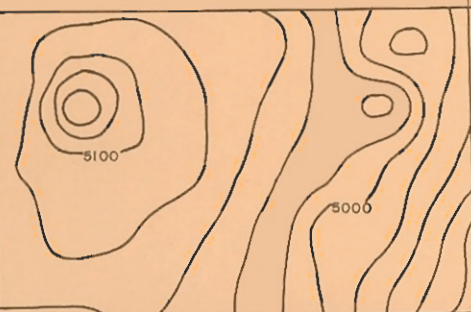
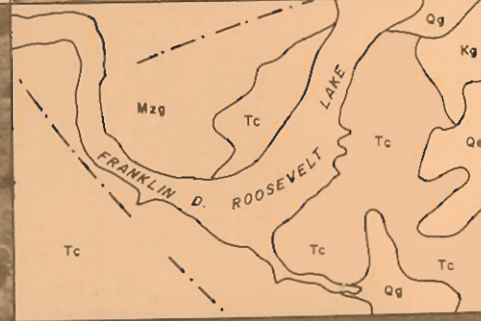
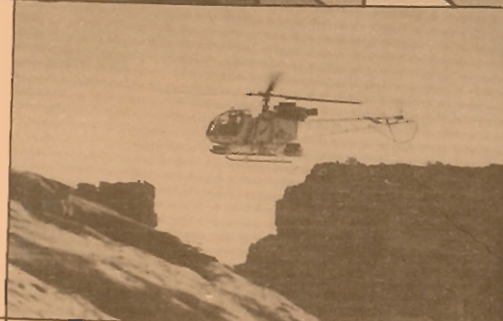


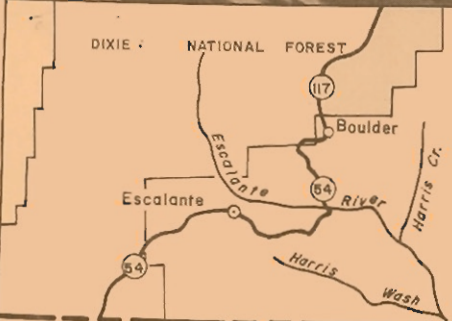
VERNAL



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NURE 1979

National Uranium Resource Evaluation Annual Activity Report

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On the Cover: The different types of acquisition methods used to obtain data for evaluating a quadrangle are indicated by the photographs as: surface geologic investigation, stream water sampling, aerial radiometric surveying, drilling, and logging. So that the data may be used by the principal investigator in his evaluation procedures; the acquired data is presented in the quadrangle folio in reduced form, exemplified by: the plots; contour and density and the maps; geologic and cultural.

DOE NEWS:

FOR IMMEDIATE RELEASE
May 29, 1980

ANNUAL NURE ACTIVITY REPORT ISSUED

The Grand Junction, Colorado, Office, U.S. Department of Energy (DOE), has issued the fourth annual activity report of the National Uranium Resource Evaluation (NURE).

The 106-page report, GJBX-11(80), "NURE 1979 — National Uranium Resource Evaluation Annual Activity Report," was prepared by Bendix Field Engineering Corp., operating contractor for DOE's Grand Junction facility. The publication is a description of work done during calendar year 1979 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 will be issued as GJO-100(80), "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(80) may be obtained at no cost by writing to:

Technical Library
Bendix Field Engineering Corp.
P. O. Box 1569
Grand Junction, Colorado 81502
Tel: 303/242-8621, Ext. 278.

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PR No. 80-91

Library Reference Inquiries: 303/242-8621, Ext. 279

News Media Contact: Peter Mygatt, 303/242-8621, Ext. 293

NURE 1979

National Uranium Resource Evaluation

Annual Activity Report

March 1980

Bendix Field Engineering Corporation
Grand Junction, Colorado 81502

Prepared for the
U.S. Department of Energy
Assistant Secretary for Resource Applications
Grand Junction Office, Colorado
Under Contract No. DE-AC13-76GJO1664

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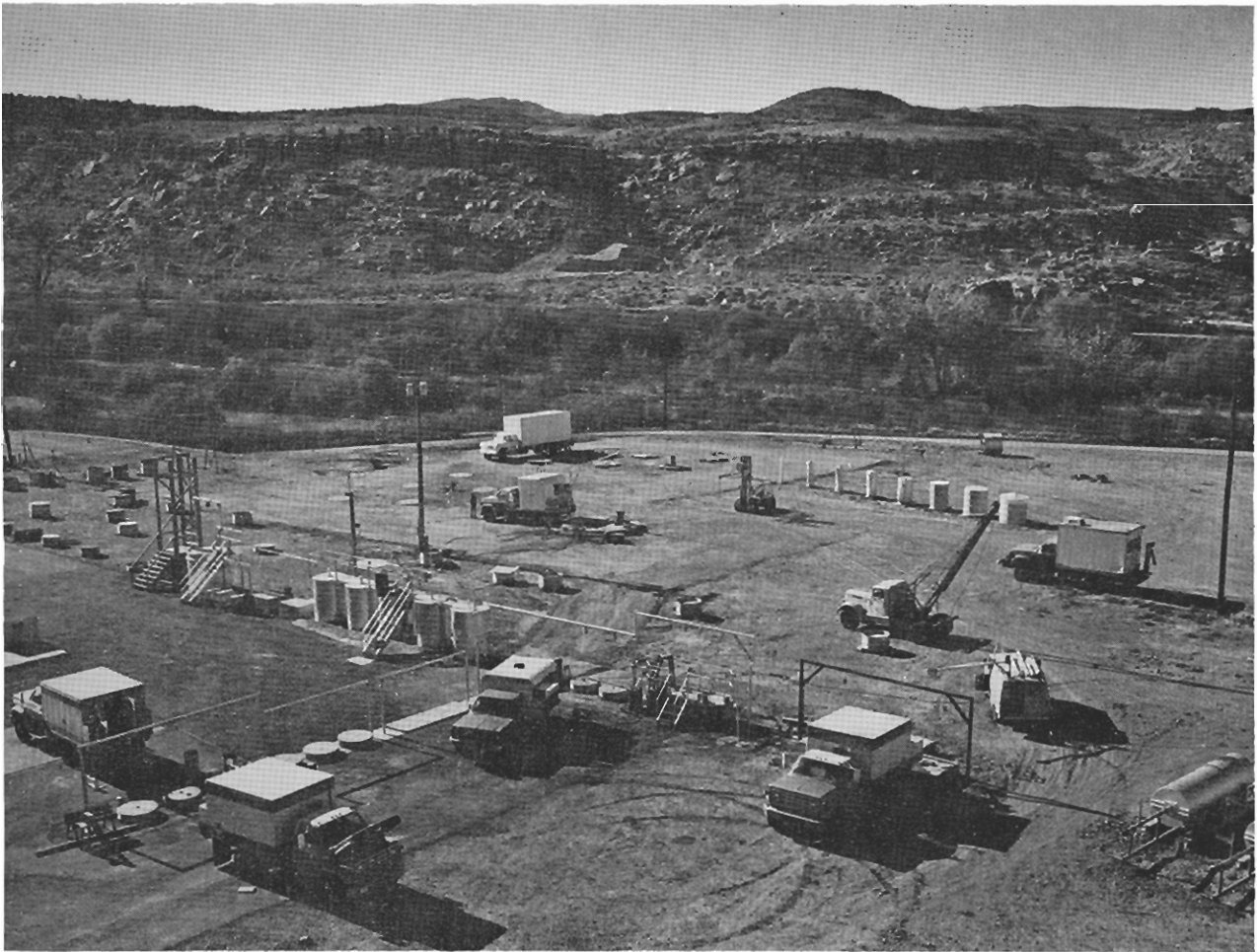
Foreword

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 fourth annual activity report summarizes technical activities undertaken during calendar year 1979 to support DOE's National Uranium Resource Evaluation (NURE) program.

