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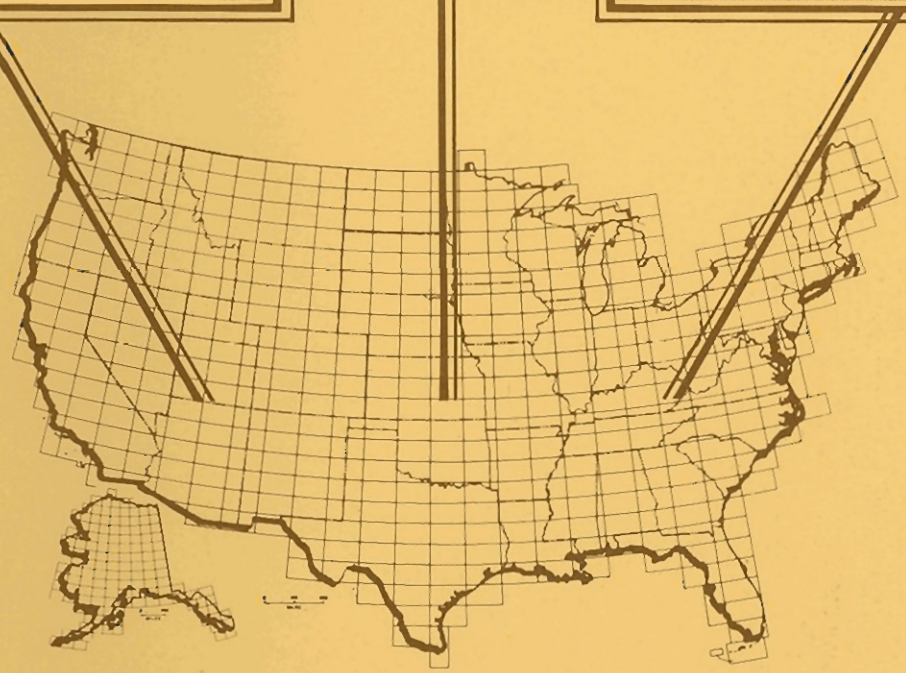


NURE 1977

National Uranium Resource Evaluation

Annual Activity Report

GJBX-11(78)R

NURE 1977

National Uranium Resource Evaluation

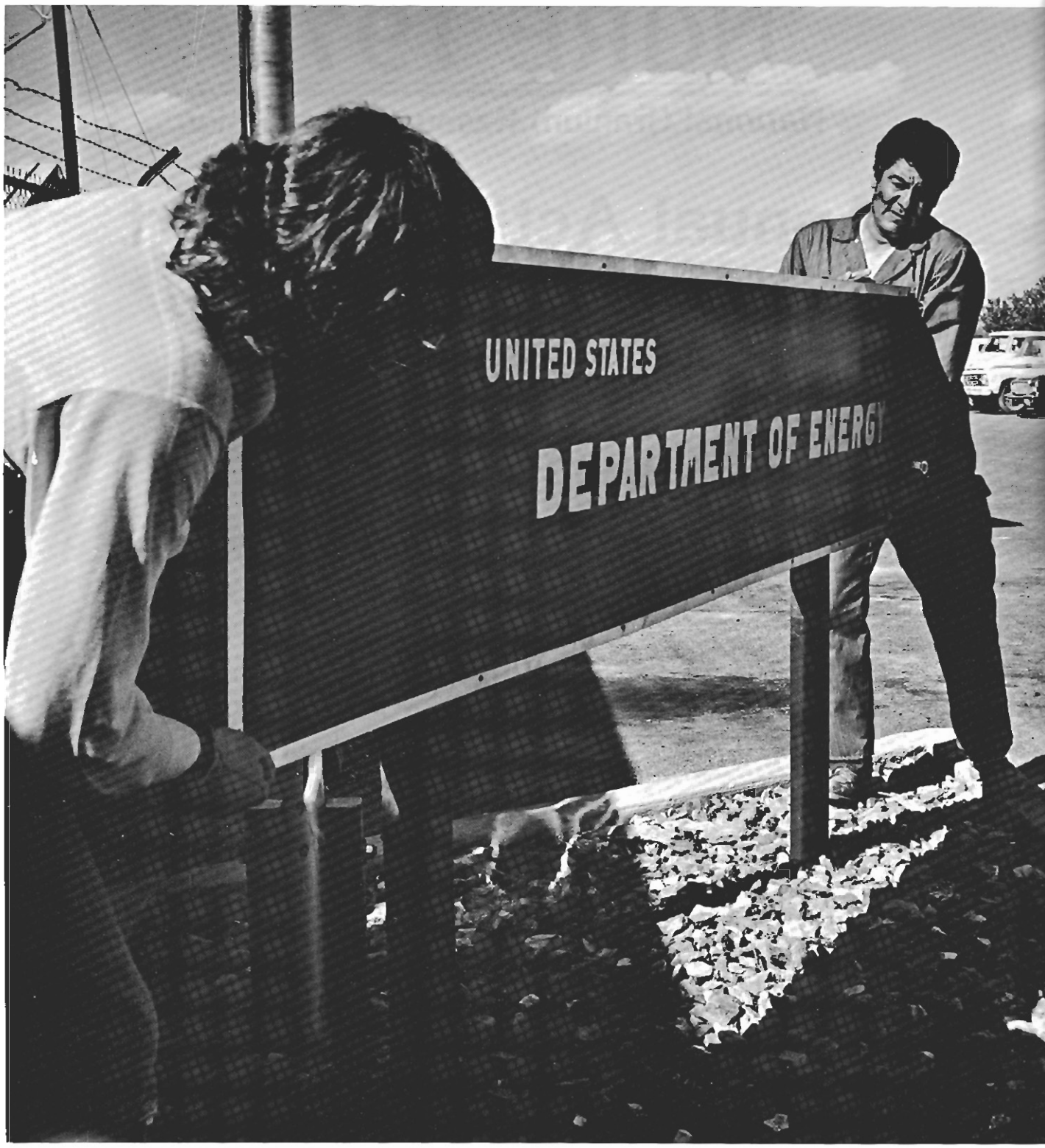
Annual Activity Report

May 1978

Bendix Field Engineering Corporation
Grand Junction Operations
Grand Junction, Colorado 81501

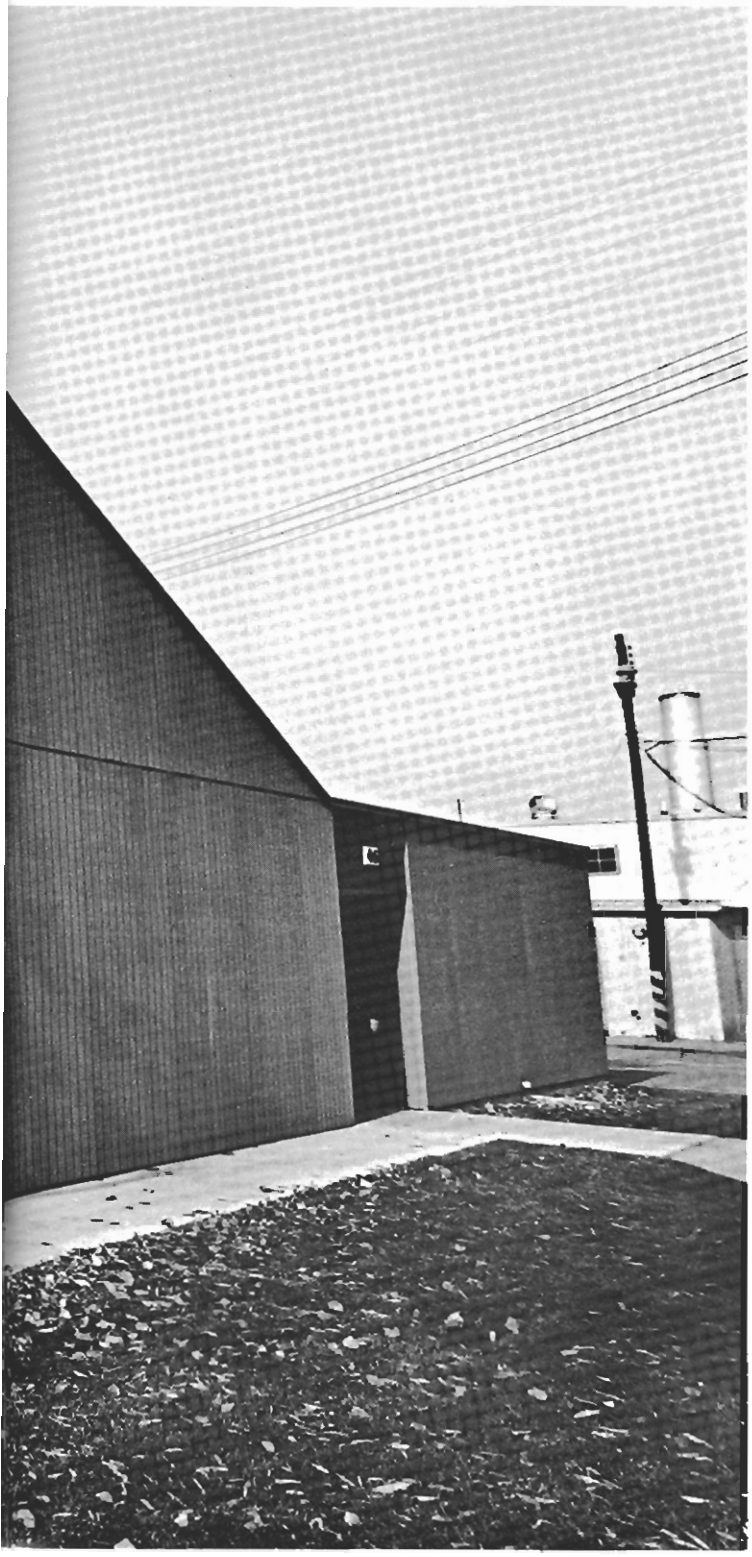
Prepared for the
U.S. Department of Energy, Grand Junction Office
Under Contract No. EY-76-C-13-1664

On October 1, 1977, the Energy Research and Development Administration (ERDA) was incorporated into the newly organized Department of Energy (DOE). The Grand Junction Office managers, Charles L. Greenslit of Bendix and Eugene W. Grutt, Jr., of DOE look on as the new sign at the front gate was erected soon after the official name change.



Contents

DOE demonstrated its interest and concern for new and experimental forms of energy this year with the construction of a solar-heated cafeteria at GJO. The fluid flowing through the panels on the roof heats not only hot water used in the kitchen, but is used as the heat source for the forced air heating system in the 3,000 sq ft building.



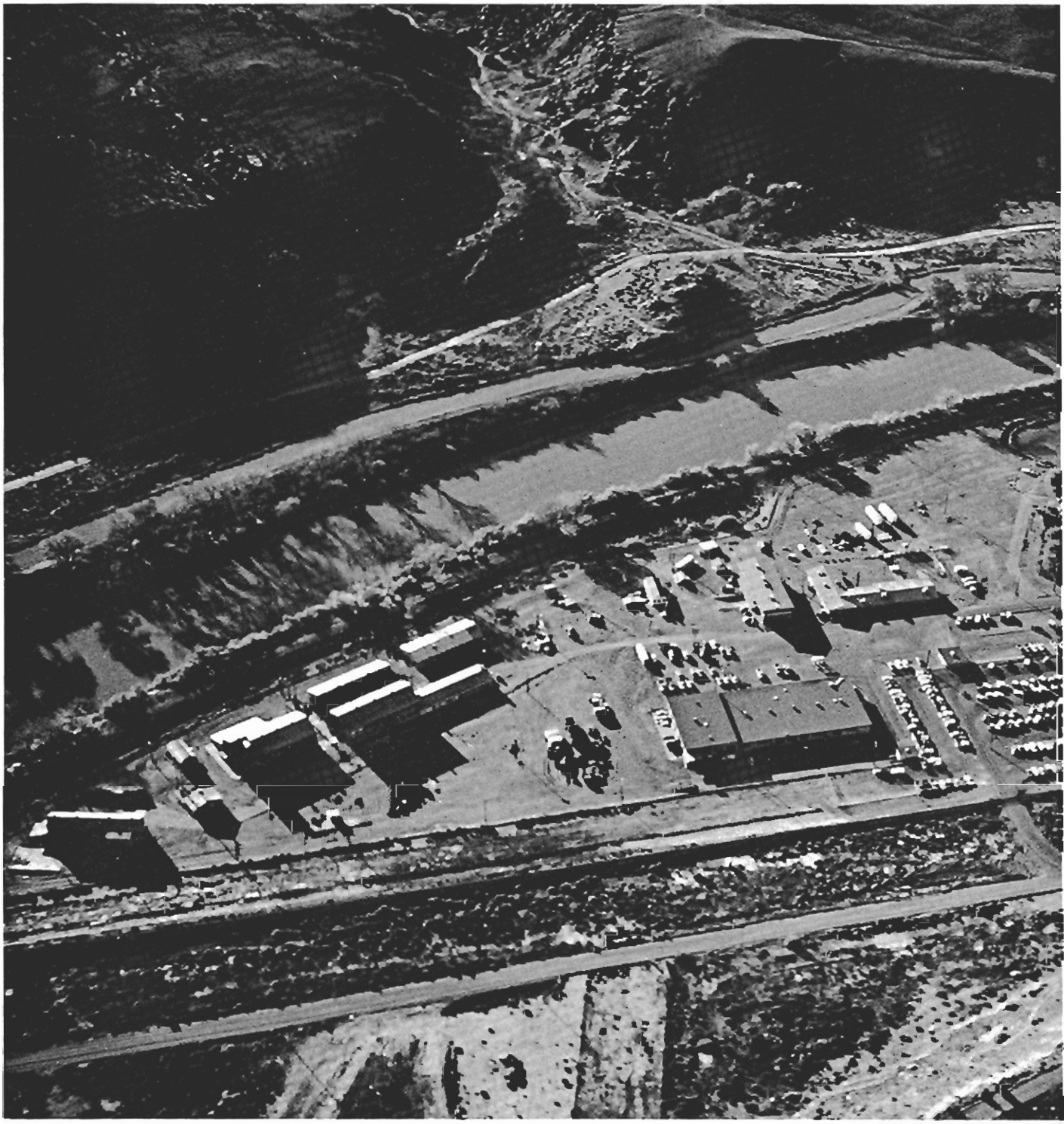
Foreword

Bendix Field Engineering Corporation (BFEC), as prime operating contractor, provides management, technical, and support services to the U.S. Department of Energy's (DOE) Grand Junction (Colorado) Office.

This second annual report summarizes technical activities undertaken during calendar year 1977 to support DOE's National Uranium Resource Evaluation (NURE) program.

Bendix operates under United States Contract EY-76-C-13-1664 with all activities performed under the supervision of the Grand Junction Office of DOE.

Bendix acknowledges the many individuals within BFEC, DOE, and the other organizations participating in NURE who contributed to this report.



National Uranium Resource Evaluation

NURE's home is located on 57 acres along the Gunnison River near where it joins the Colorado River in Grand Junction, Colo., an energy capital on the western slope of the Rockies in the heart of uranium and oil shale country.

NURE is a DOE-directed program with the major goal of establishing reliable and timely comprehensive estimates of the uranium resources of the nation. To develop and compile geologic, geophysical, and other information which will contribute to assessing the distribution and magnitude of uranium resources and to determine areas favorable for the occurrence of uranium in the United States, NURE has been organized into the following elements:

1. NURE Quadrangle Evaluation
2. Aerial Radiometric Reconnaissance
3. Subsurface Studies
4. Hydrogeochemical and Stream-Sediment Reconnaissance
5. Topical Geologic Studies
6. Technology Development
7. NURE Information Dissemination

The extensive effort now planned for each of these NURE program elements will result in a systematic collection and compilation of data which will be used to prepare a comprehensive uranium resource report in 1982 covering certain priority areas of the United States. These priority areas coincide to a high degree with those designated as having potential and as being favorable in the June 1976 ERDA Report GJO-111(76), entitled "National Uranium Resource Evaluation, Preliminary Report." The uranium resource assessment in the balance of the United States will be completed and a report issued by 1984.

It is anticipated that the resource data published periodically by DOE during the time the NURE program is being executed will reflect the latest NURE data.


CAUTION
RADIOACTIVE MATERIAL

Geologists worked out the needs of the quadangle evaluation program's geological maps with a fictitious sample quadrangle. The prototype folio of maps and text are presently being reviewed at GJO.

1977 NURE Summary and Highlights

By far the most significant development in 1977 for NURE was planning, organizing and initiating the quadrangle evaluation studies program which calls for a thorough, uniform, and systematic approach to evaluating the uranium resources of the United States. The basic geographic work units will be the 2-degree (scale 1:250,000) National Topographic Map Series quadrangles. Some 272 quadrangles have been designated as priority areas to be evaluated by 1982 with the remaining 340 quadrangles to be completed by 1984.

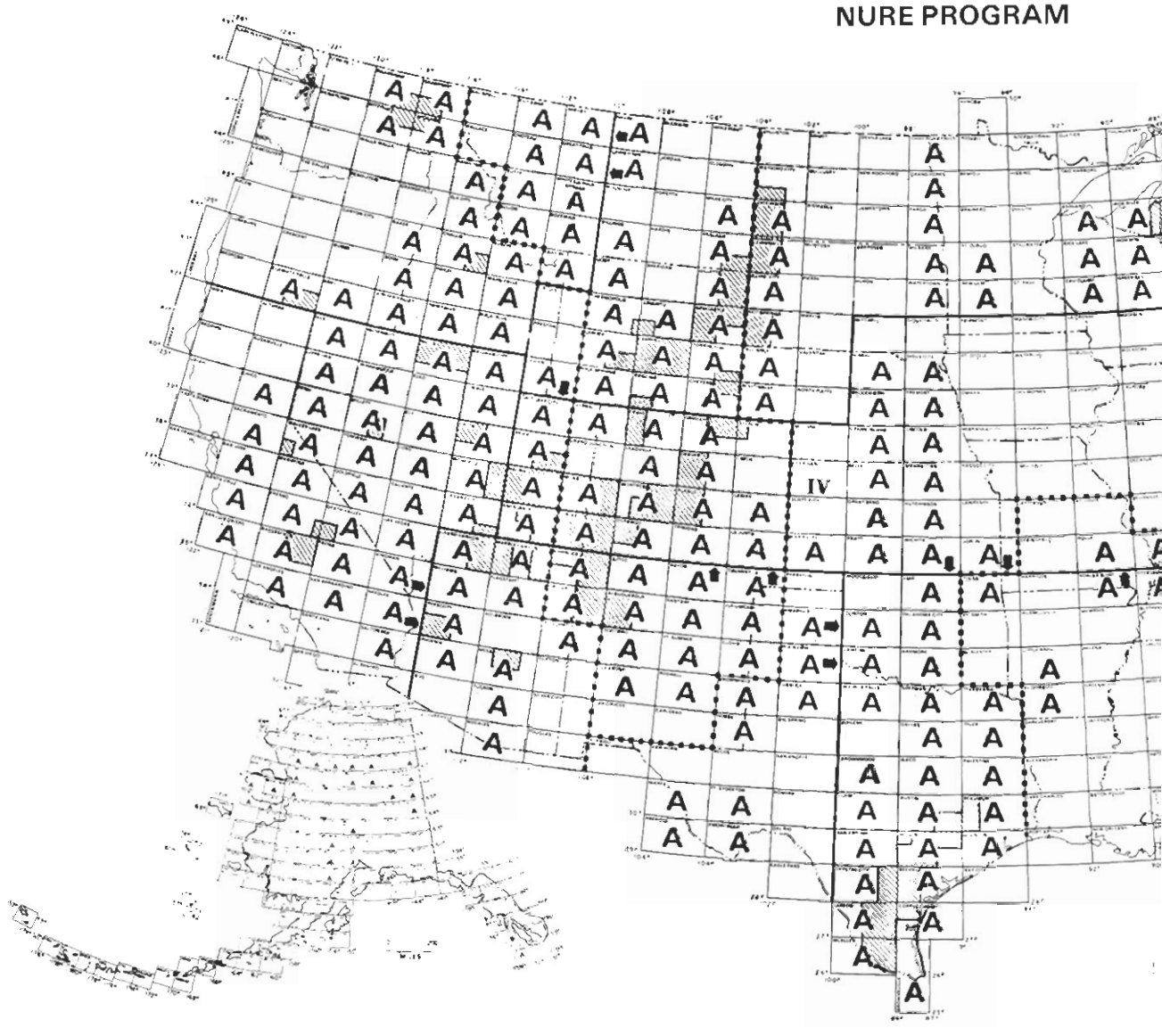
In support of the quadrangle evaluation plan, the Aerial Radiometric Reconnaissance program and the Hydrogeochemical and Stream-Sediment Reconnaissance (HSSR) program schedules have been modified to coincide as nearly as possible with the quadrangle evaluation schedule. By the end of 1977, the number of airborne contractors bidding competitively for NURE projects had increased to six. These contractors have provided a total of 12 systems which have flown some 400,000 line miles of survey. The DOE laboratories participating in the HSSR program had completed sampling in 60 quadrangles with sampling underway in 25 additional quadrangles at the end of 1977.

In the topical geological studies program this past year special attention was given to those types of non-sandstone environments found throughout the world that might lead to the discovery of new uranium districts in the United States. Australia, South West Africa, Canada, Greenland, Mexico, and Brazil were visited by Bendix and subcontractor personnel to study uranium occurrences in calcretes, Proterozoic metamorphics, volcanic sediments, and alkaline rocks.

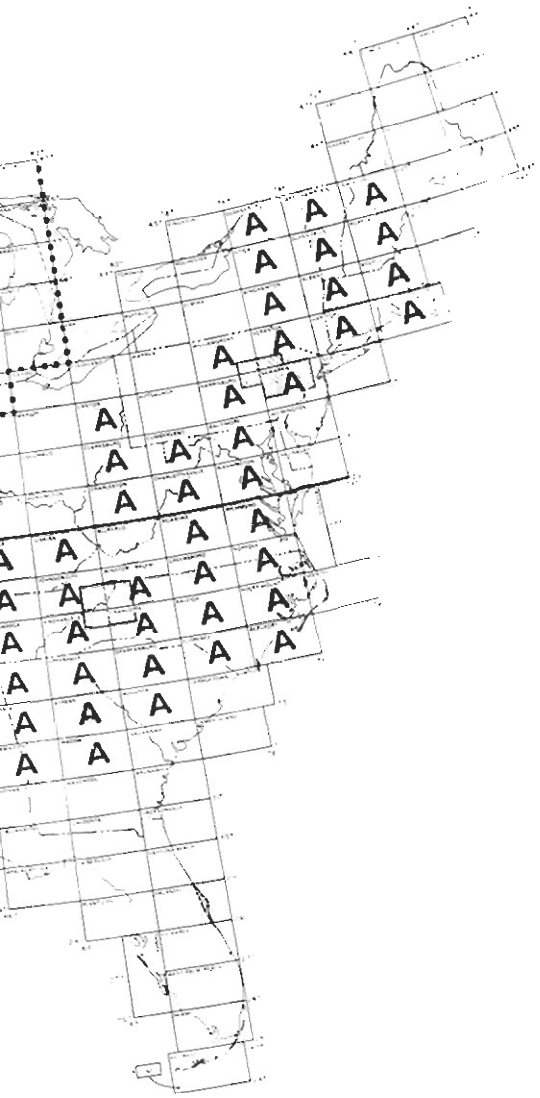
One new drilling project was subcontracted during 1977, bringing the total of subsurface investigations undertaken to date to four. The Michigan Basins Project in the Upper Peninsula of Michigan was started in June. Field work for the three other drilling projects, at Carson Sink, Nev., Red River Valley, N.D. and Minn., and Granite Mountain, Wyo., was completed and some reports are still forthcoming from these projects.

Technology development emphasized the application of a number of state-of-the-art techniques which had been developed for the assessment and exploration of uranium resources. New calibration and test facilities were placed in operation for both borehole logging and airborne radiometric surveying systems. Based on the new facilities, standardization of subcontractor airborne and ground-based systems was made a major thrust for data acquisition and data reduction procedures. Borehole logging development work culminated in the start of field testing for both the fast and delayed fission systems. Bendix introduced an improved gamma-ray spectral logging system (KUT), using a microprocessor-based control. During the summer field season, exploration system studies were initiated in three test areas where several emanometry techniques were employed to evaluate their potential for uranium exploration.

Information dissemination activity increased significantly with 167 reports open filed, 136 news releases issued, and three meetings held in Grand Junction attended by a total of more than 2,000 technical and management personnel representing industry, government, education, and private consultants.



NURE Quadrangle Evaluation



Quadrangles marked with the letter "A" will receive top priority in the quadrangle evaluation udies program which was implemented this year. hese quadrangles, most likely to contain uranium deposits, will be evaluated by 1982.

As an operating contractor for the U.S. Department of Energy (DOE), Grand Junction Operations of Bendix Field Engineering Corporation (BFEC) is responsible for conducting projects of the National Uranium Resource Evaluation (NURE) program to assess the potential uranium resources of the United States. These projects include:

- Regional Geologic Studies
- Preliminary Studies of Uranium Deposits
- Topical Studies
- Airborne Radiometric and Magnetic Surveys
- Drilling and Logging
- Quadrangle Evaluation Studies
- Development of Evaluation and Assessment Techniques.

The large scale of the NURE program requires utilization of many sources of geologic expertise. They now include:

- U.S. Department of Energy
- Bendix Field Engineering Corporation
- U.S. Geological Survey
- State geological surveys
- State and private universities
- Private consultant geologists.

All projects are directed toward the support of the quadrangle evaluation studies and assessment of the potential uranium resources of the United States. A program as large as the NURE program must be divided into work elements if it is to be scheduled and administered. The basic work units, geographic areas, are the 2-degree (scale 1:250,000) National Topographic Map Series quadrangles.

Preliminary planning resulted in the decision to evaluate by 1982 those quadrangles most likely to contain uranium deposits. Criteria for selecting those quadrangles were a record of the presence of:

1. Active uranium production
2. Past uranium production
3. Active exploration for uranium
4. Moderate to large volumes of favorable rocks.

Quadrangles not meeting these criteria will be evaluated by 1984. For ease of discussion the first group of quadrangles, 272 in number, have been designated as "A" quadrangles and the second group "B" quadrangles.

An electron microscope at GJO is used to assess samples of possible uranium-bearing ores which are sent from the various field offices.

Spokane Field Office

The Bendix geologists of the Spokane office are responsible for conducting geologic investigations within the states of Washington and Oregon, the major portion of Idaho, western Montana, and extreme northwestern Wyoming. In addition to completing one major project and several preliminary studies during the year, they began work on evaluation of four quadrangles.

Quadrangle Evaluation

Work toward evaluating uranium potential in the Okanogan, Spokane, Sandpoint, and Challis quadrangles is underway, with most of the planning and some of the investigation completed for each quadrangle.

Okanogan quadrangle, Washington

Work is centered on uranium potential in plutonic rocks and associated sedimentary and metasedimentary rocks intruded by the plutonic rocks.

Spokane quadrangle, Washington, Idaho, and Montana

Postmagmatic rocks of Cretaceous and early Tertiary age, as well as Precambrian metasedimentrary rocks, are being evaluated for uranium potential.

Sandpoint quadrangle, Washington, Idaho, and Montana

Potential for uranium resources in Cretaceous and Eocene plutonic rocks and in associated metasedimentary rocks is under evaluation.

Challis quadrangle, Idaho

The focus of work in the Challis quadrangle is on Tertiary volcanic and associated volcaniclastic rocks and on underlying Cretaceous rocks of the Idaho batholith.

Stream-Sediment Sampling Program

In conjunction with the Lawrence Livermore Laboratory, the entire geology staff engaged in collecting stream-sediment samples in the Sandpoint quadrangle.

Projects and Preliminary Studies

Big Meadow, Idaho

Radioactive "black sand" placers may have originated in specific rock types of the Idaho Batholith. A summary report, GJBX-15(77), of the study was placed on open file in June 1977.

Southwestern Montana Tertiary Basins

Favorability for sandstone-type uranium deposits was determined for Tertiary sedimentary rocks in basins of southwestern Montana. The project report, GJBX-56(77), was open filed in October 1977.

Boulder Batholith, Montana

A preliminary investigation of the Boulder Batholith and associated rocks consisted of an in-depth literature review coupled with field sampling of selected outcrops. Results were open filed early in 1978 as GJBX-5(78).

Southeastern Oregon

Selected volcanic, intrusive, and sedimentary rocks were investigated as potential uranium hosts. The report of the investigation, GJBX-92(77), was open filed in December 1977.

Latah Formation, Washington and Idaho

The Latah Formation was investigated as a possible host for uranium deposits. Results will be open filed in 1978.

Northeastern Washington and Northern Idaho Pluton

Cretaceous and early Tertiary intrusive rocks were sampled extensively to determine uranium and thorium content. Results will be open filed in 1978.

Malheur County, Oregon

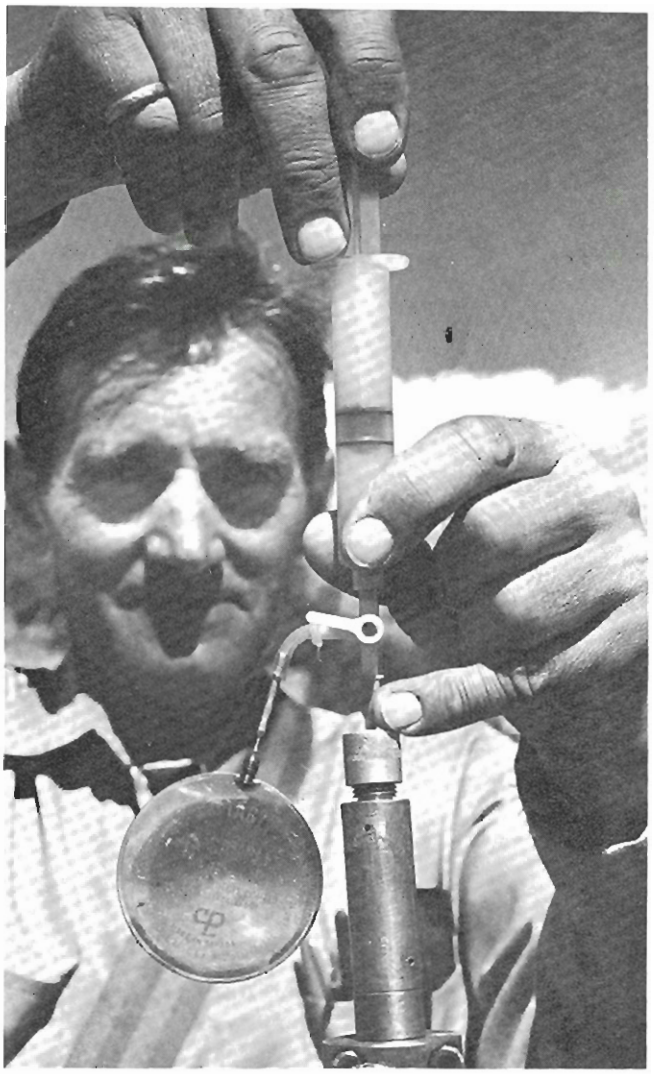
Tertiary volcaniclastic, sedimentary, and felsic volcanic rocks were examined to determine their favorability for uranium. The results of the study were open filed in December 1977 as GJBX-91(77).

Challis Volcanic Study

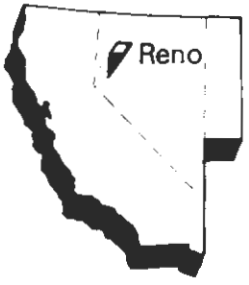
- Subcontractor: University of Idaho
- Subcontract Value: $40,474
- Start Date: 9 May 1977
- Completion Date: 5 May 1978

Uranium is known to occur in the Idaho Batholith and in sedimentary rocks of Tertiary age adjacent to the contact between the Batholith and Challis Volcanics in the Stanley Basin. The work will trace and define the nature of the contact and assess the potential for uranium-bearing formations lying beneath the Challis Volcanic rocks north of the contact. The project will also establish the details of the Challis Volcanics stratigraphic succession, establish the presence of faults and relative displacement of the volcanics and the batholith, locate areas where the volcanics may have been domed by resurgent intrusions, locate any uplifted fault blocks of the volcanics, and locate any areas where glacial domecutting and valley erosion have nearly unroofed the batholith.

Field geologists work in many geological settings collecting samples, performing some field analyses, and recording data. This geologist, working in northeast Washington, is from the Spokane office.



Reno Field Office



Geologists from the Reno office conducted investigations in a region encompassing California, Nevada, western Utah, and extreme western Arizona. In 1977 the geologists assisted in collecting samples for the HSSR program and began evaluation work on six quadrangles. Reports of some earlier studies were also completed by the Reno office.

Quadrangle Evaluation

Planning tasks for the Millett, Goldfield, Death Valley, Tonopah, Vya, and Winnemucca quadrangles began in October, and data gathering is underway.

Millet quadrangle, Nevada

Favorability evaluations for uranium resources will focus on fractured intrusive contact zones in precious metal districts and on volcaniclastic rocks that surround eruptive centers and cauldron subsidence structures.

Goldfield quadrangle, Nevada and California

Tertiary intrusive rocks, as well as fault and fracture zones in pre-Tertiary sedimentary and metasedimentary rocks, are the principal targets for evaluation in the Goldfield quadrangle.

Death Valley quadrangle, California and Nevada

Geologic environments in the Death Valley quadrangle that are potentially favorable for uranium resources include Tertiary sedimentary and felsic pyroclastic rocks, granitic rocks of Mesozoic age, Paleozoic carbonate strata, and Precambrian granitic and metasedimentary rocks.

Tonopah quadrangle, Nevada

Granitic intrusives and Tertiary volcanic rocks, as well as younger sedimentary materials derived from those sources, appear to be the most promising environments for potential uranium deposits in the Tonopah quadrangle.

One of the field geologists in the Reno office is bagging a sample of radioactive sediments in the Red Rock Canyon area of California.

Vya quadrangle, Nevada

The principal environments in which potential uranium resources are anticipated include Cretaceous granites and pegmatites and a Tertiary sequence composed of volcanic ash, tuff, and sedimentary rocks with opal interbeds.

Winnemucca quadrangle, Nevada

Evaluation of the Winnemucca quadrangle will focus on the following geologic environments: contact metamorphic zones and areas of base metal occurrences in pre-Tertiary rocks; Tertiary sedimentary rocks derived from volcanic eruptives; areas of hot springs; and minor petroliferous deposits.

Stream-Sediment Sampling Program, Nevada and California

Geologists in the Reno Field Office completed the collection of HSSR samples in the Millett, Lovelock, Winnemucca, Tonopah, Reno, and Walker Lake quadrangles and assisted in collecting samples in the Goldfield, Ely, Elko, and Lund quadrangles.

A radioactive outcrop at the Garrett prospect in the Virginia Mountains of Nevada is being measured by a field geologist.

Projects and Preliminary Studies

Hallelujah Junction

Tertiary volcanic and sedimentary rocks in Washoe County, Nevada, and Lassen County, California, were studied to determine their favorability for uranium resources. The project report was open filed in May 1977 as GJBX–16(77).

Basin and Range Low Grade

The Virgin Valley, northern Reese River Valley, East Walker River, northwestern Garfield Hills, Coaldale, and Meadow Valley areas in Nevada were investigated in reconnaissance fashion to determine their potential for low-grade uranium resources. A report on the results was open filed in December 1977 as GJBX–74(77).

Juab County, Utah

A study of known uranium occurrences in the Spor Mountain and adjacent areas was made to determine the extent of favorable ground. The results were open filed early in 1978 as GJBX–23(78).

Central Mojave Desert

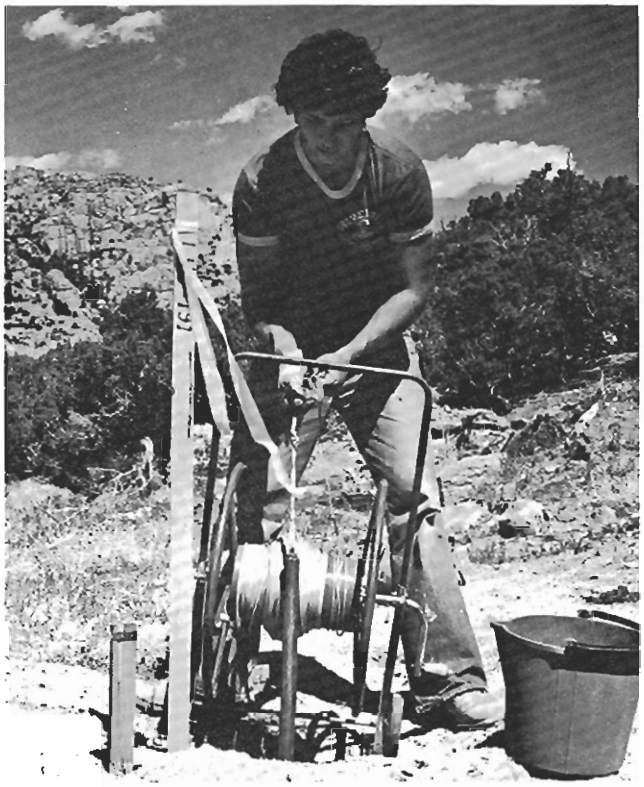
Mesozoic intrusive and Tertiary volcanic and sedimentary rocks were examined and sampled to determine favorability for uranium deposits. The project report will be open filed early in 1978.

