Community Relations

Book 1

The Rulison Project in Retrospect

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The Rulison Project in retrospect

by Paul Haas

A number of problems—technological, economic, political, and legal—must be overcome before commercial application of the Plowshare gas stimulation technique will be possible. A question of paramount concern throughout the development program has been and will continue to be that of public safety. Obviously, testing and eventual commercial application is not possible without assurance that all reasonable steps have been taken toward protection of the public from hazards. This problem is the primary interest of this article. Looking, in particular, at the controversial Project Rulison, which I have investigated, I will attempt to draw conclusions concerning the potential hazards, the measures taken by the government-industry sponsors to protect the public, and the questions and objections raised by opponents of the project.

The Rulison controversy

Project Rulison was a cooperative effort by the United States government, represented by the AEC and the Department of Interior, in "partnership" with the Austral Oil Company and its manager-consultant, CER Geonuclear Corporation, with the general objective ". . . to determine the potential of nuclear stimulation for commercial development of low permeability gas fields."[1] Specific technical objectives were to:

- Measure changes in gas production produced by the nuclear explosion.
- Measure the effective flow capacity of the nuclear fracture zone with time and decreasing reservoir pressure.
- Determine the gas quality with regard to contamination and possibly indicate techniques to reduce contamination.
- Identify effective height and volume of chimney and effective fracture zone radius as determined by production testing.
- Evaluate seismic effects produced by detonation to provide information for future shots in the Rulison field.

The safety hazard associated with an underground nuclear blast such as Rulison can be categorized into two broad areas: radioactivity effects and seismic effects. Potential methods of radioactivity release to the public include:

- Venting of radioactive material at the detonation point, either at the time of explosion or later at the time of reentry to initiate processing.
- Contamination of ground water that may be transported from the site and consumed directly or introduced into the food chain.
- Contamination of the product.

Seismic damage to surface and subsurface structures may prove to be a more severe limitation on the widespread industrial application of contained underground explosions than the radiological hazard.

The potential hazards mentioned above aroused fears in numerous individuals and groups concerned with public safety and danger to the environment, and eventually produced a controversy that became Colorado's top news story of 1969 and drew considerable national attention.

Probably the foremost critic—certainly the most publicized—was H. Peter Metzger of the Colorado Committee for Environmental Information. He and two other scientists on the committee, Robert H. Williams and Edward A. Martell, brought the already simmering controversy to a boil with their statements beginning in late July of 1969 proclaiming the hazards associated with Rulison. These three claimed the AEC had not made clear to the public the dangers present and had not done enough to assure the public safety. They frequently expressed fears of the seismic effects and the long-term hazard of the flaring of radioactive gas. They indicated danger from tritium and krypton-85, the principal gaseous contaminants, directly to the public and indirectly through introduction into the water or the food chain. One very significant point underlying all of their expressed fears, and pointed out in each of their protests, was the fact that Rulison was only one test shot—that the real danger lay in the fact that more test shots and ultimately a very large number of explosions might follow if Rulison proved to be successful and commercial operations were initiated. They asserted the hazard was directly proportional to the total yield, or to the total number of blasts.

A number of other groups became actively involved in the protest against the Rulison shot, including the Colorado chapter of the American Civil Liberties Union (ACLU), Citizens Concerned About Rulison (an *ad hoc* committee of citizens in the Denver area), and People United to Reclaim the Environment (PURE), who indicated civil disobedience might be necessary to halt the shot. Reasonable, orderly objections as well as emotional appeals were published to arouse the public interest. Caswell Silver, president of Sundance Oil Company, claimed the burden should be on the AEC to prove there is no harm to the environment, rather than opponents having to prove that it *is* harmful. He attacked the AEC, claiming ". . . throughout its history, it has lied and misrepresented many aspects. It has antagonized every thinking scientist by saying that this radiation (low levels such as predicted from Project Rulison) is below acceptable levels."[2] He said the AEC was callously ignoring the radiation pollution problem and the genetic threat and was wildly extravagant in the realm of costs.

