GJBX-11(79)

NURE 1978

National Uranium Resource Evaluation

Annual Activity Report

U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION OFFICE
P.O. BOX 2567
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DOE NEWS:

FOR IMMEDIATE RELEASE
June 29, 1979

DOE ISSUES ANNUAL NURE ACTIVITY REPORT

The Bendix Field Engineering Corporation, operating contractor for the Grand Junction, Colorado, Office, U.S. Department of Energy (DOE), has issued its third annual activity report of the National Uranium Resource Evaluation (NURE).

The 116-page publication, GJBX-11(79), "NURE 1978, Annual Activity Report," is a description of work done during calendar 1978 by Bendix and DOE and their contractors in support of NURE. The report does not contain information on the status of uranium resources; this information is being issued as GJO-100(79), "Statistical Data of the Uranium Industry."

NURE is a program of DOE's Grand Junction Office to acquire and compile geologic and other information with which to assess the magnitude and distribution of uranium resources and to determine areas favorable for the occurrence of uranium in the United States.

Single copies of GJBX-11(79) may be obtained at no cost by writing to: Technical Library, Bendix Field Engineering Corporation, P.O. Box 1569, Grand Junction, Colorado 81502; Tel: 303/242-8621, Ext. 278.

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Annual Activity Report

June 1979

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

Prepared for the
U.S. Department of Energy
Assistant Secretary for Resource Applications
Grand Junction Office, Colorado
Under Contract No. DE-AC-13-76-GJO-1664

Contents

Foreword

Bendix Field Engineering Corporation (BFEC), as prime operating contractor, provides management, technical, and facility support to the United States Department of Energy (DOE), Grand Junction (Colorado) Office (GJO).

This third annual activity report summarizes technical activities undertaken during calendar year 1978 to support DOE's National Uranium Resource Evaluation (NURE) program.

Bendix operates under U.S. Contract DE-AC-13-76-GJO-1664 with all activities performed under the supervision of DOE-GJO.

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

The new R&D logging system, also shown on the cover, was developed by Bendix for DOE. The system, complete with an on-board minicomputer, serves as a mobile laboratory for borehole geophysics and in-situ assaying of subsurface uranium deposits.

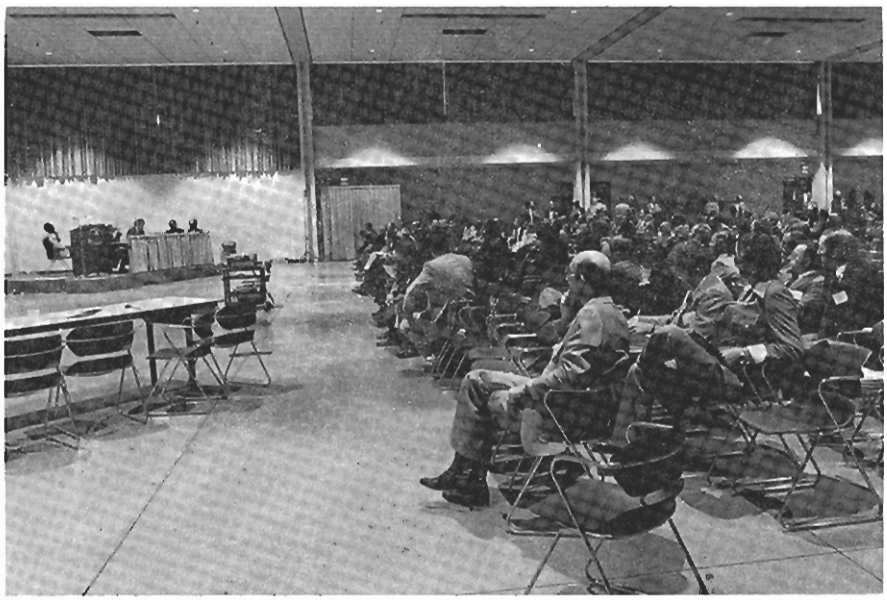
National Uranium Resource Evaluation

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. Quadrangle Evaluation
2. Aerial Radiometric Reconnaissance
3. Subsurface Geologic Investigations
4. Hydrogeochemical and Stream-Sediment Reconnaissance
5. Geologic Studies
6. Technology Applications
7. Information Dissemination

The extensive effort now under way on each of these NURE program elements will result in a systematic collection and compilation of data which will be used in a series of uranium resource reports starting in 1980 and culminating in a comprehensive report in 1983, which will cover 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 270,000 line miles (434,430 line km) of survey, bringing the total to 600,000 miles (965,400 km), representing about half the total reconnaissance surveys to be flown in the NURE program. In addition to reconnaissance surveying, a number of areas were selected for detail surveying to provide additional data

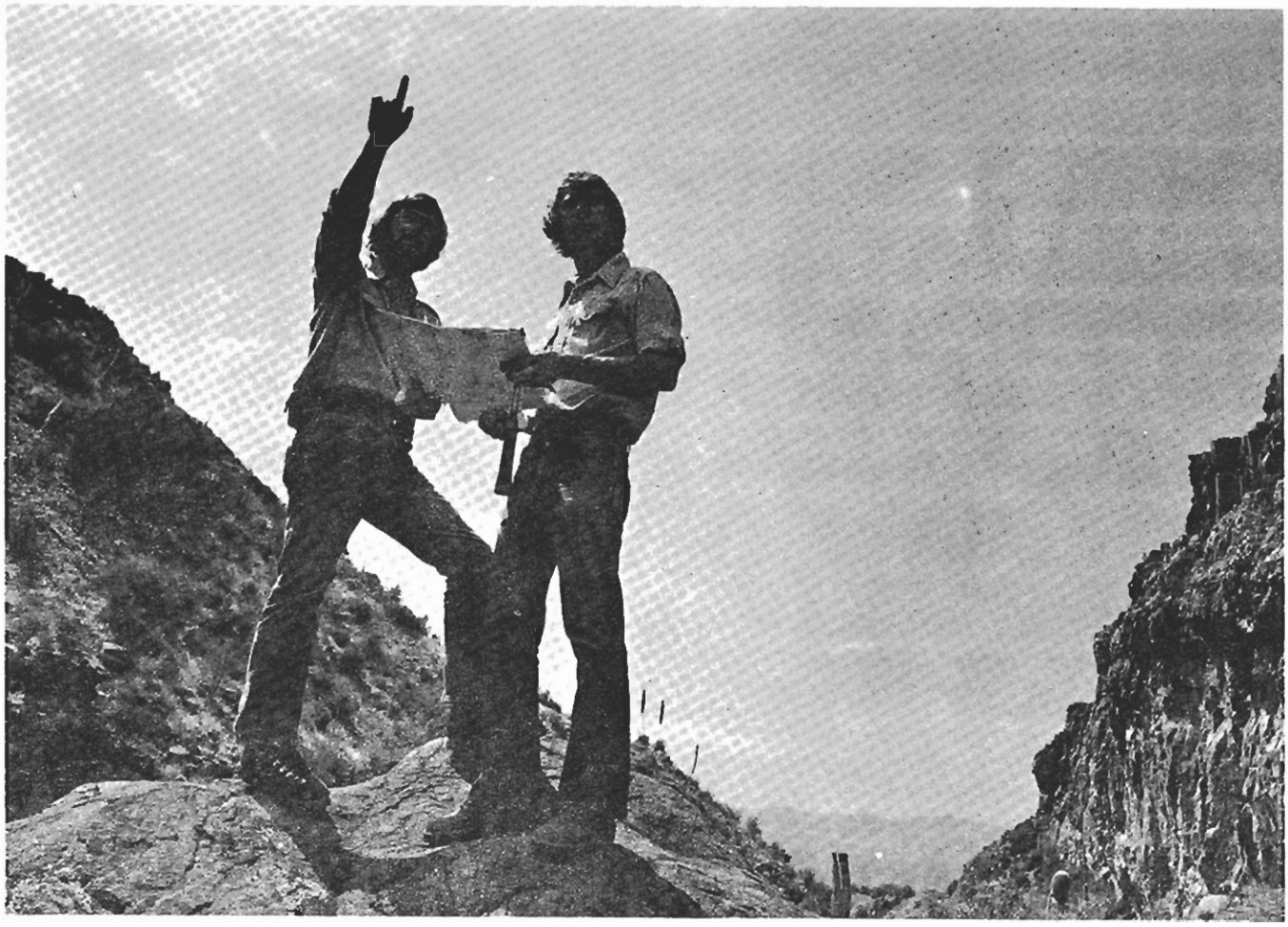
Bendix participated in the 1978 Mining and Petroleum Days in Grand Junction. The display (above) consisted of more than 50 color photographs highlighting NURE's major activities.



The Uranium Industry Seminar, sponsored annually by DOE, was held at Grand Junction's Two Rivers Plaza. Donald Everhart told participants of NURE plans and progress.

uranium resource assessment in the balance of the United States is currently scheduled to be completed and a report issued in 1985.

It is planned that the resource data published periodically by DOE—such as those found in GJO-100(78), *Statistical Data of the Uranium Industry*—during the time the NURE program is being executed will reflect the latest NURE data, along with the latest industry information.



1978 Summary and Highlights

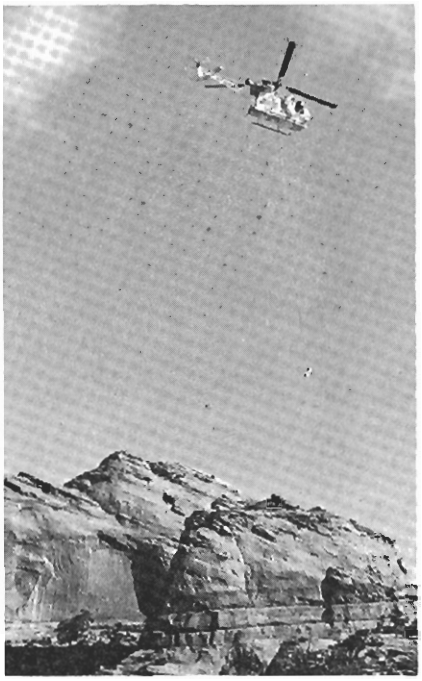
When the quadrangle evaluation studies program was initiated in 1977, the NURE effort was organized in a thorough, uniform, and systematic manner to examine the uranium resources of the United States. The emphasis in the early part of 1978 was on program implementation by assignment of responsibility for the priority quadrangles.

Early in the year, a DOE task force assigned to review the program made recommendations which resulted in changes in the quadrangle evaluation schedule. An interim goal of evaluating 116 of the 272 so-called "A" priority quadrangles and reporting the results by 1980 was established. Increased emphasis was placed on examining and evaluating the most favorable areas for intermediate-grade resources and nonsandstone geologic settings (identified as "world-class") that have been known in other nations to contain large uranium resources.

By the end of the year, geologic investigations were under way in nearly all the 116 priority quadrangles, with the effort divided among the many organizations participating in the program, including Bendix, U.S. Geological Survey, state geologic surveys, universities, and private firms. To guide the investigations and provide a common base for evaluating and classifying project areas, Bendix provided each investigating group with specifications for preparing the quadrangle work plan and the assessment folio. *Geologic Characteristics of Environments Favorable for Uranium Deposits*, GJBX–67(78), a major reference document for classifying deposits, was published and supplied to all participants. Bendix is working with DOE to develop procedures and methods for the final step in the assessment process—estimation of the amount of ore in a given area.

In direct response to changes in the quadrangle evaluation schedule, both the aerial radiometric reconnaissance program and the hydrogeochemical and stream-sediment reconnaissance (HSSR) program were modified to make the data covering the 116 priority quadrangles available to investigators at the earliest possible date.

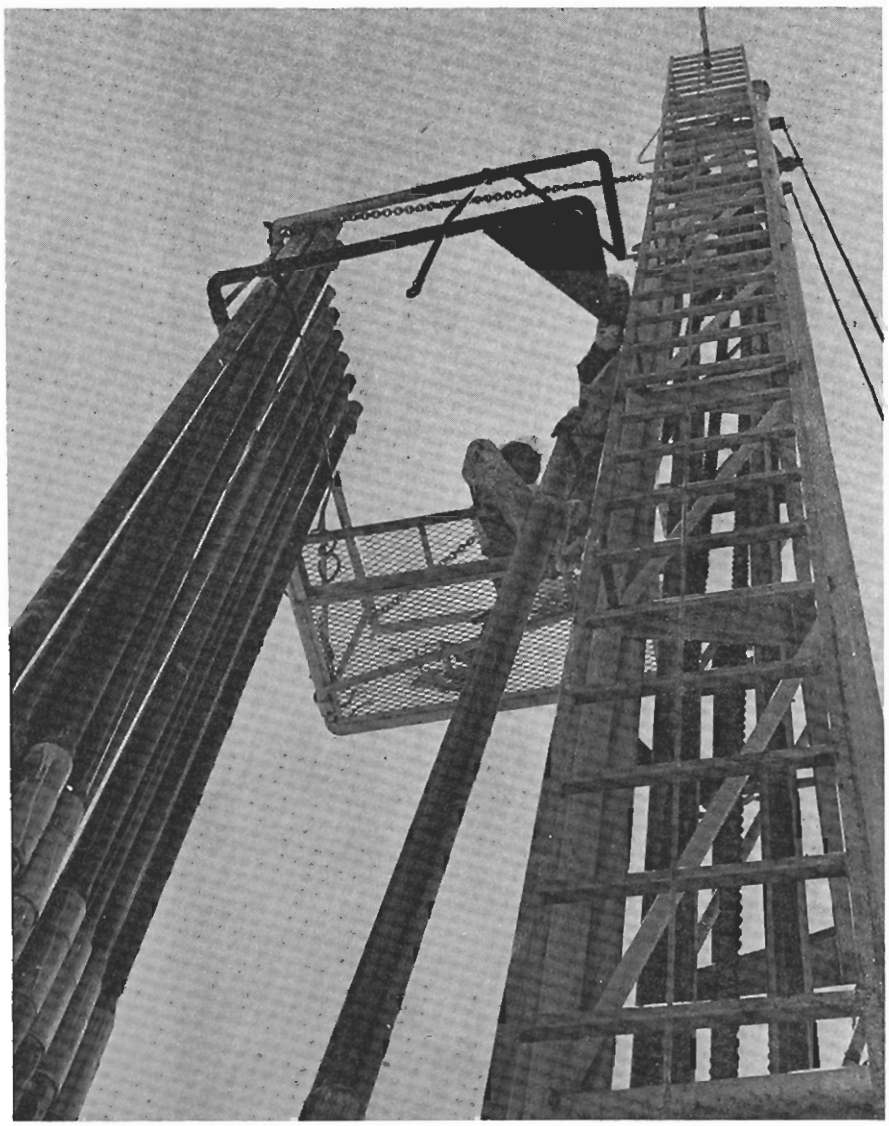
During 1978, 6 contractors used 11 airborne gamma-ray spectrometer systems to perform approximately



in support of the 1980 goal; 21,000 line miles (33,789 line km) of detail surveying were flown.

By the end of 1978, the DOE laboratories participating in the HSSR program had completed sampling in 241 quadrangles and had done partial sampling in an additional 92 quadrangles. Open-file reports on the sample data were issued for 54 quadrangles, bringing the total to date to 57. In addition to reconnaissance sampling, a number of areas were selected for detailed sampling in support of the 1980 goal.

During 1978, drilling activity on NURE increased substantially to accelerate the acquisition of subsurface data needed to confirm, with improved confidence, uranium resource estimates in areas of known occurrences and to aid in evaluating uranium resources in areas of high



The most advanced technology in field surveying, aerial reconnaissance, and subsurface investigations with sophisticated laboratory research methods are used in the evaluation of uranium resources.

potential. Drilling was completed on 2 projects started in 1977: the Red River Valley Project in North Dakota and Minnesota, and the Michigan Basins Project. Final geologic reports on both projects will be finished early in 1979. Five new projects were started in potential resource areas: Missoula/Bitterroot basins, San Rafael, Lemhi Pass (thorium), Spor Mountain, and East Chaco Canyon. Drilling on the Missoula/Bitterroot and San Rafael projects was completed in 1978, while a small amount of drilling remains to be done in 1979 at the other 3 sites. Final geologic reports will be issued on all 5 projects in 1979.

By the end of 1978, plans were well under way to orient the 1979 drilling effort to conform to the 116 quadrangle program by identifying 9 new projects in favorable resource areas and to provide drilling support for the newly established geologic studies of world-class deposits and intermediate-grade resources.

Two technology applications drilling projects were initiated in 1978 in support of the "halo" or "near-miss" integrated exploration systems program being carried out by Bendix in the Copper Mountain and the Red Desert test areas in Wyoming.

To provide additional in-house capacity for specialized logging on NURE drilling projects, including KUT gamma-ray spectrometer logs and magnetic-susceptibility logs, Bendix added an operational logging system to 2 already in the field. In addition, 2 more operational systems were requisitioned for delivery early in 1979.

To focus the geologic studies program on 2 areas of DOE task force concern, Bendix and its subcontractors will concentrate on world-class deposits and intermediate-grade resources. A number of geologic studies, started in 1977 and relating to nonsandstone geologic environments found in other parts of the world, were completed, with reports either published or due to be published early in 1979. Noteworthy among these were the studies on calcretes, Proterozoic metamorphics, volcanic sediments, and alkaline rocks. During 1978, world-class studies were started on Precambrian quartz-pebble conglomerates and identification of geologic environments in the United States which may offer uranium potential in nonsandstone environments.

The low-grade resource study on Chattanooga Shale, started in 1977, was completed during the year, with the final report to be open filed in 1979. In addition, subcontractors started resource studies in 1978 to determine the potential of phosphate and seawater as uranium sources.

During the initial phase of the quadrangle evaluation program, it was determined that only 187 of the 621 National Topographic Map Series (NTMS) quadrangles for the United States had geologic maps scaled 1:250,000. To furnish the remaining 434 geologic maps for use as data bases to all NURE program elements, 185 map compilations were subcontracted, with 104 completed maps delivered in 1978.

Technology applications projects during 1978 resulted in the construction in Grand Junction of 18 new calibration borehole models for neutron-fission and KUT gamma-ray spectral logging systems, and the modification of 6 models at field locations to accommodate extended length gross gamma-ray logging probes. In addition, 5 models were constructed and installed in Grand Junction for calibrating and testing portable surface gamma-ray spectrometers. These new models are a significant addition to DOE's calibration and standardization program for uranium resource data. In-situ mining techniques and the growing importance of lower grade resources have improved cost effectiveness of fission logging and KUT logging procedures in directly measuring the uranium ore grade of boreholes.

The Arizona dynamic test range and the Grand Junction airport calibration facility, put into operation in 1977, proved very effective during 1978 in standardizing data obtained from aerial radiometric surveying subcontractors. A second dynamic test range, now under development, will provide increased data for improved standardization and calibration of airborne systems. These test and calibration facilities made possible the establishment of a specialized group responsible for development of new techniques for, and the actual monitoring of, the airborne subcontractors' data quality and data reduction procedures. A second specialized group, the Aerial Interpretation Task Force, was formed to develop new methods of interpretation of aerial survey data and to demonstrate such data applicability to the quadrangle evaluation program.

Field testing of fast and delayed fission neutron borehole logging systems, developed under DOE sponsorship, continued during 1978 and culminated in a coordinated testing program at a site where the ore grade in the boreholes had been well-established by core analysis.

In order to get a comparison among the fission neutron systems and available direct assay logging systems, these same test site boreholes were logged by the Bendix KUT system and a U.S. Bureau of Mines-developed intrinsic germanium probe. The results of these comparison tests will be published in 1979.

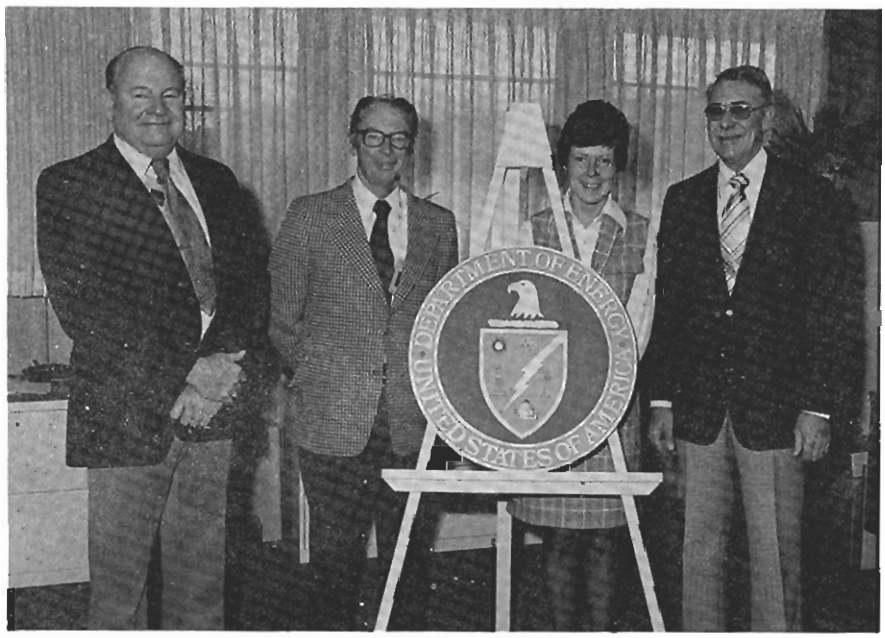
In addition to the field testing of fission neutron probes, significant progress was made on other specialized probe systems. Noteworthy was the effort to adapt DOE-developed magnetic susceptibility and KUT gamma-ray spectrometry probes to the new operational computer-based logging systems. Other exploration technique programs realized significant milestones: the optical data transmission project produced a functional fiber-optic logging cable; the ruggedized radon emanometer subcontractor delivered 16 instruments; the electronically equipped R&D logging vehicle was delivered, and field work was initiated using it; the radon calibration unit was delivered and put into operation; and high-resolution seismic surveying was established as a cost-effective method of minimizing the number of drill holes needed in the exploration

for uranium in sandstone-type environments.

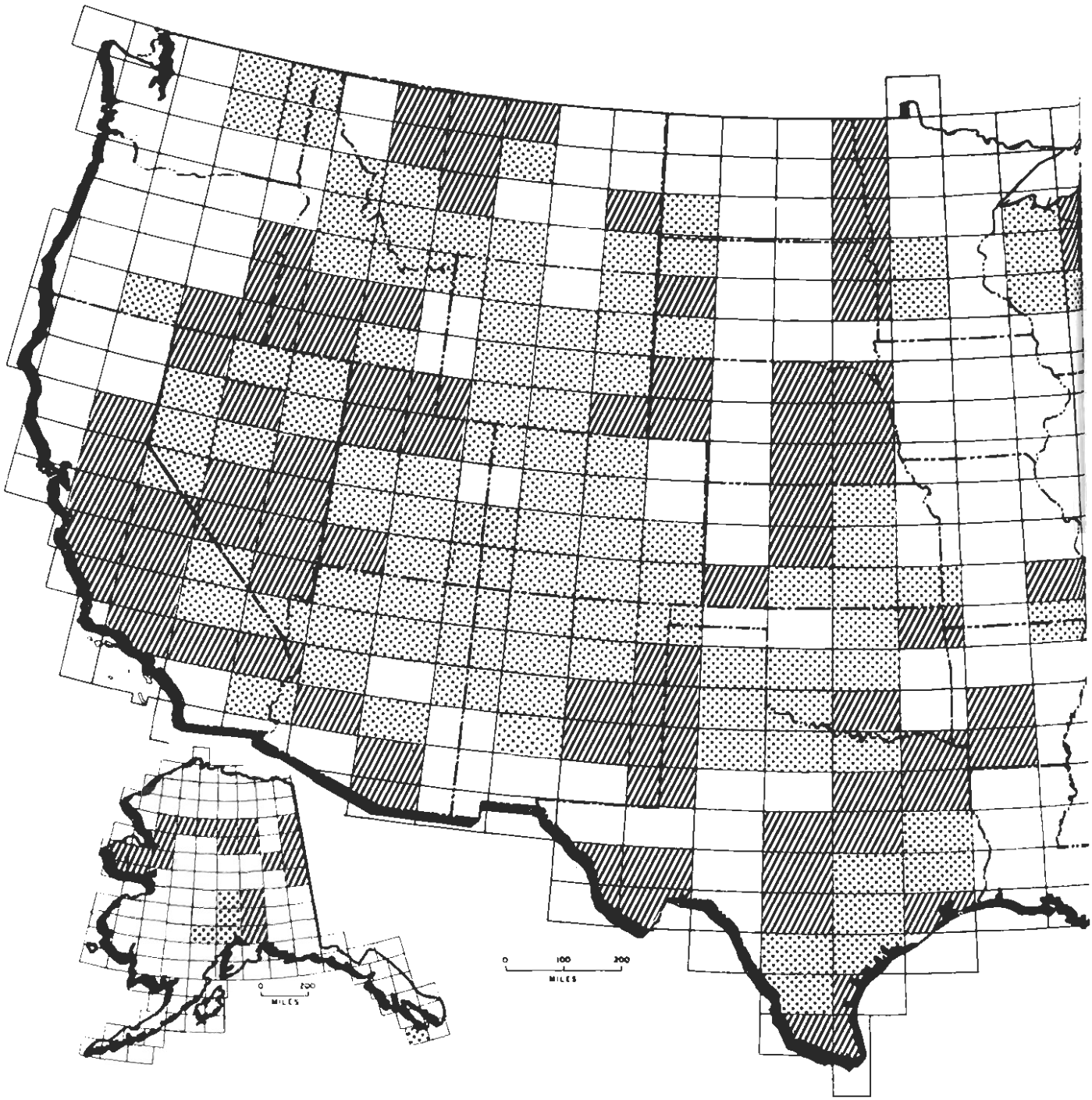
Exploration systems work was concentrated in the Red Desert, Copper Mountain, and Spokane Mountain test areas. Several techniques were used in these areas of known uranium mineralization to measure—above the ground, on the surface, and below the surface—such uranium indicators as radon, helium, argon, and KUT gamma rays, and to determine trace elements and uranium content from soil and core samples. Technical presentations were made on the analysis of preliminary data from the sites; final reports will be issued in 1979 on the integrated interim results.

Dissemination of information on the NURE program resulted in the publication and open filing of 143 project and program reports, 207 trace element memorandums, 95 trace element investigations, and some 27 other miscellaneous reports, as well as the issuance of 140 news releases. The technical program resulted in the presentation of 41 papers by the Bendix staff at professional society meetings and specialized symposiums. In March 1979, the CDC 6600 was installed as the new central on-site computer, replacing the CDC 3100. A remodeling project to house the DOE Grand Junction Technical Library was completed in May 1979.

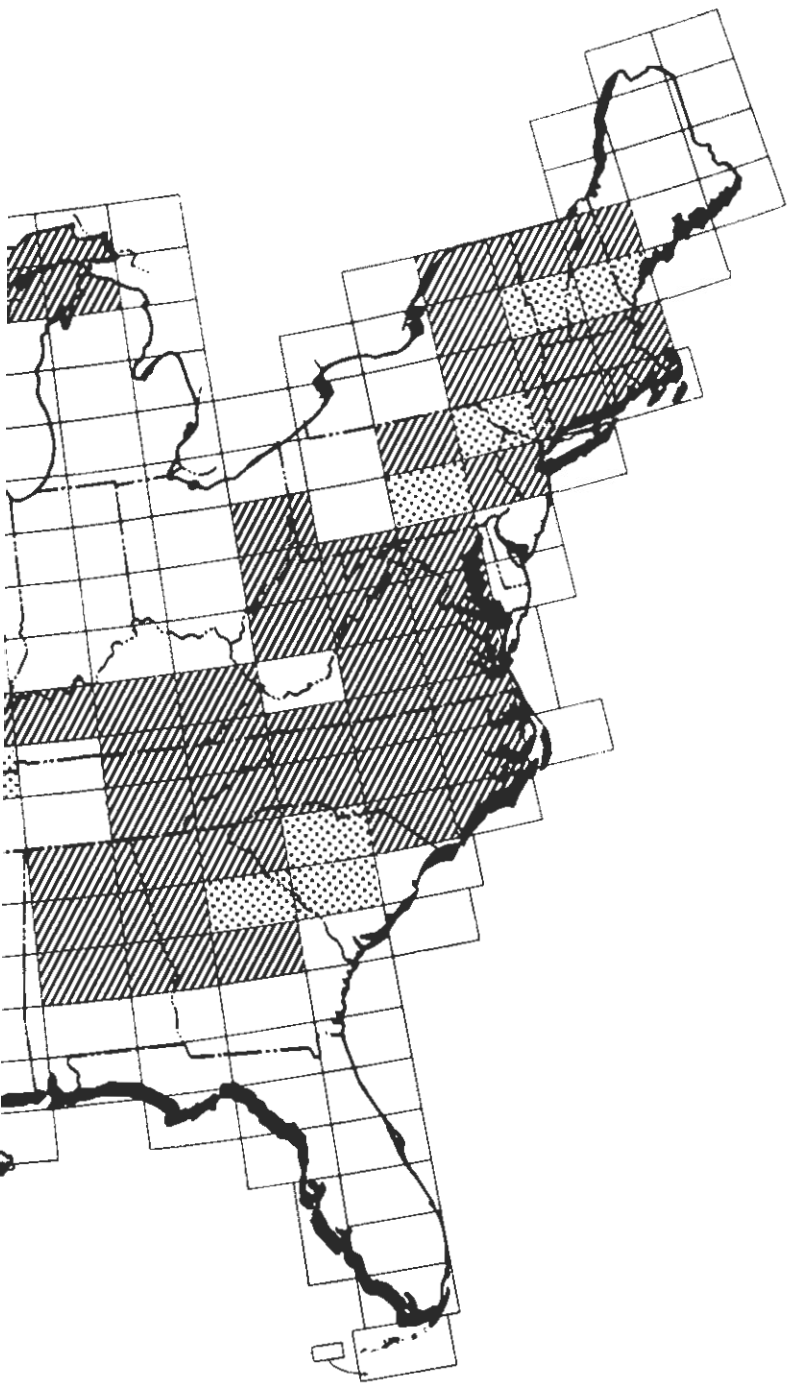
Dr. Donald Everhart, newly appointed DOE-GJO manager (center, standing), and DOE and BFEC officials inspect the CDC 6600 on-site computer. Below, DOE-GJO Manager Eugene Grutt (left), who retired in 1978, and assistant managers look over a bas-relief of the DOE seal with a Bendix graphic artist (second from right).



LOCATION AND ASSESSMENT SCHEDULE OF 272 "A" QUADRANGLES



Quadrangle Evaluation



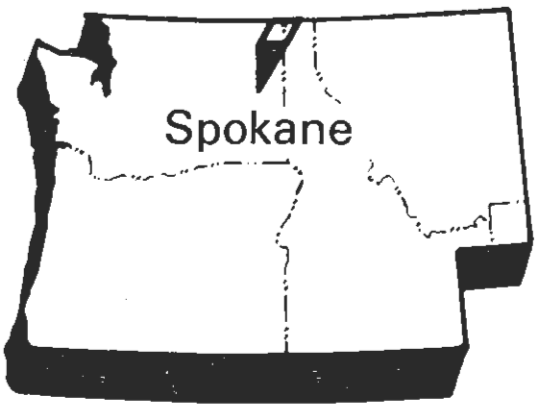
Quadrangle evaluation, the field examination of geologic features and the final interpretation and utilization of data obtained by various subprograms is the responsibility of the field geology team. To accomplish part of this work, Bendix has established field offices in Anchorage, Alaska; Spokane, Washington; Reno, Nevada; Casper, Wyoming; Grand Junction, Colorado; Albuquerque, New Mexico; Austin, Texas; Atlanta, Georgia; and Pittsburgh, Pennsylvania, with an average of 10 geologists per field office. Organizations having specific knowledge of the geology of certain quadrangles are encouraged to participate in the evaluation work. A joint working agreement was made between DOE and the USGS, and subcontracts were issued to several state geologic surveys and private firms. The 116 priority quadrangles to be evaluated before October 1980 are assigned as follows: USGS, 23; state geologic surveys, 14; private subcontractors, 36; and Bendix, 43. All quadrangle-evaluation studies are directed and monitored by Bendix.

"A" quadrangles (116) to be completed by the end of FY 1980.

"A" quadrangles (156) to be completed by the end of FY 1983.

Spokane Field Office

Bendix geologists of the Spokane field office are responsible for conducting geologic investigations in Washington and Oregon, much of Idaho, western Montana, and extreme northwestern Wyoming. In addition to completing 2 preliminary studies during the year, evaluations continued or were started on 6 quadrangles. Evaluations of 9 additional quadrangles were begun early in 1978, and a mapping project was completed by Bendix subcontractors. Work on the Choteau Quadrangle, under investigation by the USGS, was recessed in 1978.



Quadrangle Evaluation (BFEC)

Bendix geologists continued investigations of the Sandpoint, Spokane, and Okanogan quadrangles, which are scheduled to be completed in 1979, and the Challis Quadrangle, which will be finished early in 1980. In addition, planning activities are now under way for the Ritzville and Klamath Falls quadrangles.

Sandpoint Quadrangle

- Start Date: 3 October 1977
- Completion Date: 16 July 1979

Environments that appear favorable for uranium include granitic plutons and associated veins of Cretaceous and Tertiary age, fluvial sandstones of Tertiary age that are similar to the host rocks of the Sherwood Mine in the Ritzville Quadrangle to the southwest, and Precambrian meta-argillites near quartz monzonite intrusives.

Spokane Quadrangle

- Start Date: 1 November 1977
- Completion Date: 29 June 1979

The principal targets under investigation are metasedimentary rocks of Precambrian age, alaskite-bearing quartz monzonite plutons of Cretaceous age, and Tertiary sedimentary rocks that are interbedded with basalt fissure flows of the Columbia River Plateau.

Okanogan Quadrangle

- Start Date: 3 October 1977
- Completion Date: 30 November 1979

Uranium occurrences associated with a gneiss dome in the eastern part of the quadrangle may be in metamorphic differentiates that formed in zones of cataclastic deformation at contacts between major metamorphic rock types. Focus of attention is on this environment. Secondary targets include fluvial and volcanogenic deposits of Tertiary age.

Challis Quadrangle

- Start Date: 3 October 1977
- Completion Date: 29 February 1980

Uranium is known to occur in the Idaho batholith, as well as in arkosic rocks of Tertiary age adjacent to the contact between the Challis Volcanic Group and the batholith. These types of occurrences are being sought elsewhere in the quadrangle, and the Challis Group is being investigated for uranium potential elsewhere in the volcanic succession.

Ritzville Quadrangle

- Start Date: 15 November 1978
- Completion Date: 30 April 1980

Uranium is produced from the Midnite Mine in the northeastern part of the quadrangle, where uraninite occurs in and near the contact of metasedimentary rocks with granitic intrusive rocks. Similar environments are found elsewhere in the quadrangle. Sedimentary rocks interbedded with Columbia River basalts may be favorable for the occurrence of uranium.

Klamath Falls Quadrangle

- Start Date: 15 November 1978
- Completion Date: 30 May 1980

The Lakeview Mine is located in the southwestern part of this quadrangle, where uranium mineralization is found in Tertiary lacustrine strata that are partly tuffaceous. The focus of the investigations will be on rhyolite intrusive domes and plugs with which, some investigators believe, the mineralization is associated.

Quadrangle Evaluation (Subcontractor)

Pocatello Quadrangle

- Subcontractor: C. S. Robinson & Associates, Inc.
- Subcontract Value: $172,200
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

The Pocatello Quadrangle is in southern Idaho, where uranium reportedly occurs in shales and lignites of the Salt Lake Formation of Tertiary age. The uranium may have been derived from a granitic pluton in the quadrangle. Metamorphic rocks in the Albion Range, where vein-type sulfide deposits with anomalous radioactivity have been reported, are of further interest; and the Permian

Phosphoria Formation may have potential for uranium concentrations.

Lewistown Quadrangle

- Subcontractor: C. S. Robinson & Associates, Inc.
- Subcontract Value: $172,200
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

The Lewistown Quadrangle is in north-central Montana. Favorable igneous and metamorphic environments, where hydrothermal uranium deposits may occur in veins or in contact-metamorphic zones, include the Judith Mountains, southern Bearpaw Mountains, and the Little Rocky Mountains. Several sedimentary formations in the Judith Basin may be favorable for epigenetic sandstone-type uranium deposits.

Elk City Quadrangle

- Subcontractor: Salisbury & Dietz, Inc.
- Subcontract Value: $277,500
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

In the Elk City Quadrangle, portions of the Idaho batholith are anomalously high in primary uranium, and the Challis Volcanic Group, especially sedimentary portions, may be favorable for uranium deposits.

Hamilton Quadrangle

- Subcontractor: Salisbury & Dietz, Inc.
- Subcontract Value: $252,200
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

Granite pegmatites and quartz veins associated with the Idaho batholith in the Hamilton Quadrangle appear to favor uranium deposits. Portions of the Precambrian Belt Supergroup that are adjacent to the batholith, particularly the Wallace Formation, may provide chemical and (or) structural traps for uranium concentration. In addition, Tertiary sedimentary formations in intermontane basins are potentially favorable.

Butte Quadrangle

- Subcontractor: Salisbury & Dietz, Inc.
- Subcontract Value: $210,900
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

Uranium occurrences have been reported in a wide variety of rock types and environments in the Butte Quadrangle. Intrusive masses such as the Boulder and Idaho batholiths, volcanogenic materials, and sedimentary deposits in Tertiary basins are all targets for investigation.

Dillon Quadrangle

- Subcontractor: GeoExplorers Associates, Inc.
- Subcontract Value: $217,500
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

Geologic environments that appear to warrant attention in the Dillon Quadrangle, in Montana and Idaho, include silicic units within Tertiary volcanics, veins in Mesozoic and Tertiary plutons, Tertiary strata in intermontane basins, and phosphatic strata of late Paleozoic age.

Dubois Quadrangle

- Subcontractor: GeoExplorers Associates, Inc.
- Subcontract Value: $216,500
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

In the Dubois Quadrangle, which covers parts of Montana and Idaho, attention is to be focused on Tertiary volcanogenic rocks and on Tertiary arkosic sandstones and conglom-

Geologists from the Spokane field office conduct stream-sediment sampling in the Sandpoint Quadrangle.

erates in intermontane basins. In addition, the thrust-fault contact between Precambrian granite gneiss and the underlying Madison Limestone may be favorable.

Bozeman Quadrangle

- Subcontractors: University of Montana
  Montana State University
- Total Subcontracts Value: $175,500
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

The Bozeman Quadrangle investigation focuses on calc-alkaline intrusives in the Crazy Mountains, silicic intrusives and tuffs in the Independence mining district, and Tertiary sedimentary rocks in the Three Forks Basin, all of which appear to be favorable for uranium. Selected portions of the Yellowstone volcanics, intrusives in the Cooke City area, and several Precambrian units may also be favorable.

Ashton Quadrangle

- Subcontractor: Meiiji Resource Consultants
- Subcontract Value: $187,900
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

Promising environments in the Ashton Quadrangle appear to be portions of the Permian Phosphoria Formation, particularly the Meade Peak and Retort members. Other environments targeted for study include channel-type sandstones enclosed by volcanic flows and tuffs of the Yellowstone volcanics and Tertiary strata in the Centennial and Madison River basins.

Other Projects

Latah Formation, Washington and Idaho

The Latah Formation, composed of fluvial and lacustrine materials interbedded with Columbia River basalts, was investigated by Bendix geologists as a possible host for uranium deposits. Results were open filed in July 1978 as GJBX-75(78).

Northeastern Washington and Northern Idaho Pluton

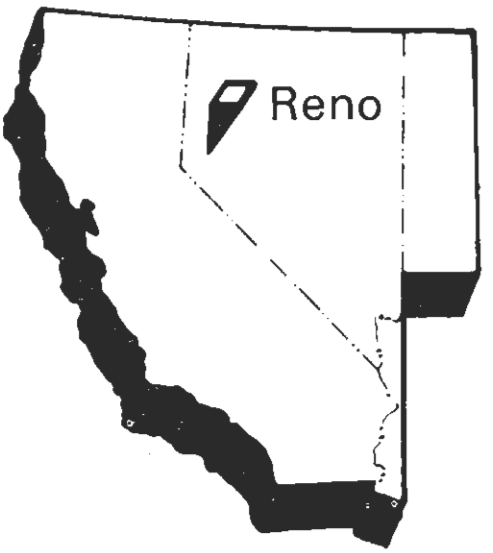
Cretaceous and Early Tertiary granitic intrusives were sampled by Bendix geologists to determine uranium and thorium content. A final (revised) report was open filed in September 1978 as GJBX-89(77)R.

Challis Volcanics

- Subcontractor: University of Idaho
- Subcontract Value: $40,500
- Start Date: 9 May 1977
- Completion Date: 5 May 1978

The University of Idaho, under a contract with Bendix, investigated the Basin Creek area northeast of Stanley, Idaho. Work consisted chiefly of detailed mapping of the Challis Volcanic Group, including its contact with the underlying Idaho batholith. Uranium is known to occur in the batholith and in sedimentary rocks of Tertiary age adjacent to the contact between the batholith and the Challis volcanics in the Stanley Basin. The chief purposes of the investigation were to complete the geologic map coverage of the area and to assess the potential for uranium-bearing formations at the base of the Challis volcanics. The project was completed in Septemeber 1978, and results were open filed as GJBX-33(79).

Reno Field Office



Geologists from the Reno field office conducted investigations in Nevada, California, western Utah, and extreme southwestern Arizona. A report based on an earlier study was completed during 1978, but the principal effort was on quadrangle evaluations. In addition to work conducted by Bendix, several quadrangle evaluation projects were undertaken by subcontractors, state surveys, and the USGS.

Quadrangle Evaluation (BFEC)

Investigations continued or were begun on 9 quadrangles that lie chiefly in the Great Basin. Four of these quadrangles, Goldfield, Tonopah, Winnemucca, and Vya, are not included in the 116 quadrangle program, and work on them has been postponed pending completion of the priority quadrangles.

Millett Quadrangle

- Start Date: 3 October 1977
- Completion Date: 31 January 1980

Death Valley Quadrangle

- Start Date: 3 January 1978
- Completion Date: 31 January 1980

Reno Quadrangle

- Start Date: 2 October 1978
- Completion Date: 30 May 1980

Wells Quadrangle

- Start Date: 2 October 1978
- Completion Date: 30 May 1980

Salton Sea Quadrangle

- Start Date: 2 October 1978
- Completion Date: 30 May 1980

Planning tasks were completed for all these quadrangles, and field work is under way on all but the Wells

Quadrangle. Because these quadrangles encompass areas in the Great Basin, the principal targets that appear to be favorable for uranium resources are similar. Uranium has been reported in silicic volcanogenic rocks, in granite plutons, in metamorphic rocks intruded by granitic rocks, and in sedimentary deposits that fill intermontane basins. Because of recent discoveries at the McDermitt caldera in northern Nevada, special emphasis is being placed on caldera complexes, as well as on ash-flow sheets associated with them. The quadrangles also contain geologic environments that closely resemble the region around the Peña Blanca uranium deposits in Chihuahua, Mexico.

A Reno office geologist uses a portable scintillometer.

Quadrangle Evaluation (Subcontractor)

McDermitt Quadrangle

- Subcontractor: Nevada Bureau of Mines and Geology
- Subcontract Value: $193,400
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

Uraniferous volcanogenic rocks associated with the McDermitt caldera are presently being explored by mining companies in this quadrangle, located in northern Nevada. Elsewhere in the quadrangle, tuffaceous sedimentary rocks are found in environments favorable for the formation of supergene uranium deposits.

Trona Quadrangle

- Subcontractor: California Division of Mines and Geology
- Subcontract Value: $170,100
- Start Date: 14 April 1978
- Completion Date: 2 May 1980

The Trona Quadrangle is located in California's Mojave Desert. The principal targets for potential uranium deposits are the sedimentary rocks of Tertiary and Quaternary ages present in basins adjacent to volcanic and granitic source rocks.

Lovelock Quadrangle

- Subcontractor: Berge Exploration, Inc.
- Subcontract Value: $187,800
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

The Lovelock Quadrangle exploration in Nevada revealed uranium deposits in rocks of the Hartford Hill rhyolite group and in metamorphic rocks associated with granitic intrusions in the Nightingale Mountains. Similar environments are anticipated in other parts of the quadrangle. Basin-fill sedimentary deposits, such as in Winnemucca Dry Lake, are also prime targets for investigation.