Owens Valley Granites

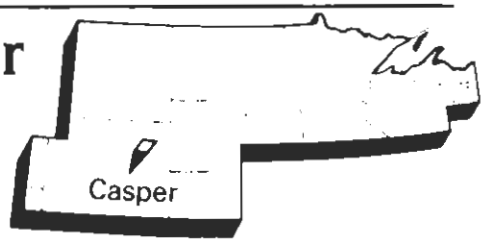
Granitic and contact-metamorphic rocks of the Owens Valley area (California and Nevada) were sampled for uranium content in order to determine favorability for uranium resources. Results were open filed in 1978 as GJBX–3(78).

Great Basin Framework and Favorability

A compilation of existing geological, geophysical, and geochemical data necessary as a beginning to uranium favorability determination was completed by the Mackay School of Mines, University of Nevada at Reno. Results were open filed early in 1978 as GJBX–36(78).



Casper Field Office



Geologists of the Bendix Casper Office are involved in evaluating the uranium favorability in an area encompassing the states of Wyoming and North Dakota and parts of South Dakota, Montana, Nebraska, Minnesota, Wisconsin, and Michigan.

The primary task of this regional office in the latter part of 1977 was the evaluation of specified quadrangles to determine areas favorable for the occurrence of uranium. Surface and subsurface investigations, followup investigations of aerial radiometric surveys, and hydrogeochemical and stream-sediment sampling programs, are being used in these studies. Work on the quadrangle evaluation was started, and a number of preliminary studies and projects were completed during the year.

Quadrangle Evaluation

Five quadrangles within a variety of geologic provinces are being studied by the Casper Field Office. All of these quadrangle evaluation projects are scheduled to be completed in 1979.

Marquette quadrangle, Michigan

Evaluation of this quadrangle involves study of lower Paleozoic rocks of the Michigan basin and of a complex series of Precambrian metasedimentary, sedimentary, and igneous rocks of the southern Canadian Shield province.

Iron Mountain quadrangle, Michigan and Wisconsin

The bedrock geologic terrane of this quadrangle consists of Precambrian sediments, metasediments, and igneous rocks of the southern Canadian Shield. The task of favorability evaluation is complicated by extensive Pleistocene glacial deposits. Localized radioactive occurrences are found in some of the Proterozoic metamorphic and sedimentary rocks. Sialic intrusions in the southern part of the area carry high background amounts of disseminated uranium.

Cheyenne quadrangle, Wyoming

Among the geologic environments which will be evaluated in this study are Tertiary and Cretaceous sediments of the Denver and Laramie basins, and the Precambrian igneous and metamorphic rocks of the Laramie Range.

Casper quadrangle, Wyoming

The quadrangle includes the Granite Mountains, Shirley Basin, northern portion of the Laramie Range, and parts of the Wind River Basin, Powder River Basin, and Great Divide Basin. Rocks in the area range in age from Precambrian to Recent. Three major uranium districts—Crooks Gap, Shirley Basin, and Gas Hills—produce from Tertiary sandstones.

Rawlins quadrangle, Wyoming

This study area includes a variety of geologic environments, from the fluvial sandstones of Tertiary basins to the Precambrian rocks of the adjacent Medicine Bow and Sierra Madre Ranges. Some of these Precambrian rocks are approximately equivalent in age and lithology to uranium bearing conglomerates of the southern Canadian Shield in Ontario.

Stream-Sediment Sampling Program, Wyoming

The Casper Field Office assisted Los Alamos Scientific Laboratory in its hydrogeochemical and stream-sediment reconnaissance program by collecting samples in the Rock Springs and Cheyenne

quadrangles. Bendix supplied four field teams of one geologist and one to two geological technicians for most of the summer field season.

Preliminary Studies and Projects

Northern Green River Basin

The results of a study of the uranium favorability of Tertiary sedimentary rocks in the northern Green River Basin and the Hoback Basin of Wyoming, completed in 1976, were placed on open file as GJBX-64(77).

Pennsylvanian-Permian, Powder River Basin and Great Plains

A preliminary study of uranium favorability in Pennsylvanian and Lower Permian strata in the Powder River Basin, Wyoming and Montana, and the northern Great Plains in South Dakota was completed early in the year. A report of the study was open filed in November 1977 as GJBX-81(77).

Bighorn Basin

This preliminary study was an evaluation of the uranium favorability of continental sediments of the Upper Cretaceous Lance, Paleocene Polecat Bench, and lower Eocene Willwood Formations in the Bighorn Basin of Wyoming and Montana, an intermontane structural basin of Laramide age. Previous work dealing with the Bighorn Basin was reviewed, and field investigations were carried out in the spring and summer of 1976. Subsurface data were collected, and results of surface and subsurface investigations were evaluated with respect to uranium favorability.

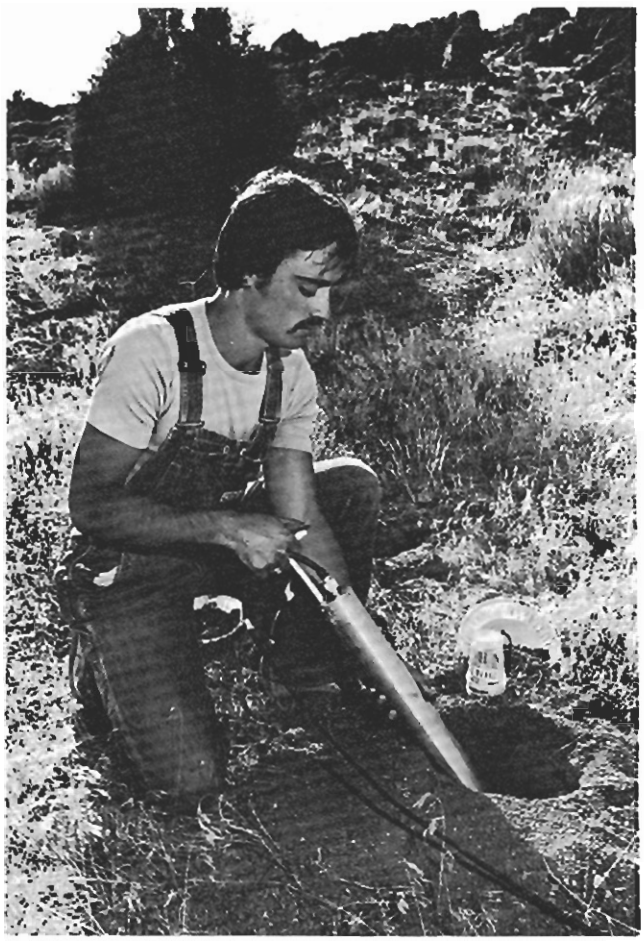
A report summarizing the findings was placed on open file as GJBX-25(78).

Mineral Resource Assessment in the Snowy Range, Wyoming

- Subcontractor: United States Geological Survey
- Subcontract Value: $44,500
- Start Date: 8 July 1976
- Completion Date: 31 December 1977

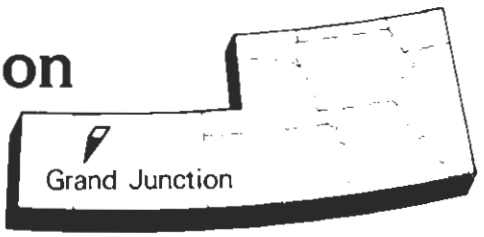
Evaluation of miogeosynclinal metasedimentary rocks of early middle Precambrian age in southeastern Wyoming as a possible host for uranium-bearing conglomerate is a cooperative effort of the USGS; the Department of Geology, University of Wyoming; the Wyoming Geological Survey; and the Department of Energy. This program was begun because miogeosynclinal metasedimentary rocks of the Medicine Bow Mountains and the Sierra Madre of Wyoming were considered possible correlatives of uranium-bearing miogeosynclinal metasedimentary rocks of the Huronian Supergroup found in the Blind River area of Canada. The study has resulted in the identification of uranium-bearing quartz-pebble conglomerate at several localities in the Medicine Bow Mountains and Sierra Madre.

To date, the USGS has released four open-file reports on the program: 75-85, 77-92, 77-574, and 77-830.



An area in the central part of Wyoming known to contain uranium was the site of field testing of several technology development projects and the Casper office assisted with these field tests. The photo on the opposite page is of ground water sampling for helium measurement. A new measuring device for in situ KUT measurement in holes used for radon determination by Track Etch is being tested in the above picture.

Grand Junction Field Office



The regional extent of the Bendix Grand Junction Field Office includes eastern Utah, Colorado, Kansas, Iowa, most of Nebraska, Missouri, and Illinois; and parts of South Dakota, Minnesota, Wisconsin, and Kentucky. The primary objective of the geologists in this regional office is to evaluate specified quadrangles to determine areas favorable for uranium occurrence. The evaluation will be accomplished by both surface and subsurface investigations and followup studies of aerial radiometric surveys and hydrogeochemical stream and sediment sampling programs. As the work on the quadrangle evaluation began, a number of preliminary projects and studies was completed during the year.

Quadrangle Evaluation

Four quadrangles in diverse geologic settings are being investigated by the Grand Junction Field Office. Preliminary data gathering began during 1977. The evaluation of the uranium favorability of these areas will be completed in 1979.

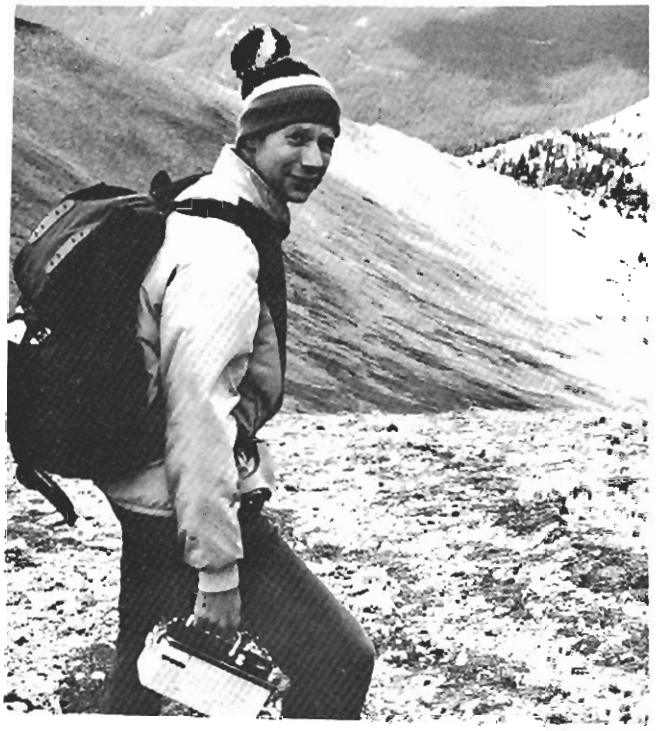
In addition to the quadrangle evaluation work described, initial geologic investigations were carried out on the Craig, Leadville, Greeley, Denver, and Pueblo quadrangles in Colorado. These projects subsequently have been assigned to the U.S. Geological Survey and the Colorado Geological Survey.

Durango quadrangle, Colorado

Evaluation of this area is concentrating on uranium associated with base metal deposits and volcanic calderas.

Montrose quadrangle, Colorado

Emphasis is being placed on examination of areas where Precambrian rocks are faulted against younger sedimentary rocks, determination of uranium enrichment of Precambrian and Tertiary alkalic intrusive bodies, and examination of rhyolitic intrusive bodies related to caldera systems.



A geologist (above) finds himself above the timberline in the Greeley quadrangle to investigate for the presence of uranium. Geologists also collect ground-water samples from wells where necessary. This (middle) is an HSSR sampling site in the Lamar quadrangle in southeastern Colorado. A seemingly pastoral scene of a man with

La Junta and Lamar quadrangles, Colorado

The major objectives of this project are subsurface examinations of the uranium favorability of Pennsylvanian-Permian sediments shed from the Sierra Grande and Las Animas arches.

Stream-Sediment Sampling Program, Colorado

Between July and October a hydrogeochemical and stream-sediment sampling program was conducted in the Pueblo, Lamar, and La Junta quadrangles in conjunction with Los Alamos Scientific Laboratory.

Preliminary Studies and Projects

Forest City Basin, Kansas and Missouri

A preliminary report on the uranium favorability of Late Pennsylvanian Warrensburg Sandstone, Tonganoxie Sandstone, and Indian Cave Formation associated with the Nemaha Uplift and

his horse (top right) is really a geologist recording data for the HSSR program in the Rawah Wilderness. Many places require the use of horses as the only means of access.

Pennsylvanian black shales of the Forest City Basin was open filed as GJBX–83(77).

San Rafael Swell

A study was made of uranium potential of the Chinle and Morrision Formations and of White Rim Sandstone with emphasis on the western and northern parts of the San Rafael Swell area of eastern Utah. A project report delineating areas for potential uranium resources in each formation studied was open filed as GJBX–72(77) in October 1977.

Brushy Basin

A study of the uranium potential of the Brushy Basin Member of the Jurassic Morrison Formation in east-central Utah was completed. The results of this work were open filed as GJBX–39(78) in April 1978.

Kaparowits Plateau, Utah

A preliminary investigation was made of the Jurassic Morrison and Triassic Chinle Formations, both known uranium producers in other areas. The results of this study will be open filed in 1978.

Gunnison Area, Colorado

A preliminary investigation was made to evaluate the favorability for vein-type uranium occurrences in the igneous and metamorphic rocks northeast of Gunnison, Colorado. The project area is similar in structure and lithology to the Cochetopa, Powderhorn, and Marshall Pass districts to the south. The results of this investigation were placed on open file in August 1977 as GJBX–61(77).

Front Range, Colorado

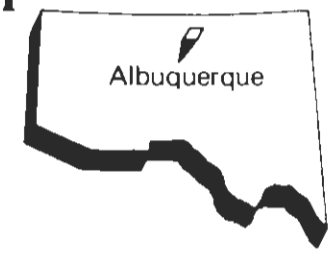
This subcontract was awarded to Dr. R. H. Carpenter, Colorado School of Mines, and will be monitored by personnel of Grand Junction Office. This study is concerned with migration and concentration of uranium in hood zones of certain Precambrian intrusive rocks, relation of uranium to the Colorado Mineral Belt and Tertiary intrusive sequences, and distribution of trace elements in plutons. This study will be completed in 1978.

Radioactive Deposits in Colorado

- Subcontractor: Colorado Geological Survey
- Subcontract Value: $68,000
- Start Date: October 1976
- Completion Date: June 1978

The Colorado Geological Survey, under direct contract to DOE, has been conducting a cooperative detailed study, inventory, and evaluation of the radioactive mineral resources in Colorado. The goal is to provide a complete bibliography and synthesis of all available data and to locate and describe all known radioactive areas in Colorado. A complete report and bibliography to be published by the Colorado Geological Survey in 1978 will summarize present widely scattered data so that they will be more useful in the exploration for and development of the radioactive minerals in Colorado.

Albuquerque Field Office



The Bendix Albuquerque Office is responsible for planning and conducting uranium favorability studies in most of Arizona, all of New Mexico, western Texas, and the Oklahoma Panhandle. Portions of the Basin and Range, Colorado Plateau, Southern Rocky Mountains, Great Plains, and Central Lowland physiographic provinces compose the diverse topography of the region. Igneous, sedimentary, and metamorphic rocks of Precambrian to Quaternary age present varied terranes.

During 1977, Bendix geologists of the field office completed reports on five projects in New Mexico, collected stream-sediment samples in northwestern Arizona and southern Nevada, and began favorability studies in seven quadrangles. Three open-file reports were issued during the year. A subcontracted study of the geochemistry of the Grants Mineral Belt, New Mexico, was monitored.

Quadrangle Evaluation Program

Quadrangle evaluation studies began in seven quadrangles: Kingman (Arizona, Nevada, California); Williams, Prescott and Nogales (Arizona); and Marfa, Presidio, and Emory Peak (Texas). Except for the Colorado Plateau portions of the Williams and Prescott sheets and the Great Plains portion of the Emory Peak sheet, the study areas lie in the Basin and Range province.

Kingman quadrangle, Arizona, Nevada, and California

Ranges, predominantly of Precambrian, Cretaceous, and Tertiary igneous and metamorphic rocks and Paleozoic sedimentary rocks, are separated by basins filled with Cenozoic sedimentary and volcanic rocks. Uranium favorability studies will concentrate on Tertiary lake beds and veins in Precambrian rocks.

Williams quadrangle, Arizona

Fault-block mountains of Precambian crystalline, Paleozoic sedimentary, and Tertiary volcanic rocks alternate with Cenozoic basins in the western portion of the Williams quadrangle; Paleozoic units, mainly marine and commonly volcanic-covered, predominate elsewhere. A uranium favorability assessment will concentrate on Precambrian granitic and gneissic rocks, Upper Paleozoic clastic units, and Tertiary strata of possible lacustrine origin.

Prescott quadrangle, Arizona

Uplands, predominantly of Precambrian igneous and metamorphic rocks, Tertiary volcanic rocks, and Cenozoic basalts, adjoin basins of Cenozoic sediments in the Prescott quadrangle. Favorability studies will be concentrated on uranium in Tertiary lake beds and Precambrian rocks.

Nogales quadrangle, Arizona

Mountain ranges, mainly of Cretaceous and Tertiary rocks, are separated by broad basins mantled by Cenozoic sediments. Studies will focus upon uranium occurrences in veins and in shear and contact zones.

Marfa, Presidio, and Emery Peak quadrangles, Texas

The area, which includes the intersection of the Marathon and Cordilleran fold belts, is structurally complex. Tertiary intrusive rocks crop out in many places and volcanic rocks blanket the area; most rocks are silicic. Recent discoveries in Mexico plus radioactive anomalies in the pyroclastic rocks and underlying Cretaceous sediments indicate possible uranium mineralization.

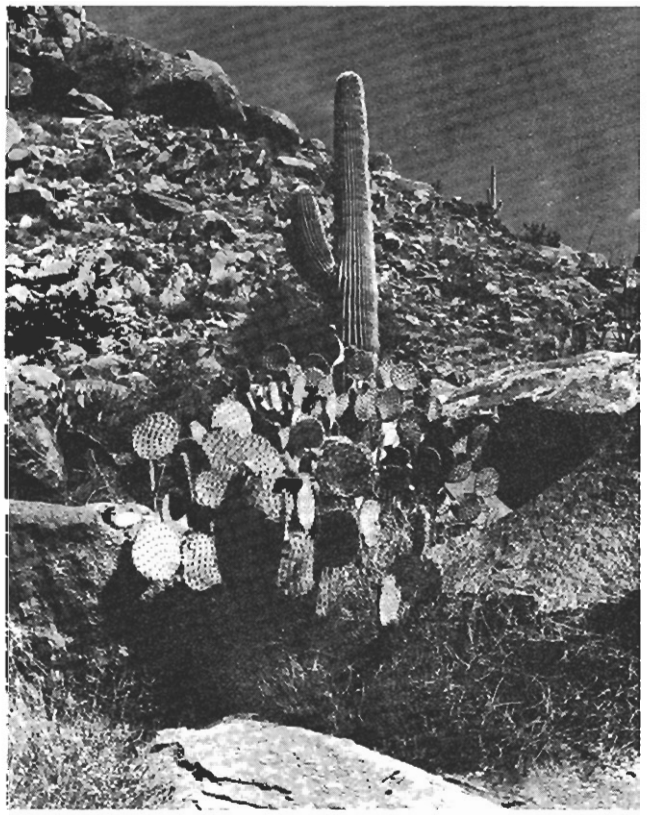
Stream-Sediment Sampling Program, Arizona and Nevada

In cooperation with the University of California's Lawrence Livermore Laboratory, and as part of the NURE program's Hydrogeochemical and Stream-Sediment Reconnaissance, the Albuquerque office's geologists conducted a stream-sediment sampling program in northwestern Arizona and southern Nevada. Samples were collected in the Prescott, Williams, the Arizona portion of the Kingman, and the eastern third of the Las Vegas quadrangles. The samples will be analyzed by Lawrence Livermore Laboratory.

Preliminary Studies and Projects

High Plains, New Mexico and Texas

Twenty-seven sections of the Triassic Dockum Group in eastern New Mexico and northwestern



Albuquerque office geologists note the geology (above) as well as the flora (right) near Kingman, Ariz., in the Basin and Range. As one geologist notes the Precambrian background and the Quaternary alluvium foreground, his assistant goes after a rock sample.

Texas, measured and sampled in 1974, are presented in open-file report GJBX-9(77).

Nacimiento-Jemez Region, New Mexico

A preliminary report on the uranium favorability of the Pennsylvanian Madera, Permian Cutler, and Triassic Chinle Formations in the Nacimiento-Jemez region was open filed early in 1978 as GJBX-4(78).

Tertiary Rocks, Central San Juan Basin, New Mexico

A preliminary report on the favorability of Tertiary beds in the central San Juan Basin was open filed as GJBX-78(77) in December 1977.

Las Vegas Basin, New Mexico

A preliminary report on the uranium favorability of the Pennsylvanian-Permian Sangre de Cristo Formation in the Las Vegas Basin was open filed as GJBX-82(77) in December 1977.

Baca Formation, New Mexico

A report of results of a preliminary study of the Baca Formation in west-central New Mexico is in preparation.

Bandelier Tuff, Jemez Mountain, New Mexico

A study of the Quaternary Bandelier Tuff as a uranium source was conducted as an adjunct to the Nacimiento-Jemez project. A report is in preparation.

Jornada Del Muerto Basin, New Mexico

Small uranium occurrences associated with faults and lenticular sandstones are present in the Jornada del Muerto region, south-central New Mexico. A preliminary study of the rock units in the region was conducted to determine the presence and favorability of potential host rocks. The results will be open filed in 1978.

Uranium Deposits of the Grants Mineral Belt, New Mexico

The results of a 1975 study conducted by the University of New Mexico under direct contract with then ERDA-GJO on aspects of geochronology, geochemistry, and clay mineralogy of uranium deposits in the Grants Mineral Belt were published in GJBX-16(76). A second phase of the investigation, under subcontract with BFEC, was begun in late 1976.

The purpose of the second phase is to investigate the relation of organic carbon to clay mineralogy, uranium mineralization, and pyrite formation in ore zones and in barren rocks up and downdip from mineralized areas. Trace element enrichment in clay minerals involved in organic reactions, radiometric dating, uranium abundance, leaching of ore and barren samples with organic acids, and Eh-pH relationships are also being investigated to elucidate aspects of ore genesis and uranium transport, and to aid interpretation of primary mineralization.

A known uranium-bearing Permian crossbedded outcrop in the Wichita Falls quadrangle of Texas is examined by a geologist from the Austin office.

Austin Field Office

Geographically, this region encompasses central and eastern Texas, all of Oklahoma except the panhandle, the entire states of Arkansas, Louisiana, and Mississippi, extreme western Tennessee, and minor portions of southern Missouri and southwestern Kentucky.

The Bendix geologists of the Austin office concentrated on completing one project and three preliminary studies. They also performed stream-sediment sampling on two quadrangles and commenced quadrangle evaluations on four quadrangles.

Quadrangle Evaluation

Planning and initial investigations of the Crystal City, Plainview, Seguin, and Ardmore quadrangles are under way.

Crystal City and Seguin quadrangles, Texas

The Crystal City and Seguin quadrangles are partially underlain by rocks of the Claiborne and Wilcox formations of Eocene age. Rocks younger than the Claiborne-Wilcox group, ranging in age from Eocene to Pliocene, are also of prime interest in these quadrangles as well as further to the northeast.

Plainview quadrangle, Texas

Primary target for uranium investigation in the Plainview quadrangle is the Dockum Group of Triassic age exposed in the Palo Duro Canyon and its tributaries and along the boundary of the cap rock plain.

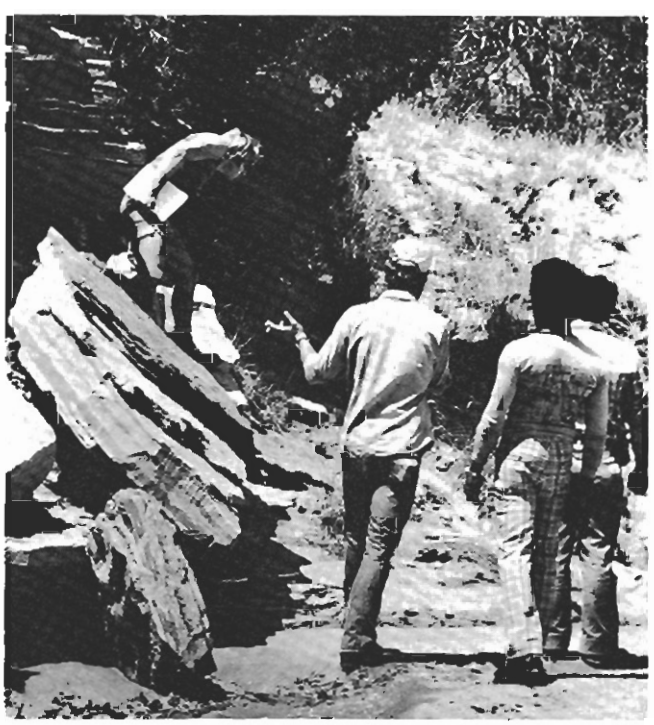
Ardmore quadrangle, Oklahoma and Texas

Prime targets for uranium investigation in the Ardmore quadrangle are some igneous rocks in the Wichita Mountains and conglomerates and sediments derived from the granites of the Wichita Mountains.

Stream-Sediment Sampling Program

Hydrogeochemical and stream-sediment reconnaissance sampling was accomplished in the Plainview and Oklahoma City quadrangles. The work was done on behalf of the Oak Ridge Gaseous Diffusion Plant.

An HSSR sampling crew from the Austin office examines the Permian Quartermaster Formation in the Palo Duro Canyon State Park in the Texas Panhandle.



Projects and Preliminary Studies

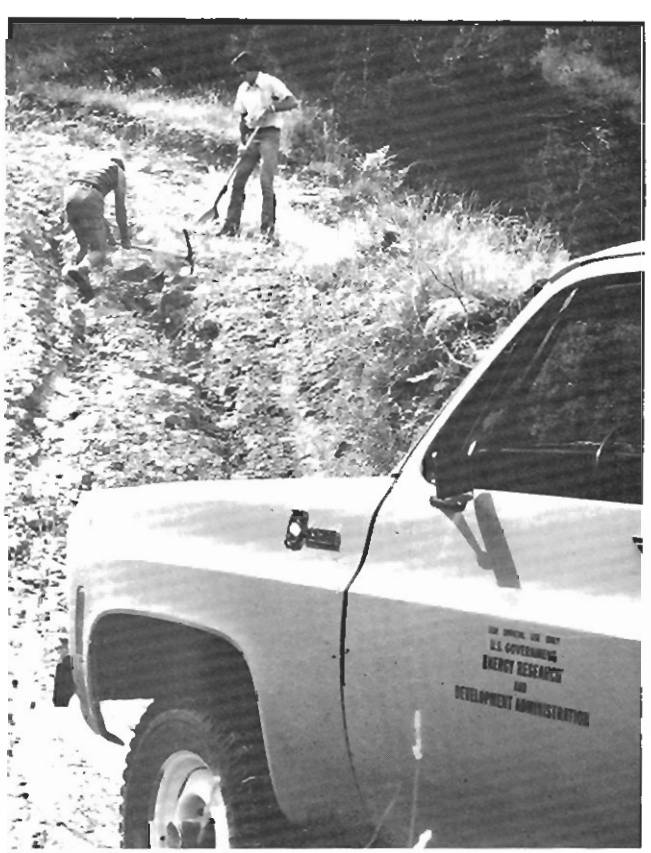
South Texas Coastal Plain

Sedimentary strata of late Eocene through Pliocene age underlying the South Texas Coastal Plain were studied with regard to uranium favorability. The units investigated—Yegua, Jackson, Frio, Catahoula, Oakville, and Goliad systems—are known to contain uranium deposits or to have lithologies favorable as host rocks. Although attention was given to sandstones that crop out, most of the findings and conclusions of this study apply to sandstones in the subsurface. The summary report of this project was prepared by BFEC and was open filed in April 1977 as GJBX–7(77).

Southwestern Oklahoma and North-Central Texas

A project to identify and delineate units in the Upper Pennsylvania and Lower Permian strata of north-central Texas and southwestern Oklahoma was completed during the year. The results, which included subsurface maps of depositional systems, were open filed as GJBX–75(77) in October 1977.

An HSSR sampling crew from the Austin office had to repair a road to gain access to a sample site in the Palo Duro Canyon in the Plainview quadrangle.



Claiborne-Wilcox Group

The Eocene Claiborne-Wilcox Group is primarily a fluvial-deltaic system with some shallow marine facies and widespread carbonaceous material. The findings of a preliminary study were released as an open-file report, GJBX–7(78), in early 1978.

East Texas-Louisiana Coastal Plain

To determine the geological conditions favorable for uranium emplacement, a preliminary study was completed in which geologic trends identified in a previous project were traced through east Texas into Louisiana. The section of interest consists of fluvial and deltaic sediments with some shallow marine facies. There is also widespread carbonaceous material in the section and extensive local structural features. A report of the results of this study was placed on open file in November 1977 as GJBX–79(77).

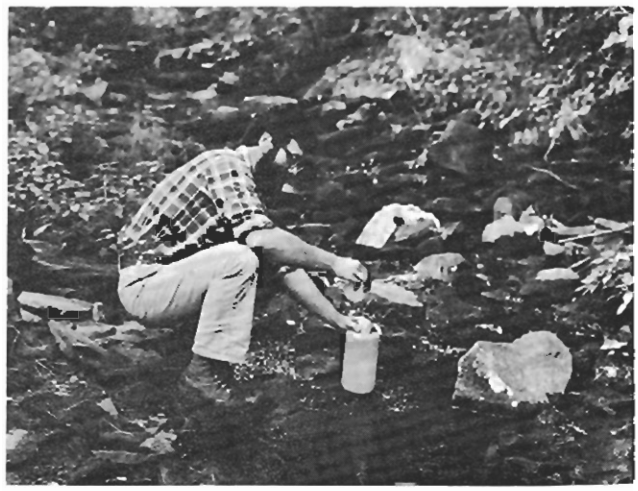
Permian-Pennsylvanian of Oklahoma

Oklahoma State University conducted a detailed followup investigation of specific Permian-Pennsylvanian units and facies, as well as certain basement rocks in which uranium occurrences are known in southwestern Oklahoma. Much of the investigation was done in the Ardmore quadrangle. The study involved field reconnaissance and sampling, petrographic examination, geochemical analysis, and differential spectrometer surveys. A summary report of the present work will be published upon completion of the project in 1978.

Catahoula Formation, Texas

To evaluate the uranium favorability of the Catahoula Formation, the Texas Bureau of Economic Geology conducted a regional analysis of the principal Catahoula facies (Oligocene-Miocene). The project included facies recognition and mapping outcrop and shallow subsurface, study of sedimentary factors such as sand distribution and sedimentary structures, and general petrography and mineralogy of selected facies. Existing well logs and seismic information were used to complete the subsurface aspects of the study.

The results of the regional surface and subsurface analyses and the development of a depositional model for the Catahoula were detailed in the project report, placed on open file as GJBX–41(77) in June 1977. Work is continuing on a second phase of this project dealing particularly with the hydrology of the models developed in the first phase.



Bendix personnel from the Pittsburgh office illustrate HSSR sampling techniques in this series of photographs. Water samples are taken at specified sites in every quadrangle (top). Stream-sediment samples are also taken whether from a wet stream or a dry stream bed (middle). Field analyses on water samples are often performed in the trunk of geologists' vehicles (bottom).

Pittsburgh Field Office

The Bendix geologists in the Pittsburgh regional office are responsible for geologic investigations in the entire northeastern corner of the United States—north of Maryland, northern Virginia, northern Kentucky, and east of Illinois and southern Michigan. In addition to completing two preliminary studies this year, the geologists began work on evaluation of three quadrangles, assisted in collecting hydrogeochemical and stream-sediment samples for three quadrangles, and began geologic reconnaissance on two quadrangles that were later turned over to the U.S. Geological Survey for completion.

Quadrangle Evaluation

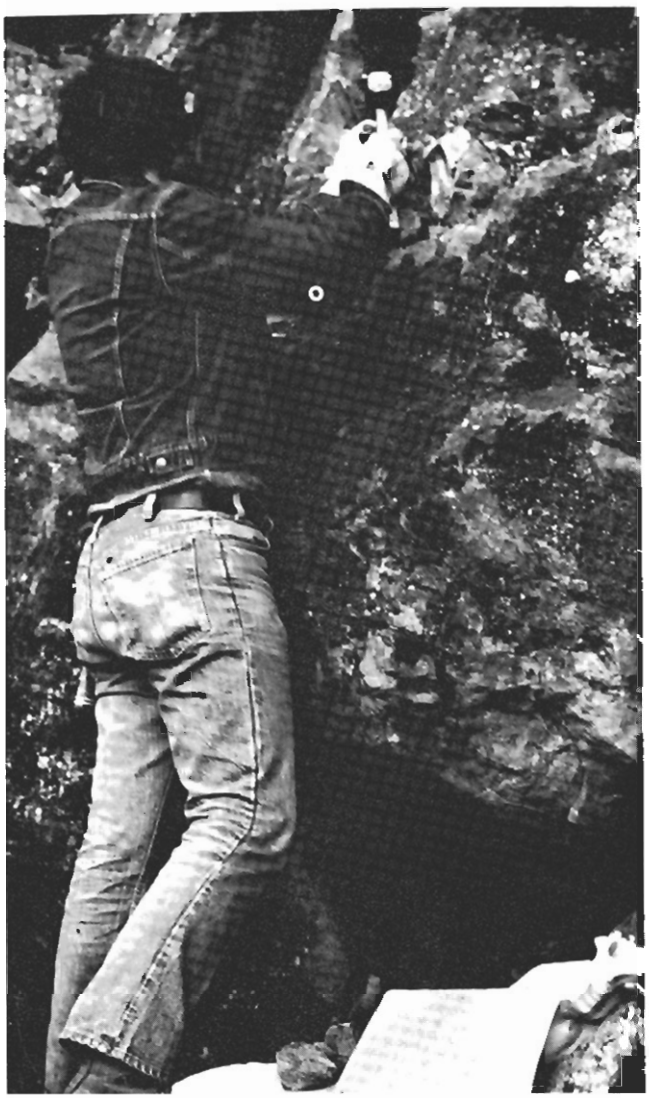
Quadrangle evaluation was commenced in the Albany, Providence, and Scranton quadrangles. Some geologic reconnaissance was performed in each of the quadrangles but most of the work consisted of literature search prior to more thorough field work which will begin in 1978.

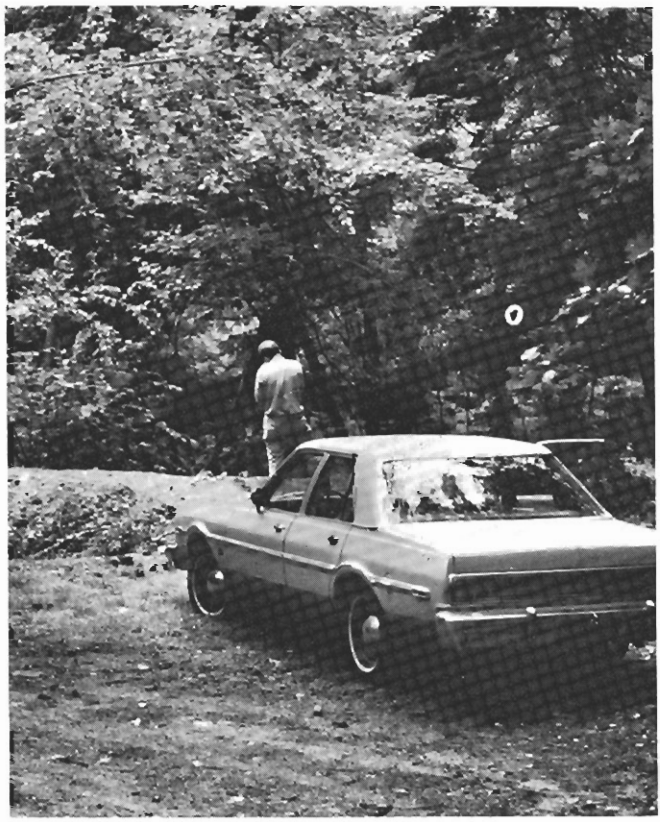
Albany quadrangle, New York, Massachusetts, Vermont, New Hampshire, and Connecticut

The northern tip of the Hartford Triassic Basin is in the Albany quadrangle and constitutes a primary target for investigation. The Precambrian-Cambrian contacts and certain gneisses also are being investigated.

Providence quadrangle, Rhode Island, Connecticut, and Massachusetts

The Narragansett Basin of Rhode Island and Massachusetts makes up a large part of the land area of this quadrangle. The units of interest are several thousand feet of Pennsylvanian nonmarine coarse clastics with coal beds, as well as various mafic dikes and quartz veins. The section has been folded, faulted, and intruded by Late Pennsylvanian granites and there is evidence of hydrothermal activity in the area.





A geologist from the Pittsburgh office (left) collects a rock sample of Claredon Springs Dolomite in the Lake Champlain quadrangle in Vermont. Another geologist (above) examines rock samples in the Loudville, Mass., prospect in the Albany quadrangle. This prospect, used since Revolutionary War days as a source of lead and zinc, is known to contain uranium.

