PROJECT RULISON

A GOVERNMENT-INDUSTRY NATURAL GAS PRODUCTION

STIMULATION EXPERIMENT USING A NUCLEAR EXPLOSIVE

Issued By

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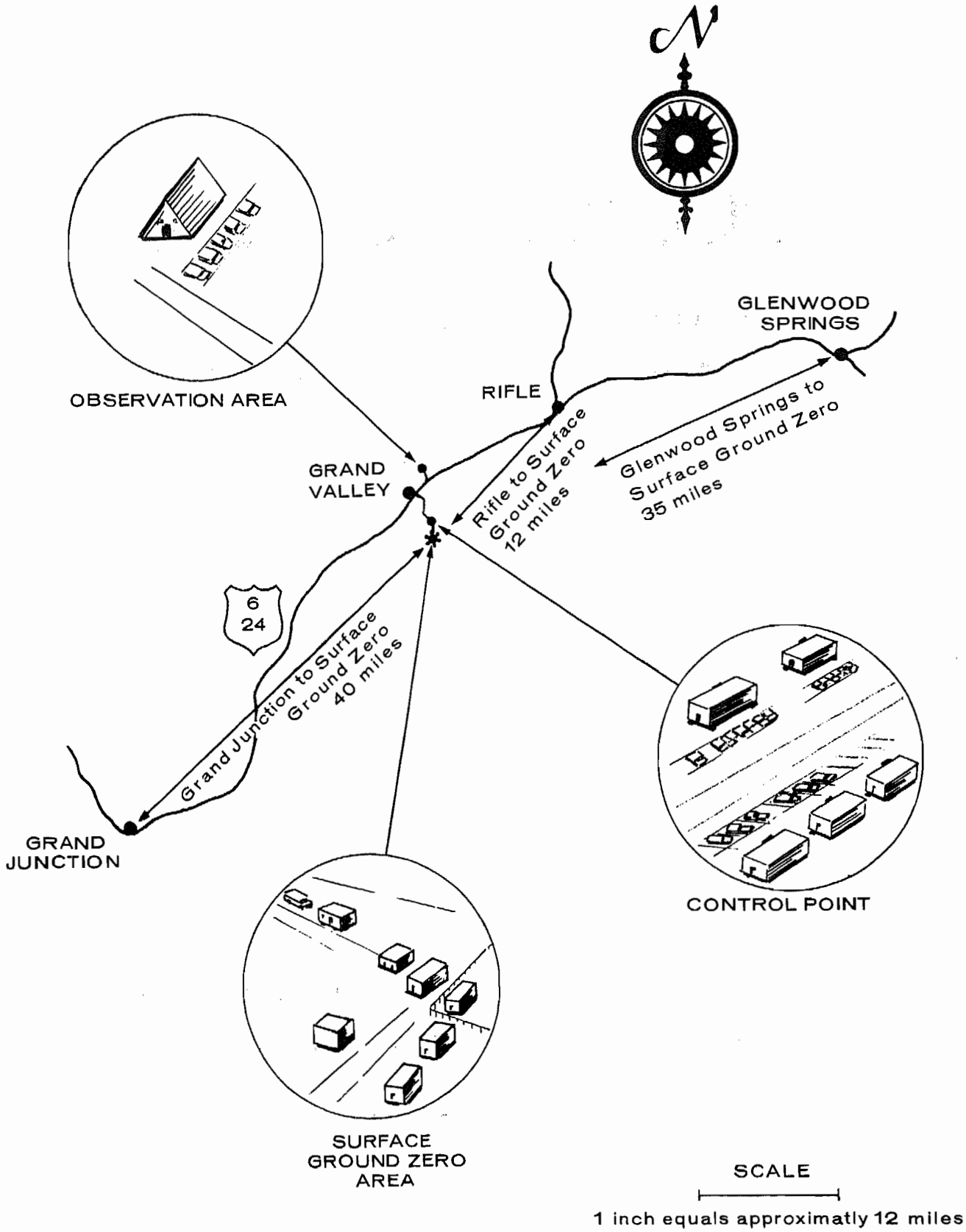

Project Rulison Area Map

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I. INTRODUCTION

Project Rulison is a joint experiment sponsored by Austral Oil Company, Incorporated, of Houston, Texas, the U. S. Atomic Energy Commission and the Department of the Interior, with the Program Management provided by CER Geonuclear Corporation of Las Vegas, Nevada, under contract to Austral. Its purpose is to study the economic and technical feasibility of using underground nuclear explosions to stimulate production of natural gas from the low productivity, gas bearing Mesaverde formation in the Rulison Field.