Elko Quadrangle

- Subcontractor: Uranium Services Co:
- Subcontract Value: $157,900
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

The Elko Quadrangle is located in northeastern Nevada. Large quantities of tuffaceous sedimentary rocks of Tertiary age, possible host rocks for uranium, are present in intermontane basins adjacent to silicic volcanogenic and granitic rocks in fault-block mountains.

Quadrangle Evaluation (USGS)

The USGS, under an interagency agreement with DOE, was engaged in uranium resource evaluation of 3 quadrangles in the Reno region in 1978—the Walker Lake, Delta, and Richfield quadrangles. Investigations of 2 other quadrangles, Tooele and Las Vegas, were recessed for higher priority work.

Walker Lake Quadrangle

- Start Date: 23 January 1978
- Completion Date: 31 January 1980

This quadrangle encompasses 2 very different geologic environments: the Great Basin and the Sierra Nevada mountain range. Paleostream channels cut in granitic rocks of the Sierra Nevada batholith and capped by silicic volcanic rocks are favorable host rocks in the western part of the quadrangle. In the eastern section, large quantities of sedimentary rocks of Tertiary and Quaternary age occur in basins adjacent to favorable source rocks.

Delta Quadrangle

- Start Date: 23 January 1978
- Completion Date: 31 January 1980

The Spor Mountain area in the Delta Quadrangle contains numerous uranium occurrences that are associated principally with beryllium-bearing rhyolite flows and ash-flow tuffs. The Yellow Chief uranium mine, in a fluvial-sandstone host rock, is in this quadrangle.

Richfield Quadrangle

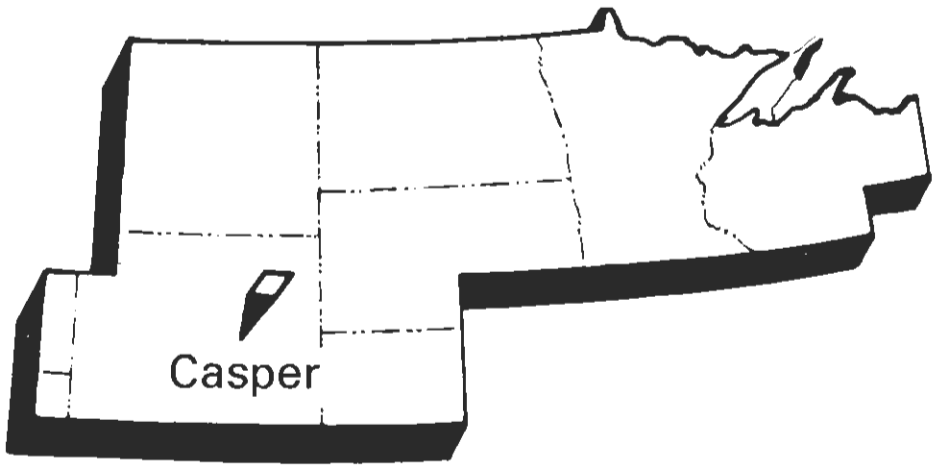
- Start Date: 23 January 1978
- Completion Date: 29 February 1980

In the Richfield Quadrangle, the Marysvale area has produced uranium in association with silicic volcanic rocks. Similar rock units are found throughout the quadrangle. Rocks of Paleozoic age in the Wah Wah and Needles ranges are also targets for study.

Other Projects

Central Mojave Desert

This preliminary study by Bendix focused on Mesozoic intrusive and Tertiary volcanic and sedimentary rocks, which were examined and sampled to determine favorability for uranium deposits. Results were open filed in April 1978 as GJBX-24(78).



Casper Field Office

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

In 1978, the Casper office used surface and subsurface investigations, followup investigations of aerial radiometric surveys, and hydrogeochemical and stream-sediment sampling programs in these studies.

Quadrangle Evaluation (BFEC)

This regional office was engaged in resource evaluation in a total of 8 quadrangles. Studies continued throughout the year on the Casper and Rawlins quadrangles and will be completed in 1980. Preliminary studies and initial field work on the Marquette, Iron Mountain, and Cheyenne quadrangles will be resumed upon completion of the 116 priority quadrangles. Preliminary study was begun on 3 priority quadrangles, Arminto, Lander, and Thermopolis, to be completed in 1980.

Casper Quadrangle

- Start Date: 3 October 1977
- Completion Date: 31 December 1979

Rawlins Quadrangle

- Start Date: 3 October 1977
- Completion Date: 29 February 1980

Arminto Quadrangle

- Start Date: 2 October 1978
- Completion Date: 31 March 1980

Thermopolis Quadrangle

- Start Date: 2 October 1978
- Completion Date: 31 March 1980

Lander Quadrangle

- Start Date: 2 October 1978
- Completion Date: 31 March 1980

These quadrangles are located in Wyoming. The geologic framework is basically that of Laramide uplifts with Precambrian cores, separated by basins with thick sections of Tertiary rocks. The mountain ranges include the Wind River, Owl Creek, and Granite Mountains, and parts of the Sierra Madre, Medicine Bow, Laramie, and Big Horn ranges. The basins include the Wind River Basin; the Hanna Basin; and parts of the Shirley, Laramie, Washakie, Red Desert, Big Horn, Powder River, and Green River basins. The Crooks Gap, Gas Hills, Shirley Basin, and Copper Mountain uranium districts lie within this quadrangle.

Resource evaluation will concentrate on the sandstone environment, which contains most of the reserves. Other promising environments include quartz-pebble conglomerates, and unconformity-related vein-type deposits.

Marquette and Iron Mountain Quadrangles

Studies of the Marquette and Iron Mountain quadrangles were begun in 1977. These studies were placed in abeyance at the end of the field season and will be resumed upon completion of work on priority quadrangles in 1980. The quadrangles lie mainly within the southern Canadian Shield, which contains major deposits in Canada. Geologic environments similar to those of the Canadian Shield in Canada, such as unconformity-related vein-type deposits and quartz-pebble conglomerates, are being evaluated. Extensive Pleistocene glacial deposits complicate the evaluation.

Quadrangle Evaluation (Subcontractor)

Ashland Quadrangle

- Subcontractor: Derry, Michener & Booth
- Subcontract Value: $191,700
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

Rice Lake Quadrangle

- Subcontractor: Derry, Michener & Booth
- Subcontract Value: $189,200
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

Eau Claire Quadrangle

- Subcontractor: Golder Associates, Inc.
- Subcontract Value: $193,700
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

Green Bay Quadrangle

- Subcontractor: Golder Associates, Inc.
- Subcontract Value: $194,700
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

These 4 quadrangles lie in the southern Canadian Shield. As in the Marquette and Iron Mountain studies, extensive Pleistocene glacial deposits complicate evaluation of the sequence of Cambrian and Precambrian units in bedrock. Potentially favorable environments being investigated are primarily in Precambrian rocks related to unconformities, which may resemble environments of large deposits in Canada and Australia.

Billings Quadrangle

- Subcontractor: Morris & Warchola
- Subcontract Value: $171,900
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

In the basins in this quadrangle, fluvial-sandstone units of Tertiary, Cretaceous, and Jurassic age appear to be favorable for uranium. In the Pryor Mountain District, uranium has been produced from paleokarst deposits developed on the Mississippian Madison Formation.

Cody Quadrangle

- Subcontractor: Garrand Corp.
- Subcontract Value: $185,400
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

The favorable environments in the Cody Quadrangle include marginal-marine and fluvial sandstones of Tertiary, Cretaceous, and Jurassic age, and paleokarst zones in the Madison limestone.

Rock Springs Quadrangle

- Subcontractor: Morris & Warchola
- Subcontract Value: $159,500
- Start Date: 1 February 1978
- Completion Date: 15 February 1980

This quadrangle includes the Rock Springs uplift and parts of the Green River and Washakie basins, where fluvial sands of Tertiary and Cretaceous age are the primary favorable environments.

St. Cloud Quadrangle

- Subcontractor: Minnesota Geological Survey
- Subcontract Value: $158,700
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

New Ulm Quadrangle

- Subcontractor: Minnesota Geological Survey
- Subcontract Value: $162,700
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

The St. Cloud Quadrangle lies within the southern Canadian Shield, as does part of the New Ulm Quadrangle. Another section of the New Ulm Quadrangle, where Cretaceous rocks overlie Precambrian rocks, is in the Great Plains province. Unconformities between the Cretaceous and the Precambrian, between the Cambrian and the Precambrian, and within the Precambrian section may resemble environments in which unconformity-related deposits are found in Canada and Australia.

Quadrangle Evaluation (USGS)

The USGS, under an interagency agreement with DOE, was engaged in uranium resource evaluation of 5 quadrangles in the Casper region in 1978. Four of these, Ekalaka, Gillette, Newcastle, and Torrington, will be completed in 1980. Work on a fifth, Iron River, has been suspended until completion of priority quadrangles.

Ekalaka Quadrangle

- Start Date: 3 January 1978
- Completion Date: 29 February 1980

Gillette Quadrangle

- Start Date: 23 January 1978
- Completion Date: 31 March 1980

Torrington Quadrangle

- Start Date: 20 January 1978
- Completion Date: 31 March 1980

Newcastle Quadrangle

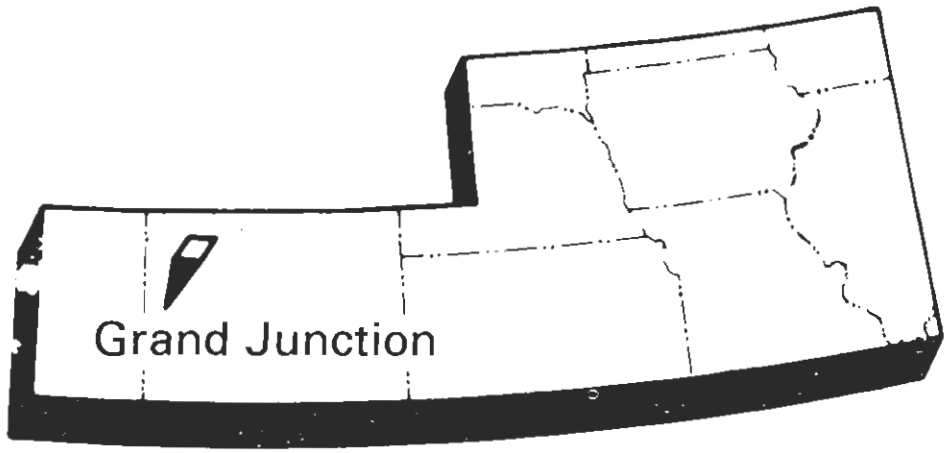
- Start Date: 1 February 1978
- Completion Date: 31 March 1980

These quadrangles encompass the eastern part of the Powder River Basin and the western flank of the Black Hills. Resource evaluation is being concentrated on fluvial and estuarine sands of Cretaceous and Tertiary age.

Iron River Quadrangle

Work in this quadrangle in the southern Canadian Shield was directed primarily at evaluation of the favorability of unconformity and vein environments in the Precambrian rocks. Work has been suspended on this quadrangle.

A geologist assigned to the Grand Junction field office samples a radioactive formation in southeastern Colorado.



Grand Junction Field Office

The area of general responsibility of the Bendix Grand Junction office includes eastern Utah, Colorado, Kansas, Iowa, most of Nebraska, Missouri, and Illinois; and parts of South Dakota, Minnesota, Wisconsin, and Kentucky. The work of Bendix geologists was concentrated in Colorado in 1978 in evaluating 5 quadrangles to determine areas favorable for uranium occurrence. Surface and subsurface geologic studies and followup studies of aerial radiometric surveys and hydrogeochemical and stream-sediment sampling programs form the general outline of investigation.

Quadrangle Evaluation (BFEC)

Four quadrangles in diverse geologic settings were investigated in 1978. Preliminary work was begun on a fifth quadrangle, Trinidad.

Durango Quadrangle

- Start Date: 3 October 1977
- Completion Date: 31 December 1979

Montrose Quadrangle

- Start Date: 3 October 1977
- Completion Date: 31 December 1979

A variety of geologic environments favorable for uranium are found in these quadrangles. These environments include caldera systems in the Tertiary volcanics of the San Juan Mountains, vein systems related to faults and fractures in Precambrian and Paleozoic sedimentary rocks, and sandstone. Work on these quadrangles is scheduled to be completed late in 1979.

Lamar Quadrangle

- Start Date: 3 October 1977
- Completion Date: 30 May 1979

La Junta Quadrangle

- Start Date: 1 April 1978
- Completion Date: 16 March 1979

These quadrangles lie in the Great Plains. Continental sandstones in Jurassic, Triassic, and Pennsylvanian-Permian sediments are the principal favorable environments recognized in the quadrangles. These studies will be completed in 1979.

Trinidad Quadrangle

- Start Date: 2 October 1978
- Completion Date: 31 March 1980

This quadrangle, scheduled for completion early in 1980, includes several favorable uranium environments, such as Tertiary valley fill in the San Luis Valley, Precambrian crystalline and associated Pennsylvanian-Permian arkoses of the Sangre de Cristo Range, and Tertiary fluvial clastics of the Raton Basin and Huerfano Park. The evaluation is scheduled for completion in 1980.

Quadrangle Evaluation (Subcontractor)

Leadville Quadrangle

- Subcontractor: Colorado Geological Survey
- Subcontract Value: $185,800
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

Many potentially favorable environments are represented in the Leadville Quadrangle, including the uplifts of the Colorado Rockies, the Pennsylvanian Beldon Basin, and part of the Piceance Basin.

Quadrangle Evaluation (USGS)

Ten quadrangles in Colorado and Utah within the Grand Junction region are being evaluated by the USGS under an agreement with DOE. Work on the Rolla and Paducah quadrangles was recessed in 1978. These studies are scheduled for completion in 1980.

Greeley Quadrangle

- Start Date: 23 January 1978
- Completion Date: 29 February 1980

Denver Quadrangle

- Start Date: 23 January 1978
- Completion Date: 29 February 1980

Pueblo Quadrangle

- Start Date: 30 January 1978
- Completion Date: 29 February 1980

The Colorado Front Range, in the western parts of the quadrangles, has favorable environments for uranium resources in vein-type deposits and sandstone deposits in Tertiary volcaniclastic sediments. The Denver Basin in the eastern parts of the quadrangles may offer uranium deposits in fluvial and marine sandstones of Cretaceous and Tertiary age.

Vernal Quadrangle

- Start Date: 23 January 1978
- Completion Date: 29 February 1980

Craig Quadrangle

- Start Date: 23 January 1978
- Completion Date: 29 February 1980

North Park Basin, Sand Wash Basin, and parts of the Piceance and Uinta basins are located in these quadrangles, with possible favorable environments in Tertiary and Cretaceous sandstones. Uplifts include part of the Front Range, the Gore Range, and the Uinta Mountains.

Moab Quadrangle

- Start Date: 23 January 1978
- Completion Date: 30 April 1980

Cortez Quadrangle

- Start Date: 23 January 1978
- Completion Date: 30 April 1980

Price Quadrangle

- Start Date: 23 January 1978
- Completion Date: 30 April 1980

Salina Quadrangle

- Start Date: 23 January 1978
- Completion Date: 30 April 1980

Escalante Quadrangle

- Start Date: 23 January 1978
- Completion Date: 30 June 1980

These quadrangles contain most of the historic uranium districts of the Colorado Plateau. Continental sandstones of Jurassic, Triassic, and Permian age are the principal targets of the investigations.

Other Projects

Kaiparowits Plateau

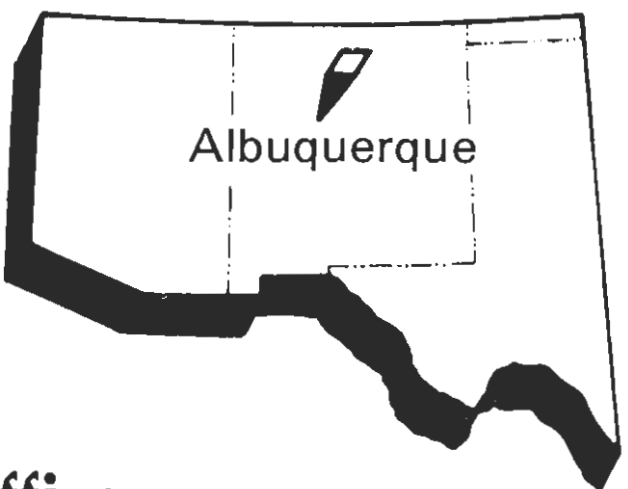
A preliminary investigation was made by Bendix of the Jurassic Morrison and Triassic Chinle formations, both known uranium producers in other areas. The results of this study were placed on open file as GJBX-64(78) in July 1978.

Radioactive Deposits in Colorado

- Subcontractor: Colorado Geological Survey
- DOE Contract
- Start Date: October 1976
- Completion Date: 31 December 1978

The Colorado Geological Survey, under direct contract to DOE, conducted an inventory and evaluation of radioactive mineral resources in Colorado. The study provided a complete bibliography and synthesis of all available data on significant radioactive deposits in Colorado, with locations and descriptions. The report was completed in December 1978 and was open filed in 1979 as GJBX-5(79).

A geologist stands atop Mount Belford.



Albuquerque Field Office

Geologists of the Bendix Albuquerque field office are responsible for uranium favorability studies in New Mexico, most of Arizona, West Texas, and the Oklahoma Panhandle. The physiographic provinces represented in this area include parts of the Basin and Range, the Colorado Plateau, the Southern Rocky Mountains, the Great Plains, and the Central Lowlands.

During 1978, Bendix geologists of the Albuquerque office continued uranium resource evaluation work on 3 quadrangles, and the study of 2 additional quadrangles was initiated. One open-file report was issued during the year. The Bendix office monitored a subcontracted study of the geochemistry of the Grants Mineral Belt, New Mexico, which was completed during the year.

Quadrangle Evaluation (BFEC)

Quadrangle evaluation studies continued throughout the year on 3 quadrangles: Kingman, Williams, and Prescott. Initial studies were begun on 2 other priority quadrangles—St. Johns and Mesa.

Kingman Quadrangle

- Start Date: 3 October 1977
- Completion Date: 1 June 1979

Williams Quadrangle
Prescott Quadrangle

- Start Date: 3 October 1977
- Completion Date: 16 July 1979

Uranium resource evaluation work on these quadrangles is scheduled to be completed in 1979. Kingman, Williams, and Prescott quadrangles lie within the Basin and Range province. Tertiary basins alternate with fault-block mountains which expose Precambrian crystalline rocks, Tertiary volcanics, Paleozoic sedimentary rocks, and Cretaceous granites. Williams Quadrangle lies partly within the Colorado Plateau physiographic province, with broad areas of exposure of gently dipping Permian rocks. The Tertiary lake sediments in the basins are the prime focus of the studies, and other possible favorable environments are vein systems in the Precambrian, calcretes of Quaternary age in the basins, and collapse structures in Paleozoic limestones.

St. Johns Quadrangle

- Start Date: 2 October 1978
- Completion Date: 31 March 1980

Evaluation of uranium resources in this quadrangle is scheduled for completion in the spring of 1980. The investigation will be concentrated on fluvial clastic sediments in the Triassic Chinle Formation and the Tertiary Baca Formation, and on marine and marginal-marine sandstones of the Cretaceous Mesa Verde Formation. These units contain occurrences of uranium in anomalous quantities.

Mesa Quadrangle

- Start Date: 2 October 1978
- Completion Date: 31 March 1980

This quadrangle lies partly in the Basin and Range province and partly in the Colorado Plateau province. Some uranium ore was produced from the Precambrian Dripping Springs Quartzite in the 1950's. Other units which may be favorable for uranium deposits are the sandstones of the Pennsylvanian and Permian and lake sediments of Tertiary age.

Nogales Quadrangle

The initial studies in this quadrangle will be resumed upon completion of priority quadrangles. Basin and Range structures of alternating Tertiary basins and mountain ranges of

Cretaceous age and Tertiary rocks predominate in this area.

Quadrangle Evaluation (Subcontractor)

Raton Quadrangle

- Subcontractor: New Mexico Bureau of Mines & Mineral Resources
- Subcontract Value: $191,000
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

Santa Fe Quadrangle

- Subcontractor: New Mexico Bureau of Mines & Mineral Resources
- Subcontract Value: $191,000
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

These quadrangles may offer favorable uranium deposits in the Precambrian crystalline and Permian arkosic rocks of the Sangre De Cristo Range in the southern Colorado Rockies province and in Mesozoic sandstones of the Great Plains.

Dalhart Quadrangle

- Subcontractor: Consulting Professionals, Inc.
- Subcontract Value: $146,700
- Start Date: 1 February 1978
- Completion Date: 1 February 1980

The Dalhart Quadrangle lies in the Great Plains. Geologic environments which may be favorable for uranium are the fluvial and marginal-marine sandstones of the Triassic, Jurassic, and Cretaceous, which underlie most of the quadrangle.

Tularosa Quadrangle

- Subcontractor: Berge Exploration, Inc.
- Subcontract Value: $187,600
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

This quadrangle is located in the Basin and Range province. Potentially favorable geologic environments include vein systems associated with fault zones and fractures in Precambrian rocks; sandstones of the Pennsylvanian, Permian, and Cretaceous; and volcanics of the Tertiary Datil Formation.

Marfa Quadrangle
Presidio Quadrangle
Emory Quadrangle

- Subcontractor: Texas Bureau of Economic Geology
- Subcontract Value: $171,100
- Start Date: 15 August 1978
- Completion Date: 15 February 1980

These quadrangles are in the Big Bend region of Texas, along the Mexico–U.S. border. Geologists of the Texas Bureau of Economic Geology began investigations of the Tertiary volcanic and volcaniclastic rocks and the Tertiary–Quaternary bolson fill deposits. Bendix geologists from the Albuquerque office are evaluating the uranium favorability of the sedimentary rocks of Tertiary, Mesozoic, and Paleozoic age, and of the Tertiary igneous rocks intrusive into Cretaceous sediments.

Quadrangle Evaluation (USGS)

The USGS, under an interagency agreement with DOE, is evaluating the uranium potential of 6 quadrangles in the Albuquerque region. These studies will be completed in 1980.

Albuquerque Quadrangle

- Start Date: 23 January 1978
- Completion Date: 31 March 1980

Aztec Quadrangle

- Start Date: 23 January 1978
- Completion Date: 31 March 1980

Gallup Quadrangle

- Start Date: 23 January 1978
- Completion Date: 31 March 1980

Shiprock Quadrangle

- Start Date: 23 January 1978
- Completion Date: 31 March 1980

Physiographically, these quadrangles are in the Colorado Plateau province. Almost all the San Juan Basin lies within them. The major uranium deposits in the Jurassic sandstones of the Grants Mineral Belt lie on the south flank of the San Juan Basin. The Jurassic units are exposed in the Defiance, Zuni, and Nacimiento uplifts, which bound the basin.

Flagstaff Quadrangle

- Start Date: 23 January 1978
- Completion Date: 31 January 1979

This quadrangle, in the southwestern part of the Colorado Plateau, contains part of the Black River Basin, with broad exposures of Triassic and Permian rocks on the southwest flank of the basin. Sedimentary formations of Permian, Triassic, Jurassic, and Cretaceous age are potentially favorable environments.

Socorro Quadrangle

- Start Date: July 1978
- Completion Date: January 1980

The Socorro Quadrangle is essentially bisected by the Rio Grande trench. Sandstones of Permian, Triassic, and Tertiary age are the principal favorable environments.

Other Projects

Uranium Deposits of the Grants Mineral Belt, New Mexico

- Subcontractor: University of New Mexico
- Subcontract Value: $94,500
- Start Date: 15 September 1976
- Completion Date: 15 September 1978

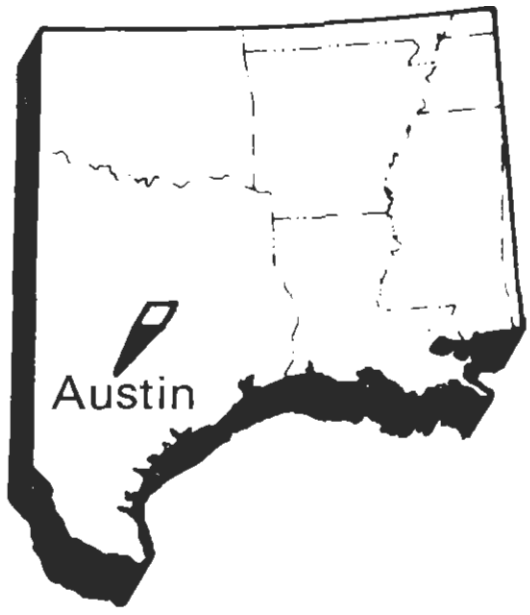
This study is the second phase of an investigation begun in 1975 by the University of New Mexico on aspects of geochemistry, geochronology, and clay mineralogy of uranium deposits in the Grants Mineral Belt. This study was under direct contract with ERDA–GJO, and the results were published as open-file report GJBX–16(76). The second phase, under subcontract to Bendix, was begun late in 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 updip 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.

Results of this study are expected to be placed on open file in 1979.

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 by Bendix to determine the presence and favorability of potential host rocks. The results were placed on open file as GJBX–80(78) in August 1978.



Austin Field Office

This region includes central and eastern Texas; all of Oklahoma except the panhandle; Arkansas, Louisiana, and Mississippi; extreme western Tennessee; and minor portions of southern Missouri and southwestern Kentucky. Bendix geologists worked on 7 quadrangles in the Coastal Plains and High Plains geologic provinces and in the Anadarko Basin–Arbuckle Mountains area during 1978. Sixteen other quadrangles were investigated by subcontractors and state geologic surveys in 5 provinces.

Quadrangle Evaluation (BFEC)

Crystal City Quadrangle

- Start Date: 1 November 1977
- Completion Date: 30 July 1979

Seguin Quadrangle

- Start Date: 3 October 1977
- Completion Date: 29 June 1979

Austin Quadrangle

- Start Date: 1 March 1978
- Completion Date: 31 January 1980

Laredo Quadrangle

- Start Date: 1 November 1978
- Completion Date: 30 May 1980

Beeville Quadrangle

- Start Date: 2 October 1978
- Completion Date: 30 May 1980

Beaumont Quadrangle

- Start Date: 1 November 1978
- Completion Date: 30 May 1980

These quadrangles are located in the Coastal Plains province. Sediments ranging in age from Cretaceous to Recent underlie these quadrangles, with the older rocks to the north and west and younger rocks to the south and east along the coast. Some faulting occurs subparallel to the coastline and is thought to have been significant to the localization of uranium deposits. The South Texas uranium district, centered around Kenedy, Texas, is in rocks of Miocene age. Rocks of Eocene age are also of interest in this area. GJBX–7(78) was released in January 1978 and describes preliminary investigations in the older sediments of the area.

Plainview Quadrangle

- Start Date: 3 October 1977
- Completion Date: 31 January 1979

This quadrangle, which is located in the High Plains province, is underlain at depths less than 5,000 ft (1,524 m) by sedimentary rocks ranging in age from Pennsylvanian to Pleistocene. Units thought to have potential for the occurrence of uranium deposits include the Permo-Pennsylvanian granite wash and associated clastics, whose source was the Wichita Mountains to the northeast; the Dockum Group of Triassic age, considered equivalent to the Chinle Formation of the Colorado Plateau; the Ogallala Formation of Pliocene age, which may contain calcrete-type deposits; and the Tule Formation of Pleistocene age. Uranium deposits are known to occur in the Dockum Group, and radioactive anomalies are known in the Permo-Pennsylvanian units and the Ogallala Formation. Bendix geologists evaluated the Plainview Quadrangle, which has been designated the prototype quadrangle for NURE, and essentially completed the folio in 1978.

Ardmore Quadrangle

The Ardmore Quadrangle includes the Arbuckle Mountains and parts of the Anadarko Basin. Work continued through the 1978 field season before being recessed for higher priority work elsewhere. Granites in the structure constitute an adequate source of uranium, and granite wash in the sediments may include environments favorable for uranium deposits.

Quadrangle Evaluation (Subcontractor)

Palestine Quadrangle

- Subcontractor: Texas Bureau of Economic Geology
- Subcontract Value: $165,300
- Start Date: 31 March 1978
- Completion Date: 31 March 1980

The Palestine Quadrangle lies in the Coastal Plains province. Sediments underlying the quadrangle range in age from Cretaceous to Recent, with older rocks to the north and west and younger rocks along the coast. Faulting may be significant to the localization of uranium deposits.

Amarillo Quadrangle

- Subcontractor: Texas Bureau of Economic Geology
- Subcontract Value: $176,700
- Start Date: 31 March 1978
- Completion Date: 31 March 1980

Lubbock Quadrangle

- Subcontractor: Texas Bureau of Economic Geology
- Subcontract Value: $172,600
- Start Date: 31 March 1978
- Completion Date: 31 March 1980

These quadrangles lie in the High Plains province and are underlain by sedimentary rocks of Pennsylvanian to Pleistocene age. Like the Plainview

Quadrangle, these quadrangles may have uranium occurrences in the Permo-Pennsylvanian granite wash and associated clastics, the Dockum Group of Triassic age, the Ogallala Formation of Pliocene age, and the Tule Formation of Pleistocene age.

Wichita Falls Quadrangle

- Subcontractor: Texas Bureau of Economic Geology
- Subcontract Value: $177,000
- Start Date: 31 March 1978
- Completion Date: 31 March 1980

Sherman Quadrangle

- Subcontractor: Texas Bureau of Economic Geology
- Subcontract Value: $175,300
- Start Date: 31 March 1978
- Completion Date: 31 March 1980

Both these quadrangles are on the south flank of the Wichita–Arbuckle Mountains structure and, in Pennsylvanian and Permian time, received sediments including granite wash from the structure. Granites in the Wichita–Arbuckle structure constitute an adequate source of uranium, and the coarser clastics may form a suitable host for uranium deposits. A preliminary study, GJBX–35(78), was open filed in July 1978.

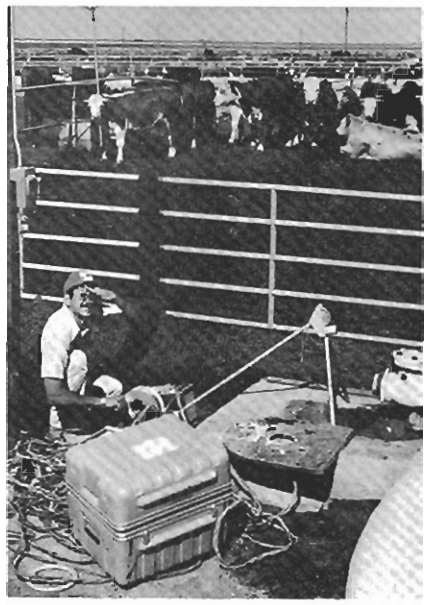
Lawton Quadrangle

- Subcontractor: Oklahoma State University
- Subcontract Value: $166,000
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

Oklahoma City Quadrangle

- Subcontractor: Geological Services of Tulsa
- Subcontract Value: $169,000
- Start Date: 16 March 1978
- Completion Date: 16 March 1980

These 2 quadrangles are on the north flank of the Wichita–Arbuckle Mountains structure and in the Anadarko Basin. They received sediments, including granite wash, from the Wichita–Arbuckle positive area. Granites in the structure constitute an adequate source of uranium, and granite wash in the sediments may be favorable for uranium deposits. The Lawton Quadrangle includes the Wichita Mountains, which contain several radioactive occurrences that may in themselves constitute uranium deposits. A preliminary study, GJBX–111(78), was open filed in October 1978.



A geologist logs a feedlot water well.

Clinton Quadrangle

- Subcontractor: Oklahoma Geological Survey
- Subcontract Value: $169,000
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

Enid Quadrangle

- Subcontractor: Oklahoma Geological Survey
- Subcontract Value: $169,000
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

Joplin Quadrangle

- Subcontractor: Geological Services of Tulsa
- Subcontract Value: $169,400
- Start Date: 16 March 1978
- Completion Date: 16 March 1980

Hutchinson Quadrangle

- Subcontractor: Wichita State University
- Subcontract Value: $149,400
- Start Date: 16 March 1978
- Completion Date: 1 March 1980

Manhattan Quadrangle

- Subcontractor: Wichita State University
- Subcontract Value: $114,600
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

Pratt Quadrangle

- Subcontractor: Wichita State University
- Subcontract Value: $181,200
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

Wichita Quadrangle

- Subcontractor: Wichita State University
- Subcontract Value: $195,800
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

These quadrangles lie across both sides of the Nemaha Ridge, or anticline. The north-trending Nemaha Ridge is composed of Precambrian granitic rocks that supplied sediments for rocks both to the east and west during Paleozoic and Mesozoic times. The clastic sections of the sediments could contain uranium deposits whose source was the granitic rocks of the Nemaha Ridge. Many wells contain water of high radium content, and sections of anomalous radioactivity show on well logs throughout the area.

Dyersburg Quadrangle

- Subcontractor: Geochemex
- Subcontract Value: $121,800
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

Poplar Bluff Quadrangle

- Subcontractor: Geochemex
- Subcontract Value: $121,800
- Start Date: 1 March 1978
- Completion Date: 1 March 1980

These quadrangles are underlain by the Ozark uplift, Nashville dome, and Mississippi embayment. The rocks of primary interest are carbonatites and granitic and pegmatitic rocks of the basement, which occurs at depths less than 5,000 ft (1,524 m) throughout the area. Base- and precious-metal deposits have been mined from the basement rocks and overlying Paleozoic limestones and dolomites for many years. A secondary target is the Cretaceous and later sediments of the Mississippi embayment, which may have environments suitable for the occurrence of uranium deposits similar to those of the Texas Coastal Plain.

Pittsburgh Field Office

Bendix geologists in the Pittsburgh regional office are responsible for geologic investigations in the entire northeastern corner of the United States. In addition to completing a preliminary study this year, the geologists continued work on evaluation of 5 quadrangles.

Quadrangle Evaluation (BFEC)

Harrisburg Quadrangle

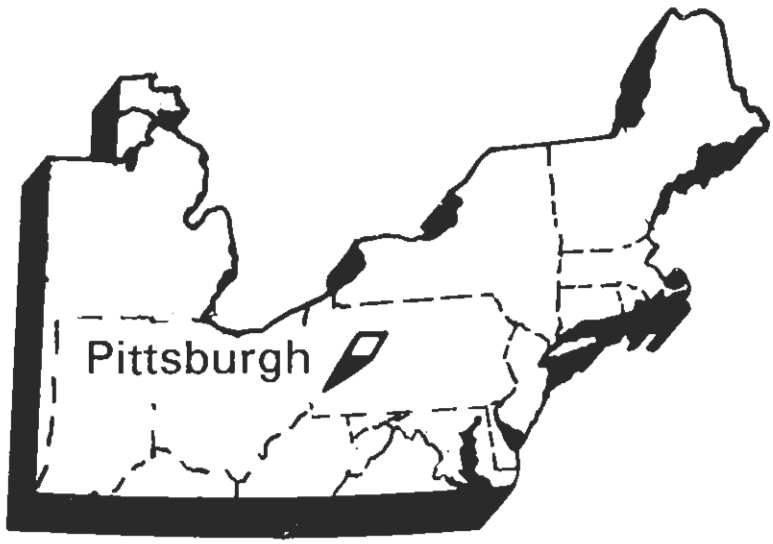
- Start Date: 1 November 1977
- Completion Date: 28 December 1979

Scranton Quadrangle

- Start Date: 1 November 1977
- Completion Date: 30 May 1979

Williamsport Quadrangle

The Catskill Group and Mauch Chunk Formation have long been known to contain significant uranium deposits in these quadrangles. A report released in November 1978, GJBX–46(78), describes several radiometric anomalies and associated uranium occurrences in the Catskill Group of the Scranton Quadrangle.



Precambrian rocks of the Reading Prong contain uranium deposits associated with magnetite deposits in metamorphic rocks. Work on the Williamsport Quadrangle was recessed in October 1978.

Grand Canyon Quadrangle

- Start Date: 1 November 1978
- Completion Date: 29 February 1980

Marble Canyon Quadrangle

- Start Date: 1 November 1978
- Completion Date: 29 February 1980

A team from the Pittsburgh office samples Narragansett granite along the coast in southern Rhode Island.

A geologist records data on sandstone, found ½ mile north of the Newgate Prison Mine in East Granby, Connecticut.

Geologists from the Pittsburgh office have been assigned to these high priority quadrangles because they are experienced in the areas or in the types of rock which occur there. Environments to be evaluated are primarily in Paleozoic and Mesozoic sedimentary rocks which are host rocks for a number of small deposits within the area. Some map work, a literature search, and field reconnaissance were done in this area in 1978 in preparation for full-scale field work in 1979.

Hot Springs Quadrangle

- Start Date: 20 November 1978
- Completion Date: 30 May 1980

The Pittsburgh office also has been assigned to this high priority quadrangle in the Dakota Badlands province. Sediments of Late Cretaceous and Early Tertiary age underlie most of the quadrangle. The Black Hills, intrusive rocks surrounded by sediments of Paleozoic and Mesozoic age, are in the northwest quarter of the quadrangle. The Edgemont, South Dakota, uranium district, active in the 1950's, is in the quadrangle. Some map work, a literature search, and field reconnaissance were done in 1978 in preparation for full-scale field work in 1979.

Albany Quadrangle
Providence Quadrangle

Granite intrusive rocks of Ordovician and later age have intruded and metamorphosed sediments of Cambrian and perhaps older age in the eastern part of the area. Less metamorphosed, Early Paleozoic sediments occur in the western part of the area. A relatively small part of the Triassic Connecticut Basin occurs in the south-central part of the Albany Quadrangle. Many radiometric anomalies occur in metasediments and granitic rocks not associated with known occurrences.

In October 1978, the Albany and Providence investigation was suspended for higher priority work elsewhere.

Quadrangle Evaluation (Subcontractor)

Glens Falls Quadrangle

- Subcontractor: Chiasma Consultants, Inc.
- Subcontract Value: $143,700
- Start Date: 9 February 1978
- Completion Date: 9 February 1980

Portland Quadrangle

- Subcontractor: Chiasma Consultants, Inc.
- Subcontract Value: $143,700
- Start Date: 9 February 1978
- Completion Date: 9 February 1980

Rocks underlying these 2 quadrangles range from the Adirondack structural front on the west to the various plutons of Maine on the east. Uranium concentrations have been reported in basement rocks of the Adirondack Mountains and the Green Mountains anticlinorium. Overlying sedimentary rocks of Early Paleozoic age may contain uranium deposits whose source may have been fluids from the underlying plutonic rocks. Plutons in New Hampshire and Maine contain radioactive dikes and areas of radioactive country rock.

Quadrangle Evaluation (USGS)

The USGS, under an interagency agreement with DOE, was to evaluate the uranium potential of 6 quadrangles in the Pittsburgh region. However, following the DOE Task Force review and program redirection, work was recessed on all these quadrangles.

Newark Quadrangle

This quadrangle contains some rocks of the Catskill Group, but the unit with the most potential for the occurrence of uranium deposits is the Precambrian of the Reading Prong. In the Reading Prong, uranium deposits associated with magnetite deposits in metamorphic rocks have long been recognized. Work was done on the quadrangle during 1978 but was recessed at the end of the year.

Boston Quadrangle
Lewiston Quadrangle
Sherbrooke Quadrangle

These quadrangles are underlain by granite and intrusive rocks of Ordovician and later age that have intruded and metamorphosed sediments of Cambrian and perhaps older age. Work was done on these quadrangles in 1978 but was recessed at the end of the year.

Hartford Quadrangle

The geologic unit of major interest in this quadrangle is the Triassic Connecticut Basin which underlies the central one-third of the quadrangle. The remainder of the quadrangle is underlain by metasediments and intrusive rocks. Several uranium occurrences are known in the Triassic Connecticut Basin. Although some work was done in the quadrangle in 1978, evaluation has been recessed.

Baltimore Quadrangle

This quadrangle is underlain by Precambrian metasediments of the Piedmont province in the eastern two-thirds and by lower Paleozoic sediments of the Valley and Ridge province in the western one-third. A few uranium occurrences are known in the quadrangle. A literature search and map work were done on this quadrangle in 1978, but the work has been recessed.

Atlanta Field Office

The Bendix geologists of the Atlanta office are responsible for geologic studies in North and South Carolina; Georgia, Alabama, Florida, central eastern Tennessee; and the southern parts of Kentucky, Virginia, and West Virginia. Work was continued on 4 quadrangles. The USGS worked on 5 other quadrangles, and 1 quadrangle is being studied by a subcontractor.

Quadrangle Evaluation (BFEC)

Athens Quadrangle

- Start Date: 18 November 1977
- Completion Date: 31 April 1979

Spartanburg Quadrangle

- Start Date: 3 October 1977
- Completion Date: 30 May 1979

Greensboro Quadrangle

- Start Date: 19 October 1977
- Completion Date: 15 August 1979

These quadrangles are largely underlain by rocks of the Piedmont province. The Piedmont is composed of Early Paleozoic and Precambrian metasediments intruded by various granitic plutons that constitute the major targets for uranium investigations. The Danville, Durham, and Sanford Triassic basins, which underlie parts of the Greensboro Quadrangle and a small part of the Spartanburg Quadrangle, are areas of interest for uranium deposits. Field work on the Spartanburg and Athens quadrangles was completed during the year. GJBX–8(78) was released in January 1978 and describes work done in the Greensboro Quadrangle. Work on the Greensboro Quadrangle was suspended in September 1978, but has since been resumed.

Johnson City Quadrangle

This quadrangle includes the Crystalline Appalachians and Allegheny Plateau provinces. The primary target for uranium investigations in this quadrangle is the Grandfather Mountain area, which includes other adjacent quadrangles at their common corner. Granitic gneisses are known to contain uranium minerals, and shear zones exhibit minor radioactivity. The Middlesboro Basin, a cryptoexplosive structure, constitutes a secondary target for uranium investigation. Bendix geologists worked on the Johnson City Quadrangle through the 1978 field season before being reassigned to other areas of higher priority.

Dickinson Quadrangle

- Start Date: 2 October 1978
- Completion Date: 30 May 1980

Lemmon Quadrangle

- Start Date: 2 October 1978
- Completion Date: 30 May 1980

The Dickinson and Lemmon quadrangles are underlain by siltstones, sandstones, and lignites of Cretaceous and Paleocene age. Uranium deposits are known in both sandstones and lignites; uranium has been produced commercially from the lignites around Belfield, North Dakota. Atlanta office personnel were assigned to these 2 quadrangles late in 1978 as part of the program to evaluate high priority areas by the latter part of 1980. Some map work, a literature search, and reconnaissance were done in preparation for the 1979 field season.

Quadrangle Evaluation (Subcontractor)

Augusta Quadrangle

- Subcontractor: Carolina Geosciences Corp.
- Subcontract Value: $168,600
- Start Date: 20 March 1978
- Completion Date: 31 March 1980

This quadrangle is largely in the Coastal Plain, although the northwestern 5 percent of the quadrangle is underlain by Piedmont rocks. Fault zones of Paleozoic age and associated crystalline rocks are the uranium targets in the Piedmont. Roll-front–type uranium deposits may occur in Coastal Plain sediments of Cretaceous age, localized by redox fronts related to ground-water geochemistry.

Quadrangle Evaluation (USGS)

The USGS, under an interagency agreement with DOE, was to evaluate the uranium potential of 5 quadrangles in the Atlanta region. However, following the DOE Task Force review and program redirection, work was recessed on all these quadrangles.