Scranton quadrangle, Pennsylvania, New York, and New Jersey

The primary target for investigation in the Scranton quadrangle is the Devonian Catskill Group. Metamorphic rocks of Precambrian age, which contain a known uranium deposit at Cranberry Lake in the Newark quadrangle occur in the southeastern part of the Scranton quadrangle. A very small part of the Scranton quadrangle is also underlain by rocks of the Newark Triassic Basin.

Stream-Sediment Sampling

Hydrogeochemical and stream-sediment reconnaissance sampling were accomplished in the Scranton, Newark, and Hartford quadrangles. The work was done on behalf of the Savannah River Laboratory. All but the most densely populated parts of each quadrangle were sampled. Areas of obvious pollution or contamination were not sampled.

Preliminary Studies

Connecticut Basin

In a preliminary study of the Connecticut Basin of Massachusetts and Connecticut, the Triassic-Jurassic formations in the area were investigated. Several prospective source rocks within the basin and in the adjacent highlands were also examined. The results were open filed in October 1977 as GJBX–68(77).

Narragansett Basin

A preliminary study was conducted in the Narragansett Basin and nearby subbasins. The sedimentary units of the basins and the adjacent highlands were studied. A report of the results will be open filed in 1978.

Atlanta Field Office

The Bendix geologists of the Atlanta office are responsible for geologic studies for North and South Carolina, Georgia, Alabama, Florida, central and eastern Tennessee, and the southern parts of Kentucky, Virginia, and West Virginia. Work was completed on four preliminary studies, and evaluation work was commenced on seven quadrangles, three of which were subsequently turned over to the U.S. Geological Survey to complete.

Quadrangle Evaluation

Preliminary data collecting and initial investigations are underway on the Greensboro, Spartanburg, Athens, and Johnson City quadrangles.

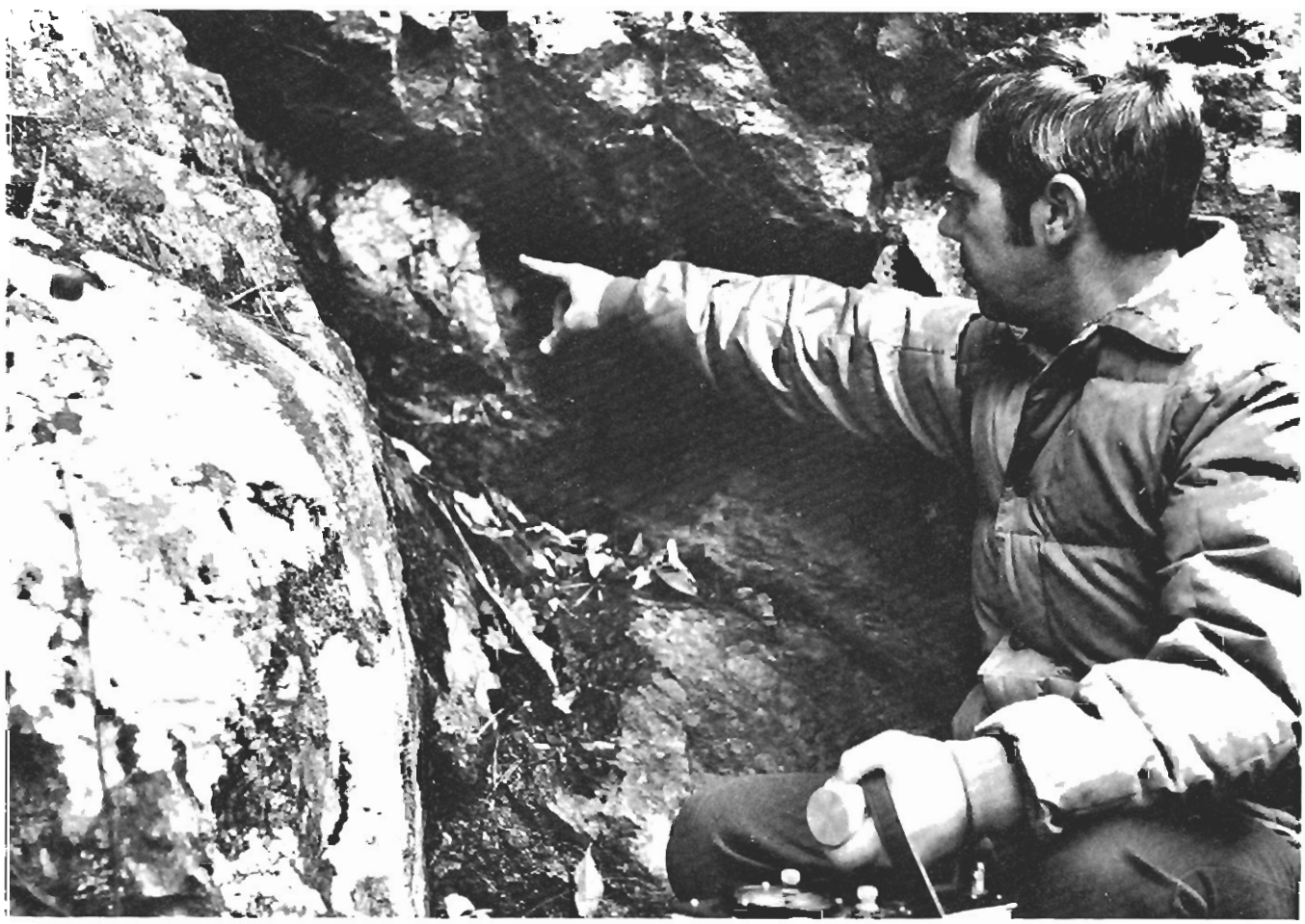
Greensboro quadrangle, North Carolina and Virginia

The primary targets in this quadrangle are the Danville, Durham, and Sanford Triassic basins. Potential source rocks in strata adjacent to the basins are also being studied.

Spartanburg quadrangle, South Carolina and North Carolina

The southern tip of the Sanford Triassic Basin extends into the Spartanburg quadrangle but the primary targets are various granitic plutons that appear to be of the same lithology as those that contain the Bokan Mountain or Rossing deposits.

An Atlanta office geologist points out a pitchblende vein in the Harper Creek prospect of North Carolina.



The Grandfather Mountain area of North Carolina in the Knoxville quadrangle is the destination of these geologists from the Atlanta office. The three are going toward the Harper Creek uranium deposit. The quadrangle has since been turned over to USGS for evaluation.

Athens quadrangle, Georgia and South Carolina

Granitic plutons are a primary target in the Athens quadrangle as well. Secondary targets are areas of known precious metals deposits and pegmatites.

Johnson City quadrangle, Tennessee, Kentucky, Virginia, and North Carolina

Primary targets in the Johnson City quadrangle are granitic gneisses containing known mineralization and shear zones cutting both gneiss and other rocks which exhibit minor radioactivity in some areas.

The Chattanooga Shale and other shales of Devonian age that are known to be radioactive in other areas crop out in the Johnson City quadrangle also and constitute secondary targets to be investigated.

Preliminary Studies

Sanford Basin-Colon Cross Structure

A preliminary study on the Sanford Basin—Colon Arch evaluated the uranium favorability and surface radioactivity of the Triassic sediments and of adjacent pre-Triassic igneous and metamorphic rocks. The study was completed in 1977 and the results were open filed early in 1978 as GJBX-8(78).

Appalachian Shear Zones

A preliminary project, employing gamma-ray spectrometry, LANDSAT imagery, and statistical analysis, was completed, investigating known uranium occurrences and areas of anomalous radioactivity. Genetic models explaining the origin and occurrence of uranium minerals in the shear zones were considered. A report will be open filed in 1978.

Coosa Basin, Alabama

A preliminary study to assess the uranium favorability of the Hartselle Sandstone and the Pottsville Formation was conducted in the Coosa Basin of northern Alabama. In this area, the strata are principally fluvial and deltaic deposits and contain many coal seams. A report of the study will be open filed in 1978.

Dan River Basin System

In a preliminary study of the Dan River and nearby Triassic basins, the pre-Triassic Inner Piedmont basement rocks adjacent to the basins were investigated as potential sources of uranium. The results will be open filed in 1978.

Helicopters are used in Alaska to gain access to remote areas as well as for aerial radiometric surveys. Here a Hiller jet helicopter is used to sample in the bush north of Fairbanks, Alaska.

Anchorage Field Office

Bendix geologists served as monitors for three subcontracted projects in Alaska (Cook Inlet, Seward-Selawik, and Fish River Flats Basin Gravity Survey). In addition, reconnaissance of several quadrangles was completed during the field season in preparation for subcontracting quadrangle evaluation projects in FY 1978.

Cook Inlet, Alaska

Under subcontract to Bendix, WGM, Inc. compiled available information on Jurassic, Cretaceous, and Tertiary sedimentary rocks in the Cook Inlet and Susitna Basin areas of Alaska. This report will be open filed in 1978.

Seward-Selawik

C. C. Hawley and Associates, under subcontract to Bendix, conducted a followup geologic evaluation of uranium favorability of the Seward Peninsula utilizing existing data from airborne radiometric and hydrogeochemical surveys. Results are expected to be open filed by mid-1978.

Fish River Flats Basin Gravity Survey

Under direct contract with DOE, the USGS conducted a helicopter-supported gravity survey of the Fish River Flats basin (McCarthy's Marsh) area of Alaska, reduced the data obtained from the survey, and prepared a reconnaissance contour map and two detailed profiles. A report has been supplied to DOE.

Three geologists in Alaska find how large a glacier can be as they are almost lost in this picture. They are walking across the Byron Glacier.

Assessment Planning

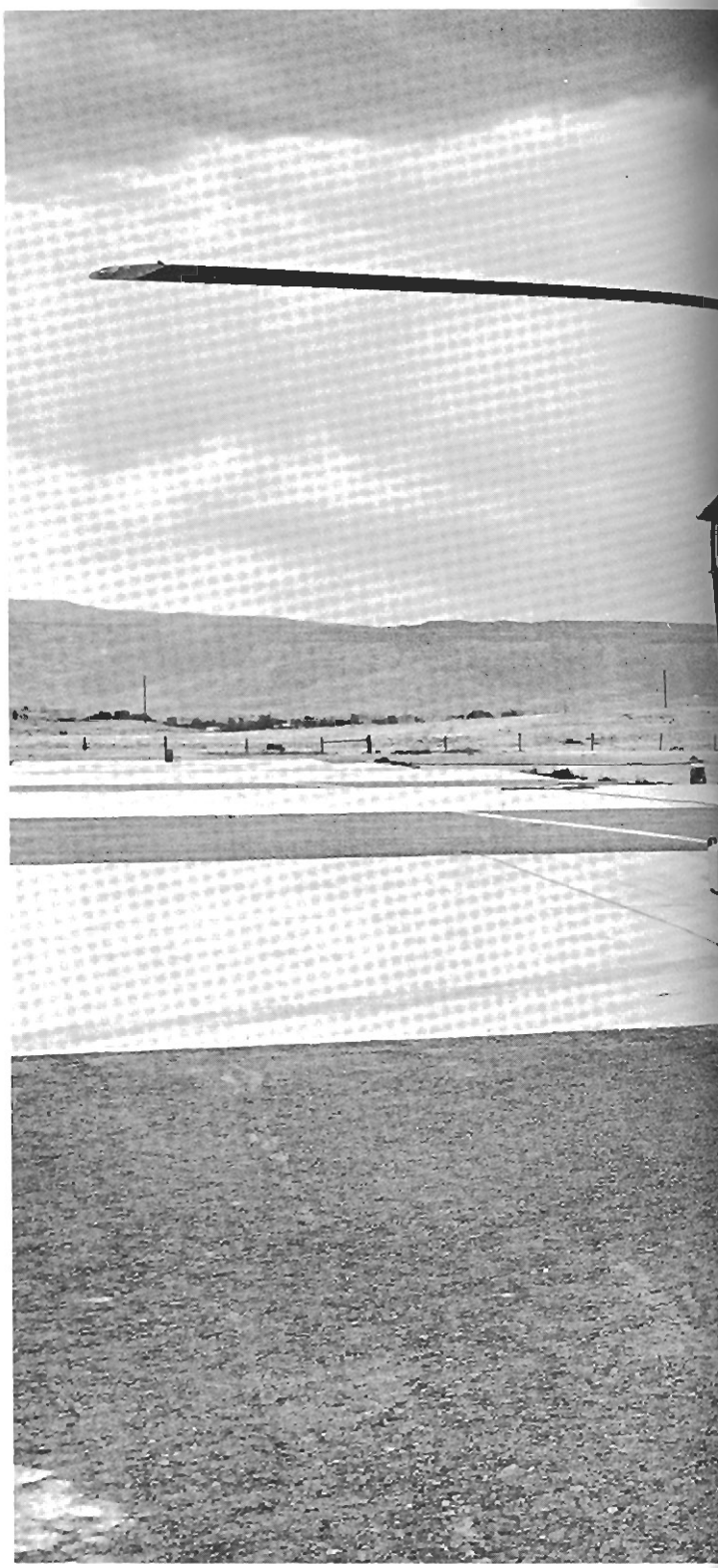
Estimation of the quantity of uranium in the United States, including undiscovered resources, requires methods that are substantially different from conventional ore reserves calculations. The basic method adopted for the NURE program is extrapolation from selected control areas of known mineralization to the areas being assessed. Because uranium deposits occur in a variety of geologic environments, the distinguishing characteristics of each environment must be determined to permit extrapolation from the control area that is most like the area being assessed.

During 1977 genetic classifications were developed for uranium deposits in sedimentary and plutonic igneous rocks, and a classification of uranium deposits in volcanic rocks was started. Identification of characteristics which distinguish geologic environments favorable for each class of deposits is in progress, making use of the results of subcontracted topical studies and in-house research. Data on known uranium resources for all significant world uranium districts are also being compiled. From this compilation the quantity of uranium per unit area or volume will be determined for each class of deposits.

A report format has been selected which will facilitate assessment of uranium resources in each quadrangle of the United States. Quadrangle folios will contain maps showing areas favorable for occurrence of uranium deposits and an accompanying text will describe the evidence of favorability observed, the class of deposits indicated, and dimensions of the favorable environment. Quantities of uranium can then be estimated by extrapolation from the control area for the appropriate class of deposits.

In December a workshop was held to discuss details of the resource assessment process. Representatives from the U.S. Department of Energy, U.S. Geological Survey, Geological Survey of Canada, universities, mining companies, consulting companies, and Bendix explored various aspects of the problem to ensure that the best available techniques will be applied to the uranium resource assessment problem.

Aerial Radiometric Reconnaissance



The Aerial Radiometric Reconnaissance program has two principal objectives in support of NURE:

1. To acquire surface radiation data for the DOE-directed uranium resource assessment effort.
2. To rapidly identify broad source regions of highest uranium favorability to help focus industry's United States exploration effort.

In accomplishing these objectives, the aerial reconnaissance program will survey all states except Hawaii and will fly about 1.24 million flight-line miles with line spacing ranging from one to six miles.

The Airborne Radiometric Reconnaissance program was initiated in 1974 and funded in 1975 at a $1 million level. In 1977, the program expanded to a $5.5 million effort.

At the end of calendar year 1977, nearly 400,000 line miles of survey had been completed; this represents nearly one-third completion of the flying portion of the Aerial Radiometric Reconnaissance program. Of the flying completed to date, results of approximately one-third have been published in 1978. Maps on the following pages show the areas completed and in progress.

During 1977, eight rotary-wing and four fixed-wing systems, belonging to six different subcontractors, were used in the aerial radiometric surveys. To ensure that each airborne system and associated data reduction were meeting survey specifications, a system qualification program was initiated. This qualification program consists of evaluating data obtained on the Walker Field Pads in Grand Junction, Colorado, and the Lake Mead Dynamic Test Range in Arizona. The items evaluated are system background, resolution, linearity and sensitivity, and data correction coefficients for stripping, altitude correction, and airborne radon correction. This evaluation program has resulted in improvements in several of these items and better reduced data.

In 1977, contracts were signed for eleven projects, two projects from 1976 were completed, and data were open filed for three projects. A total of 170,000 line miles was flown during the year.

A NURE subcontractor helicopter calibrates its radiometric instruments before takeoff on an aerial survey from the DOE Calibration Pads at Walker Field in Grand Junction. The aircraft parks at five different pads on the special extension to the taxiway. Each pad contains known concentrations of specific radioactive elements.

Alaska Fixed-Wing Survey

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $637,846
- Start Date: 15 April 1976
- Completion Date: 15 April 1977
- Line Miles: 20,157
- Aircraft: DC–3

This survey of 23 NTMS quadrangles was flown in 1976. The final report was reviewed by Bendix in 1977 and open filed as GJBX–5(77) on May 23, 1977.

Red River Block C and Delta

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $312,662
- Start Date: 19 June 1976
- Completion Date: 26 April 1977
- Line Miles: 14,068
- Aircraft: DC–3

This survey of four complete and one partial (Delta) quadrangle was flown in 1976. The final reports were reviewed by Bendix in 1977 and open filed as GJBX–17(77) and GJBX–18(77) (Delta) on May 23, 1977.

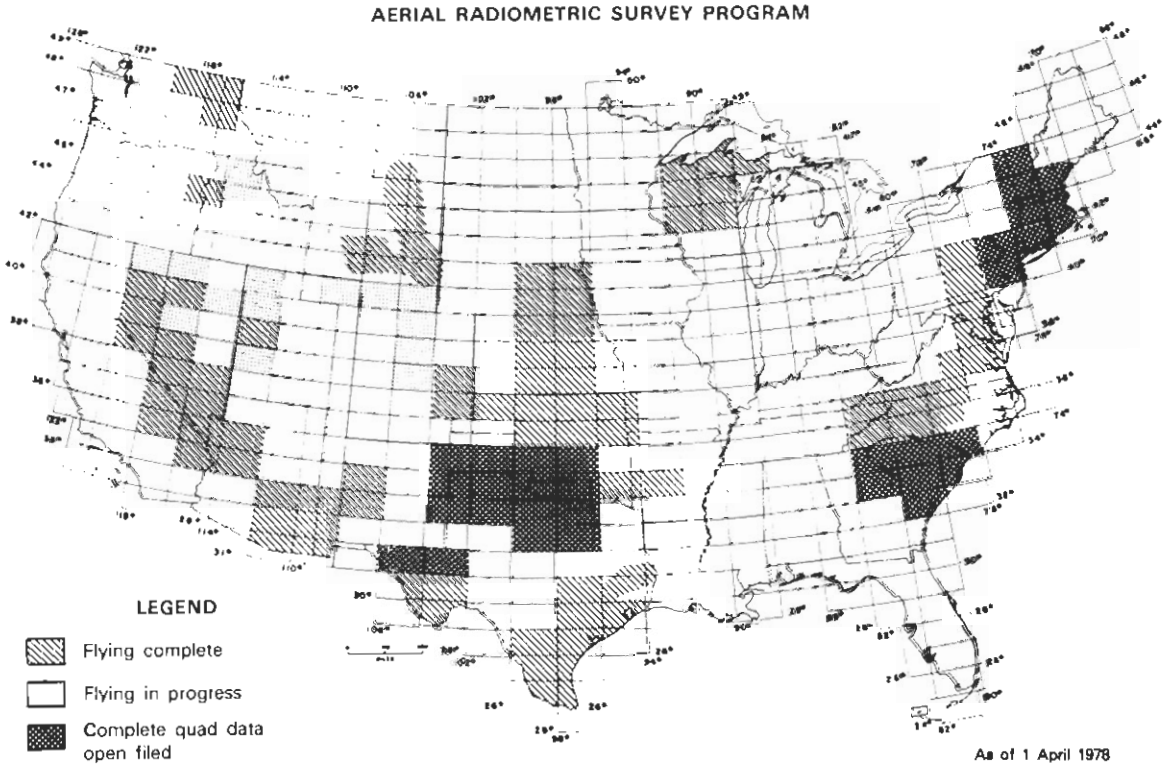
Alaska Rotary-Wing Survey

- Subcontractor: LKB Resources
- Subcontract Value: $1,063,541
- Start Date: 12 April 1976
- Completion Date: 15 April 1978 (est.)
- Line Miles: 20,929
- Aircraft: Bell 205 and Sikorsky S–58T

Flying of this survey, which was initiated in June 1976, was completed in September 1977, and included an additional three quadrangles. Weather conditions during the 1977 field season were quite good, in contrast to those encountered during the 1976 field season which caused suspension of operations. During 1977, 8,484 line miles were flown with a Sikorsky S–58T for a survey total of 20,929 line miles.

Results of the survey will be open filed in four separate phased reports: Eastern Alaska (Tanacross, Nabesna, and McCarthy quadrangles); Cook Inlet (Anchorage, Tyonek, Kenai, Seward, Seldovia, and Blying Sound quadrangles); Chugach/Yakutat (Valdez, Cordova, Bering Glacier, Mt. St. Elias, Icy Bay, and Yakutat quadrangles); and southeastern Alaska (Skagway, Atlin, Mt. Fairweather, Juneau, Taku River, Sitka, Sumdum, Port Alexander, Petersburg, Bradfield Canal, Craig, Ketchikan, Dixon

STATUS
AERIAL RADIOMETRIC SURVEY PROGRAM



Entrance, and Prince Rupert quadrangles). New geologic map compilations at 1:250,000 scale and magnetic depth-to-basement interpretations will also be included in these reports.

Thorpe–Big Bend Rotary-Wing Survey

- Subcontractor: LKB Resources
- Subcontract Value: $640,307
- Start Date: 28 October 1976
- Completion Date: 1 September 1978 (est.)
- Line Miles: 19,000
- Aircraft: Sikorsky S–58 and S–58T Helicopters

This survey covers the Williamsport, Harrisburg, Scranton, and Newark quadrangles (Thorpe) in the states of Pennsylvania, New Jersey, and New York; and the Ft. Stockton, Marfa, Presidio, and Emory Peak quadrangles (Big Bend) in the state of Texas. Open-file reports for the Thorpe areas are scheduled in January–February 1978; and for the Big Bend area in October 1978.

Wisconsin–East Salina Basin–Big Bend Fixed-Wing Survey

- Subcontractor: GeoMetrics, Inc.
- Subcontract Value: $717,935
- Start Date: 17 October 1976
- Completion Date: 30 April 1978 (est.)
- Line Miles: 35,546
- Aircraft: Grumman S–2

This survey consists of eight quadrangles in the Michigan–Wisconsin area (Hancock, Marquette, Iron River, Ashland, Iron Mt., Rice Lake, Green Bay, and Eau Claire), four quadrangles in the East Salina Basin area (Fremont, Lincoln, Manhattan, and Hutchinson) and two quadrangles in the Big Bend area (Van Horn and Pecos). Flying has been completed in all areas and reports are scheduled for open filing starting in 1978.

Texas Gulf Coast II Fixed-Wing Survey

- Subcontractor: Geodata International, Inc.
- Subcontract Value: $445,362
- Start Date: 11 January 1977
- Completion Date: 30 June 1978 (est.)
- Line Miles: 18,155
- Aircraft: DC–3

This survey completes coverage of 10 quadrangles which had been partially covered in a previous survey, the results of which were open filed in 1975 in report GJO–1632. The 10 quadrangles completed in the present survey are Houston, Bay City, Austin, Beeville, Corpus Christi, Brownsville, McAllen, Laredo, Crystal City, and Seguin. The results of both surveys will be integrated into one complete report covering each of these 10 quadrangles. These reports should be open filed by June 1978.

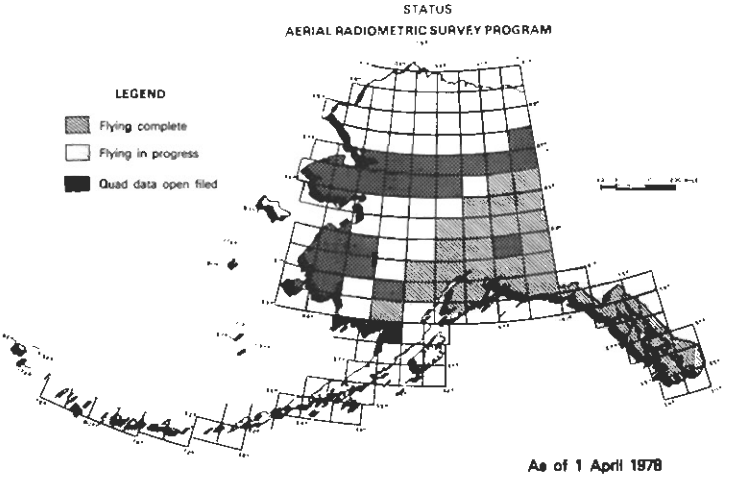
Reno–Snake River Rotary-Wing Survey

- Subcontractor: Geo-Life, Inc.
- Subcontract Value: DOE/SBA Contract
- Start Date: 11 March 1977
- Completion Date: 15 July 1978 (est.)
- Line Miles: 26,621
- Aircraft: Sikorsky S–58T and Lama

The subcontractor for this survey is a joint venture between High Life Helicopters, Inc. and Geodata International, Inc. The subcontract is handled by Department of Energy/Small Business Administration with technical monitoring by Bendix.

The contract for 1977 covers the Baker, Winnemucca, Lovelock, Millett, Reno, Walker Lake, Tonopah, Goldfield, and Caliente quadrangles. Of the total of 26,621 line miles included in the subcontract, 25,453 line miles were flown, the remainder to be completed in early 1978.

Open file reports of this work will be released in the spring of 1978.



Blue Ridge Rotary-Wing Survey

- Subcontractor: LKB Resources
- Subcontract Value: $632,328
- Start Date: 11 April 1977
- Completion Date: September 1978 (est.)
- Line Miles: 15,753
- Aircraft: Sikorsky S-58T and S-58

This survey covers the Knoxville, Johnson City, Winston-Salem, Charlotte, and Greensboro quadrangles in the states of Tennessee, Kentucky, Virginia, North Carolina, and South Carolina. Open-file reports are scheduled for July and September 1978.

Northeast Washington Rotary-Wing Survey

- Subcontractor: LKB Resources
- Subcontract Value: $552,000
- Start Date: 11 August 1977
- Completion Date: 1 May 1978 (est.)
- Line Miles: 14,754
- Aircraft: Sikorsky S-58T

This survey covers the Okanogan, Sandpoint, and Spokane quadrangles in the states of Washington and Idaho. Open-file reports are scheduled for July 1978.

Eagle–Dillingham Rotary-Wing Survey

- Subcontractor: Texas Instruments,Inc.
- Subcontract Value: $1,063,418
- Start Date: 16 May 1977
- Completion Date: 31 March 1978 (est.)
- Line Miles: 16,684
- Aircraft: Bell 212

This survey covers the Big Delta, Eagle, Mt. McKinley, Healy, Fairbanks, Talkeetna, Talkeetna Mts. (west two-thirds), Lime Hills, Lake Clark, Dillingham, Circle, Charley River, and Mt. Hayes quadrangles in Alaska. Reports covering the above quadrangles are expected to be open filed in June 1978.

Rockies–Laramie Range Fixed-Wing/Rotary-Wing Survey

- Subcontractor: GeoMetrics, Inc.
- Subcontract Value: $606,000
- Start Date: 23 June 1977
- Completion Date: 1 December 1978 (est.)
- Line Miles: 25,350
- Aircraft: Aerospatiale SA 315B (Lama) and Grumman S-2

Flying on the Pueblo, Denver, Greeley, Cheyenne, Rock Springs, and Rawlins quadrangles began in August with the Lama Rotary-Wing System. Before flying was suspended due to adverse weather conditions, all but approximately 900 line miles of the estimated 13,855 rotary-wing line miles were completed. The S-2 fixed-wing flying, estimated at 11,495 line miles, was not attempted due to adverse weather conditions and the lateness of the season (December). Survey operations will continue in early spring and flying should be completed in June 1978.

Report open filing is scheduled for December 1978.

Northwest Arizona Fixed-Wing/Rotary-Wing Survey

- Subcontractor: Aero Service Division of Western Geophysical
- Subcontract Value: $538,000
- Start Date: 10 June 1977
- Completion Date: 1 July 1978
- Line Miles: 23,091
- Aircraft: DC-3 and Aerospatiale SA 315B (Lama)

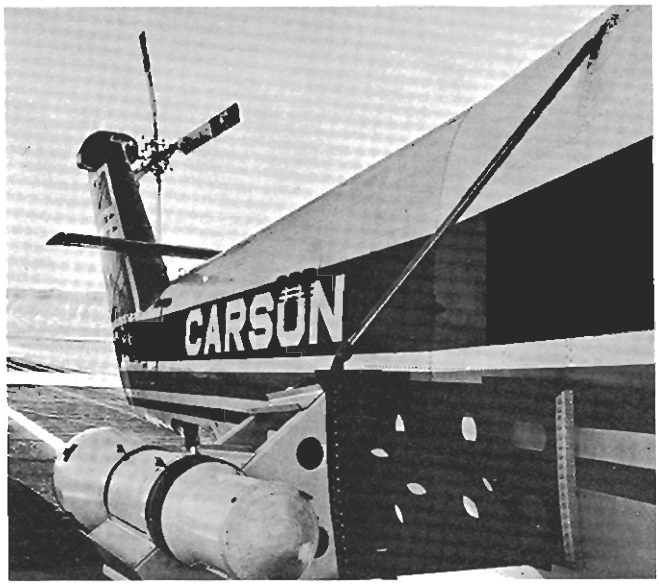
Aero Service, on this, its initial subcontract in the NURE program, utilized a unique approach to flying this combination fixed-wing/rotary-wing survey covering the Williams, Las Vegas, Kingman, and Prescott quadrangles. Essentially the entire area was flown with the DC-3 which in turn was followed up by the helicopter reflying those segments the DC-3 could not properly negotiate due to terrain conditions.

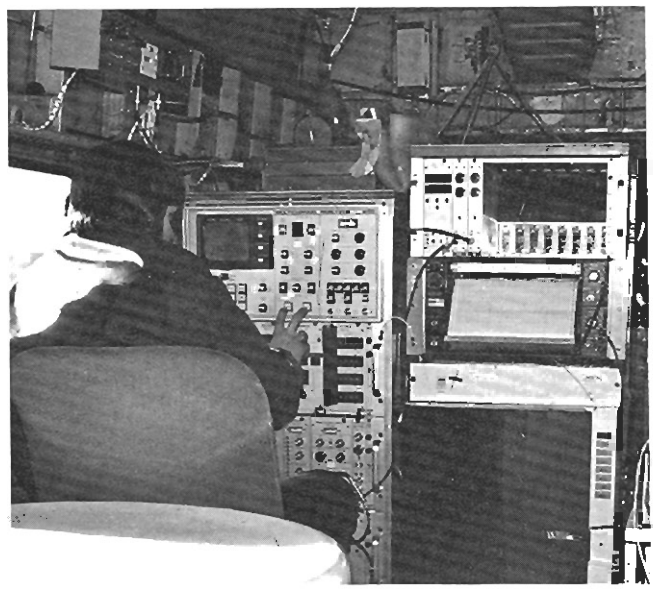
In all, 23,091 line miles were flown: 14,983 fixed-wing and 8,108 rotary-wing.

Reports of the survey will be open filed in the first half of 1978.

Great Plains Fixed-Wing Survey

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $637,000
- Start Date: 1 July 1977
- Completion Date: 31 March 1978 (est.)
- Line Miles: 29,065
- Aircraft: DC-3





The high sensitivity magnetometer detector head (left) is cradled alongside some aircraft used in the aerial radiometric surveys. Some systems, however, require that the detector head be at a greater distance from the instruments inside the aircraft. The detector head then is suspended on a long cable and the "bird" flies below the aircraft. An operator usually sits at the electronic console (right) during calibration tests. Other systems are designed so that the operator need not be at the console and so can also function as the flight navigator in the cockpit.

The Great Plains Survey includes 14 quadrangles, as follows: Tulsa, Enid, Joplin, Wichita, Pratt, Sioux City, Great Bend, Beloit, Grand Island, Broken Bow, O'Neill, Dodge City, Lamar, and La Junta. Flying was completed in October 1977, and reports will be open filed by mid-June 1978.

Utah–Arizona Rotary-Wing Survey

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $610,797
- Start Date: 13 October 1977
- Completion Date: 30 May 1978 (est.)
- Line Miles: 13,401
- Aircraft: Bell 212

This survey completes coverage of quadrangles partially flown in fixed-wing surveys in 1975 and 1976 over portions of the Tucson, Nogales, Mesa, Douglas, Silver City, Clifton, and Delta quadrangles. The new helicopter data will be integrated with the previous fixed-wing data and new reports released with statistical parameters calculated on a complete quadrangle basis. Open-file reports on the above quadrangles are planned for release in September 1978.

Baltimore Fixed-Wing Survey

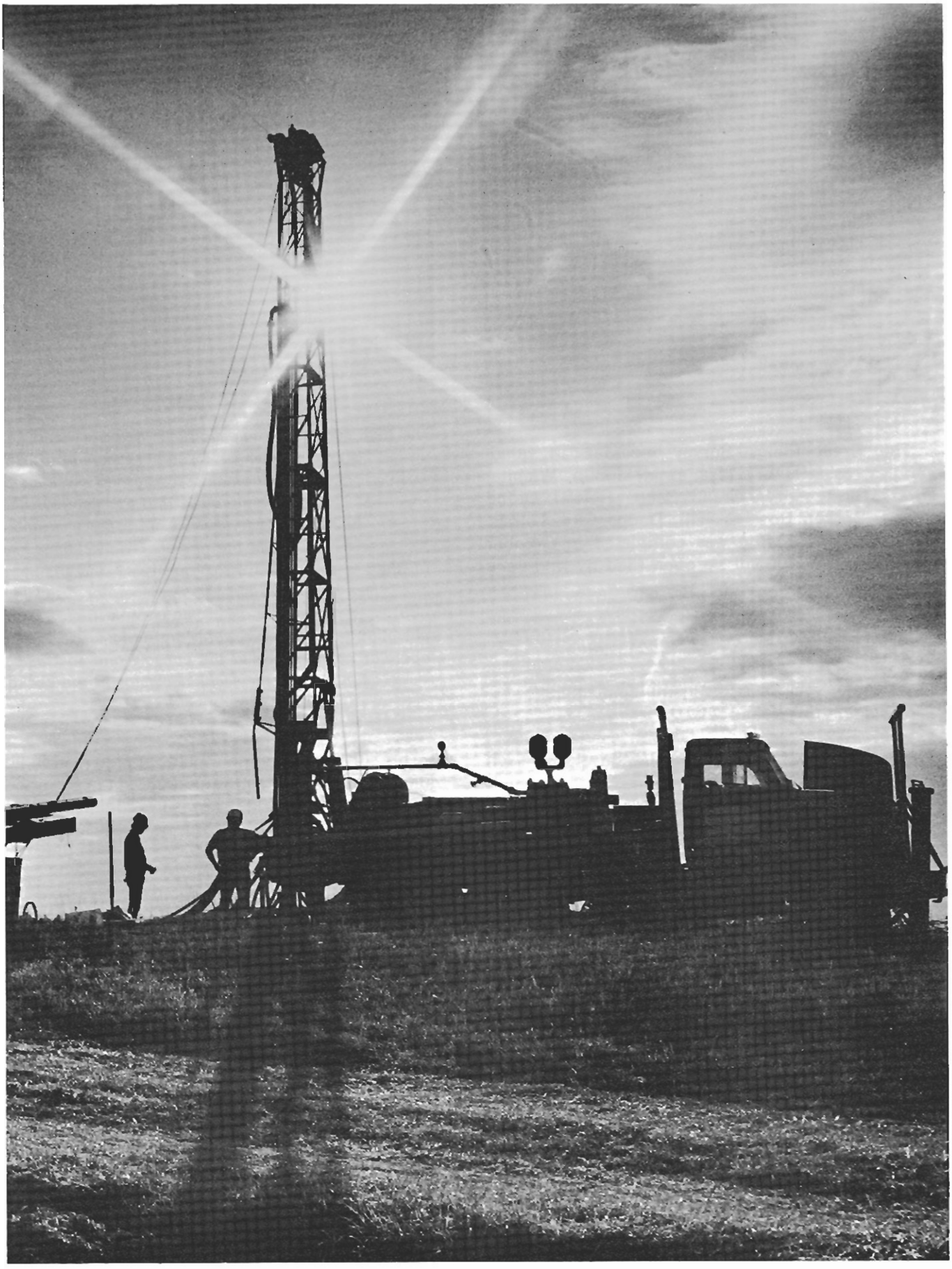
- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $147,100
- Start Date: 10 November 1977
- Completion Date: 30 June 1978 (est.)
- Line Miles: 5,944
- Aircraft: DC–3

This survey covers the Baltimore and Washington quadrangles as well as the portion of the Richmond quadrangle that was not flown in an earlier survey. The results of the survey will be open filed in the summer of 1978.

Trona Rotary-Wing Survey

- Subcontractor: Geo-Life, Inc.
- Subcontract Value: $84,150
- Start Date: 17 November 1977
- Completion Date: 1 June 1978 (est.)
- Line Miles: 3,266
- Aircraft: Lama

The survey of the Trona quadrangle is being carried out by Geo-Life, a joint venture of High Life Helicopters, Inc. and Geodata International, Inc. Despite problems caused by four restricted flying areas, 3,027 of the toal 3,266 line miles were flown in 1977. Completion of flying is scheduled for early 1978, and a report for the survey should be open filed by June 1978.