Bendix operates under U.S. Contract DE-AC13-76GJO1664 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 expanded Grand Junction calibration and standardization facility now includes the six fission neutron borehole models (upper middle of photo) and the large diameter fission neutron water factor model (center of photo).

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 Investigations
4. Hydrogeochemical and Stream-Sediment Reconnaissance
5. Geologic Studies
6. Technology Applications

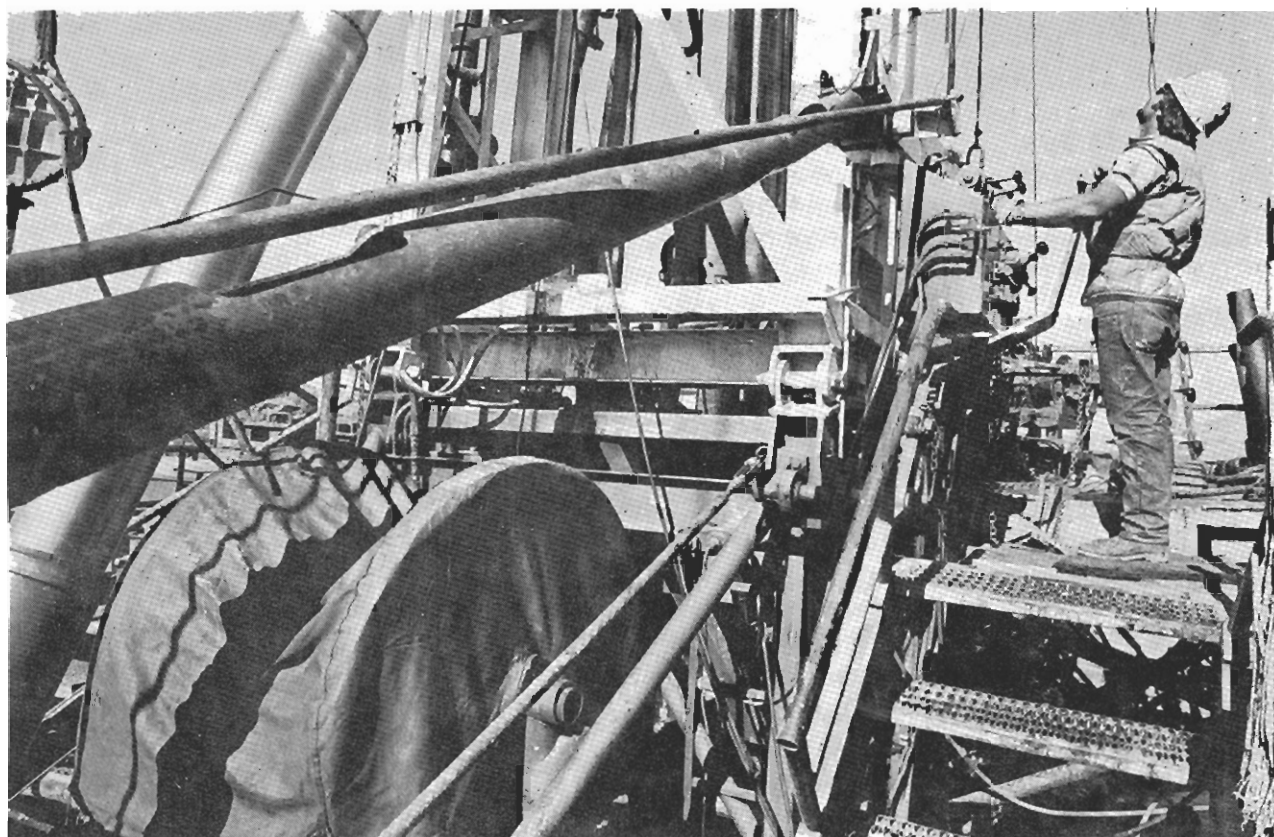
7. Information Dissemination

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 culminating in a comprehensive report covering certain priority areas of the United States. These priority areas coincide to a high degree with those designated as having potential and as being favorable in the June 1979 DOE report GJO-111(79) entitled *National Uranium Resource Evaluation, Interim Report*.

It is planned that the resource data published periodically by DOE—such as those found in GJO-100(79), *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.



The 1979 Mining and Petroleum Days in Grand Junction display used more than 40 color photographs to highlight the NURE program major activities.



1979 Summary and Highlights

The quadrangle evaluation program was initiated in 1977 to organize the NURE effort in a thorough, uniform, and systematic manner for examining the uranium resources of the United States.

Early in 1978 a DOE task force was assigned to review the program and to make recommendations. This review resulted in establishing an interim goal which was to evaluate 116 of the 272 so-called "A" priority quadrangles and to report the results in 1980. Increased emphasis was placed on examining and evaluating the most favorable areas for intermediate-grade resources and non-sandstone geologic settings identified as "world class" that, in other nations, have been known to contain large uranium resources.

By early 1979 geologic investigations were under way in all the 116 priority quadrangles. The effort was divided among the many organizations participating in the program which includes Bendix, U.S. Geological Survey, state geologic surveys, universities, and private firms. By the end of 1979 investigation of 18 priority quadrangles had been completed. To guide the investigations and to provide a common base for evaluating and classifying project areas, Bendix provided each investigating group with speci-

cations 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 in 1978, and *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, was published in 1979. Both documents have been supplied to all participants. Bendix is working with DOE to develop procedures and methods for the final step in the assessment process and to estimate the amount of ore in a given area.

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

During 1979, seven contractors used 10 airborne gamma-ray spectrometer systems to perform approximately 190,000 line miles (306,000

kilometers) of survey, bringing the total to 780,000 miles (1,255,000 kilometers), which represents approximately two-thirds the total reconnaissance surveys to be flown in the NURE program. In addition to reconnaissance surveying, 48,000 line miles (77,000 kilometers) of detail surveying were flown in support of the 1980 goal, bringing the total detail flown to 70,000 line miles (113,000 kilometers).

Drilling activity on NURE increased substantially during 1979 over 1978. This activity accelerated the acquisition of subsurface data needed to confirm, with improved confidence, the uranium resource estimates in areas of known occurrences. The acquisition of these data was to aid in evaluating uranium resources in areas of high potential, to provide subsurface information in geologic study areas, and to help define and locate halo-like zones around known uranium deposits as a part of exploration systems development.

Drilling, started in 1978, was completed for three quadrangles and two exploration systems development projects: Lemhi Pass in Montana (Dubois Quadrangle, thorium investigation); San Rafael Swell in Utah (Price and Salina Quadrangles); Missoula/Bitterroot Basins in Montana (Wallace and Hamilton Quadrangles); Copper Mountain in Wyoming (exploration systems development); and Red Desert in Wyoming (exploration systems development). Of the five new projects started in 1979, four were completed and one was continued into 1980. Those completed were Sand Wash Basin, Colorado (Craig and Vernal Quadrangles); Sonora Pass, California (Walker Lake Quadrangle); Southwest Prescott, Arizona (Prescott and Williams Quadrangles); and San Juan Basin, New Mexico (exploration systems development). To be continued into 1980 is Owens Lake, California (Death Valley Quadrangle).

