is stated that it is impossible to indicate which mines and prospects will be visited for study. The reason given is that at present it is not known which mines will permit access to their properties. This is a specious argument, since all the mines in the area have in the past graciously granted access to any qualified group that asked. Moreover, even if access is at present not assured, it should in no way prohibit preparation of a list of deposits and prospects that should be examined.

SPECIFIC COMMENTS

In Section 3.1, p.3-1, the Study Plan considers the elements gold, silver, copper, lead, zinc, tin, mercury, thorium and uranium as important commodities. Of these, gold, is, at present, the metal of greatest economic interest in the region. Uranium and thorium would appear to have little possible importance in the Yucca Mountain area. On the other hand, lithium and beryllium have been omitted. Lithium in the form of hectorite (a Li smectite) apparently is highly sought after for cosmetics. Beryllium, as bertradite, is presently produced from late Cenozoic volcanic rocks at Spor Mountain in western Utah.. Although the type of slightly peraluminous "topaz rhyolite" which hosts and is related to Be mineralization at Spor Mountain is apparently not present in the southwest Nevada volcanic field, the possibility for economic Be mineralization is at least as great as that for economic Th and U mineralization. In addition, because of rapid advances in technology, minerals that may have no significant economic value today, could become very valuable in the future.

Under Section 3.1.1.1.1, p. 3-1 in the paragraph that addresses the surface sampling activity, the Study Plan mentions the collection of "grab" samples. As generally understood, "grab samples" consist of one or more pieces of rock taken from a given outcrop, etc. This is probably not the best way to carry out systematic surface rock sampling for mineral exploration or evaluation. What should probably be taken are so-called "chip samples", which consist of aggregates of small rock fragments taken from many outcrops over an area of from 25 to 500 square meters or more.

We are also concerned about the proposed program for the sampling of drill core. Typically, core sampling involves "splitting", that is subdividing the core (by diamond saw in the case of the Yucca Mountain core) and submitting a portion (typically one half or one fourth of the core) for analysis. Short, arbitrary lengths of the core, or portions of the core, are not normally taken in mineral exploration, although parts of the core may not be analyzed if the megascopically observable petrographic character of the rock strongly suggests that anomalous geochemical values are not present.

The last sentence in the first paragraph of Section 3.1.1.1, pg. 3-1, "For example, some of the silicic tuffs in the vicinity of Yucca Mountain may be sufficiently alkaline to warrant examination of their niobium, rare earth, uranium and thorium potential", seems to demonstrate lack of contemporary experience in applied economic geology. The Gold Flat Member of the Thirsty Canyon Tuff, is the most Nb, REE, U and Th rich unit of silicic tuff in the southwestern Nevada volcanic field (Noble, 1965). However, even this unit, which does not occur in the general vicinity of the repository site, does not contain nearly high enough concentrations of these elements to make it a potential economic source. In addition, the term "industrial minerals" is used several times without any details as to which of the large number of industrial minerals might be expected to occur at the repository site.

Section 3.1.5, pages 3-2 - 3-4 discusses geochemical analytical methods. Although the analytical methods for geochemical analysis outlined appear suitable, there would appear to be a problem in how these techniques are to be applied. Specifically, it would seen that the ICP-AES multi-element procedure of Lichte et al. (1987) is going to be used to screen large numbers of samples. From the way the Study Plan is written, it would seem that more sensitive methods (e.g., Motooka, 1988) would only be used as needed. It should be emphasized that the ICP-AES method has been shown to be inappropriate for recognizing low-level geochemical anomalies of the type that must be looked for to find buried mineral bodies, particularly epithermal Au-Ag mineralization. The detection limits for gold and other important "pathfinders" elements appear to be too high. Instead, the most sensitive methods available for detecting such critical elements as Au, As, Sb, Tl, Hg and Bi (e.g. Motooka, 1988) should be used routinely for both background estimation and anomaly detection. Moreover, in addition to the elements listed, tellurium (Te) should be determined using methods that are sensitive to a few hundred parts per billion. Finally, no mention is given of evaluating the possible presence of ammonium, which is known to occur in many altered rocks of high-level hydrothermal systems. Ammonium can be readily detected by spectral methods, using either hand-held or airplane or helicopter instrumentation.

Several sophisticated laboratory techniques, including K-Ar and Ar-Ar dating, fluid inclusion studies and stable isotope measurements are mentioned several times in the Study Plan. Although all are useful techniques with which to characterize and understand igneous and hydrothermal activity, nowhere in the Study Plan is any indication given as to how the methods are to be applied or how the resultant data will be utilized other than, implicitly, to "better characterize the site".

In Section 3.2, beginning on pg.3-6, the discussion of geophysical data appears to be more credible than that of the geochemical and geological sections. The names of the individuals involved in the preparation of the report include several individuals well known for the quality of their geophysical work in the southern Great Basin and elsewhere.

In Section 3.2.1, on pg. 3-6, it is proposed in the Study Plan that the airborne radiometric data obtained as part of the NURE program be reanalyzed and interpreted. This study will add little to the mineral resource assessment. If an adequate knowledge of possible anomalous concentrations of U, Th and K are desired, the area should be reflown on a close grid pattern and at very low elevation, using a helicopter, to obtain detailed data. Care should be taken to utilize instrumentation that has the ability to discriminate the effects of short-lived radionuclides produced by NTS surface testing and other activities.