Subsurface Geologic Investigations

Subsurface geologic investigations are being conducted throughout the United States under the direction of DOE in support of NURE. These studies are directed toward obtaining subsurface data to confirm uranium resource estimates in known host areas and to obtain data in suspected host areas to evaluate favorability. Subsurface data will be generated by drilling, logging, and analyzing formations thought to be favorable for uranium deposition. Additional subsurface data will be obtained from industry records and by logging holes drilled by industry or other governmental agencies for non-uranium purposes.

Each subsurface project undergoes a geological study to determine its acceptability as a viable investigation. Upon acceptance of the project, a drilling plan is generated which includes all of the drilling requirements as well as the location of each drill site. After completion of drilling operations, two reports will be open filed: one, the Engineering Report, which will be open filed within a short period of time after completion of drilling, and the final Geologic Report which will be released within one year of completion of drilling.

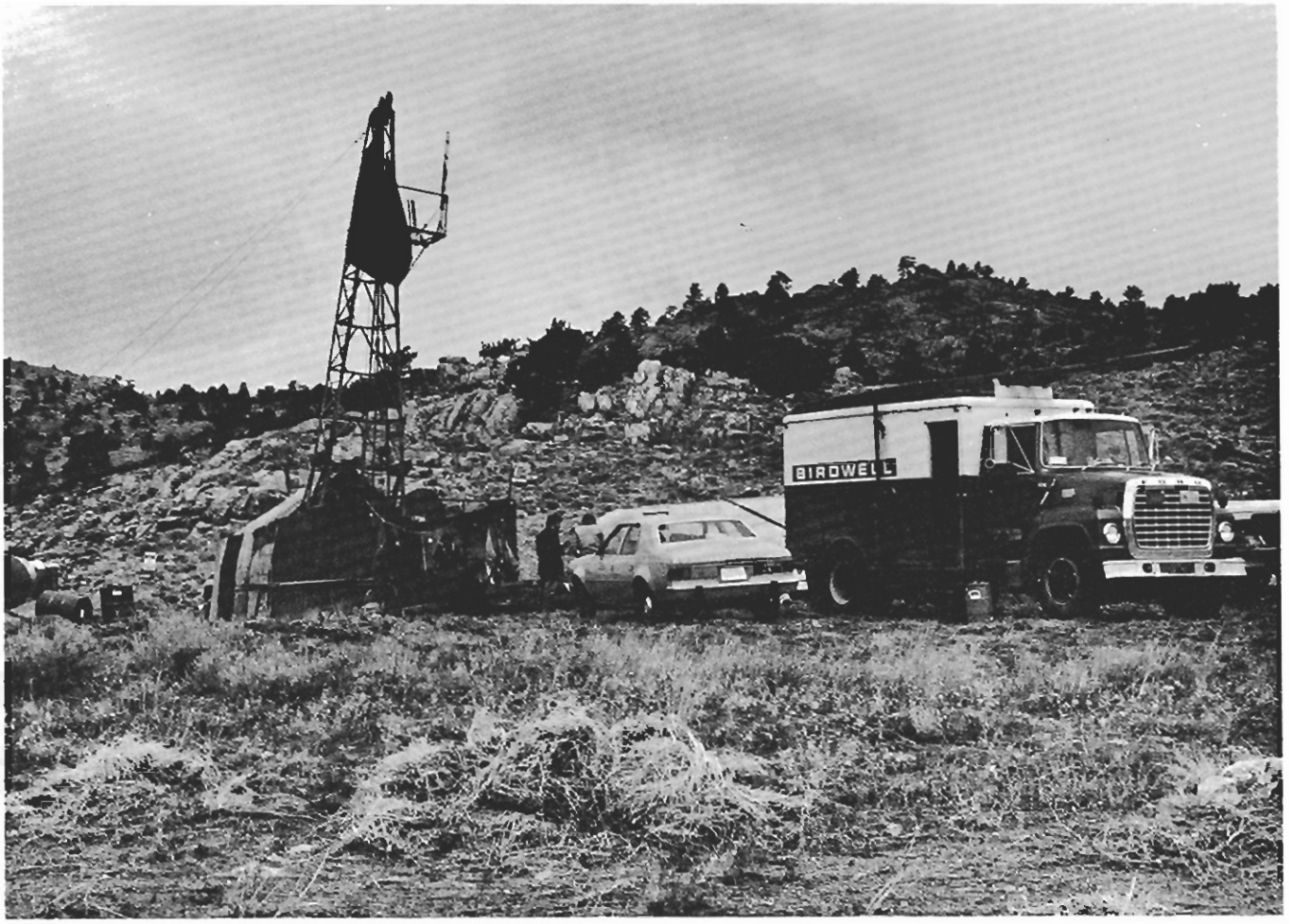
Drilling projects completed to date include the Granite Mountain Project in Wyoming, Carson Sink Project in Nevada, and Red River Valley Project in North Dakota and Minnesota. The Michigan Basins Project on the upper peninsula of Michigan is in progress and will be completed by spring of 1978.

The Carson Sink Project Engineering Report was open filed as GJBX-49(77) in July. Results of the Granite Mountain Project were released in 1976.

Projects in Colorado, New Mexico, Utah, and Montana are in the planning stage.

One of the two core rigs used in the Michigan Basins project was visited early in 1978 as drilling continued throughout the winter. Three of the six holes have been completed while two more are in progress and one of the rigs will move to the sixth hole before completion of the drilling in April. The continuous core holes range from 1,000 ft to 2,100 ft in depth in the Precambrian Upper Michigan Basins area.

It is appropriate that the photographer caught the sun rising over the Red River Valley drilling project, as this is the first full year that drilling specifically for uranium exploration has been carried out under the NURE program. Subsurface data in the past were collected by logging of oil and gas wells among other means. Some 19 relatively shallow holes were drilled in the Red River project.



The Granite Mountain project used a continuous core method of drilling to evaluate the depth of leaching. Holes were drilled to a depth of 2,197 ft.

Michigan Basins Project

- Subcontractors: Longyear Drilling Co.
  Birdwell Logging Co.
  Michigan Department of Natural Resources
- Total Subcontracts Value: $603,400
- Start Date: 1 June 1977
- Completion Date: October 1978

Known uranium-bearing rocks of the Middle Precambrian occur in Canadian mining districts. Similar Precambrian metasedimentary basins on the upper peninsula of Michigan are being drilled to obtain information on subsurface stratigraphy and uranium favorability. Open-file reports will be issued when the project is completed.

Granite Mountain Project

- Subcontractors: Himes Drilling Co.
  Birdwell Logging Co.
- Subcontracts Value: $89,205
- Start Date: 10 March 1976
- Completion Date: 23 May 1976

The Granite Mountain drilling program was part of the USGS project entitled, "Uranium Source Rock Studies—Granitic Rocks." It was done to investigate the hypothesis that the granite was the source of uraniferous sediments in nearby major mining districts. Information on uranium mobility and Th/U ratios was obtained. Results were published in open-file report GJBX-56(76), issued in December 1976.

Carson Sink Project

- Subcontractor: Signal Drilling Co.
  Dresser-Atlas
- Subcontract Value: $388,433
- Start Date: 1 February 1977
- Completion Date: April 1977

The drilling project in the Carson Sink was to obtain detailed lithology and gamma-log information on Quaternary sediments and Tertiary rocks. Several rivers draining areas of known uranium occurrences contribute to this basin. Engineering Report GJBX-49(77) was issued in July. The geologic results are available in the open-file report issued in May 1978 (GJBX-53(78)).

After the Bendix portion of the drilling project was completed, a $1\frac{1}{4}$-inch pipe was inserted down to 4,200 feet so that the hole could be used by the USGS for geothermal investigations.

Red River Valley Project

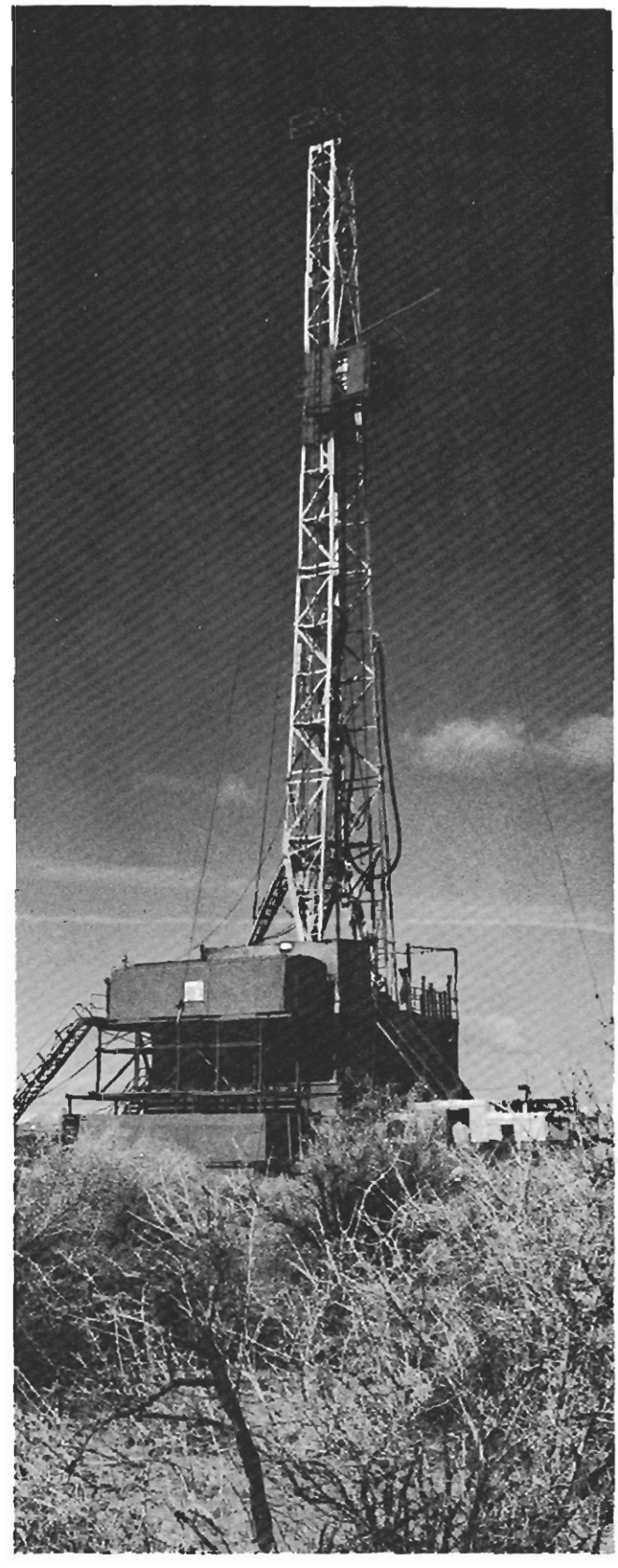
- Subcontractors: Western Well and Pump
  Century Geophysical
  University of North Dakota
- Subcontracts Value: $502,485
- Start Date: 1 May 1976
- Completion Date: June 1978

Cretaceous clastics in the Red River Valley, bearing a resemblence to uraniferous Cretaceous sandstones in the Black Hills of South Dakota, were drilled and tested for possible uranium occurrences. Drilling extended into Precambrian rocks to discern subsurface geology in an area where no surface exposures exist, and also to examine the weathered zone at the top of the Precambrian as a possible host rock for uranium weathering from source rocks in higher parts of the Canadian shield. Drilling has been completed and an open file report will be published in 1978.

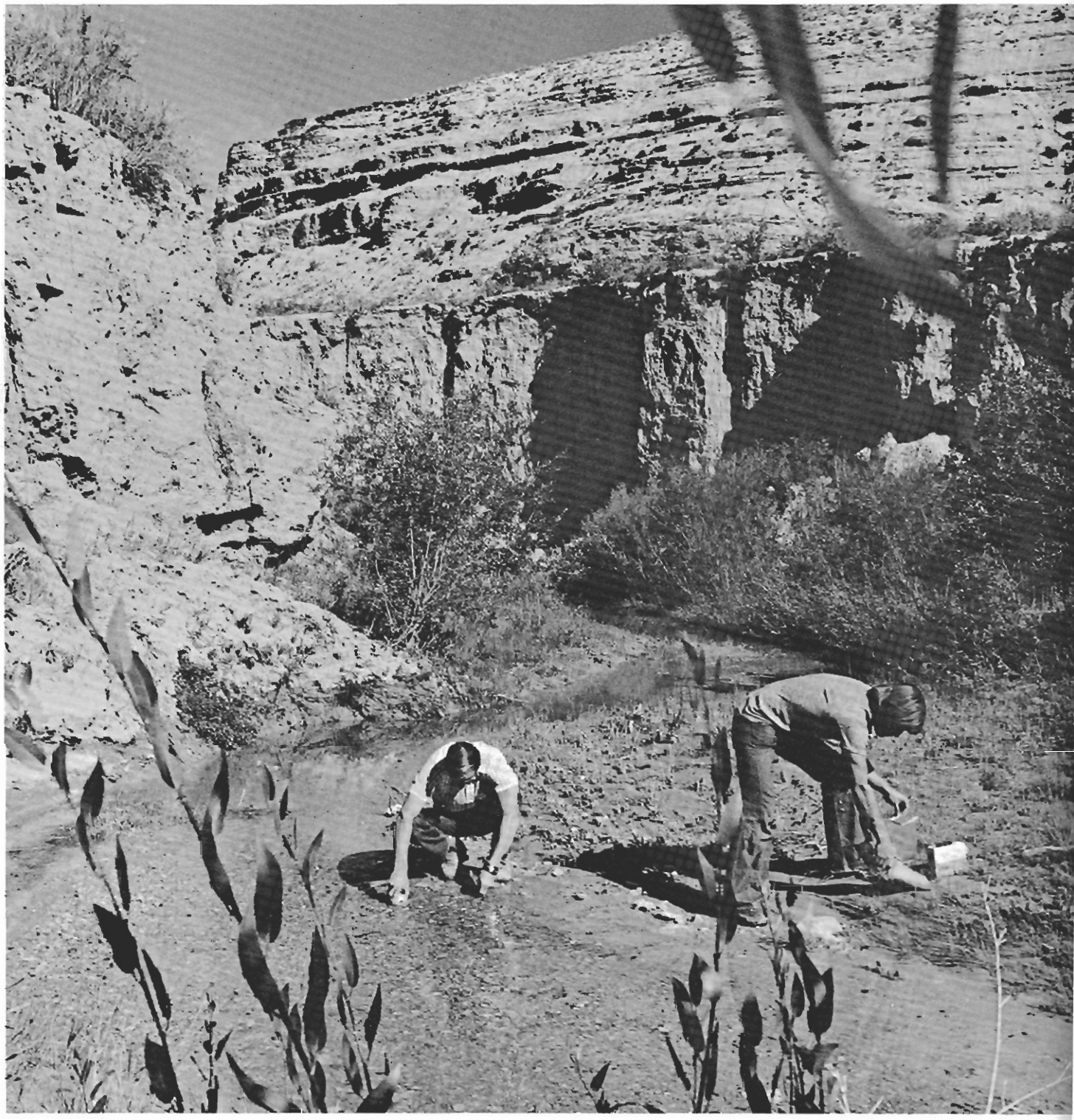
Holes completed on the project have been given to agencies in the states of North Dakota and Minnesota for their use in future geologic studies.

Thorium Study

Thorium resources are under investigation with NURE funds supporting an ongoing USGS study that includes plans for a drilling program in the Lemhi Pass area of southeastern Idaho.



A large rig was used in the Carson Sink, Nev., project because of the depth of the hole, which went down more than 8,000 ft. The hole was used for stratigraphic information gathering.



Hydrogeochemical and Stream-Sediment Reconnaissance

A LASL sampling crew collects water and stream-sediment samples for chemical analysis in the NURE program, almost unaware of the scenery provided by the central Wyoming mountains. Sampling of water and sediment is done at varying intervals in the different quadrangles under study.

The Hydrogeochemical and Stream-Sediment Reconnaissance (HSSR) of the NURE is being conducted for the U.S. Department of Energy (DOE) by four DOE laboratories. The program is directed by the DOE NURE Project Office (NPO) at Grand Junction, Colo., and coordinated with the NURE quadrangle evaluation efforts by Bendix Field Engineering Corporation. The Ames Laboratory operated for DOE by Iowa State University is charged with monitoring the uranium measuring standards at each of the four participating DOE laboratories. The program involves sampling, chemical analyses, and reporting of results for stream and lake water, ground water, and stream and lake sediment samples from the 621 NTMS quadrangles of the conterminous 48 states and Alaska. Concentrations of uranium and selected suites of other elements are determined by a variety of analytical methods by each of the four DOE laboratories.

Depending on budget constraints, the goals of the program are to produce basic data reports for up to 272 quadrangles by 1981 and the entire 621 quadrangles by 1983. These goals require sample collections at about one million sample sites. Sampling efforts have been at nearly full scale this past year. Currently 60 quadrangles have been completely sampled, mostly during 1977, and 25 more are in progress.

Sample analysis and quadrangle reporting naturally lag several months behind sample collection and only two quadrangles are fully reported while 46 are scheduled to be reported in 1978. For a complete listing of all reports issued under the HSSR program, see the "Reports Issued in 1977" list in the NURE Information Dissemination chapter. This past year quadrangle priorities were finalized for the program and a comprehensive reporting schedule was established for the high priority quadrangles that need to be reported by 1981. Scheduling of lower priority quadrangles, which are due in 1983, remains to be completed.

The analytical capabilities at the DOE laboratories have been considerably improved this past year but the maximum capabilities will not be reached until sometime this coming year. All laboratories have reported significant improvements in data management and report writing and full scale objectives are expected to be reached during fiscal year 1978. The status of sampling activities in the conterminous 48 states and Alaska is shown on the maps.

Lawrence Livermore Laboratory

The Lawrence Livermore Laboratory (LLL) is responsible for the HSSR program in the 110 quadrangles in the seven western United States, an area of about 690,000 square miles (see map).

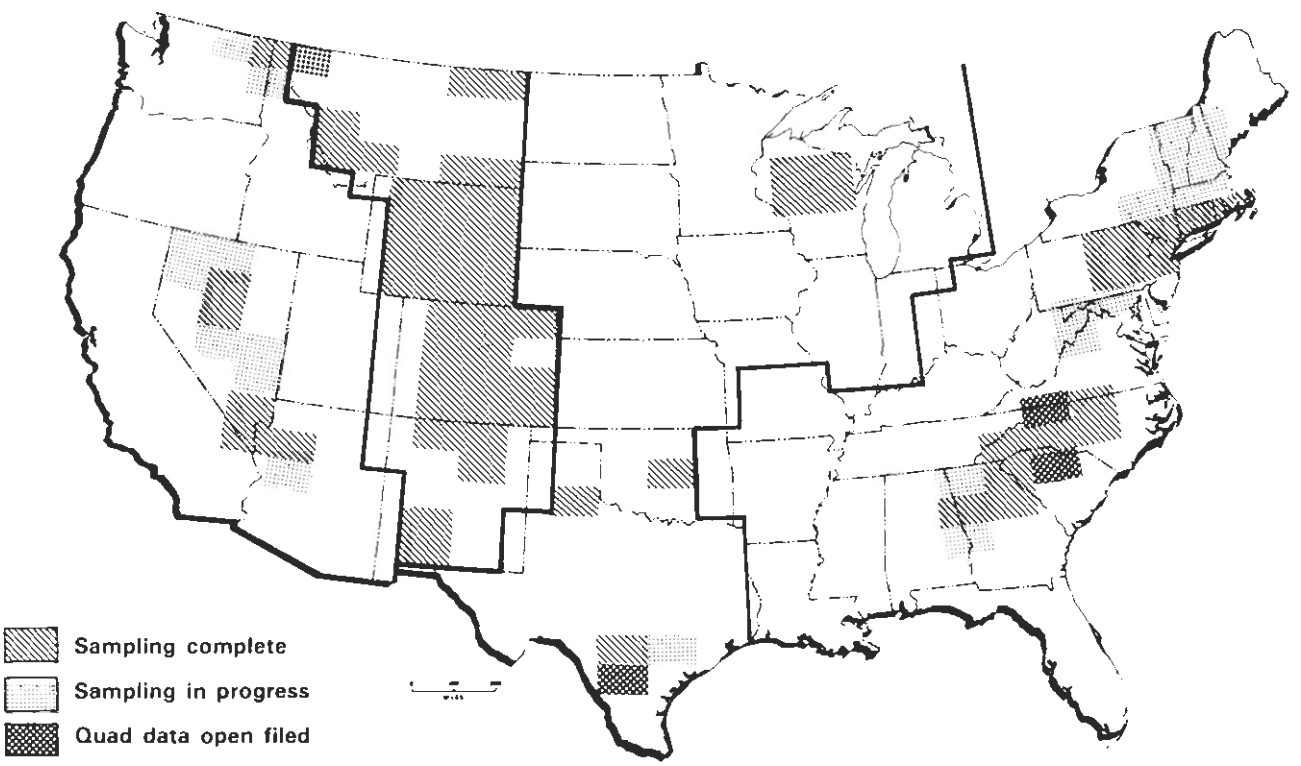
The current major milestone goals in this region are to release 67 quadrangle reconnaissance reports by August of 1981 and the rest of the 110 quadrangle reports by August of 1983. The goal for FY 1978 is to release 9 quadrangle reconnaissance reports by the end of September 1978. These milestones may change as the fiscal budget is more closely defined.

During 1977 reconnaissance survey samples were collected in 15 quadrangles divided among several sampling areas. Sampling has been completed in 6 quadrangles, and 10 other quadrangles are in progress. Bendix field personnel collected samples in portions of 10 quadrangles while subcontractors were active in 16 quadrangles.

Six pilot studies were conducted by LLL in Idaho, Washington, and Arizona, and planning was in progress for four studies in California, Arizona, Utah, and Idaho. Ground water studies were started in the Columbia River Plateau by Washington State University, and in Arizona by the University of Arizona. The Desert Research Institute was conducting a continuing study of ground water in Nevada. Hydrologists at the state universities were generally selected to collect ground water samples, since they could be expected to have special knowledge of the hydrology of their states.

The multielement analytical facility was completed to provide a neutron activation analysis system with a capacity of 25,000 samples per year, an emission spectrographic analysis system with a capacity of 40,000 samples per year, and an automated analyzer for chloride and sulfate in water. Subcontractors were selected to prepare wet and dry sediments, and to load the "rabbits" for neutron activation. Expansion of the neutron activation system to more than double throughput will take place in FY 1978.

HYDROGEOCHEMICAL PROGRAM THROUGH 1977



The study of uranium-series isotopes in the plutonic rocks supplied by Bendix-Spokane was started. Isotopic analyses via alpha spectrometry and mass spectrometry may provide information concerning the total amount of uranium lost from the granites and may indicate whether or not this is a simple, continuous leaching process due to weathering. A particle-size study of six size fractions of stream sediment from the northern Rocky Mountain province indicates that uranium in this material is highly correlative with molybdenum.

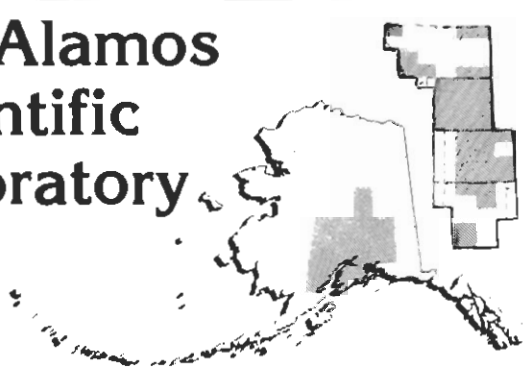
Expansion of the computer facility provided an interactive, real-time system which has been tested through issuance in expanded form of the Cave Valley preliminary report. Activities focused on the development of procedures and the assignment of responsibilities leading to the largely automated generation of raw data reports. Software development focused on CDC 7600 computer system methods for map overlay generation and data base management input/output (I/O) procedures. Map digitization software using the Tektronix 4051 calculator was also completed. Using software developed for the CDC 7600, plotting instructions will be generated for either of two, large, flat-bed precision plotters. One plotter can generate full-scale paper plots for internal review purposes, while the second will produce film plots that will be used as the masters for vellum overlay production.

Five open-file reports were issued, and four papers were presented at the Symposium on Hydrogeochemical and Stream-Sediment Reconnaissance for Uranium in the United States, Grand Junction, Colo., March 16–17, 1977.

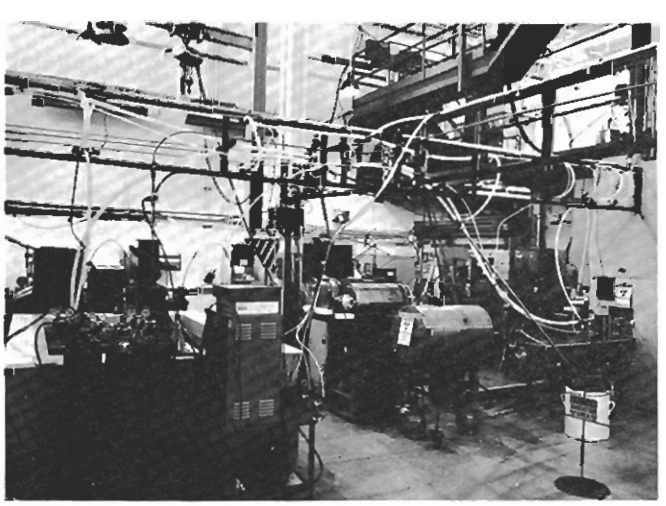
A field portable filtration unit developed by LLL is used to remove suspended material from water samples.

A LASL field team fills a sampling jar and records data along a small stream in northern New Mexico.

Los Alamos Scientific Laboratory



The Los Alamos Scientific Laboratory (LASL) is responsible for the HSSR program in 66 quadrangles of the Rocky Mountain region and the 153 quadrangles of Alaska, a total land area of about 1,040,000 square miles (see maps). In 1976 and 1977 the LASL sampled 47 percent of this area—completing 35 of the 66 quadrangles in the lower states and 28 quadrangles in Alaska. In all, about 110,000 locations have been sampled, pro-



The LASL counting room (foreground) at Omega West Reactor (far right) is used for sample analyses by delayed neutron counting and activation analysis.

viding a total of about 75,000 water samples and 80,000 sediment samples. Approximately half of these samples were collected in 1977. During the 1978 field season all sampling in the 31 unfinished quadrangles of the LASL's Rocky Mountain region will be completed. Also, it is anticipated that 60 quadrangles in Alaska will be sampled in 1978 leaving 95 to be finished during 1979 and 1980.

The major LASL milestone goals for this program are to release reconnaissance reports for all 66 quadrangles in the Rocky Mountain states and for 58 quadrangles in Alaska by August of 1981. Reconnaissance reports for the remaining 95 quadrangles in Alaska will be released by August 1983. During 1977 the LASL issued 14 reports to be open filed: 3 quarterly progress reports, 4 pilot or special study reports, 4 topical reports on analytical and data management procedures, and 3 reconnaissance reports. Four papers were presented at the symposium on Hydrogeochemical and Stream-Sediment Reconnaissance for Uranium in the United States at Grand Junction, Colo., on March 16–17, 1977. Two papers were presented at other meetings. The goals for 1978 are to release reconnaissance reports for 6 quadrangles in the Rocky Mountain states and 11 quadrangles in Alaska and to open file data from parts of 12 other quadrangles (the equivalent area of 5 quadrangles) that were sampled by the LASL and are to be reported as 2-degree map sheets by either the Oak Ridge Gaseous Diffusion Plant or the Lawrence Livermore Laboratory.

In 1977 five pilot studies were undertaken for the LASL by state universities—four in the lower states and one in Alaska. These were designed to verify, and possibly improve, the LASL sampling and data collection procedures in desert areas (University of New Mexico), on the plains and in river basins (University of Colorado), in complexly mineralized regions (University of Wyoming), in the mountains (University of Montana), and in areas covered by lakes (University of Alaska). As part of these pilot studies, a total of 3,500 locations were sampled, and 2,800 waters and 2,900 sediment samples were collected throughout an area of about 9,700 square miles. Six similar but smaller pilot studies have been contracted for 1978.

Beginning in October 1977, the scope of the HSSR for uranium was broadened to include thorium, lithium, and several other elements as selected by each laboratory. The LASL plans to analyze for, and report on, 41 elements in addition to the 3 specifically requested by DOE. Water samples will be analyzed by emission spectrography for calcium, cobalt, copper, iron, magnesium, manganese, molybdenum, nickel, lead, and zinc. Sediment samples will be analyzed by emission spectrography for beryllium and lithium and by x-ray fluorescence for silver, bismuth, cadmium, copper, niobium, nickel, lead, tin, and tungsten. Sediment samples will be analyzed by neutron activation analysis—using a short time delay—for aluminum, barium, calcium, chlorine, dysprosium, potassium, magnesium, manganese, sodium, strontium, titanium, and vanadium and—using a long time delay—for gold, cerium, cobalt, chromium, cesium, europium, iron, hafnium, lanthanum, lutetium, rubidium, antimony, scandium, samarium, tantalum, terbium, thorium, ytterbium, and zinc. The multielement data will be published as separate listings in the appendices of the LASL HSSR reports, with all water analyses in weight parts per billion and all sediment analyses in weight parts per million.

Expansion of the HSSR to include multielement analyses greatly enhances the value of the overall program. Several of the additional elements can be used to aid in evaluation of the uranium data, while many are important in themselves as essential raw materials. In effect, the HSSR has assumed a key role in assessing the long range mineral resources of the United States both for strategic and energy planning and for general industrial and economic growth.

As directed by DOE, all existing data bases are being converted from the contract boundaries to those coinciding with NTMS quadrangles. All future reconnaissance reports will cover areas conforming to the boundaries of NTMS map sheets. The first several will include analyses for uranium only, with those including multielement data to follow as soon thereafter as possible.

Oak Ridge Gaseous Diffusion Plant

The Oak Ridge Gaseous Diffusion Plant (ORGDP) is conducting the HSSR program in an area of over 970,000 square miles covering 154 quadrangles in the central United States (see map). The goals of the program are to complete 71 open-file quadrangle reconnaissance reports by August of 1981, and all 154 by August of 1983. The goal for the coming year is to open file seven quadrangle reconnaissance reports.

The clean room laboratory at ORGDP is used for the NURE analyses of stream water and stream sediment collected in the field.

ORGDP personnel collected stream-water and stream-sediment samples and made field measurements in Wisconsin during the past field season.

Reconnaissance sampling was started in early 1976 with approximately 70,000 square miles sampled in the first phase (100 mi²/sample) and 27,500 square miles in the second phase (10 mi²/sample). In FY 1977, reconnaissance Phase I sampling was conducted in the Llano, Brownwood, and Austin quadrangles in central Texas. However, in compliance with the DOE request to conduct only Phase II sampling in high-priority quadrangles, Phase I sampling has been deferred. Sampling of the Eau Claire and Green Bay quadrangles in Wisconsin and the San Antonio and Plainview quadrangles in Texas was completed during FY 1977. Sampling is progressing in the Rice Lake and Iron Mountain quadrangles in Wisconsin, the Seguin quadrangle in Texas, and the Oklahoma City quadrangle in Oklahoma, and is expected to be completed in FY 1978. Cooperative programs for setting up and conducting well sampling programs were discussed with the state geological survey offices in each state within the ORGDP sampling area. Arrangements were made with the Oklahoma Geological Survey to select well locations and to sample these wells in Oklahoma. Two quadrangles were sampled as a combined effort between Bendix and ORGDP field geologists.

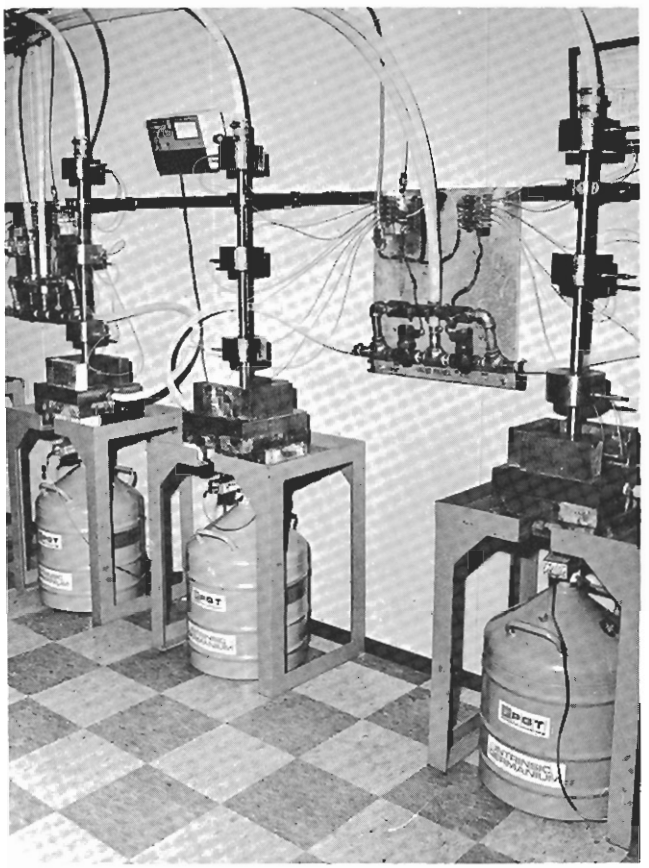
An investigation into the feasibility of using an Inductively Coupled Plasma (ICP) direct-reading spectrometer for analysis of HSSR stream-sediment samples for major, minor, and trace elements was conducted. The possibility of using this technique to determine thorium in sediments down to 5 ppm was studied.

A 6-inch radius mass spectrometer was constructed and demonstrated to adequately analyze water samples for uranium concentration down to 5–10 nanograms per liter (parts per trillion). The precision and accuracy of isotope-dilution, thermal emission (IDTE) mass spectrometry is sufficient to meet the needs of the NURE project. In excess of 50 samples per day, including all preparation and instrument time, can be analyzed by IDTE. Determinations of arsenic and selenium in sediments and water samples by atomic absorption (AA) analyses are being carried out successfully. An automated spectrophotometer system was installed for determining sulfate concentrations in water samples.

During FY 1977 a total of 4,321 samples was analyzed in the NURE project laboratory. To facilitate handling of the large volume of data generated from NURE samples, a data system has been designed which incorporates a magnetic cassette tape data collection system and utilizes a programmable calculator for data manipulation and formatting. The system involves collecting data from several instruments on magnetic cassette tapes, although some instruments are interfaced directly to the calculator. The tapes are then fed into the calculator where the data are then manipulated, formatted, and fed to a printer and another cassette

tape. The data are then transmitted via telephone line to the NURE computerized data base.

All Bendix-suggested data display changes were implemented at ORGDP. These changes include implementation of the Canadian Symbol System for plotting element concentration ranges and development of a capability for generating computer-drawn maps directly on mylar film. Other changes involve expanding the symbol plotting capability to include the LASL symbol system. A plot of population percentiles was developed to graphically display differences in geologic units. Finally, a system for submitting job requests for all required computer output via telephone lines directly from the NURE Project Office was implemented.



These are the intrinsic germanium detectors with variable geometry used at SRL to analyze the HSSR samples for the NURE program.

QRGDP reports open filed in FY 1977 in relation to the HSSR program include three quarterly reports covering the period from October 1, 1976, through September 30, 1977. Two reports dealing with data management and instrumentation improvements were issued during FY 1977. A report on the uranium geochemical survey in the Crystal City and Beeville quadrangles of Texas was open filed on March 14, 1977. The Phase I reconnaissance survey report on the Plainview, Lubbock, and Big Spring quadrangles in Texas will be open filed in FY 1978.

Open-file reports for the Plainview, Oklahoma City, Ardmore, Seguin, Iron Mountain, Eau Claire, Green Bay, Rice Lake, and Houston quadrangles will be issued during FY 1978.

Savannah River Laboratory

The Savannah River Laboratory is responsible for conducting the national HSSR program in the eastern United States (see map) which includes parts of 30 states and an area of 850,000 square miles. The goals of this program are to open file 57 quadrangle reconnaissance reports by August of 1981, and 81 more by August of 1983.

This year 20,000 ground water samples and 14,000 samples each of surface water and sediment were taken for reconnaissance surveys. Sampling was completed in 15 quadrangles this year with the assistance of Bendix personnel in four northeastern quadrangles; 12 more quadrangles are currently in progress. By the end of 1978, an additional 36 quadrangles will have been completely sampled.

A basic data report on the Spartanburg quadrangle, covering parts of South and North Carolina, and a preliminary report on stream sediments in the Winston-Salem quadrangle, which includes parts of North Carolina, Virginia, and Tennessee, were open filed this year. It is expected that 13 basic data reports will be open filed in 1978.

This year four orientation studies were completed: two in the South Carolina coastal plain, one in the North Carolina coastal plain, and one on the Chattanooga Shale in Tennessee. Studies on the carbonatite region of Arkansas, the Chattanooga Shale in Arkansas, the granitic and rhyolitic regions of Missouri, and the lake and swamp areas of Maine are now in progress. Three projects in North Carolina and one in the Gulf Coast area are planned for 1978. The usefulness of helium, neon, and radon for detecting uranium was studied this year, and efforts will continue along this line in 1978.