Project Rulison involves the detonation of a nuclear explosive equal to 40,000 tons of TNT, at a depth of 8,430 feet underground in the Mesaverde formation underlying the 60,000 acre Rulison Field. The field lies largely in the southcentral portion of Garfield County, Colorado, and partly into the northeast portion of Mesa County. The Rulison detonation will take place about 40 air miles northeast of Grand Junction, Colorado.

Rulison is expected to provide additional data to evaluate the technical and economic feasibility of nuclear stimulation. Such information includes the effects of increased temperature and pressure at greater depths on explosive performance and the effects of higher yield detonations in stimulating the production of natural gas. Austral hopes this will be the first step toward full development of this major gas reserve.

Conventional Versus Nuclear Stimulation

Natural gas is produced commercially from underground reservoirs of rock in which the gas is trapped within the pores between sand grains. When a well is drilled into such a reservoir rock, the natural reservoir pressure causes the gas to flow into the well from the pores of the rock.

In many areas of the western United States much of the natural gas is found in reservoir rock of such low permeability (called "tight" by the industry) that the gas will not flow into a well in sufficient quantity to be produced economically. Some increase in production can be obtained in such formations by conventionally fracturing the surrounding rock. This is done hydraulically by injecting sand laden fluids under high pressure into the well or chemically by detonating explosives such as nitroglycerin. The resulting increase in productivity, however, may be relatively short-lived. This is particularly true in thick formations such as the Mesaverde where a number of fractures must be created over the thickness of the formation.

Nuclear explosives, like conventional explosives, also produce broken rock and fractures, but far surpass the conventional techniques in magnitude. For example, in Project Gasbuggy, the 26 kiloton nuclear explosion about 4,200 feet underground formed a cylindrical zone of broken rock (called a chimney) about 330 feet high with a probable diameter of about 160 feet--roughly the size of a 33-story building one-half block square. Fractures in the rock outside the chimney

are believed to extend more than 300 feet beyond the chimney wall. These rock shattering and fracturing effects in tight gas bearing formations appear to be much more effective for long-term drainage and result in much greater production rates.

The advantage of nuclear over conventional stimulation techniques is further shown by the fact that conventional explosive fracturing using 1,000 to 2,500 quarts of nitroglycerin looks insignificant when compared to the Project Rulison explosion which is equivalent to about 19,000,000 quarts of nitroglycerin, or about 8,000 times as much.

III. BACKGROUND

Feasibility Study

Austral became interested early in 1965 in the application of nuclear explosives to stimulate "tight" gas reservoirs and selected the Mesaverde Formation in the Rulison Field. At Austral's request, CER started work on a detailed nuclear stimulation feasibility study. Two test wells were completed in the spring of 1966 and Austral/CER carried out an extensive well testing program to verify earlier calculations of the quantity of gas in place and to define the producing characteristics of the Mesaverde reservoir. In July, 1966 Austral/CER submitted a formal letter of intent to the Atomic Energy Commission (AEC) together with a detailed report, "The Project Rulison Feasibility Study," and in December, 1966, formally presented their proposal to the Government.

Site Investigations and Agreements

In the spring and summer of 1967, Austral/CER and the AEC's Lawrence Radiation Laboratory (LRL) inspected the proposed site area and evolved preliminary drilling specifications for the exploratory well. In October, 1967, Austral and the U. S. Geological Survey signed a unique Federal Unit Agreement which considered nuclear stimulation, and recognized the experimental nature of the project and the time periods necessary to complete the experiment. As approved, the Unit encompasses over 50,000 acres of which about half is private and half public land.

Exploratory Drilling

In November, 1967, Austral awarded a contract to Signal Drilling Company of Denver, Colorado, for the drilling of the exploratory well at the site selected for the experiment. The well, Hayward 25-95 (R-EX), was completed in early May, 1968. Since then, this exploratory well has been extensively tested to define the production characteristics of the gas reservoir before the proposed nuclear explosion.

Project Assignments

In April, 1968, the AEC assigned the Los Alamos Scientific Laboratory (LASL) to work with Austral, CER, and the Bureau of Mines personnel to incorporate this laboratory's concept for nuclear explosive emplacement and detonation into project planning. In May, 1968, the AEC authorized its Nevada Operations Office (NVOO) to cooperate with Austral/CER in preparation of a Project Definition Report. This report defines the full experimental, operational, support and managerial plans necessary to accomplish the project and provided a basis for contract negotiations. The completed "Project Rulison Definition Plan" was submitted to NVOO in December 1968 for final government review.