Atlanta Quadrangle
Charlotte Quadrangle
Greenville Quadrangle

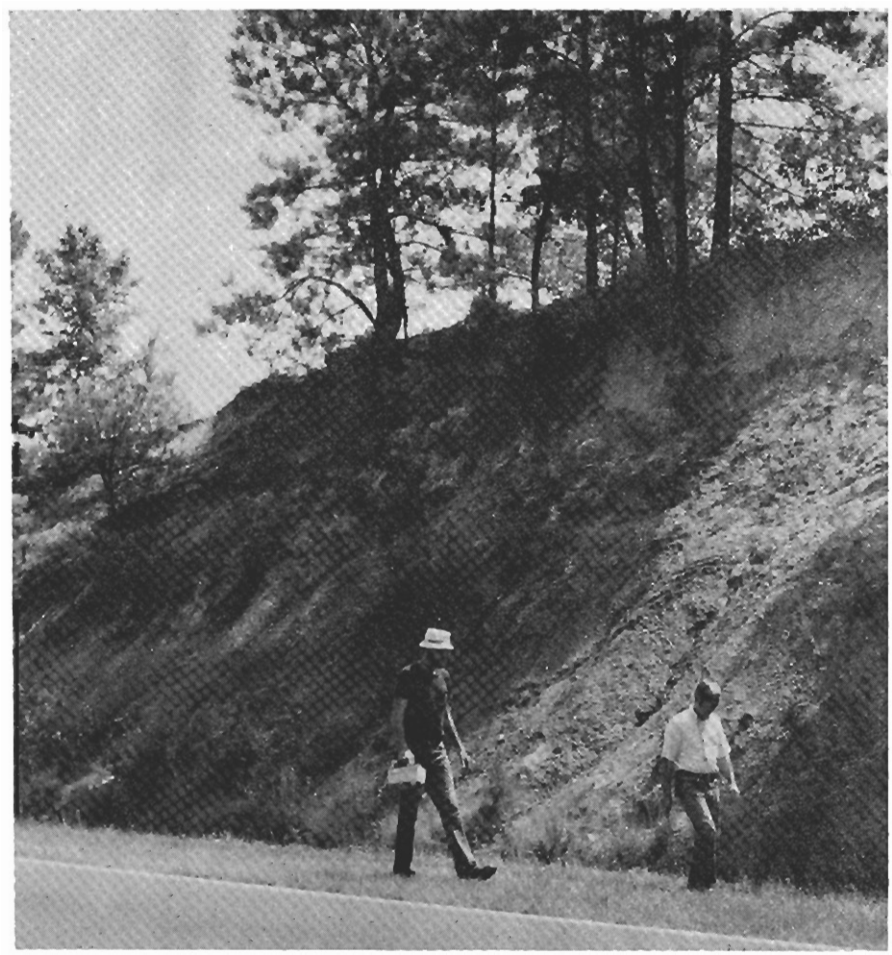
These quadrangles are largely underlain by rocks of the Piedmont province. The Piedmont is composed

of Early Paleozoic and Precambrian metasediments intruded by various granitic plutons that constitute the major targets for uranium investigations. GJBX-83(78), open filed in June 1978, describes work done by Bendix in the Paleozoic sediments which underlie part of the Atlanta Quadrangle. Map work and a literature search were done, along with some field work in the Atlanta Quadrangle before work was suspended.

Knoxville Quadrangle
Winston-Salem Quadrangle

These quadrangles encompass parts of the Crystalline Appalachians and Allegheny Plateau provinces. The primary target for uranium investigations in these 3 quadrangles is the Grandfather Mountain area, which lies in parts of the Knoxville and Winston-Salem quadrangles contiguous to the Johnson City Quadrangle. Some map work and a literature search were accomplished before the work was suspended.

Above, geologists examine rocks of the Sanford Triassic Basin near the Charlotte Quadrangle. At right, another team from the Atlanta field office conducts sampling at the Tuscaloosa Formation, in the Spartanburg Quadrangle.



A geologist uses a hand-held scintillometer in Alaska's Dixon Entrance Quadrangle.

Anchorage Field Office

In 1978, Bendix geologists in the Anchorage field office served as monitors for 2 subcontracted projects and began evaluation work on 1 quadrangle in southeastern Alaska.

Quadrangle Evaluation (BFEC)

Dixon Entrance Quadrangle

- Start Date: 1 March 1978
- Completion Date: 31 March 1980

Uranium has been mined in this quadrangle at Bokan Mountain on Prince of Wales Island. Similar geologic environments are being sought, and the Precambrian Wales Group metamorphic complex is being investigated for possible vein-type occurrences. Radiometric reconnaissance by helicopter was conducted at the beginning of the investigation, and the data retrieved were open filed as GJBX-19(79).

Quadrangle Evaluation (Subcontractor)

Mount McKinley Quadrangle

- Subcontractor: C. C. Hawley & Associates
- Subcontract Value: $179,900
- Start Date: 11 April 1978
- Completion Date: 31 July 1979

Talkeetna Quadrangle

- Subcontractor: C. C. Hawley & Associates
- Subcontract Value: $179,900
- Start Date: 11 April 1978
- Completion Date: 31 July 1979

Tyonek Quadrangle

- Subcontractor: C. C. Hawley & Associates
- Subcontract Value: $179,900
- Start Date: 11 April 1978
- Completion Date: 31 July 1979

Lime Hills Quadrangle

- Subcontractor: C. C. Hawley & Associates
- Subcontract Value: $180,000
- Start Date: 11 April 1978
- Completion Date: 31 July 1979

These quadrangles encompass an area that includes part of the southern

Alaska Range and the adjoining lowlands, including the northern part of Cook Inlet. Targets that appear to be favorable include granitic plutons, felsic volcanogenic rocks, fluvial sandstones, and schists.

Other Projects

Seward-Selawik

- Subcontractor: C. C. Hawley & Associates
- Subcontract Value: $542,100
- Start Date: April 1977
- Completion Date: March 1978

C. C. Hawley and Associates, under contract to Bendix, conducted a followup geologic evaluation of 8 quadrangles that encompass the Seward Peninsula and adjacent Selawik area. Favorability for uranium resources was interpreted from data derived from existing hydrogeochemical and aerial radiometric surveys, and from geochemical sampling. The results were open filed in November 1978 as GJBX-105(78).

Quadrangle Assessment

The process of providing an assessment of uranium resources within different cost categories depends heavily upon the quadrangle evaluation results. In order to provide as much assistance as possible to the field geologists and to enhance the evaluations, Bendix in Grand Junction provides guides to the quadrangle principal investigators for the evaluation process and interpretations of hydrogeochemical and stream-sediment reconnaissance and aerial radiometric reconnaissance and detail surveys data. So that uniformity among the quadrangle evaluation folios will be achieved in terms of evaluation methodology and geologic interpretation, Bendix has provided the quadrangle investigators with the following reports:

1. *A Preliminary Classification of Uranium Deposits*, GJBX-63(78), which classifies environments favorable for the occurrence of uranium deposits.
2. *Geologic Characteristics of Environments Favorable for Uranium Deposits*, GJBX-67(78), which discusses in detail the geologic attributes of favorable environments.
3. *Preliminary Recognition Criteria for Uranium Occurrences: A Field Guide*, GJBX-32(79), which gives a checklist of the types of information essential to the description of favorable environments and a convenient reference to the recognition criteria.

The assessment technique is based on the assumptions that: (1) additional uranium resources will be discovered in geologic environments similar to those of known uranium deposits and (2) quantities of uranium likely to be present are proportional to the sizes of individual environments. An *Assessment Manual*, which is currently in final draft form, will detail the procedure for the process. In the meanwhile, preliminary assessments have been made of the Plainview Quadrangle, Texas; Athens Quadrangle, Georgia; and La Junta Quadrangle, Colorado. Sixteen additional assessments will be completed by the end of August 1979, a major milestone in the NURE program.

Study to Integrate NURE Data

- Subcontractor: Woodward-Clyde Consultants
- Subcontract Value: $58,200
- Start Date: 17 January 1978
- Completion Date: January 1979

The primary objective of this study as reported in GJBX-25(79) is to present a methodology to integrate the information obtained from the NURE program elements in order to estimate the amount of uranium ore contained within a sandstone formation. Under this study, the information obtained for the aerial radiometric and hydrogeochemical elements is examined, with a view toward incorporating these data in the procedure to reduce the uncertainty associated with the estimate of quantity of uranium present. The borehole drilling and remote sensing elements contribution to an understanding of the geologic conditions also are considered. Although the focus of this study has been on sandstone-type deposits, it is believed the general approach also will be applicable to several other types of uranium deposits.

In the approach developed in this study, a set of parameters that quantitatively describe the geologic history and structure of a potential sandstone host formation are defined. These parameters are then assessed and used as the input variables to a material balance model of uranium flow, which gives the amount of uranium entering and precipitating within a potential host. A procedure also is presented for combining the radiometric and hydrogeochemical information with that obtained from geologic studies to achieve better estimates of uranium resources. The method explicitly recognizes the uncertainties involved in estimating the geologic parameters and in modeling the precipitation mechanism. Consequently, the estimates made by the model are expressed as probability distributions over uranium resources.

The method has been applied to the Shirley Basin and Gas Hills mining districts in Wyoming to test the feasibility of its implementation and the validity of its estimates.

Using data similar to those to be collected under NURE, it was quite feasible for experienced geologists to make the estimates required by the model. However, before the method is implemented on a large scale, it will be helpful to develop and analyze standard guidelines and procedures for making the estimates.

This Lama helicopter includes as part of its equipment a "bird" magnetic sensor extended from a 50-ft cable to survey the Moab Quadrangle. Survey specifications call for altitudes between 200 and 700 ft, with an optimal altitude of 400 ft. The gamma-ray spectrometer crystal packages on the front and rear of the helicopter are designed to drop away in case of emergency.

Aerial Radiometric Reconnaissance and Detail Surveys

The Aerial Radiometric Reconnaissance program has 2 principal objectives in support of NURE: (1) to acquire surface gamma radiation data for the DOE-directed uranium resource evaluation effort, and (2) to rapidly identify broad source regions of highest uranium favorability to help industry's U.S. 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 (2 million flight-line km) with line spacing ranging from 1 to 12 miles (1.6 to 19.3 km).

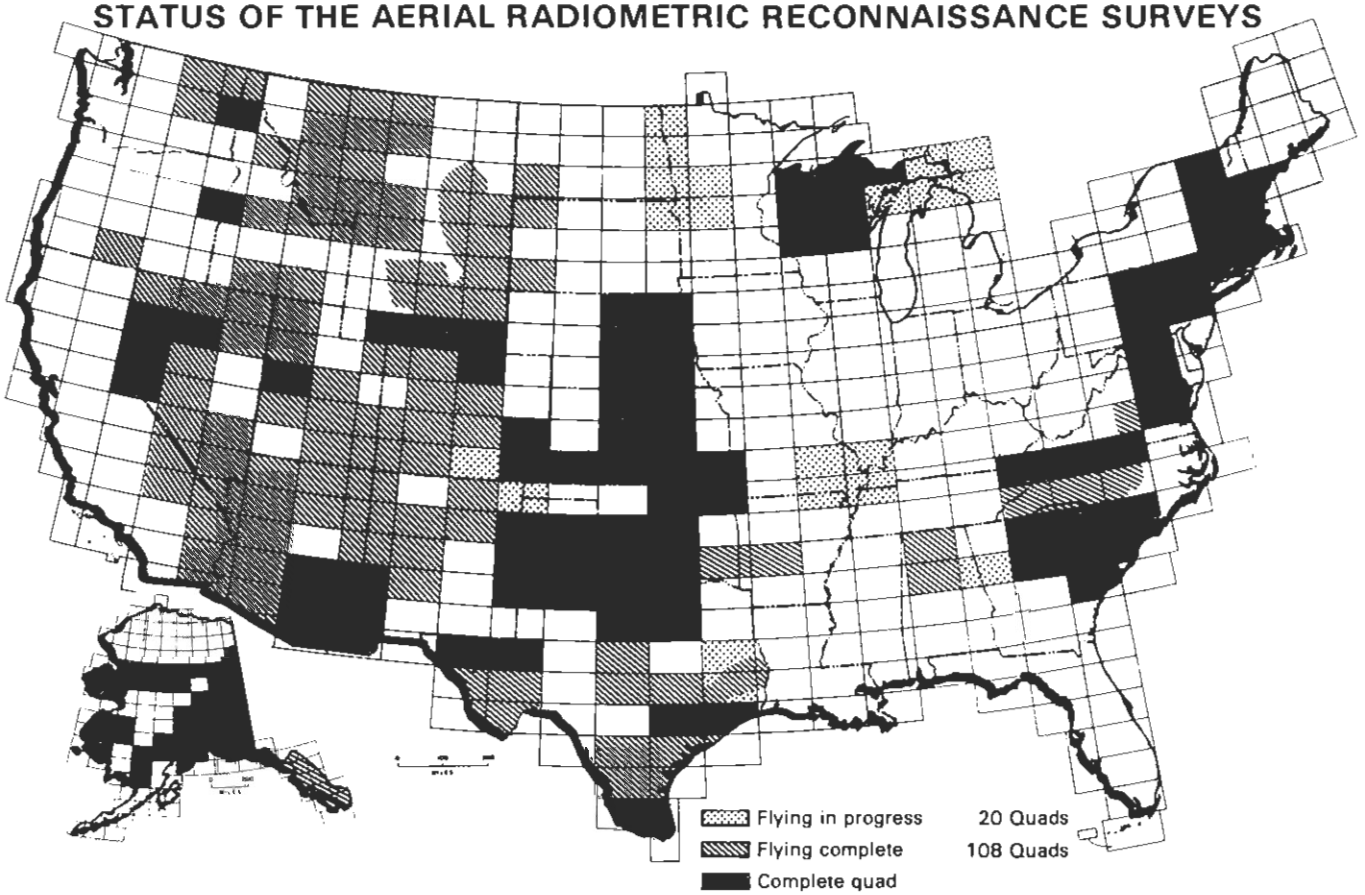
The Aerial Radiometric Reconnaissance program was initiated in 1974 and funded in 1975 at a level of $1 million. In 1978, the program expanded to a $7 million effort.

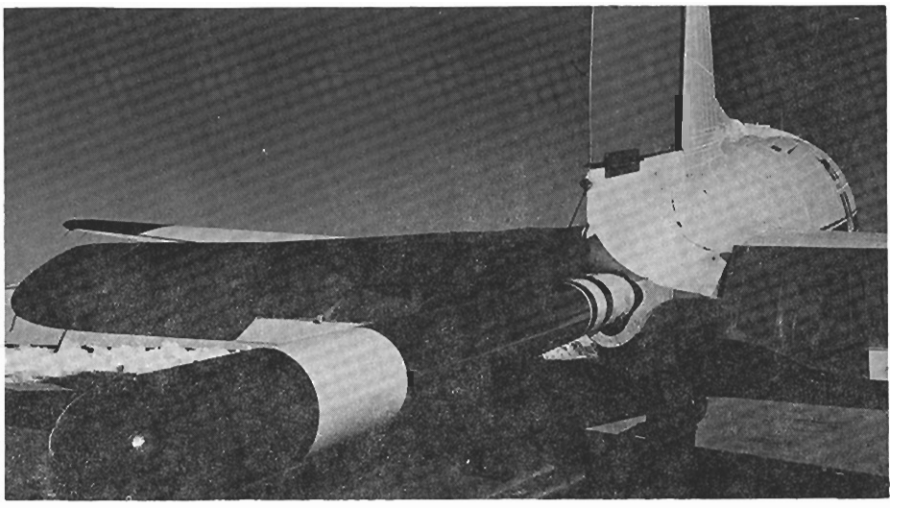
At the end of the year, over 600,000 line miles (965,400 line km) of survey had been completed; this represents about one-half of the flying portion of the aerial reconnaissance program. The map presented below shows the areas completed and in progress.

During 1978, 8 rotary-wing and 3 fixed-wing systems, belonging to 6 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, started in 1977, was continued. This qualification program consists of evaluating data obtained at the Walker Field facility in Grand Junction, and over 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 establishing system parameters and better reduced data. A long-term goal is a common data reduction scheme for all subcontractors.

In 1978, contracts were signed for 14 projects, and reports on 64 quadrangles were open filed. A total of approximately 270,000 line miles (434,430 line km) were flown during the year.

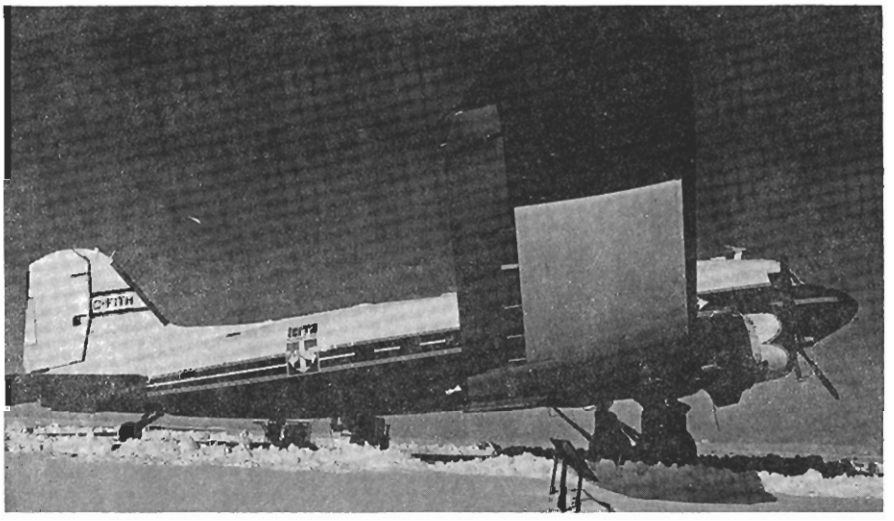
STATUS OF THE AERIAL RADIOMETRIC RECONNAISSANCE SURVEYS





The calibration facility in Grand Junction is used by private industry, as well as by government and NURE-related agencies. Below, equipment aboard a Geoterrex DC-3 is being calibrated prior to surveying in Iran. The "stinger" magnetic sensor mounted on the back of the plane is shown at left.

A program was started to perform detail surveys in selected areas, with line spacings as close as ¼ mile. Detail surveys were carried out in 6 areas which were selected on the basis of favorable geology, known occurrences, or other selection criteria. Approximately 21,000 line miles (33,789 line km) of detail surveys were completed; funding was approximately $500,000.



Alaska Rotary-Wing Survey

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: $1,063,541
- Start Date: 12 April 1976
- Completion Date: 31 December 1978
- Line Miles: 20,929 (33,675 km)
- Aircraft: Bell 205 and Sikorsky S-58T

Flying of this survey was initiated in June 1976 and was completed in September 1977.

Results of the survey were open filed in 4 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, Mount St. Elias, Icy Bay, and Yakutat quadrangles); and Southeastern Alaska (Skagway, Atlin, Mount Fairweather, Juneau, Taku River, Sitka, Sumdum, Port Alexander, Petersburg, Bradfield Canal, Craig, Ketchikan, Dixon Entrance, and Prince Rupert quadrangles).

To date, all 4 reports have been open filed. On October 18, 1978, Eastern Alaska was open filed as GJBX-91(78); on November 15, 1978, Cook Inlet was open filed as GJBX-108(78); and on December 28, 1978, Chugach/Yakutat was open filed as GJBX-127(78). Southeastern Alaska was open filed on May 16, 1979, as GJBX-48(79).

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

- Subcontractor: GeoMetrics, Inc.
- Subcontract Value: $717,935
- Start Date: 17 October 1976
- Completion Date: 25 May 1978
- Line Miles: 35,546 (57,194 km)
- Aircraft: Grumman S-2

This survey was flown in 1977 and the results were open filed in 1978. The Big Bend portion (Van Horn and Pecos quadrangles) was open filed March 16, 1978, as GJBX-2(78) and the East Salina Basin portion (Fremont, Lincoln, Manhattan, and Hutchinson quadrangles) was open filed April 14, 1978, as GJBX-20(78). The Wisconsin portion was open filed in 2 releases. The first release, GJBX-26(78), on May 25, 1978, covered the Eau Claire, Rice Lake, Green Bay, and Iron Mountain quadrangles, while the second release, GJBX-50(78), on August 7, 1978, covered the Hancock, Marquette, Iron River, and Ashland quadrangles.

Thorpe/Big Bend Rotary-Wing Survey

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: $640,007
- Start Date: 28 October 1976
- Completion Date: 31 January 1979
- Line Miles: 19,000 (30,571 km)
- Aircraft: Sikorsky S-58 and S-58T

This survey, under the Thorpe area, covers the Williamsport, Harrisburg, Scranton, and Newark quadrangles in Pennsylvania, New Jersey, and New York. In the Big Bend area, the survey covers the Fort Stockton, Marfa, Presidio, and Emory Peak quadrangles in Texas.

Flying on the Thorpe survey was conducted between November 8, 1976, and April 11, 1977. The Newark and Scranton reports were open filed on March 16, 1978, as GJBX-16(78) and GJBX-32(78), and the Harrisburg and Williamsport reports were open filed on July 10, 1978, as GJBX-33(78) and GJBX-34(78).

Flying on the Big Bend survey was conducted between January 13, 1978, and February 13, 1978. Open-file reports are scheduled for 1979.

Blue Ridge Rotary-Wing Survey

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: $741,148
- Start Date: 11 April 1977
- Completion Date: 31 January 1979
- Line Miles: 15,753 (25,347 km)
- Aircraft: Sikorsky S-58 and S-58T

This survey covers the Knoxville, Johnson City, Winston-Salem, Charlotte, and Greensboro quadrangles in Tennessee, Kentucky, Virginia, North Carolina, and South Carolina. Flying on this survey was conducted between April 16, 1977, and January 21, 1978. Reports open filed in 1979 are GJBX-16(79) and GJBX-57(79).

Reno/Snake River Basin Rotary-Wing Survey

- Subcontractor: GeoLife, Inc.
- DOE/SBA Contract
- Start Date: 11 March 1977
- Completion Date: 30 June 1979
- Line Miles: 84,629 (136,168 km)
- Aircraft: Sikorsky S-58T and Lama

The subcontract for this survey is a joint venture between High Life Helicopters, Inc., and Geodata International, Inc. The subcontract is handled by DOE/Small Business Administration, with technical monitoring by Bendix, and has been in effect for 2 years.

Project reports which have been open filed are: Baker Quadrangle, GJBX-101(78), September 28, 1978; Lovelock Quadrangle, GJBX-125(78), November 15, 1978; Walker Lake Quadrangle, GJBX-126(78), November 15, 1978; and Reno Quadrangle, GJBX-117(78), December 20, 1978.

Reports open filed in 1979 are: Winnemucca, GJBX-21(79), February 27, 1979; Goldfield Quadrangle, GJBX-66(79), May 31, 1979; and Tularosa Quadrangle, GJBX-67(79), May 31, 1979.

Other quadrangles flown under this subcontract are Millett, Tonopah, Caliente, Death Valley, Needles, Socorro, Little Rock, McAlester, Richfield, Elko, Tooele, Brigham City, Challis, McDermitt, Vya, Escalante, Price, Vernal, Klamath Falls, and Wells. Reports on this work are planned for open filing at intervals during 1979.

Texas Gulf Coast II Fixed-Wing Survey

- Subcontractor: Geodata International, Inc.
- Subcontract Value: $445,362
- Start Date: 11 January 1977
- Completion Date: 31 March 1979
- Line Miles: 18,155 (29,211 km)
- Aircraft: DC-3

This survey completed coverage of 10 quadrangles which had been partially covered in a previous survey, the results of which were open filed in 1975 as report GJO-1632. Results of the present survey, which include data from the earlier surveys, have been open filed for the Houston Quadrangle as GJBX-102(78) on September 28, 1978, and for the Brownsville and McAllen quadrangles on December 20, 1978, as GJBX-118(78).

In 1979, the Seguin Quadrangle was released as GJBX-37(79) on April 12, 1979; and the Beeville and Bay City quadrangles as GJBX-69(79) on May 31, 1979.

The remaining 4 quadrangles, Austin, Corpus Christi, Laredo, and Crystal City, are scheduled for open filing in 1979.

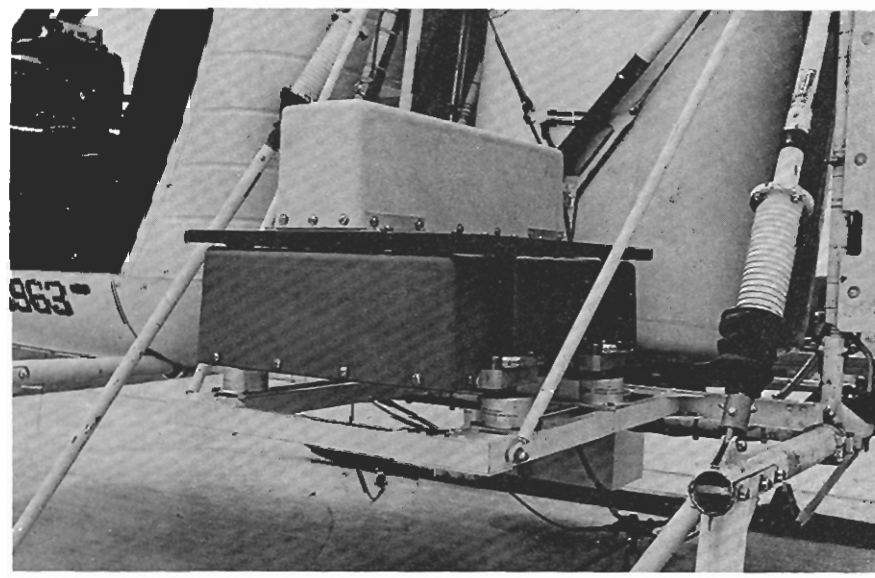
Northwest Arizona Fixed-Wing/Rotary-Wing Survey

- Subcontractor: Litton Aero Service Corp.
- Subcontract Value: $538,000
- Start Date: 10 June 1977
- Completion Date: 31 March 1979
- Line Miles: 14,983 (24,108 km) fixed wing and 8,108 (13,046 km) rotary wing
- Aircraft: DC-3 and Lama

This survey, which used both fixed-wing and rotary-wing systems to match varying terrains, was flown in 1977. The survey covered the Las Vegas, Kingman, Williams, and Prescott quadrangles. Results were open filed as GJBX-59(79) on May 29, 1979.

Eagle/Dillingham Rotary-Wing Survey

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $1,063,418
- Start Date: 16 May 1977
- Completion Date: 26 September 1978
- Line Miles: 16,684 (26,845 km)
- Aircraft: Bell-212



This crystal package, attached to a Lama survey helicopter, consists of sodium iodide crystals for gamma-ray detection, and lead shielding. The unit has both downward and upward sensors.

This survey covers the Big Delta, Eagle, Mount McKinley, Healy, Fairbanks, Talkeetna, Talkeetna Mountains (western two-thirds), Lime Hills, Lake Clark, Dillingham, Circle, Charley River, and Mount Hayes quadrangles in Alaska. Flying on this survey was conducted between June 5, 1977, and September 15, 1977. Reports for all quadrangles were open filed on October 18, 1978, as GJBX-113(78).

Rockies/Laramie Fixed-Wing/Rotary-Wing Survey

- Subcontractor: GeoMetrics, Inc.
- Subcontract Value: $606,000
- Start Date: 23 June 1977
- Completion Date: 28 February 1979
- Line Miles: 11,495 (18,495 km) fixed wing and 13,855 (22,293 km) rotary wing
- Aircraft: Grumman S-2 and Lama

Flying was started on this project in 1977 and completed in the summer of 1978. Open filing of reports for the Rock Springs, Rawlins, Cheyenne, Greeley, Denver, and Pueblo quadrangles was completed in 1979 as GJBX-17(79) and GJBX-49(79).

Great Plains Fixed-Wing Survey

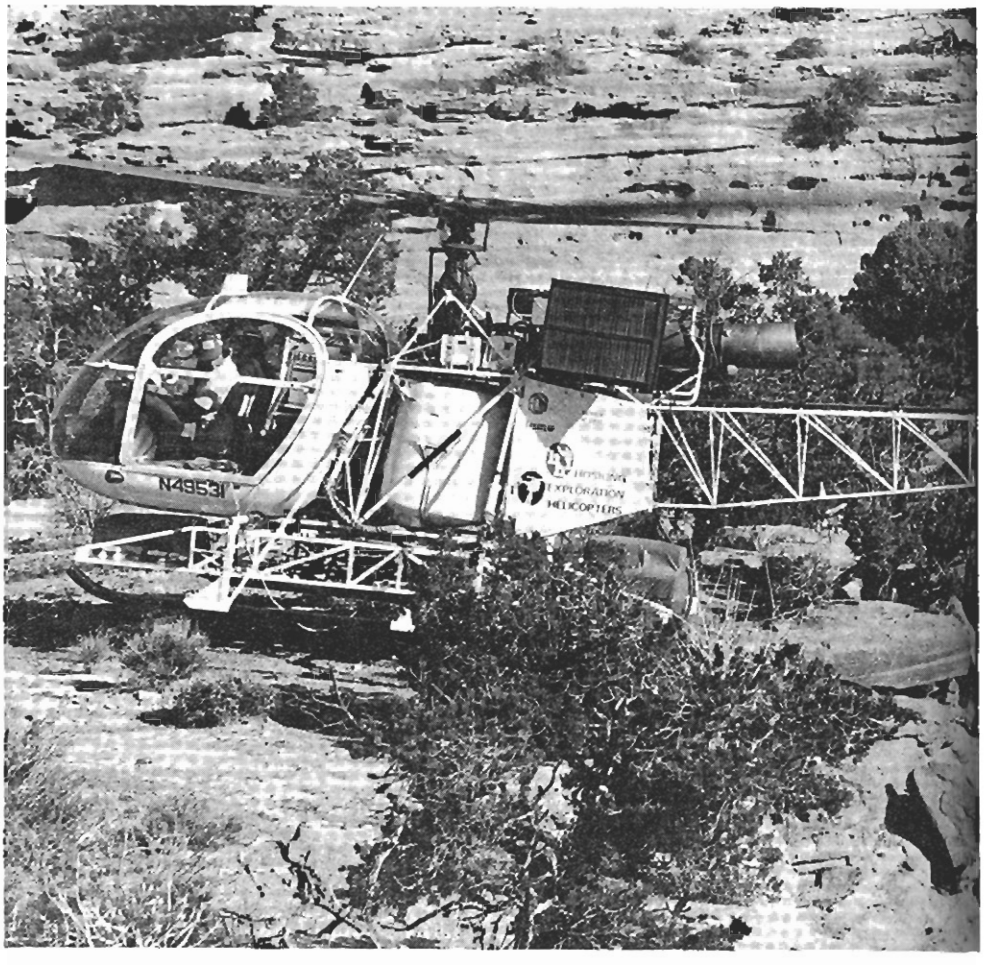
- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $637,000
- Start Date: 1 July 1977
- Completion Date: 28 September 1978
- Line Miles: 29,065 (46,766 km)
- Aircraft: DC-3

The Great Plains survey included 14 quadrangles: 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 for all 14 quadrangles were open filed September 28, 1978, as GJBX-100(78).

Northeast Washington Rotary-Wing Survey

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: $642,950
- Start Date: 11 August 1977
- Completion Date: 31 January 1979
- Line Miles: 14,754 (23,739 km)
- Aircraft: Sikorsky S-58T

This survey covers the Okanogan, Sandpoint, and Spokane quadrangles in Washington and Idaho. Flying on the survey was conducted between August 10, 1977, and October 3, 1977.



An open-file report for the Spokane Quadrangle was released on December 28, 1978, as GJBX-121(78). The Okanogan and Sandpoint quadrangles are scheduled to be open filed in 1979.

Utah/Arizona Rotary-Wing/Fixed-Wing Survey

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $664,900
- Start Date: 13 October 1977
- Completion Date: 30 December 1978
- Line Miles: 13,401 (21,562 km)
- Aircraft: Bell-212 and DC-3

This survey completes coverage of quadrangles partially flown with fixed-wing surveys in 1975 and 1976 over portions of the Tucson, Nogales, Mesa, Douglas, Silver City, and Clifton quadrangles in Arizona and New Mexico, and the Delta Quadrangle in Utah. The new data will be integrated with the previous fixed-wing data parameters, calculated, and presented on a complete quadrangle basis. Open-file reports for the Utah/Arizona survey were released as GJBX-23(79) and GJBX-24(79).

Baltimore Fixed-Wing Survey

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $147,100
- Start Date: 10 November 1977
- Completion Date: 20 December 1978
- Line Miles: 5,944 (9,564 km)
- Aircraft: DC-3

The Baltimore survey was flown in November and December 1977, and was open filed December 20, 1978, as GJBX-133(78). It includes the Baltimore, Washington, and Richmond quadrangles.

Trona Rotary-Wing Survey

- Subcontractor: GeoLife, Inc.
- Subcontract Value: $84,150
- Start Date: 17 November 1977
- Completion Date: 31 March 1979
- Line Miles: 3,266 (5,255 km)
- Aircraft: Lama

Flying in the Trona Quadrangle was completed in January 1978, and the final report was open filed on May 31, 1979 as GJBX-65(79).

A survey helicopter refuels during radiometric reconnaissance over the Moab Quadrangle.

Yellowstone Rotary-Wing Survey

- Subcontractor: Litton Aero Service Corp.
- Subcontract Value: $667,931
- Start Date: 23 June 1978
- Completion Date: 5 March 1979
- Line Miles: 15,433 (24,832 km)
- Aircraft: Sikorsky S-58T

Flying was completed on the Yellowstone project in November 1978, with final reports scheduled to be open filed in 1979. Quadrangles included in this subcontract are Dubois, Ashton, Cody, Durango, and Cortez.

Uncompahgre Rotary-Wing Survey

- Subcontractor: GeoMetrics, Inc.
- Subcontract Value: $476,374
- Start Date: 28 June 1978
- Completion Date: 12 February 1979
- Line Miles: 13,369 (21,511 km)
- Aircraft: Lama

The Uncompahgre survey was flown during the summer of 1978 and covers the Leadville, Montrose, Moab, and Salina quadrangles. Final reports are scheduled for open filing in 1979.

Powder River II Rotary-Wing/Fixed-Wing Survey

- Subcontractor: GeoMetrics, Inc.
- Subcontract Value: $339,000
- Start Date: 28 June 1978
- Completion Date: 5 March 1979
- Line Miles: 17,466 (28,103 km)
- Aircraft: Lama and Grumman S-2

This survey covers the Ekalaka, Gillette, Newcastle, Torrington, and Casper quadrangles in Wyoming and Montana. Flying on this survey was conducted between August 12, 1978, and September 28, 1978. Data on the Casper Quadrangle will be integrated with earlier data covering a portion of the quadrangle that was acquired by Texas Instruments in 1975 and reported under GJO-1631-1. Open-file reports are scheduled for 1979.

Raton Basin Rotary-Wing/Fixed-Wing Survey

- Subcontractor: GeoMetrics, Inc.
- Subcontract Value: $502,302
- Start Date: 28 June 1978
- Completion Date: 4 April 1979
- Line Miles: 15,995 (25,736 km)
- Aircraft: Lama and Grumman S-2

This survey covers the Raton, Santa Fe, Albuquerque, Shiprock, Gallup, and Flagstaff quadrangles in New Mexico and Arizona. Flying was conducted between October 18, 1978, and December 1, 1978. Open-file reports are scheduled for 1979.

Llano Uplift Fixed-Wing Survey

- Subcontractor: Geodata International, Inc.
- Subcontract Value: $249,500
- Start Date: 28 June 1978
- Completion Date: 13 February 1979
- Line Miles: 11,658 (18,758 km)
- Aircraft: DC-3

The Llano Uplift project consists of the Llano, Brownwood, Lemmon, and Dickinson quadrangles. Flying was complete in October 1978, and final reports are scheduled for open filing in 1979; the Brownwood Quadrangle being open filed on May 31, 1979, as GJBX-68(79).

Sweetgrass Rotary-Wing/Fixed-Wing Survey

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $940,000
- Start Date: 20 June 1978
- Completion Date: 27 July 1979
- Line Miles: 29,210 (46,999 km)
- Aircraft: Sikorsky S-58T and DC-3

This survey covers the Shelby, Great Falls, Lewistown, Butte, Choteau, Havre, and Cut Bank quadrangles in Montana; the Twin Falls and Pocatello quadrangles in Idaho; the Ritzville Quadrangle in Washington; the Hot Springs Quadrangle in South Dakota; and the St. Johns Quadrangle in Arizona and New Mexico. Flying on this survey was conducted between July 31, 1978, and September 28, 1978. Open-file reports are scheduled first for the Montana and Idaho quadrangles and later for Ritzville, Hot Springs, and St. Johns quadrangles.

Northern Rockies Rotary-Wing Survey

- Subcontractor: High Life Helicopters, Inc.
- Subcontract Value: $336,500
- Start Date: 23 June 1978
- Completion Date: 4 April 1979
- Line Miles: 13,370 (21,512 km)
- Aircraft: Lama

This survey covers the Hamilton, Dillon, Bozeman, White Sulphur Springs, and Billings quadrangles located in Montana and Idaho. Flying was completed for this contract in October 1978, and the report will be open filed in 1979.

Survey sensors aboard a Lama helicopter are calibrated at the Walker Field calibration facility in Grand Junction.

Colorado/Arizona Rotary-Wing Survey

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: $764,199
- Start Date: 6 September 1978
- Completion Date: 3 June 1979
- Line Miles: 18,911 (30,428 km)
- Aircraft: Sikorsky S-58T

Flying on this subcontract started in October 1978 and continued through the winter in southern quadrangles. The quadrangles included in the survey are Craig, Grand Canyon, Marble Canyon, Salton Sea, Ajo, Phoenix, Lukeville, and El Centro.

Open filing of reports is scheduled for 1979.

Trinidad Project

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $149,900
- Start Date: 19 October 1978
- Completion Date: 1 July 1979
- Line Miles: 3,212 (5,168 km)
- Aircraft: Sikorsky S 58T

This survey covers the Trinidad Quadrangle in Colorado. Open-file reports scheduled for 1979 will cover the 80 percent completed before being snowed out in November 1978.

High Life/SBA Rotary-Wing Survey

- Subcontractor: High Life Helicopters, Inc.
- DOE/SBA Contract
- Start Date: 1 October 1978
- Completion Date: 28 February 1980
- Line Miles: 5,946 (9,567 km)
- Aircraft: Lama

This project is in the third year of a DOE/SBA contract, with technical monitoring by Bendix. The line miles presently assigned are on the Gadsden and Birmingham quadrangles; additional areas will be assigned up to a total of approximately 20,000 line miles (32,180 km). Reports for quadrangles are scheduled to be open filed approximately 6 months after completion of flying.

Durango Detail Rotary-Wing Survey

- Subcontractor: Litton Aero Service Corp.
- Subcontract Value: $160,394
- Start Date: 23 June 1978
- Completion Date: 9 May 1979
- Line Miles: 3,706 (5,963 km)
- Aircraft: Sikorsky S-58T

This project consists of 4 areas in the Durango Quadrangle to be flown at ¼-mile spacing. Only 1 area was completed before snow forced termination of the survey for the winter. A report on the area completed is scheduled for open filing in 1979, and the other 3 areas are being rescheduled.

Montrose Detail Rotary-Wing Survey

- Subcontractor: GeoMetrics, Inc.
- Subcontract Value: $150,753
- Start Date: 28 June 1978
- Completion Date: 8 May 1979
- Line Miles: 4,231 (6,808 km)
- Aircraft: Lama

The Montrose detail survey consists of 5 separate areas in the Montrose Quadrangle. Flying was completed in the summer of 1978, and final reports are scheduled for open filing in 1979.

Gillette Detail Airborne Survey

- Subcontractor: GeoMetrics, Inc.
- Subcontract Value: $21,287
- Start Date: 28 June 1978
- Completion Date: 14 May 1979
- Line Miles: 810 (1,303 km)
- Aircraft: Lama

This survey covers the Bear Lodge Mountains over portions of the Devil's Tower, Alva, Nefsy, and Sundance 15-minute quadrangles in northeastern Wyoming. A ¼-mile grid, both north-south and east-west, was flown in the period between August 12, 1978, and August 22, 1978. Open-file reports are scheduled for 1979.

Brushy Basin Rotary-Wing Survey

- Subcontractor: High Life Helicopters, Inc.
- Subcontract Value: $115,523
- Start Date: 7 September 1978
- Completion Date: 4 June 1979
- Line Miles: 3,310 (5,326 km)
- Aircraft: Lama

This detail survey was flown at ¼-mile spacing over an area of numerous outcrops of the Brushy Basin Member of the Morrison Formation. The areas flown were near Green River, Utah, and the San Rafael Uplift in the Price and Salina quadrangles in Utah. Flying was completed in October 1978, and the report is scheduled for open filing in 1979.

Reading Prong Detail Rotary-Wing Survey

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: $217,054
- Start Date: 6 September 1978
- Completion Date: 3 June 1979
- Line Miles: 5,936 (9,551 km)
- Aircraft: Sikorsky S-58T

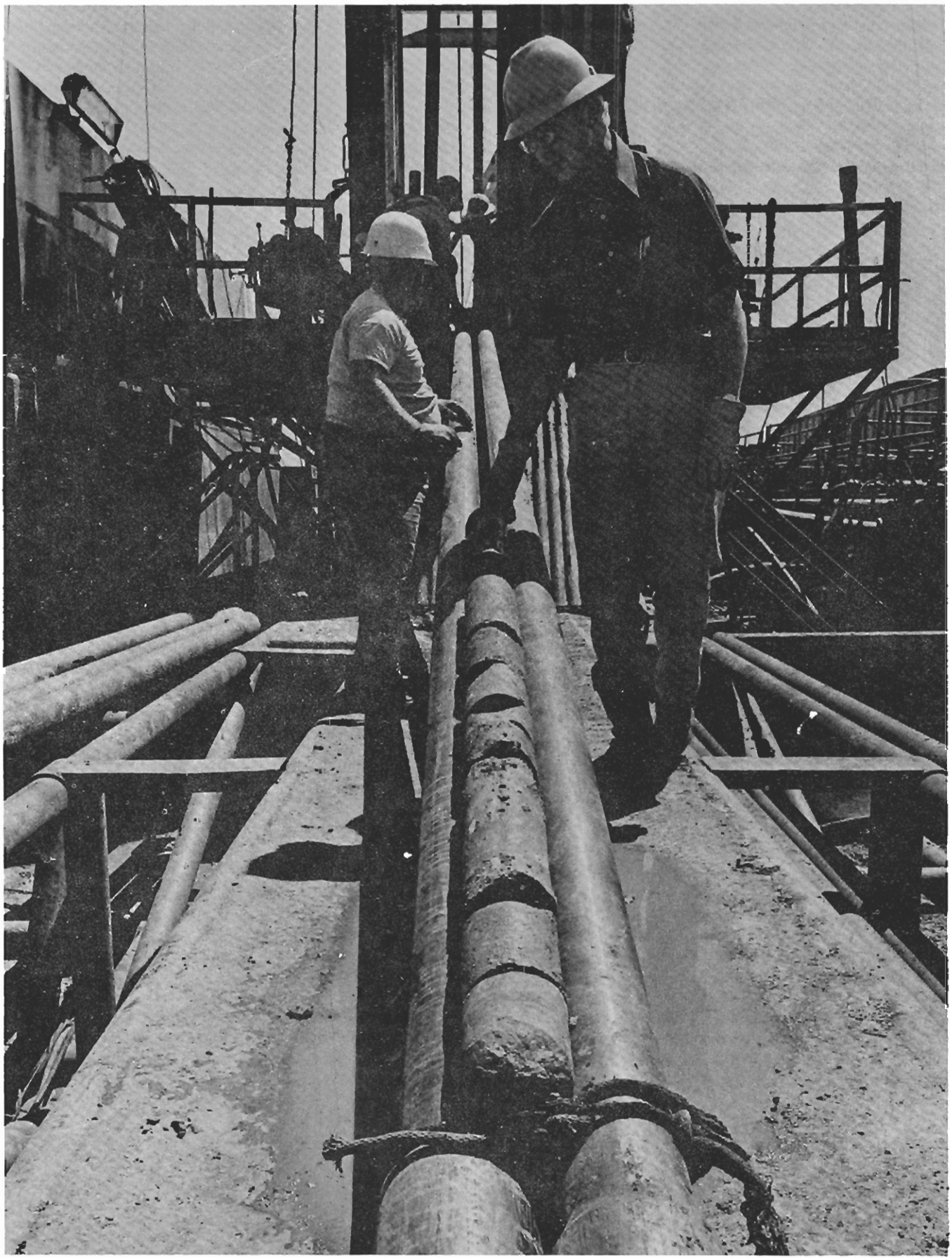
The Reading Prong detail survey was flown during the months of September and October 1978, with ¼-mile line spacing. The final report is scheduled for open filing in 1979. The detail survey area lies in the Newark and Scranton quadrangles.