The very successful pilot scale reactor activation facility was removed late this year after reaching an analysis rate of 8,000 samples per quarter and performing approximately 400,000 multielement analyses. The pilot scale facility provided many of the design criteria for the full scale reactor activation facility, which along with an SEL 32/55 computer (to provide control, data acquisition, and data reduction) is now completely installed. Calibration and determination of the operating parameters of the computer are in progress. The equipment should be in production by March and reach a capacity of 25,000 samples per quarter by mid-1978.

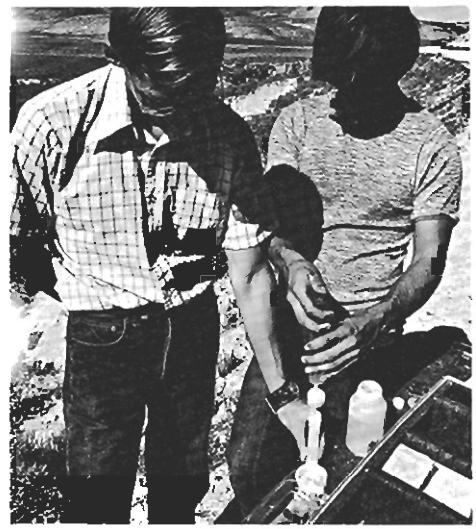
An automated electron microprobe has been installed to provide mineral component identification of selected sediment samples. This should greatly aid in understanding the distribution of uranium in these materials.

A system to produce 1:250,000 scale, 1-degree by 2-degree quadrangle map overlays from computer generated microfilm is now operational. A digitizer was added to the computer to automatically calculate sample site coordinates. A semi-automated system was developed to generate tables, figures, and quality assurance data for basic data reports. Programming was completed to produce all quadrangle data on magnetic tape.

Bendix

During July of this year Bendix Field Engineering Corporation established the Geochemical Department which serves as the principal point of contact among the four DOE laboratories and BFEC for technical matters concerning the HSSR program. The department has been authorized a staff consisting of a manager, four staff geoscientists, and one clerk. Since its formation the efforts of the Geochemical Department have been directed towards finalizing quadrangle priorities, coordinating the scheduling for the high priority quads, establishing procedures for and collecting quadrangle status information, and staffing of the department. Along with the ongoing status and scheduling activities, considerable effort is being spent to prepare the requirements for the basic data reports for the HSSR program.

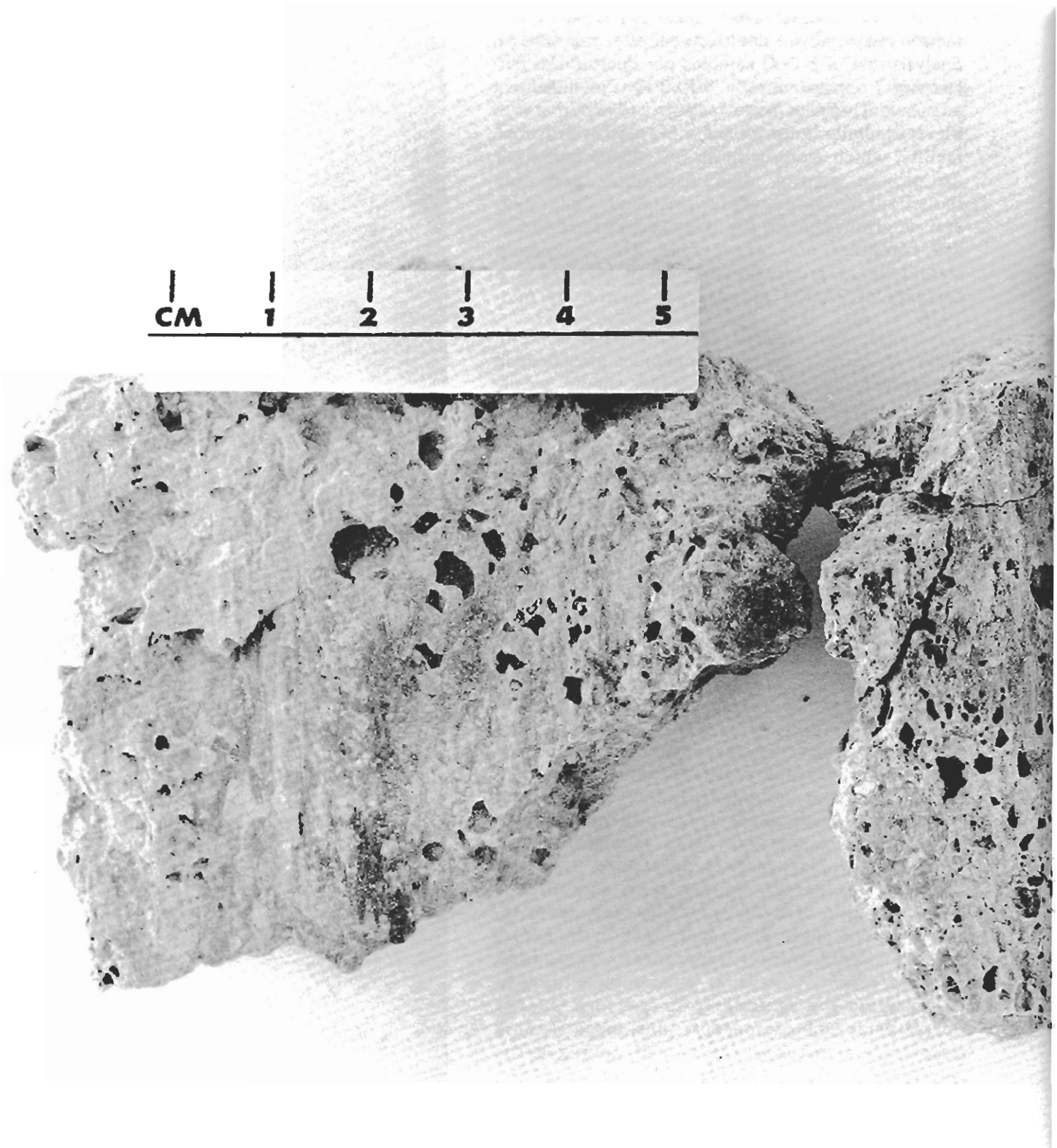
The Geochemical Department, which is part of the Data Acquisition and Development Division, coordinates its efforts with the Planning and Information Systems Division on matters of scheduling, planning, and status. The department also coordinates its efforts with the Geology Division and Data Processing Division on matters of reporting requirements, scheduling, and quadrangle interpretation.



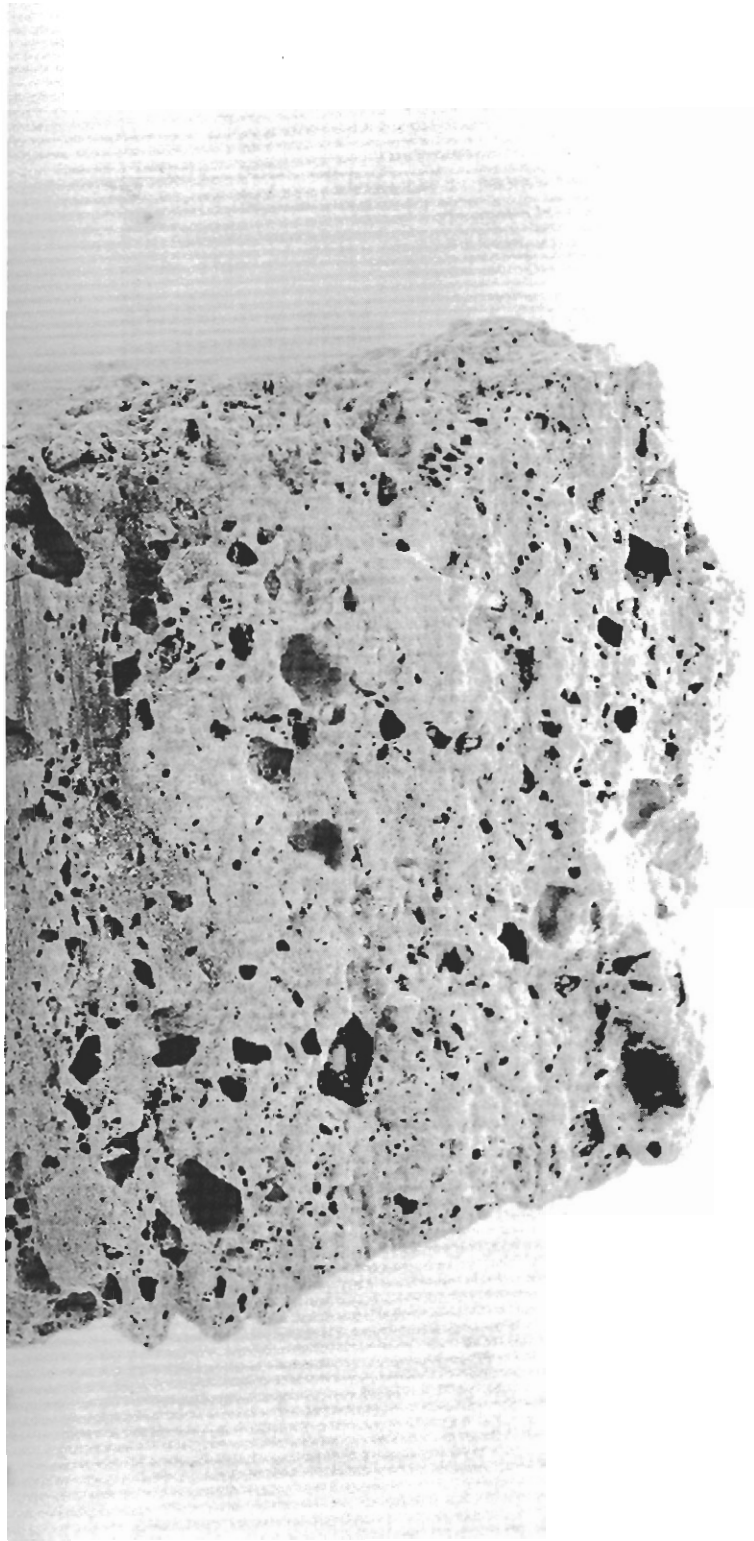
Bendix field geologists load a ground-water sample into a "rabbit" for automatic chemical analysis by neutron activation and delayed neutron counting at LASL. The rabbit, loaded in the field, carries the sample throughout the analyses, which is a big time saver.

This past summer and fall Bendix augmented each of the four DOE laboratories in their sample collection efforts. Personnel from seven regional offices of the Geology Division collected samples in all or portions of 22 quadrangles. This effort has improved the sample collection status of the four laboratories and should be of considerable help in meeting the program goals for 1981.

A Bendix geology technician from the Pittsburgh office collects a stream-sediment sample for the HSSR program in the Scranton quadrangle. Geologists from seven of the nine Bendix field offices participated in the HSSR sampling program.



Topical Geological Studies



Calcrete ore samples (left) are from the Yeelerrie deposit in Western Australia (above). The calcrete ore is exposed at the bottom of the flooded open-pit mine and averages 0.15 percent U_3O_8.

The topical Geological Studies program is dedicated to the enhancement of geological concepts. In 1977, special attention was given to those studies which would provide information leading to the development of new uranium districts. Whereas uranium production in the United States has been approximately 97 percent from sandstone-type deposits, uranium production from non-U.S., free-world sources has been over 80 percent from non-sandstone environments. These non-sandstone environments have come under scrutiny in this study. Three studies of these oversea environments were carried out this year, and will continue into 1978. The studies are designed to contribute to our knowledge of the behavior of uranium, provide us with criteria for exploration targets in the United States, and provide exploration guides for use in the field. Topical Geological Studies will enable Bendix geologists to more effectively assess non-sandstone uranium resources in the United States.

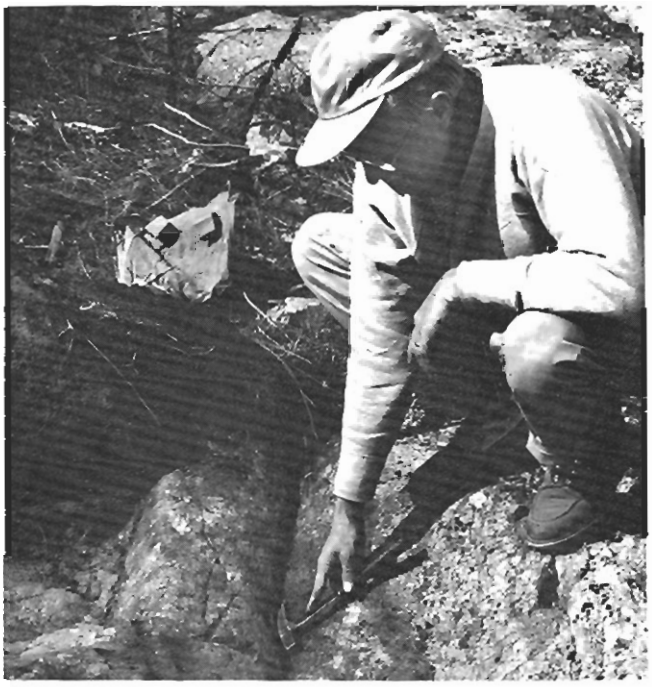
Uranium Favorability of Calcretes

- Subcontractor: University of California at Los Angeles
- Subcontract Value: $96,004
- Start Date: 21 June 1976
- Completion Date: 31 December 1977

A study was inaugurated in June 1976 to determine the distribution of calcretes and gypcretes in the southwestern United States and their uranium favorability. The economic occurrence of uranium in calcretes in Australia and in calcretes and gypcretes of South West Africa provides the impetus for the investigation since supposedly similar environments are present in the United States. The final report will contain a model of uranium emplacement, preliminary work on uranium genesis, and cataloging of favorability criteria developed from a detailed study of economic deposits in Australia and South West Africa. The model, to which uranium favorability is related is applied to calcreted areas in the United States and the findings are reported.

The calcrete study has been executed under the leadership of Dr. Donald Carlisle of the University of California at Los Angeles. The final report was open filed in 1978 as GJBX-29(78).

One of the principal investigators for the Proterozoic metamorphic rock studies indicates an unconformable contact in the Beaverlodge uranium district in Canada.



Uranium in Proterozoic Metamorphic Rocks

- Subcontractor: Michigan Technological University
- Subcontract Value: $100,892
- Start Date: 29 March 1977
- Completion Date: 15 July 1978

Discoveries at Key Lake in Canada and Jabiluka in Australia have had a tremendous impact on uranium economics. Since these are in an environment which has not been evaluated for the United States, Bendix has planned a study to this end.

The Study of Uranium in Proterozoic Metamorphic Rocks was subcontracted to Michigan Technological University. The principal investigators are Dr. Jorma Kalliokoski of Michigan Tech., Dr. Richard W. Ojakangas of the University of Minnesota (Duluth), and Dr. Fred F. Langford of the University of Saskatchewan. Field investigations were carried out in Australia and Canada to determine the relevant criteria pertaining to uranium emplacement in this particular geological setting.

The group was further charged to determine, from the literature, analagous settings in the United States and evaluate them for uranium potential.

Excellent progress has been made to date, and field work in both Canada and Australia has been successfully completed and reported. The study should be completed in the summer of 1978 and is expected to open up new opportunity in a new uranium environment.

Formation of Uranium Ores by Diagenesis of Volcanic Sediments

- Subcontractor: Texas Bureau of Economic Geology
- Subcontract Value: $73,764
- Start Date: 1 June 1977
- Completion Date: 30 June 1978

One of the most promising topical investigations being conducted is the study on formation of uranium deposits by diagenesis of volcanic sediments. Principal investigators on this project are Dr. L. F. Brown, Jr. and Dr. C. D. Henry of the University of Texas at Austin, assisted by Dr. C. G. Groat and Dr. Philip Goodell of the University of

Texas at El Paso and Dr. A. W. Walton of Kansas University.

Field investigations are being conducted in the piles of tuff, pyroclastic material, volcaniclastic sediment, and volcanic sediment that accumulated around the Cenozoic Trans-Pecos volcanic center in West Texas. The objective of the project is to identify and define the process(es) by which uranium deposits form in volcanic material by studying known uranium occurrences in the Trans-Pecos area. This study is intended to provide a model of the uranium depositional process resulting from diagenesis of volcanic sediments and volcaniclastics which can be applied to other volcanic areas of the western United States.

Impetus for this study comes from the recent discovery of large deposits of uranium in volcanic rocks in the Pena Blanca mountains near Chihuahua City, Mexico. At that locality, some 4,000 to 50,000 tons of U_3O_8 have been developed near the base of a sequence of tuffs and rhyolite flows where they rest on an eroded surface of Cretaceous limestone reefs. Mexican geologists interpret these deposits as hydrothermal, whereas U.S. geologists favor formation by leaching from tuffaceous material and subsequent deposition in topographic lows.

A project geologist overlooks Tunugdliarfik Fjord and the North Atlantic in the distance from the Kvanefjeld in the Ilimaussauq intrusion in Greenland on on a visit to the area during the past field season.

Uranium in Alkaline Rocks

- Subcontractor: Lawrence Berkeley Laboratory
- Subcontract Value: $89,000
- Start Date: 28 March 1977
- Completion Date: 28 March 1978

Alkaline and peralkaline rocks in the United States have not been considered a major source of uranium mineralization. Worldwide, however, these rocks are known to contain significant amounts of uranium, particularly at Ilimaussauq in Greenland and Pocas de Caldas in Brazil. With the abundance of alkaline and peralkaline rocks in the United States, it is reasonable to assume that there could be analogs to the foreign deposits in this country. Therefore, a geologic study entitled, "Uranium in Alkaline Rocks," was undertaken by Lawrence Berkeley Laboratory in March 1977.

During the first phase of the project, a literature search of documents associated with uranium mineralization in alkaline rocks was made. Over 1,700 references were uncovered in this search. Field trips were taken to Ilimaussauq and Pocos de Caldas where the uranium associations in the peralkaline intrusives were studied. Synthesis of the literature has been completed and will result in a compilation of criteria favorable to uranium occurrence in alkaline and peralkaline rocks throughout the world. The final report will also identify areas thought to be favorable for uranium occurrences in alkaline rocks in the United States.

Lithium Study

A modest program for the study of lithium resources has been initiated by USGS. NURE is funding USGS to assist with an enlarged exploration drilling effort.

Improved Appraisal System for U_3O_8 Endowment

- Subcontractor: University of Arizona
- Subcontract Value: $188,000
- Start Date: 18 January 1977
- Completion Date: 18 January 1979

The object is to design and demonstrate an improved methodology for the appraisal of U_3O_8 endowment as a function of the level of information and the status of geological variables of a given area. Selected experts will exchange information and ideas via interactive remote terminals that are coupled to a computer which is programmed to force an appraisal using a decision-tree process.

Technology Development

The major goal of the Technology Development program is to provide new and improved instrumentation and techniques for uranium exploration, exploitation, and resource assessment. The program is, therefore, structured to include a number of geoscience technology areas including conventional and nuclear geophysics, geology, geochemistry, geostatistics, and remote sensing.

Activities are conducted by Bendix through a combination of in-house and subcontracted projects, many of which are initially small-scale investigations undertaken to evaluate a particular technique or approach. The mix of activities contains some high-risk, low-cost projects which, if successful, could have a significant programmatic impact, as well as a number of moderate-cost projects which carry a high-success probability and a predictable programmatic impact. There were 24 subcontracted and 17 in-house projects underway during 1977; these are subdivided into three categories: Support of Resource Assessment, Exploration Techniques, and Exploration Systems.

Support of Resource Assessment

A number of projects in the Technology Development area is designed to provide near-term benefit to the resource assessment activity within the NURE program. These include 1) the provision of calibration models for use by the uranium exploration industry, government organizations, and DOE subcontractors, 2) the in-house capability to perform surface and subsurface geophysical surveys in areas of specific interest to the resource assessment geologists, 3) the development of improved methods of acquiring, reducing, and interpreting geophysical, geochemical, and geological data, and 4) the provision of state-of-the-art geochemical analysis facilities at the DOE facility in Grand Junction.

New Calibration and Test Facilities

- Start Date: 1 July 1975
- Completion Date: Open

Major accomplishments in this in-house project lie in the design and construction of new calibration

Industry and DOE borehole logging units use borehole models to calibrate gamma-ray detection systems at the DOE calibration facility on the grounds of the Grand Junction Office.

models at the DOE–GJO compound. Expansion of the system of borehole models for calibration of gamma logging systems is in progress, and construction has begun on borehole calibration facilities for neutron logging systems.

Two horizontal borehole models with a total of four thin and dipping ore zones, each of grade 0.21 percent eU_3O_8 and thickness 2 inches were completed in 1977. Dip angles are 0, 30, 45, and 60 degrees. The 4½-inch diameter borehole has a 1/16-inch thick aluminum casing.

A 5-ft-by-5-ft-by-5-ft granite block with a 4½-inch borehole was completed for logging with density, magnetic susceptibility, neutron, and sonic probes. Porosity of the block is about 0.3 percent.

A group of borehole models for calibration of fission neutron logging systems is scheduled for completion in January 1978. The first six models will feature eight 6-ft thick ore zones with four different ore grades, three porosity values, and two values of formation thermal-neutron-cross-section.

A borehole-size-correction/water-factor model and additional porosity, density, and formation thermal-neutron-cross-section models for neutron tool calibration are included in future plans. A new KUT/water-factor model is also planned. Calibration facilities similar to those in Casper, Grants, and George West are tentatively planned for Spokane, Phoenix, Atlanta, and Pittsburgh.

Chemical and radiometric assays and other analyses of core materials from existing models and the resultant possibility of ore grade revision remain under continual review. A program for regular and complete monitoring of all calibration facilities is being formulated.

Existing DOE Calibration Facilities

Through Bendix, DOE provides the uranium industry with calibration facilities for borehole probes in Grand Junction, Colo.; Casper, Wyo.; Grants, N.M.; and George West, Tex. The design of the calibration models is basically the same in all areas, and consists of a 3-ft ore zone that is underlain and overlain by 3-ft barren zones. The ore zone consists of concrete containing a measured amount of ore material; the barren zones consist only of concrete. A 4½-inch borehole extends through the three concrete zones and into a run pipe extending below the steel cylinder containing the concrete. A probe is calibrated by determining its response characteristics in the known grades of the ore zones in the calibration models.

The facilities outside of Grand Junction each have two calibration models with nominal ore grades of 0.3 percent and 2 percent eU_3O_8. Grand Junction has 5 calibration models and 18 other models for gross gamma-ray investigation with grades ranging from 0.2 percent to 2.0 percent eU_3O_8. In addition, Grand Junction has facilities for obtaining calibration factors for the gamma-ray attenuation due to water and borehole size, and for the calibration of borehole and surface gamma-ray spectrometers.

The response characteristics of the probes in the known grade and thickness of the ore zones in the calibration models are determined from data obtained by logging the ore zones in the models. These data are provided to Bendix personnel in Grand Junction who calculate a K-factor and dead-time for each probe/unit and are used in the interpretation of uranium exploration logs. Accurate calibration information is an essential element of accurate ore reserve calculations and ore-potential estimates.

DOE also provides a facility, located at Walker Field in Grand Junction, for the calibration of aerial gamma-ray spectrometers, and a test range at Lake Mead, Ariz., for aerial radiometric survey systems. (See descriptions of these in the sections that follow.)

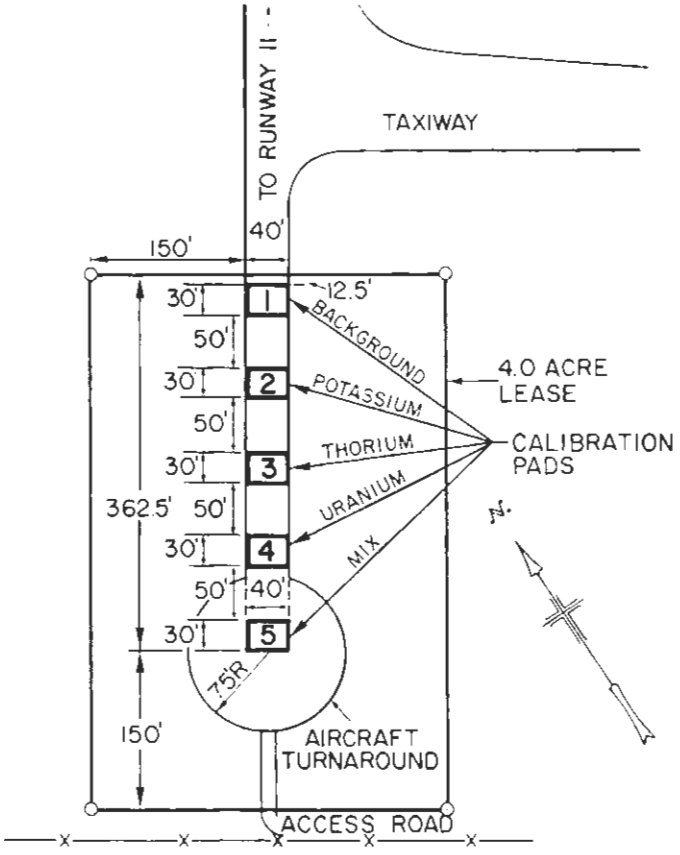
The calibration service provided by DOE, through Bendix, is significantly beneficial to the uranium industry in that it provides standards to which ore grades obtained by geophysical measurement are referenced. This standardization through calibration is a voluntary and cooperative effort undertaken by government and industry to obtain reliable information regarding a critical natural resource. All DOE calibration facilities are operated by BFEC from their Grand Junction, Colo., offices.

Airport Calibration Facility

- Start Date: 7 January 1976
- Completion Date: Open

The only large-scale facility in the United States for the calibration of airborne spectrometers is located at Walker Field, Grand Junction, Colo. Built and operated by Bendix Field Engineering Corporation for the Department of Energy, the facility is available, free of charge, to firms wishing to calibrate airborne, vehicle, or portable radiation detectors.

The facility consists of five concrete pads, 30 ft by 40 ft by 1.5 ft thick, containing various concentrations of radioactive potassium, uranium, and thorium. Since concentrations of the radioactive elements in the pads are known, detector response to these concentrations can be accurately determined by having the instrumented aircraft which is being calibrated remain parked over the pad for a



The diagram (left) illustrates the DOE Calibration Pads at Walker Field Airport in Grand Junction. An aircraft, with its radiometric survey instruments on board, parks on each of the different pads to take appropriate calibration measurements. The helicopter (above) uses a separate generator to run its instruments while it is parked on one of the pads.

specified time. The large area of the pads provides a geometry similar to that often encountered in surface surveys; thus, they are particularly well suited for testing radiation detectors.

A program has been initiated to monitor the radiation from the pads for possible seasonal variations and effects of moisture. In this work, a large sodium iodide (NaI) detector is used to collect spectral radiation data which is recorded on magnetic tape. Subsequent analyses of the recorded data provide a means of identifying any changes in the radioactive character of the pads.

During its first year of operation (1977), the facility was used for calibration of aerial spectrometers 19 times and for surface spectrometers, 15 times.

A report on the construction of the facility will be open filed early in 1978. Additional reports pertaining to the characterization of the airport pads will be published as the data become available.

Dynamic Test Range

- Start Date: 1 December 1976
- Completion Date: Open

The Aerial Radiometric Dynamic Test Range, first of its kind in the United States, was developed during 1976 and was made fully operational in 1977. The range is located in Arizona adjacent to Lake Mead's Bonelli Bay. Its primary purpose is to provide a uniform calibration standard for industry and those actively participating in the NURE Aerial Radiometric Reconnaissance Program.

The range is one of the facilities provided for evaluation of NURE aerial subcontractor performance, using data obtained from controlled range overflights and concurrent ground and meterologic measurements. Also, because the range has a nearly uniform ground distribution of radioelements, it is invaluable in determining data normalization parameters necessary for intercalibrating subcontractor radiometric detection systems.

There were 19 BFEC/DOE supported range overflights during 1977 by instrumented subcontractor aircraft.

Geophysical Survey and Log Interpretation Studies

- Start Date:
- Completion Date: On-going in-house project

At this time, Bendix operates two subsurface logging vehicles with the capability of recording natural

A DOE logging unit and support vehicle are operated by Bendix personnel at a uranium exploration borehole in Wyoming.

gamma-ray, resistivity, spontaneous potential, KUT (spectral gamma), caliper, temperature, neutron (epithermal and thermal), magnetic susceptibility, and density logs to a depth of 6,000 feet. Currently, one vehicle contains an in-house fabricated microprocessor system for on-board data acquisition. A surface surveying unit is also operated with the prime objective of collecting surface KUT data for aerial radioelement studies and periodic monitoring of the airport calibration pads.

An increasing amount of data are being generated by geophysical survey techniques; therefore, the need for more sophisticated interpretation procedures has also increased. Studies concerning the application of borehole geophysical data show that in many instances, measurements taken with one logging instrument may be used to correct measurements taken with other devices. These corrections result both in more accurate data and more complex log interpretation problems. Computer programs are in preparation which will decrease data processing time and increase data reliability. Particular emphasis is being placed on the influence of varying borehole parameters on KUT, neutron, and density logs. These logging devices are particularly affected by borehole size and borehole fluid, formation fluids, and rock densities.

Electronics Support Activities

- Start Date:
- Completion Date: On-going in-house project

The Bendix electronics laboratory provides technical support to DOE and BFEC divisions in resource evaluation and technology development. Services provided include technical consultation; design engineering; hardware implementation; and test, evaluation, and maintenance of geophysical and geochemical instrumentation systems.

Specialized instruments and borehole probes, which are not commercially available, are developed and tested by the electronics laboratory. During 1977, a microcomputer-based, borehole-logging system and dual detector KUT (spectral gamma-ray) borehole probes were developed and fielded. A report describing this effort will be published early in 1978.

Support for Operational Aerial Surveys

- Start Date: March 1977
- Completion Date: Open

Data collection and reduction procedures for the NURE Aerial Radiometric Reconnaissance program are published in Bendix specifications BFEC 1200–B, General Specification for Airborne Geophysical Surveys, and 1250–A, General Procedure and Documentation for Normalization and Calibration of Airborne Gamma-Ray Systems. These specifications define aerial survey procedures assuring collection of high quality data. As its primary function, the in-house "Support for Operational Aerial Surveys" project monitors subcontractor compliance with specifications BFEC 1200–B and BFEC 1250–A.

Prior to Bendix awarding an aerial survey subcontract, the participating subcontractor's Airborne Gamma-Ray System (AGRS) undergoes a system performance evaluation. This consists of requiring the AGRS to be operated 1) at high altitudes over water, 2) over the Lake Mead, Ariz., Dynamic Test Range, and 3) on the Grand Junction, Colo., Walker Field Calibration Pads. Data collected over these sites are analyzed to determine the system's capability of operating within Bendix specifications, and will be used as the basis for normalization between the various AGRS.

A second activity in this project is the assistance of subcontractors in the improvement of their data acquisition and reduction procedures. This is accomplished both directly, in response to specific requests from subcontractors, and indirectly, through technical publications.

Support for Aerial Research and Development

- Start Date: December 1976
- Completion Date: Open

In any technology development program there are a number of short projects that are necessary to fill the gaps between other project elements as they are brought together in pursuit of program goals. Also, due to the unpredictable nature of development work, occasionally there will be projects that must be pursued immediately, to support or maximize the benefits of other projects. Often, it is not effective to pursue these short or immediate-need projects through the subcontracting process. In such cases, the projects are pursued in house.

Bendix electronics technicians test the borehole probe and surface electronics of a DOE logging unit.

In the past year, there have been supportive in-house efforts involving: 1) modeling of aerial radiometric data, 2) modeling of the altitude dependence of the Bismuth-air correction, 3) development of computer programs for calibration of aerial systems, 4) design of an optimum numerical filter for aerial survey data, and (5) calculations of the extent to which a moving detector "sees" aerial data to the side. Several of these activities have been reported in technical papers and others will be similarly reported.

Airborne Data Procedures

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $289,000
- Start Date: 1 October 1976
- Completion Date: 1 September 1978

Under a 1976–77 subcontract, Texas Instruments performed an extensive followup study of their 1974–75 aerial survey of the Casper, Wyo., quadrangle. The Casper quadrangle was chosen for further investigation because of the quantity and diversity of uranium occurrences and sources as well as the availability of abundant "ground truth" information.

The initial subcontract consisted of two tasks which were completed in October and November, 1977, with the submission of the final reports. The first task consisted of detailed investigations into data limitations, sampling rationale, preliminary data analysis and display treatments, relationship between aerial radiometric and other geotechnical parameters, and development of more appropriate operational and equipmental survey specifications. The second task entailed the preparation of a manual for the use of pre-1977 aerial radiometric reconnaissance data. Both reports will be open filed in 1978.

An extension to the subcontract was negotiated in mid-1977, which provides for the application and refinement of Task I and will result in the investigation of the aerial radiometric surveys carried out over three quadrangles adjoining the Casper survey area. The original survey data for the Arminto, Lander, and Thermopolis quadrangles will be reprocessed to make them compatible with the new Casper quadrangle presentation. All four areas will then be studied to produce improved formats for the display of data variations ranging from locating single anomalies along flight lines to identification of uranium provinces with dimensions of hundreds of square miles. The study will include design of a data filter technique and a line-tying method for radiometric data.

A report describing the procedures and results of the subcontract extension will be open filed upon completion of the project.

Airborne Radiometric Data Statistical Analysis

- Subcontractor: Los Alamos Scientific Laboratory
- Subcontract Value: $150,000
- Start Date: 1 October 1977
- Completion Date: 30 September 1978

Under direct contract to DOE, this multiyear program, which was started in 1975, has as its objective the development and application of statistical methods to the analysis of data collected by airborne instrumentation in the assessment of uranium ore deposits throughout the continental United States and Alaska.

Spectrum Enhancement (Phase II)

- Subcontractor: Science Applications, Inc.
- Subcontract Value: $84,144
- Start Date: 1 February 1977
- Completion Date: 1 December 1977

This is the second phase of a study to demonstrate the applicability of the spectrum enhancement technique (MAZE) to data acquired with the sodium iodide detector systems currently used in aerial radiometric surveys. The technique treats spectral data mathematically to extract more accurate information on the potassium, uranium, and thorium signature gamma-ray intensities. The technique also has the ability to reveal previously hidden spectral features, which may be helpful in making corrections for the presence of airborne bismuth-214 (^{214}Bi).

In the present phase of this project:

(1) The performance of the technique, as a function of counting statistics, has been evaluated,

(2) The effects of ground moisture and ground cover on the aerial gamma-ray spectrum has been investigated,

(3) Corrections for non-linearities in sodium iodide (thallium drifted) [NaI(Tl)] data have been analyzed,

(4) A fast running version of the computer code has been written.

Results of this study will be contained in a report to be open filed early in 1978.

Soil Moisture Measurements

- Subcontractor: Geodata International, Inc.
- Subcontract Value: $32,272
- Start Date: 1 October 1976
- Completion Date: 28 February 1978

In order to make reliable radioelement concentration measurements, aerial survey data should be corrected or at least normalized to standard conditions of soil moisture and vegetation attenuation. Such corrections may be possible using a portion of the radiometric data itself. Under a follow-on to the Dynamic Test Range development contract, Geodata International is investigating the feasibility of a technique to correct for attenuation of gamma radiation due to soil moisture and surface vegetation.

The effect of gamma attenuation is strongest for low-energy gamma rays; thus, if the high-energy portions of the composite spectrum can be reconstructed with sufficient accuracy, the low-energy residual spectrum might be used for correction of soil moisture and vegetation attenuation. The Geodata study is testing the feasibility of this low-energy residual technique. Project tasks include performance of a series of experiments under controlled conditions to determine whether effects of distributed-source attenuation can be identified in the low-energy region of the spectrum, and performance of detailed calculations to explain the observed experimental results.

A detailed report will be placed on open file upon completion of the project.

Video Image Enhancement

- Subcontractor: University of Wyoming
- Subcontract Value: $119,925
- Start Date: 1 April 1975
- Completion Date: 30 September 1978

During 1977 the original contract with the University of Wyoming, as reported in the 1976 Annual NURE Report, was twice modified to: 1) allow varied demonstrations of the capabilities of the video enhancement system, and 2) establish ground truth correlation with proposed uranium-associated alteration evident in video-processed LANDSAT and aerial false-color infrared imagery.

As a result of the first modification, LANDSAT imagery was analyzed and interpreted for nine areas in the southern and western United States, selected by Bendix and DOE geologists. Different procedures were used in each area, depending on specific problems and objectives. Lithologic distinctions and detection of altered zones were accomplished with spectral processing; edge enhancement and contrast stretching were used as aids for structural interpretation. An open-file report on this work will be published in 1978.

Soil and rock samples from the Pumpkin Buttes region in the Powder River Basin were taken on both reconnaissance and detailed grids, as specified in the second modification to the subcontract. Sample locations were chosen on the basis of the imagery interpretation of altered and unaltered ground in an effort to determine the geochemical reasons for the distinctions. Nineteen geochemical analyses were performed on each of 205 samples, and trace and major element analyses were run on a select group of 30 samples. Interpretation of these analyses and thin-section analyses for 21 samples will be completed in the spring of 1978. A final report on this work will be published by September 1978.