In September, 1968, Austral awarded a contract to Superior Drilling Company, an affiliate of Signal Drilling Company, for drilling the explosive emplacement hole (R-E) near the exploratory hole. The total depth of the hole, 8,700 feet below the surface, was reached on January 19, 1969.

Contractual Arrangements

On March 26, 1969, the contract for Project Rulison between the United States Government, represented by the Atomic Energy Commission and the Department of Interior, and Austral Oil Company, Incorporated, as industrial sponsor, and CER Geonuclear Corporation, as Program Manager, was formally executed. Under the terms of the contract, Austral would provide specified work and services for the project and the AEC would provide for the nuclear explosive and certain related services such as explosive arming and firing and nuclear operational safety procedures.

Major Participants

Responsibility for the project rests with Austral Oil Company, Incorporated, the Atomic Energy Commission, the Los Alamos Scientific Laboratory, the Bureau of Mines representing the Department of the Interior and CER Geonuclear Corporation.

Austral Oil Company, Incorporated

Austral Oil Company, Incorporated, the industrial sponsor of Project Rulison, was organized in 1950 and has its principal business office in Houston, Texas. In addition to its Rulison properties Austral owns interests in 490 wells having proved recoverable reserves of 8.6 million barrels of oil, condensate and natural gas liquids and 239 billion cubic feet of gas. Such reserves are located in six states, primarily in Louisiana and Texas. In addition to the productive properties Austral has undeveloped oil and gas leases and mineral mining claims and leases located in Texas, Louisiana, Wyoming, Mississippi, Arizona, Idaho, Nevada, Utah and New Mexico as well as leasehold interest covering 1/2 interest in 460,000 acres in New Zealand where an exploratory well is currently being drilled. Austral is a publicly owned company.

In 1965 Austral acquired interests in the Rulison Field looking forward to the commercial production from the tight Mesaverde formation through application of fracturing methods from advanced technology such as nuclear stimulation. If the technique is proven economically feasible through Project Rulison and succeeding tests, it will not only be used to develop Austral's leasehold interest in the Rulison Field but also a substantial leased area of more than 100,000 acres in the Pinedale Field area of Wyoming.

The funding of the Rulison Project at December 31, 1968, had been solely at non-Government expense. To this date more than 5 million dollars has been expended in the acquisition of the Rulison Field properties, in the drilling of wells, and for the project exploratory well and emplacement hole.

Atomic Energy Commission

The Division of Peaceful Nuclear Explosives of the AEC, which has responsibility for direction of the AEC's Plowshare Program, is responsible for overall direction of the AEC's participation in the project. Overall nuclear management, including on-site and public safety, security, and construction and support related to safe project execution, has been assigned to the Nevada Operations Office, Las Vegas, Nevada, which manages all underground nuclear explosions.

Los Alamos Scientific Laboratory

The Los Alamos Scientific Laboratory, operated by the University of California for the AEC, is responsible for the design, emplacement, and firing of the nuclear explosive to be used in Project

Rulison. LASL also will provide the operations director, scientific advisor, and staff to coordinate, direct and execute the nuclear explosion under the NVOO Director of Nuclear Operations.

The Department of the Interior

The Department of the Interior's Bureau of Mines is the Government agency responsible for promoting advancement of mineral conservation technology. It conducts its own extensive research on more efficient ways of extracting oil and gas from underground reservoirs, and will use its expertise in this field to help develop the reservoir evaluation program for Project Rulison. In cooperation with CER Geonuclear Corporation and Austral Oil Company, Incorporated, the Bureau will participate in the design and conduct of the long-term tests needed to provide data on the degree to which the Rulison detonation enhances the productivity of the gas-bearing formation. As part of the Department, the Bureau also coordinates Plowshare activities with other Interior agencies, particularly the U. S. Geological Survey, and provides liaison with other Government agencies and industry.

CER Geonuclear Corporation

CER Geonuclear Corporation provided consulting services for Austral Oil Company, Incorporated, for the conceptual development of Project Rulison and it has subsequently been retained by them to act as Program Manager for the project. In this capacity, CER Geonuclear Corporation is responsible for the overall project coordination and management. CER Geonuclear Corporation will also provide for the performance of technical tasks, the principal area being in the evaluation of the gas reservoir.

III. OBJECTIVES

The objective of Project Rulison is to demonstrate the potential of nuclear stimulation for the commercial development of the Rulison Field. Also, since the geology and gas reservoir characteristics of the Rulison area are typical of many gas fields, the information obtained from the project would have an important bearing on the commercial possibilities of nuclear stimulation in other areas. Both technical and economic data will be obtained from the project.

