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Statement of Yuri Dublyansky
IEER Press Conference
December 1, 1998, National Press Club

My name is Yuri Dublyansky, and I am Senior Scientist at the Institute of Geology, Geophysics and Mineralogy of the Siberian Branch of a Russian Academy of Sciences. My field of expertise is fluid inclusions in minerals. I have been studying Yucca Mountain since 1994. Initially I did so as a consultant to the State of Nevada.

According to the current concept a repository is proposed to be constructed within the unsaturated zone of Yucca Mountain that is, in relatively dry rocks, far above the water table. Regulations require that the repository ensures safe containment of radionuclides for at least 10,000 years. Peak radiation doses are expected to occur on far longer time scales. In order to be able to forecast repository performance in the future, we need to carefully understand the geologic history of Yucca Mountain.

The concept of a high-level nuclear waste repository at Yucca Mountain critically relies on the assumption that the repository zone will remain unsaturated during the time period required for protection of the public (on the order of tens of thousands of years). Therefore, an indication that the mountain may have been saturated in the geologic past would be very troubling.

The first doubts regarding the long-term stability of the unsaturated zone at Yucca Mountain were raised as early as 1987 by the DOE Yucca Mountain Project staff geologist J. Szymanski. His hypothesis regarding the possibility of excursions of thermal waters into the currently unsaturated zone was criticized and eventually discarded by a National Research Council Panel in 1992.

The DOE and its contractors remain publicly confident that Yucca Mountain has been unsaturated for millions of years and therefore that the future stability of the unsaturated zone is reasonably assured for the relevant time periods. Specifically, according to the DOE, the unsaturated zone at Yucca Mountain was formed 9-10 million years ago and since that time the water table has never risen more than about 300 feet above its present level (which is 1000 feet below the planned repository horizon). Therefore, any flooding of the repository in the future is deemed unlikely.

A potential stumbling-block for the DOE-endorsed concept was discovered during extensive exploration drilling at Yucca Mountain. Cores recovered from boreholes often contained veinlets of calcite - a mineral which is practically always formed by precipitation from water. These veinlets represented "footprints" of ancient waters that moved inside the mountain in the past. In 1995-1997, when a 5 mile-long tunnel (called Exploratory Study Facility or ESF) was excavated into Yucca Mountain, many more occurrences of secondary minerals became available for study.

DOE researchers interpreted this calcite as being deposited in the unsaturated zone by rain water percolating through interconnected fractures and carrying dissolved calcium carbonate from overlying soils. Calcite was extensively studied in terms of its stable (carbon, oxygen) and radiogenic (strontium, uranium, thorium, lead) isotope compositions to determine its origin. The problem with this methodology is that isotopic methods, on their own, are not capable of distinguishing between different origins of minerals. The only method which can provide unequivocal determination of the origin - the fluid inclusion method - has never been adequately applied in the DOE studies

Fluid inclusions are tiny vacuoles in minerals, filled with the liquids from which minerals grow. If these fluids are trapped and sealed at elevated temperatures, upon cooling to ambient temperature they form tiny bubbles inside them. This stems from the physical properties of liquids and solids: on cooling liquids trapped in the inclusion contract faster than surrounding solid, the pressure in the vacuole decreases and at a certain point homogeneous liquid (e.g., water) splits onto two phases: liquid and vapor. This process is reversible: if we heat such inclusions, the pressure inside will increase and at some temperature, the bubble will disappear and fluid will become homogeneous. This temperature reflects the temperature of the liquid from which the crystal grew. Inclusions in minerals formed at low temperatures (less than ~35-40^{o}C) do not contain bubbles.

In June 1998, I collected samples covering all 5 miles of the ESF tunnel, and in October I conducted a study on the fluid inclusions in them. The report that we release today presents the results of this study.

Examination of calcite samples from the ESF tunnel leads to two principal conclusions:

- the studied calcite was formed by upwelling of water and not from percolation of surface water; and
- the water that entered the Yucca Mountain repository area in the past from below was at elevated temperatures.

The main evidence for these findings is as follows:

1. Many fluid inclusions in samples from the ESF had vapor bubbles formed in them. I obtained about 300 measurements of fluid inclusion temperatures, which indicate temperature of ancient water of 35 to 75^{o}C. Water with such temperature could not have come from surface sources.
2. In a few samples, traces of aromatic hydrocarbons were found in all-gas inclusions. Aromatic hydrocarbons are heavy molecules that could not have originated in surface sources. There is evidence of hydrocarbons (natural gas) in the geologic media beneath Yucca Mountain area. Hence, the trapped hydrocarbons provide supplementary, though at present fragmentary, evidence of upwelling of water into the repository horizon.

3. Veins and crusts at Yucca Mountain contain other minerals in addition to calcite, such as opal, quartz, and minor fluorite. These minerals typically precipitate from warm or hot water. In particular, it is extremely rare for quartz and fluorite to be formed from surface water percolation. Hence, the presence of these minerals is strong evidence of past presence of upwelling warm water in the Yucca Mountain area.
4. Minerals formed in an unsaturated zone, that is, above the water table, are typically deposited in laminated formations consisting of millions of tiny crystals. For example, stalactites in caves are created in this way. By contrast, large perfectly shaped crystals require a saturated environment to form. The calcite at Yucca Mountain often forms perfectly shaped individual crystals up to 1.5 cm in size, clearly indicating that the mountain was, at some time in the past, saturated.

My study also addresses the question of the age of the calcites, though in less detail. The timing of the formation of the calcites is important because it provides evidence of when the area was saturated and hence of the probability of its becoming saturated in the future during the period relevant to repository performance. The findings of my research for the timing of past repository saturation are only tentative and indicative. There are indications that the calcite may have been formed in the recent geologic past (less than one million years ago). This is a very complex and difficult area of work and considerable further research is needed to clarify this crucial question.

The issue addressed by my research has direct and significant bearing on the viability of the site as a potential host for the high-level nuclear waste repository. The critical questions remaining to be resolved are:

- When did the upwelling happen?
- Did it happen as a one-stage process, or did water rise and recede intermittently?
- If the upwelling occurred in pulses, what was the recurrence period of these pulses and what was the duration of each pulse?
- How much water was involved?
- What was the spatial distribution of this upwelling?
- What was the cause of the upwelling?

Only when all these questions have been satisfactorily answered can we address the ultimate question:

- Could the repository become submerged again in the future on time scales comparable to those during which radiation doses could be significant?

Without these answers, any assessment of the site viability will necessarily be incomplete. It is clearly premature at present to declare the site viable.

More data need to be acquired and analyzed in order to assess the implications of the new findings for repository viability. This may be accomplished through concerted efforts of researchers, involving:

a. Detailed fluid inclusion studies in calcite and other minerals from Yucca Mountain. Such studies may provide important information on the spatial structure of the ancient hydrological system;

b. Careful dating of calcite samples hosting fluid inclusions indicating elevated entrapment temperatures, which would constrain timing of ancient hydrothermal system; and

c. Detailed isotopic study of minerals, which could provide important information on the origin of fluids and pattern of fluid migration. Saturation of the Yucca Mountain repository after burial of highly radioactive waste could cause the waste canisters to corrode far more rapidly than if the mountain remained dry allowing the radioactive materials to be carried away. Because of the great threat to the environment and to human health that would be posed by such a situation, further study is absolutely necessary.

The full report and additional resources are available online