At one of several public meetings,

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Ernest Sternglass of the University of Pittsburgh stated that ". . . if the blast weren't contained and contamination of the atmosphere occurred, there could be consequences as grave as the death of nearly every infant in the next 10 years in an area of 10,000 square miles around the blast site."

Other individuals attacked Rulison from legal and economic viewpoints, claiming the AEC participation in the industrial event was illegal and that the economic gain implied by the AEC and the industry was impossible to realize.

The controversy culminated in a U.S. District Court suit, with the ACLU and the Colorado Open Space Coordinating Council (COSCO) representing four area individuals in an attempt to halt the testing. After a two-day hearing the judge ruled that the AEC had taken all reasonable precautions and that the shot would not be halted. Further review and appeal ruled in favor of the shot. After the hearing the AEC published a report providing written answers to a long list of very pertinent, reasonable questions about Gasbuggy and Rulison asked by the Colorado Committee for Environmental Information—questions that Metzger had testified he had not been able to get answered previously by the AEC. These questions and answers provide an excellent summary of most of the safety hazards involved with gas stimulation and the precautions taken. They have been reprinted in USAEC Report PNE-G-48 and paraphrased in less technical language in the *Denver Post* of August 31, 1969.

The Rulison blast was detonated on September 10, 1969. There was no measurable radioactivity at the detonation point. As suggested by the AEC prior to the hearing, and then officially ordered by the federal court, there was a six-month waiting period before reentry to the cavity. During this time, amid numerous reports of data indicating that Project Rulison was progressing precisely as predicted, reports for damage claims were processed by the AEC as provided for prior to the shot. By April 1, 1970, some 260 claims totaling more than $72,400, mostly for minor structural damage, had been paid under a very lenient policy set up by the project management. From newspaper reports, it is clear that the seismic motion was more than some local residents had anticipated or were led to believe.

As the time for reentry drew closer, the controversy again swelled until another suit was entered in federal court in an attempt to prohibit the reentry. After a seven-day hearing, Federal Judge Alfred A. Arraj again ruled in favor of the Rulison Project in a 63-page opinion[4] in which he made several significant comments and implications:

- Each project must be reviewed on its own merits. There can be no blanket approval of all Rulison-type projects.
- The AEC has shown radiation hazards to be below "acceptable" limits as defined by competent authority (NCRP, FRC, ICRP), and the question of safety becomes one of the validity of these limits and of the theory that there are acceptable safe limits.
- The law provides "a strong presumption of validity" in favor of responsible administrative officials. Plaintiffs who wish to claim that these limits are a factor of 10 too high (as A. G. Tamplin testified at the hearing) have the burden to present sound evidence to prove that they are right. The burden is *not* on the AEC to prove the contrary.

Reentry operations began April 26, 1970, and took about six weeks. As of December 1970, gas was still being flared with extensive monitoring as programmed by the AEC. Temporarily at least, the controversy is now dead.

One conclusion that appears obvious concerning the controversy surrounding Rulison is that the AEC could have done a great deal to reduce the adverse publicity by a timely dissemination of the facts. An immense amount of material has been printed explaining the shot and, in particular, the elaborate safety program devised by the project managers. Had the information been clearly and openly presented to the leading critics and the public on a timely basis, much of the conflict might have been avoided.

The AEC safety program

An examination of the numerous reports on the effort leaves little doubt that the AEC did provide for a thorough investigation of all hazards involved with the project and for assurance of public safety, at least under standards accepted by most of the scientific community.

As prescribed in the Project Rulison planning directive, responsibility for the public safety lies with the AEC. All AEC agencies involved have strict safety requirements on their individual efforts. The Nevada Operations Office reviewed all aspects of the proposal in terms of public safety.