Technical data needed are: (1) Comparison of gas production rates before and after the detonation and determination of estimates of ultimate gas recovery; (2) measurement of the amount and kinds of radioactivity that are recovered with the gas at different production rates and for differing periods of time; and (3) assessment of ground motion effects to establish yield limits for future nuclear explosions to stimulate gas production in the Rulison Field.

Economic data needed are the costs of: (1) drilling, construction, and logistic support; (2) fielding nuclear explosives on a routine basis; and (3) related safety programs. These items will provide a yardstick for measuring the costs of potential commercial development of the Rulison Field.

IV. EXPERIMENTAL DETAILS

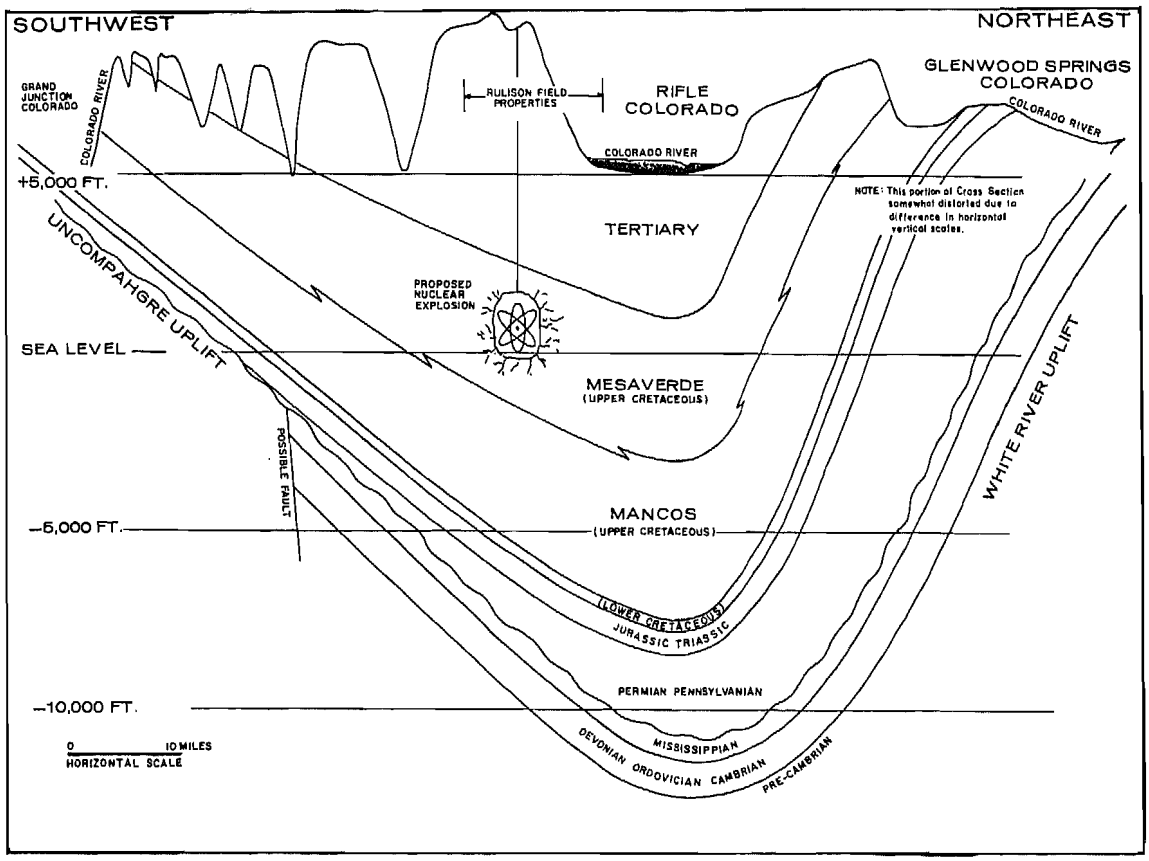
The Rulison experimental concept calls for a fully contained nominal 40 KT nuclear explosion buried in the Mesaverde Formation at 8,430 feet below the surface on the north slopes of Battlement Mesa.

The elevation of Rulison surface ground zero is 8,154 feet above sea level and is located in Section 25, Township 7 South, Range 95 West. It is on private land just outside the portion of the

White River National Forest covering Battlement Mesa. The nearest community is Grand Valley, about 6 miles northwest of the site. Grand Valley has a population of approximately 245. The nearest sizable town is Rifle, about 12 air miles to the northeast of the site, with a population of approximately 2,200.