Geochemical Relationship of Organic Matter and Uranium Deposits

- Subcontractor: Denver Research Institute
- Subcontract Value: $63,201
- Start Date: 30 September 1976
- Completion Date: March 1978

The association of uranium with organic matter in several major mining districts is well known, and studies of this association have demonstrated that the uranium concentration resulted from organic chemical interactions. Denver Research Institute undertook a study to develop further understanding of the association of uranium deposition with the presence of organic matter in host rocks.

The following progress was accomplished: a detailed literature search was completed; fulvic and humic acids were fractionated and characterized after being extracted from peat samples; and stability constants of uranyl ion with several simple model organic compounds, as well as association constants of uranyl ion with various fractions of fulvic and humic acids, were determined.

A detailed report will be placed on open file at the completion of project.

Ge(Li) Lab Assay

- Start Date: 1 January 1975
- Completion Date: 1 November 1978

A high-resolution germanium (lithium) [Ge(Li)] detector system has been developed by the Bendix

Uranium ore samples are being loaded into the automated sample changer of the germanium (lithium) lab system at Grand Junction. The detector is within the lead brick "cave" on the right, and the data acquisition system is on the left.

geochemical analysis laboratory for radiometric analysis of geologic samples. This system provides a more accurate determination of potassium, uranium, and thorium values, along with direct measurement of uranium concentrations and reduced sample turnaround time.

The hardware has been received and completely assembled. Samples containing high concentrations of uranium have been measured using an analysis technique similar to that presently used for NaI spectrometers.

A magnetic disk (memory) and associated software were acquired to enable real-time multitasking of analytical operations while the system is in an acquisition mode. This upgrade to the computer-based multichannel analyzer will be implemented in early 1978.

An analysis scheme will be developed to utilize the full capability of the high resolution Ge(Li) detector, and allow measurement of emanation coefficients and disequilibrium in the uranium chain.

A report describing the procedures used and results obtained will be placed on open file late in 1978.

Spectrophotometer

- Start Date: 12 March 1976
- Completion Date: 30 September 1977

This project, now completed, was initiated to develop new analytical procedures for selected trace elements. As a first step toward accomplishing this improvement, a dual beam fluorescence spectrophotometer was installed in the geochemical analysis laboratory at Grand Junction.

In 1977 a fluorescence spectrophotometric procedure for the analysis of selenium in geological samples was developed and implemented into routine analysis. This procedure provides a lower limit of detection and better precision than the colorimetric procedure used in the past. A users' guide and report, evaluating system capabilities and performance, was written for internal use.

X-Ray Fluorescence

- Start Date: 1 April 1975
- Completion Date: Open

To enable rapid, automated identification of low level concentrations of a large number of elements in geologic field samples, an x-ray fluorescence analysis system has been installed in the geochemical analysis laboratory in Grand Junction. This new system, which provides specific-element and multi-element surveys, has several advantages over present techniques, including simple and rapid sample preparation and minimal effort for training, operation, and data reduction. X-ray fluorescence, moreover, is capable of providing valuable additional data not readily generated by current methods.

Instrumentation has been tested, modifications made, and additional hardware purchased, while various sample preparation and analytical techniques are under investigation. Current usage of the system includes analytical evaluations of tentative procedures and characterization of numerous reference materials necessary for evaluation and monitoring of subcontracted analytical laboratories to be used in connection with the quadrangle evaluation program.

In 1978 a report on system capabilities and on the utility of energy dispensive x-ray fluorescence for rock analysis will be published.

Automated Techniques and Methods Development

- Start Date: 1 October 1976
- Completion Date: 30 September 1977

A Bendix in-house project to develop automated techniques and laboratory methods was initiated in 1976 to provide new geochemical analytical capabilities, increase production capacities of ex-

isting procedures, and replace unreliable hardware with dependable equipment.

The project was completed in 1977 with the following accomplishments: installed a new alpha-beta system and adapted routine alpha-beta procedures to new system; implemented an automated calculation program for calculating atomic absorption and fluorometric uranium results; developed and implemented a time-saving fusion technique for preparing geological samples for subsequent fluoride determination; acquired an atomic absorption analyzer with microprocessor electronics and heated graphite accessory; and acquired semi-automated block digestor for batch sample preparation.

Thermoluminescence Techniques for Uranium Ore Exploration

- Subcontractor: Brookhaven National Laboratory
- Subcontract Value: $117,000
- Start Date: October 1976
- Completion Date: September 1977

Under an agreement with DOE, funds are provided to extend radiation damage research results based on thermoluminescence techniques to exploring for uranium ore by: (1) determining the flow paths of uranium-bearing solutions through sandstone beds and (2) demonstrating that thermoluminescence measurements can be used to locate lead, zinc, and fluorite ore in limestone beds. Results obtained in FY 1977 will be reported along with those expected from an extension of the program funded in FY 1978.

Engineering Assessment and Feasibility Study of Chattanooga Shale as a Future Source of Uranium

- Subcontractor: Mountain States Mineral Enterprises
- Subcontract Value: $256,600
- Start Date: 6 September 1977
- Completion Date: June 1978

Initiated to help determine the technical, economic, and environmental feasibility of large-scale uranium production from Chattanooga Shale, the work will be accomplished in two phases: first, collection and evaluation of information and data on the technology of mining and processing marine shales to recover uranium; and second, preparation of a report on current and projected economics and feasibility of large-scale production of uranium from Chattanooga Shale, including evaluation of environmental and socioeconomic impacts.

Uranium and Coal Mining Impact Study

- Subcontractor: University of Utah
- Subcontract Value: $10,000
- Start Date: 11 April 1977
- Completion Date: 10 August 1978

The objective is to determine and evaluate the environmental and societal impact of the mining, processing, and transportation of uranium and coal in the western United States, which includes Montana, Wyoming, Colorado, New Mexico, Idaho, Utah, Arizona, Washington, Oregon, and California.

A summary document will be open filed in 1978.

Recovery of Uranium from Wet-Process Phosphoric Acid

- Subcontractor: Oak Ridge National Laboratory
- Subcontract Value: $52,000
- Start Date: May 1977
- Completion Date: September 1977

Under direct contract with DOE, this is the first year of a multiyear project to provide the basic information needed to implement commercial-scale recovery of the uranium that is contained in the phosphoric acid produced each year by the fertilizer industry.

Exploration Techniques

Bendix is involved in many projects which may improve the geophysical methodology pertinent to exploration. This technology will be transferred to industry, government agencies, and the general public via open-file reports, professional meetings, and journal publications.

The fundamental areas of interest are nuclear logging, aerial radiometric surveying, and radon and helium emanometry.

This is the GJO logging vehicle which was transferred to Sandia personnel for their use in PFN probe development. At the time this photo was taken, the vehicle had just been substantially refurbished. The PFN probe is shown hanging from the sheave wheel.

Uranium Borehole Logging with PFN

- Subcontractor: Sandia Laboratories
- Subcontract Value: $600,000
- Start Date: October 1976
- Completion Date: September 1977

The beginning of this report period was marked by the transition from analog to digital pulse recording of fission neutron (PFN) log data used in log analysis. The results obtained using both data forms were presented at a seminar hosted by Sandia for the uranium industry in February 1977. The status of the PFN project, as presented at the seminar, has been open filed; report GJBX-23(77). The early work on this project which featured the analysis of analog data, was also open filed; report GJBX-47(77).

The response of the industry representatives at the seminar was valuable in assaying and directing the PFN logging project. The evaluation of the PFN system will continue; however, the field evaluation will now be made through a joint effort by Sandia and Bendix. The development by Sandia of the high output (Zetatron) neutron tube will continue; the transfer of the tube technology will now proceed as the final tube design evolves.

Field operations during the spring of 1977 quickly revealed the rapidly deteriorating state of the Sandia logging vehicle. A major renovation of the logging vehicle was undertaken and at the same time, the logging capability expanded to include hydrogen (neutron and thermalneutron), density, natural gamma, and caliper logs. The PFN system was field operational during the last quarter of the calendar year. Logging was carried out at selected sites in Texas, Wyoming, and New Mexico.

Californium-252-Based Borehole Logging System

- Subcontractor: IRT Corporation
- Subcontract Value: $240,464
- Start Date: 1 June 1977
- Completion Date: 31 October 1977

A draft report detailing previous ERDA(DOE)-sponsored work on the Californium (^{252}Cf) based delay fission neutron (DFN) logging system was submitted to the Grand Junction Office early in the 1977 calendar year. Although the report has not yet been open filed, it has served to highlight certain aspects of the system that require rework and show the lack of sufficient field evaluation of the system. The work in 1977 was undertaken to correct these two deficiencies.

The winch on the IRT logging vehicle was upgraded and the data acquisition system was converted from a time-based to a distance-based radiation/counting sequence. Improvements to correct some of the hardware deficiencies already identified and also to improve the data analysis and interpretation were initiated. Since all of this work was not completed in 1977, a new subcontract to complete these improvements and to conduct additional field evaluations is to be initiated early in 1978.

Some field work using the IRT system has been done in Texas, Wyoming, and Arizona. The log results are quite satisfactory, considering that the compensated monitor system (i.e., dual detector systems for environmental corrections) is not yet operational.

Pulse DFN Logging Probe

- Subcontractor: Kaman Sciences Corporation
- Subcontract Value: $83,434
- Start Date: 22 July 1976
- Completion Date: 27 July 1977

The work begun by Kaman Sciences Corporation to optimize, calibrate, and field test a delayed fission neutron probe (with its supporting electronics) was completed during 1977. Kaman subcontracted those field operations requiring a logging vehicle to Century Geophysical Corporation of Tulsa, Okla.

Optimization work was undertaken to decrease excessive system generated noise. The results of

the field work, unfortunately, revealed that this problem was not cured. The effort expended in determining the cause of the noise decreased the time and effort which could be devoted to field operations; therefore, only a total of seven holes were logged in Texas and New Mexico. A more complete description of Kaman Sciences Corporation's work can be found in the open-file report: "Calibration and Field Testing of Pulsed, Delayed Fission Neutron Logging Probe"; GJBX-29(77).

In-House Support of the Neutron Borehole Logging Program

- Start Date: 1 July 1975
- Completion Date: 31 October 1979

The principal areas of activity during the year have been the organization and coordination of field logging activity and the dissemination of information to the principals involved. Late in 1977 efforts to process fission neutron data from Sandia Laboratories (PFN system) and from the IRT Corporation (^{252}Cf-based DFN system) were begun.

Although most of the fission neutron field work was carried out in the Texas Gulf Coast area, field operations also were conducted in Wyoming, New Mexico, and Arizona. On two occasions commercial logging services were purchased to compliment the logs taken in the field by Sandia and IRT and to assist the Bendix in-house groups working on the design of new and improved calibration models for the fission neutron logging systems. Plans are underway to purchase additional commercial logging from service companies; these data will be compared to, and correlated with, the fission neutron logs.

Borehole Model Neutron Calculations/Experiments

- Subcontractor: Science Applications, Inc., with Bendix support
- Subcontract Value: $134,090
- Start Date: 1 August 1977
- Completion Date: June 1978

Initial results of this neutron transport calculational effort are summarzied in the report GJBX-44(77) placed on open file in September 1977. This early work produced a two-part data base for neutron transport in a sandstone formation. The entire data base consists of approximately two million computer words and is stored on magnetic tape. The first part presents forward neutron propagation into the formation from ^{252}Cf and 14 MeV (pulsed tube) sources located in the borehole. The second part of the data base presents neutron signal return to the borehole due to uranium fissions in the formation. Results are presented as functions of probe detector type, probe detector-source separation, borehole diameter, and formation moisture content.

The current phase of this work has extended the data base to include a shale formation and the generation of gamma-ray return signals. Work is now under way to include the effects on logging data of eccentric probe location, presence of borehole casing, presence of strong thermal neutron absorbers, and formation invasion by drilling mud. Calculations will also be performed to study the influence of design parameter variations on probe response and to determine the intercalibration of existing probe designs.

Experiments will be performed during the first half of 1978 to verify the results of the data base calculations. Bendix personnel are collaborating with Science Applications in these measurements. Additional experiments will determine the feasibility of uranium (^{238}U) lined proportional counters as source monitors for 14 MeV pulsed neutron probes.

An open-file report will be published upon completion of this project.

Computation and Nondestructive Assay Methods

- Subcontractor: Los Alamos Scientific Laboratory
- Subcontract Value: $218,000
- Start Date: October 1976
- Completion Date: September 1977

Discrete ordinates and monte carlo gamma-ray radiation transport calculations for rock media which contain K, U, and Th, and their daughters are under development at the Los Alamos Scientific Laboratory. Three configurations are under consideration: 1) an infinite homogeneous rock medium, 2) an infinite homogeneous rock medium pierced by a borehole, and 3) two "semi-infinite" homogeneous media, air and rock, which meet at a planar boundary. The Los Alamos calculations include determination of gamma-ray fluxes as functions of gamma-ray energy and the gamma-ray direction at various points in the models.

The first configuration, for which calculations are complete, served as an exercise for developing the calculational techniques. The second configuration simulates gamma-ray fluxes in a borehole, and the third configuration simulates gamma-ray fluxes encountered in airborne surveys. In each case, the in-

fluence of variations in rock density; moisture content; and K, U, and Th content are being calculated. In the third configuration, additional variables considered include borehole diameter, borehole casing type, and casing thickness. In a future task, NaI and other detector response functions will be combined with the calculated gamma-ray flux spectra. The calculations will, therefore, reveal the relative influence that each of the above variables exerts on gamma-ray survey data. It will then be possible to formulate a data correction method to account for fluctuations in any of the variables studied.

State-of-the-art spectral gamma-ray surveys detect certain energetic gamma-ray emitting daughters of U, notably radium (Ra) and ^{214}Bi, instead of U itself. Such a survey will, therefore, yield an incorrect estimate of the U concentration if some geochemical process has selectively removed either the U or some members of the daughter chain from the rock mass being interrogated. Calculations are in progress to determine optimal parameters for spectral gamma-ray probes specifically designed for the assessment of such disequilibrium situations.

Experiments and calculations are in progress to evaluate a proposed photoneutron source system for neutron logging. The system consists of a zirconium-88/yttrium-88 (^{88}Zr/^{88}Y) gamma-ray source, a liquid scintillation detector, and a new type of neutron gamma-ray discriminator. Neutrons are to be generated through the bombardment of beryllium (Be) with gamma-rays from ^{88}Y, a daughter of ^{88}Zr. Because the disintegration of ^{88}Zr (85-day half-life) constantly replenishes the ^{88}Y (107-day half-life), this source should provide a much longer useful life than either a ^{88}Y source or the antimony-124 (^{124}Sb) (60-day half-life) source which has been used.

Phase reports, describing the various phases of this project, are in preparation. These reports will be open filed upon completion.

Research and Development Logging Vehicle

- Start Date: August 1977
- Completion Date: December 1978

Bendix personnel are developing a R&D logging vehicle to support the field testing of direct and indirect borehole uranium assay techniques. Particular emphasis will be placed on the prompt-fission neutron (PFN) method of direct assay and on the passive spectral gamma-ray method of indirect assay.

The vehicle fabrication is nearing completion at Energy Products, Ltd., Forth Worth, Tex. It will be instrumented by Bendix upon delivery to Grand Junction. Equipment will include a pulse-height analyzer, multichannel scalers, interface hardware for both digital and analog probe signals, and a minicomputer. The minicomputer will be used for both data acquisition and control and for data analysis using FORTRAN programs. Multitasking will permit data analysis to be carried on concurrently with data collection.

Bendix expects to receive two PFN probes from Sandia Laboratories, Albuquerque, during March 1978. A dual-crystal spectral gamma-ray probe is under construction by Bendix. Probes required for ancillary measurements, such as density and porosity, and non-nuclear probes, such as sonic velocity and magnetic susceptibility, are being purchased from industry sources.

A field testing and demonstration phase will begin about June 1978. Analysis routines and calibration procedures for both PFN and spectral gamma-ray logs will be developed and refined.

A final report will be written late in 1978.

Optical Data Transmission Evaluation

- Supplier: Optelecom, Inc.
- Purchase Value: $7,200
- Start Date: January 1977
- Completion Date: February 1978

A fiber-optic borehole logging cable should increase the data transmitting capabilities of logging systems many times over the industry-standard, four-conductor logging cable. The objective of this project is to develop a fiber-optic well logging cable to replace the standard four-conductor cable. The fiber-optic cable should have the same mechanical characteristics as the four-conductor cable.

A 1,000 ft prototype fiber-optic logging cable should be completed and a report submitted in early 1978. A subcontract to develop a production version, including transmitter and receiver hardware, for installation on an R&D logging vehicle will follow. Bendix personnel will evaluate the optical data transmission system for use in uranium exploration.

Solid State Photomultiplier Tube

- Subcontractor: Science Applications, Inc.
- Subcontract Value: $78,000
- Start Date: 10 September 1977
- Completion Date: 10 July 1978

The technology development logging vehicle nears completion at the Energy Products, Ltd., shop in Fort Worth, Tex. Its design includes a tool handling boom and mast in a central location with hydraulic controls below deck level.

Conventional spectral-scintillation-type uranium exploration systems are limited, to a large extent, by undesirable characteristics inherent in the photomultiplier tube. The principal undesirable characteristic is poor energy resolution, resulting from statistical variability in secondary-electron emission rates at the first few dynodes in the photomultiplier tube. Other important drawbacks in photomultipliers include sensitivity to voltage and temperature variation, relatively high power requirements (for field instruments), and fragility.

This project entails the construction and evaluation of a solid-state photomultiplier tube which should minimize system degradation through elimination, or reduction, of all of these unfavorable characteristics by capitalizing on the advantages inherent in solid-state devices. If the tube meets expectations, plans include evaluation of its advantages for all types of uranium scintillation exploration systems.

Open filings of the results from the initial phase of this project is expected in mid-1978.

Airborne Detector Improvement

- Subcontractor: Grumman Aerospace Corporation
- Subcontract Value: $253,492
- Start Date: 27 April 1976
- Completion Date: 17 November 1978

In the first phase of this project, Grumman Aerospace conducted experimental and theoretical comparisons between a large volume sodium iodide detector and a large volume collimated phoswich detector. The study indicated that airborne phoswich detector systems can provide approximately a factor-of-two increase in detection sensitivity for uranium when compared to existing sodium iodide systems. The report of this study, GJBX-40(77) was open filed in August 1977.

Based on the Phase I effort, Grumman Aerospace currently is evaluating possible phoswich detector systems and conducting a trade-off study on size, weight, sensitivity, and cost to determine which configuration is optimal for aerial radiometric surveys. Grumman will then design, fabricate, and test a prototype phoswich detector system. The testing will involve both laboratory and flight measurements.

A report on this project will be placed on open file in 1979.

Large Volume Ge Detector

- Subcontractor: Naval Research Laboratory (NRL)
- Subcontract Value: $15,000
- Start Date: March 1976
- Completion Date: February 1977

A high-resolution intrinsic germanium detector array was developed for aerial surveying of gamma-ray surface nuclear radiation.

The NRL, under an ERDA letter of agreement, conducted an aerial survey using a prototype array of 12 intrinsic germanium detectors, each having a volume of 36 ml, and in addition, used a 1 ft by 1 ft NaI(Tl) detector. Gamma-ray signals from potassium (^{40}K), uranium (actually ^{214}Bi), and thorium (^{208}Tl) were analyzed using both systems, at four flight altitudes (200, 400, 800, and 3,000 ft).
Data were collected over a previously flown 45-mile flight path near Richmond, Va. Interference from airborne radon daughter activities and the effect of air attenuation of the gamma-ray signals of interest are discussed for both systems in open-file report GJBX-38(77). The gamma-ray data from both systems are plotted at all altitudes and the advantages and disadvantages discussed. It was concluded from this study that high resolution germanium is not a cost effective replacement for the NaI(Tl) systems presently in use.

Development of a Flight-Path Recovery System

- Subcontractor: SysTech, Inc.
- Subcontract Value: $61,970
- Start Date: 26 August 1976
- Completion Date: March 1978

The purpose of this project is to specify and recommend a complete system for use by radiometric survey aircraft that:

1. Can locate the aircraft within the survey grid,
2. Inform the flight crew of the aircraft's position relative to the flight plan, and
3. Write the aircraft's position coordinates on the same record the radiometric data is being stored on for subsequent computer analysis.

The study by SysTech is complete but the report is long overdue. The prime contributor to the delay in the report is the difficulty in assembling a flight plan for the testing of such a system.

The work completed covers all components of the flight-path recovery system both in the aircraft and on the ground. The authors have examined in detail the equipment that is commercially available and military equipment that can be made commercially available. The complete report is expected in 1978.

Airborne Temperature Profiler

- Subcontractor: Science Applications, Inc.
- Subcontract Value: $16,788
- Start Date: 21 May 1976
- Completion Date: 7 January 1977

The main objective of this project was to determine, computationally, the feasibility of developing a downward-looking airborne temperature profiler. This effort entailed use of spectral radiance measurements to estimate the temperature profile of the atmosphere below an aircraft flying at a nominal radiometric survey ground clearance of 400 ft. Hopefully, these measurements would identify the temperature inversion conditions which lead to an unacceptably large background of gamma-rays originating from atmospheric radon.

In open-file report GJBX-1(77), "Remote Temperature Inversion Sensor," it was concluded that the uncertainties in the temperature profile resulting from expected measurement errors were too large to warrant further pursuit of this study. Alternative approaches were considered, e.g. spatial rather than spectral scanning, and determined not to be feasible.

Optical Detection of Atmospheric Radon

- Subcontractor: Naval Undersea Center
- Subcontract Value: $115,000
- Start Date: 1 June 1976
- Completion Date: 31 December 1977

This study was carried out to determine the applicability of active optical methods for the detection of ambient levels of atmospheric radon or its daughters. These measurements were made from a radiometric survey aircraft and used to remove this portion of background from the survey data.

Phase I was computational and showed that lead-210 (^{210}Pb) would be the "target specie" of choice for a system designed to measure the concentration of airborne decay products of radon-222.

Phase II was designed to empirically test the validity of the assumptions made and the calculations performed in Phase I. This laboratory study showed that the 2170A–2614A scattering channel in lead would have extremely high sensitivity, but it would fall short of the projected operational requirements by almost two orders of magnitude. Further, a large technological investment would be required to make the system even marginally operational. The conclusion, as expressed in a report to be open filed in 1978, is that such a remote detection system would not be feasible in the sensing of radon-222 background daughter products.

Optical Detection of Uranium

- Subcontractor: Radiation Research Associates
- Subcontract Value: $17,188
- Start Date: 19 January 1977
- Completion Date: 13 September 1977

The objective of this project was to determine, computationally, the feasibility of locating uranium resources using an airborne optical system that measures the air-fluorescent signal produced by gamma-ray energy deposition into the lower atmosphere. Seven fluorescence wavelengths between 0.3 and 0.9 microns were considered, but scattering was neglected. It is concluded that state-of-the-art photodetectors and the naturally occurring background of optical radiation preclude any serious consideration as to implementation of such a detection scheme.

This work is presented in open-file report GJBX-73(77) "Studies on Airborne Optical Detection of Uranium Ore."

Numerical Modeling of the Subsurface Distribution of Gaseous Uranium Decay Products

- Subcontractor: Teledyne Isotopes
- Subcontract Value: $89,046
- Start Date: 29 September 1976
- Completion Date: 30 November 1978

In the first phase of this project, Teledyne Isotopes developed several one-dimensional mathematical models to simulate the distribution of radionuclides in soil overlying uranium ore deposits. The migration of gaseous products away from the ore was simulated by mechanisms of molecular diffusion, advective transport, and barometric pumping. A steady-state diffusion model predicts the detectability of radon-222 (^{222}Rn) several tens of feet from a uranium deposit, while xenon-133 is detectable at half this range. The influence of barometric variations on the migration of ^{222}Rn was found to be ±15 percent at the near surface. The report of this effort, GJBX–67(77), was open filed in November 1977.

In order that the transport model for gaseous uranium decay products in the earth may be more realistic, a number of the simplifying assumptions used in the first phase will be removed in the second phase. The model will include a distributed source of uranium above the ore body and stratigraphic inhomogeneity. The generation of helium-4 by the three natural radioactive decay series will also be included in the model.

A report on this project will be placed on open file late in 1978.

Radon Emanation Studies

- Subcontractor: General Electric Company
- Subcontract Value: $159,940
- Start Date: 1 April 1977
- Completion Date: 30 September 1978

A prime candidate as an indicator of subsurface uranium is the noble gas radon-222 (^{222}Rn), the sole distinctive gaseous daughter nuclide of ^{238}U.

A commercially available radon-in-water measurement system is being evaluated by a Bendix geophysics technician in southwestern Wyoming.

Before the radon levels present just below the surface of the earth can be reliably used in exploration, they must be understood; that is, the components must be separated so that the erratic or irrelevant portions of the signal can be eliminated. Two categories of signals are to be separated. First, there are radon isotopes that result from both uranium and thorium. Separation of the ^{220}Rn, which derives from thorium, would provide an immediate simplification when uranium is the target. The second separation that is required is that of local versus distant signals. There will always be radon emanating from the material immediately around the hole used for a measurement. It is the signal from a distant source, which may only be present at specific places and certain times, that is of special interest. If both the thorium-related signals and the local signals can be eliminated or identified, the residual long-range, uranium-related signal would be easily identified when present, and could, therefore, be used and studied.

By eliminating these interferring signals, General Electric will determine whether long-range transport of radon through the earth does occur. This work will be performed at a site of known uranium mineralization. The results of the study will be related to the transport mechanisms of the radon.

A report on this project will be placed on open file early in 1979.

Helium Surveying

- Subcontractor: Helium Surveys, Inc.
- Subcontract Value: $80,010
- Start Date: August 1977
- Completion Date: 6 May 1978

A primary goal of the DOE–BFEC/GJO program is to determine whether a correlation exists between surface gross helium measurements and subsurface uranium ore bodies. As part of this project, gross helium surveys have been performed over three areas of known uranium mineralization. Sampling will be repeated over one area during the winter months (January–February 1978) to determine the seasonal effects on helium surveys.

The helium contents in soil, soil gas, and water samples, as well as integrated helium in soil gas, accumulated over several days, have been measured. All samples were collected as a grid pattern at each test site.

Preliminary processing, geologic correlation, and evaluation of the data from the three test sites was completed in December 1977 and the results are encouraging.

Results of this project will be placed on open file during mid-1978.

Helium-4/Argon-36 Ratio

- Subcontractor: Teledyne Isotopes
- Subcontract Value: $163,983
- Start Date: 1 April 1976
- Completion Date: June 1978

Alpha particles are among the many radioactive decay products of uranium and attract free electrons to produce ^{4}He nuclei. Radon gas (^{222}Rn) also decays in the uranium chain via alpha emission. Presumably, these gases created by a uranium ore body migrate to the surface where they can be detected. Therefore, the development of a methodology for measuring the helium and radon, combined with a knowledge of favorable geologic characteristics, will aid in locating subsurface uranium ore bodies. The primordial gas argon (^{36}Ar) is assumed to be stable in abundance throughout the earth. Thus, ^{36}Ar should reflect the local variations in soil gas movement and the ratio $^{4}He/^{36}Ar$ should not be sensitive to meteorological conditions or changes.

In the initial phase of this work, which ended in January 1977, Teledyne Isotopes collected soil gas samples from boreholes over two known uranium deposits located in the Red Desert and the Powder River Basin of Wyoming. The gas samples were analyzed for $^{4}He/^{36}Ar$ ratios which were compared to ^{222}Rn gas concentrations collected in the same location. Gas sampling techniques and instrumentation used in the analysis are described and discussed in a report to be open filed in 1978.

The results of this phase suggest that the sensitivity and stability of the mass spectrometer used for the $^{4}He/^{36}Ar$ needed to be improved to reduce analytical error. Attempts to relate the analyzed $^{4}He/^{36}Ar$ and ^{222}Rn data to the subsurface ore bodies were inconclusive; however, several of the high radon values at the Red Desert test site would have led to the ore body. Meteorological parameters did not show any apparent relation to the ^{222}Rn content of soil gas.

The second phase, initiated in August 1977, includes sampling three different areas of known uranium mineralization, one of which is a repeat of an area in Phase I. Soil and soil gas samples have been collected at two sites on a grid pattern. The third site became inexcessible due to bad weather and will be completed in May 1978.

The $^{4}He/^{36}Ar$ ratio and radon gas will be measured at each grid point and also in 12 drill holes ranging in depth from 100 to 600 ft to determine variabililty with depth. Measurements of all the ^{222}Rn from two sites were completed in December 1977.

An improved mass spectrometer, devoted only to the $^{4}He/^{36}Ar$ measurements, should achieve a measurement precision of ± 1 percent (a factor of 10 better than Phase I). The soil samples will also be analyzed for leachable ^{226}Ra, total ^{210}Pb and leachable ^{210}Pb, and emanation factor (total rate of ^{222}Rn emanation from unleached and leached soil). These measurements will be completed early in 1978.

The results of this project will be placed on open file during mid-1978.

Helium-4/Helium-3 Ratios

- Subcontractor: Martin Marietta
- Subcontract Value: $61,941
- Start Date: 1 April 1976
- Completion Date: September 1977

As part of a cooperative program involving Westinghouse Corporation, Colorado School of Mines Research Foundation, Electric Power Research Institute, and DOE, Martin Marietta conducted a program to develop a technique for detecting the ^{4}He isotope for evaluation as a signature of uranium deposits. The technique involved comparison of ^{4}He to ^{3}He, and evaluation of the sensitivity and reliability of this ratio as a uranium indicator. Radon (^{222}Rn) data were also collected using a Martin Marietta developed solid-state detector.

The comparative sampling scheme required several traverses of portions of the Powder River Basin in Wyoming, taking soil and air samples at pre-selected intervals, and finally a regional traverse from Douglas, Wyo., to the Montana border. Samples were sent to Martin Marietta's Denver facility for processing and subsequent computer analysis of the chemical and field data.

Results of the investigation show that diurnal effects do not influence the ratio data but are observable in the gross helium data. The in situ gross helium values analyzed by a truck-mounted mass spectrometer do correlate slightly to subsurface mineralization; however, the helium ratio data do not.

The radon data from the solid-state detectors were correlated to ^{214}Bi soil analysis and track-etch data and suggested that the radon alpha counts were primarily due to concentrations of uranium in the surface soil.

This report, GJBX-58(77), was open filed October 1977.

Geochemical Reconnaissance for Uranium in NE Pennsylvania

- Subcontractor: Pennsylvania State University
- Subcontract Value: $74,000
- Start Date: 1 June 1976
- Completion Date: 30 December 1977

Under direct contract with DOE, Pennsylvania State University is continuing work started in 1974 which involves: (1) a detailed geochemical study of the Penn Haven Junction area; (2) a radon survey of the Jim Thorpe area; and (3) a study of methods of ground-water uranium surveys. Two reports were open filed: GJBX-59(77) and GJBX-60(77).

Ruggedized Radon Emanometer

- Subcontractor: Tom Scurry Associates
- Subcontract Value: $3,816
- Start Date: 1 December 1977
- Completion Date: 31 March 1978

A prototype ruggedized radon emanometer is being provided for use in NURE emanometry and geological survey programs. After a satisfactory evaluation of the prototype instrument, additional units will be procured and distributed to Bendix and DOE personnel for field use.

A Tom Scurry Associates commercial instrument is being modified to include the characteristics of a feasibility model which had been developed by Bendix personnel in 1976 and used by Penn State University in 1977 to measure radon in streams and ground waters in Pennsylvania.

A report on this project will be published in 1978.

Radon Calibration Unit and Instrument Evaluation

- Subcontractor: Martin Marietta Corporation and Bendix in-house.
- Subcontract Value: $160,816
- Start Date: 28 February 1977
- Completion Date: 31 May 1978

The detection of gaseous emanations characteristic of radioactive deposits shows definite promise of becoming a widespread, economical approach to the exploration of subsurface uranium deposits. One of the detectable signatures of the uranium decay series is gaseous radon-222 (^{222}Rn) produced from the decay of radium-226 (^{226}Ra).

As more radon detection instruments become available, the need for analyzing their integrity and accuracy will become increasingly important. A standard automated laboratory calibration capability will be essential for evaluating instrument performance and sensitivity. Martin Marietta is designing and fabricating such a laboratory unit for calibrating, in absolute terms, a variety of radon detection instruments.

Delivery of the unit is expected in mid-1978; at that time, a report will be placed on open file.

After calibration of individual instruments Bendix will continue testing them both in the laboratory and the field; their ease of operation and performance will be evaluated over long-term usage. To correlate meterological effects on the radon data, we will monitor barometric pressure, air and soil temperature, wind velocity and direction, rainfall, and soil moisture.

Reports on these evaluations will be placed on open file as they are completed.

High Resolution Seismic Reflection

- Subcontractor: Boise State University
- Subcontract Value: $78,218
- Start Date: 12 August 1977
- Completion Date: 15 April 1978

Geophysical techniques applied to uranium exploration have primarily been borehole oriented, with only occasional use of surface, non-nuclear techniques. As exploration progresses to greater depths, however, the latter will undoubtly be more seriously considered in an effort to reduce drilling costs. The high resolution seismic reflection technique appears to be applicable to the exploration for uranium deposits which are controlled by geologic structure and paleotopographical surfaces. Extensive evaluation of the technique can be made either by performing experimental surveys at a large number of sites representing different geological environments or by modeling studies at these sites, using synthetic seismograms computed from sonic and density logs. If feasible, the latter method of evaluation will be more cost effective. The purpose of this initial work is to determine and demonstrate this feasibility through use of sonic and density logs and acquisition of multifold seismic reflection data.

In late 1977 Boise State, in collaboration with Geophysical Services, Inc., collected vibrator and dynamite data in the Gas Hills uranium district of central Wyoming. Numerous source and receiver configurations were used to determine the technique that would best delineate the pre-Tertiary unconformity and uranium-favorable sand channels

The high-frequency vibrator truck of Geophysical Services, Inc., is gathering seismic reflection data in the Gas Hills uranium district, central Wyoming.

within the Tertiary section. A total of five boreholes along the 2-mile seismic line were logged for density and sonic velocity. These data were used to generate synthetic seismic traces for comparison with the surface seismic data.

Preliminary interpretation of all available data indicates that: 1) targets of interest are well defined on the seismic sections, and 2) synthetic seismic traces acquired prior to any seismic reflection survey would have predicted the success of such a survey.

A detailed presentation of this work will be placed on open file in the spring of 1978.

Ground Truth for Remote Sensing

- Subcontractor: Jet Propulsion Laboratory
- Subcontract Value: $103,475
- Start Date: 1 April 1977
- Completion Date: 15 March 1978

Recently, attempts have been made to delineate uranium-associated alteration zones on the basis of spectral characteristics using LANDSAT multispectral data. These studies have shown that alteration zones can be recognized based on the spectral characteristics of iron-oxide minerals; however, red-beds, altered material associated with fault zones, and several other surface materials cannot be unambiguously separated from uranium-associated alteration. To resolve this ambiguity, it is necessary to quantitatively relate spectral properties with the mineralogy. Then, it should be possible to determine the optimal wavelength regions and the computer processing techniques required for separating uranium-associated alteration from other materials, using remote sensing data.

The objective of this project is to determine if known uranium-associated alteration zones in sandstone areas possess unique properties, which can be determined with Jet Propulsion Laboratory's portable field reflectance and spectrometer; and then to determine the specific reasons for this uniqueness by examination of the mineralogy and geochemistry of altered and unaltered materials. This knowledge will be used to indicate how aircraft and satellite multispectral imagery can best be used for detection of uranium deposits.

Results of this work (as of December 1977) show that, for sites on the San Rafael Swell, nearly unambiguous separation of uranium-associated alteration from other altered and unaltered rocks is possible using wavelengths in the spectral region from 1 to 2.4 microns. Analysis using only the LANDSAT 1 and 2 bands yields relatively poor separation, while the LANDSAT D Thematic Mapper bands, with a 2.2 micron band, provide surprisingly good separation.

Mineralogical and geochemical analyses are nearly complete, and interpretation of all data will be presented in an open-file report upon completion of the project.

Exploration Systems

The Exploration Systems portion of our program currently has three major objectives: 1) establish integrated approaches, using state-of-the-art and developing technologies for uranium exploration in specific geologic environments, 2) characterize types of uranium occurrences by suites of physiochemical measurements, and 3) develop genetic models for these occurrences.

Achievement of the objectives will aid the exploration for new uranium deposits and the NURE resource assessment activities. To this end, deposits representative of both traditional and "frontier" types will be investigated using conventional and developmental (see the Exploration Techniques section) techniques. Bendix personnel will integrate these data sets for each site studied, and address the main objectives via open-file reports.

Field work in 1977 was concentrated on one test site in Wyoming where aerial geophysical surveys, consisting of radiometrics and magnetics, and ground surveys, consisting of VLF-EM and magnetics, were acquired. An aerial geochemical survey in this area is discussed below.

Aerial Geochem Survey Evaluation

- Subcontractor: Barringer Research, Inc.
- Subcontract Value: $168,635
- Start Date: 7 September 1977
- Completion Date: 1 March 1978

A program was initiated in mid-1977 to evaluate aerial geochemical sampling techniques as rapid, cost effective alternatives to gamma-spectrometry for the detection of uranium mineralization. Two proprietary systems, both based on geochemical phenomena occurring in the surface micro-layer of soil and vegetation, were helicopter mounted for the systematic collection and multielement analysis of airborne and surface particulate matter from a test area in central Wyoming. The geochem systems were supported by concurrently acquired magnetic and gamma-spectrometric data.