A panel of safety consultants, appointed from recommendations made by the National Academy of Sciences, also reviewed the entire project from the standpoint of public safety. A special AEC Test Evaluation Panel provided a thorough review of containment aspects, including hydrology, geology, stemming, and other factors, to assure that the blast would be contained. In addition, nine other organizations contributed major efforts to the safety program including: U.S. Geological Survey (USGS); Isotopes, a Teledyne Company; Environmental Research Corporation (ERC); John A. Blume and Associates, Incorporated (JAB); the Environmental Science Services Administration's Air Research Laboratory (ESSA/ARL); the U.S. Coast and Geodetic Survey (C&GS); the U.S. Public Health Service (USPHS); Eberline Instrument Corporation; and Battelle Memorial Institute (BMI).

A summary[5] of the effects studied by these organizations is given below:

- *Ground Motion.* ERC conducted a study assuming the 40-kt predicted yield and another for the 60-kt maximum credible yield explosive. The primary assumption was that ground motion would be similar to that of the Gasbuggy shot, mainly justified for three reasons: (1) The two tests had very much similar geologic environments. (2) Both explosives were extremely overburied; the depth of burial affects the frequency of the motion. (3) The amplification of near surface materials was very similar. Based on the Gasbuggy results, the volume of data from numerous previous shots, and on a thorough study of the ecology of the Rulison area, ERC made predictions of various seismic effects such as particle acceleration, velocity, and displacement.
- *Structural Response.* Based on ERC predictions of ground motion, JAB Research Division performed a detailed investigation of structural response to be expected. A precise inventory was prepared of all structures within 15 miles from the detonation point, and a general survey was prepared of the number and types of buildings out to 60 miles. Canyon and valley sections with slope areas and cliffs that might be unstable under the predicted motion were identified. The response of irrigation facilities, dams, and reservoirs was evaluated.
- *Ground Water Contamination.* The USGS conducted hydrologic testing of the exploratory hole drilled prior to the test shot well. They perforated the well casing at depths below 6,000 feet. Any zone producing water was evalu-

ated. The conclusion was that there was no mobile water in the geological strata likely to yield water to the hole.

Isotopes, Inc. made ground water contamination predictions based on conservative assumptions and concluded that the probability of transmission of greater than MPC levels of radioactivity in the underground water to any known use point was extremely remote.

In the unlikely event of venting of gaseous debris, there could be radionuclide contamination of surface water. Consequently, all wells within 6 miles and major wells within a 12-mile radius were sampled before and after the test shot to assure safety to the public. Near-surface waters were monitored at a test well drilled downgradient from site ground zero (SGZ).

• *Containment.* The depth of burial of the 40-kt explosives was extremely conservative. From past experience at the NTS, a safe burial depth, assuming no major faults are present, for an explosive of yield x kilotons is $350/x^{1/3}$ to $450/x^{1/3}$ or greater. For the 40-kt Rulison shot, buried at 8,440 feet, this scaled depth is 2,140 ft/$kt^{1/3}$—a factor of 6 deeper than necessary. The assurance of proper containment, then, depended primarily on the assurance that there were no faults in the area. An extensive geologic examination revealed no faults or major displacements, and containment was assured.

• *Meteorology and Fallout.* ESSA/ARL gathered and interpreted weather data in the Rulison area, correlated that with national data, and produced predictions on all pertinent meteorological conditions that might affect the distribution of radioactivity to the public. They produced weather predictions that permitted detonation at a time when atmospheric conditions would produce the minimum possible effects in the event of an accident.

• *Bioenvironmental Effects.* The USPHS Southwestern Radiological Health Laboratory (SWRHL) maintained a current census on humans and dairy cows and their distribution within a 25-mile radius of SGZ and to 150 miles in the semicircle of prevailing downwind direction. BMI conducted an exhaustive ecological survey to evaluate seasonal wild game and range livestock population and to identify any significant ecological hazard, which even included the seismic effects on local wildlife.

• *Snow Slides.* Reviews of the area nonths before the shot and near the time of the blast indicated that the possibility of a snow slide hazard was extremely remote. A thorough roadblock plan was, of course, in effect at the time of the shot to keep personnel out of the area.