Marysvale Rotary-Wing Survey

- Subcontractor: GeoLife, Inc.
- DOE/SBA Contract
- Start Date: 31 May 1978
- Completion Date: 31 December 1979
- Line Miles: 3,882 (6,246 km)
- Aircraft: Lama

Flying on the Marysvale detail survey started in October 1978 and was terminated in November 1978 due to snow in the survey area. Approximately two-thirds of the proposed area was flown before termination; the remainder will be flown in 1979. Line spacing is ¼ mile. An interim data release may be arranged to make results of the completed portion of the survey available. Marysvale is in the Richfield Quadrangle.

The rough terrain of the Moab Quadrangle was surveyed during the summer of 1978. This area, as well as the Leadville, Montrose, and Salina quadrangles, is included in the Uncompahgre survey.



A Bendix geologist and an assistant examine drill cores at the Chaco Canyon Project.

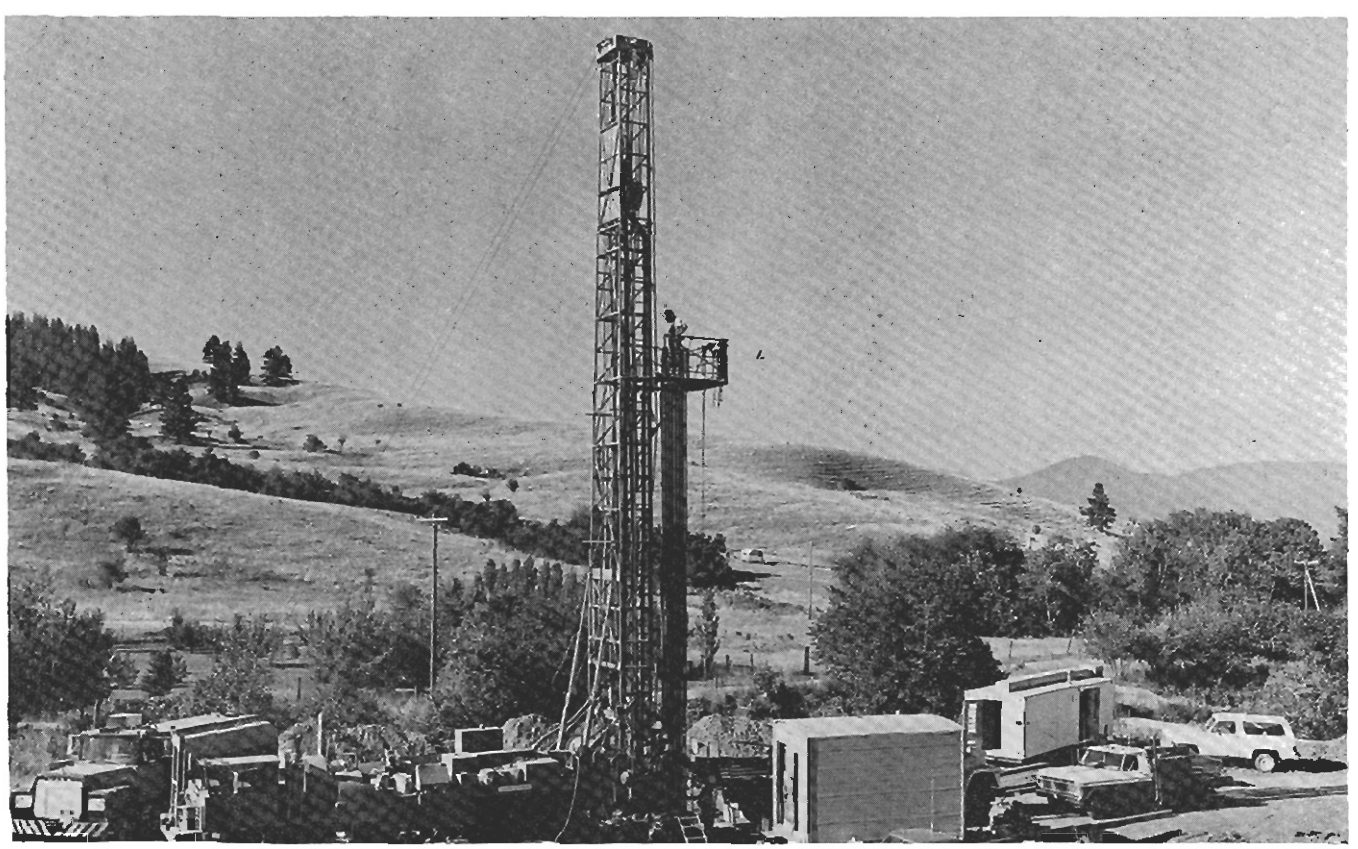
Subsurface Investigations

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 areas of known occurrences, and to obtain data for evaluating favorability in areas of suspected occurrences and areas containing potentially uraniferous host rocks. Subsurface data are generated by drilling, logging, and analyzing formations with potential for uranium deposition. Additional subsurface data are obtained from industry records and by logging holes drilled by industry or other governmental agencies for nonuranium purposes.

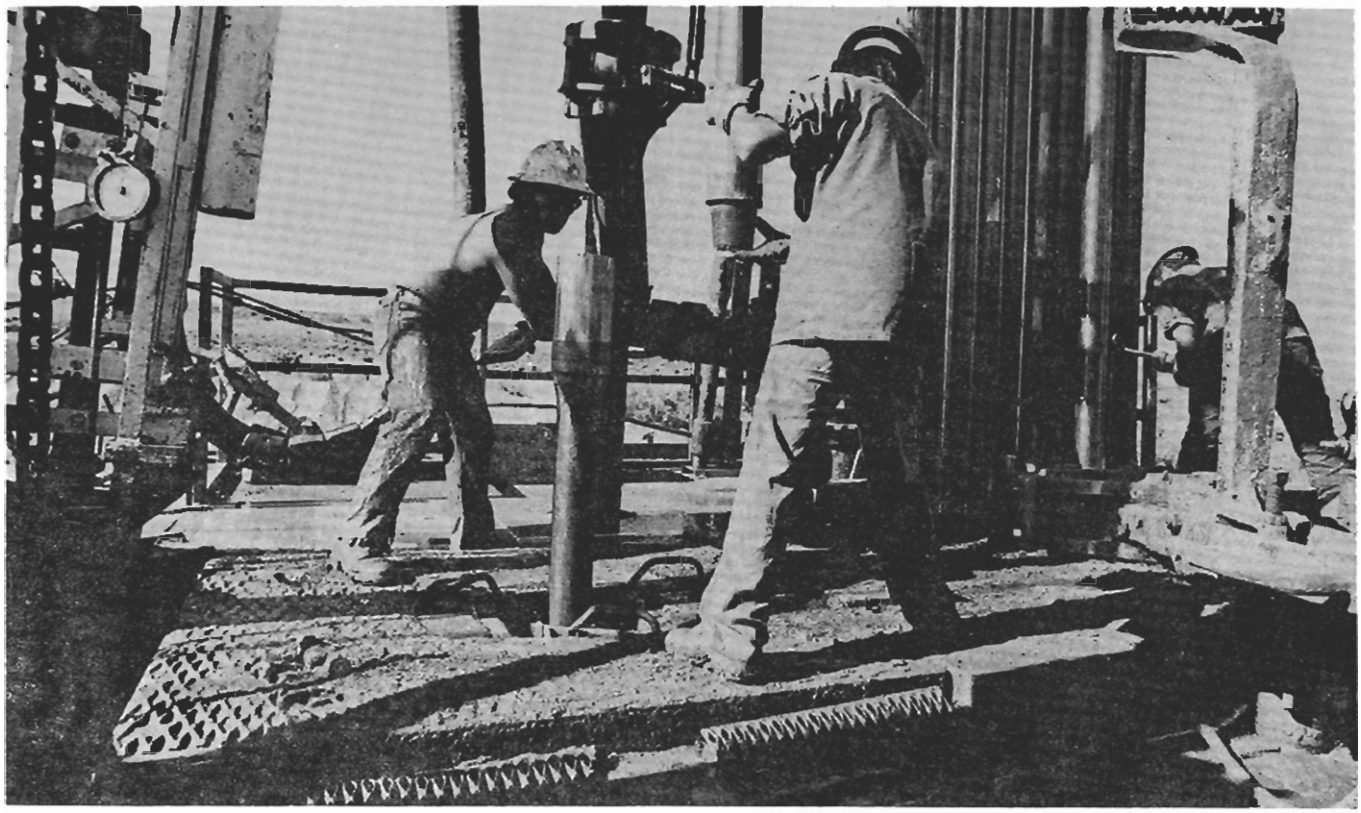
Each subsurface project undergoes a geologic study to determine its acceptability as a viable investigation. Upon acceptance of the project, a drilling plan is generated which includes all drilling requirements, as well as the location of each drill site. Drilling operations are subcontracted and are directed by Bendix engineers and geologists. In-house logging operations provide downhole log data supplementary to commercial logging. After completion of drilling operations, 2 reports are open filed: (1) the engineering report, containing a description of technical aspects of the drilling project, is open filed approximately 2 months after completion of drilling, and (2) the final geologic report, containing a description of lithology and stratigraphy, as well as an analysis of mineralization, is released within 1 year of completion of drilling.

Drilling projects completed to date include the Granite Mountains Project in Wyoming [GJBX-56(76)], the Carson Sink Project in Nevada [GJBX-49(77) and GJBX-53(78)], and the Red River Valley Project in North Dakota and Minnesota [engineering report GJBX-130(78)]. The Red River Valley Project geologic report was subcontracted to the University of North Dakota and was open filed in 1979 as GJBX-3(79). The Michigan Basins Project, started in June 1977, was finished in April 1978. The geologic report is subcontracted to the Michigan Department of Natural Resources and was completed and open filed in 1979 as GJBX-50(79).

Drilling projects currently identified and in the planning stage for 1979 drilling are the South Texas Project, the Sonora Pass and Owens Valley projects in California, and the Sand Wash Basin Project in Colorado. States in which areas are under investigation for future drilling projects include Nevada, Utah, New Mexico, Texas, Arizona, and Wyoming.



A hole depth of 2,907 ft was reached at the Missoula/Bitterroot Project in Montana.



Diversity marked the scope, equipment, terrains, and field crews of the various subsurface investigations. Drilling depths ranged from 350 ft at Spor Mountain to 5,130 ft at Chaco Canyon. Here, driller's helpers pull up pipe.

1978 Drilling Projects

Missoula/Bitterroot Basins

- Subcontractors: X-L Drilling Co.
  Goodwell Logging Co.
  Monaco Engineering
  Montana Bureau of Mines
- Total Subcontracts Value: $560,300
- Start Date: 10 May 1978
- Completion Date: April 1979

This project is being conducted in conjunction with the USGS and the State of Montana. The purpose of the project is to examine Tertiary basins in southwestern Montana for potential uranium deposition. Similar Tertiary basins south of the study area, in Wyoming, have known uranium occurrences.

San Rafael

- Subcontractors: Chesney Drilling Co.
  Century Geophysical
  Baroid Engineering
- Total Subcontracts Value: $658,600
- Start Date: 20 September 1978
- Completion Date: May 1979

This project examines 2 known uranium hosts, the Chinle and Morrison formations, for uranium favorability. The San Rafael Swell area of east-central Utah has had uranium production from both these Mesozoic formations.

Lemhi Pass (Thorium)

- Subcontractors: Udy Drilling Co.
  Goodwell Logging Co.
- Total Subcontracts Value: $74,900
- Start Date: 5 August 1978
- Completion Date: 1 November 1978

This project was performed in conjunction with the USGS, which will issue the geologic report. Two holes were drilled in the Belt Series on the Idaho-Montana border to examine thorium occurrences.

Spor Mountain

- Subcontractors: Boyles Bros.
  Century Geophysical
  Baroid Engineering
- Total Subcontracts Value: $873,100
- Start Date: 20 June 1978
- Completion Date: 8 November 1978

This drilling project examined Tertiary volcanics in west-central Utah in an area of known potential for uranium deposition. Data on subsurface stratigraphic sequences obtained from the drilling program furthered subsurface geologic knowledge of the area.

East Chaco Canyon

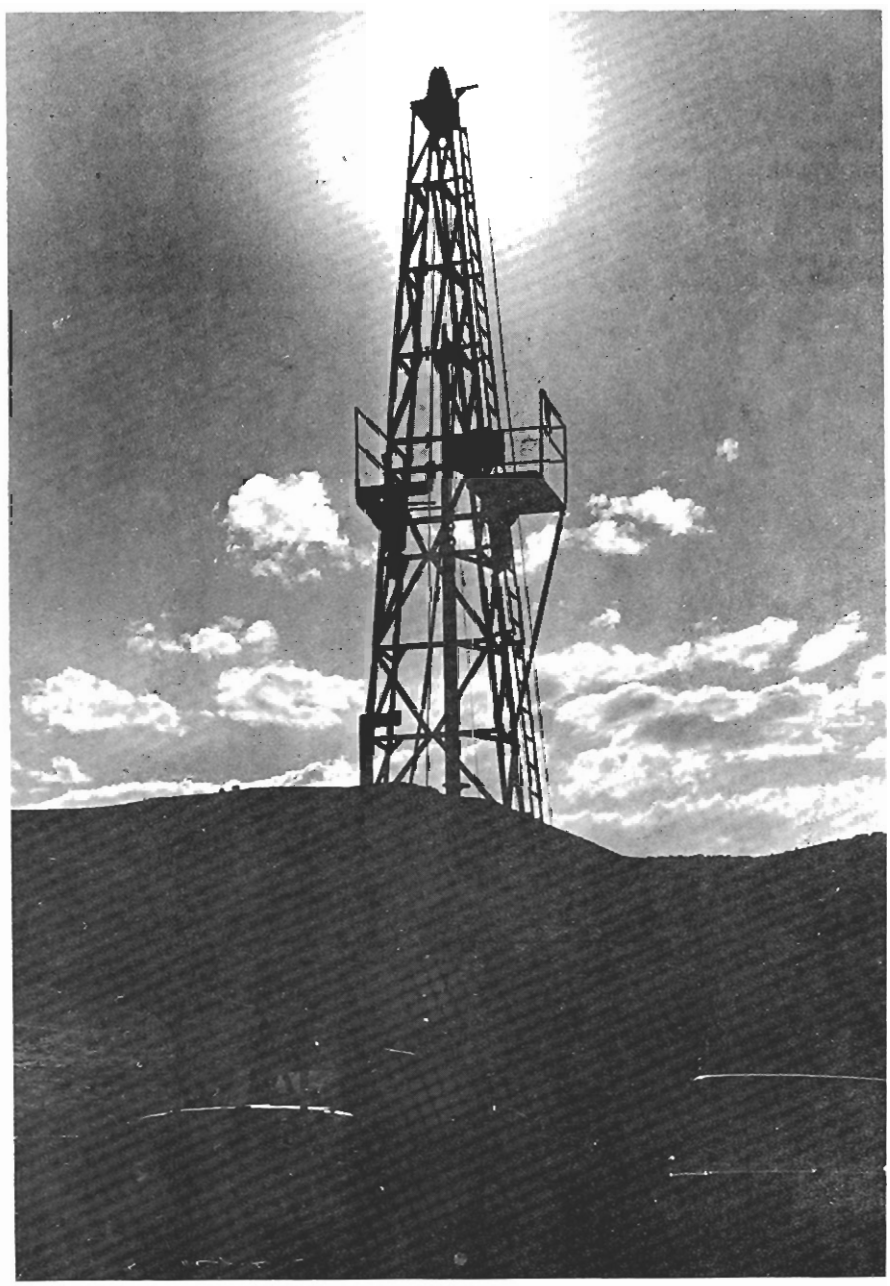
- Subcontractors: Brinkerhoff Drilling Co.
  Chesney Drilling Co.
  Century Geophysical
  Core-Lab
  D. C. Brookins
  (University of
  New Mexico)
- Total Subcontracts Value: $1,734,200
- Start Date: 15 July 1978
- Completion Date: 19 November 1978

The Grants mineral province of northwestern New Mexico contains known uranium occurrences and potentially favorable host rocks. This project examined the Westwater Member of the Morrison Formation in East Chaco Canyon and encountered some uranium mineralization. Lithologic evaluation is expected to yield further information on uranium deposition in the area.

1978 Logging Projects

The principal function of the Bendix in-house logging program is to perform KUT (spectral gamma) and other specialized logging of holes drilled by Bendix. At the end of 1978, there were 2 borehole logging systems with the capability of recording natural gamma-ray, resistivity, spontaneous potential, KUT, caliper, temperature, neutron (epithermal and thermal), magnetic susceptibility, and density logs to a depth of 6,000 ft (1,829 m). A surface surveying system also is in operation, primarily to collect surface KUT data.

Five more borehole logging systems (all with on-board computers) and an additional surface survey unit are being obtained and prepared for the 1979 field season. Bendix also makes extensive use of commercial logging companies to perform standard logging services on Bendix holes. Logging companies are identified in drilling project reports in the previous section. The results of specialized logging performed by Bendix are issued as a geophysical report approximately 1 month after completion of each project.



A drilling rig for the Spor Mountain Project looms against the backdrop of the Thomas Range in western Utah.

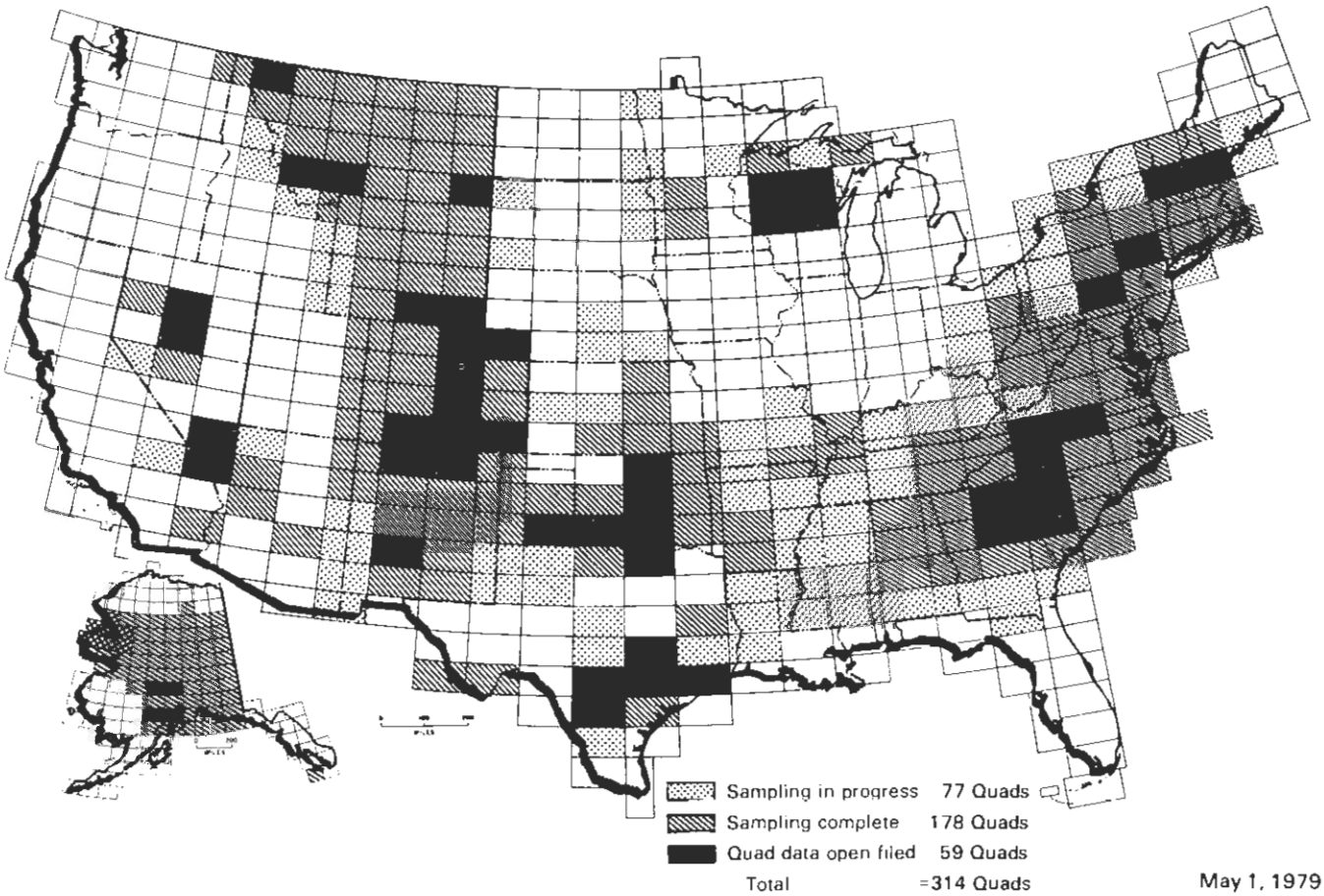
Hydrogeochemical and Stream-Sediment Reconnaissance

The Hydrogeochemical and Stream-Sediment Reconnaissance (HSSR) is directed by DOE's NURE Project Office (NPO) at Grand Junction, Colorado. Through September 30, 1978, the program in the field was conducted by 4 DOE laboratories. Beginning October 1, 1978, responsibility for the Far Western States was transferred to Savannah River Laboratory when Lawrence Livermore Laboratory began to phase out of the program. A quality assurance project that supports the field effort is being conducted by the Ames Laboratory, which is located on the campus of Iowa State University.

The field program involves the collection of samples of ground water, stream water, and streambed sediments at a density of 1 sample per 5 to 10 square miles. The sample materials are chemically analyzed for uranium and other selected elements that are useful for geochemical interpretation of the geologic environment.

In October 1978, in line with revised NURE program goals, the HSSR project was modified to emphasize 116 high priority quadrangles. These 116 quadrangles are to be reported on and the HSSR data merged with other quadrangle evaluation information for a preliminary resource report that is scheduled for completion by

STATUS OF THE HYDROGEOCHEMICAL PROGRAM



May 1, 1979

October 1980. Upon completion of these 116 quadrangle goals, HSSR work will resume on the 156 remaining "A" priority quadrangles, which are scheduled for completion in 1982, with all 621 quadrangles of the United States scheduled for completion in 1984.

Beginning in October 1978, detailed hydrogeochemical and stream-sediment surveys were added to the hydrogeochemical program. These detailed surveys will investigate local areas of interest at densities from 1 to 4 sample sites per square mile. These surveys will be carried out to support quadrangle evaluations and studies related to intermediate-grade and world-class uranium resources.

As of December 1978, reports on 39 quadrangles had been open filed.

Sampling for 229 quadrangles had been completed, and 96 quadrangles had been partly sampled, leaving 297 quadrangles to be sampled. During 1978, 37 quadrangles were reported, 168 were completely sampled, and 71 were partly sampled.

During the past year, 3 of the 4 DOE laboratories achieved their maximum planned rate of sample analysis for uranium and multielement analysis.

The Bendix geochemical department of 5 professional geochemists and 1 clerk have carried out the necessary liaison with the DOE laboratories, collaborated with the laboratories in rescheduling to meet the new program goals, and initiated planning for detailed hydrogeochemical and stream-sediment surveys.

A field geologist from ORGDP gathers stream samples in the Ardmore Quadrangle in Oklahoma. ORGDP is responsible for 30 high priority quadrangles in the central United States.

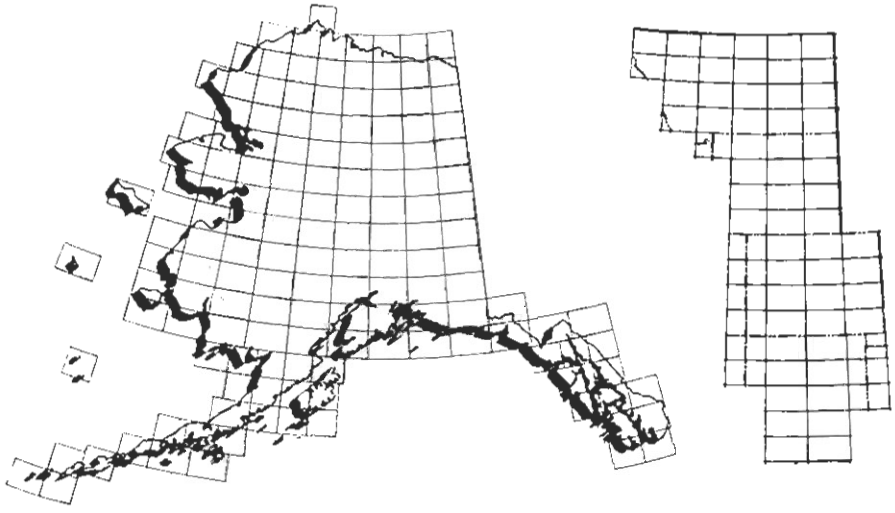
Lawrence Livermore Laboratory

Lawrence Livermore Laboratory (LLL) has had responsibility for the HSSR program for about 690,000 square miles (1,787,000 square km), covering 110 quadrangles in 10 Western States. A DOE decision led to the reassignment of all but 9 of the 110 quadrangles to other laboratories. Major accomplishments by LLL during 1978 included collection of about 22,000 HSSR samples, analysis of about 32,000 samples, release of 3 quadrangle reports, and transfer of samples, maps, and field forms to Savannah River Laboratory.

Ground-water, stream-sediment, and surface-water HSSR samples were collected by subcontractors in Washington, Idaho, Nevada, Oregon, Utah, Arizona, and California. Samples were analyzed for uranium by delayed-neutron counting and for other elements by neutron-activation analysis (NAA), optical-emission spectroscopy, and spectrophotometry. The capacity of the NAA system was expanded to exceed 50,000 samples per year.

Revisions of the reports on pilot studies at Cave Valley, Roach Lake, and Winnemucca Dry Lake were open filed during 1978. Quadrangle reconnaissance reports were open filed for the Winnemucca, Las Vegas, and Kingman quadrangles.

The HSSR data should be useful in evaluating the relationship between hot springs and uranium deposits in some quadrangles. One area of possible thorium enrichment has been identified, as well as several areas in which uranium deposition may have occurred.



Los Alamos Scientific Laboratory

Los Alamos Scientific Laboratory (LASL) is responsible for the HSSR program in 70 quadrangles of the Rocky Mountain Region, including 4 quadrangles—St. Johns, Hamilton, Dubois, and Elk City—added in September 1978, and the 153 quadrangles of Alaska, a total land area of about 1,070,000 square miles (2,771,000 square km) (see maps). Among LASL's noteworthy accomplishments during 1978 were collection of 155,000 HSSR samples, analysis of 36,000 samples, and publication of reconnaissance reports for 19 quadrangles.

By the end of 1977, LASL had completed sampling in 35 of the original 66 Rocky Mountain Region quadrangles. This past year, the remaining 31 were finished, leaving only parts of the 4 newly added quadrangles to be sampled in 1979. Thirty-eight Alaska quadrangles were sampled in 1978, bringing the number completed to 66 and leaving 87 to be done in 1981 and thereafter to meet the HSSR long-term 1982 and 1984 goals. Approximately 180,000 locations have been sampled, providing a total of roughly 150,000 water samples and 160,000 sediment samples. Over 50 percent of these samples were collected in 1978.

LASL, responding to DOE's October 1977 request for multielement analyses of HSSR samples, expanded and upgraded its analytical program so that it now routinely analyzes sediments for 43 elements and water for 13 elements by delayed-neutron counting, short- and long-time delay NAA, energy dispersive X-ray fluorescence, arc-source emission spectrography, fluorometry, and inductively coupled plasma-emission spectrography. The maximum sample throughput for all methods except NAA is 400 per day. The NAA production rate is 200 per day and will be doubled in 1979 with the addition of a second reactor port for sample irradiation, 4 more Ge(Li) gamma-ray detectors, and a computer with more than twice the memory of the unit presently in use. LASL's annual analytical capability will be more than 80,000 samples per year when this additional NAA equipment is online.

The net result of LASL's aggressive sampling program and expanded analytical capabilities was that 11 HSSR reconnaissance reports covering 12 Rocky Mountain Region quadrangles and 3 HSSR reports covering 7 Alaskan quadrangles were submitted for open filing in 1978. Six other reconnaissance reports concerning parts of 13 quadrangles (some of which will be reported as full 1° by 2° quadrangles by the Oak Ridge Gaseous Diffusion Plant or the Savannah River Laboratory) were also submitted, as were 4 quarterly progress reports, 3 pilot or special study reports, and 2 topical reports on field procedures and data management.

LASL's inductively coupled plasma source emission spectrograph determines the presence of 12 elements in water samples.

In the context of the September 1978 reorientation of the NURE program, known as the 116 quadrangle program, LASL has responsibility for 48 quadrangles. It has sampled all of those except for portions of 4 newly added to its area. HSSR reconnaissance reports covering 11 of the 48 are open filed or have been submitted for that purpose.

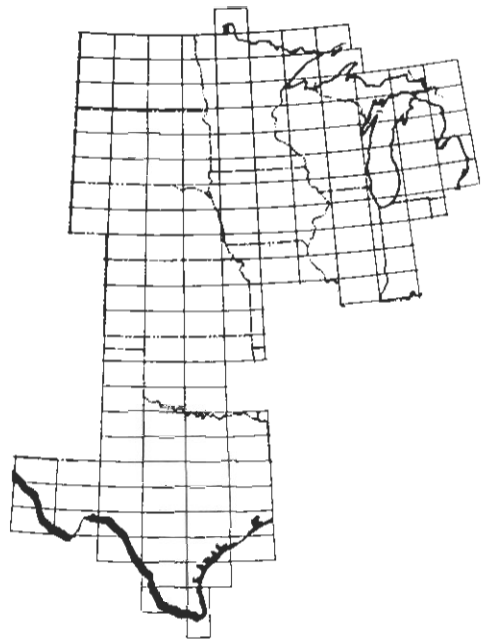
LASL completed the first HSSR detailed geochemical study covering 4 areas in the northwestern portion of the Pueblo Quadrangle. Sampling of stream sediments and ground and surface waters was conducted at a density of 4 sites per square mile over the 140 square miles (363 square km) composing the target areas. The closely spaced data, when combined with the reconnaissance data in the Pueblo HSSR report, are expected not only to increase the reliability of estimates of uranium reserves in the quadrangle, but also to offer opportunities for statistical approaches to the relative value of different sampling densities in an area of known uranium deposits.

This report was open filed as GJBX–42(79).

A team from LASL obtains stream samples and makes field measurements in Montana. In 1978, LASL completed work on 31 Rocky Mountain Region quadrangles.

LASL personnel fuel a helicopter at a remote base camp in Alaska. The helicopter allows LASL crews to collect samples in the rough terrain of Alaska's 153 quadrangles.

Oak Ridge Gaseous Diffusion Plant



The Oak Ridge Gaseous Diffusion Plant (ORGDP) is conducting the HSSR program over an area of more than 970,000 square miles (2,512,000 square km), covering 154 quadrangles in the central United States (see map). Major accomplishments by ORGDP during 1978 included collection of approximately 33,000 HSSR samples, analysis of 26,000 samples, and release of 11 quadrangle reconnaissance reports.

Samples collected for the HSSR studies include ground water, stream sediment, and stream water. The samples are collected by ORGDP field geologists, state geologic surveys, and contractors from industry.

Uranium content in water samples is determined by fluorometry and isotope-dilution mass-spectrometry methods, and in sediments by fluorometry and neutron-activation, delayed-neutron counting techniques. Atomic absorption, plasma source emission spectrometry, and spectrophotometry are used for analysis of 28 additional variables in sediment and water samples.

In October 1978, 30 quadrangles in the ORGDP area of responsibility were assigned a high priority status for reporting within the next 2 years as a result of reorientation of the NURE program. During 1978, HSSR reports for the following high priority quadrangles were open filed: Plainview, Seguin, Sherman, Oklahoma City, Rice Lake, Green Bay, and Eau Claire. High priority quadrangles open filed in 1979 include Austin, Enid, Lawton, Ashland, and Clinton.

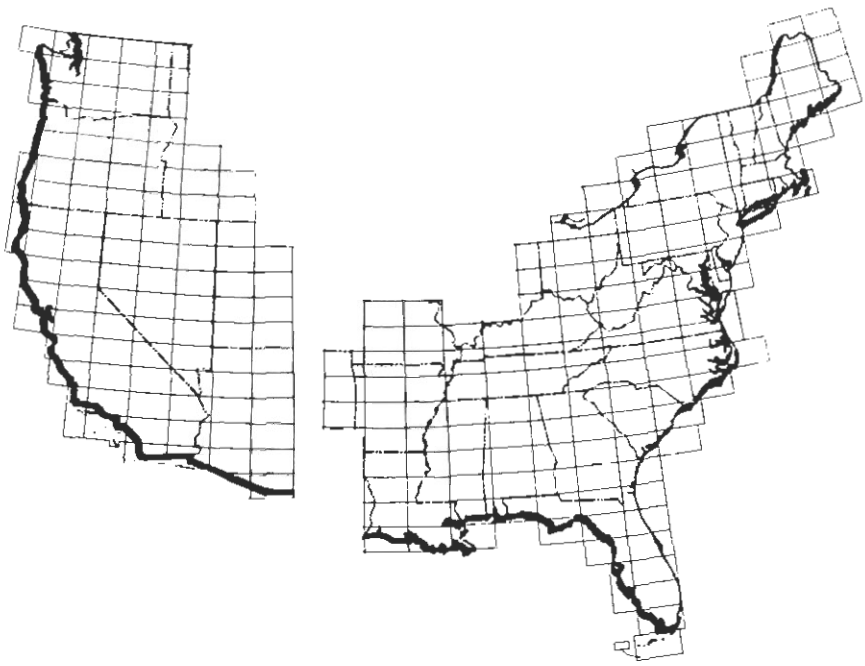
Reports also were issued in 1978 for San Antonio, Houston, Iron Mountain, and Ardmore; and in 1979, Emory Peak, Presidio, Wichita, and St. Cloud.

ORGDP field geologists conduct stream-sediment sampling in the Amarillo Quadrangle in Texas.

Other HSSR reports issued in 1978 include a wide-spaced (1 sample of ground water and sediment per 100 square miles [259 square km]) uranium geochemical reconnaissance in Plainview, Lubbock, and Big Spring quadrangles, Texas; a report on computerized correlation analysis; and procedures manuals for ground-water and stream-sediment sampling.

Reports for Wichita Falls, Palestine, Joplin, Pratt, Amarillo, New Ulm, Manhattan, Hutchinson, Lubbock, Beeville, Laredo, Hot Springs, Marquette, Watertown, and Milbank quadrangles are scheduled for release during 1979.

A detailed geochemical study was initiated in selected areas within the Trans-Pecos, Texas, region. The collection of approximately 1,200 stream-sediment and 200 ground-water samples is planned for 5 different areas totaling approximately 2,350 square miles (6,090 square km).



Savannah River Laboratory

The Savannah River Laboratory is responsible for conducting the HSSR program over an area of more than 1,500,000 square miles (3,885,000 square km), covering 235 quadrangles in all or part of 30 Eastern States and 9 Western States. Major accomplishments in 1978 were collection of approximately 91,000 samples, completion of the full-scale reactor-activation analysis facility, and completion of plans to conduct the HSSR program in the 9 Western States that were transferred from LLL.

During 1978, over 37,000 ground-water samples, 28,000 stream-sediment samples, and 14,000 surface-water samples were collected during reconnaissance surveys. An additional 12,000 ground-water samples were taken for helium and neon analyses in the Southeastern Coastal Plain from Montgomery, Alabama, to Washington, D.C. Sampling was completed in 49 quadrangles in 1978, and 31 other quadrangles have been partly sampled.

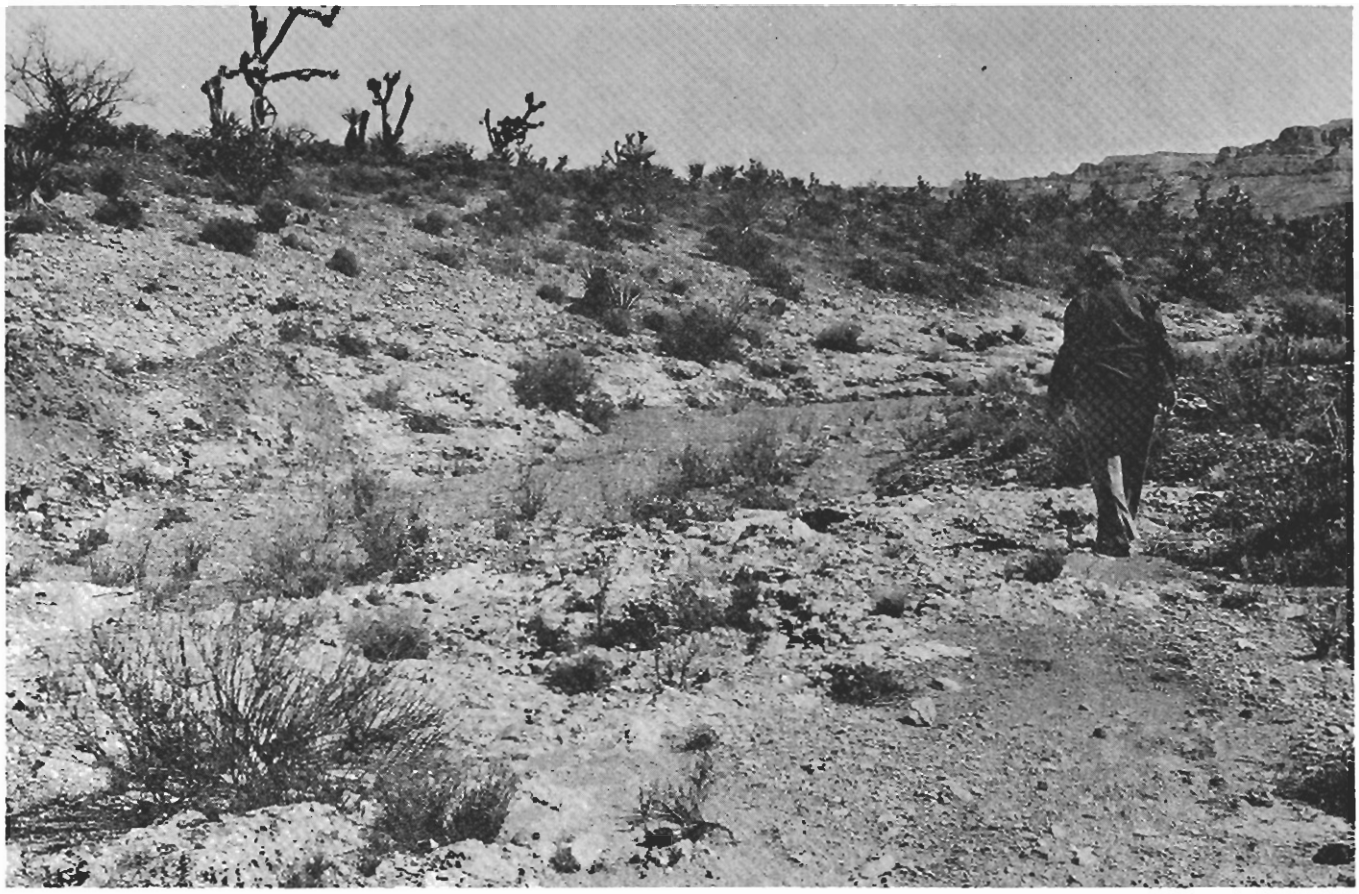
The full-scale activation facility became operational in July 1978. The system is capable of operating at a rate greater than 11,000 samples per month.

Six orientation studies were completed in 1978: 1 in the carbonatite region of Arkansas, 1 in areas including the Chattanooga Shale in Arkansas, 1 each in the granitic and rhyolitic regions of Missouri, 1 in central Maine, and 1 in the phosphate rock area of central Florida.

In October 1978, 32 quadrangles in the Savannah River Laboratory area of responsibility were assigned a high priority status for reporting in the next 2 years. Only one of these high priority reports was open filed in 1978, the Spartanburg report. In 1979, 8 more were completed: Scranton, Athens, Portland, Glens Falls, Augusta, Harrisburg, Dyersburg, and Poplar Bluff. Reports also were issued for Greensboro, Charlotte, Greenville, and Winston-Salem. Other reports open filed in 1978 were: orientation study data from the Spruce Pine, Moore, and Johnston, North Carolina, areas and the Leesville, South Carolina, area; a radiometrics study in the Spruce Pine area; and a description of the geology of the Raleigh Quadrangle. Three papers on the HSSR program were presented by Savannah River Laboratory personnel during the year.

A detailed geochemical study was initiated in the Glen Wild, New York, area of the Scranton Quadrangle. The collection of approximately 200 samples each of ground water, stream water and stream sediment is planned for an area of 230 square miles (596 square km).

Technicians package ion-exchange resin samples in "rabbits" for Savannah River Laboratory. The laboratory's new reactor-activation system is capable of analyzing more than 11,000 samples per month.



Calcreted terrain in the Columbus area of New Mexico was visited by a Bendix geologist as part of Topical Geologic Studies.

Geologic Studies

The reoriented NURE program created 2 new high priority geologic studies categories: (1) World-Class Deposit Studies, and (2) Intermediate-Grade Studies. Investigations carried out under these 2 categories will expand the scope of uranium assessment beyond the more familiar low-cost (less than $50 forward cost) sandstone deposits with selective examination of relatively unknown and higher cost domestic resources that may be feasible supply alternatives to advanced nuclear and fossil-fuel technologies.

General geologic studies started prior to the reoriented program will be completed and reported under Topical Geologic Studies.

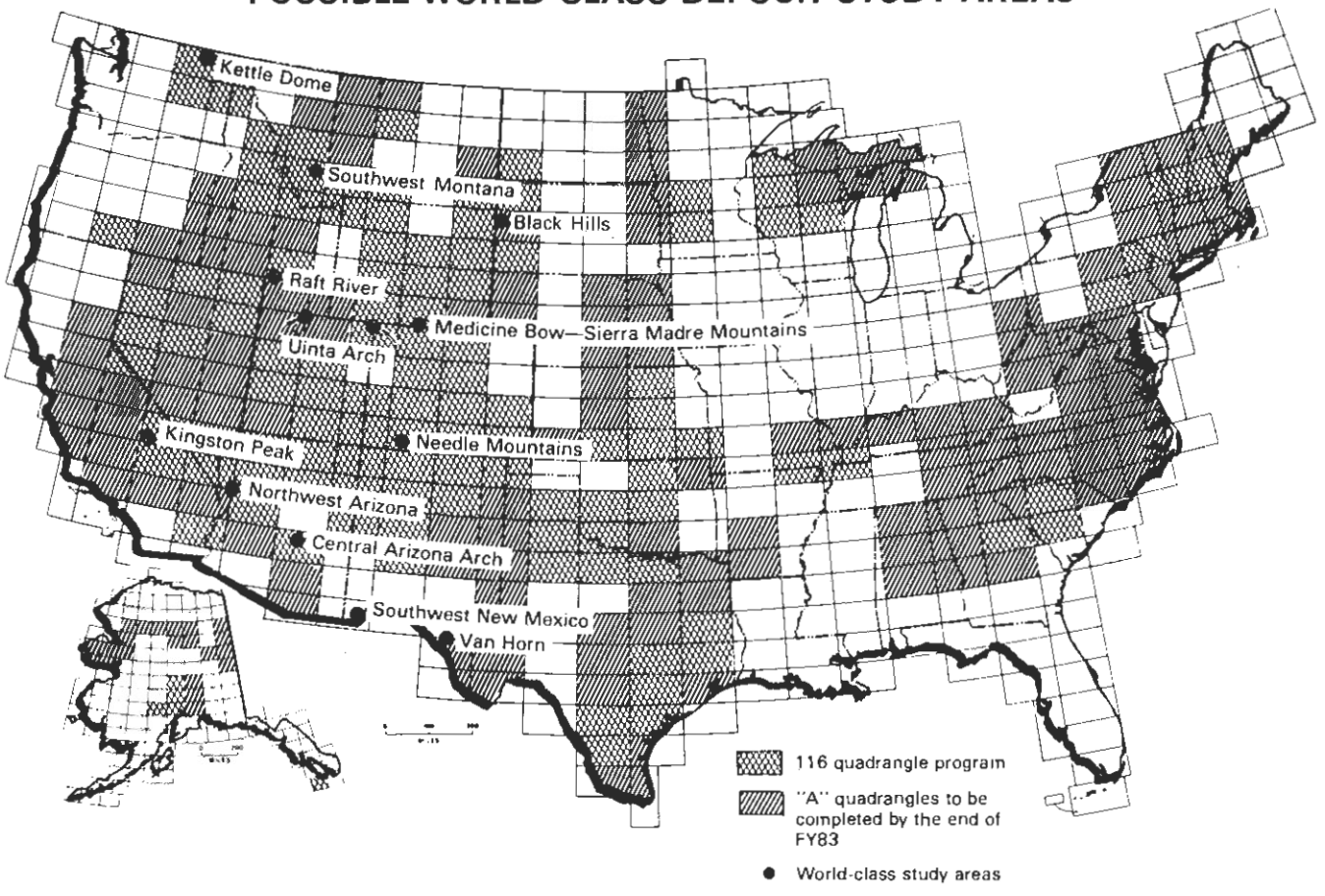
World-Class Deposit Studies

The major goal of the World-Class Deposit Studies, an outgrowth of the Topical Geologic Studies, is to complete by October 1980 geologic examination of 1 to 3 major environments favorable for uranium occurrence.