Emplacement

The explosive will be emplaced in the Mesaverde Formation (see geological cross section) at a depth of about 8,450 feet through a 10¾-inch outside diameter well casing set in a 15-inch diameter drill hole. After emplacement, the well will be stemmed (filled) to the surface with alternating layers of pea gravel and sand.



Piceance Creek Basin — Northeast - Southwest Cross Section

Cavity Formation

The energy of the nuclear explosion will melt and vaporize the nearby rock and will crush and fracture the rock beyond. In about one-tenth of a second, the spherical cavity containing melted and vaporized rock will have grown to a diameter of about 160 feet. As the cavity cools, most of the melted rock will collect in a puddle at the bottom, trapping most of the radioactive fission products.

Rock Fracturing

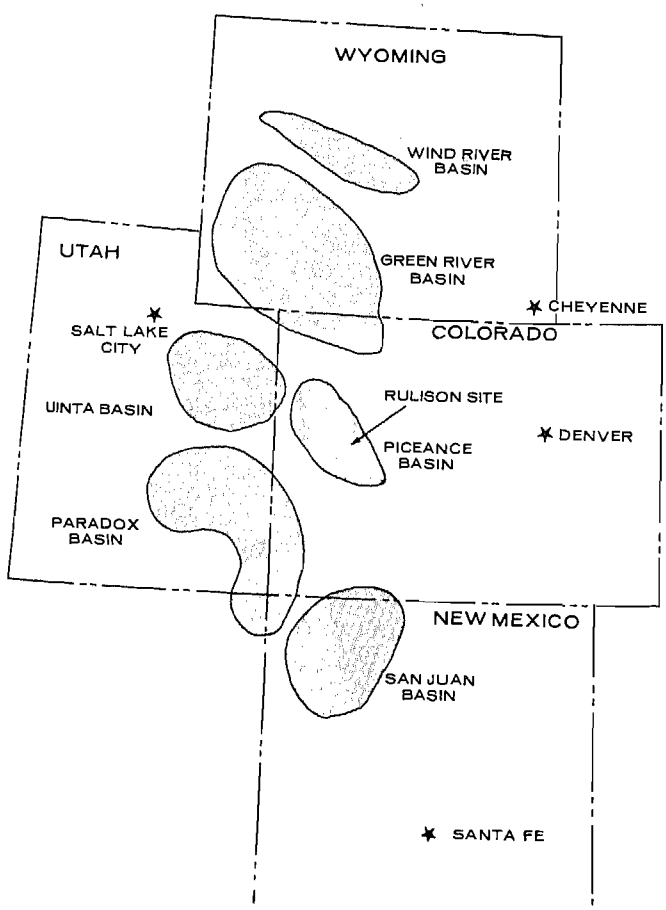
A substantial amount of the released energy is in the form of shock waves causing fracturing of the surrounding rock. The expected horizontal diameter of this fractured zone is about 740 feet.

Within a few minutes to a few hours, it is expected that the roof of the cavity will collapse progressively upward to form a cylindrical chimney of broken rock to a height of about 370 feet above the point of detonation. This fracturing and chimneying phenomena is what caused experts to believe that nuclear stimulation could lead to natural gas production becoming commercially feasible in very low permeability natural gas fields. Even hairline fractures are expected to provide flow channels for gas trapped in the surrounding rock, and the chimney is expected to act as a chamber where the gas will collect to be drawn off after drilling back into the chimney.

Potential for Nuclear Stimulation

A major incentive for experiments like Rulison is the widespread occurrence of deep, "tight" gas-bearing formations like the one in which the Rulison test will take place. Although these formations contain natural gas in abundance, their low permeability makes it impossible to extract the gas economically with conventional methods. Successful development of nuclear stimulation technology, however, could provide a way to tap this vast resource. The Bureau of Mines estimates that nuclear stimulation could virtually double the Nation's natural gas reserves by adding 300 trillion cubic feet of gas from "tight" formations to the present known supply, estimated at approximately 293 trillion cubic feet.

Most of the formations to which nuclear stimulation would be applicable are found in Wyoming, Colorado, Utah, New Mexico and Arizona (though Kansas, Oklahoma and Texas also have some potential). These formations are frequently found in "basins" - subterranean geologic features characterized by rock strata that slope downward from all directions toward the center. Rocky Mountain basins with nuclear stimulation potential are shown on the following map.



