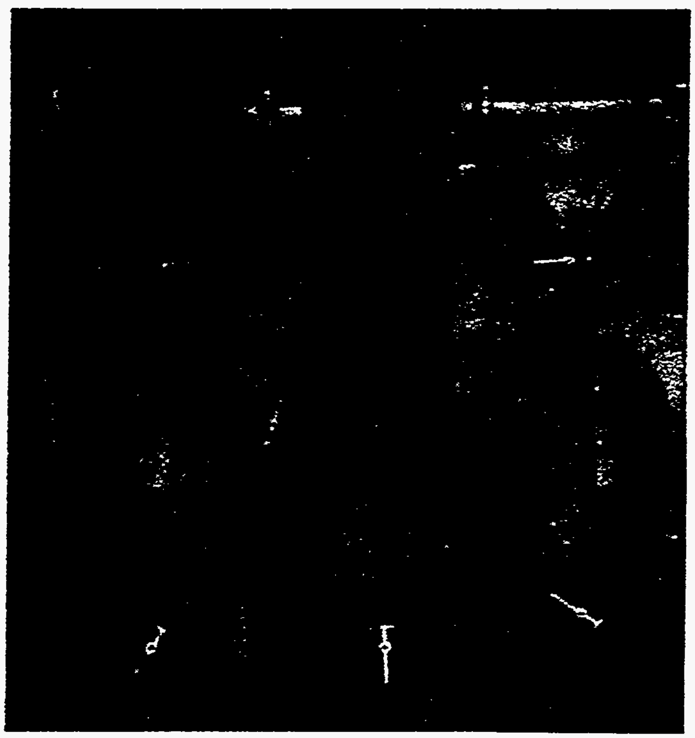
EM

INEL-96/00079

CONF-9606116--80

DOE Spent Nuclear Fuel and Fissile Material Management



June 16-20, 1996 • Reno, Nevada

THE 10,000-YEAR DEBATE

by James R. Wilson
Idaho National Engineering Lab
Box 1625, MS-3412
Idaho Falls, ID 83415

ABSTRACT

Probabilistic Risk Assessment (PRA) has developed into a respected tool within the reactor community. Now, this PRA technique is being applied to a new arena, the distant future of the nuclear waste repository. Problems are already testing the credibility of PRA.

1. UNCERTAINTY IN TIME AND POPULATION

The distant future is very difficult to predict. For example, uncertainties include the geohydrological conditions, the laws and form of government at that time, the type of surface activities, and subsurface exploration. In addition, population distribution, water usage and sources, water testing capabilities and remediation abilities are very uncertain.

Therefore, the National Academy of Sciences (NAS)[1] recommended that future repository risk be based on consequences only, to reduce the uncertainties and modeling complexities.

However, no probability cutoff was specifically mentioned in the NAS report. Without a probability cutoff, no bounding accident exists. For example, the following scenarios could be postulated:

1) A large meteorite impacts the repository shortly after closure, aerosolizing 10% of the fission products

2) A future tenant-government having sovereignty over the repository land does underground nuclear bomb testing (or whatever the future weapon would be) and a breach to the surface occurs, aerosolizing 10% of the repository fission products

Obviously, the list of postulatable scenarios is endless, with more believable ones than mentioned above. If no probability cutoff exists, the postulated consequences would exceed any reasonable acceptability criteria and any implementable engineered safeguards.

One proposal has been that the regulator must specify scenarios, to avoid the incredible ones. Such overprescriptive regulation has proven to be very expensive and complicated in the past. Legislation should not attempt to address highly technical issues that the technical community is still wrestling with.

A probability cutoff of 10^{-8}/year was suggested in 40CFR 191,[2] which is now restricted to the WIPP repository in New Mexico. Efforts are now underway to get some form of probability cutoff into the new regulations going through Congress and the EPA for the High Level Nuclear Waste Repository.

The 10^{-8}/year cutoff is a step forward, but it has not been adequately tested by PRA community and peer review bodies. The problem with specifying a cutoff before determining its achievability was demonstrated in the 10^{-6}/year cutoff originally selected as a design goal for nuclear reactors. For years PRA analysts tried to stretch their art to meet this incredible goal, and the Advisory Committee on Reactor Safeguards exposed their weaknesses. Eventually, approved reactor PRAs admitted to accident frequencies as high as 10^{-3}/year.[3]

The repository PRA community also needs time to determine a credible probability cutoff.

Unfortunately, the NAS also recommended extension of the previous 10,000-year repository mission time to one million years. Part of their justification for going so far into the future was "reasonable geologic stability."

The problems with analyses one million years in the future are discussed elsewhere,[4] but may be briefly summarized as geological dating uncertainties and extrapolation of trends.