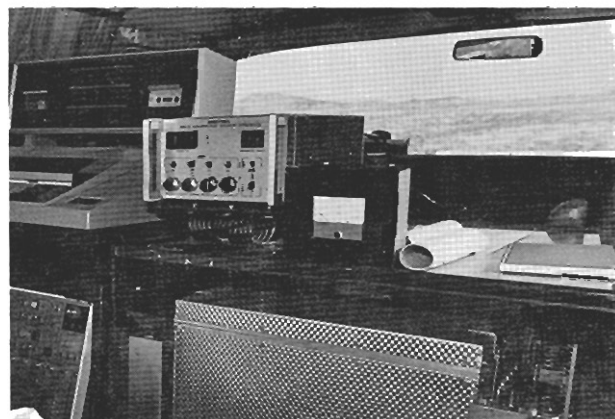
Geologic studies drilling in 1979 included two world-class deposit projects: Northeast Black Hills in South Dakota (Precambrian quartz-pebble Estes conglomerate) and Southeast Wyoming (Precambrian quartz-pebble conglomerate), and two intermediate-grade

deposit projects: Cedar Mountain, Utah (Brushy Basin Member of Jurassic Morrison Formation) and Red Desert, Great Divide Basin in Wyoming (lacustrine paludal facies).

Increased emphasis was placed on the quadrangle logging program in 1979; first, by augmenting Bendix in-house logging capability with two additional operational logging systems bringing to five the total number of specialized systems that have KUT gamma-ray spectrometer capability, and second, by initiating projects through subcontractors to obtain spectral and/or gross gamma-ray calibrated logs in designated regions from new and existing boreholes that were not drilled for uranium. The in-house logging effort resulted in 1,100,000 total feet (335,280 meters) logged in holes, a number of which were drilled specifically for the quadrangle evaluation program. The subcontracted logging resulted in 363 holes aggregating 949,500 feet (289,410 meters) logged along the eastern slope of Colorado, eastern Nevada, and the San Joaquin Valley, California.

By the end of 1979 the DOE laboratories participating in the HSSR program had completed samples for 328 quadrangles. Open-file reports on the sample data were issued for 58 quadrangles which brought the total to date to 97. In addition to reconnaissance sampling, 27 detailed sampling studies were initiated. One was completed and the results were open filed in support of the 1980 goal.

During 1979 Bendix continued to focus the geologic studies program on two areas of the 1978 DOE task force concern, by increasing the in-house and subcontracted study effort on world-class deposits and intermediate-grade resources. As elements in the 1980 world-class goal for evaluating the Precambrian pebble-conglomerate environment, drilling projects and field work were conducted in the northeastern



Interior view of ground support vehicle #1 at Dynamic Test Range I.

Black Hills of South Dakota and in southeast Wyoming. In addition to Precambrian pebble conglomerate, other geologic environments were studied in the United States which may offer uranium potential in a non-sandstone environment including: unconformity, volcanic, plutonic-metamorphic, and regolith-related.

Work during 1979 on intermediate-grade resources (0.01 to 0.05 percent U_3O_8) was concentrated on sandstone environments located near known producing areas. In addition to studying the information available in the literature on four areas, field investigation and drilling projects were conducted in two: Cedar Mountain, Utah where the Brushy Basin Member of the Jurassic Morrison Formation is the target, and Red Desert, Great Divide Basin, Wyoming where lacustrine paludal facies are being examined.

Three studies on low-grade resources (less than 100 ppm U_3O_8) were completed in 1979 which included the release of final reports: Chattanooga Shale, Phosphate, and Sea Water. Commercialization of any of the processes proposed for extracting uranium from these low-grade resources would place the recovered U_3O_8 in the \$200 to \$3,600 per pound category. During the year asphaltite was examined as a fourth potential low-grade resource.

During the initial phase of the quadrangle evaluation program, it was determined that only 189 of the 621 National Topographic Map Series (NTMS) quadrangles for the United States had geologic maps scaled 1:250,000. To furnish the remaining 432 geologic maps for use as data bases to all NURE program elements, 232 map compilations have been subcontracted, with 222 maps delivered by the end of 1979. This leaves 210 maps to be obtained.

Technology Applications during 1979 emphasized those projects which should meet near-term technical requirements of the NURE program in the areas of: exploration techniques and systems integration, borehole logging systems, data reduction and calibration facilities, airborne radiometric data quality control and interpretation, and laboratory geochemical analytical techniques and systems.

Analysis of data taken in the three research test areas of Red Desert, Copper Mountain, and Spokane Mountain resulted in a better understanding of how data on such uranium indicators as radon, helium, argon, as well as various trace elements, may be integrated for effective use in resource assessment and exploration. A fourth research test area was established in the San

Juan Basin as a representative sandstone environment to be studied and compared with the Red Desert. Drilling programs were completed at all four sites.

The delayed fission neutron (DFN) logging system using ^{252}Cf was introduced as a commercial service for directly assaying uranium ore in a borehole. A project was initiated to develop a neutron activated gamma-ray spectroanalysis borehole probe for determining the presence of trace element or "halo" indicators for uranium exploration. The GJO-developed gamma-ray spectrometer (KUT) borehole probe system was added to the three computer-based operational logging systems introduced in late 1978 and early 1979.

The R&D logging vehicle was used effectively to evaluate improvements in KUT and magnetic susceptibility (MS) probe development. Using the vehicle, testing of an operational prompt fission neutron (PFN) logging system developed by Sandia was under way at year's end.

During 1979 a fission neutron water factor model was installed and a 300-foot (91.44 meter) test borehole was drilled at the Grand Junction facility as important additions to DOE's calibration and standardization program for uranium resource data. At the three calibration field sites, two KUT models and one fission neutron model were added to the two existing gross gamma-ray models giving each site a total of five models.

Statistical analysis computer programs using principal component theory were made operational for the interpretation of airborne radiometric data. A 100-percent sampling quality control program on contractor-supplied airborne radiometric data magnetic tapes was initiated, using a dedicated mini-computer system. The phoswich detector development program has resulted in a unit with approximately 50 percent improved sensitivity, compared to a like-size/weight sodium iodide detector.

Development and testing of instrumentation equipment for field use continued, including the introduction of the production ruggedized radon emanometer and the delivery of the developmental drilling-mud emanometer.

Instrumentation equipment added to the geochemical laboratory included two gamma-ray spectrometers for use in analyzing field samples for radiometric potassium, uranium, and thorium. Laboratory personnel developed a new analytical procedure which is five times more cost

effective than the previous method in determining arsenic and selenium content of samples.

Dissemination of information on the NURE program resulted in the publication and open filing of 176 project and program reports, some 13 other miscellaneous reports, as well as the issuance of 157 news releases. The technical program resulted in the presentation of 20 papers by the Bendix staff at professional meetings and specialized symposiums. In March 1979 the CDC 6600 was installed as the new central on-site computer, replacing the CDC 3100, which will be phased out during 1980.



DOE sponsored the 1979 Uranium Industry Seminar that was held at Grand Junction's Two Rivers Plaza.