• *Close-In Effects.* Studies of streams in the immediate area of SGZ indicated no significant blockage due to earth moved by ground motion would occur. Surface fracturing effects were investigated, and only a temporary minor disturbance to streams was indicated. The USGS monitored local streams.

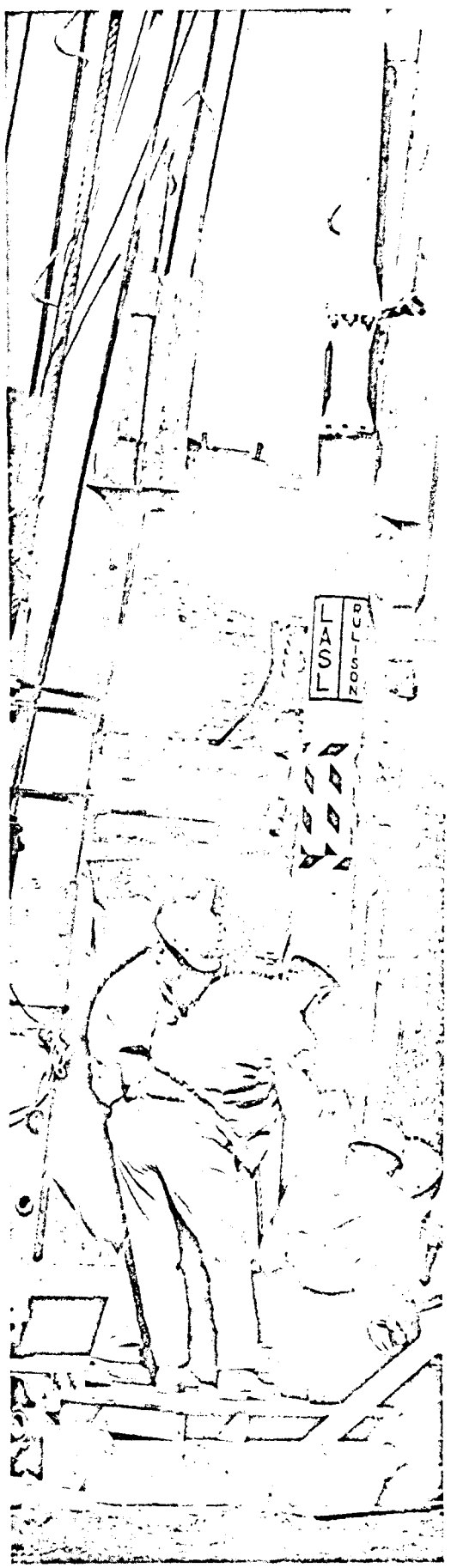
• *Aftershocks.* Some aftershocks have occurred in previous underground tests, but were at least two orders of magnitude lower than the primary shock. Experience indicated that aftershocks from a Rulison-size blast would not be readily measurable. The possibility of activating earthquake centers was investigated by the C&GS. A literature search indicated 300 earthquakes had occurred in the general region with a magnitude scale factor of 3 or greater. None had its epicenter within a 50-mile radius of SGZ.

• *Reservoir Structures.* A preliminary study of the generation of water waves in lakes and reservoirs by ground motion, and their effect on dams, indicated that a possible hazard to one dam might exist (structural details were not completely known). This was one of the main reasons given for a postponement of the shot from the original date of May to September, when the water level in the dam lowered by about 15 feet. Subsequent investigation showed the possibility of failure remote. However, the possibility of some cracking and slumping was recognized, and appropriate precautions were taken to protect residents downstream and to maintain the dam in the event of damage. Seismic monitoring of all important dams in the area was performed by the C&GS, U.S. Corps of Engineers, and the U.S. Bureau of Reclamation.

• *Mines and Gas Wells.* A survey was conducted for possible sites, active or inactive, up to 40 miles away that might be affected by the blast. It was indicated that two mines within 10 miles of SGZ might experience minor rock fall. Evacuation procedures were established for personnel in any mines where any conceivable danger existed. The only gas well in the area was expected to receive no damage, based on experience with wells from the Gasbuggy shot.