The project will result in an assessment of:

1. Direct uranium detection using fission track analysis;
2. Geochemical sampling from an aerial platform, particularly in areas of difficult terrain;

as well as evaluation of:

3. Micro-layer and multielement analysis techniques in the search for uranium deposits; and
4. Benefits and cost effectiveness resulting from rapid aerial geochemical reconnaissance.

It is anticipated that the evaluation will be complete by early April, with an open-file report to follow.

Pattern Recognition Applied to Uranium Prospecting

- Subcontractor: Massachusetts Institute of Technology and Bendix In-House
- Subcontract Value: $100,000
- Start Date: September 1976
- Completion Date: August 1978

In exploration for minerals and hydrocarbons, prospecting targets are commonly selected on the basis of a geologist's subjective interpretation of a combination of diverse geological data. This work investigates the possibility of automating and standardizing this interpretation task. Four pattern recognition algorithms that provide quantitative, reproducible means of coding, organizing, and interpreting geological data have been used to make exploration decisions. Although data collection is still a fundamental, somewhat subjective input, the remainder of a combined interpretation problem is handled in an automated, algorithmic method.

Reconnaissance level data are used to estimate favorability for sandstone-type uranium deposits on the Colorado Plateau and in the Casper quadrangle of central Wyoming. Pattern recognition procedures are used to identify geological features that mark areas favorable for ore. They provide a logical framework for organizing these features for the recognition of areas favorable for uranium ore occurrence. Automated data evaluations have produced geologically reasonable predictions of new exploration targets.

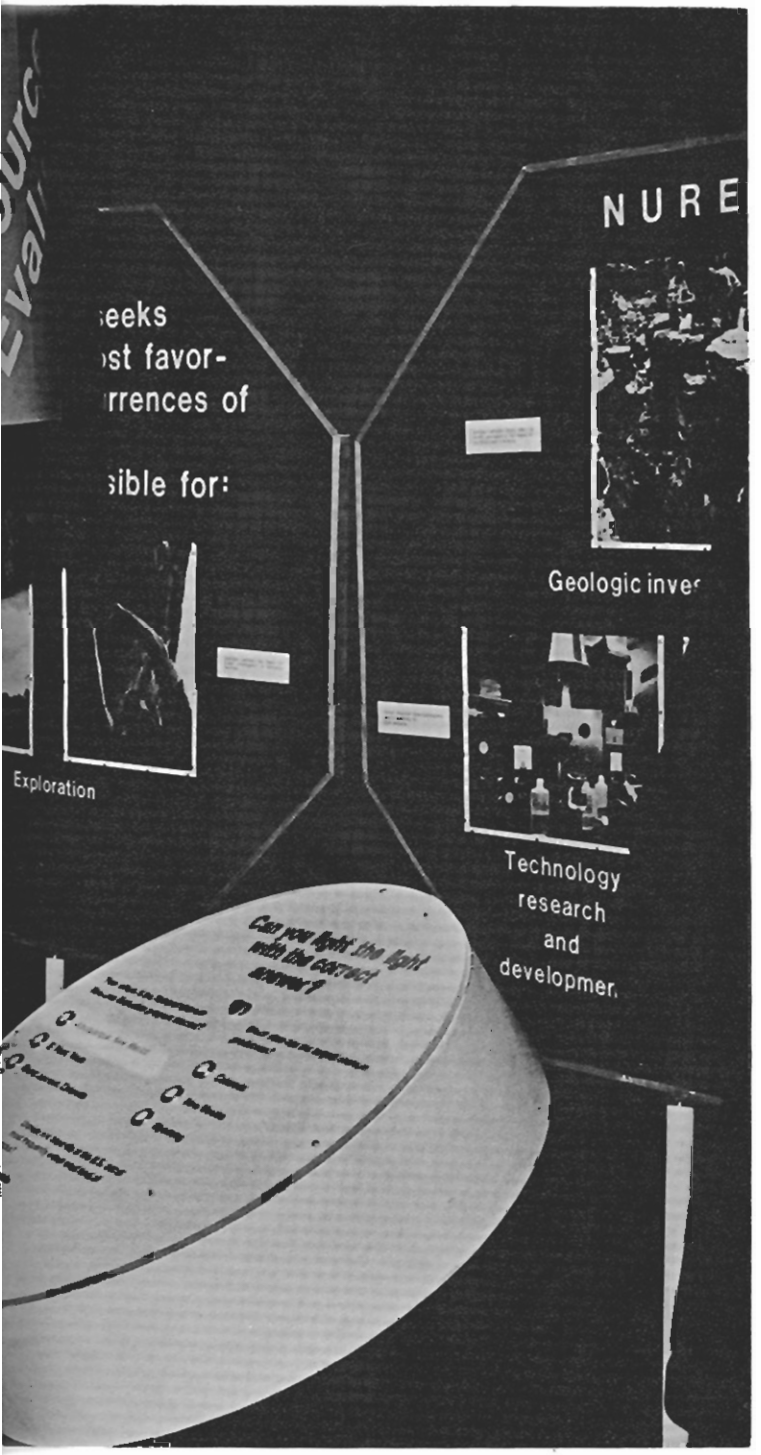
Variations in the performance of the four algorithms suggest guides to the use of these and other pattern recognition procedures in geological problems. Control experiments test the predictive potential of these techniques and verify the stability of pattern recognition analyses.

Pattern recognition techniques may be useful in a variety of exploration problems where large amounts of diverse data must be winnowed, integrated, and interpreted for decision making.

This work is discussed by Dr. Peter Briggs in his February 1978 Ph. D. thesis from the MIT Department of Earth and Planetary Sciences. Further professional publications will be forthcoming in 1978.

NURE Information Dissemination

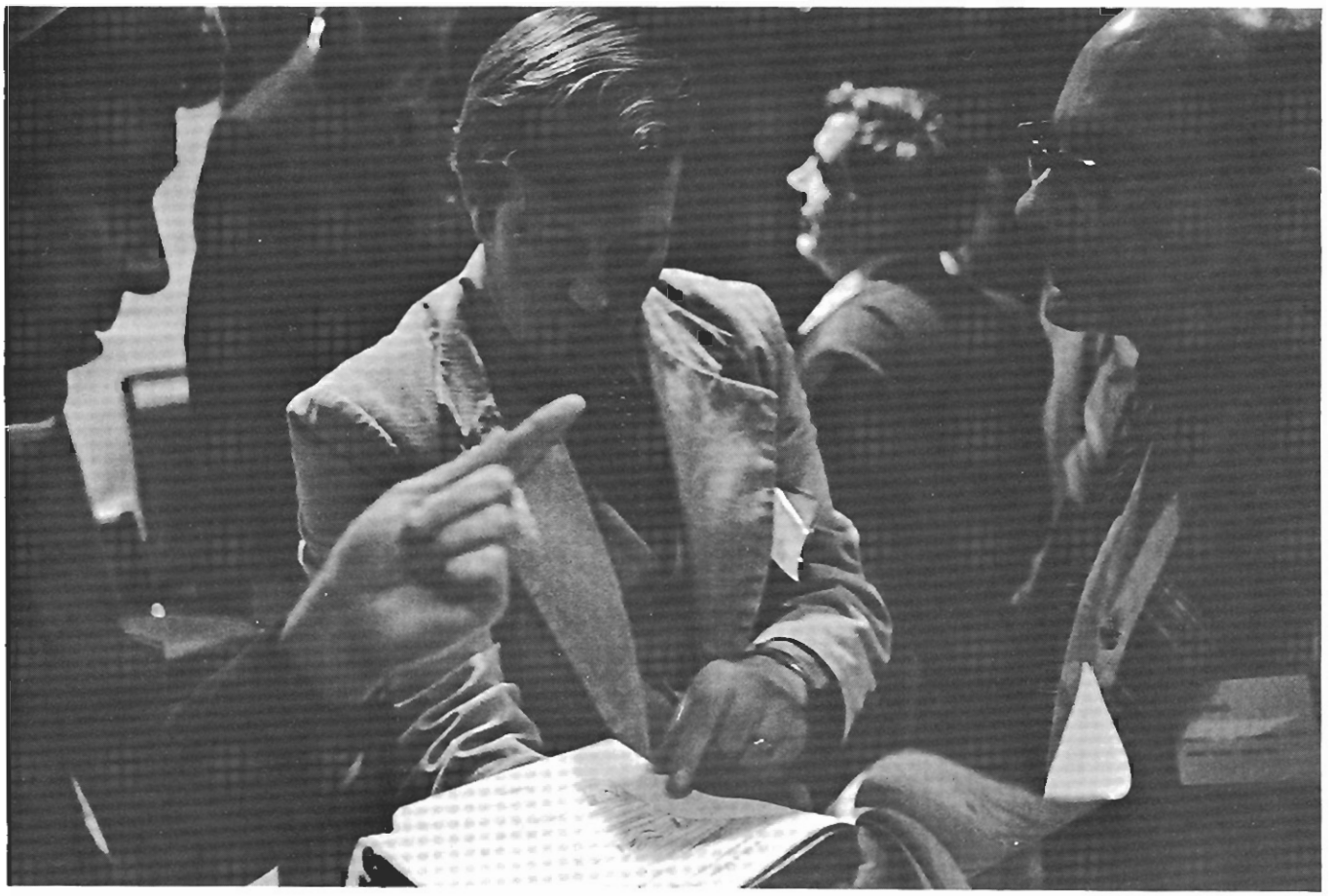
A modular graphic display, designed by Bendix personnel, has been on display at many energy seminars in the Grand Junction area as well as at museums and libraries. The "lollipop"-like display features ore samples, graphics and pictures, and a quiz machine.



Cataloging and shelving the many technical reports and reference materials in the Bendix library at GJO is a never-ending job for the library staff. In addition, the library is the distribution center for all technical reports generated at GJO.

Results of NURE-oriented activities described in previous sections are made public as soon as they become available, primarily through the publication of open-filed technical reports. Other methods of NURE information dissemination include attendance at and sponsorship of technical meetings, demonstrations of new hardware, the annual release of updated statistical data of the uranium industry, and the development of the NURE data bank.

Activities during 1977 included presentations at technical meetings, sponsorship with DOE of two technical symposia to describe NURE activities within specific uranium-related technological areas, assistance to DOE in hosting the annual Uranium Industry Seminar, open filing and distribution of 167 NURE-related reports, issuance of 136 news releases, participation in community functions, and conducting tours of the Grand Junction facility.



Spontaneous small-group discussions of symposium papers are a valuable part of any technical meeting, facilitaing the direct interchange of ideas.

Technical Meetings

Face-to-face dissemination of information is accomplished through participation by DOE and Bendix Field Engineering Corporation personnel in technical discussions both at meetings in Grand Junction and at meetings of national and international professional societies and at specialized symposia and workshops. Such participation by technical personnel not only reduces the lead time associated with the publication of printed material, but also provides the opportunity for an exchange of ideas between industry, other government agencies, and DOE/BFEC representatives concerning key technical issues in areas of specific interest to NURE.

The following is a listing of those presentations on NURE program topics made by Bendix personnel during 1977 at meetings not sponsored by DOE or Bendix at GJO.

Kosanke, K., "Technology Development to Improve the Quality of Airborne Radiometric Data." **At** Radiation Measurement in the Environment, American Nuclear Society, Las Vegas, Nevada, March 7–11, 1977.

Dribus, J., "Petrology and Pertofabric Analysis of the Deposits at Number 9 Dunite, Macon County, North Carolina." **At** Southeastern U.S. Geological Society of America (GSA), Winston-Salem, North Carolina, March 25, 1977.

Kosanke, K., "Development of Geophysical Techniques for Uranium Assessment." **At** American Association of Petroleum Geologists (AAPG), Washington, D.C., June 12–16, 1977.

Kosanke, K., "Fields of View of Airborne Gamma-Ray Spectrometers." **At** Society of Exploration Geophysicists (SEG) Symposium, Calgary, Canada, September 18–22, 1977.

Moore, D., "Interpretation of Neutron Fission Logging Tools in the Evaluation of Uranium." **At** Rocky Mountain West Chapter of Society of Professional Well Log Analysts, Grand Junction, Colorado, October 5, 1977.

Stromswold, D., "Calibration of Radiation Monitors Including Error Analysis." **At** Institute of Electrical and Electronics Engineers (IEEE), Nuclear Science Symposium, San Francisco, California, October 19–21, 1977.

Kosanke, K., "Results from an Aerial Radiometric Data Modeling Program." **At** IEEE Nuclear Science Symposium, San Francisco, California, October 19–21, 1977.

Pacer, J., "Relevance of Gases in Uranium Exploration." **At** International Atomic Energy Agency (IAEA) Workshop, Ottawa, Canada, October 24–26, 1977.

Jones, L., "Slice Technique Applied to Uranium Favorability in Uppermost Tertiary Strata of East Texas and Western Louisiana." **At** Gulf Coast Association of Geological Societies, Austin, Texas, October 26–28, 1977.

Stanton, G., "Secondary Porosity in Sandstones of the Lower Wilcox (Eocene), Karnes County, Texas." **At** Gulf Coast Association of Geological Societies, Austin, Texas, October 26–28, 1977.

Wopat, M., "Favorability for Uranium in Tertiary Sedimentary Rocks, Southwestern Montana." **At** Symposium—Uranium Exploration in Pacific Northwest, Cheney, Washington, November 14, 1977.

Castor, S., "Uranium Potential of Igneous Intrusive Rocks of Northeastern Washington." **At** Symposium—Uranium Exploration in Pacific Northwest, Cheney, Washington, November 14, 1977.

Kosanke, K., "A Review of Current Practices and Suggested R&D Areas in the Measurement of Natural Gamma Radiation in Uranium Exploration." **At** IAEA Workshop on the "Measurement of Natural Gamma Radiation in U Exploration," Harwell, United Kingdom, November 21–24, 1977.

Price, T. "Grand Junction, Colorado, DOE Solar Demonstration Project." **At** Solar Heating and Cooling Program Contractor's Review, New Orleans, Louisiana, December 5–7, 1977.

The HSSR symposium had a display of equipment available for attendees during breaks in the large-group sessions.

Symposium on Hydrogeochemical and Stream-Sediment Reconnaissance For Uranium in the United States

March 16–17, 1977

In March, Bendix conducted the DOE-sponsored symposium on Hydrogeochemical and Stream-Sediment Reconnaissance (HSSR) for uranium in the United States. Speakers from the DOE national laboratories that are engaged in the HSSR program covered the progress to date in the areas of sample collection methods, analytical methods, statistical procedures, and surveys completed. Speakers invited from the U.S. Geological Survey and the Geological Survey of Canada covered hydrogeochemistry programs carried out by their respective organizations. Professor Rose of Pennsylvania State University gave an introductory talk on geochemical exploration for uranium. This two-day technical meeting attracted approximately 530 attendees. The papers given at the symposium were published in report GJBX-77(77) which was open filed in October. The agenda follows:

Geochemical Exploration for Uranium ..... A. W. Rose, Jr. (Penn State)

The HSSR Program and its Relation to the NURE Effort ..... S. S. Shannon, Jr. (DOE–GJO)

Collection and Preparation of Wet and Dry Stream-Sediment Samples..... K. Puchlik (LLL)

Collection and Preparation of Water Samples for Hydrogeochemical Reconnaissance..... E. Baucom (SRL)

Ground Water Sampling in Uranium Reconnaissance ..... T. R. Butz (ORGDP)

Description of Quality Assurance in the HSSR Program and Summary of Analytical Methods Used..... T. L. Steinborn (LLL)

Neutron Activation Analysis for Uranium and Associated Elements .. W. W. Bowman (SRL)

The Oak Ridge Analytical Program..... G. Cagle (ORGDP)

Fluorometric Analysis for Uranium ..... G. Waterbury (LASL)

Computerized Data Treatment Technology..... R. R. Ferguson (SRL)

Geostatistics ..... V. E. Kane (ORGDP)

Data Verification Procedures .. V. E. Kane (ORGDP)

Sample Density Investigations in Lake-Sediment Geochemical Surveys of Canada's Uranium Reconnaissance Program ..... R. G. Garrett (GS of Canada)

The Effectiveness of Stream-Sediment Sampling Along the Rio Ojo Caliente, New Mexico..... K. J. Wenrich-Verbeek (USGS)

Helium Analyses of Subsurface Waters as a Uranium Exploration Guide .. R. Rice (USGS)

Results of a Uranium Hydrogeochemical and Stream-Sediment Reconnaissance in the San Juan Mountains, Southwest Colorado ..... J. C. Maxwell (LASL)

Uranium Stream-Sediment and Hydrogeochemical Pilot Survey of Estancia Valley, New Mexico .... C. Olsen (LASL)

Geochemical Interpretation of Kings Mountain, North Carolina Orientation Area..... V. Price (SRL)

Geochemical Reconnaissance for Uranium in the Arid Regions of the Western United States ..... D. Leach (LLL)

Operating Summary of SRL's HSSR Program ..... E. Baucom (SRL)

The Oak Ridge Geochemical Reconnaissance Program . J. W. Arendt (ORGDP)

Uranium Geochemical Survey of the Crystal City-Beeville Quadrangles Texas..... T. R. Butz (ORGDP)

The LASL Approach to Geochemical Reconnaissance..... R. R. Sharp, Jr. (LASL)

The HSSR Program at LLL..... J. F. Tinney (LLL)

Uranium Industry Seminar

October 26–27, 1977

DOE's 1977 Uranium Industry Seminar, held at Grand Junction in October, was attended by 740 people. During the seminar, DOE staff members from the Grand Junction Office and DOE Headquarters, Washington, D.C., presented papers on the current and probable future status of uranium resources and the uranium industry both in the United States and in foreign countries. Topics discussed included enrichment, markets, NURE, resources, exploration, and supply. In addition,

Question-and-answer sessions at the Uranium Industry Seminar were handled in a panel discussion, with the speakers from each half-day session available for questioning at one time.

Leland C. Rouse of the National Regulatory Commission gave an overview of the mill licensing activities.

The proceedings of the seminar have been published as GJO-108(77) which was open filed in February 1978. The agenda follows:

Uranium Enrichment Policies ..... J. L. Schwennesen (DOE–HQ)

Uranium Enrichment Plans ..... R. W. Gagne & D. C. Thomas (DOE–HQ)

Uranium Market Developments ..... J. A. Patterson & G. F. Combs, Jr. (DOE–HQ)

Domestic Uranium Requirements ..... R. W. Bown & R. H. Williamson (DOE–HQ)

Status and Progress of the NURE Program ..... D. L. Everhart (DOE–GJO)

NURE Data Collection and Evaluation Strategies ..... R. C. Horton (Bendix)

USGS Uranium and Thorium Resource Assessment and Exploration Research Program, Fiscal Year 1978 ..... T. W. Offield (USGS)

Ore Reserves ..... R. J. Meehan (DOE–GJO)

Potential Resources ..... D. L. Hetland & W. D. Grundy (DOE–GJO)

Exploration Activities ..... W. L. Chenoweth (DOE–GJO)

Uranium Production Trends ..... J. F. Facer, Jr. (DOE–GJO)

Uranium Processing Developments ..... J. Q. Jones (DOE–GJO)

Production Capability and Supply ..... J. Klemenic & D. Blanchfield (DOE–GJO)

Overview of NRC Mill Licensing Activities ..... J. B. Martin (NRC) (presented by L.C. Rouse)

Foreign Uranium Developments ..... R. J. Wright (DOE–HQ)

1977 NURE Uranium Geology Symposium

December 7 – 8, 1977

In December, Bendix conducted a DOE-sponsored symposium on NURE and uranium-related geological activities. Speakers from DOE, Bendix, NURE subcontractors, and USGS covered topics on remote sensing, uranium in sedimentary, igneous, and metamorphic host rocks and other geologic environments favorable for uranium resources. This two-day technical meeting was attended by approximately 800 people. The abstracts and visuals of the papers given at the symposium were published in report GJBX-12(78) which was open filed in February 1978. The agenda follows:

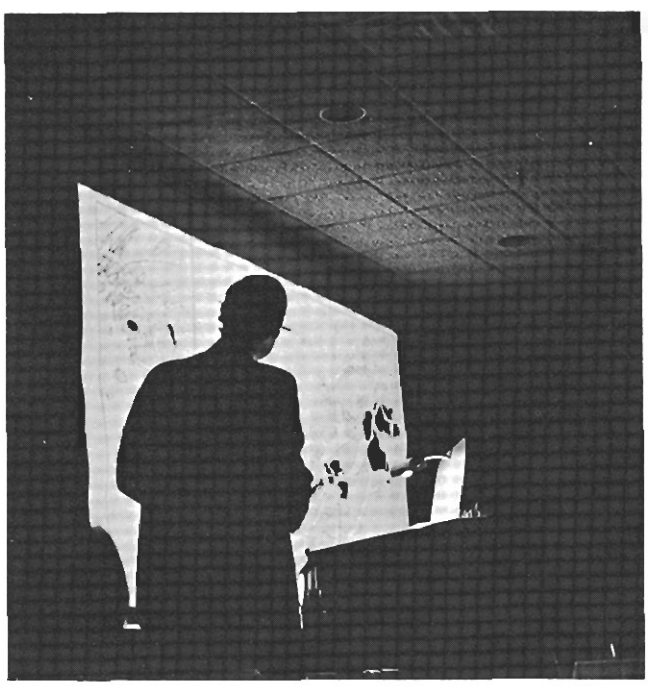
Geology and the National Uranium Resource Evaluation Program ..... D. L. Everhart (DOE–GJO)

Symposium Scope and Objectives ..... S. D. Mitchell (Bendix)

A Classification of Uranium Deposits in and Related to Plutonic Igneous Rocks ..... G. W. Mathews (Bendix)

A Classification of Uranium Deposits in Sedimentary Host Rocks.. C. A. Jones (Bendix)

The speakers for the Uranium Geology Symposium came with many slides to illustrate their presentations.



Trends in Remote Sensing Data Processing for Geological Purposes ..... E. M. Zaitzeff & J. B. McKeon (Bendix)

LANDSAT Data Analysis of Some Known Uranium Areas .... C. L. Kober (DEMEX)

Video Image Processing for Uranium Resource Assessment..... R. W. Marrs (U. Wyo.)

Optimum Multispectral Scanner ..... A. F. H. Goetz, J. E. Conel, & M. J. Abrams (JPL)

Geological Applications of Remote Sensing from Space..... F. B. Henderson III (Geosat. Comm.)

An Overview of Uranium in Sedimentary Rocks..... R. G. Young (Bendix)

Geochemical Genesis of Uranium in the Southern San Juan Basin.. D. G. Brookins (U. New Mexico)

Calcretes and their Uranium Potential in the Southwestern United States ..... D. Carlisle (UCLA)

Sedimentologic and Structural Controls of Uranium Deposits in the Tertiary Basins of Wyoming..... D. A. Seeland (USGS)

Criteria for Uranium Deposition in the Date Creek Basin and Adjacent Areas, West-Central Arizona.. J. K. Otton (USGS)

Uranium In Devonian Shales... L. P. Fulton (Exxon)

A Synthesis of Uranium-Related Studies in the Precambrian Rocks of the Granite Mountains, Wyoming ..... J. S. Stuckless (USGS)

Criteria for Pocos de Caldas-Type Uranium in the United States ..... M. McNeil (Bendix)

Criteria for Ilimaussaq-Type Uranium in the United States ..... H. Wollenberg (LBL)

Uranium and the Diagenesis of Volcanic Sediments ..... P. C. Goodell (UTEP)

Uranium Potential of the Challis Volcanics of the Stanley Basin, Idaho ..... P. K. Siems (U. Idaho)

Uranium-Rich Pegmatite Dikes in Wichita Mountains, Oklahoma ..... Z. Al-Shaieb (Okla. State U.)

The geology symposium in December attracted the largest crowd this year, with over 800 in attendance.

Uranium and Thorium Content of Intrusive Rocks in Northeastern Washington and Northern Idaho .... S. B. Castor, M. A. Berry, & J. W. Robins (Bendix)

Uranium Potential of the Crystalline Rock Areas of the Southeastern United States... P. C. Ragland (U. North Carolina)

An Overview of Uranium in Metamorphic Rocks..... W. L. Chenoweth (DOE–GJO)

Criteria for Alligator River-Type Uranium Deposits in the United States ..... R. W. Ojakangas (U. Minn.)

Criteria for Northern Saskatchewan-Type Uranium Deposits in the United States ..... F. F. Langford (U. Saskatchewan)

Uranium Indications in the Precambrian Rocks of Southern Wyoming ..... R. Houston, K. E. Karlstrom,& P. J. Graff (U. Wyo.)

The Unconformity-Type Proterozoic Pitchblende Ore Body Model and Its Application to Northern Michigan ..... J. Kalliokoski (Mich. Tech.)

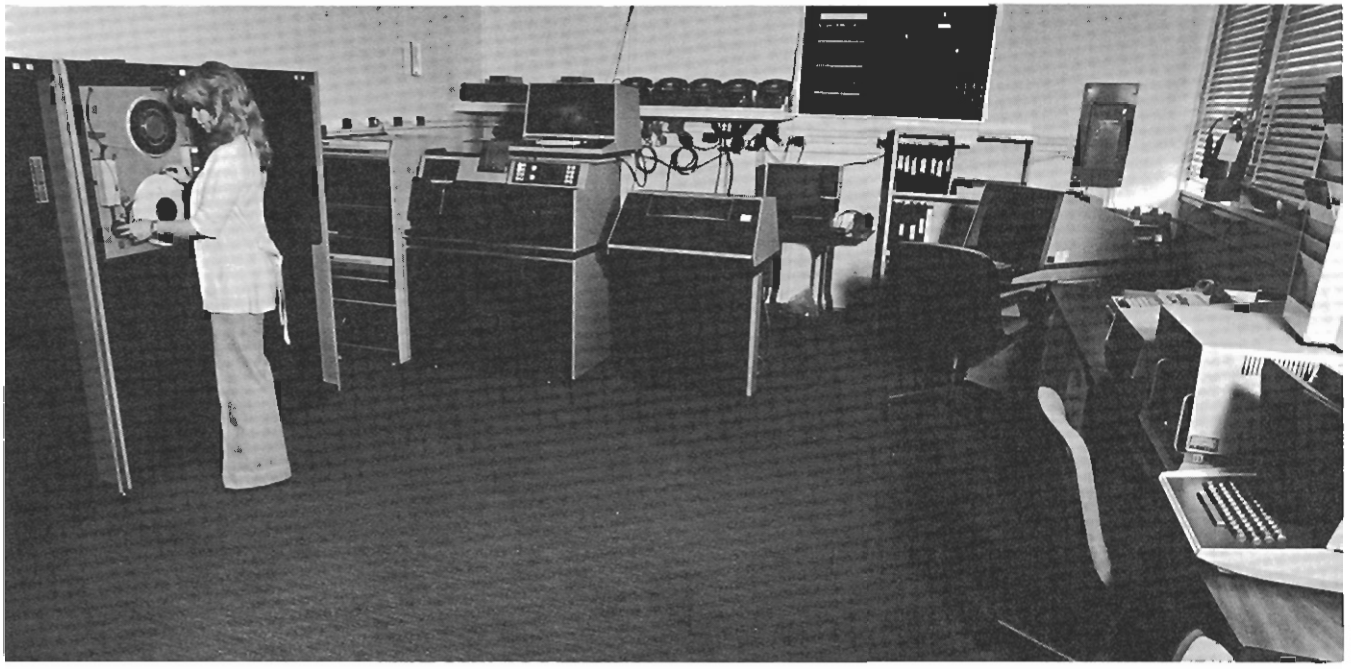
Uranium in the Precambrian Conglomerates of the Black Hills, South Dakota ..... F. A. Hills (USGS)

Computerized Information

DOE's Grand Junction Office has entered into a contractual agreement through the Oak Ridge Operations office to establish supplemental computer support for the NURE program. Support includes the establishment of a data bank of technical information, execution of resource calculations and prediction models, and access to Oak Ridge computers for the development of technical procedures and systems. This system, which includes a batch terminal, several interactive and graphics terminals, and two leased lines, is known as the Grand Junction Office Information System (GJOIS).

The data bank of technical information consists of information collected by aerial radiometric reconnaissance and hydrogeochemical surveys. Currently, data from 58 complete or partial quadrangles are accessible through GJOIS; additional data is included as it becomes available. Copies of these technical data sets are available through DOE on a cost-to-copy basis. BFEC expects to make extensive use of these data bases to design computerized evaluation models in support of the NURE program assessment.

GJOIS support is provided for resource assessment and prediction modeling efforts which exceed



This computer system, consisting of a batch terminal, several interactive and graphic terminals, and two leased lines connecting to a DOE computer center at Oak Ridge, Tenn., is known as GJOIS.

the capacity of on-site computers at Grand Junction. Bendix is providing some programming and analysis support for these functions.

Development of technical procedures and systems was begun with several familiarization sessions, including a demonstration of interactive graphics capability. Accounts have been established for personnel in several Bendix divisions. Initial development of quadrangle analysis procedures through GJOIS is underway, and data base systems for ore reserves and other applications are being developed for future implementation on a replacement computer under consideration for the Grand Junction Office.

Printed Material

The DOE/BFEC Technical Library in Grand Junction is responsible for the control and timely distribution of all printed information—technical reports, maps, and raw data—resulting from the NURE efforts of DOE, Bendix, and their subcontractors. This information is made available by two basic methods: technical library reference services, and the DOE open-file report system. Reference services include answering telephone and written inquiries, as well as assisting library visitors. The open-file report system requires the distribution of printed material to selected open-file repositories throughout the United States.

To reproduce the necessary copies of the open-file reports and other printed material for the NURE program, Bendix operates a printing facility at Grand Junction. In addition, Bendix provides graphic support for all NURE program areas with a drafting and photography section. This past year Bendix added a word processing center and editing staff.

Microform Material

Microfiche copies of GJO open-file reports in the DOE/BFEC Technical Library collection are available at nominal cost. Microfiche copies of the reports are at a 24:1 reduction; accompanying maps and oversize charts are on 35-mm film. At the present time, 533 reports are available on microfiche. Since the begininning of the microfiche program in 1976, 3,283 microfiche copies of reports have been sold.

Any individual or organization wishing to automatically receive all future GJO open-file publications on microfiche may do so by establishing a deposit account with the Bendix library in Grand Junction.

Reports Issued in 1977

GJBX-1(77): "Remote Temperature Inversion Sensor," W. Malkmus and M. Griggs, Science Applications, Inc. (SAI), January 1977

GJBX-2(77): "Survey of Lands Held for Uranium Exploration, Development and Production in Fourteen Western States for six-month period ending June 30, 1976," Bendix Field Engineering Corporation (BFEC), n.d.

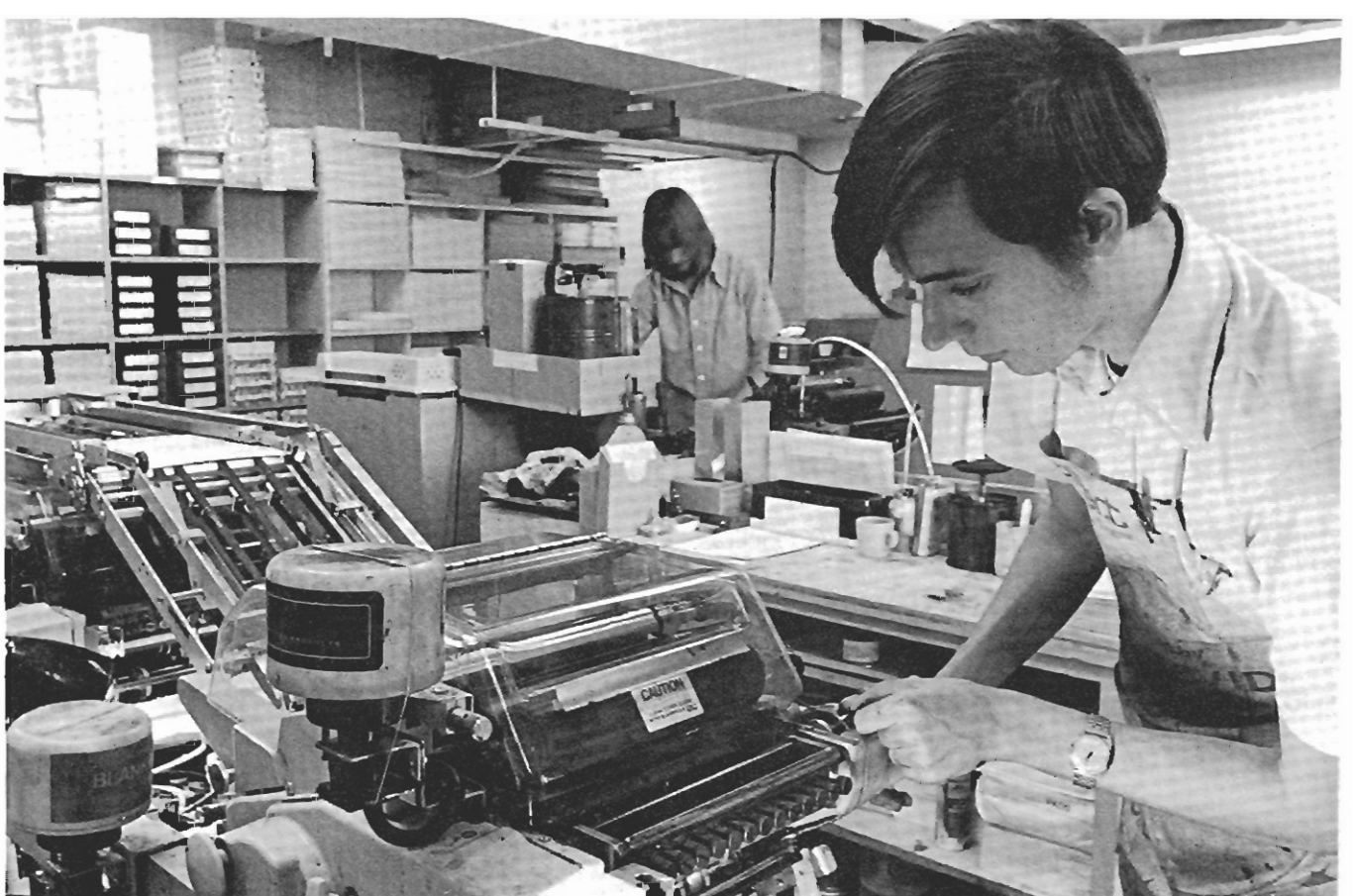
GJBX-3(77): "Geostatistical Ore Reserve Estimation for a Roll-Front Type Uranium Deposit (Practitioner's Guide)," Young C. Kim, et al, University of Arizona, January 1977

GJBX-4(77): "Discrimination of Uranium Alteration Zones in Selected Areas by Use of LANDSAT MSS Imagery," Carl L. Kober and H. David Procter-Gregg, Denver Mineral Exploration Corporation, February 1977

GJBX-5(77): "Aerial Gamma Ray and Magnetic Survey of the Bethel and Yukon Areas, Alaska," Texas Instruments, Inc., (TI), December 1976

GJBX-6(77): "Hydrogeochemical and Stream Sediment Reconnaissance Eastern United States," October-December 1976 quarterly report, Savannah River Laboratory (SRL), n.d.

The small quantity runs of the various technical reports and other program support printing are done in the Bendix printing facility at GJO.



GJBX-7(77): "Uranium Favorability of Late Eocene through Pliocene Rocks of the South Texas Coastal Plain," J. V. Quick, et al, BFEC, February 1977

GJBX-8(77): "Microcomputer-Based Pneumatic Controller for Neutron Activation Analysis," J. S. Byrd and R. J. Sand, SRL

GJBX-9(77): "Measured Sections and Analyses of Uranium Host Rocks of the Dockum Group, New Mexico and Texas," R. E. Dickson, et al, BFEC, February 1977

GJBX-10(77): "Hydrogeochemical and Stream Sediment Reconnaissance—Western United States," July-September 1976, Lawrence Livermore Laboratory (LLL), n.d.

GJBX-11(77): "Annual NURE Report 1976," BFEC, n.d.

GJBX-12(77): "Hydrogeochemical and Stream Sediment Reconnaissance of the National Uranium Resource Evaluation Program," covering New Mexico, Colorado, Wyoming, Montana, and Alaska, July-September 1976, Los Alamos Scientific Laboratory (LASL), n.d.

GJBX-13(77): "Uranium Deposits in Granitic Rocks," R. K. Nishimori, et al, University of North Carolina, January 1977

GJBX-14(77): "Quantitative Methods for the Appraisal of Mineral Resources," DeVerle P. Harris, University of Arizona, n.d.

GJBX-15(77): "Provenance of Radioactive Placers, Big Meadow Area, Valley and Boise Counties, Idaho," Dale Truesdell, et al, BFEC, February 1977

GJBX-16(77): "Geology, Uranium Deposits, and Uranium Favorability of the Hartford Hill Rhyolite and Truckee Formation, Southwestern Washoe County, Nevada, and Eastern Lassen County, California," G. M. Cupp, et al, BFEC, April 1977

GJBX-17(77): "Aerial Gamma Ray and Magnetic Survey of the Red River Area—Block C, Texas and Oklahoma," TI, March 1977

GJBX-18(77): "Aerial Gamma Ray and Magnetic Survey of the Delta Area, Utah," TI, March 1977

GJBX-19(77): "Uranium Geochemical Survey in the Crystal City and Beeville Quadrangles, Texas," C. E. Nichols, et al, Oak Ridge Gaseous Diffusion Plant, (ORGDP), n.d.