Quadrangle Evaluation

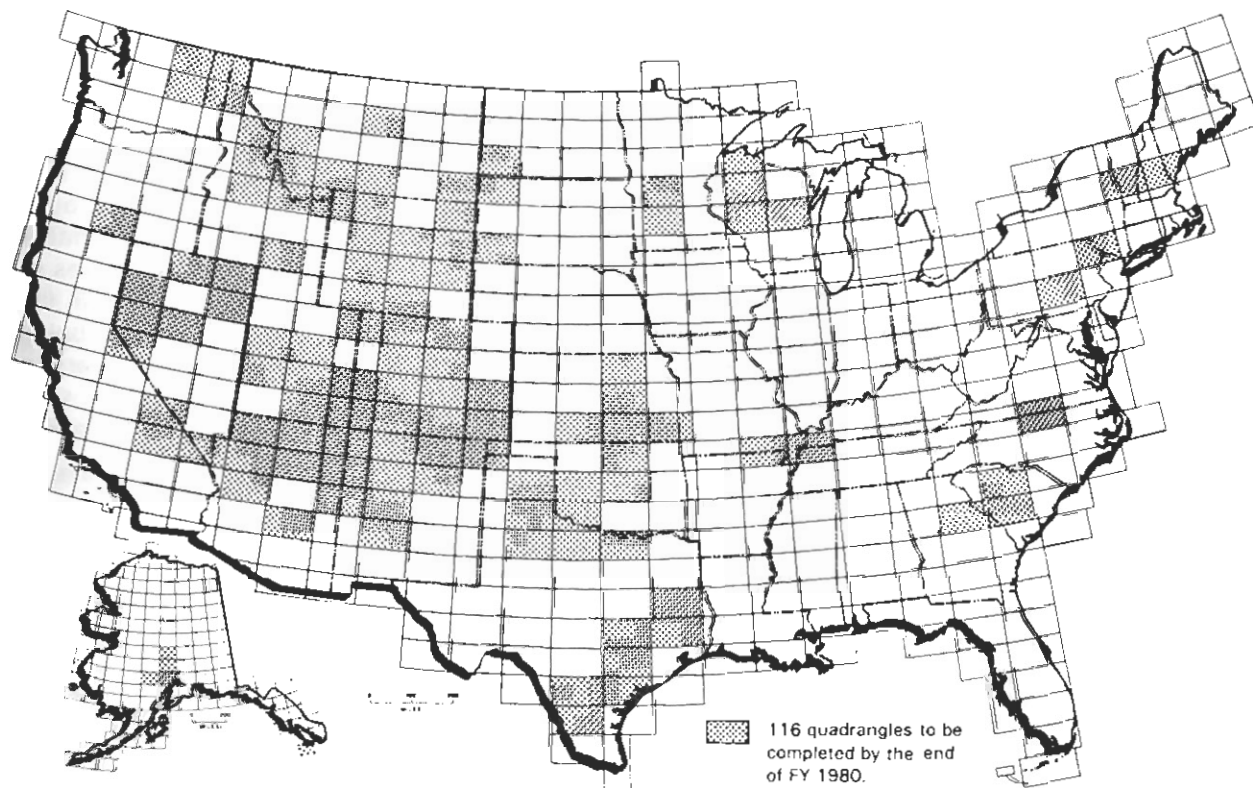
The basic work units of the NURE program are the 1:250,000-scale quadrangles of the National Topographic Map Series. Quadrangle evaluation is comprised of the data-collection and analysis activities that attempt to classify geologic environments within a selected quadrangle as favorable or unfavorable for the occurrence of uranium deposits.

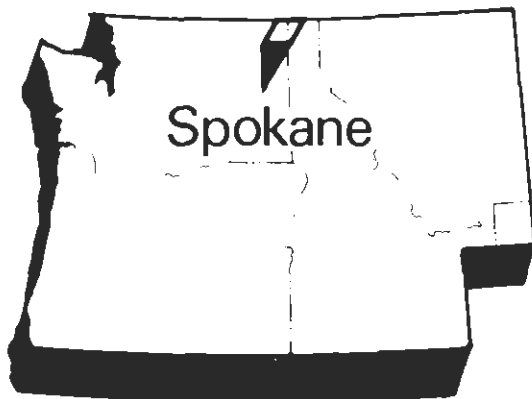
In this context, the term "favorable environment" refers to an area or a geologic unit that, on the basis of all available geologic evidence, could contain at least 100 tons U_3O_8 at an average grade not less than 100 ppm. Designation of a favorable environment is based on the similarity of its geologic characteristics (recognition criteria) to those found in close association with known uranium deposits.

To implement quadrangle evaluation activities, Bendix has established nine field offices, each with the responsibility for a particular region. In addition, organizations having specific knowledge of the geology in certain quadrangles have been encouraged to participate in the evaluation procedure. To this end, a joint working agreement was made with the U.S. Geological Survey (USGS), and subcontracts were let to state geological surveys, universities, and private firms. All subcontracted investigations are directed and monitored by Bendix.

Of the 116 priority quadrangles to be evaluated before October 1980, 23 are assigned to the USGS, 14 to state geological surveys, 36 to subcontractors in the private sector, and 43 to Bendix field offices. A total of 18 was completed by the end of 1979 and folios are currently in preparation.

LOCATION AND ASSESSMENT SCHEDULE OF 116 QUADRANGLES





Spokane Field Office

The area of responsibility for the Spokane field office encompasses Washington, Oregon, much of Idaho, western Montana, and extreme northwestern Wyoming. In 1979 Bendix geologists submitted reports for the Spokane and Sandpoint Quadrangles and conducted field work in four other quadrangles. Private subcontractors continued work in nine quadrangles.

Quadrangle Evaluation (BFEC)

Sandpoint Quadrangle

- Start Date: 3 October 1977
- Completion Date: 15 August 1979

The principal targets for investigation included granitic plutons and associated veins of Cretaceous and Tertiary age, Tertiary fluvial sandstones 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. Field work, delineation of favorable areas, report preparation, and resource evaluation were all completed this year.

Spokane Quadrangle

- Start Date: 1 November 1977
- Completion Date: 31 July 1979

Environments evaluated for uranium resources included Precambrian metasedimentary rocks, alaskite-bearing quartz monzonite plutons of Cretaceous age, and Tertiary sedimentary rocks that are interbedded with basalt fissure flows of the Columbia River Plateaus. The investigation was completed in late spring and a report of results was submitted in July. Resource evaluation was completed shortly thereafter.

Okanogan Quadrangle

- Start Date: 3 October 1977
- Completion Date: 14 December 1979

Gneissic domes and associated metamorphic rocks have been the main geologic environments under investigation. Uranium occurrences are found in zones of probable cataclastic deformation at contacts between major metamorphic rock types. Secondary targets were Tertiary fluvial and volcanogenic deposits. Field work was completed in August. Compilation and interpretation of data have since been finished and the report is in the final stage of preparation.

Ritzville Quadrangle

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

In the northeastern part of the quadrangle, uranium is produced from the Midnite Mine, 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 also may be favorable for the occurrence of uranium. Field work was completed in October and preparation of a final report is in progress.

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 Tertiary arkosic rocks adjacent to the contact between the Challis Volcanics and the batholith. These types of occurrences are being sought elsewhere in the quadrangle and the Challis Volcanics are being investigated for uranium potential elsewhere in the volcanic succession. Field work was completed in October with analysis of data and preparation of a final report now under way.

Klamath Falls Quadrangle

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

Near Lakeview, Oregon in the southwestern part of this quadrangle, uranium occurs in Tertiary lacustrine strata that are partly tuffaceous. Targets for investigation are rhyolite intrusive domes and plugs with which the mineralization may be associated. Field investigations were completed in November; compilation and analysis of data are in progress.