Basins Sufficient to be Considered for Nuclear Stimulation

A number of full scale field tests are needed to demonstrate the feasibility of nuclear stimulation. Project Rulison is the second such experiment. The first, Project Gasbuggy, was a 26 kiloton nuclear explosive detonated 4,200 feet underground in northwestern New Mexico in December 1967. Results, still being analyzed, indicate that nuclear explosive fracturing of natural gas formations appear to increase production and ultimate gas recovery. More detailed assessments will be made after completion of a six-month production test which is still in progress.

V. EXPERIMENTAL PHASE AND RELATED STUDIES

The Rulison experimental program is divided into three phases. Phase I included drilling a pre-shot exploratory well, performing pre-shot gas production tests, and geological, hydrological and other studies for technical and safety confirmation. The emplacement hole was drilled as a part of Phase I.

Phase II includes surface construction, emplacement of the explosive, detonation, and measurements of any immediate detonation effects.

Phase III will begin after a six-month waiting period following the detonation and will include all post-shot drilling, investigations of gas quality, and production tests.

Radioactivity control procedures will be undertaken if data from the gas analyses indicate a need. The particular explosive being used for Rulison and the higher formation gas pressure will result in less than one-tenth of the amount of gaseous radioactivity encountered in Gasbuggy.

VI. THE SAFETY EVALUATION PROGRAM

No nuclear detonation is ever authorized unless there is assurance of safety for the public. All government agencies and other organizations connected with Project Rulison are governed by this policy. The utmost attention is paid to all factors that may have any influence on safety of individuals or the general public.

Safety Consultants

A panel of safety consultants, a number of whom were recommended by the National Academy of Sciences, have reviewed the geology, hydrology, and anticipated structural response and seismology of the Rulison site. This panel works with the Nevada Operations Office in an advisory capacity and conducts a continuing study of project proposals in terms of public safety.

Members of the safety panel, and areas in which they specialize are:

Dr. Lydik S. Jacobsen, structural response to earthquakes and ground motion, Professor Emeritus, Stanford University.

Dr. Nathan M. Newmark, structural response and ground motion, Head, Department of Civil Engineering, University of Illinois.

Dr. George B. Maxey, hydrogeology, University of Nevada.

Dr. Don U. Deere, rock mechanics and foundation and underground construction problems, University of Illinois.

Mr. Lewis G. von Lossberg, hydrogeology, Sheppard T. Powell and Associates.

Mr. Thomas F. Thompson, consultant in geological engineering.

Mr. Stanley D. Wilson, soil mechanics, Shannon and Wilson, Inc.

Underground Detonation Experience

Since the panel was organized, much new knowledge has become available about underground nuclear detonations and their effects.

The Project Gnome detonation near Carlsbad, New Mexico in December, 1961, was the first nuclear detonation in the AEC Plowshare program. Since then, there have been more than 270 Plowshare and weapons-related underground detonations at the Nevada Test Site plus seven off-site detonations, two in New Mexico, two in Mississippi, one near Fallon, Nevada, one near Warm Springs, Nevada and one at Amchitka, Alaska. The data from these experiments have given scientists a firm basis for predicting possible effects of nuclear detonations.

Containment

One example of a completely contained experiment was Boxcar, conducted at the AEC's Nevada Test Site in April, 1968. Boxcar was detonated about 3,800 feet below the earth's surface or less than one-half the burial depth of the Rulison detonation (8,500 feet). Moreover, the Boxcar explosive was about one megaton (the equivalent of 1,000,000 tons of TNT) or about 25 times larger than Rulison. Analyses of data from this and other underground nuclear detonations provide the necessary knowledge and experience to insure that Project Rulison can be conducted in complete safety.

Response to Ground Motion

No significant damage is expected from ground motion outside the Rulison site area. However, some hazard from rockfalls exists along roadways and canyon walls. Surface motion from Rulison will be measured at various locations on and off the site by the U. S. Coast and Geodetic Survey which will set up seismometers and recording equipment around the Rulison site.

In addition, mines out to a radius of about 40 miles have been located. Seismic predictions indicate only a low probability of rockfall in the nearest mines will be caused by the Rulison detonation.

Project personnel will be located at the Control Point (CP) two and one-half miles from the emplacement hole.

The condition of gas wells and pipelines within a radius of a few miles of Rulison surface ground zero will be surveyed both before and after the detonation. Damage to existing wells and related facilities surrounding the site appears to be unlikely in view of past experience.

Effects on Ground Water

The safety panel of engineers and scientists, together with Colorado State health organizations, have evaluated the hydrology of the site and are convinced that there will be no hazard to the local water supply.