GJBX-20(77): "Hydrogeochemical and Stream Sediment Reconnaissance of the National Uranium Resource Evaluation Program," October-December 1976, P. L. Aamodt, et al, LASL, n.d.

GJBX-21(77): "Uranium Hydrogeochemical and Stream Sediment Pilot Survey of the Estancia Valley, Bernalillo, Santa Fe, San Miguel, and Torrance Counties, New Mexico," Clayton E. Olsen, LASL, January 1977

GJBX-22(77): "Uranium Hydrogeochemical and Stream Sediment Reconnaissance in the San Juan Mountains, Southwest Colorado," James C. Maxwell, LASL, February 1977

GJBX-23(77): "Seminar Proceedings: I. Pulsed Neutron Uranium Borehole Logging with Prompt Fission Neutrons (PFN); II. Neutron Tube Technology for PFN Logging Equipment," February 24, 1977, Albuquerque, Sandia Laboratories, n.d.

GJBX-24(77): "The Fluorometric Determination of Uranium in Natural Waters," A. D. Hues, et al, LASL, March 1977

GJBX-25(77): "Gamma-Ray Spectrum Enhancement," J. H. Reed and G. M. Reynolds, SAI, n.d.

GJBX-26(77): "Field Manual for Ground Water Reconnaissance, R. B. Ferguson, et al, SRL, January 1977

GJBX-27(77): "An Evaluation of High-Frequency Electromagnetic Sounding for Uranium Exploration and Mining," R. S. Vickers, SRI, October 1976

GJBX-28(77): "Investigation of Alaska's Uranium Potential," G. R. Eakins, et al, Alaska Dept. of Natural Resources, February 1977

GJBX-29(77): "Calibration and Field Test of a Pulsed Delayed Fission Neutron Logging Probe, John Reichardt, Kaman Sciences Corporation, May 1977

GJBX-30(77): "Field Manual for Stream Sediment Reconnaissance," R. B. Ferguson, et al, SRL, July 1976

GJBX-31(77): "Uranium Concentrations in Lake and Stream Waters and Sediments from Selected Sites in the Susitna River Basin, Alaska," Dwight E. Hill, LASL, March 1977

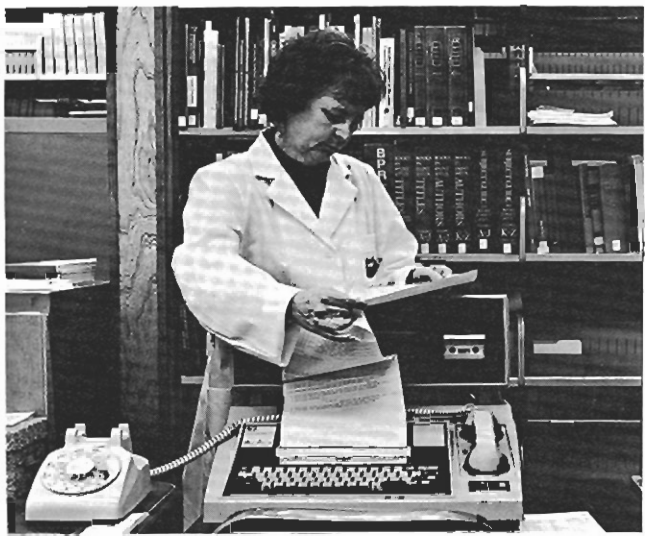
GJBX-32(77): "Investigations of the Inductively Coupled Plasma Source for Analyzing NURE Water Samples at the Los Alamos Scientific Laboratory," Charles T. Apel, et al, LASL, March 1977

GJBX-33(77): "Survey of Lands Held for Uranium Exploration, Development, and Production in Fourteen Western States for Period Ending December 31, 1976," BFEC, n.d.

GJBX-34(77): "Hydrogeochemical and Stream Sediment Survey of the National Uranium Resource Evaluation (NURE) Program—Western United States," October-December 1976, LLL, n.d.

GJBX-35(77): "Hydrogeochemical and Stream Sediment Reconnaissance Eastern United States," January-March 1977, SRL, n.d.

GJBX-36(77): "Rapid Determination of Uranium in Natural Waters by Thermal Emission Mass Spectrometry, J. R. Ferguson, et al, ORGDP, March 1977



The Bendix library has access to the main-frame computer at GJO with this telephone terminal to assist with accounting functions.

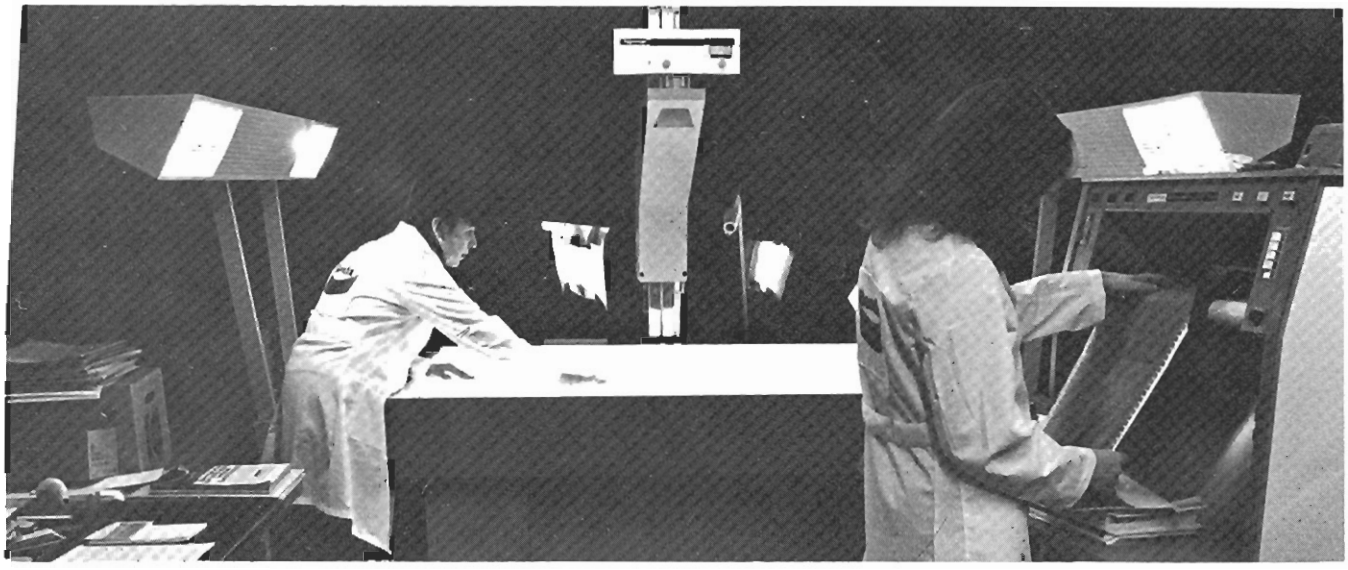
GJBX-37(77): "Stratigraphy and Sedimentology of Radioactive Devonian-Mississippian Shales of the Central Appalachian Basin," Linda J. Provo, University of Cincinnatti, n.d.

GJBX-38(77): "Use of an Intrinsic Germanium Detector Array for an Aerial Survey of Surface Nuclear Radiation," K. W. Marlow and G. W. Phillips, Naval Research Laboratory, February 1977

GJBX-39(77): "Raw Data Report on Elemental Analyses from Hydrogeochemical and Stream Sediment Samples Taken near Sterling and Fort Morgan, Northeastern Colorado, December 1976 and January 1977," James C. Maxwell, LASL, n.d.

GJBX-40(77): "Airborne Detector Improvement," E. J. Schneid, et al, Grumman Aerospace Corporation, March 1977

GJBX-41(77): "Catahoula Formation of the Texas Coastal Plain: Depositional Systems, Composition, Structural Development, Ground-water Flow History, and Uranium Distribution," William E. Galloway, Bur. of Economic Geology, Univ. of Texas at Austin, n.d.



The micrographics operator on the left places a large geologic map on the planetary camera, one of the largest microfilming cameras available. GJO needs such a large camera to handle all the geologic maps and other geology-related documents generated at GJO. Another micrographics operator on the right feeds the high-speed rotoline microfilmer which handles the bulk of the documents.

GJBX-42(77): "Hydrogeochemical and Stream Sediment Reconnaissance Program in Central United States," October-December 1976, ORGDP, n.d.

GJBX-43(77): Supplement to GJBX-48(76), "Uranium, Thorium, and Potassium Content of Precambrian Rocks, Upper Peninsula of Michigan and Northern Wisconsin," J. Kalliokoski, Michigan Tech. University, February 1977

GJBX-44(77): "Borehole Model Calculations for Direct Uranium Measurements with Neutrons," W. A. Woolson and M. L. Gritzner, SAI, n.d.

GJBX-45(77): "Chemical and Physical Analyses of Selected Soil Samples in Wyoming, 1967-1969," John R. Ellis, DOE, June 1977

GJBX-46(77): "Lake Mead Dynamic Test Range for Calibration of Airborne Gamma Radiation Measuring Systems," Vols. 1 and 2, Geodata International, Inc., n.d.

GJBX-47(77): "Status Report on the Development of a Prompt Fission Neutron Uranium Borehole Logging Technique," Gerald W. Smith, Sandia Laboratories, May 1977

GJBX-48(77): "Uranium Hydrogeochemical and Stream Sediment Reconnaissance in Lincoln and Flathead Counties, Northwest Montana," Paul L. Aamodt, LASL, May 1977

GJBX-49(77): "NURE Engineering Report, Carson Sink, Nevada, Borehole," Robert C. Horton, BFEC, July 1977

GJBX-50(77): "Geostatistics Project of the National Uranium Resource Evaluation Program," January-March 1977, T.R. Bement, et al, LASL, May 1977

GJBX-51(77): "Hydrogeochemical and Stream Sediment Reconnaissance of the National Uranium Resource Evaluation Program," January-March 1977, P. L. Aamodt, et al, LASL, n.d.

GJBX-52(77): "Automated Energy-Dispersive X-Ray Determinations of Trace Elements in Stream Sediments," J. M. Hansel and C. J. Martell, LASL, June 1977

GJBX-53(77): "Hydrogeochemical and Stream Sediment Reconnaissance of the National Uranium Resource Evaluation Program—Western United States," January-March 1977, LLL, n.d.

GJBX-54(77): "Computer Program for Universal Transverse Mercator Map Projection," J. Cheadle III, LASL, August 1977

GJBX-55(77): "Hydrogeochemical and Stream Sediment Reconnaissance—Eastern U.S.," April-June 1977, SRL, n.d.

GJBX-56(77): "Favorability for Uranium in Tertiary Sedimentary Rocks, Southwestern Montana," M. A. Wopat, et al, BFEC, October 1977

GJBX-57(77): "Preliminary Geologic Investigation of Uranium Favorability in the Red River Valley of North Dakota and Minnesota," R. E. Rood, BFEC, August 1977

GJBX-58(77): "Study of the Applicability of $^{3}He/^{4}He$ Ratio for Uranium Prospecting," J. P. Martin and L. E. Berquist, Martin Marietta Corporation, n.d.

GJBX-59(77): "Geochemical Dispersion of Uranium near Prospects in Pennsylvania," Arthur W. Rose, et al, The Pennsylvania State University, June 1977

GJBX-60(77): "Radon in Streams and Ground Waters of Pennsylvania as a Guide to Uranium Deposits," Lisa A. Korner and Arthur W. Rose, The Pennsylvania State University, June 1977

GJBX-61(77): "Preliminary Evaluation of the Uranium Favorability in the Area Northeast of Gunnison, Colorado," G. L. Gallagher, et al, BFEC, August 1977

GJBX-62(77): "The Origin of Low-Level Airborne Radiometric Anomalies in the Copper River Basin Region, Alaska," Robert B. Forbes, et al, Geophysical Institute, University of Alaska, Fairbanks, n.d.

GJBX-63(77): "Results of Elemental Analyses of Water and Waterborne Sediment Samples from the Proposed Cape Krusenstern National Monument, Alaska," Robert R. Sharp, Jr., LASL, August 1977

GJBX-64(77): "Uranium Favorability of Tertiary Sedimentary Rocks in the Northern Green River Basin and Hoback Basin, Wyoming," L. W. Lease, et al, BFEC, n.d.

GJBX-65(77): "Advanced Geostatistics in Ore Reserve Estimation and Mine Planning (Practitioner's Guide)," Young C. Kim, et al, University of Arizona, October 1977

GJBX-66(77): "Preliminary Raw Data Release, Winston-Salem 1°x2° NTMS Area, North Carolina, Virginia, Tennessee, Hydrogeochemical and Stream Sediment Reconnaissance," E. I. Baucom, et al, SRL, September 1977

GJBX-67(77): "Migration of Gaseous Radionuclides through Soil Overlaying a Uranium Ore Deposit. A Modeling Study," H. W. Jeter, et al, Teledyne Isotopes, n.d.

GJBX-68(77): "Preliminary Study of the Uranium Potential of the Triassic-Jurassic Basin in Connecticut and Massachusetts," D. B. Truesdell and R. C. Zollinger, BFEC, n.d.

GJBX-69(77): "A Tectonic Atlas of Uranium Potential in Crystalline Rocks of the Eastern United States," J. K. Greenberg, et al, University of North Carolina, n.d.

GJBX-70(77): "Hydrogeochemical and Stream Sediment Reconnaissance Program in Central United States; Second and Third Quarters FY 1977, January 1, 1977-June 30, 1977," ORGDP, n.d.

GJBX-71(77): "National Uranium Resource Evaluation, Principal Component Testing for Outliers," V. E. Kane, et al, ORGDP, July 1977

GJBX-72(77): "Uranium Favorability in the San Rafael Swell Area, East-Central Utah," D. G. Mickle, et al, BFEC, n.d.

GJBX-73(77): "Studies of Airborne Optical Detection of Uranium Ore," C. M. Lampley and M. B. Wells, Radiation Research Association, Fort Worth, Texas, n.d.

GJBX-74(77): "Pre-Study of the Favorability for Uranium in Selected Areas in the Basin and Range Province, Nevada," G. M. Cupp, et al, BFEC, October 1977

GJBX-75(77): "Uranium Favorability of Southwestern Oklahoma and North-Central Texas," G. D. Stanton, et al, BFEC, October 1977

GJBX-76(77): "Geostatistics Project of the National Uranium Resource Evaluation Program," R. K. Zeigler, et al, April-June 1977, LASL, September 1977

GJBX-77(77): "Symposium on Hydrogeochemical and Stream-Sediment Reconnaissance for Uranium in the United States," March 16-17, 1977, BFEC, October 1977

GJBX-78(77): "Preliminary Study of Uranium Potential of Tertiary Rocks in the Central San Juan Basin, New Mexico," H. P. Vizcaino and A. J. O'Neill, BFEC, December 1977

GJBX-79(77): "Preliminary Study of Uranium Favorability for Uranium, East Texas and West Louisiana Coastal Plain," L. P. Jones, et al, BFEC, November 1977

GJBX-80(77): "Field Manual for Stream Water and Sediment Reconnaissance," R. B. Ferguson, et al, SRL, November 1977

GJBX-81(77): "Preliminary Study of Uranium in Pennsylvanian and Lower Permian Shale in the Powder River Basin, Wyoming and Montana, and the Northern Great Plains," J. F. Dunagan, Jr., and K. A. Kadish, BFEC, November 1977

GJBX-82(77): "Preliminary Study of Favorability for Uranium of the Sangre de Cristo Formation in the Las Vegas Basin, Northeastern New Mexico," R. J. May, et al, BFEC, December 1977

GJBX-83(77): "Preliminary Study of the Geology and Uranium Favorability of the Forest City Basin in Kansas, Missouri, and Nebraska," V. C. Johnson and W. S. Dubyk, BFEC, n.d.

GJBX-84(77): "Preliminary Study of the Favorability for Uranium in Northeastern Oklahoma and Southeastern Kansas," BFEC, n.d.

GJBX-85(77): "Development of a Conceptual U_3O_8 Production Forecasting Model," R. K. Doran, et al, DRI, n.d.

GJBX-86(77): "Development of U_3O_8 Mining and Milling Cost and Material Models," Phase I progress report, 2 vol., W. L. Clem, et al, NUS Corporation, n.d.

GJBX-87(77): "Hydrogeochemical and Stream Sediment Survey of the National Uranium Resource Evaluation (NURE) Program—Western United States," April-June 1977, LLL, n.d.

GJBX-88(77): "Study of Airborne Gamma Ray Spectrometer Data Procedures, Casper Quadrangle, Wyoming," October 1977

GJBX-89(77): "Preliminary Report on the Uranium and Thorium Content of Intrusive Rocks in Northeastern Washington and Northern Idaho," S. B. Castor, et al, BFEC, November 1977

GJBX-90(77): "Hydrogeochemical and Stream Sediment Reconnaissance—Eastern United States," July-September 1977, SRL, n.d.

GJBX-91(77): "Preliminary Study on Uranium Favorability of Malheur County, Oregon," Erik H. Erikson, BFEC, November 1977

GJBX-92(77): "Preliminary Study of the Uranium Favorability of Tertiary Rocks, Southeastern Oregon: Eastern Klamath, Southern Lake, Harney, and Western Malheur Counties," E. H. Erikson and W. E. Curry, BFEC, November 1977

GJBX-93(77): "Regional Geochemical Model for Groundwater Associated with Uranium Mineralization in Northwest Texas," C. E. Nichols, et al, ORGDP, n.d.

GJBX-94(77): "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Northern Part of the Powder River Basin, Wyoming," Wayne A. Morris, LASL, November 1977

Union Mines Reports

(S-37 = uranium minerals; SOM = uranium; SOQ = uranium oxide)

RMO-23: "Report on SOM Possibilities in the East Central Alabama District of the Southern Appalachian Area," W. G. Valentine, June 1944, 16 p.

RMO-26: "Report on SOM Investigations in Arizona (Except the Plateau Province Area)," J. M. Hill, February 1946, 14 p.

RMO-27: "Report on the Possibility for S-37 in Nine Mountain Ranges in the Vicinity of Tucson, Arizona," J. M. Hill, October 1948, 4 p.

RMO-32: "Reconnaissance for S-37 Minerals in the San Bernardino Mts., San Bernardino County, California," A. F. Carper, September 1945, 2 p.

RMO-33: "Possibilities for SOQ in the Wingate Pass Area, Death Valley, Inyo County, California," A. F. Carper, April 1945, 4 p.

RMO-34: "Preliminary Reconnaissance Survey of Southern California Placer Deposits with Minor Work in Oregon and Arizona," J. H. Skidmore, December 1944, 39 p.

RMO-35: "Northeast Portion San Bernardino County, California and Area Adjacent," A. F. Carper, May 1944, 20 p.

RMO-36: "Reconnaissance Survey Riverside County, California," A. F. Carper, May 1944, 19 p.

RMO-39: "Examinations for SOM at Two Localities in Southern California," A. F. Carper, October 1948, 4 p.

RMO-40: "Reconnaissance Survey of Northern California," A. F. Carper, November 1945, 9 p.

RMO-41: "Reconnaissance Study of Pegmatite Deposits in San Diego County, California," A. F. Carper, May 1944, 52 p.

RMO-42: "Preliminary Report on Possibilities of SOM Occurrences in Oregon and California," M. Cooper, April 1944, 15 p.

RMO-45: "The Geology and Ore Deposits of the Brown Derby Pegmatites, Box Canyon Mining District, Gunnison County, Colorado," G. B. Guillotte, June 1945, 13 p.

RMO-46: "S-37 Occurrences in the Grover Pegmatite Mine on North Beaver Brook, Clear Creek County, Colorado," G. B. Guillotte, June 1944, 11 p.

RMO-47: "Unwatering and Sampling of the Kirk Mine, Gilpin County, Colorado," J. M. Hill, April 1945, 23 p.

RMO-48: "Report on Field Reconnaissance Survey of S-37 Deposits in Gilpin County, Colorado, United States," G. B. Guillotte, February 1944, 20 p.

RMO-49: "Report of Preliminary Field Reconnaissance of Reported SOM Occurrences in Eastern Colorado," G. B. Guillotte, February 1944, 4 p.

RMO-76: "SOM Possibilities in N. Georgia District of Southern Appalachian Area & SOM Possibilities at Stone Mountain, De Kalb City, Georgia," W. S. Valentine, June 1944, 76 p.

RMO-80: "Reconnaissance Survey for S-37 Minerals in Idaho," A. F. Carper, November 1945, 34 p.

RMO-81: "Preliminary Reconnaissance Survey of Idaho Placer Deposits," J. H. Skidmore, March 1944, 13 p.

RMO-84: "Reconnaissance Survey of Montana," A. F. Carper, October 1945, 24 p.

RMO-87: "Examination of Alleged SOM Occurrences in Southeast Nevada," A. F. Carper, May 1946, 13 p.

RMO-88: "The Rink Copper and Gold Properties near Yerington, Lyon County, Nevada," A. F. Carper, October 1948, 9 p.

RMO-89: "Report on Reconnaissance Survey of Marjuba Hill, Pershing County, Nevada," J. M. Hill, 1946, 10 p.

RMO-90: "Reconnaissance of Placer and Opalite Deposits in Nevada," A. F. Carper, November 1945, 31 p.

RMO-92: "Report on the Caliente-Pioche Area, Lincoln County, Nevada," A. F. Carper, May 1944, 2 p.

RMO-93: "Report on the Erie to Ardern Area, Clark County, Nevada," J. M. Hill, May 1944, 3 p.

RMO-94: "Report on SOM Occurrences in the Yellow Pine or Goodsprings District, Clark County, Nevada," J. M. Hill and A. F. Carper, November 1944, 18 p.

RMO-95: "Investigation of New England Pegmatites for SOM Production Possibilities," T. B. Holmes and G. W. Bourret, June 1944, 83 p.

RMO-96: "Report on Reconnaissance Survey of SOM Possibilities near Netcong, New Jersey," W. G. Valentine, July 1945, 7 p.

RMO-101: "Notes on the Use of the Geiger-Muller Counter in the White Signal District, Grant County, New Mexico," S. B. Keith, October 1945, 4 p.

RMO-102: "Report on Examinations for SOM in New Mexico," J. M. Hill, September 1945, 29 p.

RMO103: "The White Signal and Associated -Districts, Grant County, New Mexico," S. B. Keith, July 1945, 57 p.

RMO-104: "Reconnaissance of the White Signal, Black Hawk, and San Lorenzo Districts and the Swanson-Laur Property, New Mexico," S. B. Keith, April 1944, 16 p.

RMO-105: "Reconnaissance Study of Pegmatite Deposits in Petaca Area, New Mexico," C. N. Apsouri, March 1944, 57 p.

RMO-107: "Report on Reconnaissance Surveys of SOM Possibilities in Jackson and Henderson Counties, North Carolina," W. G. Valentine, July 1945, 13 p.

RMO-108: "Report on a Reconnaissance Survey of the Bedford Feldspar Quarries of Southeastern New York," W. G. Valentine, July 1945, 1 p.

RMO-110: "Supplementary Report on SOM Possibilities in the Spruce Pine District of North Carolina," W. G. Valentine, June 1944, 20 p.

RMO-111: "Report on Reconnaissance Surveys in Eastern Pennsylvania," W. G. Valentine, July 1945, 28 p.

RMO-112: "Report on Reconnaissance Survey for S-37 in Chester County, Pennsylvania," G. B. Guillotte, August 1944, 9 p.

RMO–114: "Report on a Reconnaissance Survey of SOM Possibilities in South Carolina," W. G. Valentine, July 1945, 4 p.

RMO–116: "Reconnaissance of SOM Possibilities in the Bailey Springs and Union Grove Districts, North Carolina," W. G. Valentine, June 1944, 9 p.

RMO–117: "Report of Reconnaissance Study of the Occurrence of SOM in the Pegmatite Veins of the Spruce Pine District of North Carolina," W. G. Valentine, March 1944, 215 p.

RMO–119: "Reconnaissance Survey of Oregon," A. F. Carper, November 1945, 54 p.

RMO–122: "Report on the Southern Black Hills Mineral Area, South Dakota," J. F. West, June 1944, 69 p.

RMO–123: "Report on the Northern Black Hills Mineral Area, South Dakota," J. F. West, March 1944, 59 p.

RMO–135: "Reconnaissance Report on Silver Reef District, Southwest Utah Area, Utah," C. T. Smith, February 1946, 6 p.

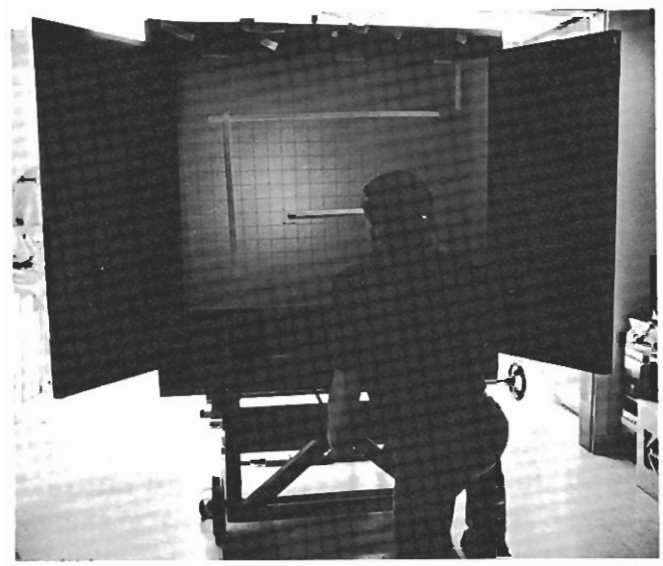
RMO–137: "SOM in the Hydrocarbons of the Uinta Basin of Utah and Colorado," G. B. Guillotte, June 1944, 16 p.

RMO–138: "Reconnaissance Report on the Trans-Pecos Region, Texas," J. M. Hill, September 1945, 13 p.

RMO–148: "Reconnaissance Report on the Rossman SOM Prospect, Hudspeth County, Texas," B. N. Webber, March 1946, 3 p.

RMO–151: "Schroeckingerite Deposits at Lost Creek, Sweetwater County, Wyoming," G. B. Guillotte, March 1945,12 p.

RMO–152: "Examination of the Silver Cliff Mine, Lusk District, Hartville Uplift Area, Wyoming," J. F. West, April 1944, 11 p.



Bendix industrial photographers handle the engineering drawings and geologic maps on the process camera in addition to their work with documenting the activities of the geologists with color and black and white photography.

RMO–402: "Merry Widow Mine, White Signal District, (Grant County) New Mexico Interim Report on Treatment Procedures Applicable to Ores Sampled by S. B. Keith," R. W. Handley, June 1945, 11p.

RMO–438: "Report on SOM Occurrences near Garo, Park County, Colorado," L. B. Riley, May 1946, 7 p.

RMO–482: "Summary of Investigation of Vanadium and Uranium Occurrence in Huerfano Park District, Raton Basin Area, Huerfano and Costilla Counties, Colorado," J. F. Emerson, 1943, 14 p.

Miscellaneous Reports

RMO–704–R: "Geological Investigations Report of the North Wash Mining District, Henry Mountains, Utah," October 1951

RMO–830(rev.): "Drilling in the Monument Valley Area of Arizona and Utah," J. W. Chester and P. H. Donnerstag, June 4, 1952

GJO-100(77): "Statistical Data of the Uranium Industry"

GJO-103(77): "Uranium Exploration Expenditures in 1976 and Plans for 1977 and 1978"

GJO-108(77): "Uranium Industry Seminar," October 26-27, 1977

ERDA 77-46: "Survey of United States Uranium Marketing Activity"

The following reports issued by the Grand Junction Office, DOE, are entitled "Phase II—Title I Engineering Assessment of Inactive Uranium Mill Tailings, (Site and State)":

GJT-2: Shiprock Site, Shiprock, New Mexico

GJT-3: Mexican Hat Site, Mexican Hat, Utah

GJT-4: Monument Valley Site, Monument Valley, Arizona

GJT-5: Tuba City Site, Tuba City, Arizona

GJT-6: Durango Site, Durango, Colorado

GJT-7: Slick Rock Sites, Slick Rock, Colorado

GJT-8: Naturita Site, Naturita, Colorado

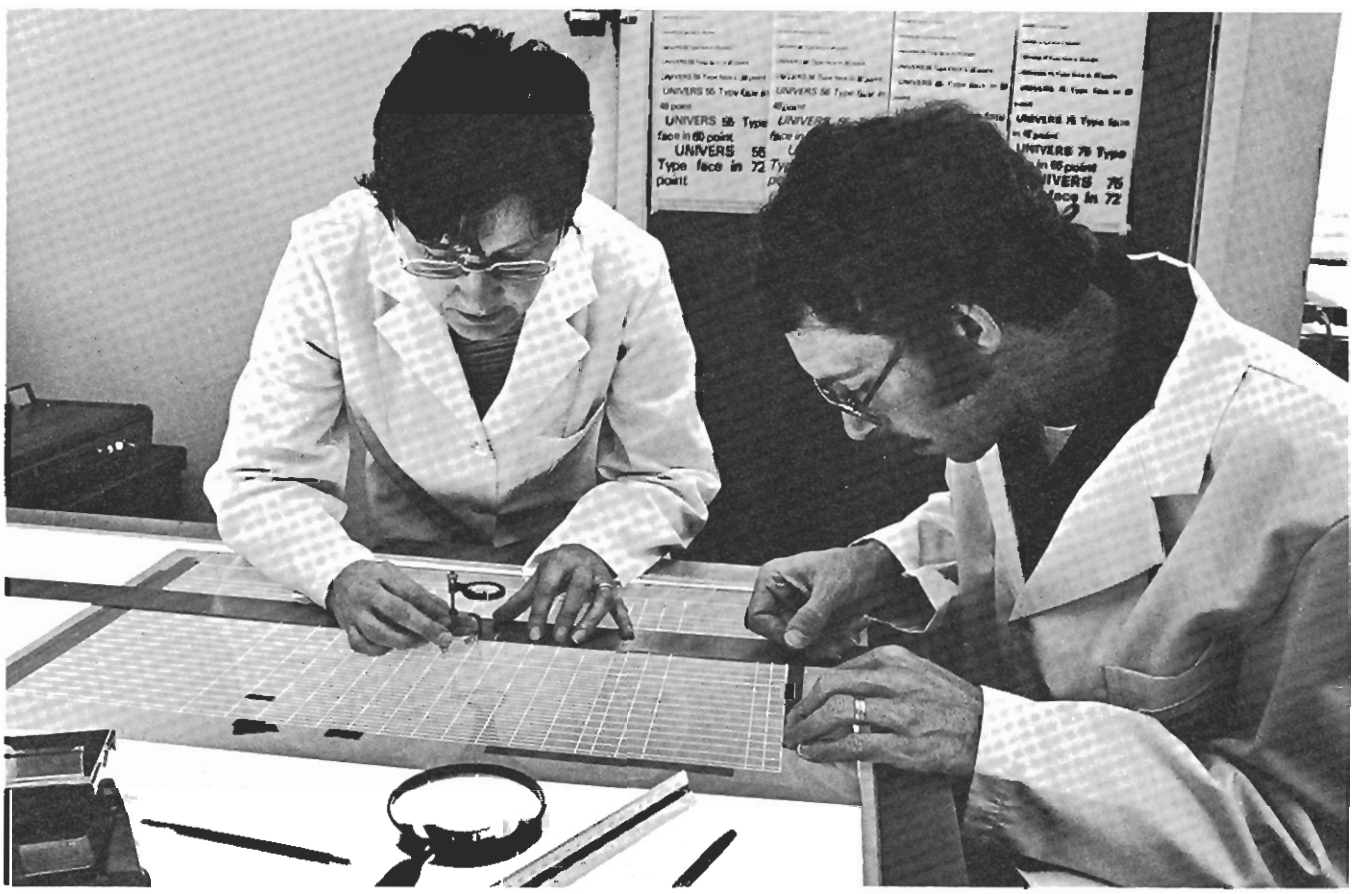
GJT-9: Grand Junction Site, Grand Junction, Colorado

GJT-10: Rifle Sites, Rifle, Colorado

GJT-11: Maybell Site, Maybell, Colorado

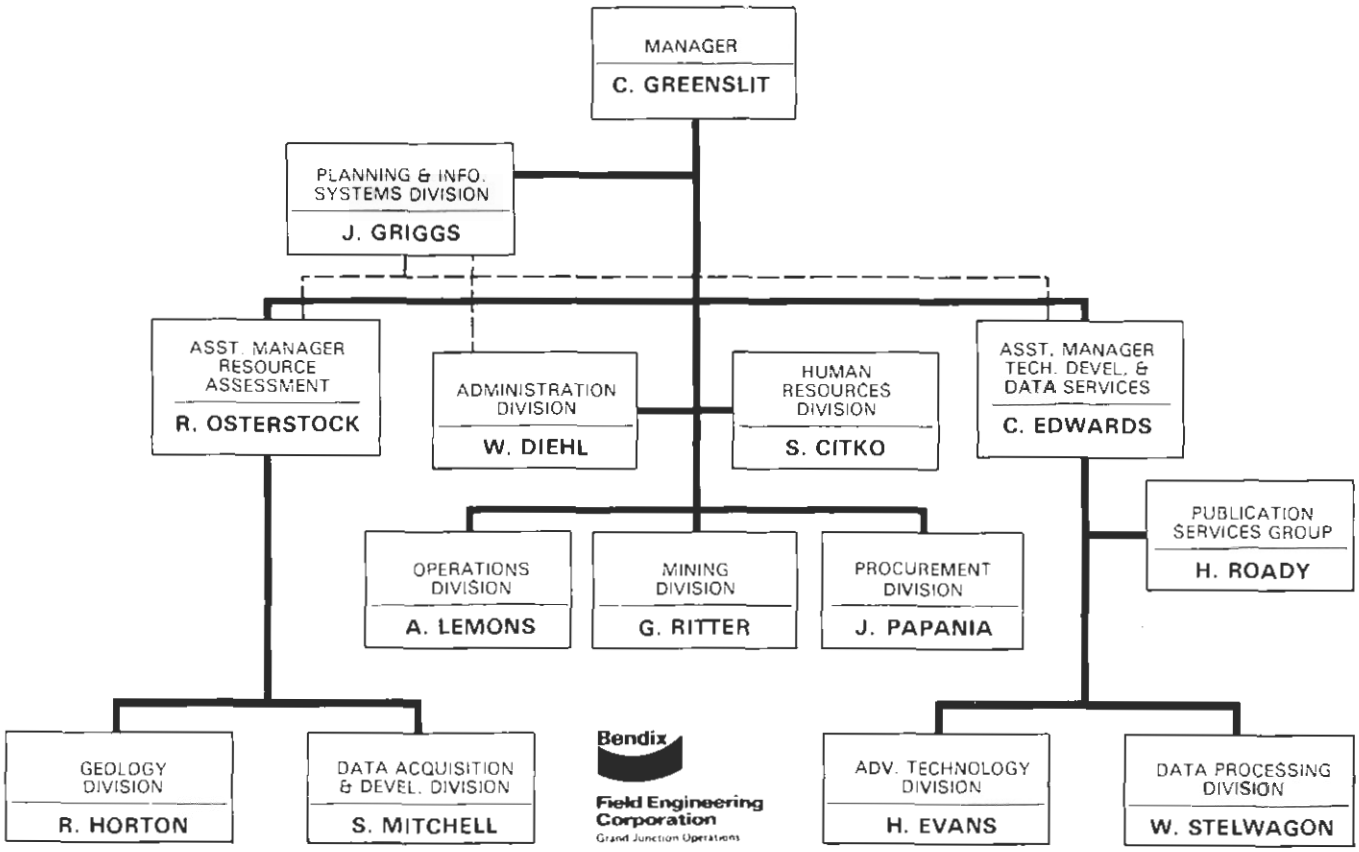
GJT-12: Gunnison Site, Gunnison, Colorado

Bendix drafting personnel prepare the geologic maps, drawings, and visuals that are needed by the geologists at GJO and also work on other program support material.



Bendix Field Engineering Corporation

Organizational Chart



Bendix Field Engineering Corporation

Bendix Field Engineering Corporation (BFEC) was selected by the Energy Research and Development Administration (ERDA), the predecessor of the Department of Energy (DOE), in June 1975, as the on-site contractor for the Grand Junction Office (GJO). Under the contract, Bendix supports DOE in carrying out a number of responsibilities including: conducting the National Uranium Resource Evaluation (NURE) program and managing the program of leasing U.S. government lands for the production of uranium and vanadium ores. In addition to performing in these program areas, Bendix handles all "housekeeping" functions required at the DOE Grand Junction facility.

During 1977, Bendix Grand Junction Operations grew from 280 to 400 employees. To handle the increased emphasis on the resource assessment effort, organizational changes were effected as reflected in the organization chart, above. A second Assistant Manager position was established responsible for the Geology and Data Acquisition and Development (formerly Project Management) Division, a Planning and Information Systems Division was established and a Procurement Division was organized. The majority of this annual report describes those technical activities which are the responsibility of the Geology, Data Acquisition and Development, and Advanced Technology Divisions.

The high level of technical effort in the Bendix Grand Junction Operations is reflected in the educational background of the managerial and professional personnel: of these 215 employees, approximately 120 have bachelor's degrees, 60 have master's degrees and 35 have doctor's degrees.