Quadrangle Evaluation (Subcontractors)

Pocatello Quadrangle

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

In the Pocatello Quadrangle of southern Idaho, uranium reportedly occurs in shales and lignites of the Tertiary Salt Lake Formation. A granitic pluton in the quadrangle may have been the uranium source. In the Albion Range, where vein-type sulfide deposits with anomalous radioactivity have been reported, metamorphic rocks are of further interest; and the uranium-bearing Permian Phosphoria Formation may have potential for uranium concentrations. Field work and evaluation of results have been completed and preparation of the final report is in progress.

Lewistown Quadrangle

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

In this north-central Montana quadrangle, 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. The Judith River Formation and Eagle Sandstone of Cretaceous age may be favorable for epigenetic sandstone-type uranium deposits. Both surface and subsurface investigations were completed this year. Preparation of a final report is near completion.

Elk City Quadrangle

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

Hamilton Quadrangle

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

Butte Quadrangle

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

These three contiguous quadrangles lie in parts of Idaho and Montana. Portions of the Idaho batholith are targets for evaluation in all three

quadrangles. Also potentially favorable are sedimentary portions of the Challis Volcanics in the Elk City Quadrangle; portions of the Precambrian Belt Series adjacent to the Idaho batholith in the Hamilton Quadrangle; Tertiary sediments that occupy intermontane basins in the Hamilton and Butte Quadrangles; and portions of the Boulder batholith where uranium occurrences are found with quartz-sulfide veins. Field investigations were completed this year for all three quadrangles. Compilation of results and preparation of final reports are near completion.

Dillon Quadrangle

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

Dubois Quadrangle

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

Dillon and Dubois are contiguous quadrangles in Montana and Idaho. Tertiary volcanogenic deposits, as well as other Tertiary strata in intermontane basins, are important targets for investigation in both quadrangles. In addition, veins in Mesozoic and Cenozoic plutons in the Dillon Quadrangle and the thrust-fault contact between Precambrian granite gneiss and the Madison Limestone in the Dubois Quadrangle may be favorable targets. The subcontractor completed field investigations in October and is in the process of analyzing results and preparing final reports.

Bozeman Quadrangle

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

The primary targets for uranium resource evaluation in this quadrangle are calc-alkalic intrusives in the Crazy Mountains, silicic intrusives and tuffs in the Independence mining district, and Tertiary sedimentary rocks in the Three Forks Basin. Selected portions of the Yellowstone volcanics, intrusives in the Cooke City area, and several Precambrian units may also be favorable for uranium. Field investigations and compilation of results were completed in October. Preparation of a final report is under way.



A Bendix geologist samples an outcrop.

Ashton Quadrangle

- Subcontractor: Meliji 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 Shale 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. The subcontractor completed final field investigations and subsequent data compilation and analysis this year and a final report of results is near completion.



Reno Field Office

The Reno field office is responsible for Nevada, California, and extreme western Utah and Arizona. In 1979 field examinations were conducted in five quadrangles by Bendix geologists, in three quadrangles by the U.S. Geological Survey, in two quadrangles by state surveys, and in two quadrangles by private subcontractors.

Bendix-Albuquerque geologists completed evaluation of the Kingman Quadrangle; their work is discussed briefly in the Albuquerque section of this report.

Quadrangle Evaluation (BFEC)

Death Valley Quadrangle

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

Millett Quadrangle

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

Reno Quadrangle

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

Salton Sea Quadrangle

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

Wells Quadrangle

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

These quadrangles lie largely in the Great Basin. The principal geologic environments under investigation are calderas and associated volcanogenic rock suites, granitic plutons and metamorphic complexes intruded by them, and sedimentary deposits that fill intermontane basins. Field work was completed this year on all five quadrangles. Data compilation and preparation of final reports are in progress.

Gravity Survey of the Wells Quadrangle, Nevada

- Subcontractor: Nevada Bureau of Mines and Geology
- Subcontract Value: \$14,035
- Start Date: 1 October 1978
- Completion Date: 1 March 1980

This survey was performed to provide a gravity map of the Wells Quadrangle which would be useful for selecting drill-site locations and estimating depths of basin fill.

Data from 500 gravity stations were collected and incorporated with data from 1,074 gravity stations previously collected by the Nevada Bureau of Mines and Geology and 376 gravity stations collected by the Department of Defense. All data (1,950 gravity stations) were cross-tied, terrain corrected, and contoured at a scale of 1:250,000.

Results are complete and will be open filed by the Nevada Bureau of Mines and Geology in 1980.

Quadrangle Evaluation (Subcontractors)

Elko Quadrangle

- Subcontractor: Uranium Services Co.
- Subcontract Value: \$157,900
- Start Date: 1 March 1978
- Completion Date: 31 March 1980

Lovelock Quadrangle

- Subcontractor: Berge Exploration, Inc.
- Subcontract Value: \$187,800
- Start Date: 1 March 1978
- Completion Date: 31 March 1980

McDermitt Quadrangle

- Subcontractor: Nevada Bureau of Mines and Geology
- Subcontract Value: \$193,400
- Start Date: 1 March 1978
- Completion Date: 31 March 1980

These three quadrangles are in the northern Nevada part of the Basin and Range Province where the main targets for evaluation are felsic volcanogenic deposits, tuffaceous sedimentary rocks, and metamorphic complexes associated with granitic intrusions. Basin-fill sedimentary deposits adjacent to favorable source rocks in fault-block mountains are also under investigation. Field investigations were completed this year and all three projects are now in the report preparation phase.

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 the Mojave Desert in southern California. Tertiary and Quaternary strata in basins adjacent to volcanic and plutonic source rocks are the principal targets being investigated. Field investigations were completed at the close of 1979.

Quadrangle Evaluation (USGS)

Delta Quadrangle

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

Numerous uranium occurrences in the Spor Mountain area are associated principally with beryllium-bearing rhyolite flows and ash-flow tuffs. The Yellow Chief uranium mine, in a fluvial-sandstone host rock, is also in this quadrangle. USGS geologists completed field work and data compilation this year and are preparing a final report.

Richfield Quadrangle

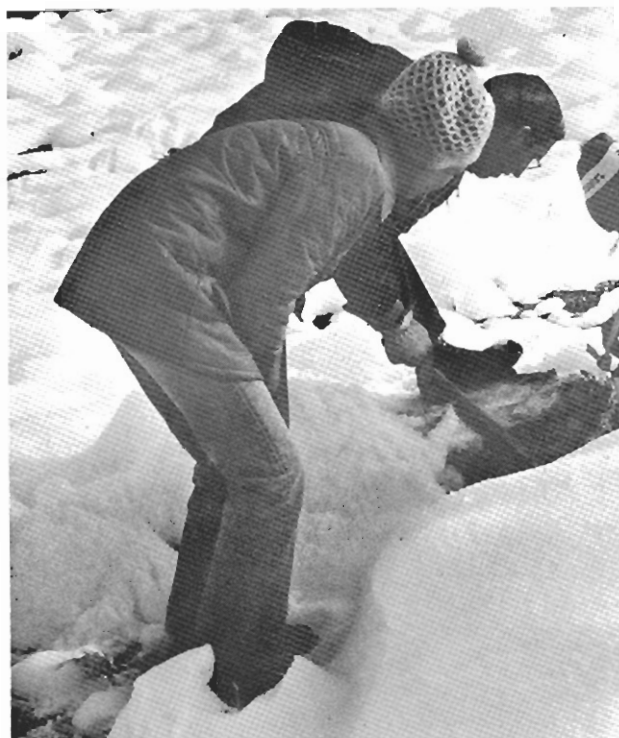
- Start Date: 23 January 1978
- Completion Date: 29 February 1980

Uranium has been produced from silicic volcanic rocks in the Marysvale area; similar rock units are found throughout the quadrangle. Paleozoic rocks in the Wah Wah Mountains and Needle Range are also being investigated. Field investigations were completed in 1979 and a final report of results is near completion.

