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**Fluid inclusion studies of samples from the Exploratory Study
Facility, Yucca Mountain, Nevada**

By: Yuri V. Dublyansky, Ph.D.

Foreword

By Arjun Makhijani

In July 1998 IEER commissioned Dr. Yuri Dublyansky of the Siberian Branch of the Russian Academy of Sciences to prepare and study mineral samples that he collected in the previous month from the Yucca Mountain tunnel in Nevada. This five-mile tunnel has been drilled to study the suitability of the site for disposal of spent fuel from US nuclear power plants and highly radioactive waste from military plutonium production. Dr. Dublyansky is a geologist who specializes in fluid inclusions in minerals.

Fluid inclusions are small amounts of liquid and/or gas trapped in tiny cavities in mineral deposits. Study of these inclusions can yield information about whether an underground area had been dry or saturated in the past. When analyzed using isotopic dating techniques, such inclusions can also be used to estimate the date(s) in the past when water may have entered a particular area. It should also be possible to distinguish whether the water entered into the repository zone as a result of percolation from above or an upwelling from below. Finally, estimates can also be made of the temperature of the water.

Water is expected to be the main pathway by which the radioactive materials in spent nuclear fuel and other highly radioactive waste would reach the human environment. Water is also a principal means by which the containment of the wastes may become compromised. Hence, the question of whether a repository location has been dry or saturated in the past is an important one. This is especially the case when metal canisters are to be used in an oxidizing environment, as the Department of Energy is proposing to do at Yucca Mountain.

IEER's purpose in commissioning this report was to enable an independent assessment of these crucial questions. This study will help concerned policy-makers and the public to examine independently collected evidence important in evaluating the official study of the Yucca Mountain site, known as the Viability Assessment, which is to be issued in December 1998.

There has long been a controversy as to the presence of groundwater at some time in the past in the region of the proposed repository. This controversy has not yet been resolved. It is of the utmost importance to resolve it, since the presence of warm or hot water in the repository would change considerably the assessment of its suitability. For instance, technical details of the Viability Assessment revealed so far show that the DOE will be relying heavily on the integrity of the canisters containing the

wastes over tens of thousands of years to keep long-lived radioactive materials out of the groundwater. But under saturated, warm conditions these canisters could deteriorate very rapidly. Dr. Dublyansky's study does not resolve all the questions and should be regarded as preliminary. But its findings are very disturbing and call for careful and intensive further work, especially as regards the age of the formation of the minerals in which the fluid inclusions have been found.

The subject matter is as complex as it is important. Questions relating to the management of long-lived radioactive wastes are among the most difficult that we face. The science is difficult enough. If it is confounded with opportunistic politics, as it has been throughout the DOE repository program, it will be impossible to make the sound technical judgments that are necessary to protect future generations. IEER's previous work has discussed many reasons that DOE's repository program should be terminated, not least because of the severe institutional problems in its management. Further, the radiation doses estimated for Yucca Mountain, should the groundwater become contaminated, have been far higher than for other sites that have been studied. The fact that historical claims of Native Americans to the land are not an important part of the official evaluation of the site or of the broader debate about it continues to be very troubling. But we have not before this time issued a special report dedicated to the specific issue of the geologic suitability of the Yucca Mountain site.

We have had Dr. Dublyansky's report extensively reviewed by independent scientists unaffiliated with the Yucca Mountain program as well as by scientists who are one way or another involved in evaluating that effort. We sent a draft copy of Dr. Dublyansky's report to Dr. Lake Barrett, Acting Director of the Office of Civilian Radioactive Waste Management (OCRWM), so that scientists of his choosing could review it. Generally, the reviews found Dr. Dublyansky's work to be of exemplary quality. The one exception was the review arranged by the DOE and compiled by Joe Whelan.¹

I have worked closely with Dr. Dublyansky to ensure that all comments, including those made by DOE-selected reviewers, have been carefully addressed on their merits. When warranted, Dr. Dublyansky has made changes to his draft report. In other cases he has provided clarifications and additional explanations. Of course, since he is the author of the study, he has had the normal prerogative of making the judgment of how each review comment should be addressed.

One of the most interesting things about the DOE-arranged review compiled by Joe Whelan is its misrepresentation of some of the reviewers own data regarding certain mineral deposits at Yucca Mountain. As one who has had occasion to review many studies, I also found the *ad hominem* tone of some of the remarks highly inappropriate. This was not a final report we sent for review. It was a draft, sent out for review in the full expectation and commitment that we would take reviewers comments seriously. The *ad hominem* comments were therefore completely uncalled for and are not in keeping with normal scientific discourse. Despite the personal innuendoes, gross misreading of evidence clearly presented in the report, and misrepresentation by the reviewers of their own data, IEER has worked to treat their comments fairly. To enable the public to see all the evidence, IEER is going to the extraordinary length of publishing some of the reviews, including the DOE-arranged review compiled

¹ Joe Whelan, James Paces, Brian Marshall, Zell Peterman, John Stuckless, Leonid Neymark (all of the US Geological Survey) and Edwin Roedder (Harvard University), "Review of 'Fluid Inclusion Studies of Samples from the Exploratory Studies Facility, Yucca Mountain, Nevada,'" forwarded to IEER with a cover memo by Joe Whelan to Dennis Williams, dated November 9, 1998 and a cover letter from J. Russell Dyer to Dr. Arjun Makhijani, dated November 13, 1998. Review "compiled by" Joe Whelan.

by Joe Whelan. A reply by Dr. Dublyansky on a point-by-point basis to the DOE-arranged review is also published in an appendix to this report.