The studies will provide complete analysis of the geologic environments of uranium deposits that are important producers throughout the world and have the highest probability of occurring in the United States. Occurrence models based on these studies will guide the evaluation of analogous U.S. geologic environments to broaden the domestic resource base.

The major uranium deposits of the world may be grouped, according to similar geologic backgrounds, into: (1) unconformity related (vein-breccia), (2) plutonic-metamorphic (porphyry-pegmatite-syenite-carbonatite-metasomatic), (3) Precambrian pebble conglomerate, (4) volcanics, (5) gneissic domes, and (6) calcrete. U.S. areas most likely to contain analogs of important world-class-type deposits are shown on the map on page 51.

POSSIBLE WORLD-CLASS DEPOSIT STUDY AREAS



Intermediate-Grade Resource Studies

The types of uranium resource to be examined under intermediate grade range from 0.01 to 0.05 percent U_3O_8. Among the types to be surveyed and evaluated are: (1) continental sandstone, (2) shales, (3) uranium/thorium in igneous rocks, and (4) volcanic rocks. By October 1980, 3 to 5 major candidate areas for the intermediate grade will be examined. U.S. areas most likely to contain important intermediate-grade deposits are shown on the map on page 54.

Aerial radiometric detail surveys, outcrop sampling, ground radiometric and other geophysical surveys, ground-water hydrogeochemical studies, and delineation drilling and logging technologies will be used to accumulate the required data on each deposit selected for world-class and intermediate-grade studies.

Topical Geologic Studies

Colorado Front Range Uranium Study

- Subcontractor: Dr. R. H. Carpenter
- Subcontract Value: $69,040
- Start Date: 23 May 1977
- Completion Date: 31 July 1978

The objectives of this study were: (1) to determine the modes of occurrence of uranium in the igneous and metamorphic terrains of the Colorado Front Range based upon field observations and literature review, and (2) to develop models for each type of uranium occurrence through consideration of the sources and concentration mechanisms of uranium in the various dynamic environments represented by major stages in the evolution of the Front Range—Proterozoic deposition and subsequent metamorphism, Middle and Late Proterozoic igneous events, Proterozoic and Phanerozoic tectonism, and finally, Late Cretaceous and Tertiary igneous activity.

The study was completed and a draft report was submitted to Bendix on July 31, 1978. The report was open filed in 1979 as GJBX-15(79).

Formation of Uranium Ores by Diagenesis of Volcanic Sediments

- Subcontractor: Texas Bureau of Economic Geology
- Subcontract Value: $73,764
- Start Date: 15 May 1977
- Completion Date: 31 October 1978

The objective of the project is to identify and define the processes by which uranium deposits form in volcanic material by studying known uranium occurrences in volcanic terrains. The study also provides a model of uranium depositional processes resulting from diagenesis of volcanic sediments.

Field and laboratory investigations were conducted on piles of tuff, pyroclastics, volcaniclastic sediments, and volcanic sediments in the Trans-Pecos, Texas, and Peña Blanca, Mexico, areas. Criteria for release, mobilization, and redeposition of uranium in volcanic rocks were examined.

The principal investigators on the project are Dr. C. D. Henry, Texas Bureau of Economic Geology, and Dr. A. W. Walton, University of Kansas, in collaboration with Dr. P. G. Goodell, University of Texas at El Paso, and others.

The final report was open filed in 1979 as GJBX-22(79).

Experimental Leaching of Uranium From Tuffaceous Rocks

- Subcontractor: University of Texas at El Paso
- Subcontract Value: $33,815
- Start Date: 1 June 1978
- Completion Date: 31 May 1979

Tuffaceous volcanics are considered a possible source rock in many of the major uranium environments in sedimentary basins. Such potential sources have been proposed for uranium in the Colorado Plateau, Wyoming, and Texas Coastal Plains. The hydration and vitrification processes of volcanic rocks have been studied experimentally, though not with uranium in mind.

The objective of this study, encompassing field, laboratory, and experimental investigations, is directed toward understanding the processes of zeolitization associated with early diagenetic changes. Silica activity variations in transporting solutions that may be important in uranium depositional processes will be examined. During the course of investigation, thermodynamic properties of uranyl silicate and zeolite phases, essential to designing experimental conditions and interpreting results, will be compiled. Hydrometallurgical leaching experiments on uranium ores will be performed on mineralized tuffs from Sierra Vieja, West Texas, and Peña Blanca, Mexico.

Dr. Goodell of the University of Texas at El Paso is the principal investigator for the project.

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

Preparation and Publication of Chronometric-Geologic Correlation Charts for the Precambrian of the United States and Mexico

- Subcontractor: University of Wyoming
- Subcontract Value: $15,000
- Start Date: 1 November 1977
- Completion Date: 31 December 1978

Precambrian metamorphic, igneous, and sedimentary rocks are recognized by geologists to be favorable hosts for many types of base-metal and precious-metal mineralization. Recent discoveries of uranium and thorium mineralization in Precambrian host rocks provide the need to further understand the chronometric relationships of Precambrian rocks on a "continent-wide" basis.

This project, under the direction of Dr. R. S. Houston of the University of Wyoming, is providing a vital link in the completion of this task for the contiguous areas of the United States and Mexico, and Alaska. Funds for this project will allow Dr. Houston and various team members of the International Union of Geophysical Societies Working Group on the Precambrian for the United States and Mexico to complete the work initially funded by the USGS.

The correlation charts, with companion manuscripts, will be released jointly by a GJO open-file report and by a special issue of *Economic Geology* late in 1979.

Study of Uranium- and Thorium-Bearing Pegmatites

- Subcontractor: Derry, Michener & Booth
- Subcontract Value: $83,000
- Start Date: 5 October 1978
- Completion Date: 30 April 1980

The main purpose of this project is to study economically important radioactive pegmatites in order to formulate a set of favorability criteria which can be utilized in assessing the uranium/thorium potential of individual pegmatites and pegmatite provinces in the United States.

A minimum of 8 pegmatite localities currently being exploited within the United States and Canada will be studied and sampled in detail to develop and confirm the reliability of favorability criteria.

Regional Geology and Uranium Favorability in Alaska

- Subcontractor: Geophysical Institute, University of Alaska
- Subcontract Value: $50,112
- Start Date: 3 August 1978
- Completion Date: 3 February 1980

This project is a study of the tectonic evolution of Alaska to ascertain the relationship between tectonic events and variations in uranium and thorium content in the 14 metamorphic terrains recognized in Alaska. Enriched and depleted uranium/thorium provinces will be identified and rank ordered on the basis of developed uranium favorability criteria.

Representative samples for the required studies and analyses will be collected from those terrains for which samples have not previously been collected. Petrologic and geochemical studies will be performed on both metamorphic and alkaline igneous rocks.

Uranium in Precambrian Quartz-Pebble Conglomerates

- Subcontractor: University of Wyoming
- Subcontract Value: $76,145
- Start Date: 1 August 1978
- Completion Date: 1 November 1979

Uranium mineralization in Precambrian quartz-pebble conglomerates has been widely recognized in the shield areas of most continents. These deposits have been recognized in the United States, but little is known in comparison to foreign deposits, such as those in Witwatersrand, South Africa, and the Blind River-Elliot Lake area, Canada.

The objectives of the project are twofold. The initial thrust by the principal investigator, Dr. Houston of the University of Wyoming, is the compilation and integration of the diverse sources of literature that pertains to the foreign occurrences of uraniferous quartz-pebble conglomerates. The output of the literature survey will be the formulation of a general exploration model that can be used in the United States. Phase II will involve testing and refining the model by its application to the Proterozoic quartz-pebble metaconglomerates exposed in the Medicine Bow and Sierra Madre Mountains of southeastern Wyoming.

Additional impetus for the project comes from the recognition of Precambrian quartz-pebble conglomerates in southeastern Wyoming, the Black Hills of South Dakota, and possibly the Michigan Peninsula area. The ultimate output of the project will greatly assist in the evaluation of the uranium favorability of these areas, as well as advance our basic geologic understanding of the genetic processes that create the deposits.

Geologic Phase of the Red River Valley Drilling Project, North Dakota-Minnesota

- Subcontractor: University of North Dakota
- Subcontract Value: $58,324
- Start Date: 9 May 1977
- Completion Date: 31 August 1978

This project represents the geologic followup to the Red River Valley Drilling Project recently completed by Bendix along the border between North Dakota and Minnesota. The objectives of the core and rotary drilling were to penetrate the basal Mesozoic and Paleozoic sedimentary rocks that onlap on the Precambrian rocks of the Canadian Shield.

The goals of the geologic work, directed by Dr. W. L. Moore of the University of North Dakota, were to gather as much pertinent geologic data as possible on the uranium favorability of 4 major subsurface horizons: the Cretaceous Dakota Sandstone, the basal Ordovician sedimentary unit, the weathered zone at the unconformity, and the unweathered Precambrian basement rock. The data were generated from the study of core, rotary cuttings, geophysical logs, and water samples. The results of the geologic study were released in open-file report GJBX-3(79).

Geochemical Exploration for Sandstone-Type Uranium Deposits

- Subcontractor: Pennsylvania State University
- Subcontract Value: $58,475
- Start Date: 2 January 1978
- Completion Date: 1 December 1979

The objective of the study is to investigate the physical and geochemical controls for uranium transportation and deposition in 2 sandstone uranium districts in the Eastern (Pennsylvania) and Western (Colorado) United States. The leaching and (or) addition of uranium in the deposits will be examined. The degree of mobilization, source, and initial uranium content of the 2 deposits will be determined from regional variation in uranium/thorium ratios. The study will concentrate on methods of anomaly interpretation, and followup studies will be based on geochemical data collected.

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

Russian Literature Translation

- Subcontractor: Dr. Alexander Avrasbov
- Subcontract Value: $5,000
- Start Date: 1 August 1978
- Completion Date: 1 November 1978

The objective of the study was to review published Russian literature, and select and translate articles dealing with albitite uranium deposits in the USSR.

Six articles on the subject matter were translated.

Uranium in Proterozoic Metamorphic Rocks

- Subcontractor: Michigan Technological University
- Subcontract Value: $100,892
- Start Date: 29 March 1977
- Completion Date: 30 April 1979

Model studies of the environment and genesis of Proterozoic unconformity vein deposits have been progressing well over the past 2 years. The report, "Criteria for Uranium Occurrences in Saskatchewan and Australia as Guides to Favorability for Similar Deposits in the United States," GJBX-114(78), open filed October 25, 1978, has been well received.

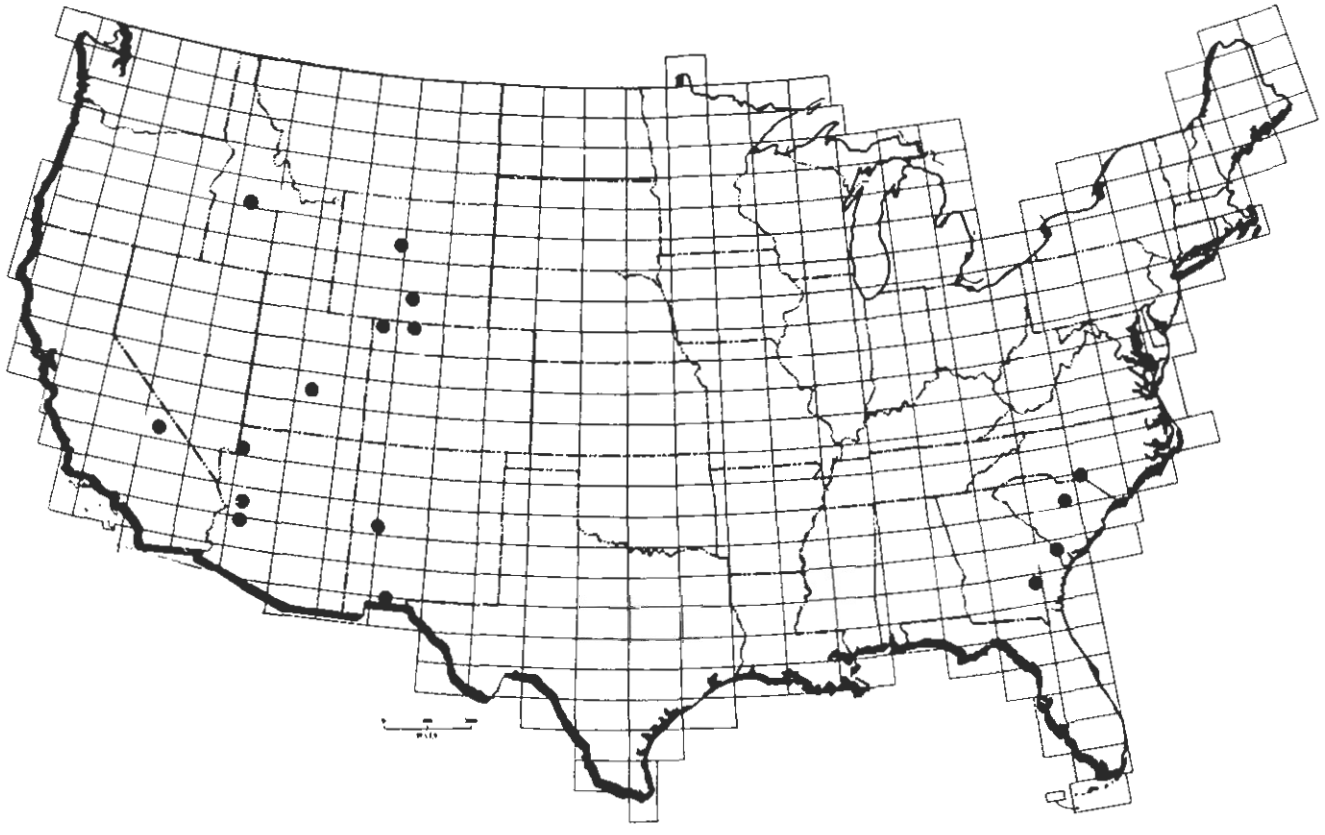
All 3 investigators, Dr. Jorma Kalliokoski of Michigan Tech, Dr. Fred Langford of the University of Saskatchewan, and Dr. R. W. Ojakangas of the University of Minnesota (Duluth), contributed substantially to the study. An extension to the original contract with Michigan Tech was given to allow Dr. Ojakangas to complete current studies at Jabiluka, N. T., Australia. These studies were an expansion of the original scope and should contribute greatly to an understanding of paleodrainage and its relation to uranium emplacement.

Lacustrine Uranium Distribution, Kern Lake, California

- Subcontractor: Lamarr-Merifield
- Subcontract Value: $20,600
- Start Date: 18 October 1978
- Completion Date: 18 October 1979

Many hypotheses have been formulated as to the distribution of uranium in lake sediments in interior basins. Testing to date has not been conclusive. The opportunity arose to sample Kern Lake, south of Bakersfield, California, piggybacking on the microseismic work of the USGS. Utilizing trenches cut across the lake, a sampling program was initiated to determine, if possible, which facies was the most likely receptor for uranium. Uranium sources exist around the periphery, and the catchment area of the Kern

LOCATION OF POSSIBLE INTERMEDIATE-GRADE STUDY AREAS



River is host to the Miracle Mine. The report of the findings will be open filed in 1979.

Uranium in Red Muds

- Subcontractor: Zellars-Williams
- Subcontract Value: $44,500
- Start Date: 12 September 1978
- Completion Date: 12 March 1979

Bauxitic ores have long been known to be mildly uraniferous. The Bayer process of fabricating the bauxite into aluminum tends to concentrate uranium in the red muds. Red muds tend to accumulate at the rate of 1 ton of red mud for every ton of aluminum produced. These muds therefore are conceivably a source of intermediate-grade uranium.

The present study is a physical inventory of the red muds and an assessment of the uranium they contain. It does not address possible modifications to processing to produce a byproduct uranium nor any metallurgical problems which may be a limiting factor on production from this source.

Development of Data Enhancement and Display Techniques

- Subcontractor: University of Georgia
- Subcontract Value: $55,000
- Start Date: 1 August 1978
- Completion Date: 1 August 1979

Enormous amounts of highly reliable geochemical data, consisting of multielement analyses of waters and sediments from many sites in each quadrangle, are being generated in the HSSR portion of the NURE program. In order to extract the maximum benefit from this mass of information, most specifically in the identification of areas favorable for uranium exploration, appropriate statistical methods for enhancing the data and bringing out anomalous signals from the background noise are a necessity. Further, geochemical mapping and graphic display techniques must be developed to optimize portrayal of the statistically treated parameters for visual interpretation of uranium favorability.

Dr. George Koch Jr. of the University of Georgia has undertaken this study with the assistance of Dr. Richard Howarth (University of London), Dr. J. H. Schunemeyer (University of Delaware), and Dr. S. Carpenter (University of Georgia). The group has selected the data from 3 quadrangles—Charlotte, Crystal City, and Pueblo—of differing geographical, climatological, hydrological, and geological conditions, for analysis by statistical and graphic methods.

At the conclusion of the project, the group will have selected a set of computer-referenced methods most suitable for the treatment and portrayal of HSSR multivariable data. Recommendations will also be presented for the application of these and other geostatistical procedures to

exploratory drill site evaluation and resource evaluation.

Uranium Distribution in Fluorine-Enriched Volcanic Environments

- Subcontractor: Arizona State University
- Subcontract Value: $81,799
- Start Date: 1 January 1979
- Completion Date: 29 February 1980

Uranium enrichment in fluorine-enriched peralkaline and alkaline volcanic rocks is generally 5 or 10 times the average for other silica volcanics in the Western United States. As such, these fluorine-enriched volcanics provide excellent source rocks for leaching of uranium into peripheral volcaniclastic and sedimentary environments. With primary petrochemical enrichment, the fluorine-enriched volcanics may achieve sufficient uranium mineralization for consideration as an intermediate-grade uranium resource in themselves.

The objectives of the project are to study the dynamics of the uranium-fluorine relationship during magmatic differentiation; eruption, welding, secondary crystallization, and diagenesis of tuff sheets; and hydrothermal fluid migration. The primary study area is the Spor Mountain-Thomas Range area of western Utah. Secondary sites will be studied where there are known occurrences of fluorine-enriched peralkaline and alkaline volcanics, and (or) topaz-bearing rhyolite. At Spor Mountain, the principal investigators, Drs. D. M. Burt and M. F. Sheridan, will integrate preexisting geologic and geochemical information from government, industry, and Bendix sources with their own field and laboratory data to formulate a geologic-geochemical occurrence model(s) for the various types of uranium mineralization that might be found in a peralkaline volcanic environment. Recognition and favorability criteria will be generated from the model. The final report will also identify areas in the United States where the model(s) might be applied for uranium exploration purposes.

Uranium in Accessory Minerals

- Subcontractor: Colorado School of Mines Research Institute
- Subcontract Value: $82,296
- Start Date: 27 September 1978
- Completion Date: 27 May 1979

A series of whole rock samples relating to known uranium mines and occurrences have been collected and are being analyzed for their accessory mineral content. This effort is an attempt to answer in part the hypothesis that certain trace elements other than thorium may be reliable indicators of uranium districts. This is part of NURE's ongoing effort to enhance uranium exploration.

The analytical effort will be completed in 1979 and the results will then be correlated with the geologic background data in a further study.

Uranium Favorability of Calcretes

- Subcontractor: University of California at Los Angeles
- Subcontract Value: $111,300
- Start Date: 21 June 1976
- Completion Date: 15 October 1978

The final report of the initial study performed by Dr. Donald Carlisle of UCLA was open filed on March 13, 1978, as GJBX-29(78). New information relative to the calcrete environment in South Africa was investigated by Dr. Carlisle as an add-on to an already scheduled trip to the Middle East sponsored by the UCLA Board of Regents. This information, updating the model, will be published in 1979.

Uranium Distribution and Mined Deposits in the Earth's Crust

- Subcontractor: Princeton University
- Subcontract Value: $49,692
- Start Date: 1 January 1976
- Completion Date: 15 August 1978

The goal of this project was to statistically evaluate the magnitude of U.S. uranium resources and their future availability. This was done by studying the geochemical distribution and mining history of uranium in comparison with the distribution and mining history of copper, lead, and zinc.

Work included an extensive literature search and compilation of geochemical distribution and production statistics for the metals of interest, compilation of basic nonproprietary data on uranium production from DOE-GJO computer files, and analytical processing of the data.

The results of the research are included in open-file report GJBX-1(79).

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, released in April 1978, as GJBX-78(78), also identifies areas thought to be favorable for uranium occurrences in alkaline rocks in the Untied States.

Low-Grade Studies

Low-grade resources are defined as those containing less than 100 ppm uranium. They include such materials as seawater, marine shales, lignite, and granite. The purpose of the low-grade resources program is to confirm the existence, location, and apparent extent of such deposits and to study selected categories in order to develop basic information required to estimate their general magnitude and economics or viability of extraction.

Chattanooga Shale

- Subcontractor: Mountain States Mineral Enterprises
- Subcontract Value: $270,732
- Start Date: 6 September 1977
- Completion Date: 15 November 1978

The Chattanooga Shale has long been of interest as a large-volume, low-grade source of uranium. The thrust of the study by Mountain States has been to assess the feasibility of extraction from an economic and engineering standpoint. An overview of the resources is an integral part of the study as well. This feasibility study was open filed as GJBX-4(79).

Phosphate Studies

- Subcontractor: Earth Sciences, Inc.
- Subcontract Value: $504,454
- Start Date: 26 June 1978
- Completion Date: 31 March 1979

Phosphates and phosphate rock have been of continuing interest as a source of uranium. The technology for extraction has become quite sophisticated. A resource evaluation of the uranium contained in these phosphate units in the United States and around the world is being conducted. The contract also calls for a feasibility analysis of state-of-the-art mining beneficiation and uranium recovery.

The project is proceeding according to schedule, and the final results will be open filed in 1979.

Seawater Project

- Subcontractor: Exxon Nuclear Co., Inc.
- Subcontract Value: $29,311
- Start Date: 6 June 1978
- Completion Date: 5 March 1979

Although the content of uranium in seawater is only on the order of 3 to 3.5 ppb, many countries have been working on extraction since the supply would be virtually unlimited. The technology has therefore been developing rapidly. Exxon, the Oceanography Department of Oregon State University, and Vitro are investigating the feasibility of extraction.

They have made specific site selections to take advantage of optimum current conditions and are developing the plant technology and economics. The project, completed on schedule, resulted in 2 open-file reports: GJBX-35(79) and GJBX-36(79).

A Zellars-Williams field team samples a sandy layer at a depth of 10 ft with a 3-in. diameter auger.

Geologic Map Compilation Program

- Subcontractors: approximately 20
- Total Subcontracts Value: $2,120,000
- Start Date: October 1977
- Completion Date: September 1981

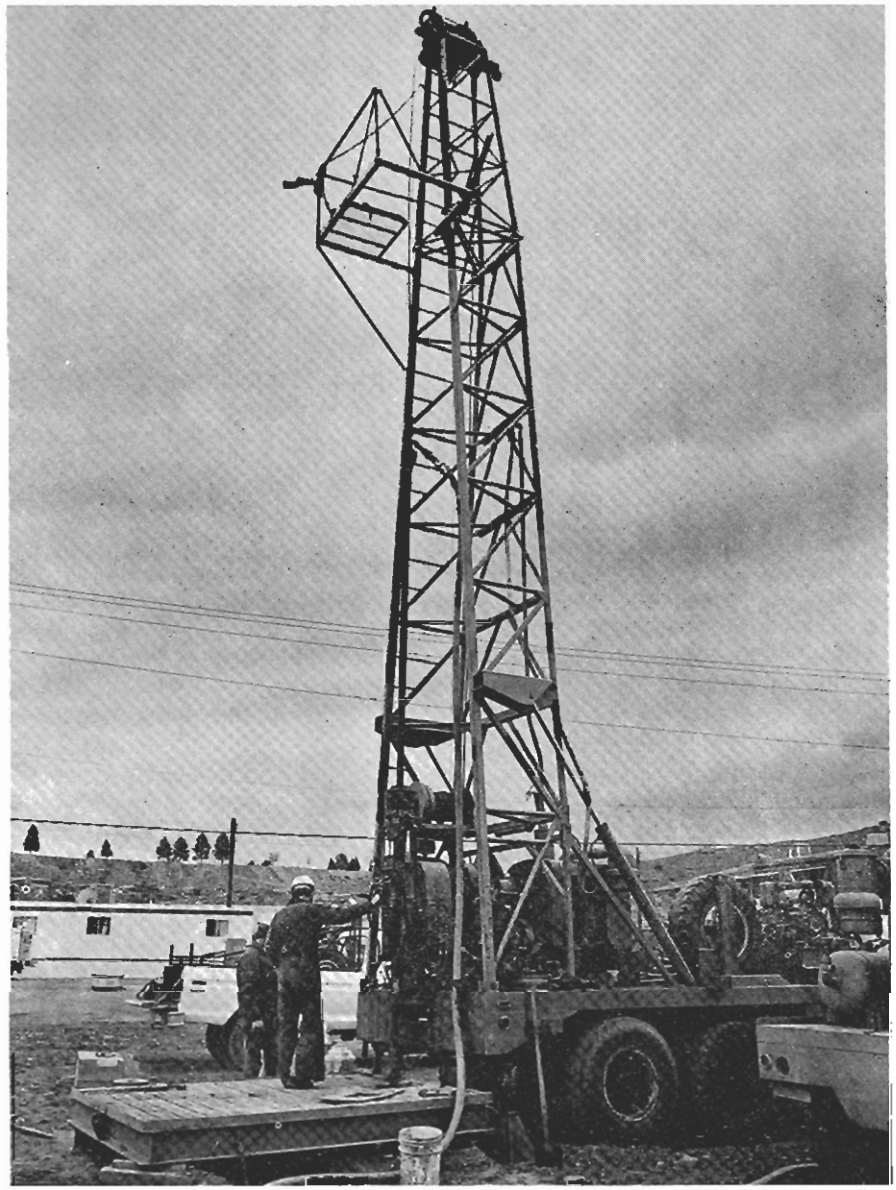
The Geologic Map Compilation Program is designed to provide 1:250,000 scale geologic maps for use as data bases for all NURE program elements. Since only 187 of the 621 NTMS quadrangles are presently covered by acceptable published surface geology maps with a scale of 1:250,000, subcontractors must produce 434 maps.

To date, 185 subcontracted maps have been delivered. Of these, 104 were delivered during 1978. At this time, 11 additional maps remain in the hands of producing subcontractors.

The major sources for the production of new 1:250,000 scale maps are previously published maps of different scales. These are checked for specification compliance, reduced or enlarged to 1:250,000 scale, and compiled. Where gaps occur in the published sources, air photography geologic maps are utilized. Original field studies have not as yet been used to produce or supplement maps because of the tight schedule required by NURE.

The acquisition of a 1:250,000 scale geologic map is essentially the first step for any NURE program element. The first users are normally the HSSR and aerial radiometric reconnaissance surveys. The geology serves as a base for the compilation and interpretation of the geochemical and radiometric data. Findings from these surveys are then passed on to the quadrangle evaluation teams where the geologic map becomes a reference point for the ensuing detailed uranium favorability evaluation.

A geologist extrudes a 2-ft sample of soft, red mud from a piston core sampler.



Work at the Grand Junction test and calibration site continued in 1978. Below, workmen level concrete over the "D" fission neutron model, and, at right, drillers core 1 to 7 "D" model test holes to a depth of 27 ft.

Technology Applications

The Technology Applications element of NURE provides research, development, and applications effort on new and improved devices, techniques, and methodologies for uranium exploration and uranium resource assessment. The program includes several disciplines in the pursuit of these objectives: physics, geophysics, geology, geochemistry, computer science, geostatistics, and remote sensing. Program activities are conducted by Bendix using both in-house specialists and subcontractor expertise.

The information obtained from these investigations is disseminated to industry and the public through reports and meetings. Testing and evaluation of logging and geophysical equipment used by the uranium industry are accomplished through this program. Technology Applications projects are classified into the categories of Exploration Techniques; Exploration Systems; Aerial Technology; and Calibration, Testing, and Laboratory Applications.

Exploration Techniques

Bendix is involved in a number of projects with the potential to improve instrumentation and methodology in resource exploration.

Areas of broad interest in Exploration Techniques include prompt and delayed fission neutron logging, gamma-ray spectral logging, and emanometry.

This technology also has a transfer capability to industry, other government agencies, and the general public via open filing, seminars, professional forums, and journal publications.

Uranium Borehole Logging with PFN

- DOE Contractor: Sandia Laboratories
- Subcontract Value: $650,000
- Start Date: October 1978
- Completion Date: September 1979

The activity during this report period can be broadly categorized under 2 headings: commercialization support and prompt fission neutron (PFN) logging development/demonstration.

In order to make Sandia's tube technology available for eventual commercialization, a request for bids was issued to build, in sequence: (1) 10 development Controlatron tubes, (2) 5 transformers and 3 tube-transformer assemblies (TTA), (3) 20 high output tubes (referred to as Zetatrons), and (4) a total of 5 TTA's using previously built Zetatron tubes. A bidders' meeting was held at General Electric's Neutron Device facility for respondents to the request. After a thorough evaluation of the responses, the Kaman Sciences Corporation of Colorado Springs, Colorado, was awarded a contract in April 1978.

The first request for neutron tube targets was received and honored by DOE, Albuquerque. The request specified deuterium-loaded scandium targets. A mechanism was established allowing future requests for targets to be handled on a routine basis.

The development/demonstration of the PFN logging system emphasized field operations. A better calibration between chemical uranium grade and probe response was established, although more work remains to be done. The logging system was converted to a depth-based system in midyear, and a 4-wheel-drive van was acquired to support the field operations.

Field operations, with the support of Bendix personnel, were conducted primarily in Texas and Wyoming. Most notable were the use of direct uranium techniques in Texas in the DOE/U.S. Bureau of Mines (USBM) field evaluation project and a closely spaced drilling/logging project in Wyoming. Both projects were designed to demonstrate the use of PFN log data in a reserve calculation and are expected to be completed in 1979.

Californium-252–Based Borehole Logging System

- Subcontractor: IRT Corp.
- Subcontract Value: $240,464 (Phase I)
  $528,297 (Phase II)
- Start Date: 1 June 1977 (Phase I)
- Completion Date: 1 January 1979 (Phase II)

Phase II work was begun in November 1977 to complete the upgrading of the californium-252–based delayed fission neutron (DFN) probe built for DOE and certain components of the computer-based system within the logging vehicle. A hiatus of 3 months occurred while additional funding was allocated. Due to budget limitations, the originally planned task of converting the logging system to a 1-man operation had to be abandoned and the amount of time in the field shortened.

Notable probe hardware improvements were made to the neutron monitor system, the source insertion/retrieval mechanism, the source stop and shuttle cord tension, the gamma-ray detection system, and the high-voltage isolation of the DFN detectors. A good deal of effort also went into coding for the data reduction and data presentation. Field work was conducted in Arizona, Wyoming, and Texas. The Texas work included an impressive participation in the DOE/USBM field evaluation of direct uranium techniques. Logging in air-filled holes was successfully demonstrated during a field operation in Richland, Washington, in which the logging equipment was loaned by DOE for use at Rockwell's Hanford Operations.

A draft report of Phase I activities was prepared but, for reasons of cost and economy of effort, was not submitted for open file. Instead, it will be incorporated in the report due at the end of current work.

Fiber-Optic Logging Cable Development

- Subcontractor: Optelcom, Inc.
- Subcontract Value: $59,306
- Start Date: October 1978
- Completion Date: 1 July 1979

A fiber-optic borehole logging cable should increase the data-transmitting capabilities of logging systems many times over the industry-standard, 4-conductor, logging cable. The objective of this project was to develop such a fiber-optic logging cable.

A fiber-optic logging cable system and report will be provided under this subcontract. The system includes a 1-mile (1.5-km) length of fiber-optic cable containing 3 optical fibers, 3 copper conductors, and 2 armor layers, resulting in a cable with the same mechanical characteristics as a standard 4-conductor logging cable. A transmitter/cable head and receiver/interface electronics also are provided to transmit digital data through the optical fibers from borehole electronics to the surface, as well as to control and power the probe using the copper conductors.

Construction of a 400 ft (122 m) prototype fiber-optic logging cable has been completed. This prototype cable was tested and proved to be feasible for borehole logging. A draft report has been submitted for open filing.

Data and Power Transmission Study—Phase I

- Subcontractor: MDH Industries, Inc.
- Subcontract Value: $17,776
- Start Date: May 1978
- Completion Date: 1 April 1979

The Data and Power Transmission Study (Phase I) project will provide a report on data and power transmission technologies and methods applied to borehole logging. It will propose, in detail, an actual prototype hardware data and power transmission/processor system.

The system will include a downhole electronics package that contains 2 multichannel analyzers (or scalers), 6 scalers, 6 low-frequency analog-to-digital converters, and a modern digital transmission scheme to transmit the data from the above-mentioned processors to the surface. At the surface, an interface to a minicomputer will be placed in the Bendix R&D logging vehicle.

The Phase I report will be open filed in 1979.

KUT Probe Development

- Ongoing in-house project

Energy-selective (KUT) gamma-ray borehole logging systems can provide in-situ subsurface assay of potential uranium-bearing formations through the analysis of natural radioactivity. Borehole probes employing large sodium iodide crystal detectors have been developed for this purpose. Continuing efforts focus on improved probe performance, better resistance to effects of external environment, and the addition of sensors to measure borehole diameter and temperature.

A method to stabilize probe energy-detection accuracy through the use of a light-emitting diode embedded in the detector crystal has been developed and tested. A technical paper documenting the results was presented by Bendix scientists at the October 1978 IEEE Nuclear Science Symposium in Washington, D.C.

R&D Logging Vehicle

- Start Date: August 1977
- Completion Date: July 1979

The purpose of this project is construction of an R&D logging vehicle. Fabrication of the vehicle's logging cabin, draw works, and boom was completed in August 1978 by Energy Products, Ltd., of Fort Worth, Texas. The installation and checkout of electronics systems, including a Data General Nova–3 minicomputer, were completed by Bendix personnel in February 1979.

The vehicle will support Bendix R&D work in borehole logging techniques and geophysics. Major projects that will make use of the vehicle are gamma-ray spectral R&D, PFN demonstrations, gamma-gamma density development, and magnetic susceptibility (MS) development.

With the on-board minicomputer, the vehicle will support almost any borehole R&D function, with exceptional data-taking and presentation capabilities. It has already supported preliminary gamma-ray spectral studies in eastern Utah and MS work in central Wyoming.

New Operational Borehole Logging Systems

- Ongoing in-house project

In 3 related projects, 3 computer-based borehole logging systems have been procured and retrofitted with Bendix-developed spectral-gamma logging subsystems. MS subsystems will be procured in FY79 and added to the logging systems.

Subcontracts were placed with Century Geophysical Corporation to supply the 3 computer-based systems. The first system was delivered in FY78; the remaining 2 were delivered early in FY79. Retrofitting of the systems for spectral-gamma logging is to begin at the start of FY79, and the systems are to be operational by mid-FY79.

Surface KUT—Technical Development

- Ongoing in-house project

It has recently been determined that 10 to 30 percent of the uranium signals detected by a vehicle-borne spectral-gamma system are the result of atmospherically borne bismuth-214 sources. In addition, there is a cosmic gamma-ray background present in all spectral regions. Resulting errors should be minimized by correcting for these backgrounds. This Bendix in-house project, started in October 1978, will develop the instrumentation, calibration, and data-reduction procedure necessary to make these corrections.

Intrinsic Germanium Probe Evaluation

- Subcontractor: Princeton Gamma-Tech, Inc., through USBM
- Start Date: March 1978
- Completion Date: September 1979

Princeton Gamma-Tech, Inc., has developed a borehole probe containing a high-resolution intrinsic germanium gamma-ray spectrometer under a contract with the USBM. The USBM is cooperating with DOE on this project. The intrinsic germanium probe and associated logging systems are being evaluated for direct uranium assay in extensive field tests on CONOCO properties in southern Texas.

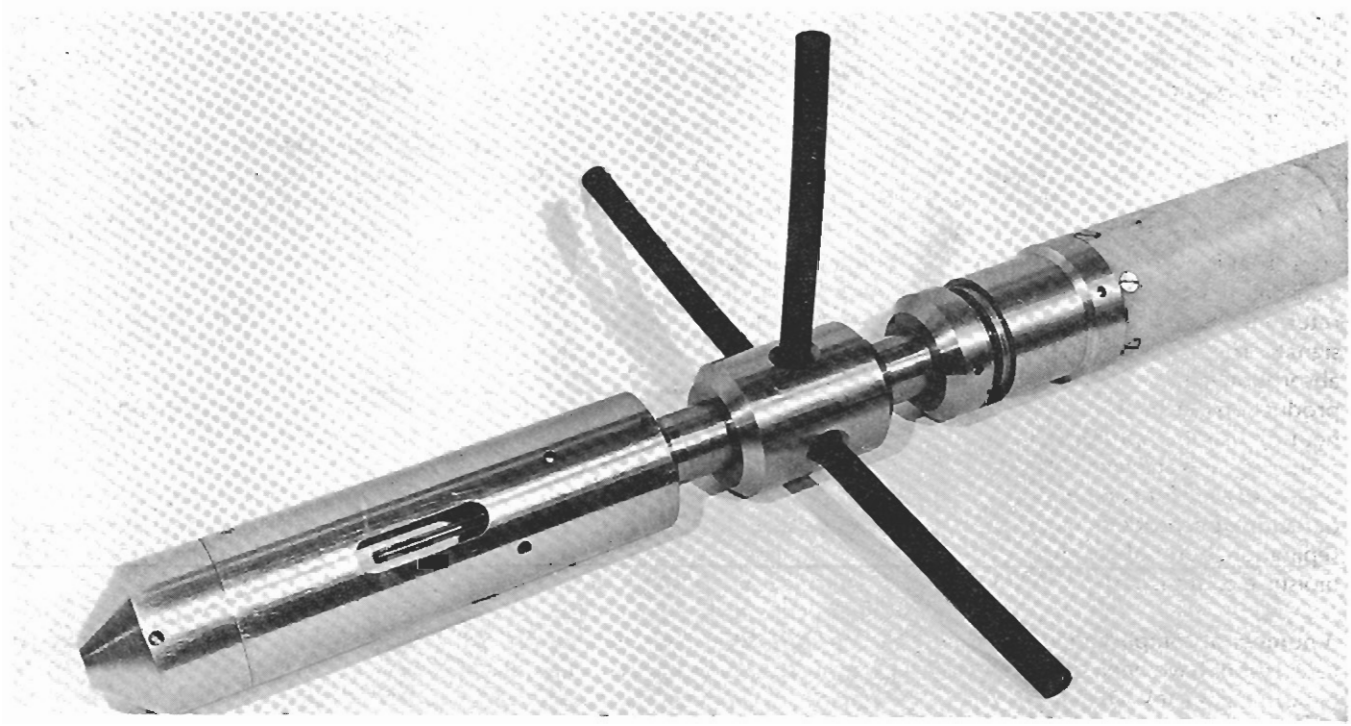
Preliminary results indicate the intrinsic germanium probe functions reliably in the field and can provide a direct uranium borehole assay, independent of uranium/radium disequilibrium.

Results for the Princeton Gamma-Tech probe will be compared to those obtained using the 14 MeV/DFN, 14 MeV/PFN, and californium-252/DFN probes. Logging of the CONOCO properties was completed by all systems in October 1978. When logging and core data have been completely analyzed, results of the evaluation will appear in a GJO open-file report.

Geophysical Survey and Log Interpretation Studies

- Ongoing in-house project

Currently, Bendix is operating 3 surface logging vehicles with the capability of recording natural gamma-ray, resistivity, spontaneous potential, spectral gamma (KUT), caliper, temperature, density, neutron (epithermal and thermal), magnetic susceptibility, and deviation logs to a depth of 6,500 ft (2,000 m). One vehicle contains an in-house fabricated microprocessor system for on-board data acquisition, and the second vehicle contains a purchased



This magnetic susceptibility probe was developed in a cooperative effort between Bendix and Simplex Manufacturing Company for possible use in uranium exploration.

minicomputer system for on-board data acquisition and routine log reduction.

A surface unit also is operated to collect surface KUT data for aerial radioelement surveys and monthly monitoring of the airport calibration pads.

To meet the increasing amount of data to be analyzed and reduced, a real-time computer Log Analysis System (LAS) has been written to make more sophisticated log interpretation possible. LAS provides such capabilities as definable algorithms, cross-plots, and Z-plots.

Studies in applying borehole geophysical data to correct measurements taken with other devices is continuing, with emphasis being placed on the influence of borehole parameters on KUT, such as borehole size, casing, and borehole fluid.

Borehole Model Neutron Calculations/Experiments

- Subcontractor: Science Applications, Inc., with Bendix support
- Subcontract Value: $134,090
- Start Date: August 1977
- Completion Date: 31 March 1979

The calculational data base of borehole neutron transport results has been extended to include both sandstone and black shale formation matrices and the generation of gamma-ray return signals. Neutron sources considered were 14 MeV and californium-252. The 2-part data base consists of forward-source neutron transport into the formation and returning neutron or gamma-ray signals produced by neutron absorption in the formation. The production mechanisms include neutron fission, capture, inelastic scattering, and activation. The data base exists as a function of probe detector type, probe detector-source separation, borehole diameter, and moisture content of the formation.

A number of complex geometry calculations have been performed to determine 14 MeV/DFN, 14 MeV/PFN, and californium-252 /DFN probe response to thin dipping uranium beds, to decentralization of the probe, and to the presence of borehole casing.

A novel technique was developed to obtain fission neutron probe sensitivities to various perturbations in formation and borehole parameters not included in the original data base. These results are valid for small changes in quantities, such as the thermal neutron absorption cross section for the borehole mud cake, for the formation itself, and for total and scattering cross-sectional changes over the entire neutron energy range from source to thermal.

Monte Carlo transport calculations modeled details of existing fission neutron probe types and established their absolute calibration. Experiments have been performed to test the results of these calculations. The measurements were carried out in the C model of the Grand Junction calibration facilities. These data are presently under evaluation. Bendix personnel are providing support for the Grand Junction measurements.

A final report [GJBX-52(79)] has been completed for the calculational effort. The report on experiments remains to be written.

Borehole Neutron Correlations

- Subcontractor: Consolidated Controls Corp.
- Subcontract Value: $29,944
- Start Date: 1 May 1978
- Completion Date: 31 March 1979

In the search for uranium, an effective technique is lowering a probe with a neutron generator down a borehole to produce interactions in the surrounding formation. Gamma rays and secondary neutrons are emitted from these interactions, and the number of interactions detected provides information on the uranium along the borehole.

Consolidated Controls Corporation is conducting a theoretical study of the time correlation between neutrons leaving the probe and detection of interaction gamma rays and neutrons returning from the formation. This correlation presents the possibility of separating prompt and delayed interactions and provides additional information about the elements occurring along the borehole.

A report describing the results of this study will be placed on open file in 1979.

Spectral Gamma Evaluation/Refinement

- Ongoing in-house project

This is an ongoing Bendix project to develop data-reduction and correction procedures for spectral gamma-ray borehole logs. The project also seeks to improve the hardware systems utilized in spectral KUT logging.

A series of extensive spectral gamma-ray measurements was initiated in 1978 using recently completed and existing borehole models at the Grand Junction calibration facilities. Results have helped to better characterize these calibration models and have led to preliminary recommendations for borehole water-factor and casing corrections to KUT logging data.

Other measurements have produced probe-response profiles for thin horizontal beds of potassium, uranium, and thorium. These results will be used in attempts to apply the computer deconvolution program (GAMLOG) to KUT data.