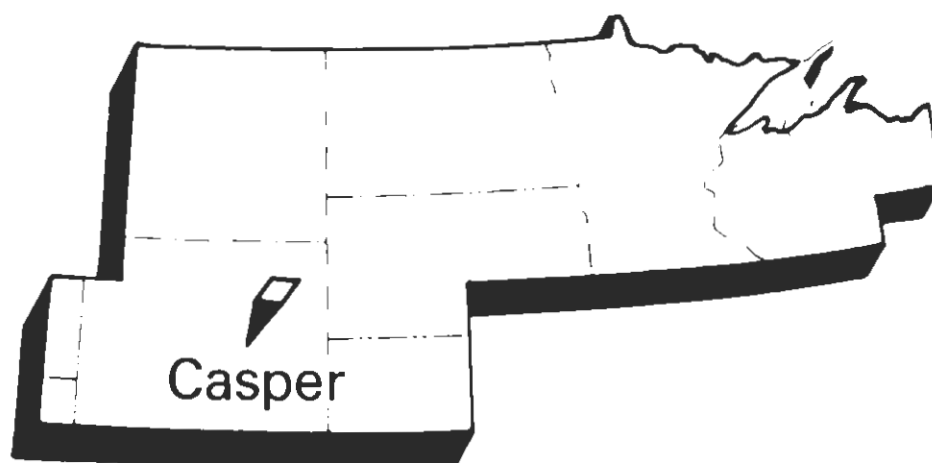
Walker Lake Quadrangle

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

In the western part of this quadrangle, environments being investigated for uranium favorability are paleostream channels cut in granitic rocks of the Sierra Nevada batholith and capped by silicic volcanics. In the eastern section, Tertiary and Quaternary sediments occur in basins adjacent to favorable rock sources. Rock sampling and other field investigations were finished this year. Compilation and evaluation of results are nearly complete and report preparation is in progress.



Geologists check a uranium occurrence in the Rawlins Quadrangle.



Casper Field Office

The Casper field office is responsible for evaluating uranium favorability in an area encompassing Wyoming; North Dakota; most of Montana, South Dakota, and Minnesota; and

parts of Idaho, Nebraska, Wisconsin, and Michigan. During 1979 Bendix geologists from the Casper office were engaged in resource evaluation of five quadrangles. The U.S. Geological

Survey continued work on four quadrangles, state surveys on two, and private subcontractors on seven. In addition, geologists from the Bendix Atlanta and Pittsburgh offices were temporarily assigned to investigate three high-priority quadrangles in North and South Dakota. Work on the Hot Springs Quadrangle is briefly described in the Pittsburgh field office section of this report; work on the Dickinson and Lemmon Quadrangles is in the Atlanta section.

Quadrangle Evaluation (BFEC)

Casper Quadrangle

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

In these five Wyoming quadrangles, Laramide uplifts with Precambrian cores and intermontane basins with thick Tertiary sections form the geologic framework. Included are the Wind River, Owl Creek, and Granite Mountains; parts of the Sierra Madre, Medicine Bow, Laramie, and Big Horn Mountains; the Wind River and Hanna Basins; and parts of the Shirley, Laramie, Washakie, Great Divide, Big Horn, Powder River, and Green River Basins. Uranium districts lying within these quadrangles are Crooks Gap, Gas Hills, Shirley Basin, and Copper Mountain. Resource evaluation is being concentrated on the sandstone environment, which contains most of the reserves. Other promising environments include quartz-pebble conglomerates and unconformity-related vein deposits. Field work consisted of geochemical sampling, radon surveys, and study of known occurrences.

Quadrangle Evaluation (Subcontractors)

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 four Wisconsin quadrangles lie in the southern Canadian Shield. The investigation of potentially favorable environments has been concentrated primarily on Precambrian rocks related to unconformities. Extensive Pleistocene glacial deposits complicate evaluation of the sequence of Precambrian and Cambrian units in bedrock. Almost all the known outcrops were visited and sampled during an intensive field investigation. The field work was completed in 1979 and final reports are in preparation.

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

Lower and Middle Precambrian rocks, a south-westward extension of the Canadian Shield, underlie a thin veneer of Cretaceous clastics in the St. Cloud and New Ulm Quadrangles. Unconformities within the Precambrian section, between the Precambrian and Cretaceous rocks, and, in restricted areas, between the Precambrian and a Cambrian sandstone, may be similar to environments in which unconformity-related deposits occur in Canada and Australia. Soil-gas surveys for helium and radon constituted a major part of the field program.

Billings Quadrangle

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

Cody Quadrangle

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

In these two adjoining quadrangles in south-central Montana and northwestern Wyoming, fluvial sandstones of Jurassic, Cretaceous, and Tertiary age appear to be favorable for uranium. In the Pryor Mountain district of the Billings Quadrangle, uranium has been produced from paleokarst deposits developed in the Mississippian Madison Limestone; similar paleokarst zones in the Cody Quadrangle are being investigated. Extensive studies of both sandstone and limestone facies were carried out using surface and subsurface information.

Rock Springs Quadrangle

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

This quadrangle in southwestern Wyoming includes the Rock Springs uplift and parts of the Green River and Washakie Basins. The potentially favorable environments being evaluated are Cretaceous and Tertiary fluvial sands. During 1979 geochemical data, together with

stratigraphic information from outcrops and drill holes, were analyzed.

Quadrangle Evaluation (USGS)

In 1979 the USGS, under an interagency agreement with DOE, was engaged in uranium resource evaluation of four quadrangles in the Casper field office region. These quadrangles—Ekalaka, Gillette, Torrington, and Newcastle—encompass the eastern part of the Powder River Basin and the western flank of the Black Hills. Investigations were being concentrated on fluvial and estuarine sands of Cretaceous and Tertiary age. Data from electric and gamma-ray logs were used extensively to locate favorable environments in the subsurface.