2. GEOLOGICAL DATING UNCERTAINTIES

Frequently, geologic events are assigned dates for which uncertainties are presumed to be very small in spite of great variability between methods. For example, Table 1[5, 6, 7, 8, 9] is an illustration of the variability of geological dating for the basaltic rocks of the Uinkaret Plateau on the lip of the Grand Canyon.

The variation between methods used in Table 1 is quite large, but the uncertainty assigned to each method is quite small. For instance, the K-Ar uncertainty is 3% to 17%. But the small uncertainties stated are misleading: One experimenter in a radiometric dating lab privately stated that 50% of the K/Ar results are discarded -- and never reported -- in order to preserve the apparent accuracy of the method (When this experimenter was encouraged to document his experience, he refused, in fear of being blackballed from the industry). This was qualitatively confirmed by McDougall: "The criterion for exclusion of a datum was that the calculated age differed by more than twice its error (2σ) from that of the plateau."[10] And, what else should be expected but small uncertainties when the uncertainties are calculated after the outliers are discarded, based upon the expected uncertainties?

A geologist can look at these dates and pick the "right" method because he "knows the approximate date." And that approximate date is based upon similar selection processes elsewhere, ad infinitum. For the most part, their conclusions tend to cluster, and they have ample reasons for throwing out any dates that don't conform to their expectations.[11] But, subjectivity and circular reasoning are involved in this approach, and disagreements do arise. This may work well amongst peers, but such circular reasoning and subjectivity will be very easy to attack in the licensing process.

3. EXTRAPOLATION OF TRENDS

An implicit assumption in extrapolating past history to predict the future is the hypothesis of Uniformitarianism (i.e., that past and future processes proceed at current rates using current mechanisms). Catastrophes are by nature unpredictable.

For some catastrophes, we haven't even decided upon the cause, much less the return period. For example, one theory is that the last ice age was caused by a reduction (or increase!) in solar output. The model allows an increase in solar output to increase evaporation and snowfall, adding to the polar packs and further increasing the surface reflectance of the earth (albedo).

A second ice age theory is that increased vulcanism could have both brought the earth into an ice age, by solar obscurance, and warmed the earth later by greenhouse gases. A third ice age theory is that ice ages are caused by earth's orbital relation to the sun. Indeed, over 60 theories have been proposed to explain the Ice Age, all with serious difficulties.[12] The uncertainty in a predictive model incorporating all 60 theories would be huge.

Source	Date (years)
American Indian Legend	few thousand
K-Ar	10,000
K-Ar	1.2 ± 0.2 million
K-Ar	117 ± 3 million
Stratigraphic controls	low thousands to a few million
Rb-Sr Isochron	1.34 ± 0.04 billion
Pb-Pb Isochron	2.6 ± 0.21 billion

Table 1: Dates for Volcano on Grand Canyon Rim

Even if we did find a group of geologists who could consistently and unarguably date all matters having to do with the past earth, agreeing on mechanisms and models as well, they could not guarantee that new mechanisms wouldn't be introduced in the future.

The boundary between historic/prehistoric times occurred between 5,000 and 6,000 years ago. Since then, man has progressed from a creature that was dominated by his environment into a being that can destroy his environment. Given a similar change in man's technology and effect on the environment for the next 5,000 years, predict groundwater flow paths, human/environment interactions and individual doses. For example, people of the future may be living in multi-story underground apartment complexes in the vicinity of the repository. Now, multiply these projected changes by two for a 10,000-year repository horizon, or by 200 for a million-year horizon.

Another example of the difficulties in predicting earth's future is that the one-time proponent of global freezing[13] is now a main proponent of global warming[14] (and his credibility and popularity has not suffered!) In fact, though most climatic scientists do not support his theories, most of the public do!

This touches upon another factor in this difficult issue. The audience isn't only technical people, but the public at large. Thus, any technical arguments must be conservative enough to defend against unreasonable challenges (e.g., nontechnical, indefensible, yet popular). The technical playing field is constrained on one end by the excessive conservatism that must be used to satisfy nontechnical people and constrained on the other end by goals made all the more difficult by this conservatism.

4. LICENSING DIFFICULTIES

Because repository issues will be debated within a legal context, some nonscientific considerations must be dealt with here:

1) In June, 1993, the Supreme Court struck down the rule of evidence that scientific testimony must be widely or generally accepted among scientists or published in peer-reviewed journals. Now, the nonscientist must judge what constitutes scientific proof.[15]

2) The scientific basis for geohydrological models were argued in court in 1991 hearings for the candidate low-level nuclear waste site at Martinsville, Illinois[16] and in 1992 State of Nevada hearings on a water permit for site characterization at Yucca Mountain.[17] In both cases, the models were rejected as scientists lined up on both sides of the issues.

Scientists may desire to leave no rock unturned in their pursuit of knowledge, out as many years as curiosity dictates. However, they cannot allow a nonscientific process to hold a scientifically-necessary repository hostage just because the constantly changing rules of "legal truth" haven't yet been satisfied.