All project results are being written as a continuing series of internal technical notes titled *Spectral Gamma-Ray Logging Technology.* Technical notes completed by October 1978 are: *Calibration Methods, Background Subtraction, Borehole Water-Factor Corrections, Casing Corrections, Signal Deconvolution,* and *Dynamic Logging of Calibration Models.*

The measurements program continues, and future technical notes will deal with formation corrections, improved detector stabilization methods, additional results for borehole corrections, and thin beds.

Results presented in the technical notes are considered preliminary. This work should appear in an open-file report by 1980.

Radon Emanation Studies

- Subcontractor: General Electric Co.
- Subcontract Value: $159,940
- Start Date: 1 April 1977
- Completion Date: 1 April 1979

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 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 radon-220, which derives from thorium, would provide an immediate simplification when uranium is the target. Second, local signals must be separated from distant signals. There will always be radon emanating from the material immediately around the hole used for 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 pinpointed when present and could, therefore, be used and studied.

By eliminating these interfering 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 radon.

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

Numerical Modeling of the Subsurface Distribution of Gaseous Uranium Decay Products

- Subcontractor: Teledyne Isotopes
- Subcontract Value: $95,750
- Start Date: 29 September 1976
- Completion Date: 31 March 1979

In the first phase of this project, Teledyne Isotopes developed several 1-dimensional computer models to simulate the distribution of radionuclides through strata 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 several 10's of feet from a uranium deposit, while xenon-133 is detectable at half this range. The influence of barometric variations on the migration of radon-222 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, the second phase model will include a distributed source of uranium above and below the orebody, with a maximum of 25 stratigraphic units. The generation of helium-4 by the 3 natural radioactive decay series also will be included in the model.

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

A Bendix geoscientist takes soil and soil-gas samples with a radon emanometer.

Ruggedized Radon Emanometers

- Subcontractor: TSA Systems, Inc. (Formerly Tom Scurry & Associates)
- Subcontract Value: $58,120
- Start Date: 1 December 1977
- Completion Date: 1 April 1979

Sixteen ruggedized radon emanometers are being procured and distributed to Bendix personnel for evaluation of gaseous emanations from near-surface soil and ground-water sampling sites.

These emanometers employ a small microcomputer to control the data collection, processing, and calibration operations. Built-in programs relieve the operator of the tedious calculations involved in count integration, solubility/temperature correction, and conversion from counts-per-minute to pico-Curies-per-liter of radon.

Reports on laboratory and field evaluation of these instruments will be placed on open file as they are completed.

Drilling Mud Emanometer

- Subcontractor: Overhoff & Associates
- Subcontract Value: $19,800
- Start Date: 18 August 1978
- Completion Date: 16 December 1978

Radon gas emanating from deeply buried uranium orebodies may not reach the surface in concentrations that are easily detectable by currently used emanometric techniques. If, however, some of the migrating gas is intersected by a borehole, some of the gas should be carried rapidly to the surface in the circulating mud column used to lubricate the drill bit.

Overhoff and Associates is developing an instrument which will separate the trapped gases from the drilling mud and provide a real-time record of radon concentration which can be correlated with drilling depth. The prototype instrument from this project is expected to be available for field test and evaluation in 1979.

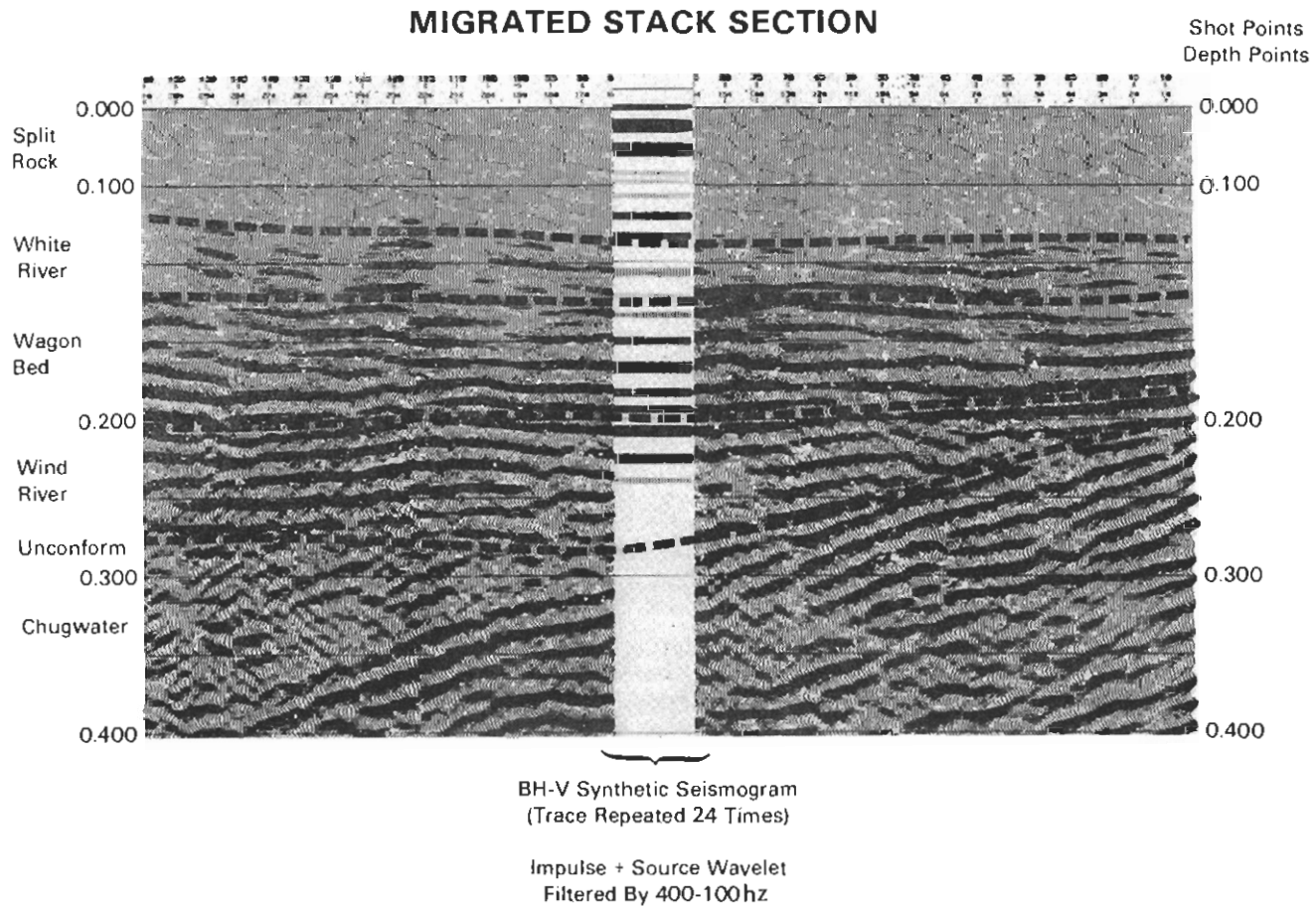
High-Resolution Seismic Reflection

- Subcontractor: Boise State University
- Subcontract Value: $78,218
- Start Date: 12 August 1977
- Completion Date: 31 December 1978

A study was undertaken to evaluate effectiveness of the high-resolution seismic technique for mapping of stratigraphic and structural controls in the Gas Hills uranium district in Wyoming. The test area contains uranium deposits in Tertiary sediments overlying a Mesozoic/Paleozoic section. Paleochannels on the unconformity between the Tertiary and Mesozoic appear to have significant control over localization of the uranium deposits. Extensive drilling in the area allows an evaluation of the effectiveness of the study. The objective of the research was to use sonic and density logs and computed synthetic seismograms to evaluate the feasibility of predicting success of the seismic reflection technique and to test this prediction using surface seismic data.

The field study was undertaken utilizing primarily 2 energy sources—a high-frequency vibrator (40–350 hz) and 1-lb (0.5-kg) dynamite charges shot in 10-ft (3-m) holes. A limited amount of data also was acquired utilizing detonating cord on the surface. Some 3-D reflection and passive seismic data were also acquired.

The seismic reflection data were clearly successful not only in delineating the unconformable surface and mapping paleodrainages on the unconformity, but also in defining channel deposits within the Tertiary section. Correlation with the well logs clearly shows the success of



This graph from a study in the Gas Hills uranium district indicates that both stratigraphy and structure can be meaningfully defined by high-resolution seismic reflection techniques.

the study. Several areas were delineated where tight drilling patterns might be undertaken, and other areas were delineated in which drilling might be minimized or eliminated. The synthetic seismograms could have predicted success of the seismic work.

In conclusion, the study indicates that in a geologic environment such as the Gas Hills uranium district, the high-resolution seismic reflection technique offers a cost-effective approach to minimizing the total number of drill holes and favorably locating those that are drilled. A detailed presentation of this work is scheduled to be open filed in 1979. Verbal presentations were given at the 1978 annual meeting of the Society of Exploration Geophysicists—"High-Resolution Seismic Methodology for Minerals Exploration" and "High-Resolution Seismic Study in the Gas Hills Uranium District, Wyoming."

Ground Truth for Remote Sensing

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

This study is a detailed investigation of alteration associated with tabular uranium occurrences in the San Rafael Swell, Utah, and remnants of roll-front-type deposits in the Powder River Basin, Wyoming. Field and laboratory spectral reflectance studies on these uranium deposits or occurrences have been carried out. These have been supplemented with mineralogical and chemical analyses to determine the origin of spectral features observed. The principal alteration products are (1) goethite/limonite (Utah deposits), and (2) goethite/limonite and hematite (Wyoming deposits). The principal clay mineral present in the deposits is montmorillonite.

Statistical analysis of the field data was performed using a stepwise linear discriminant function analysis computer program. This program determines which combinations of input wavelength bands provide best separation of specified groupings of data. Altered and unaltered rocks could be repeated with 95 percent accuracy using spectral data, including all wavelength bands. Of the satellite-simulated wavelength region tests, Landsat D bands gave the best classification accuracy. Details are presented in open-file report GJBX-120(78), "A Study of Alteration Associated with Uranium Occurrences in Sandstone and Its Detection by Remote Sensing Methods."

A geoscientist records water-sample data from a radon emanometer during evaluation of a site near Spokane, Washington.

Uranium Isotopes in Ground Water as a Prospecting Technique

- Subcontractor: Florida State University, Tallahassee
- Subcontract Value: $60,000
- Start Date: 1 April 1978
- Completion Date: 31 March 1979

This project involves the evaluation of the uranium-234/uranium-238 Activity Ratio (AR) as a ground-water prospecting tool for uranium. The technique evaluation required ground-water/borehole-water sampling adjacent to 3 known uranium districts. Preliminary results exhibit a strong increase in the AR of ground water flowing from known occurrences. As an example, the high AR persists 2.5 miles (4 km) downdip at 1 site. The results of this project will be open filed in 1979.

Geochemical Relationship of Organic Matter and Uranium Deposits

- Subcontractor: Denver Research Institute (DRI)
- Subcontract Value: $63,201
- Start Date: 30 September 1976
- Completion Date: March 1979

The association of uranium with organic matter in several major mining districts is widely 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 goals were accomplished: a detailed literature search was completed; fulvic and humic acids were fractionated and characterized after being extracted from peat samples; and association constants of uranylion with various fractions of fulvic and humic acids were determined. DRI has submitted a final report, which will be open filed in 1979.

Thermoluminescence Techniques for Uranium Ore Exploration

- Subcontractor: Brookhaven National Laboratory
- Subcontract Value: $150,000
- Start Date: October 1977
- Completion Date: September 1978

Uranium exploration techniques are being developed which are based on the thermoluminescence properties of the host rock for uranium mineralization. The project has concentrated on the thermoluminescence properties of the quartz component of sandstone hosts. Radiation-induced defects in the crystal structure of a quartz grain will release light in going back to their equilibrium state when heated. The light or luminescence produced in this thermal process is proportional to the amount of radiation energy absorbed by the crystal. The natural thermoluminescence of the quartz component of a sandstone is thus indicative of whether uranium-bearing solutions have passed through that sandstone bed.

Initial studies have been concentrated on 2 subjects. First, basic studies have been conducted on the thermoluminescence of quartz to ensure that this material possesses the requisite properties to be used as an exploration tool. Completed studies indicate that the thermoluminescence properties of this mineral make it quite suitable for exploration purposes. For example, the temperatures necessary to produce radiation-induced luminescence are sufficiently high to "remember" exposures to radiation for 10 to 100 million years. Furthermore, samples which have been heated, or for some reason do not exhibit thermoluminescence, can "remember" past radiation exposures by laboratory-induced thermoluminescence.

The second principal part of the initial program involves studies of sandstones containing known uranium mineralization. Work performed to date indicates that the thermoluminescence exhibited by the quartz component of the sandstone follows the expected general pattern. In going from the oxidized to the reduced side of a "roll-front" deposit, the intensity is low at a large distance from the front, gradually increases and becomes very high in the mineralized zone, drops abruptly on the reduced side, and at a short distance is only slightly above that associated with barren ground.

A report on this project will be open filed in 1979.

Solid-State Photomultiplier Tube

- Subcontractor: Science Applications, Inc.
- Subcontract Value: $83,929
- Start Date: 10 September 1977
- Completion Date: 1 April 1979

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

This project, started in 1977, has resulted in production of 4 solid-state photomultiplier tube (SSPMT) prototypes. Preliminary laboratory testing has shown that the energy resolution of the SSPMT prototype is equal to the best achievable results of conventional photomultiplier tubes, and that performance is superior in terms of temperature, voltage, and power consumption. An open-file report documenting construction and testing of the SSPMT will be released in 1979.

Geochemical Reconnaissance for Uranium in Northeastern Pennsylvania

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

This project, which is under a direct contract with DOE, involves a detailed geochemical study of the Penn Haven Junction area and a radon survey of the Jim Thorpe area. Two reports, GJBX-59(77) and GJBX-60(77), were open filed in 1977. A third part of the project, a study of ground-water uranium survey methods, generated 2 reports, GJBX-54(78) and GJBX-132(78).

Uranium and Coal Mining Impact Study

- Subcontractor: University of Utah
- Contract Value: $9,970
- Start Date: 11 April 1977
- Completion Date: 31 December 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 1979.

Potential Supply Systems

- Subcontractor: University of Arizona
- Subcontract Value: $317,106
- Start Date: 18 September 1978
- Completion Date: October 1980

The objective of this study is development of a model for uranium resource assessment that integrates geologic favorability data with mining and processing factors. This economic and engineering analysis of uranium exploration and exploitation should provide the capability of examining the effects of cost fluctuations and technological advances on potential supply.

A Bendix geoscientist gathers data with a portable gamma-differential spectrometer near Spokane, Washington.

Improved Appraisal System for U_3O_8 Endowment

- Subcontractor: University of Arizona
- Subcontract Value: $188,000
- Start Date: 18 January 1977
- Completion Date: 1 September 1979

The purpose of this project is to develop an improved methodology for the appraisal of U_3O_8 endowment as a function of the information level and geologic variables of a given area. Experts will exchange information and hypothesis via interactive computer terminals. The computer is programmed to force an appraisal using a decision-tree process.

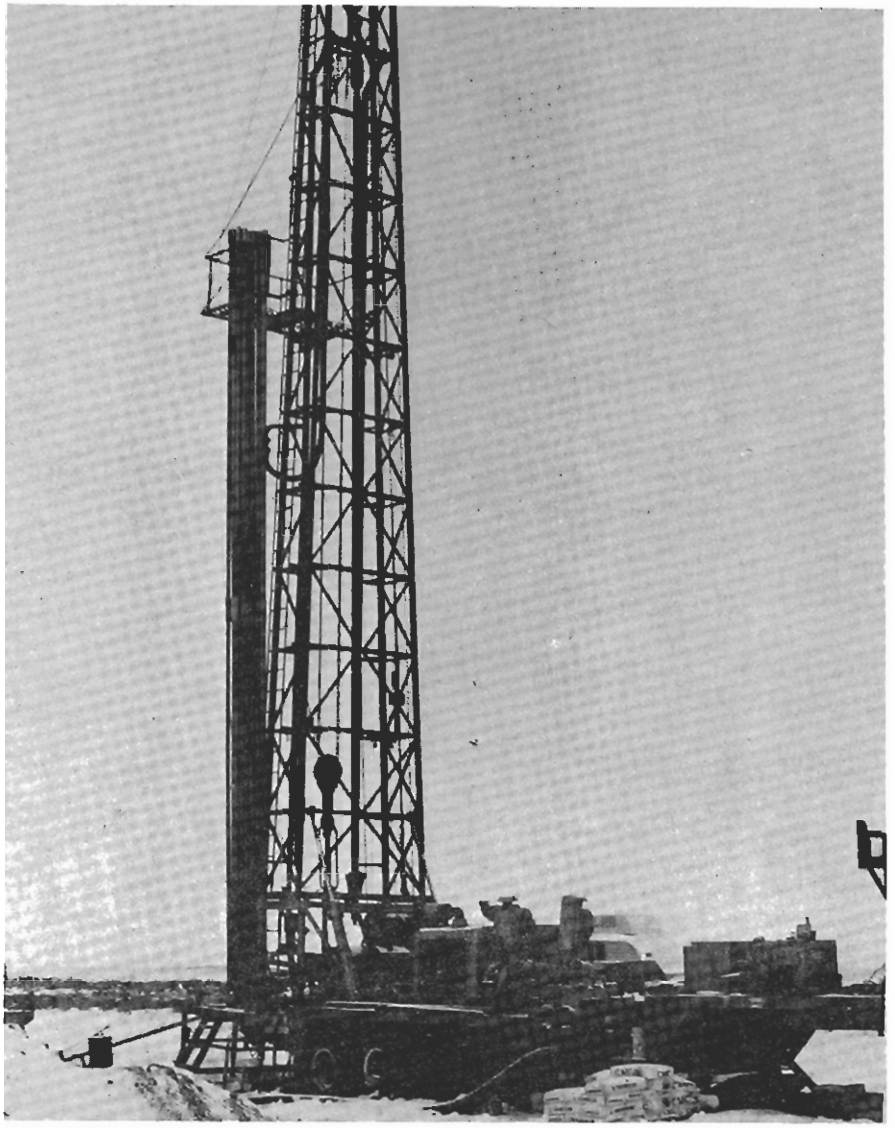
Exploration Systems

The Exploration Systems program has as its major objectives: (1) establishment of highly integrated approaches for uranium exploration and resource assessment, (2) characterization of uranium occurrences by suites of chemical, geologic, and geophysical parameters, and (3) development of ore genesis models.

These objectives are being pursued with state-of-the-art and developing technologies, and application of the newest data processing techniques. Pattern recognition in uranium prospecting is an example of such systems.

Results of this work could assist in exploration for new deposits and enhance the NURE resource assessment report. Such systems may be even more important in development of intermediate- and low-grade resources. Conventional and known mineralization are compared to classes of geologic and geophysical environments that may be relatively productive.

Bendix personnel are in the process of integrating these data sets for various



Drilling continued at the Red Desert project through the end of 1978 despite harsh winter conditions. At left, a student geoscientist, washes down core samples at the Copper Mountain drilling site in Wyoming.

locations studied. Objectives and results will be addressed in open-file reports as the studies progress.

Field work during 1978 was expanded from that of 1977 at the 1 Wyoming test site to 2 in Wyoming, Copper Mountain and Red Desert; and 1 test site in Washington, Spokane Mountain. Data were collected at these sites using certain basic types of geophysical surveying techniques: aerial radiometrics and magnetics, ground geochemical radon and helium, ground VLF-EM and magnetics, and borehole logging.

Imagery Pattern Recognition

- Subcontractor: Earth Satellite Corp.
- Subcontract Value: $99,960
- Start Date: June 1978
- Completion Date: July 1979

This project is designed to evaluate geometric pattern recognition and textural analyses of Landsat imagery with respect to uranium exploration and resource assessment. Five signature "training" areas (at least one-quarter Landsat frame) have been selected: San Juan Basin, Wind River Basin, Roessing, Athabasca, and the San Juan Mountains. These data will be preprocessed to maximize utility for subsequent textural and geometric pattern analyses. Various approaches to these 2 types of analyses were attempted in 1978 in an effort to obtain signatures of uranium-favorable environments. In 1979, the most geologically useful and meaningful measures or methods will be established and estimates made of their ultimate value in different uranium environments.

Final evaluation will involve application to a second series of 5 "test" areas (at least one-quarter Landsat frame) that include both favorable and unfavorable uranium environments: San Rafael Swell, Powder River/Shirley Basin, Colorado Front Range/South Park, Northern Michigan, and Marysvale.

Based on extensive review of this work, the general utility of the preprocessing, texture, and geometric-pattern techniques for uranium exploration and resource assessment will be determined and documented in an open-file report.

Uranium Pattern Recognition in the Casper Quadrangle

- Start Date: July 1977
- Completion Date: November 1978

In exploration for minerals and hydrocarbons, prospecting targets are commonly selected on the basis of a geologist's subjective interpretation of diverse geologic data. Numerous pattern-recognition algorithms are currently available that can significantly aid in the final interpretation and decisionmaking by providing quantitative and reproducible means of coding, combining, and evaluating the pertinent data sets. Other studies have shown the Bongard algorithm to be quite appropriate for uranium application. In this study, the Bongard algorithm was applied to reconnaissance-level data from the well-studied and uranium-rich Casper Quadrangle in central Wyoming.

This aerial photograph shows the topography of the Copper Mountain area, where subcontractors are researching halo zones around granitic uranium deposits.

Various data sets—such as aerial radiometrics, Landsat imagery, and presence of favorable structure and source and host rocks—are important, but when used separately, each provides many uranium-occurrence false alarms. Using these data in combinations via the Bongard algorithm results in elimination of many of the false leads. The "favorable" areas remaining outside currently known occurrences may be considered geostatistically significant.

Three major uranium districts were used as training areas: Gas Hills, Shirley Basin, and Crooks Gap. Many significant uranium-favorable patterns or traits were found, such as (1) presence of aerial radiometric anomaly—structural dip less than 5 degrees—close proximity to Wagon Bed Formation, and (2) proximity to major Landsat lineament—presence of Wind River Formation—proximity to an axis of drainage unit. These traits are consistent with favorable features cited in previous publications and support the most popular theories of ore genesis. Also, less familiar patterns, which may be useful as exploration guides, have emerged from this study.

Most of the new areas designated as economically feasible uranium deposits are, as expected, extensions of known mining areas. However, 3 of these are separate and distant from current mining activity, and should be considered in future exploration programs.

This project was outlined at the 1978 annual meeting of the Society of Exploration Geophysicists.

Complex Resistivity Survey

- Subcontractor: Phoenix Geophysics Ltd.
- Subcontract Value: $26,500
- Start Date: 6 September 1978
- Completion Date: 31 March 1979

Uranium deposits are known to contain certain unique spacial distributions of associated minerals such as iron pyrite, molybdenum, selenium, and calcite. These distributions also provide for a larger exploration target in drilling programs.

Complex resistivity, the measurement of phase and magnitude of a received voltage signal across a wide frequency range, is a technique that has previously found success in exploration for base metals and their associated minerals. Such a survey was conducted over 2 known uranium deposits in Wyoming to determine how this system could be used in uranium exploration.

Preliminary results from the sandstone research site indicate that the pyrite and uranium matter zone around the deposit was verified by field data. Data from the granitic deposit, which had a very low sulfide content, revealed more information about ground preparation favorable to uranium deposition. Survey results will be integrated with other data in an open-file report on both deposits.

R&D Drilling Program—Copper Mountain

- Subcontractors: Longyear Drilling Co.
  Mineral Service Co.
- Total Subcontracts Value: $135,005
- Start Date: 14 September 1978
- Completion Date: December 1978

This drilling program is part of an extensive research program to define and locate halo-like zones around a uranium deposit within granitic rocks. As uranium exploration programs expand away from the traditional sandstone deposits into granitic and volcanic terrains, new exploration procedures are needed. The Bendix program to define favorability criteria for the location of geochemical and geophysical halos around these deposits will help industry develop new ways to explore for uranium in granites. It is anticipated that this work will support the uranium favorability program through development of criteria for "near miss" boreholes. The results of this work will be open filed.

R&D Drilling Program—Red Desert

- Subcontractors: Hol-Han Drilling Co.
  Minerals Service Co.
- Total Subcontracts Value: $136,805
- Start Date: 20 September 1978
- Completion Date: January 1979

This drilling program also is part of an extensive research program to define and locate halo-like zones around a sandstone uranium deposit. As exploration companies continue to search for deeper and deeper uranium deposits, the cost of drilling consumes an ever-increasing part of the exploration dollar.

The Bendix program to define favorability criteria for the location of geochemical and geophysical halos around these deeper deposits will provide industry with significant cost-saving exploration procedures. This project, the results of which will be open filed, also is expected to produce criteria for "near miss" boreholes.

Emanometry

- Ongoing in-house project

Emanometry is the measurement of gaseous decay products from the uranium chain. These gases, radon and helium, are inert and have inherent mobility, which allows them to migrate from their source and be remotely detected.

Bendix has an ongoing, in-house effort to evaluate the usefulness of radon and helium measurements for uranium exploration. The radon and helium concentrations in soil, soil gas, and ground water have been determined at 3 geologically different sites having known subsurface uranium mineralization. The geologic sites include a sandstone environment at the Red Desert in Wyoming, a granitic environment at Copper Mountain in Wyoming, and a metamorphic environment at Spokane Mountain in Washington.

At each site, radon and helium measurements were collected over a 15.4-square mile (40-square km) area having a grid sampling pattern with 1,148.4-ft (350-m) intervals and a 0.4-square mile (1-square km) area, with 98.4- or 196.9-ft (30- or 60-m) intervals. Radon techniques used were zinc sulfide detectors, thermoluminescence detectors, charcoal canisters, and the partial extraction of lead-210. Helium techniques included gross-helium measurements, helium corrected for variation in other gas constituents in a sample, and the ratio of helium-4 to argon-36.

Core samples are taken at the Copper Mountain site, as a helicopter arrives to provide transportation to the next sampling area.

Results of these field measurements characterize radon and helium techniques as to their variability, distribution of values obtained, and relationships between techniques. The project will determine the association between known mineralization and emanometric signals obtained.

Reports on the evaluation of radon and helium techniques will be open filed during 1979.

Helium Surveying

- Subcontractor: Helium Surveys, Inc.
- Subcontract Value: $80,010
- Start Date: August 1977
- Completion Date: January 1979

The goal of this project is to determine whether a useful correlation exists between surface gross-helium measurements and subsurface uranium concentrations. As part of this project, gross-helium surveys have been performed over 3 areas of known uranium mineralization. Sampling was repeated over an area during the winter months (February through March 1978) to determine the seasonal effects on helium surveys.

The helium content in soil, soil gas, and water samples, as well as steady-state helium in soil gas—collected over several days—has been measured. All samples were collected on a grid pattern at each test site. Preliminary results show that the helium content in soil and soil gas is indicative of the known deposits at all 3 geologically diverse sites. Helium values in ground water appear to be too sparse to give definite trends. The collection of steady-state helium in soil gas appears to have more variability than instantaneous soil-gas samples.

Results of this project will be placed on open file in 1979.

Helium-4/Argon-36 Ratio and Radon-222 Measurements

- Subcontractor: Teledyne Isotopes
- Subcontract Value: $141,000
- Start Date: 19 August 1977
- Completion Date: February 1979

Alpha particles are among the many radioactive decay products of uranium; they attract free electrons to produce helium-4 nuclei. Radon gas also decays in the uranium chain via alpha emission. Presumably, these gases created by a uranium orebody 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 orebodies. The primordial gas argon-36 is assumed to be stable in abundance throughout the earth.

Thus, argon should reflect the local variations in soil-gas movement and the ratio helium-4/argon-36 should not be sensitive to meteorological conditions or changes.

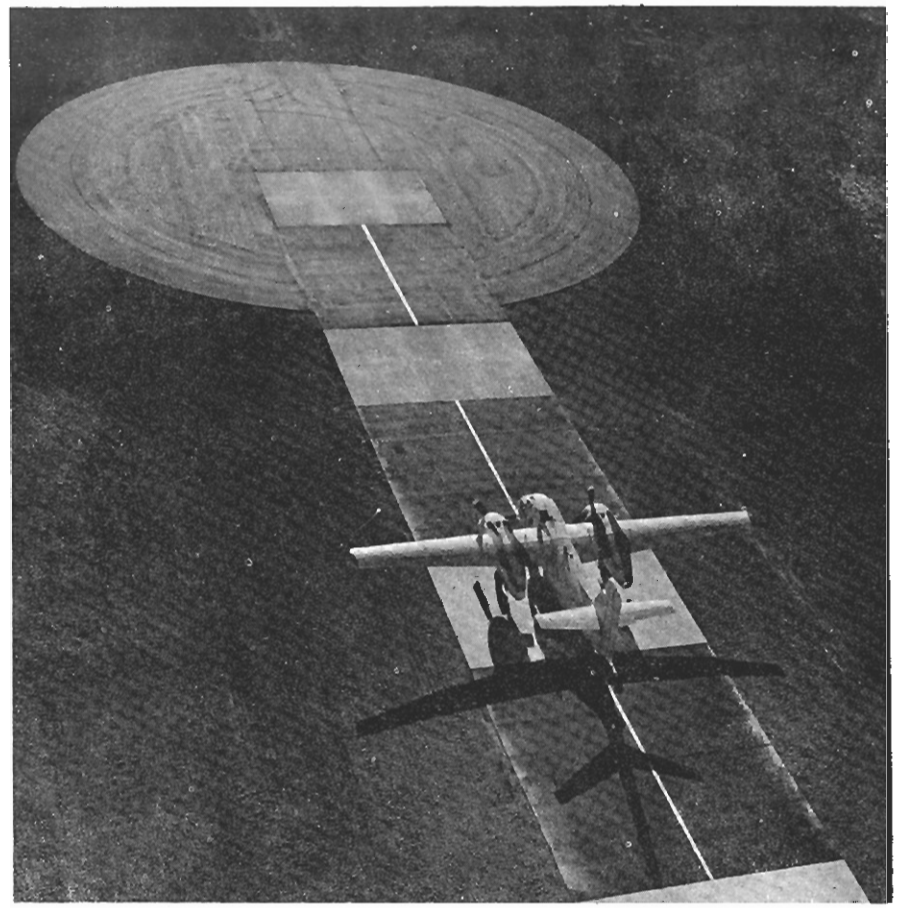
The project includes sampling 3 different areas of known uranium mineralization. Soil and soil-gas samples have been collected at 3 sites on a grid pattern.

The helium/argon ratio and radon gas were measured at each grid point and also in 12 drill holes ranging in depth from 98 ft (30 m) to 558 ft (170 m) to determine variability with depth.

An improved mass spectrometer for the helium/argon measurements achieved a precision of ±1 percent. The soil samples also were analyzed for leachable radium-226, total lead-210, and an emanation factor (total rate of radon-222 emanation from unleached and leached soil).

The results of this project will be placed on open file in 1979.

Aerial Technology



All types of radiometric survey aircraft—including the Grumman S-2 Tracker, above, and the Sikorsky S-58, at left—make use of the Grand Junction calibration pads. The Bendix-operated facility calibrates both aerial and ground-vehicle radiation detection systems.

One of the principal areas of technology application under NURE is support of aerial radiometric surveying. There is a diverse group of projects designed to contribute to uranium exploration efforts, as well as to NURE quadrangle evaluation and assessment. The research and applications projects fall into the 3 categories of data acquisition, reduction, and interpretation. The progress made in these areas has significantly improved the quality of aerial radiometric data obtained both by industry and as part of the NURE program.

Powder River Basin Airborne Survey

- Subcontractor: GeoMetrics
- Subcontract Value: $105,400
- Start Date: 28 June 1978
- Completion Date: 4 January 1979

Three special aerial radiometric surveys were flown over portions of the Powder River Basin. A reconnaissance survey was flown coincident with the flight lines of the original 1974 Texas Instruments reconnaissance survey. This survey will be used for a reproducibility check of reconnaissance data and for correlation with hydrogeochemical and stream-sediment reconnaissance data and mapped geology. A detail survey was flown over a small area of known mineralization to aid in the interpretation of mineralization in the Powder River Basin. Several lines were flown at various times to test reproducibility of the aerial radiometric data with respect to time. This reproducibility survey was conducted over 2 areas of known mineralization to aid in interpretation and correlation with geology. The data from these 3 surveys will aid in improving interpretation and application of aerial survey data.

Airborne Data Evaluation

- Subcontractor: G-Cubed, Inc.
- Subcontract Value: $154,000
- Start Date: 1 August 1978
- Completion Date: 31 July 1979

The intent of this program is to acquire an independent assessment of the exploration utility of NURE aerial survey data. The Lubbock, Texas, NTMS Quadrangle was selected as the study area.

Three tasks were undertaken to determine the practical exploration applications of the NURE aerial radiometric reconnaissance survey as evaluated for the Lubbock Quadrangle.

The tasks include (1) evaluation and interpretation of the aerial survey data for exploration targets, (2) determination of ground truth for specific areas chosen and (or) eliminated as exploration targets, and (3) evaluation of the available NURE hydrogeochemical and stream-sediment reconnaissance data for the quadrangle and correlation of results with the survey interpretation.

A detailed report will be open filed upon completion of the project.

Support for Operational Aerial Surveys

- Ongoing in-house project

The primary function of this ongoing project is to monitor subcontractor compliance with Bendix specifications. These specifications define aerial survey procedures, thus assuring collection of high-quality data. Prior to acquiring an aerial survey subcontract, the prospective subcontractor's Airborne Gamma-Ray System (AGRS) undergoes a performance and calibration evaluation. This consists of requiring the AGRS to operate (1) at high altitudes over water, (2) over the Lake Mead dynamic test ranges, and (3) on the Grand Junction Walker Field calibration pads. Data collected over these sites are analyzed to determine the system's capability of operating within Bendix specifications and are used as the basis for normalization among the various AGRS competitors.

Considerable effort has been made to develop a standardized calibration and data-reduction procedure, as well as a standardized format for recording data on magnetic tape. These new specifications are presently nearing completion and will be implemented for the 1979 surveys. Another part of this program provides assistance to subcontractors for improving data acquisition and reduction procedures. This is accomplished both in response to specific requests and through technical publications.

Airport Calibration Facility

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

As reported in 1977, the only large-scale facility in the United States for the calibration of airborne spectrometers was completed at Walker Field in Grand Junction. Built and operated by Bendix for DOE, the facility is available free of charge to firms wishing to calibrate airborne, vehicular, or portable radiation detectors.

The facility consists of 5 concrete pads, 30 ft (9.1 m) by 40 ft (12.2 m) by 1.5 ft (0.5 m) 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 remain parked over the pad for a 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.

The radiation from the pads is monitored to detect possible seasonal variations due to moisture and other atmospheric changes. An open-file report, GJBX-99(78), describes the monitoring techniques and initial results.

Information on the construction of the airport calibration facility is contained in open-file report GJBX-37(78), and guidelines for use of the facility are contained in open-file report GJBX-38(78).

Dynamic Test Range I Follow-On

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: $130,822
- Start Date: 6 September 1978
- Completion Date: 6 March 1979

Dynamic Test Range I (DTR-I), located adjacent to Lake Mead in Arizona, became operational in 1977 and has proved invaluable in

supporting the NURE aerial subcontractor systems calibration program. This follow-on effort will result in maximization of effectiveness of the range as a calibration tool by providing more detailed radiometric and aeromagnetic knowledge of the facility. One of the immediate benefits of this knowledge will be the development of radiometric concentration-contour maps which will be used to assist range users in further improving their airborne calibrations by providing effective range concentrations that are location and altitude dependent.

Dynamic Test Range II

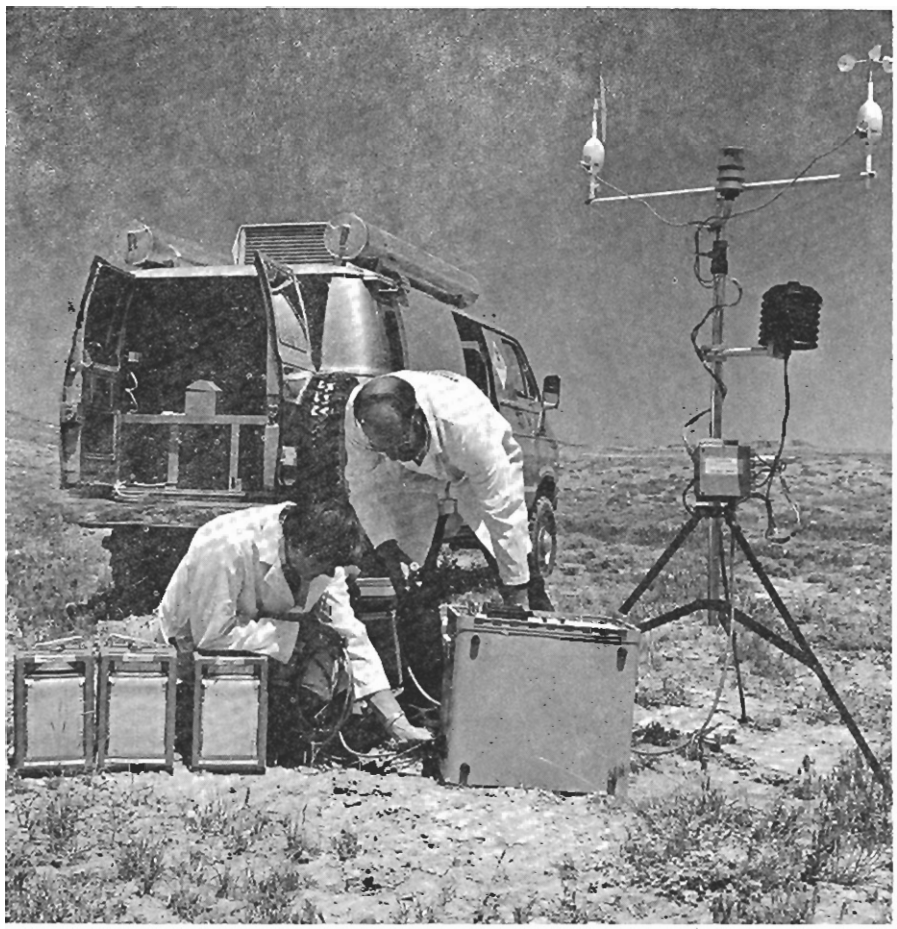
- Subcontractor: Golder Associates Inc.
- Subcontract Value: $197,646
- Start Date: 1 December 1978
- Completion Date: 1 November 1979

Because DTR-I proved to be an effective aerial radiometric calibration facility, it will be complemented by establishment of Dynamic Test Range II (DTR-II), having different radiometric characteristics. When operational in 1979, calibration overflights on DTR-II (by NURE aerial subcontractors) will provide additional information that will dramatically increase confidence in established calibration coefficients by allowing data cross-checking not presently possible with a single test range. The data from DTR-II will also provide assistance in the verification of new data-reduction procedures presently under development by Bendix.

Radiometric Surveillance Van

- Subcontractor: Jack C. Webster, Inc.
- Subcontract Value: $85,440
- Start Date: 23 January 1978
- Completion Date: 13 April 1978

Normalization of dynamic test range overflight data requires that correlative real-time ground radiometric and meteorological data be obtained as close as possible to the time of calibration overflight. Under this project, an off-road vehicle, capable of obtaining the required radiometric and meteorological information, was designed and constructed. It has been fully operational since May 1978 and is actively supporting NURE aerial subcontractor calibration overflights at DTR-I. Work is in progress to contract for the construction of a second vehicle to support calibration overflights at DTR-II.



This vehicle and equipment are used at the dynamic test range near Lake Mead to take ground measurements during calibration flights.

Development of a Flight-Path Recovery System

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

The purpose of this project was 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) include the aircraft's position coordinates in the same record in which the radiometric data is being stored for subsequent computer analysis.

The study was completed and the final draft report was submitted for review. The report was open filed as GJBX-9(79).

The report covers a complete flight-path recovery system; components for the aircraft and the ground stations are detailed. The report examines in some detail the equipment that is commercially available, as well as military equipment. Types of equipment are recommended and a flight test plan is presented in the report.

Airborne Detector Improvement

- Subcontractor: Grumman Aerospace Corp.
- Subcontract Value: $253,492
- Start Date: 27 April 1976
- Completion Date: May 1979

Grumman Aerospace has conducted a tradeoff study on possible Phoswich detector systems to determine the optimal configuration for aerial radiometric surveys. Based on size, weight, sensitivity, and cost considerations, a hybrid detector design was selected for fabrication

and testing. The hybrid detector has a sodium iodide main crystal, a cesium iodide back crystal, and a sodium iodide annulus. It is expected that this detector will have a greater sensitivity for uranium than a sodium iodide detector by about 50 percent for equal volume or weight systems. This configuration also should provide information concerning atmospheric radon and topographic changes.

Once fabricated, both laboratory and flight testing of the hybrid Phoswich detector will be conducted.

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

Vertical Radon Propagation

- Subcontractor: Radiation Research Associates, Inc.
- Subcontract Value: $158,508
- Start Date: 31 January 1978
- Completion Date: 31 January 1979

Aerial survey data must be corrected to eliminate gamma radiation from airborne radon daughter. To obtain only the contribution from ground sources, it is necessary to quantify the relative amount of radon to be found at various altitudes throughout the year.

This contract is part of an ongoing effort to accurately determine the natural ground emanation and vertical distribution of radon over various topographic regions by installing radon detectors at various levels on existing, conveniently located towers. In this manner, long-term measurements of actual radon concentrations at various altitudes to 1,500 ft (457 m) above the ground are being made and seasonal variations studied at relatively low cost. This effort is approximately 50 percent complete. Also completed are an extensive literature search summary on radon emanation and migration. This data will be used in model calculations to establish effectiveness of present corrective techniques for airborne radon daughter.

Soil Moisture Measurements

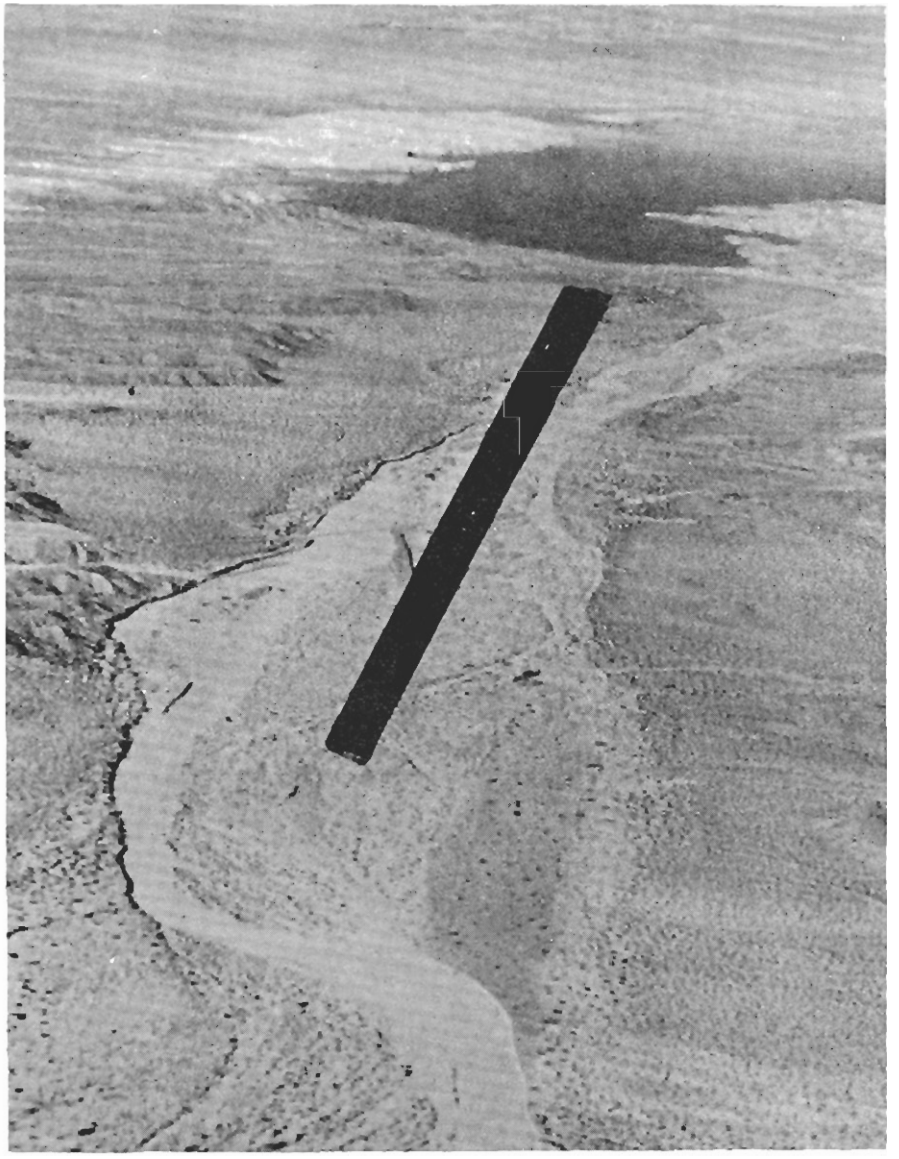
- Subcontractor: Geodata International, Inc.
- Subcontract Value: $32,272
- Start Date: 1 October 1976
- Completion Date: 28 February 1978

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. It was hoped that such corrections might be possible using a portion of the radiometric data. Under a follow-on to the dynamic test range development contract, Geodata International investigated the feasibility of a technique to correct for attenuation of gamma radiation from soil moisture and surface vegetation.