Ekalaka Quadrangle

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

Gillette Quadrangle

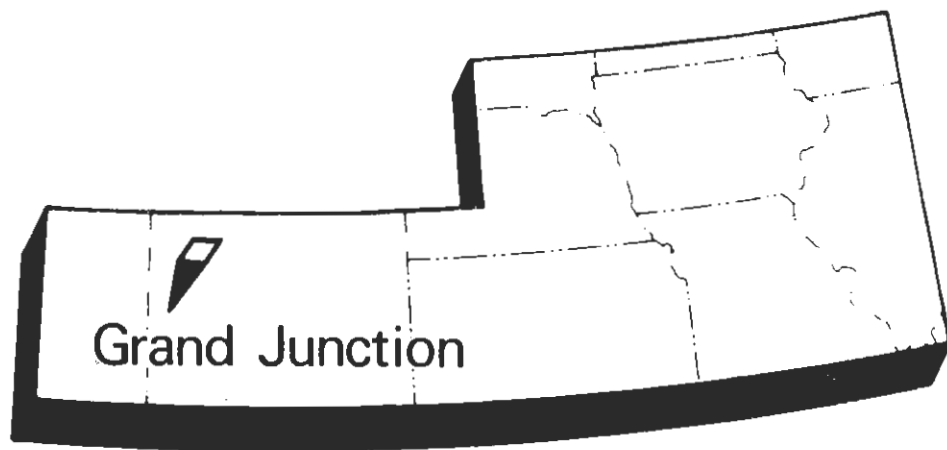
- Start Date: 23 January 1978
- Completion Date: 31 March 1980

Torrington Quadrangle

- Start Date: 30 January 1978
- Completion Date: 31 March 1980

Newcastle Quadrangle

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



Grand Junction Field Office

The Grand Junction field office is responsible for uranium resource evaluations in Colorado, Kansas, and Iowa; eastern Utah; most of Nebraska, Missouri, and Illinois; and parts of South

Dakota, Minnesota, Wisconsin, and Kentucky. In 1979 Bendix geologists investigated five quadrangles in diverse geologic settings in Colorado; work was completed on four of these, with the

fifth scheduled for completion early in 1980. In addition, one quadrangle in this field region is being evaluated by a state geological survey, four by a subcontractor, and ten by the U.S. Geological Survey.

Quadrangle Evaluation (BFEC)

Durango Quadrangle

- Start Date: 3 October 1977
- Completion Date: 21 January 1980

Montrose Quadrangle

- Start Date: 3 October 1977
- Completion Date: 21 December 1979

These quadrangles contain a variety of geologic environments favorable for uranium deposits, including 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. Field work consisted of outcrop studies, examination of known occurrences, and geochemical and radiometric surveys. Remote areas were reached with the aid of helicopters. Field investigations have been completed and folios are being prepared for publication.

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

In these two quadrangles, both of which lie in the Great Plains, continental sandstones in Pennsylvanian-Permian, Triassic, and Jurassic sediments are the principal favorable environments evaluated. A major part of the work on these quadrangles consisted of analyses of subsurface information from drill holes. These studies were completed in 1979 and the folios are being prepared for publication.

Trinidad Quadrangle

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

Several potentially favorable environments for uranium are found in the Trinidad Quadrangle: Tertiary 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. Results of outcrop studies and geochemical sampling were analyzed to delineate favorable environments.

Quadrangle Evaluation (Subcontractors)

Leadville Quadrangle

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

Within the Leadville Quadrangle many environments favorable for uranium are represented, including uplifts of the Colorado Rockies, part of the Piceance Basin, and the Pennsylvanian Belden Formation. Field work consisted of outcrop studies, examination of occurrences, and geochemical and radiometric sampling.

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 four quadrangles, all in Kansas, lie along and to the west of the northern part of the Nemaha Ridge. The north-trending Nemaha Ridge, or anticline, is composed of Precambrian granitic rocks that were the source of clastic sediments deposited during Paleozoic and Mesozoic times. These sediments could contain deposits of uranium derived from granites along the Ridge. Many water wells throughout the area have a high radium content and well logs show sections of anomalous radioactivity. Because most favorable environments are expected to be subsurface, evaluation of these quadrangles was based largely on data from water wells and drill holes.

Quadrangle Evaluation (USGS)

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

In the eastern part of these quadrangles, the Denver Basin may offer favorable environments for uranium resources in Cretaceous and Tertiary fluvial and marine sandstones. In the western part, the Colorado Front Range has potentially favorable environments in vein deposits and in sandstone facies of Tertiary volcaniclastic sediments.

Geochemical data, together with stratigraphic and radiometric information from outcrop and drill holes, were analyzed this year and final reports are in preparation.

Vernal Quadrangle

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

Craig Quadrangle

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

Located in these quadrangles are North Park Basin, Sand Wash Basin, and parts of the Piceance and Uinta Basins. Uplifts include part of the Front Range, the Gore Range, and Uinta Mountains. Geologic environments being evaluated for uranium favorability are primarily Cretaceous and Tertiary sandstones. These evaluations are based on geochemical studies and facies analyses.

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

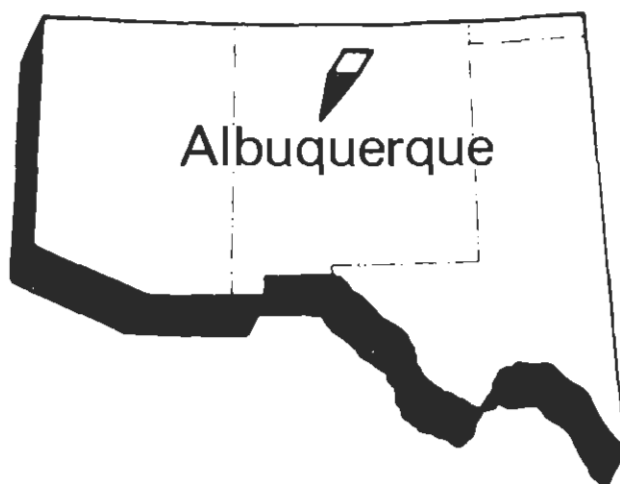
Salina Quadrangle

- 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 Permian, Triassic, and Jurassic age are the principal targets of investigations. The geochemical and stratigraphic characteristics of these sandstones are being compared to uranium host rocks in the known uranium districts.



Albuquerque Field Office

The Bendix Albuquerque field office is responsible for uranium favorability evaluations in New Mexico, most of Arizona, west Texas, and the Oklahoma Panhandle. During 1979 Bendix geologists, state agencies, the U.S. Geological Survey, and private contractors investigated 20 quadrangles in this four-state area.

Personnel in the Albuquerque office were engaged in resource evaluation of four Arizona quadrangles, as well as the Kingman Quadrangle in the Reno field office region. In a joint effort with the Texas Bureau of Economic Geology, Bendix Albuquerque geologists continued studies of three Texas quadrangles. Six quadrangles were investigated by the USGS, two by a New Mexico state agency, and two by subcontractors.

In addition, Bendix geologists from the Pittsburgh office were assigned to investigate two high-priority quadrangles in Arizona. A brief description of their work in the Grand Canyon and Marble Canyon Quadrangles is contained in the Pittsburgh office section of this report.

Quadrangle Evaluation (BFEC)

Kingman Quadrangle

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

Williams Quadrangle

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

Prescott Quadrangle

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

In these three quadrangles that lie within the Basin and Range Province, Tertiary basins alternate with fault-block mountains. Precambrian crystallines, Paleozoic sediments, Cretaceous granites, and Tertiary volcanics are exposed in the mountains. Part of the Williams Quadrangle also lies within the Colorado Plateau Province, with broad exposures of gently dipping Permian rocks. The prime focus of uranium resource evaluation has been on the Tertiary lake sediments in the basins; other possible favorable environments investigated are vein systems in the Precambrian, collapse structures in Paleozoic limestones, and Quaternary calcretes in the basins. Evaluation of the basins was based primarily on the study of outcrops and of available drill-hole data. Work was completed in 1979 and folios are being prepared for publication.

Mesa Quadrangle

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

In this quadrangle, which lies partly in the Basin and Range Province and partly in the Colorado Plateau Province, units being investigated for uranium favorability include the Precambrian Dripping Spring Quartzite, Pennsylvanian and Permian sandstones, and Tertiary lake sediments. In the 1950s some uranium was produced from the Dripping Spring Quartzite. Field work this year consisted of geochemical sampling and study of outcrops and known occurrences.