Radiological hazards

The primary radiological hazard was recognized to be the potential release of gaseous radionuclides upon reentry to the chimney either by some accidental blowout or during the flaring process. The total inventory of gaseous



Rulison: Lowering the "boom"

"Certainly the publicity was harmful to the AEC image. Perhaps this . . . is largely responsible for the virtual freeze on Plowshare funds."

radionuclides present at 180 days after detonation is listed below:

Nuclide	*Curies*
Krypton-85	9.6×10^{2}
Xenon-133	8.6×10^{-4}
Argon-37	1×10^{2}
Argon-39	1×10^{-1}
Carbon-14	1×10^{-1}
Tritium	1×10^{4}

In order to evaluate the potential hazard from the release of these gaseous radioisotopes, a maximum hypothetical accident is postulated in much the same general manner as is done for power plants. All consequences of the hypothetical accident are then considered, and measures are taken to assure that the public is exposed to the minimum amount of radiation possible and certainly to levels below accepted federal and international standards.

The maximum hypothetical accident postulated was an uncontrolled blowout through an open drill hole releasing 94 percent of the gaseous radioactive nuclides present at 180 days from detonation, over a 24-hour period. The description of the maximum hypothetical accident[4] presents a rather succinct view of the technological and philosophical approach of the AEC to the safety problem, and should be read by those who wish to argue, pro or con, concerning the radioactivity hazard of Rulison-type projects. In summary, calculations indicate that even in the event of the maximum hypothetical accident, considering three primary environmental pathways of radionuclides to man (air, drinking water, and food), the total dose to the public would be small compared to the accepted standard of 170 mrem per year.

Final reports on testing at Rulison are not yet available. In fact, flaring and some measurements are still in progress at the site. There was, of course, no accident at the detonation or upon reentry. All preliminary reports and news accounts indicate that the Rulison blast behaved, seismically and radiologically, precisely as predicted, with virtually no unexpected results and with essentially no hazard to the public.

The controversy surrounding Rulison has essentially died, perhaps because of the successful execution of the shot, but more likely because of indifference produced by the passage of time. Its consequences are hard to evaluate directly. Certainly the publicity was harmful to the AEC image. Perhaps this adverse publicity is largely responsible for the virtual freeze on Plowshare funds. Combined with various other discussions and attacks currently leveled at the AEC and the nuclear industry, it could bring about great changes in high-level policy concerning nuclear energy. On the other hand, thorough review by sound-thinking responsible authority could reveal to the public the competence of the AEC and the extreme measures taken to assure public safety.

Conclusions

A number of conclusions—or, more precisely, opinions and impressions—have come to mind during the literature review of Project Rulison. One important conclusion, previously mentioned, was that the AEC was to a large extent responsible for the controversy and the adverse publicity surrounding the project. The AEC chose to remain somewhat aloof and at times gave an appearance of indifference to public opinion. It did not present enough information publicly on a timely basis, especially in layman's language. Apparently, officials are becoming aware of this problem of lack of communication, heightened by perhaps an air of superiority or unquestioned authority. An overt effort to improve public relations and communications has been noted recently, as well as attempts to provide for more rapid, more complete dissemination of technical information.

There is little doubt that the AEC provided for a safety program that considered all possible aspects of public safety and took measures necessary to assure the safe execution of Project Rulison. Exhaustive research and excellent management combined to produce the minimum of hazardous effects reasonably attainable. The net effect of the Rulison shot itself on man and the environment is probably inconsequential. There is considerable merit, however, to the assertion of the opponents of Rulison that although the Rulison shot itself may be safe, the real threat lies in the test shots and perhaps eventual commercial use that would likely follow if Rulison were successful. What would be the accumulative, long-range hazard from a large number of shots? Although many of the opponents' claims were exaggerated, it appears that more consideration must be given to the consequences, radiological and especially seismic, of extended operations in a given gas field.