The effect of gamma attenuation is strongest for low-energy gamma rays; thus, if 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 or vegetation attenuation. Geodata has completed testing the feasibility of using this low-energy residual technique, and it was determined that the statistical precision of aerial data was not sufficient for this purpose. Results of this study have been compiled in report GJBX-49(78).

Effect of Vegetation

- Subcontractor: Radiation Research Associates, Inc.
- Subcontract Value: $25,657
- Start Date: 29 September 1978
- Completion Date: 29 March 1979



Dynamic Test Range I, near Lake Mead in Arizona, is a calibration facility for radiometric systems. The actual test flight ground track is indicated.

This contract examines the magnitude of the effect of surface vegetation on natural gamma transport. Various surface covers (vegetation) will be divided into about 5 easily recognizable categories, and a map will be prepared showing the extent of each category over the continental United States. Each ground-cover category will be mathematically modeled to quantify its effect on radiometric system calibration constants and system fields of view.

MAZE Detector Response Code

- Subcontractor: Science Applications, Inc.
- Subcontract Value: $49,977
- Start Date: 1 September 1977
- Completion Date: 4 October 1978

The implementation of spectrum enhancement techniques in the processing of aerial radiometric data requires an accurate knowledge of the detector's energy response function. Unfortunately, detector response function measurements proved to be a costly and time-consuming process. In order to reduce the cost of determining these functions, an effort was undertaken by Science Applications, Inc. (SAI), to develop an automated procedure. The procedure uses a fast-running Monte Carlo gamma-transport code (GAMRES) developed at Los Alamos Scientific Laboratory (LASL). This output is smoothed in 2 dimensions and response functions are generated by interpolation. The SAI procedure generates output compatible with both its MAZNAI and its MAZAS-DELPHI codes, developed for DOE/BFEC. That effort was successful and is detailed in open-file report GJBX-119(78).

Spectrum Enhancement (Phase II)

- Subcontractor: Science Applications, Inc.
- Subcontract Value: $141,149
- Start Date: 1 February 1977
- Completion Date: 31 March 1979

This is the second phase of a study to demonstrate the applicability of the spectrum-enhancement technique (MAZE) to data acquired with 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 is capable of revealing previously hidden spectral features, which may be helpful in making corrections for the presence of airborne bismuth-214.

In the present phase of this project: (1) performance of the technique, as a function of counting statistics, has been evaluated, (2) ground moisture and ground cover on the aerial gamma-ray spectrum have been investigated, (3) corrections for nonlinearities in sodium iodide (thallium drifted) data have been analyzed, (4) a fast-running version of the computer code has been written, (5) a new data-filtering technique has been developed for aerial data, and (6) MAZE techniques have been compared to conventional processing methods.

Results of this study will be open filed in 1979.

Airborne Data Procedures

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $120,500
- Start Date: 1 October 1976
- Completion Date: 31 March 1979

Under a 1976–77 subcontract, Texas Instruments performed an extensive followup study of their 1974–75 aerial survey of the Casper, Wyoming, 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 2 tasks which were completed in October and November 1977 with the submission of final reports. Task I consisted of detailed investigations into data limitations, sampling rationale, preliminary data analysis and display treatments, relationships between aerial radiometric and other geotechnical parameters, and development of more appropriate operational and equipmental survey specifications. This work was reported in GJBX-88(77). Task II entailed the preparation of a manual for use of pre-1977 aerial radiometric reconnaissance data. Task II resulted in GJBX-13(78).

An extension to the subcontract, negotiated in mid-1977, provides for the application and refinement of Task I and will result in the investigation of aerial radiometric surveys carried out over 3 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 4 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 includes design of a data filter technique and a line tying method for radiometric data and was open filed as GJBX-40(79).

Uranium Favorability Symposium

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: $17,380
- Start Date: 8 June 1978
- Completion Date: 30 November 1978

In July 1978, a panel of geologists and geochemists from industry, academia, and government (U.S. and Canadian) met in Denver. The purposes of the meeting were to review aerial radiometric data formats and interpretive techniques, assess the methods discussed, select techniques which showed the most promise for future development, and discuss the implementation methods for evaluating these techniques. The symposium generated the following recommendations: evaluate numerous statistical techniques and select those suitable for the derivation of favorability indexes, establish data sets for U.S. uranium occurrences, compile a regional radiometric map of the United States, and compile regional radiometric maps by geologic formations.

Aerial Interpretation

- Start Date: September 1978
- Completion Date: September 1979

This is a Bendix in-house project to investigate the general increase in the count rate for thallium, bismuth, and potassium aerial data in a north to

south progression along the Texas Gulf Coast. An explanation for this rate increase in terms of geology and other phenomena is being sought.

Aerial Interpretation R&D Support

- Ongoing in-house project

This Bendix in-house effort was initiated in April 1978 to develop new methods of interpretation of aerial survey data and demonstrate their applicability to the quadrangle evaluation program. A 3-man group (Aerial Interpretation Task Force), composed of individuals with appropriate geoscience backgrounds, was commissioned with the following tasks in support of the program: (1) initiate, monitor, and evaluate subcontracts dealing with interpretation and evaluation of the applicability of aerial data to NURE; (2) undertake in-house projects using special survey and reconnaissance data presently in the Grand Junction Office Information System data base to develop, test, and evaluate data interpretation methods for optimizing data formats and statistical methods; and (3) consult, advise, and generally interface (for interchange) with BFEC–GJO and quadrangle assessment subcontractors who will be using special surveys for NURE.

Project results will be disseminated in periodic open-file reports and (or) presentations at public technical meetings.

Geostatistical Interpretive Methods

- DOE Assignment: Los Alamos Scientific Laboratory
- Start Date: July 1978
- Completion Date: July 1979

Los Alamos Scientific Laboratory (LASL) has been working to develop and apply statistical methods to the analysis of data collected by airborne instrumentation. This program is designed to provide LASL with input from 3 areas of investigation: (1) Assuming fixed first and second moments (or mean and standard deviation) for a distribution of signal intensities or ore grades, what effect does the assumption of a particular probability distribution (Gaussian, lognormal, etc.) have on conclusions regarding the percentage of a region falling above some grade or signal threshold? (2) How well do distribution-free (nonparametric) techniques compare to techniques based on distributions, such as the lognormal where one is attempting to estimate the percentage of a region falling above a fixed grade or signal-intensity threshold? (3) Can the results obtained in 1 and 2 above be applied to the aerial radiometric data from quadrangles using realistic threshold values?

Four reports were released: GJBX-6(78), GJBX-44(78) GJBX-72(78), and GJBX-115(78).

In addition to LASL's work, Oak Ridge Gaseous Diffusion Plant is developing several vector-processing routines for use with interactive graphics software. These will aid the Aerial Interpretation Task Force in the evaluation of new aerial data processing techniques.

Reconnaissance Magnetics Interpretation

- Subcontractor: QEB, Inc.
- Subcontract Value: $54,849
- Start Date: 23 October 1978
- Completion Date: 20 June 1979

The aerial gamma-ray spectrometer surveys subcontracted under the aerial radiometric reconnaissance element of the NURE program include collection of aeromagnetic data. The surveys are designed for the collection of high-quality radiometric data and are not limited by some of the constraints of good magnetic data collection.

This project is designed to examine the usefulness of combining magnetic data from the NURE surveys with available gravimetric data to provide a more complete regional subsurface interpretation. In addition to use of this interpretation in evaluation of uranium resource potential, the quality of NURE-collected aeromagnetic data will be assessed and calibration procedures and checks recommended.

Data will be evaluated for a series of NTMS quadrangles for quality assessment purposes, and a quadrangle with sufficient, high-quality data will be selected for the combined magnetic/gravity interpretation technique.

Airborne Electromagnetic Evaluation

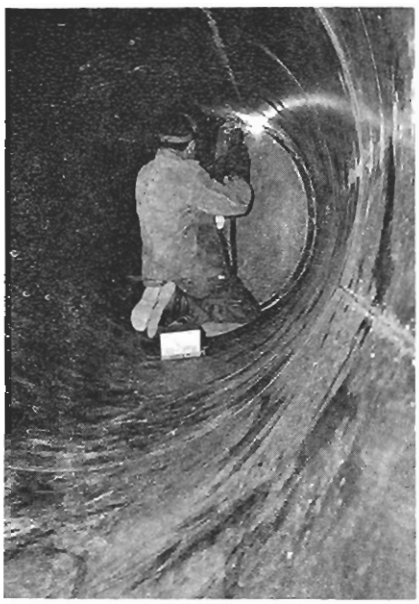
- Subcontractor: Geoterrex Ltd.
- Subcontract Value: $66,170
- Start Date: 14 November 1978
- Completion Date: February 1979

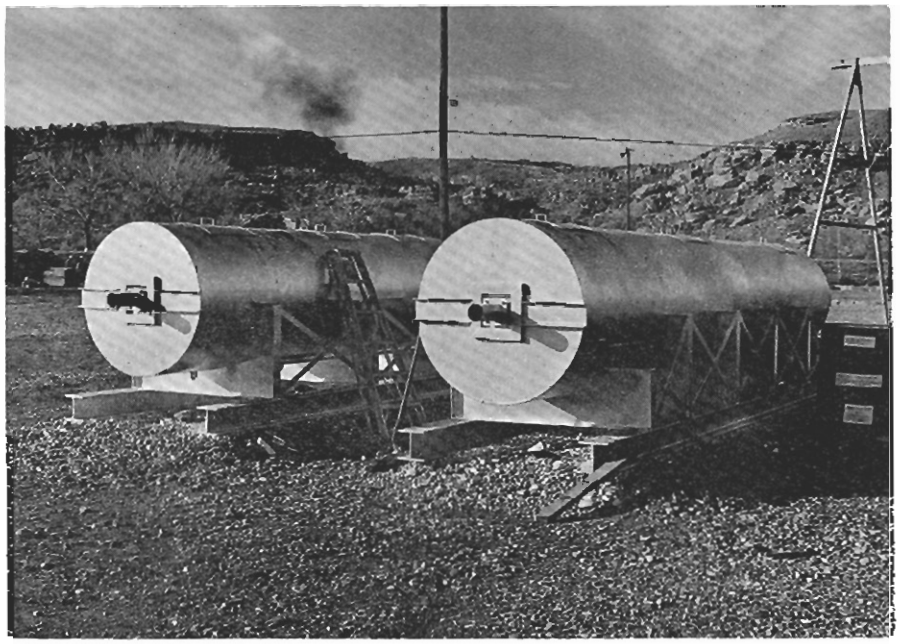
Certain geological features within the uranium depositional environment, such as channelways and mud flats, produce distinct changes in the earth's resistivity.

Electromagnetic aerial surveying can be used to map these changes in resistivity to depths of 400 ft (122 m).

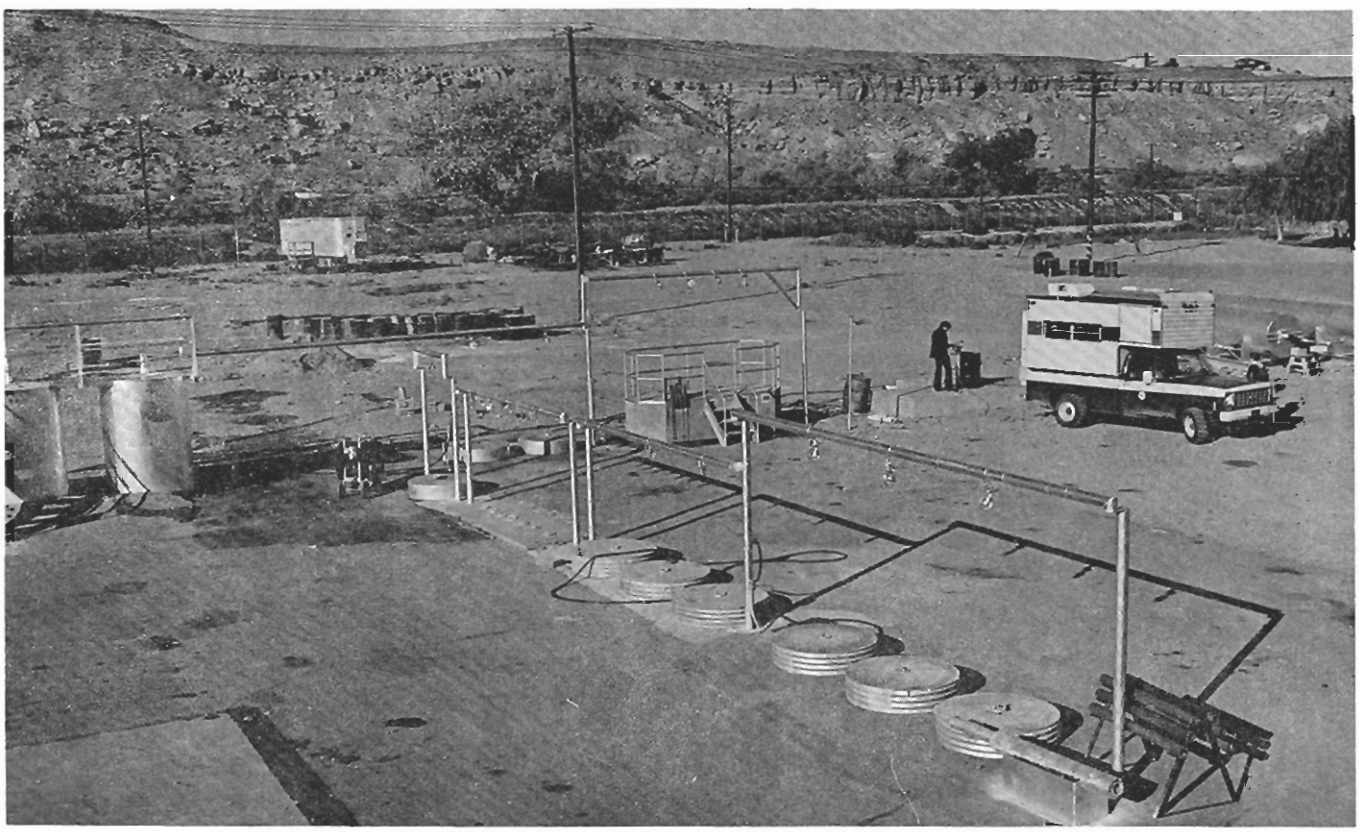
To pursue this possibility of aerial geologic mapping, Bendix has initiated an evaluation of combined INPUT electromagnetic gamma-ray spectrometer and proton precession magnetometer surveys over 2 uranium districts in Wyoming. Both these surveys were flown during 1978 and data reduction is now in progress. Results of this study will show how regional permeability and porosity variations, which directly influence both uranium deposition and the earth's resistivity, are related at known uranium deposits.

Construction on the thin dipping bed logging models, shown at right, was completed in the spring of 1978. Below, a welder finishes up inside 1 of 2 test tanks.





Calibration, Testing, and Laboratory Applications



A Canadian Geological Survey vehicle has its equipment calibrated at the new borehole-size/water-factor model at the Grand Junction test facility.

Existing Calibration Facilities and Services

Through Bendix, DOE has provided for participants in the NURE program and makes available to the uranium industry facilities for calibrating and certifying borehole probes, portable scintillometers, portable spectrometers, and airborne spectrometers. Based on measurements made in the model with the instrument to be calibrated, Bendix personnel in Grand Junction calculate the calibration factors for the particular instrument. These factors are then supplied to the owners in the form of a certificate. In addition, these factors are stored in Grand Junction for use in the DOE ore-reserve calculations and ore-potential estimates.

Facilities for calibration of borehole probes and portable instruments are located in Grand Junction; Casper, Wyoming; Grants, New Mexico; and George West, Texas. The facilities outside Grand Junction each have 2 borehole models for calibration of borehole probes and 2 models (blocks) for calibration of portable scintillometers and spectrometers. The borehole models have nominal ore grades of 0.3 percent and 2 percent eU_3O_8, and the surface block models have nominal 0.03 and 0.15 percent eU_3O_8.

Grand Junction facilities for routine calibration of gross count gamma-ray probes consist of 4 models featuring ore grades from 0.24 percent to 2.0 percent eU_3O_8, and 1 model featuring 4 holes ranging in size from 2-3/8 in. (6 cm) to 8-5/8 in. (21.9 cm). For routine calibration of portable scintillometers, there are 4 blocks with ore grades from 0.008 percent to 0.33 percent eU_3O_8. Several other models are available for specialized calibrations or research measurements.

DOE/BFEC also provides a facility located at Walker Field in Grand Junction and a dynamic test range located at Lake Mead, Arizona, for the calibration of airborne gamma-ray spectrometers, as discussed in the section on aerial technology.

This cooperative standardization and calibration effort is a voluntary undertaking by industry using facilities supplied by government in order to obtain a consistent, reliable data base for establishing the uranium resources of the nation.

New Calibration and Test Facilities

During 1978, 13 new in-the-ground borehole models were constructed at Grand Junction and 6 existing models were modified at the 3 field locations.

Six borehole models were constructed for use in calibrating and testing fission neutron logging systems. These models are 6 ft in diameter and 15 ft deep, each with a 15-ft run tube. They feature 8 ore zones having characteristics needed to study tool responses versus ore grade (4 values), density (2 values), porosity or moisture (3 values), and thermal neutron cross section (2 values). Another borehole model for calibration and testing of fission neutron logging systems in different size holes was partially constructed in 1978 and completed in 1979. The model features a single ore zone penetrated by 7 boreholes, ranging in size from 3 in. (7.6 cm) to 13 in. (30 cm).

A borehole model was completed for calibrating and testing hole size/fluid effects in spectral gamma-ray (KUT) logging systems. The model features a single ore zone containing approximately 5.2 percent potassium, 370 ppm equivalent uranium, and 275 ppm equivalent thorium; there are 5 boreholes ranging in size from 3 in. (7.6 cm) to 12 in. (30 cm).

The borehole models at the field calibration facilities in Casper, Grants, and George West were modified to accept longer, modern logging probes. The run tubes below the ore zones were extended from an original 5 ft to 13 ft.

A set of 5 surface models for calibration and testing of portable gamma-ray spectrometers was constructed. The models are cylindrical blocks, 5 ft (1.5 m) in diameter by 2 ft (0.6 m) in length, featuring radioelement concentrations of principally potassium, uranium, thorium, a mixture, and 1 with nominal natural radioelement materials (barren).

Plans for 1979 call for initiating construction of new calibration models at field locations. Three borehole models will be added to each of the 3 existing field calibration facilities. The 3 models at each site will feature 4 ore zones for calibration and testing of KUT logging systems and 2 ore zones for calibration and testing of fission neutron logging systems.

Four models will be placed at each of 4 new field locations—tentatively planned for Spokane, Washington; Pittsburgh, Pennsylvania; Atlanta, Georgia; and an undetermined site in the Southwest. Three of the models at each site will be identical to those just mentioned, and the fourth will feature 2 ore zones for calibration and testing of gross count gamma-ray logging systems.

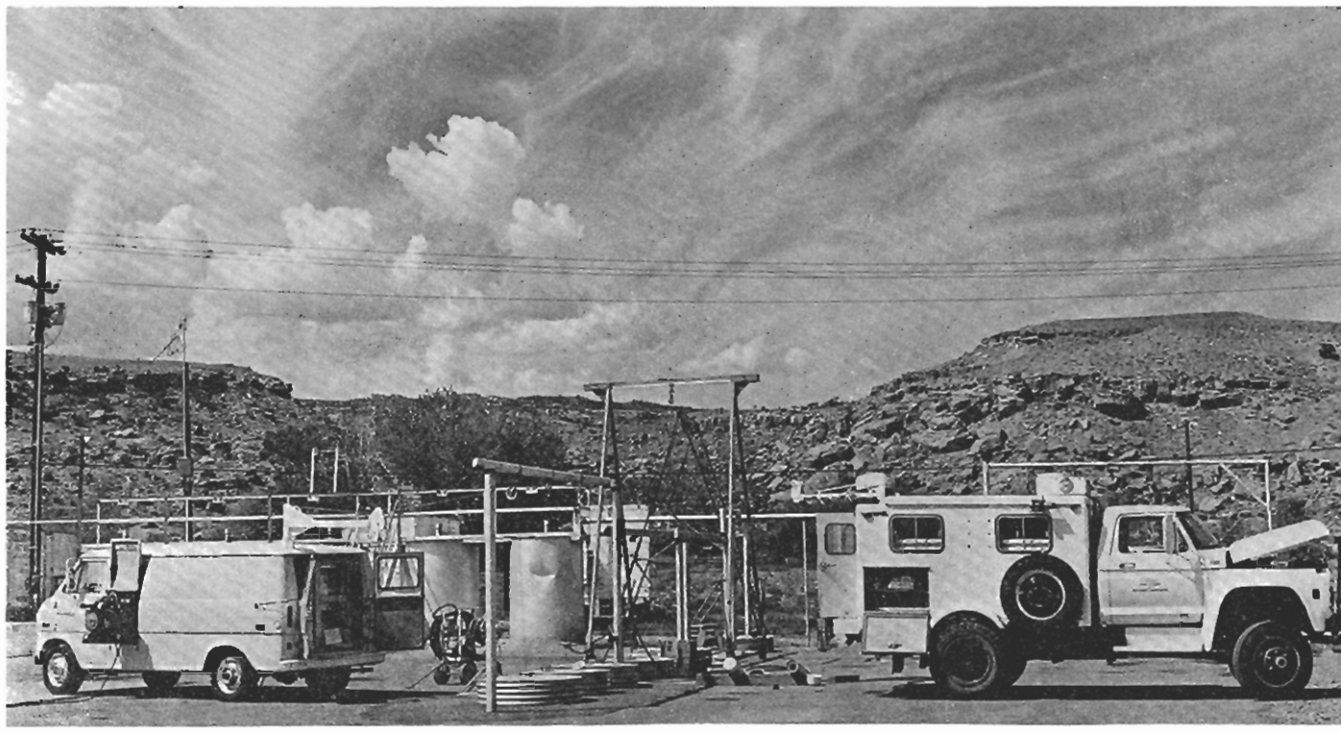
Efforts to assay samples and analyze borehole logs from newly constructed models continue. Reports to be open filed early in 1979 will include data on 2 models which were completed late in 1977 and feature thin, dipping ore zones, and data on the 6 fission neutron models mentioned above. Reports on assay and logging data from other models will be open filed later in 1979 as assay data are available.

Seven models were constructed for use in the calibration and characterization of magnetic susceptibility probes. Each consists of the same dry sand packed into 6-ft high nonmagnetic cylinders standing above ground. Model diameters range from 14 in. (35.5 cm) to 69 in. (175.3 cm).

Calibration Facilities Monitoring System

- Start Date: 1 March 1978
- Completion Date: October 1978

A special system is being developed by Bendix to monitor and better characterize calibration models at Grand Junction and field locations. The system will contain several specially constructed sensors for passive gamma-ray, scattered gamma-ray (density), and neutron (moisture) measurements; it will be automated to allow long-term, statistically precise measurements.



Logging vehicles undergo instrument calibration at the Grand Junction test facility.

A problem in design of the system is insuring stability. Because the calibration models are "standards," it is difficult to determine whether the model or the monitoring system has changed between 2 differing measurements. To define limits of stability, a set of precision references will be used to check system stability before, during, and after measurements in calibration models.

Radon Calibration Unit and Instrument Evaluation

- Subcontractor: Martin Marietta Corp. and Bendix in-house
- Subcontract Value: $160,816
- Start Date: 28 February 1977
- Completion Date: December 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, produced from the decay of radium-226.

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 and Bendix have designed and fabricated such a laboratory unit for calibrating, in absolute terms, a variety of radon detection instruments.

The unit was delivered in December 1978. A report will be placed on open file after a period of examination and testing in 1979.

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

Reports on these evaluations will be placed on open file as they are completed. A report on the laboratory testing of 2 electronic radon detectors will be open filed in 1979.

Ge(Li) Lab Assay

- Start Date: 1 January 1975
- Completion Date: 1 September 1979

A high-resolution germanium (lithium) [Ge(Li)] detector system has been implemented by Bendix for routine radiometric analysis of geologic samples. This system improved accuracy in determination of potassium, uranium, and thorium values. Samples containing high concentrations of uranium are measured using an analysis technique similar to that presently used for sodium iodide spectrometers.

A magnetic disc (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 early in 1979.

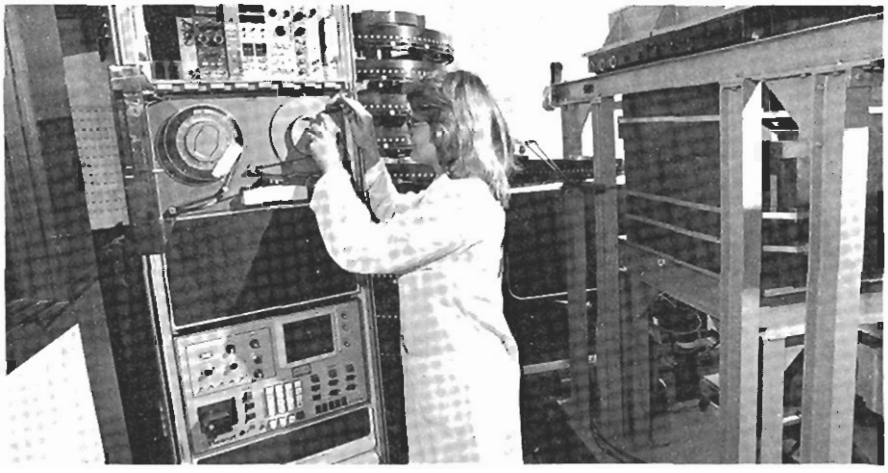
An analysis scheme developed by Science Applications, Inc., is presently being implemented which will allow the measurement of emanation coefficients and disequilibrium in the uranium chain. A report describing procedures and results was written late in 1978.

Ge(Li) Detector Data Analysis

- Subcontractor: Science Applications, Inc.
- Subcontract Value: $49,977
- Start Date: February 1977
- Completion Date: 1 April 1979

New and improved techniques have been developed for reducing high-resolution gamma-ray spectral data acquired for uranium ore samples with a laboratory lithium-drifted germanium, or Ge(Li), spectrometer system. The techniques permit bulk sample assay for actual uranium, equivalent uranium (radium-226), potassium, thorium, and the relative radon emanation coefficient with the highest attainable precision. The spectrometer is calibrated using a unique method developed by Science Applications. This calibration considers the effects of gamma-ray self-absorption within the bulk sample and the effects of sample detector geometry.

This technician is calibrating a radon emanometer, which was devised by Bendix personnel and developed by a subcontractor. The instrument is commercially available to private industry.



The Ge(Li) detector system is used in assaying closed can samples. The Bendix technician is loading the detector with magnetic tape for recording data.

A report detailing this development effort has been submitted to Bendix for review with open filing in 1979.

The procedures and software developed under this contract are being implemented on the Ge(Li) spectrometer, and it is expected that the software will be operational for routine sample analysis in 1979.

X-Ray Fluorescence

- Start Date: 1 April 1975
- Completion Date: Routine production late 1979

To provide rapid, fully automated qualitative and quantitative multielemental analysis on common geologic field samples, an energy-dispersive X-ray fluorescence analysis system is being developed by Bendix in Grand Junction.

Various sample preparation methods have been evaluated, and procedures for internal use are being written. Several different sample preparation techniques are required for specific-element and multielement analyses.

Numerous data-reduction methods are being investigated for broad-range, multielemental work. A simple Compton-Backscatter matrix-correction routine appears adequate for quantitative analysis of some elements.

Instrument modifications are currently being made to increase the number of samples and the quantity of useful data processed in a 24-hour period.

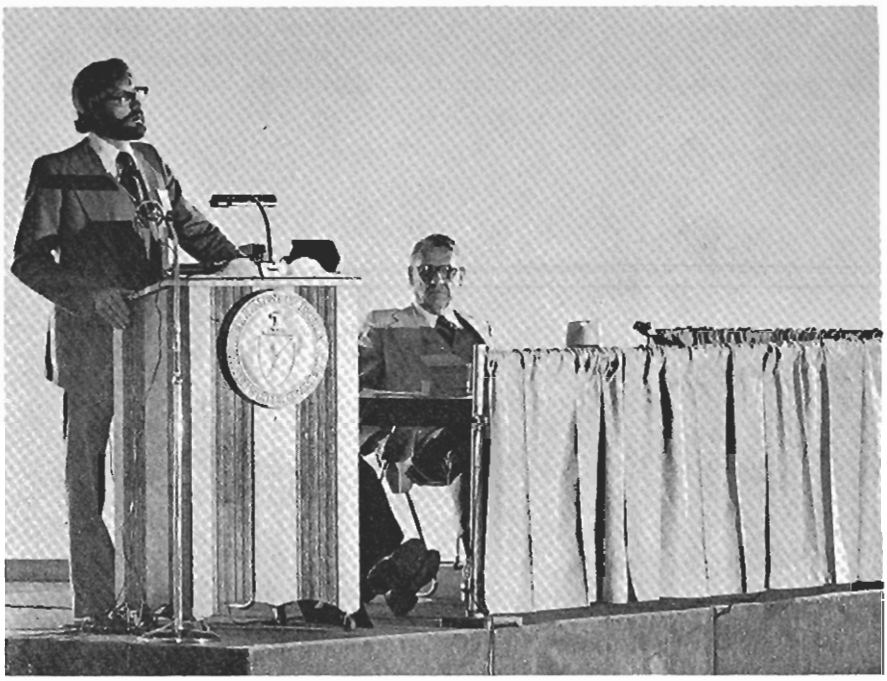
A user's guide and report evaluating system capabilities and performance will be written in 1979.

Electronic Support Activities

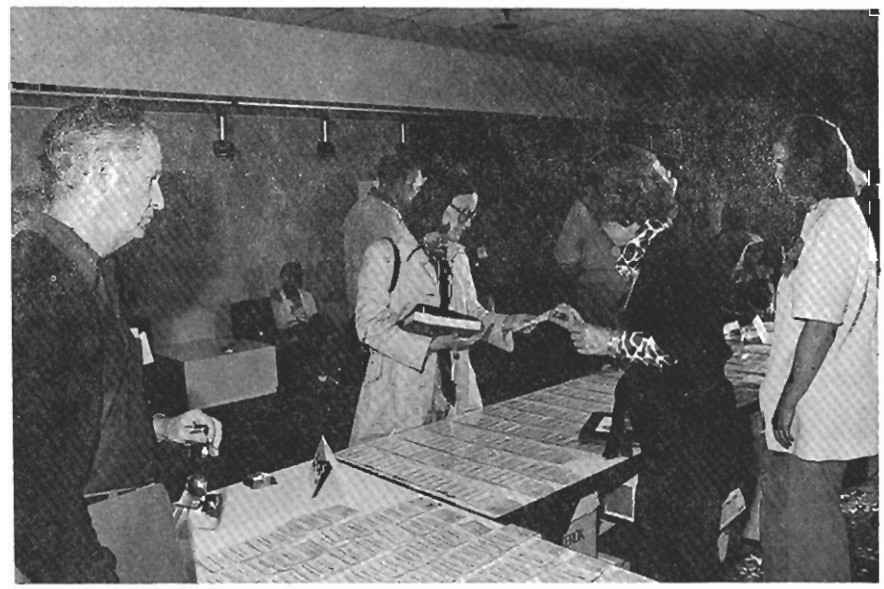
- Ongoing in-house project

This ongoing Bendix project provides technical support to the NURE program in resource evaluation and technical development. Primary functions are the design, fabrication, testing, and maintenance of geophysical and geochemical instrumentation systems. Electronic engineers also provide technical consultation, system specification, performance evaluation, and contract monitoring services to DOE and Bendix divisions.

Current activities include projects to implement several energy-selective gamma-ray logging systems which can differentiate among the gamma rays from potassium, uranium, and thorium.



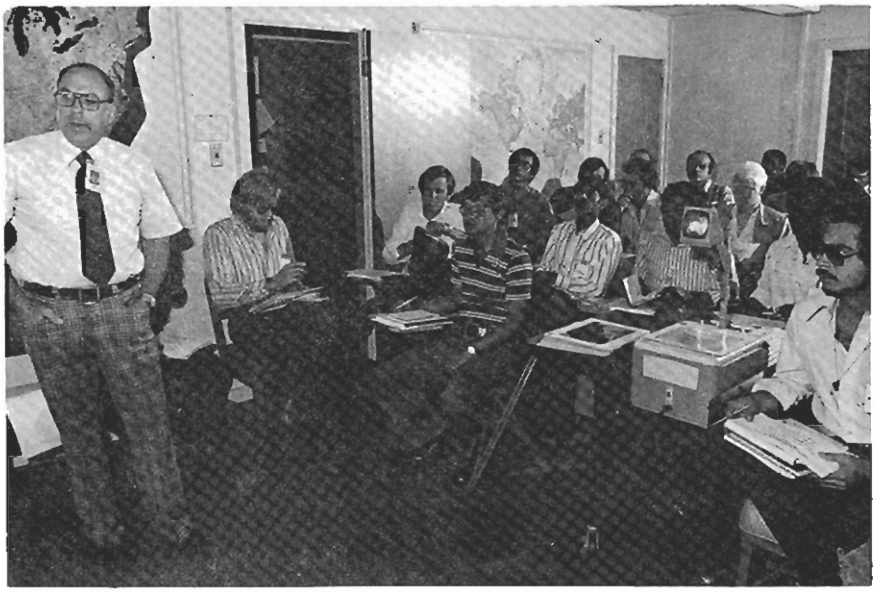
The 1978 Uranium Industry Seminar drew representatives from all facets of uranium exploration and technology. Terry W. Offield of the USGS (top left) tells attendees of the Geological Survey's part in the NURE program. Frank McGinley (top right) explains DOE's role. At right, some of the more than 800 participants register at Two Rivers Plaza for the uranium seminar.



Information Dissemination

Information generated from NURE-related activities is published as technical reports and maps and is released to the public as soon as it is open filed by DOE. Other sources of information for the public and the uranium industry are DOE-sponsored technical meetings, tours of the GJO facilities, demonstrations of new hardware, release of annually updated uranium industry statistical techniques must be developed to optimize portrayal of the statistically treated parameters for visual interpretation of uranium favorability.

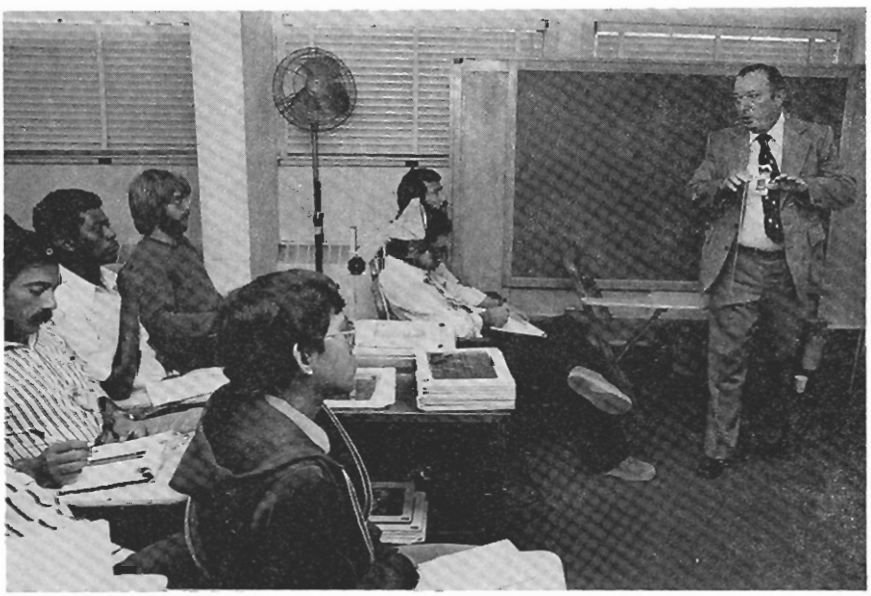
Activities in 1978 were highlighted by the annual Uranium Industry Seminar, 2 seminars conducted for the International Atomic Energy Agency (IAEA), including tours and demonstrations at Grand Junction, the issuance of 140 press releases, open filing of 472 technical reports, and participation in community affairs.



The IAEA's Uranium Exploration Training Course, conducted by the Colorado School of Mines in September 1978, attracted 26 geologists from 19 countries.

Technical Meetings

Technical meetings provide a forum for the dispersal and exchange of information. In addition to the DOE-sponsored annual Uranium Industry Seminar in October, DOE and Bendix personnel participated in other technical discussions at meetings of national and international professional societies and at specialized symposiums and workshops. These opportunities reduce the leadtime associated with publication of printed material and provide face-to-face exchange of ideas among industry, other government agencies, and DOE/BFEC representatives concerning key technical issues in areas of interest to NURE.



The following bibliography lists papers on NURE-related topics presented by GJO personnel at various national and international meetings:

Classification and Origin of Uranium Deposits; R. G. Young, Bendix; American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), Tucson, Arizona; March 7, 1978.

DOE Calibration Facilities Operated by BFEC; H. B. Evans, D. A. Emilia, Bendix; University of North Carolina, Raleigh, North Carolina; March 23, 1978.

NURE Data Collection and Evaluation Strategies; R. C. Horton, Bendix; Northwest Mining Association, Spokane, Washington; April 5, 1978.

Vertical Distribution of Ra-226, Rn-222 and Pb-210 Over a Strata-Bound Uranium Deposit, Red Desert, Wyoming; D. F. Schutz, Teledyne Isotopes; American Association of Petroleum Geologists (AAPG), Oklahoma City, Oklahoma; April 11, 1978.

Energy Minerals; L. A. Carlson, Bendix; AAPG, Oklahoma City, Oklahoma; April 11, 1978.

Classification of Uranium Occurrences in and Related to Plutonic Igneous Rocks; G. W. Mathews, Bendix; Indiana University Geology Colloquium, Bloomington, Indiana; April 21, 1978.

Techniques and Principles for Mapping of Integrated Radon Emanation Within the Earth; R. L. Fleischer, General Electric; Natural Radiation Environment III, Houston, Texas; April 24, 1978.

Interfacing a Minicomputer to a Mobile Geophysical Laboratory; J. I. Gould, Bendix; American Association

of Physics Teachers, Canadian Association of Physics, University of Western Ontario, Ontario, Canada; June 12–16, 1978.

Survey of Uranium Exploration and Assessment Technology; K. L. Kosanke, Bendix; American Nuclear Society (ANS), San Diego, California; June 18–23, 1978.

Radiation Transport Analysis for Borehole Logging Probes; William Woolson, Science Applications, Inc.; ANS, San Diego, California; June 18–23, 1978.

Computer Modeling of the Prompt Fission Neutron Uranium Logging Technique; Dal Jensen, Sandia Laboratories; ANS, San Diego, California; June 18–23, 1978.

Interpretation of Prompt Fission Neutron Uranium Borehole Logs; Ralston Barnard, Sandia Laboratories; ANS, San Diego, California; June 18–23, 1978.

Field Measurement of Delayed Neutron Probe Characteristics for Uranium Exploration; R. C. Smith, Westinghouse; ANS, San Diego, California; June 18–23, 1978.

Cf-252-Based Borehole Logging System for Uranium; D. Steinman, IRT Inc.; ANS, San Diego, California; June 18–23, 1978.

Photoneutron-Based Assay Method for Direct Uranium Ore-Grade Determination; M. P. Baker, LASL; ANS, San Diego, California; June 18–23, 1978.

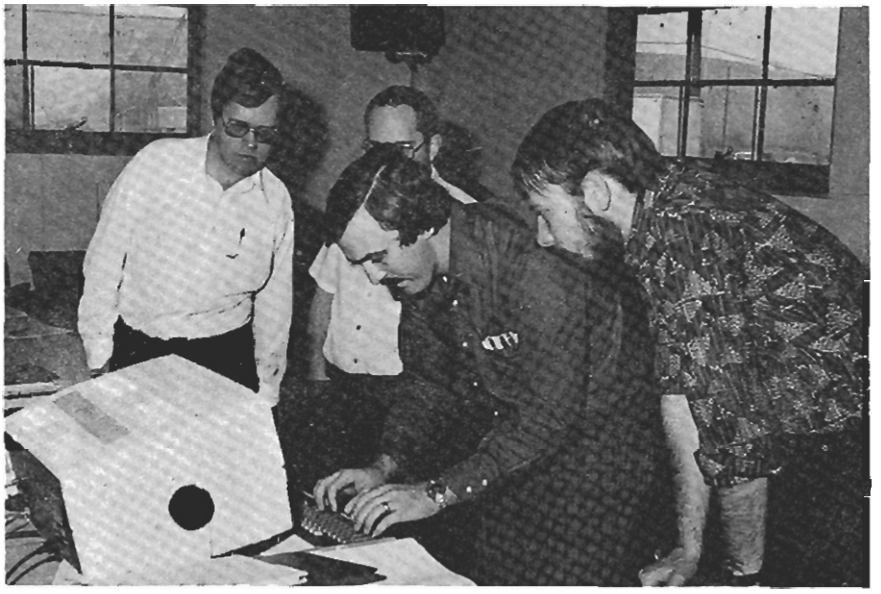
Uranium Assay in Boreholes by Means of Germanium Gamma Spectrometers; A. B. Tanner, USGS; ANS, San Diego, California; June 18–23, 1978.

Gamma-ray Spectral Calculations for Uranium Well-Logging; Mahavir Jain, LASL; ANS, San Diego, California; June 18–23, 1978.

Radon Measurements Using the Nuclear Track Technique; R. L. Fleischer, General Electric; ANS, San Diego, California; June 18–23, 1978.

Estimates of Ground Concentrations from Airborne Radiometric Data; R. L. Grasty, Geologic Survey of Canada; ANS, San Diego, California; June 18–23, 1978.

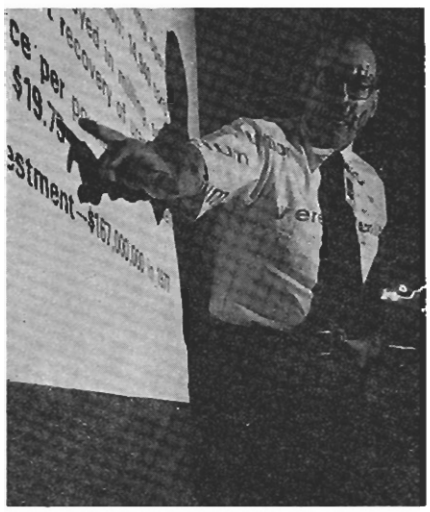
Airborne Phoswich Detector Systems; E. J. Schneid, Grumman Aerospace Corporation; ANS, San Diego, California; June 18–23, 1978.



Bendix geophysicists (above) undergo training in data manipulation on a new minicomputer. Foreign geologists (left), taking part in the Uranium Exploration Training Course, tour the Grand Junction test facility and pause to pose for a group portrait (opposite page).

A Large Volume Plastic Detector for Aerial Gamma-ray Spectroscopy; J. S. Duval, USGS; ANS, San Diego, California; June 18–23, 1978.

MAZAS: A Line-Intensity Estimation Code for the Analysis of Aerial Radiometric Data; S. M. Sperling, Science Applications, Inc.; ANS, San Diego, California; June 18–23, 1978.



A DOE geologist makes a point during a uranium exploration training session.