It is stated in the second paragraph, last sentence on page 3-7: "Similarly, gold associated IP anomalies at Bare Mountain will also be traced eastward to Yucca Mountain, particularly in the vicinity of the magnetic anomalies near the proposed repository (Bath and Jahren, 1984)." The "gold associated IP anomalies" presumably refer to the Joshua Hollow gold occurrence. Considering the small size of disseminated gold deposits relative to the distance from Bare Mountain to Yucca Mountain, the above-quoted statement seems to demonstrate a lack of practical understanding of the geology involved.

In Section 3.2.5 on pg. 3-8, deep induced potential (IP) and audio magnetotelluric (AMT) surveys are proposed as methods for locating possible buried gold and silver deposits. There may be some question as to whether IP measurements can be effective in locating local concentrations of disseminated sulfides at depths equivalent to those of the proposed repository. It is our understanding that there is a trade off between depth and resolution with IP methods. It would seem likely that a deep, buried unoxidized deposit might not be resolvable. Moreover, it is our understanding that various magnetotelluric methods measure only resistivity, and that only IP methods can discern the chargeability produced by the presence of sulfides. The examples cited on p.3-8, particularly that at Joshua Hollow, are near-surface occurrences.

Even more troublesome is the fact that there are no IP anomalies related to gold mineralization at either the Mother Lode mine or the Joshua Hollow prospect. We have spoken to two geologists, S. Ristorcelli and S. Green, who have both worked in this area. (Steve Green is referenced as personal communication, 1987 on page 3-8, next to last paragraph.) Both are closely familiar with the geophysical work done at Mother Lode and Joshua Hollow. Contrary to what the Study Plan implies, both geologists stated that the only IP response is a very weak anomaly that is probably related to carbonaceous material in the sedimentary rocks. There is no IP anomaly related to mineralization. The Mother Lode mine was discovered by drilling, which in turn was directed by surface geological information, and the Joshua Hollow occurrence was discovered accidentally during drilling for water.

Section 3.5. pg. 3-29 - 3-36, outlines the procedures that will be utilized to evaluate the mineral potential of the Yucca Mountain area. We believe that utilization of these methods may be inappropriate for several of the following reasons.

First is the nature of the deposit models themselves. Certain models are oversimplified and/or incomplete. Some of the "standard" U.S.G.S. models (Cox and Singer, 1986; 1992), for example the Creede, Comstock and Sado types of epithermal precious metal deposits, are not utilized by most mineral deposits geologists (including many geologists of the U.S. Geological Survey).

Second, the grade-tonnage models of the U.S. Geological Survey are also subject to serious criticism. Specifically, the average grade and tonnage of deposit is a complicated function of metal price, ease of mining, amenability of the ore to metallurgical treatment, other production costs, economic and political factors, etc. Grades and tonnages utilized by the U.S. Geological Survey have been obtained at various times from published sources, some of which are old, and from various mining companies. An example of such confusion is provided by the recent updating of the sedimentary rock-hosted (Carlin type) gold deposit model (Mosier et al., 1992). Deposits containing oxidized ores are lumped together with deposits consisting largely or entirely of unoxidized (refractory) ore. Refractory ores require expensive milling and oxidation by roasting, treatment with gaseous chlorine, or pressure autoclaving whereas many oxide ores can be treated by much less expensive heap leaching methods. Therefore, although both oxidized and unoxidized deposits formed by the same general ore-forming process, an all-important practical economic consideration and presence or absence of later oxidation in large part controls the grade-tonnage data reported by producers. Therefore, we think the grade-tonnage model of Mosier et al., may be highly distorted.

Over the past several years the U.S. Geological Survey has received strong criticism and has been the subject of litigation from certain groups with regard to the application of its procedures for estimation of the size and number of undiscovered deposits of various types within potential wilderness areas (p.3-31 of the Study Plan). It would seen unwise to base such an important matter as the mineral potential of the repository on a procedure that is highly controversial.

REFERENCES

In general, the references for the geochemical and geological parts of the Study Plan are inadequate. The geophysics and geothermal sections would appear to be much more adequately documented.

Major shortcomings include almost complete lack of primary citations for the mineral deposits of both the region surrounding the repository site and the entire southern Great Basin. Moreover, there is a conspicuous lack of citations of important specific and general papers on the types of precious metal and other types of deposits that might be present in the Yucca Mountain area. Virtually the only citations are to various descriptive and grade and tonnage models as presented in Mineral Deposits Models, U.S. Geol. Survey Bull. 1693, 1986, and subsequent additions and modifications. Although these short, summary publications contain useful information, they are in no way equivalent to the many important scientific contributions that have appeared in the scientific and professional literature over the past decades. As mentioned above, certain of the classes of deposits proposed by the U.S. Geological Survey are not in general use.

A similar restriction to publications of the U.S. Geological Survey is apparent for geochemical analysis methods. However, this is perhaps not as serious because the personnel and analytical methods of the U.S. Geological Survey are, in general, of high quality.

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