The DOE has an unfortunate history of rushing into large projects with huge budgets and jumping to conclusions about them before the scientific work is complete.² This Yucca Mountain project is no exception. The Department claims that it has completed work on assessing the viability of Yucca Mountain as a repository site. Yet, at the same time, it is preparing to conduct joint sampling and study of the critical issue of fluid inclusions (the subject of this report) with Dr. Dublyansky. The DOE-appointed reviewers of this report, while highly critical in their detailed remarks, agree that further work is warranted:

Although we question Dublyansky's science and biases, we cannot reject his fluid inclusion data out of hand. Despite the fact that calcite is a notoriously difficult mineral for fluid inclusion studies, those difficulties are surmountable with care, and Dublyansky claims to have taken all reasonable precautions in conducting his studies. The fluid inclusion data should therefore be verified...and the timing of their formation should be constrained by isotopic dating of the host minerals.³

Dr. Dublyansky's recommendations are very similar. He does not claim to know the date of the mineral deposits that have the fluid inclusions studied in this report. That remains to be established. Other crucial facts, such as the presence of high molecular weight hydrocarbons in a few samples, provide further indicative, though not definitive, evidence of water ingress into the Yucca Mountain repository location. Further work is also needed in this respect.

Dr. Dublyansky's work has impressed the independent reviewers immensely. These reviewers, who have never before done any work with IEER, concurred in their evaluation of the high quality of the report and the research on which it is based. One of them, Professor Larry W. Diamond, of the Department of Mineralogy and Petrology, Institute of Earth Sciences in the University of Leoben in Austria, conducted an independent evaluation of some of the mineral samples. It is also noteworthy that the principal expert on fluid inclusions of the Congressionally-mandated Nuclear Waste Technical Review Board, Dr. Robert Bodnar, reassessed some of his previous opinions of the subject after he worked with Dr. Dublyansky in June 1998 and had a chance to study some of the samples Dr. Dublyansky had taken in 1995. In a letter to the NWTRB, dated July 8, 1998, Dr. Bodnar agreed that elevated-temperature fluid inclusions were present in the samples and that they were not artifacts of the preparation of the samples. Further, he found evidence, though not conclusive, of the presence of aromatic hydrocarbons. Finally, he also recommended further sampling and study.⁴

When Dr. Dublyansky visited Nevada earlier this year, he discussed the subject of a joint sampling program with DOE and the US Geological Survey. There was interest on the part of some scientists but the USGS refused to go ahead with it.

² IEER analyzed this tendency in DOE's Environmental Management program in a report by Marc Fioravanti and Arjun Makhijani, entitled [*Containing the Cold War Mess*](#), published in October 1997.

³ Joe Whelan to Dennis Williams, memorandum regarding review of Yuri Dublyansky's report, November 9, 1998.

⁴ Robert Bodnar to Leon Reiter (Nuclear Waste Technical Review Board), letter dated July 8, 1998.

Dr. Dublyansky collected his own samples from the Yucca Mountain tunnel in June 1998. The locations have been marked and bar-coded by the Yucca Mountain Characterization Project. The present study is based on data derived from that sampling.

The DOE will be making a grave technical mistake if it declared Yucca Mountain to be a viable site, as it seems set to do later in December 1998, before this crucial issue is resolved. Such a finding, issued in the face of considerable agreement about the need for further examination of fluid inclusions would be at variance with sound scientific practice.

IEER believes that it is crucial that a joint sampling program be established, that careful joint studies be done, and that they be subjected to truly independent review. Draft findings should be presented to the public with the underlying data so that the broadest possible scrutiny is possible. This will likely take two years or more. The issuance of the Viability Assessment should be put off until that time.

Given the many problems with Yucca Mountain, and the possibility that these joint studies will yield further negative findings for the suitability of Yucca Mountain as a repository, it would be prudent for the DOE to begin making back-up plans for long-term management of spent fuel and military high-level waste. The DOE has typically failed to provide any insurance for many of its key programs, resulting in higher expenditures, greater delays, and larger environmental risks. IEER has put forward such a plan, but the DOE has ignored it.⁵ We believe that it is high time for the DOE to address our specific recommendations.

Financial support for IEER's work on nuclear waste (including DOE's Yucca Mountain program) and other environmental and security issues related to nuclear weapons and nuclear power is provided by support from individual donors and the Beldon II Fund, the C.S. Fund, the DJB Foundation, the HKH Foundation, the John D. and Catherine T. MacArthur Foundation, the John Merck Fund, the New Land Foundation, the Ploughshares Fund, the Public Welfare Foundation, the Town Creek Foundation, the Turner Foundation, the Unitarian Universalist Veatch Program at Shelter Rock, and the W. Alton Jones Foundation. Their generous support makes our independent work and outreach possible. We hope and expect that Dr. Dublyansky's report will initiate a new and more scientifically thorough phase of work on one of the most vital environmental issues that we all face.

Arjun Makhijani, Ph.D.
President, IEER
Takoma Park
November 25, 1998

The [full report and additional resources](#) are available online

⁵ See *Science for Democratic Action*, [Vol. 6, No. 1](#), May 1997.