The evaluation of the exploratory and emplacement holes drilled on the Rulison site indicated that there are some sandy zones in the lower Green River Formation which appear to be water bearing. In the immediate site area these zones occur at elevations greater than 6,600 feet above sea level and are 6,900 feet above the detonation point. They are also remote from permanent habitation.

In general, the Wasatch Formation underlying the alluvial deposits is relatively impermeable and is not used as a ground water source. There are some sandy zones near the top and in the

middle of the Wasatch, but because of the general flat-lying nature of the beds and the lack of permeability found in the exploratory R-EX well, it is believed that very little, if any, ground water movement occurs.

The Ohio Creek Formation, lying between the Wasatch and the Mesaverde Formation is water productive in some areas of Rulison Field, but was impermeable at the R-EX well and produced no water when tested by the USGS.

Some water production was encountered in an upper Mesaverde sandstone while air drilling R-EX. Since the Mesaverde sands are quite lenticular and since similar water production has not been found in other Mesaverde wells at Rulison, this is believed to be a local phenomenon. The productivity and storage capacity of this and other high water saturation zones in the Mesaverde were tested and no measurable water production was obtained. In addition, the USGS will sample water from springs in the area for natural (background) radiation. Some of the springs around the site will be instrumented to measure any temporary change in flow that may occur, although none is expected.

Previous studies of the effects on ground water from underground nuclear tests at the Nevada Test Site, in Mississippi, Amchitka and in New Mexico indicated that no harmful disturbance of the flow or supply of water resulted from these underground nuclear detonations. Where such tests have been conducted near the water table, it has been found that most of the radioactivity is removed from the water by filtration through the surrounding earth. Further, these experiments show that underground water movement is very slow -- a few feet per year. The combination of adsorption qualities, slow movement, and decay of radioactivity with time provides a great deal of assurance that radioactivity will not be carried any significant distance by ground water.

AEC Test Evaluation Panel

In addition to the review by the safety panel, a comprehensive review of the geology, hydrology, stemming (filling of the drilled hole) and other containment factors is made by an AEC Test Evaluation Panel before approval is given to emplace the nuclear explosive underground and to complete the final preparations for the test. The nuclear explosive may be emplaced only when the panel is satisfied that no safety factors have been overlooked and that all safety criteria have been met.

Radiation Release Safety Measures

A Remote Area Monitoring System (radiation detectors called RAMS units) will surround surface ground zero, and air sampling equipment will be arrayed at varying distances within the Rulison site.

The U. S. Public Health Service is providing the following precautionary services in the very remote case of release of radioactivity: (1) Present sampling of air, water, milk and vegetation to determine their natural radioactivity; (2) distributing and collecting radiation measuring equipment such as film badges and dosimeters; (3) maintaining radiation monitoring teams at detonation time in selected population centers based on a USPHS-conducted census and predicted weather conditions; and (4) preparing evacuation plans for any persons living down wind from the site should evacuation become desirable.

The USPHS will work closely with the Colorado State Health Department and County health units as well as other federal, state and local agencies. State and county health unit members will be part of the radiation monitoring and evacuation teams posted around the project site on detonation day.

Detonation Day Safety Precautions

As part of the Atomic Energy Commission's policy of taking no chances with public safety, residents living near the Rulison site will be asked to be in perfectly safe places at the time of the detonation.

All persons living within a five-mile radius of surface ground zero will be evacuated. This includes about 110 persons in some 35 homes, most of which are east of Grand Valley or south of Rulison. Persons living between five to eight and one-half miles in radius from surface ground zero will be given the option of evacuating the area or congregating in small groups in predesignated locations outside and away from structures. This area includes about 65 widely separated homes and about 200 persons. Some 325 persons clustered in 80 homes in Grand Valley and Rulison also will be asked to be outside and away from structures at least twice the distance of the building height.

These precautions are based on predicted ground motion expected to result from the detonation and on a conservative prediction of what the motion might do to buildings. Austral Oil Company, Incorporated, will pay the direct costs associated with this safety program, including compensation for those persons who are asked to evacuate.

U. S. Public Health Service personnel will give whatever evacuation assistance is needed, and they will man check points to make sure that all persons have left. The check points also will assure that no unauthorized persons enter the evacuated area until the residents return. PHS and other personnel will advise all affected residents on securing their property, including disconnecting gas and electric power sources. These utilities will be inspected by qualified personnel before they are put back into use.

Residents will be asked to leave in the early morning of detonation day. Return to the area will be permitted as soon as it is determined that there is no hazard, probably within an hour or so after detonation.