5. PROPOSAL

Because of these difficulties, I make the following proposals:

1) Within a licensing context, we should deal with initiators that can occur within 10,000 years (during which a probability cutoff, similar to the old 10^{-8}/year, would be applied). This will allow our technical work to be more defendable, "stretch the art" a little, and provide the necessary measure of confidence in the thoroughness of the study.

2) Once a scenario is started, the consequences of that scenario may be followed out to its peak. This may also be presented in a licensing context.

3) If further events beyond 10,000 years are analyzed for information purposes, they may be presented, but it would not be required by the licensing criteria.

4) Stricter licensing criteria should be delayed until our confidence in our modeling and predictive capabilities increases. No purpose is served by prematurely tightening the licensing criteria so much that our technical tools lose credibility.

We have seen in the past the vast resources wasted on premature conclusions in risk assessments (e.g., the dioxin and alar scares,[18] formaldehyde/insulation removal). We cannot always predict true risk, but experience teaches us that we tend to be conservative, both because science requires it and fear of the unknown tends toward it. However, painful experience has taught us that simply pouring vast resources into the latest "hot topic" under study, without consideration of cost-benefit or relative risks, is poor stewardship of public funds.

ACKNOWLEDGEMENTS

Prepared for the U.S. Department of Energy Assistant Secretary for Environmental Management (EM) under the DOE Idaho Operations Office Contract DE-AC07-94ID13223.

References:

1. Technical Bases for Yucca Mountain Standards, Board on Radioactive Waste Management, National Academy Press, Washington, D.C. (1995).

2. 40CFR 191, Appendix B, Guidance for Implementation of Subpart B (1985).

3. V. Joksimovich, "A Review of Plant Specific PRAs", Risk Analysis, Vol. 4, #4 (1984).

4. James R. Wilson, "Problems with Distant Horizons," ESREL'96 - PSAM-III, June 24-28, 1996, Springer London Limited, Crete, Greece (1996).

5. Reynolds, S. J., et al., "Compilation of Radiometric Age Determinations in Arizona," Arizona Bureau of Geology and Mineral Technology Bulletin 197, p. 8 (1986).

6. E. D. McKee, W. K. Hamblin, and P. E. Damon, "K-Ar Age of Lava Dam in Grand Canyon," Geological Society of America Bulletin, 79, January 1968, pp. 133-136 (1968).

7. P. E. Damon and others, "Correlation and Chronology of the Ore Deposits and Volcanic Rocks," U.S. Atomic Energy Commission Annual Report, No. C00-689-76, p. 82 (1967). Olivine is not considered a suitable mineral for K-Ar dating.

8. Dr. Steve Austin, Editor, Grand Canyon: Monument to Catastrophe, ICR, (1994).

9. C. Alibert, "Isotope and Trace Element Geochemistry of Colorado Plateau Volcanics," Geochimica et Cosmochimica Acta, Vol. 50, pp. 2735-2750 (1986).

10. Ian McDougall, "$^{40}Ar/^{39}Ar$ Age Spectra from the KBS Tuff, Koobi Fora Formation," Nature 294, November 12, 1981, p. 123 (1981).

11. G. Faure, Isotope Geology, Wiley and Sons, New York, New York (1986), is a popular textbook that gives a very good discussion of the weaknesses of each dating technique, including all the accepted reasons for throwing out displeasing results.

12. M. L. Lubenow, Bones of Contention, Baker Book House, Grand Rapids, Michigan (1992).

13. S. Schneider and L. Mesirow, *The Genesis Strategy: Climate and Global Survival,* Plenum, New York, New York (1976).

14. S. Schneider, *Global Warming: Are We Entering the Greenhouse Century?* Vintage, New York, New York (1989).

15. U.S. Supreme Court, Ruling on William Daubert and Joyce Daubert, Individually and as Guardians Ad Litem for Jason Daubert, and Anita De Young, Individually and as Guardian Ad Litem for Eric Schuller, Petitioners, v. Merrell Dow Pharmaceuticals, Inc., Respondent, The United States Law Week, 6-29-93, 61 LW 4805 (1993).

16. Illinois Low-Level Radioactive Waste Disposal Facility Siting Commission, Commission Deliberations in the Matter of the Safety and Suitability of the Martinsville Alternative Site, October 9, 1991 (Recorded by Wolfe, Rosenberg & Associates, Inc., 188 W. Randolph St., Chicago, IL 60601, 1991), 104 pp (1991).

17. Department of Conservation and Natural Resources, State of Nevada, Ruling in the matter of Application 52338 filed to appropriate the waters from an underground source within the Forty Mile Canyon-Jackass Flats Groundwater Basin, Nye County, Nevada (March 1, 1992), 52 pp (1991).

18. Dixy Lee Ray and Lou Guzzo, Trashing the Planet, Harper Perrenial, New York, New York (1992).