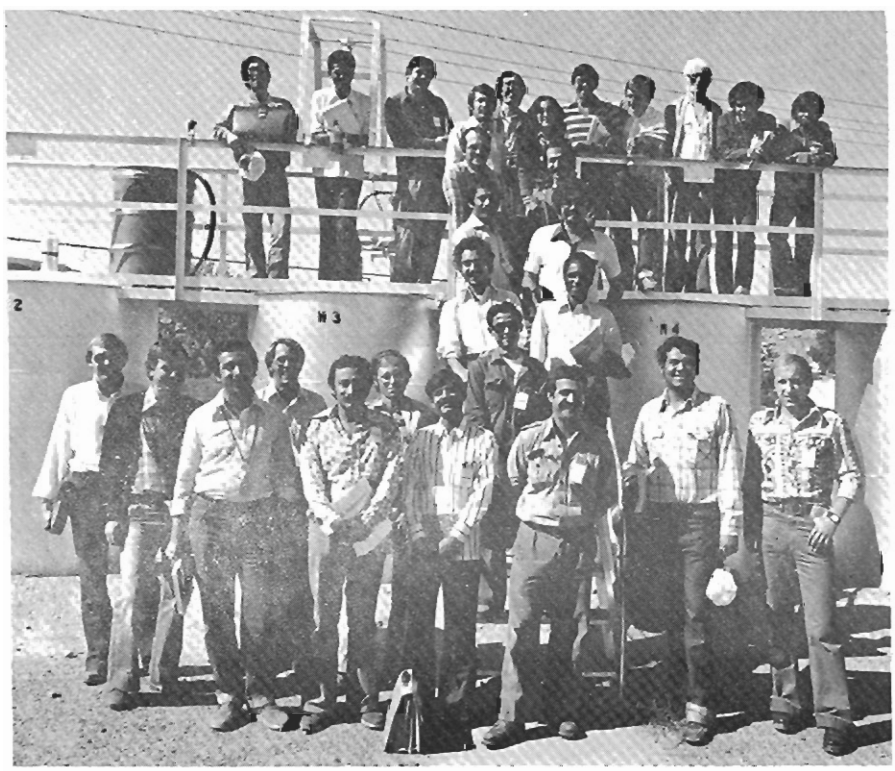
A "Solid-State" Photomultiplier Tube for Improved Gamma Counting Techniques; V. Orphan, Science Applications, Inc.; ANS, San Diego, California; June 18–23, 1978.

Multielement Geochemical Exploration for Uranium in Diverse Environments; L. M. Bramlett, and J. C. Pacer, Bendix; AIME, Orlando, Florida; September 11, 1978.

Gamma-ray Spectrum Stabilization in a Borehole Probe Using a Light Emitting Diode; D. C. Stromswold, Bendix; Institute of Electrical and Electronics Engineers, Nuclear Science Symposium, Washington, D.C.; October 18–20, 1978.

Definition of the Geologic Responses of Three Uranium Environments Using an Exploration System Approach; D. A. Emilia, L. M. Bramlett, and R. M. Sadowski, Bendix; Geological Society of America, (GSA),Toronto, Canada; October 19–22, 1978.

Petrogenesis of a Metamorphic Garnetite, Tobacco Root Mountains, Southwestern Montana; Linda McClain, Bendix; GSA, Toronto, Canada; October 19–22, 1978.



An Integrated Exploration Systems Approach Over Known Uranium Deposits; R. M. Sadowski, Bendix; Society of Exploration Geologists (SEG), San Francisco, California; October 29–November 2, 1978.

Uranium Pattern Recognition in the Casper Quadrangle; D. A. Emilia, Bendix, and Peter L. Briggs, M.I.T.; SEG, San Francisco, California; October 29–November 2, 1978.

Problems Associated with Calibration of Radiation Detectors for Measurements in Thin and Dipping Uranium Ore Zones; D. C. Moore, Bendix; SEG, San Francisco, California; October 29–November 2, 1978.

An Evaluation of Helium and Radon for Uranium Prospection; J. C. Pacer, Bendix; SEG, San Francisco, California; October 29–November 2, 1978.

A Borehole Gamma-ray Spectrometer for Uranium Exploration; D. C. George, Bendix; SEG, San Francisco, California; October 29–November 2, 1978.

High Resolution Seismic Study in the Gas Hills Uranium District, Wyoming; J. K. Applegate, Boise State University; Ed Nitzel, Teledyne Isotopes; SEG, San Francisco, California; October 29–November 2, 1978.

Construction of Airport Pad Facility, Walker Field, Grand Junction, Colorado; D. L. Ward, Bendix; SEG, San Francisco, California; October 29–November 2, 1978.

Classification of Uranium Occurrences in Sedimentary Host Rocks for the National Uranium Resource Evaluation (NURE) Program; C. A. Jones, Bendix; GSA, Toronto, Canada; October 22–30, 1978.

Classification of Anomalous Uranium Occurrences in and Related to Intrusive Igneous Rocks for the National Uranium Resource Evaluation (NURE) Program; G. W. Mathews, Bendix; GSA, Toronto, Canada; October 22–30, 1978.

The Behavior of Uranium in an Igneous Environment; G. W. Mathews, Bendix; University of Rhode Island; October 30–November 3, 1978.

Anomalies from Aerial Spectrometric and Total-Count Radiometric Surveys in the Southeastern U.S.; C. H. Lee, D. E. Lawton, Bendix; Coastal Plains Industrial Forum, Atlanta, Georgia; November 8–9, 1978.

Gross Gamma Assessment of Uranium; J. R. Duray, Bendix; Nuclear Atomic Energy Commission, Buenos Aires, Argentina; November 21–25, 1978.

National Uranium Resource Evaluation (NURE) Program in Alaska; W. A. Girdley, Bendix; Northwest Mining Association, Spokane, Washington; December 1, 1978.

Grand Junction, Colorado—DOE Solar Demonstration Project; T. D. Price, Bendix; Second Annual Solar Heating and Cooling Demonstration, San Diego, California; December 13–15, 1978.

Tours and training courses for 2 international groups were conducted this year. A symposium on uranium borehole logging, which was sponsored by IAEA and the Nuclear Energy Agency, was conducted at GJO in February, and the IAEA's Uranium Exploration Training Course toured the compound in September.

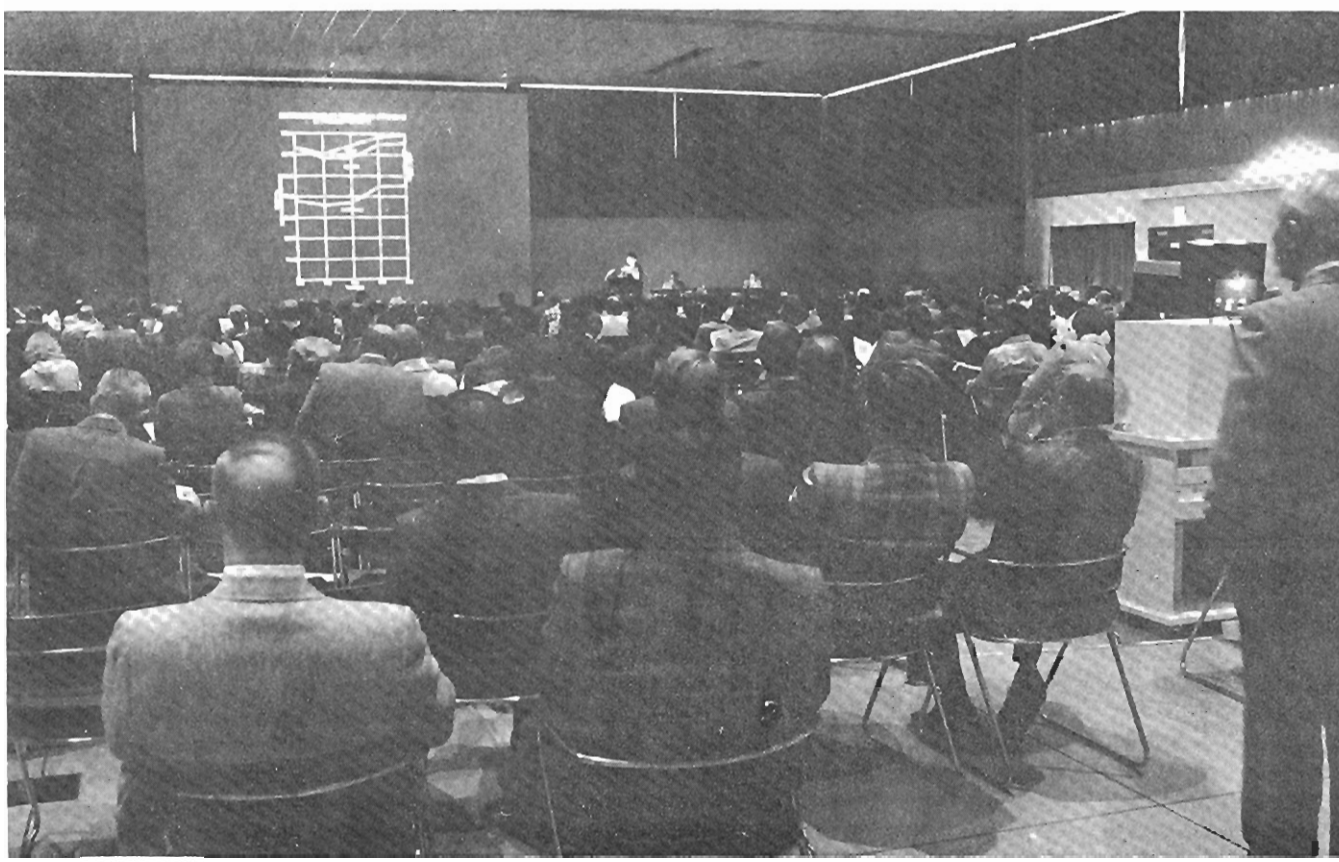
Experts from 6 countries and IAEA took part in the borehole logging symposium held February 14–16, 1978. Participants exchanged information on the current status of uranium logging in their countries, which included Australia, West Germany, and India. The workshop also generated proposals for greater use of supporting logs, better portable systems, and slim probes for smaller diameter holes in crystalline rock environments.

The IAEA's Uranium Exploration Training Course, which was conducted by the Colorado School of Mines and included 26 geologists representing 19 foreign countries, toured the Grand Junction facility September 29. The visiting geologists were presented with overviews of the uranium industry in the United States, functions of GJO, and the NURE program, especially borehole logging and aerial spectrometric survey techniques.

Uranium Industry Seminar

This annual seminar was held October 17 and 18 in Grand Junction. DOE staff members from GJO and DOE headquarters in Washington, D.C., presented 13 papers on the current and probable future status and activities of the uranium industry. Three additional papers were presented, 2 of which dealt with the status of the USGS uranium and thorium resource assessment and exploration research program, and an update on thorium resources presented by members of the Branch of Uranium and Thorium Resources, USGS, Denver. The third paper, presented by a representative of the Nuclear Regulatory Commission, Washington, D.C., concerned uranium mill licensing and related activities.

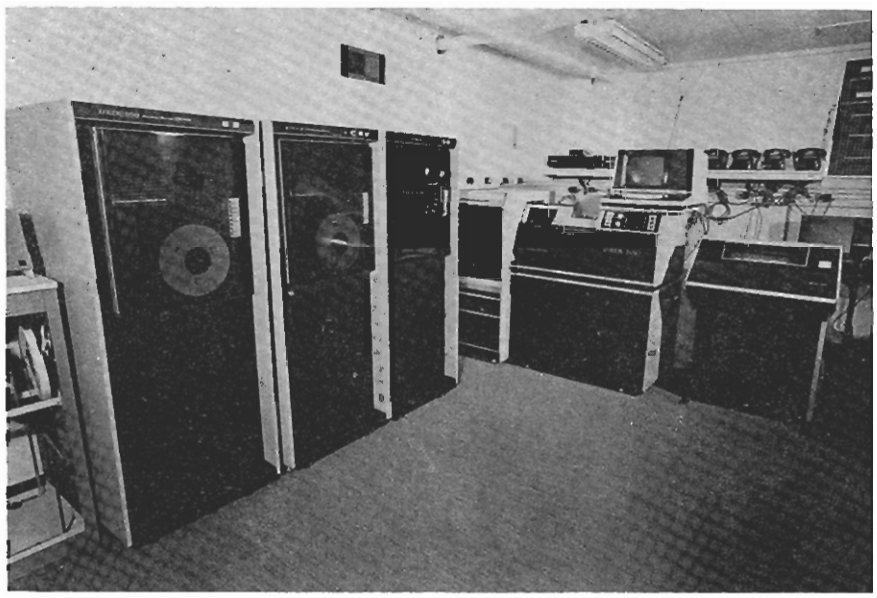
The annual Uranium Industry Seminar attracted participants from all over the world. The seminar, held in October, fills Grand Junction's convention facilities and hotels to capacity.



The 829 attendees represented various organizations, including energy companies, electric utilities, private consultants, state and federal governments, universities, foreign companies, and service, manufacturing, and construction companies. The proceedings of the seminar have been published as GJO-108(78), released in February 1979. The agenda follows:

Uranium Enrichment Policies, W. R. Voigt, Jr.
Uranium Enrichment Plans, D. C. Thomas and R. W. Gagne
Uranium Market Activity, G. F. Combs, Jr., and J. A. Patterson
Uranium Market—Domestic and Foreign Requirements, R. G. Clark and A. W. Reynolds
Foreign Uranium Supply, J. A. Patterson and R. K. Pitman
NURE Plans and Progress, D. L. Everhart
United States Geological Survey Uranium and Thorium Resource Assessment and Exploration Research Program, Fiscal Year 1979, T. W. Offield
Update on Thorium Resources, M. H. Staatz

Foreign Exploration, R. J. Wright
Uranium Ore Reserves, R. J. Meehan
Potential Uranium Resources, D. L. Hetland and W. D. Grundy
Low-Grade and Byproduct Uranium Resources, F. E. McGinley
U.S. Exploration Activities and Significance, W. L. Chenoweth
Trends in Uranium Production, J. F. Facer, Jr.
Production Capability, John Klemenic
Update of NRC Uranium Mill Licensing Activities, J. B. Martin



The Grand Junction Operations Information System (GJOIS) serves as a communications link for NURE activities to the computer center and data bank at the Oak Ridge Operations Office.

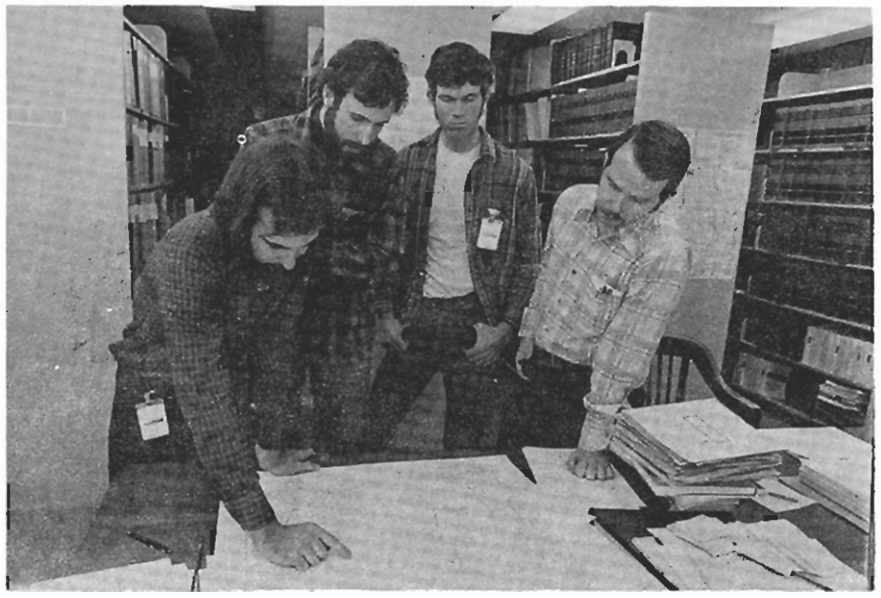
Computerized Information

The large quantities of data that must be processed and analyzed in the course of the NURE program require that these data be processed by computer. The facilities currently available for processing this data at Grand Junction include an on-site CDC 3100 computer and a remote access link to the Oak Ridge Operations Office. During 1978, the Grand Junction Office was authorized to procure a CDC 6600 computer system to replace the CDC 3100 system in order to provide adequate capacity for satisfying the needs of the program. This large-scale computer system was received in December and became operational in March 1979.

The CDC 6600 computer will provide on-site batch operations, as well as local and remote interactive capability. Development of a system for handling the large quantities of ore reserves data on the CDC 6600 began in 1978 using the data base management system DMS-170. Design of systems for quadrangle analysis and laboratory bookkeeping for samples, which have been temporarily implemented at Oak Ridge, has also been started in order to provide a permanent and adequate capability for handling these data. In addition to applications directly related to the technical aspects of the NURE program, GJO accounting applications for both Bendix and DOE will be implemented on this system.

The remote access link to the computer center at Oak Ridge Operations Office, known as the Grand Junction Office Information System (GJOIS), includes a batch terminal, several interactive and graphics terminals, and 2 leased lines. In addition to providing access to computer interim capability for analyzing and processing NURE data, GJOIS provides access to the data bank of technical information collected under the NURE program. Data from aerial radiometric reconnaissance and hydrogeochemical surveys, which are archived by quadrangle at the Oak Ridge Operations Office, are accessible through GJOIS; additional data are included in this data bank as they become available. Currently, data from 180 complete or partial quadrangles are available through GJOIS. Copies of these technical data sets are available from DOE on a cost-to-copy basis. Computerized evaluation models used in support of the NURE program assessment rely heavily on these data sets.

The GJOIS system was located with the CDC 6600 system and was put into operation in May 1979. The combination of these systems will provide a powerful tool for analysis and graphic display of the results of the analysis on sophisticated color plotting equipment.



Mesa College geology students are researching GJO's extensive collection of uranium-related literature, some of which was generated over 25 years ago. The project, to prepare a computer-based bibliography of GJO reports, is under a Bendix subcontract. Below, a Bendix librarian retrieves NURE data on a microfiche reader-printer.

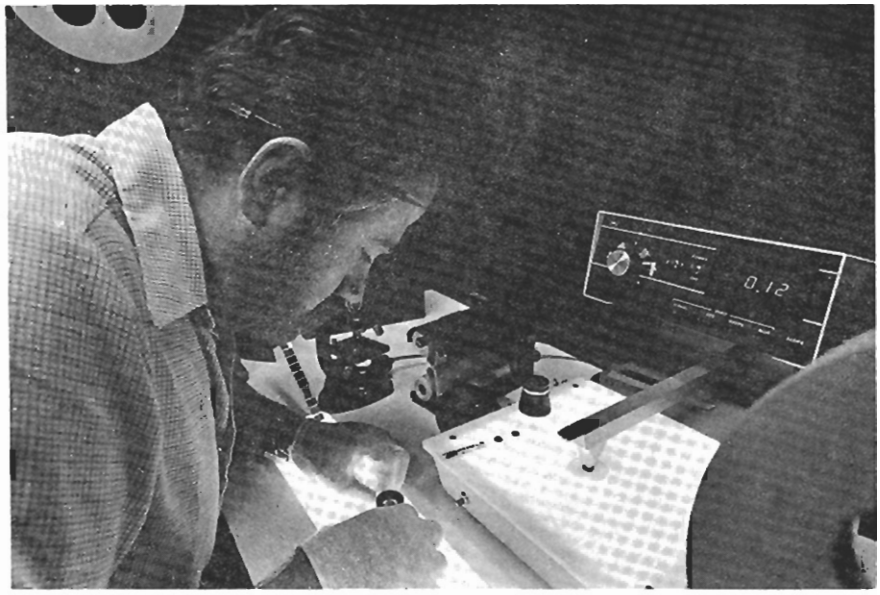
Upgrading of micrographics equipment in 1978 included delivery of a new silver microfilm duplicator, shown below.

Technical Library Services

The DOE/BFEC Technical Library, located at the Grand Junction Office, maintains an estimated 100,000-volume collection of uranium-related books, periodicals, legal references, maps, and drilling information, which is used daily by the public, as well as by DOE and Bendix personnel. Reference services include answering telephone and written inquiries and assisting library visitors. The technical library is also the local open-file report repository and houses almost 400 current NURE-related open-file reports and several thousand open-file reports dating back to 1948, which deal with uranium exploration, mining, and milling activities.

The library has microfiche copies of GJO open-file reports available for sale to the public at a nominal charge. At present, 1,134 titles are available on microfiche. In 1978, microfiche sales almost doubled sales of the 2 previous years combined—6,223 microfiche copies of technical reports were sold in 1978, compared to 3,283 sold in 1976 and 1977.

Microfiche copies of reports are at a 24:1 reduction; accompanying maps and oversize charts are on 35 mm film. 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 library in Grand Junction.



Quality control of silver microfilm intended for archival use is a crucial operation in the micrographics section (left). Below, a technician starts up a new micrographics film processor.

Technical Reports

Technical reports, maps, and raw data generated by DOE, Bendix, and subcontractors about NURE activities are released to the public via open filing. This open-file report system requires the distribution of printed material to selected open-file repositories throughout the United States. At present there are 16 open-file locations which receive all reports except aerial radiometric reconnaissance volumes, and 17 open-file locations which receive technical reports on a case-by-case exception basis. (See map on page 90.)

1978 Open-File Reports

In the listing that follows, a GJBX prefix designates reports of current research by Bendix or subcontractors in support of NURE. In addition to 143 GJBX reports released in 1978, over 300 trace element reports were open filed this year, which, for the most part, were released only on microfiche. These TEM's and TEI's, originally developed by the USGS in the early days of uranium exploration (1948 through 1957), were open filed for the first time this year.

Ten reports released in 1978, dealing with inactive mill tailings, are designated GJT. The section listing 17 miscellaneous reports contains 3 reports produced annually by DOE at GJO, 2 of which deal with statistical data of the uranium industry and exploration expenditures. The prices in the following list refer to microfiche unless otherwise noted.

The new floppy-disc phototypesetter, delivered in December 1978, is a major part of upgrading and expansion in the word processing center.

OPEN-FILE REPORT REPOSITORIES

● Permanent open-file locations (except airborne)

▲ Case-by-case open-file locations

Reports Issued in 1978

GJBX Reports

GJBX-1(78) "Design of a Groundwater Sampling Network for Minnesota," Roman Kanivetsky, Minnesota Geological Survey, University of Minnesota, January 1978, $4.50.

GJBX-2(78) "Aerial Gamma Ray and Magnetic Survey Van Horn and Pecos Quadrangles, Texas," GeoMetrics, Inc., October 1977, $25.00.

GJBX-3(78) "Preliminary Study of the Uranium Favorability of Granitic and Contact-Metamorphic Rocks of the Owens Valley Area, Inyo and Mono Counties, California, and Esmeralda and Minaral Counties, Nevada," G. M. Cupp and T. P. Mitchell, Bendix Field Engineering Corporation (BFEC), January 1978, $3.00.

GJBX-4(78) "Preliminary Study of the Favorability for Uranium in the Madera Limestone, and Cutler and Chinle Formations of the Sierra Nacimiento-Jemez Mountains Area, New Mexico," H. P. Vizcaino, A. J. O'Neill, and F. E. Dotterrer, BFEC, January 1978, $3.00.

GJBX-5(78) "Preliminary Study of Uranium Favorability of the Boulder Batholith, Montana," S. B. Castor and J. W. Robins, BFEC, January 1978, $3.00.

GJBX-6(78) "Geostatistics Project of the National Uranium Resource Evaluation Program," July-September 1977, T. R. Bement and F. C. Genter, Los Alamos Scientific Laboratory (LASL), November 1977, $3.00.

GJBX-7(78) "Preliminary Study of the Uranium Favorability of the Wilcox and Clairborne Groups (Eocene) in Texas," W. P. Wilbert and C. J. Templain, BFEC, January 1978, $3.00.

GJBX-8(78) "Preliminary Study of the Uranium Potential of the Triassic Sanford Basin and Colon Cross Structure, North Carolina," C. H. Lee, BFEC, January 1978, $3.00.

GJBX-9(78) "Preliminary Raw Data Release Spartanburg 1° x 2° NTMS Area, North Carolina and South Carolina," J. D. Heffner and R. B. Ferguson, Savannah River Laboratory (SRL), December 1977, $5.50.

GJBX-10(78) "Survey of Lands Held for Uranium Exploration, Development, and Production in Fourteen Western States in the Six Month Period Ending June 30, 1977," BFEC, January 1978, $3.00.

GJBX-11(78)R "NURE 1977 Annual Activity Report," BFEC, May 1978, free.

GJBX-12(78) "1977 NURE Uranium Geology Symposium, December 7-8, 1977, Abstracts and Visual Presentations," BFEC, February 1978, $10.00.

GJBX-13(78) "Manual for the Application of NURE 1974-1977 Aerial Gamma-Ray Spectrometer Data," Donald F. Saunders and Mark J. Potts, Texas Instruments, Inc. (TI), September 1977, $3.00.

GJBX-14(78) "Hydrogeochemical and Stream Sediment Reconnaissance Program in the Central United States," Fourth Quarter FY-1977, July 1 through September 30, 1977, J. W. Arendt, Oak Ridge Geseous Diffusion Plant (ORGDP), November 1977, $3.00.

GJBX-15(78) "Geological and Geochemical Aspects of Uranium Deposits; A Selected, Annotated Bibliography," Volume 1, M. B. White and P. A. Garland, Oak Ridge National Laboratory (ORNL), June 1978, $3.00.

GJBX-16(78) "NURE Aerial Gamma Ray and Magnetic Reconnaissance Survey, Thorpe Area, Newark NK18-11 Quadrangle," LKB Resources, Inc., November 1977, $10.00

GJBX-17(78) "Raw Data Release V; Orientation Studies in the Spruce Pine, Moore, and Johnston, North Carolina, Areas," R. B. Ferguson, E. I. Baucom, and V. Price, SRL, December 1977, $5.00.

GJBX-18(78) "A Computer Program to Generate Pearson, Spearman, and Kendall Correletions," V. E. Kane, N. M. Larson, and V. C. Nall, ORGDP, November 1977, $3.00.

GJBX-19(78) "Raw Data Report, Cave Valley Orientation Study, Lund 1° x 2° NTMS Area, Nevade," K. P. Puchlik, B. E. Holder, and C. F. Smith, Lawrence Livermore Laboratory (LLL), November 1977, $3.00.

GJBX-20(78) "Aerial Gamma Ray and Magnetic Survey: Fremont Quadrangle, Nebraska, Iowa; Lincoln Quadrangle, Nebraska; Manhattan Quadrangle, Kansas; Hutchinson Quadrangle, Kansas," GeoMetrics, November 1977, $35/quadrangle.

GJBX-21(78) "Hydrogeochemical and Stream Sediment Reconnaissance of the National Uranium Resource Evaluation Program; April-June 1977, the Rocky Mountain States of New Mexico, Colorado, Wyoming, and Montana, and the State of Alaska," David E. Broxton and Henry P. Nunes, LASL, January 1978, $3.00.

GJBX-22(78) "Data Manegement and Handling for the Hydrogeochemical and Stream Sediment Reconnaissance Program at the Los Alamos Scientific Laboratory," Jesse M. Cheadle, Jr., LASL, January 1978, $3.00.

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GJBX-26(78) "Aerial Gamma Ray and Magnetic Survey: Rice Lake Quadrangle, Wisconsin; Iron Mountain Quadrangle, Wisconsin, Michigan; Eau Claire Quadrangle, Wisconsin, Minnesota; Green Bay Quadrangle, Wisconsin," GeoMetrics, April 1978, $35/quadrangle.

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GJBX-30(78) "A Radiometric Study of Rocks in Three Selected Drainage Basins in the Spruce Pine Area, North Carolina," Joan M. Galipeau and Paul C. Ragland, SRL, December 1977, $3.00.

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GJBX-32(78) "NURE Aerial Gamma Ray and Magnetic Reconnaissance Survey, Thorpe Area, Scranton NK18-8 Quadrangle," LKB Resources, Inc., February 1978, $10.00.

GJBX-33(78) "NURE Aerial Gamma Ray and Magnetic Reconnaissance Survey, Thorpe Area, Harrisburg NK18-10 Quadrangle," LKB Resources, Inc., February 1978, $10.00.

GJBX-34(78) "NURE Aerial Gamma Ray and Magnetic Reconnaissance Survey, Thorpe Area, Williamsport NK18-7 Quadrangle," LKB Resources, Inc., March 1978, $10.00.

GJBX-35(78) "Evaluation of Uranium Potential in Selected Pennsylvanian and Permian Units and Igneous Rocks in Southwestern and Southern Oklahoma," John W. Shelton and Zuhair-Al-Shaieb, Oklahoma State University, June 1977, $10.00.

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GJBX-48(78) "Raw Data Report, Roach Lake Basin Orientation Study, Nevada," K. P. Puchlik, B. E. Holder, and C. F. Smith, LLL, December 1977, $5.00.

GJBX-49(78) "Evaluation of Soil Moisture Measurement Using Gamma Ray Spectroscopy," Geodata International, Inc., December 1977, $3.00.

GJBX-50(78) "Aerial Gamma Ray and Magnetic Survey: Peninsula Portion, Hancock Quadrangle, Michigan; Ashland Quadrangle, Wisconsin, Minnesota, Michigan; Iron River Quadrangle, Michigan, Wisconsin; and Marquette Quadrangle, Michigan," GeoMetrics, Inc., May 1978, $10.00/quadrangle.

GJBX-51(78) "Geology of the Raleigh 1° x 2° Quadrangle, North Carolina," William F. Wilson, et al., Geology and Mineral Resources Section, Division of Earth Resources, North Carolina Department of Natural Resources and Community Development, March 1978, $5.50.

GJBX-52(78) "Survey of Lands Held For Uranium Exploration, Development, and Production in Fourteen Western States in the Six Month Period Ending December 31, 1977," BFEC, April 1978, $3.00.

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GJBX-59(78) Gross Gamma-Ray Calibration Blocks," Part I. "Gross Gamma-Ray Calibration Blocks; Construction," by Mark A. Mathews, Part II. "Gross Gamma-Ray Calibration Blocks; Grade Assignment," by Kenneth L. Kosanke, BFEC, May 1978, $3.00.

GJBX-60(78) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Denver and Greeley NTMS Quadrangles, Colorado," Stephen L. Bolivar, David E. Broxton, and Clayton E. Olsen, LASL, March 1978, $7.00.

GJBX-61(78) "Orientation Study Data Release VI: Leesville, South Carolina, Area," Van Price and P. L. Jones, SRL, March 1978, $3.00.

GJBX-62(78) "Procedures Manual for Groundwater Reconnaissance Sampling," ORGDP, March 1978, $3.00.

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GJBX-71(78) "Hydrogeochemical and Stream-Sediment Reconnaissance Survey of the National Uranium Resource Evaluation (NURE) Program—Western United States, Quarterly Progress Report, October through December 1977," LLL, April 1978, $3.00.

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GJBX-73(78) "Wide-Spaced Uranium Geochemical Survey in the Plainview, Lubbock, and Big Spring Quadrangles, Texas," C. E. Nichols, et al., ORGDP, December 1977, $10.00.

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GJBX-99(78) "Monitoring of the Airport Calibration Pads at Walker Field, Grand Junction, Colorado, for Long-Term Radiation Variations," David Stromswold, BFEC, August 1978, $3.00.

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GJBX-101(78) "Aerial Radiometric and Magnetic Survey, Baker National Topographic Map, Idaho and Oregon," Geo-Life, February 1978, $10.00.

GJBX-102(78) "Aerial Radiometric end Magnetic Survey, Houston National Topographic Map, Texas Gulf Coast," Geodata International, Inc., June 1978, $10.00.

GJBX-103(78) "Uranium Hydrogeochemical and Streem Sediment Reconnaissance Date Release for the New Mexico Portions of the Hobbs and Brownfield NTMS Quadrangles, New Mexico/Texas," R. G. Warren and H. P. Nunes, LASL, June 1978, $4.00.

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GJBX-106(78) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Cheyenne NTMS Quadrangle, Wyoming," Pam K. Trexler, LASL, June 1978, $4.00.

GJBX-107(78) "Hydrogeochemical and Stream-Sediment Reconnaissance of the National Uranium Resource Evaluation (NURE) Program, Western United States, Quarterly Progress Report, January through March 1978," LLL, May 1978, $3.00.

GJBX-108(78) "NURE Aerial Gamma-Ray and Magnetic Reconnaissance Survey, Cook Inlet Alaska Area," (Tyonek, Anchorage, Kenai, Seward, Seldovia, and Blying Sound NTMS Quadrangles), LKB Resources, Inc., July 1978, $30.00.

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GJBX-114(78) "Criteria for Uranium Occurrences in Saskatchewan and Australia as Guides to Favorability for Similer Daposits in the United States," J. Kalliokoski, Michigan Technological University, F. F. Lengford, University of Saskatchewan, and R. W. Ojakangas, University of Minnesota, Duluth, July 1978, $3.00.

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GJBX-116(78) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Seguin NTMS Quadrangle, Texas," ORGDP, September 1978, $5.00.

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GJBX-122(78) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Date Report for Kingman NTMS Quadrangle, Arizona, California, and Nevada," B. J. Qualheim, LLL, July 1978, $6.00.

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GJBX-138(78) "Uranium, Hydrogeochemical and Stream Sediment Reconnaissance of the Raton NTMS Quadrangle, New Mexico," Terrance L. Morgan and David E. Broxton, LASL, October 1978, $4.00.

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TEM-2 "Majuba Hill Mine, Pershing County, Nevada; Preliminary Report," Donald G. Wyant, November 23, 1948, 10 p., $3.50.

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GJT-19 Riverton Site, Riverton, Wyoming, $3.00.

GJT-20 Ray Point Site, Ray Point, Texas, $3.00.

GJT-21 "Laboratory Research on Tailings Stabilization Methods and Their Effectiveness in Radiation Containment," Ford, Bacon, and Davis, Utah, April 1978, $3.00.

GJT-22 "Radiation Pathways and Potential Health Impacts from Inactive Uranium Mill Tailings," Ford, Bacon, and Davis, Utah, July 1978, $3.00.

Miscellaneous Reports

GJO-100(78) "Statistical Data of the Uranium Industry," January 1978, $3.00.

GJO-103(78) "Uranium Exploration Expenditures in 1977 and Plans for 1978-1979," April 1978, free.

GJO-108(77) "Uranium Industry Saminar Proceedings," October 26-27, 1977, $10.00.

DOE/RA-0006 "Survey of United States Uranium Marketing Activity," May 1978, free.

GJBX-89(77)R "Preliminary Report on Uranium and Thorium Content of Intrusive Rocks in Northeastern Washington and Northern Idaho," S. B. Castor, M. R. Berry, and J. W. Robins, BFEC, September 1978, $3.00.

DAO-4-TM-10 "The Mammoth Mine, Tierra Vieja Mountains, Presidio County, Texas," T. S. Nye, U.S. AEC, December 1957, May 1978, $3.00.

RA-12 "Thorium and Rare Earth Resources of the Lemhi Pass Area, Idaho and Montana," Byron J. Sharp and Donald L. Hetland, U.S. AEC, July 1968, January 1978, $6.00.

RME-1002 "Results of Diamond Drilling at the Silver Cliff Mine, Lusk, Wyoming," by Charles P. Bromley, U.S. AEC, June 1953, May 1978, $3.00.

RME-1099 "Geochamical and Geophysical Reconnaissance in Northern Peninsula Michigan and Northeastern Wisconsin," R. L. Kinnaman and C. T. Illsley, U.S. AEC, June 1962, April 1978, $3.00.

RME-2049 "Some Uranium Deposits Associated with Volcanic Rocks, Westarn United States," A. C. Watars, Johns Hopkins University, U.S. AEC, November 1955, November 1978, $3.00.

RME-2071 "Uranium Occurrences of Gila County, Arizona," R. J. Schwartz, U.S. AEC, October 1957, June 1978, $3.00.

RMO-864 "Preliminary Memorandum on the Trinity Mines, Marysvale, Utah," Jack Green, Paul F. Kern, Columbia University, U.S. AEC, December 1951, September 1978, $3.00.

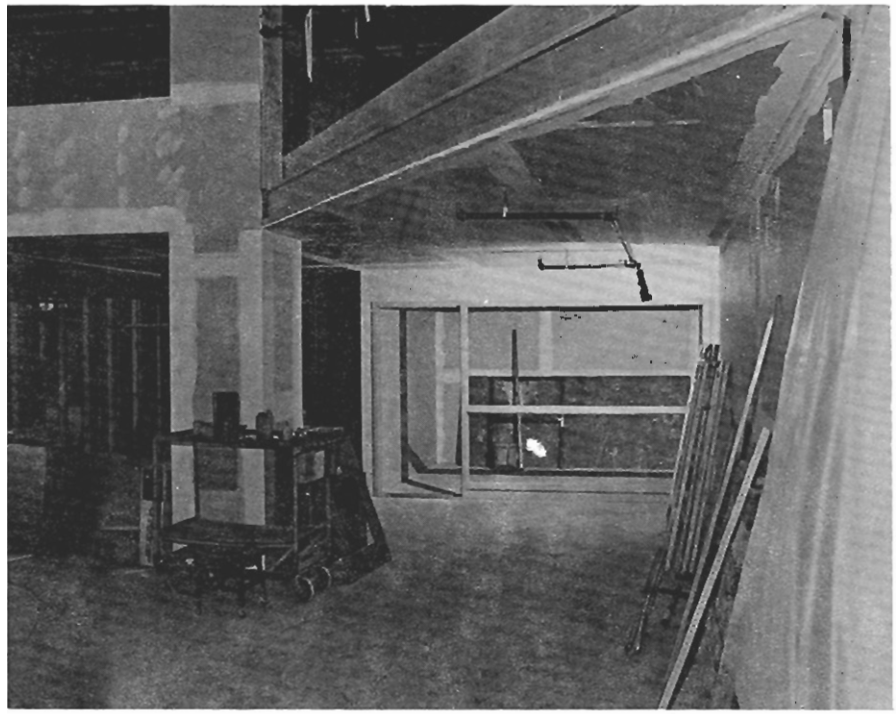
TM-196 "Report of Examination, Little Wolf Mining and Minerals, Inc., Anklam Property, Big Falls, Waupaca County, Wisconsin," John W. King, U.S. AEC, July 1960, March 1978, $3.00.

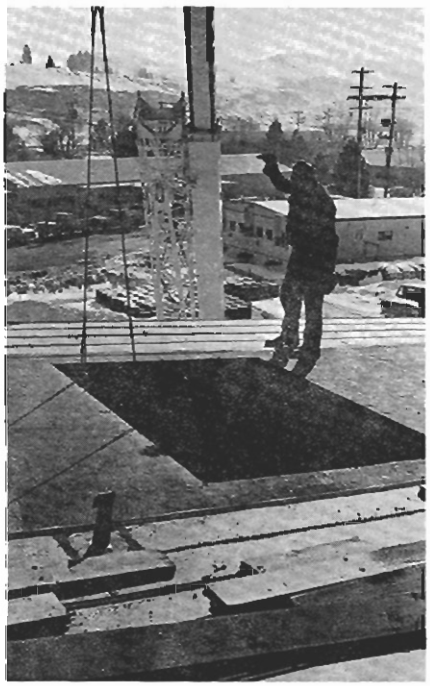
TM-197 "Ground Water Conditions and the Relation to Uranium Deposits in the Gas Hills Area, Fremont and Natrona Counties, Wyoming," L. Y. Marks, U.S. AEC, November 1958, March 1978, $3.00.

"Log Information on East Chaco Canyon Drilling Project, San Juan Basin, McKinley County, New Mexico," December 1978, $10.00.

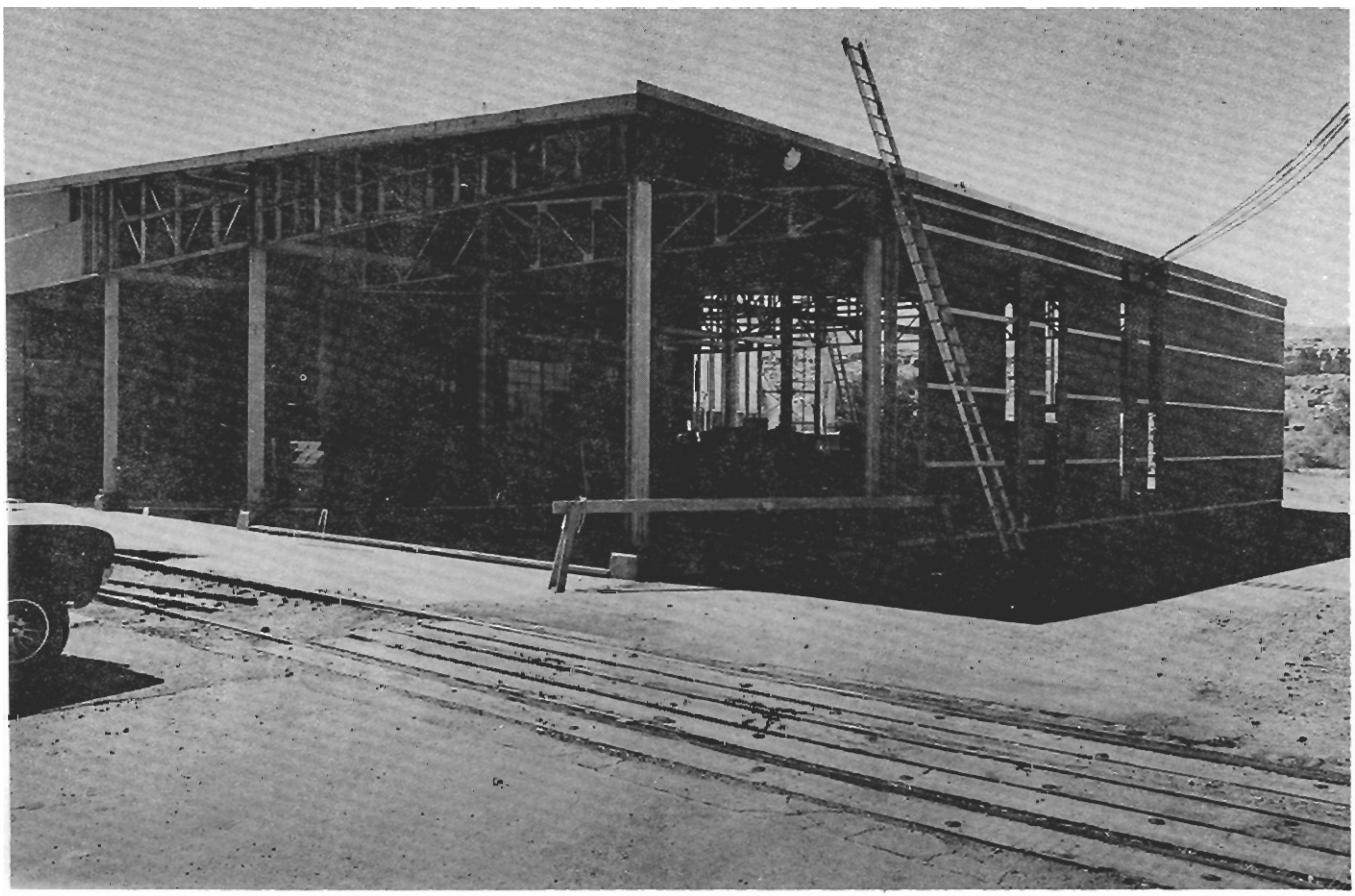
Preliminary Map No. 25 "Areas in Which Potential Uranium Resources Have Been Estimated," DOE/GJO Resource Division, January 1978, $1.50.

Preliminary Map No. 26 "Areas Identified as Favorable but with Insufficient Basis for Estimation of Potential Uranium Resources," DOE/GJO Resource Division, January 1978, $1.50.





Construction on the new DOE-GJO Technical Library got under way in 1978 and was completed in May 1979. The facility houses photography laboratories and editorial offices, as well as the library (above). At left, a worker supervises as a heating unit is lowered through the roof. Building the new library involved enclosing a storage area at the Grand Junction facility (below).



Bendix managers and division directors keep abreast of policy changes and developments at regular staff meetings. Below, Bendix GJO Manager Charles Greenslit, left, and Judy Bowles, United Way campaign manager, show BFEC President Murray Weingarten the trophy Bendix received as largest contributor to United Way in Mesa County in 1978.