Seismic consequences of underground nuclear explosions may produce more severe limitations on the commercial application of the gas stimulation technique than will the radiological consequences. Radiological hazards, already known to be low, have the possibility for further reduction through improved techniques—possibly separation of contaminants. On the other hand, there is little that can be done to modify the seismic effects at a given site; one can only carefully predict the consequences, judge whether or not they are acceptable, and take measures to assure no one is injured. It was seen that even for an area rather sparsely populated, as was the Rulison area, this required considerable effort in terms of manpower and money.

Moreover, it is apparent from news accounts that the ground motion and related events had a profound psychological impact on many of the residents—a consequence that cannot be taken lightly, since, ultimately, some decisions as to the future of Plowshare are politically made, and public acceptance is a strong political factor. At present, then, U.S. shots are limited to remote areas, although recently a British scientist' indicated that use of underground explosives near more heavily populated areas is possible under certain conditions.

It is apparent that the quesion of radiological hazards with Rulison is intimately related to the current controversial discussion involving the adequacy of the established radiation limits. The AEC, in accordance with its expressed philosophy, has tried to keep radioactivity releases to the minimum possible. However, "low doses" are obviously justified by comparison with the established guidelines accepted by the majority of the scientific community. If these limits were significantly reduced by, say, the suggested factor of 10, then considerable technical improvement might be necessary before the gas stimulation technique would be feasible.

The AEC has the competence to conduct the necessary tests, and it is reasonably certain that in a matter of a few years commercial applicatio

of gas stimulation could be a reality from a technological and safety viewpoint. Economic factors, legal factors, and ultimately political factors will determine the fate of gas stimulation and the Plowshare program. An operation of this magnitude will always involve some risk, demanding continuing evaluation, in this case at fairly high government levels, of the risks involved versus the benefits to be derived.

Risk-benefit evaluation is a major challenge facing industry, government, and, indeed, the whole of our society as we experience the many rapid technological advances of this age. One obvious basis for comparison is economic benefit. With reference to gas stimulation projects, the economic benefit has not been clearly established; economic feasibility is still a much argued point. Probably the most thorough analysis of the economic question is offered in the booklet by Brooks and Krutilla,[8] which points out many indirect costs and some basic economic principles that often have been overlooked in cost comparisons and estimates. Thorough, objective economic analyses of this type are required if responsible officials are to make sound decisions.

Many other variables need to be considered in a risk vs benefit comparison, many of them intangible and, consequently, less easily evaluated than the economic factors. These variables —psychological, sociological, or bio-environmental effects, for example— must somehow be weighed against (or with, in the event of beneficial effects) economic gain. Emphasis should be placed on evaluation of *all* risks and *all* benefits, and thus some methods for comparing the broad spectrum of variables must be developed.

Some work along these lines has been done. Chauncey Starr[9] has presented a study of the sociological risks involved with technological development in which he came to the following interesting conclusions that provide valuable insight as to the level of hazard society is willing to accept:

"(1) The indications are that the public is willing to accept 'voluntary' risks (e.g., skiing or hunting) roughly 1000 times greater than 'involuntary' risks (e.g., electric power generation or Plowshare).

(2) The statistical risk of death from disease appears to be a psychological yardstick for establishing the level of acceptability of other risks.

(3) The acceptability of risks appears to be crudely proportional to the third power of the benefits (real or imagined).

(4) The social acceptance of risk is directly influenced by public awareness of the benefits of an activity, as determined by advertising, usefulness, and the number of people participating."

J. J. Cohen[10] has presented a method wherein he considers ". . . $250 worth of somatic and genetic damage results from the exposure of one person to one rem of radiation." He has related intangible risks to something that is tangible and, incidentally, universally recognized.

Although there may be many objections to Cohen's unusual equation, or to Starr's conclusions, these are basically the types of studies that need to be conducted. Only with methods of this sort can we evaluate the total impact of any project or technical advance that so strongly and directly affects people and the world we live in.

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