Special arrangements for care will be made for infirm or sick people who may reside in any area to be evacuated. This arrangement would be made by a USPHS medical doctor working with the sick person's physician.

In addition, school authorities in Rifle and Collbran will be asked to have children outside school buildings in case the ground motion, which is expected to be felt distinctly in those communities, should frighten the students.

Other detonation day safety precautions include: evacuating several mines in the area; asking persons living within a 15 mile radius of the surface ground zero to secure or remove precariously balanced objects or bric-a-brac from shelves; asking persons living within 50 miles to avoid precarious positions, such as being on ladders or other high places where ground motion may cause a loss of balance, and blockading several sections of federal, state, and county roads with assistance from state and county law agencies at detonation time, thus preventing traffic through potential rock fall or landslide areas.

The Denver and Rio Grande Railway will be asked to schedule its trains so that they do not pass through canyon, rockslide areas at shot time.

With the concurrence of the Federal Aviation Administration, an air space of 15-miles radius from ground zero to an altitude of 20,000 feet above sea level will be closed for a few hours on shot day. Only project aircraft will be permitted in the area.

Other Precautions

A readiness briefing will be conducted for the AEC Director of Nuclear Operations and his panel of advisors on the day before and again on the day of the scheduled detonation. The briefings include weather forecasts, plans for controlling entry to the test area and emergency evacuation of personnel, readiness of the scientific experiments, and the state of the safety programs. If all conditions are found acceptable by his advisory panel and the panel recommends that the test be conducted, the AEC will authorize final preparations for the detonation.

Approval to detonate, based on a weather briefing some two hours before the scheduled detonation time, may be given only by the AEC Director of Nuclear Operations. He may cancel or postpone the test if for any reason there is a question involving the safety of the public or of project personnel.

VII. OTHER SAFETY AGENCIES AND CONTRACTORS

In addition to the AEC, LASL, Bureau of Mines and the safety panel, nine other agencies and organizations are associated with the Rulison safety evaluation program. These include the U. S. Geological Survey, Isotopes, Inc., Environmental Research Corporation, John A. Blume and Associates, Incorporated, the Environmental Science Services Administration's Air Research Laboratory, the U. S. Coast and Geodetic Survey, the U. S. Public Health Service, Eberline Instrument Corporation and Battelle Memorial Institute.

United States Geological Survey

The U. S. Geological Survey of the Department of the Interior will be responsible for the hydrologic studies related to Project Rulison including studies of the distribution and circulation of underground water.

Isotopes Incorporated

Isotopes Incorporated will be responsible for calculations depicting any movement of radioactivity related to ground water conditions in the Rulison area. These calculations will be based on USGS hydrologic studies, and related data will be used to assure that long-range safety problems will not occur.

Environmental Research Corporation

The Environmental Research Corporation (ERC) will make predictions of ground motions and evaluate possible damage that may occur below the surface to wells, storage tanks, etc., as a result of ground motion. The ground motion predictions are based on seismic data obtained by the USC&GS from past detonations conducted in similar geologic environments.

John A. Blume & Associates

John A. Blume and Associates will evaluate the potential effect of ground motion resulting from the Rulison experiment on all structures in the area that might be affected. These evaluations are based on studies made of the response of above ground structures to ground motion resulting from earthquakes and other underground detonations.

ESSA–ARL

The Environmental Science Services Administration's Air Research Laboratory (ESSA–ARL) will gather and interpret weather data in the Rulison area, which it will correlate with national weather information before forecasting local weather just prior to the scheduled time of detonation.

USPHS

The U. S. Public Health Service (USPHS) will perform the same radiological health and safety services for Project Rulison that it routinely provides the area surrounding any Atomic Energy Commission test site. These services will include establishing natural background radiation levels, determining the level and extent of radiation in the unlikely event of an accidental release of radioactivity, and insuring the public health by being prepared to take emergency measures.

U. S. Coast & Geodetic Survey

The U. S. Coast & Geodetic Survey of the Department of Commerce's Environmental Sciences Services Administration will install, maintain, and operate the seismic or ground motion measuring equipment for Project Rulison.

Eberline Instrument Corporation

Eberline Instrument Corporation is responsible for on-site radiological safety. This will include the installation and operation of equipment and facilities to monitor and document radioactivity, to safeguard project personnel and the neighboring populace.

Battelle Memorial Institute

The Battelle Memorial Institute, a non-profit research organization based in Columbus, Ohio, will investigate possible effects from Rulison on the ecology of the area, although no harm to the environment or its life forms is expected.