St. Johns Quadrangle

- Start Date: 2 October 1978
- Completion Date: 1 March 1980

Investigation of uranium favorability in this quadrangle concentrated on fluvial clastic sediments in the Triassic Chinle Formation and in the Tertiary Baca Formation, and on marine and marginal-marine sandstones of the

Cretaceous Mesaverde Group. These units are known to contain occurrences of uranium in anomalous quantities. Evaluation of fluvial and marginal-marine sediments was based on facies analyses of surface exposures and drill-hole lithologic information.

Marfa Quadrangle

Presidio Quadrangle

Emory Peak Quadrangle

- Subcontractor: Texas Bureau of Economic Geology
- Subcontract Value: \$171,000
- Start Date: 15 August 1978
- Completion Date: 15 February 1980

These quadrangles, along the Mexico-U.S. border in the Big Bend region of Texas, are being investigated jointly by the Texas Bureau of Economic Geology and the Bendix Albuquerque field office. Geologists of the Bureau of Economic Geology are studying Tertiary volcanic and volcanoclastic rocks and Tertiary-Quaternary bolson-fill deposits. Bendix geologists are evaluating the uranium favorability of Paleozoic, Mesozoic, and Tertiary sediments and of Tertiary igneous intrusives in Cretaceous sediments. Geochemical, radiometric, and stratigraphic information is being analyzed.

Quadrangle Evaluation (Subcontractors)

Raton Quadrangle

- Subcontractor: New Mexico Bureau of Mines and 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 and Mineral Resources
- Subcontract Value: \$191,000
- Start Date: 1 March 1978
- Completion Date: 31 January 1980

These quadrangles may contain environments favorable for uranium deposits in the Precambrian crystalline and Permian arkosic rocks of the Sangre de Cristo Range in the Southern Rocky Mountains Province and in Mesozoic sandstones of the Great Plains. Intensive field studies included radiometric and geochemical sampling surveys.

Dalhart Quadrangle

- Subcontractor: Consulting Professionals, Inc.
- Subcontract Value: \$146,700
- Start Date: 1 February 1978
- Completion Date: 29 February 1980

In this Great Plains quadrangle, geologic environments that may be favorable for uranium deposits are fluvial and marginal-marine sandstones of Triassic, Jurassic, and Cretaceous age. Evaluation of these sandstones was based on both subsurface and surface information.

Tularosa Quadrangle

- Subcontractor: Berge Exploration, Inc.
- Subcontract Value: \$187,000
- Start Date: 1 March 1978
- Completion Date: 7 March 1980

This quadrangle in the Basin and Range Province contains potentially favorable geologic environments that 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. Results of outcrop studies and geochemical sampling were used to evaluate these potentially favorable environments.

Quadrangle Evaluation (USGS)

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

Almost all of the San Juan Basin lies within these four quadrangles in the Colorado Plateau Province. The major uranium deposits of the Grants Mineral Belt occur in the Jurassic sandstones on the south flank of the basin. The Jurassic units are exposed in the Defiance, Zuni, and Nacimiento uplifts that bound the basin. Stratigraphic and geochemical information was used to locate new favorable areas in this well-known uranium-producing basin.

Flagstaff Quadrangle

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

Part of the Black Mesa Basin, with broad exposures of Triassic and Permian rocks on its

southwest flank, is contained in this quadrangle in the Colorado Plateau Province. Permian, Triassic, Jurassic, and Cretaceous sedimentary formations are the environments potentially favorable for uranium deposits. Stratigraphic information from drill holes and outcrops was used to evaluate rocks in this quadrangle.

Socorro Quadrangle

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

In this quadrangle, which is bisected by the Rio Grande trench, sandstones of Permian, Triassic, and Tertiary age are the principal favorable environments. The geochemical and stratigraphic character of these sandstones was intensively studied.



Austin Field Office

The Austin field office is responsible for uranium favorability evaluations in a region that comprises Arkansas, Louisiana, and Mississippi; central and eastern Texas; all of Oklahoma except the Panhandle; western Tennessee; and minor portions of southern Missouri and southwestern Kentucky. During 1979 Bendix geologists in the Austin office conducted studies in eight quadrangles, completing the investigation

of three. The final report for one of these, the Plainview Quadrangle, was placed on open file in March. Designated GJQ-001(79), it is the first folio to be published for the NURE program. State surveys continued work on seven quadrangles and subcontractors worked on five.

Quadrangle Evaluation (BFEC)

Plainview Quadrangle

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

In this High Plains quadrangle, units investigated for uranium favorability include the Permo-Pennsylvanian granite wash and associated clastics, whose source was the Wichita Mountains to the northeast; the Triassic Dockum Group, which is considered equivalent to the Chinle Formation of the Colorado Plateau; the Pliocene Ogallala Formation, which may contain calcrete-type deposits; and the Pleistocene Tule Formation. Uranium deposits are known in the Dockum Group, and radioactive anomalies occur in the Permo-Pennsylvanian units and in the Ogallala Formation. Work has been completed on this quadrangle and the final report, GJQ-001(79), was published in March 1979.

Seguin Quadrangle

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

Crystal City Quadrangle

- Start Date: 1 November 1977
- Completion Date: 30 July 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 April 1980

Beaumont Quadrangle

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

San Antonio Quadrangle

- Start Date: 1 August 1979
- Completion Date: 31 May 1981

Sediments ranging from Cretaceous to Recent underlie these seven quadrangles in the Texas Coastal Plain. Older rocks are in the north and west, younger rocks in the south and east along the coast. Uranium deposits in the south Texas uranium district occur in formations of Miocene

age. Eocene units in this area are also being investigated for uranium favorability. Electric logs are being examined to determine the lithologic characteristics of the various rock units. Samples have been collected from outcrops of known uranium producing units. Work was completed on the Seguin and Crystal City Quadrangles. Field work was completed on all other quadrangles except San Antonio, which was started late in the year.

An open-file report on the Catahoula Formation, GJBX-131(79), was released in October 1979. It describes detailed geochemical and hydrologic characteristics of uranium deposits in this formation.

Quadrangle Evaluation (Subcontractors)

Palestine Quadrangle

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

This quadrangle in the Texas Coastal Plain is underlain by sediments ranging in age from Cretaceous to Recent. Faulting may be significant to the localization of uranium deposits. Lithology of the various rock units was investigated using both electric-log studies and field examinations. Field work was completed in December.

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 two quadrangles in the Texas High Plains are underlain by sedimentary rocks of Pennsylvanian to Pleistocene age. As in the Plainview Quadrangle, targets for uranium favorability investigations are the Permo-Pennsylvanian granite wash and associated clastics, the Triassic Dockum Group, the Pliocene Ogallala Formation, and the Pleistocene Tule Formation. Bureau personnel examined electric logs and did field work during the year. Field work was completed in December.

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

Pennsylvanian and Permian sediments, including granite wash from the Wichita-Arbuckle Mountains, are targets for uranium resource evaluation in both these quadrangles. Granites in the Wichita-Arbuckle structure constitute an adequate source of uranium and the coarser clastics may form a suitable host for uranium deposits. Both field work and subsurface geologic studies were required in these quadrangles. Data gathering was completed in December.

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 two quadrangles in Oklahoma and Texas lie on the north flank of the Wichita-Arbuckle Mountain structure and in the Anadarko Basin. The units being investigated for uranium favorability are 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 be related to uranium deposits. Outcrops were examined and samples were collected and analyzed during the year.

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

The Clinton and Enid Quadrangles lie across the southern end of the north-trending Nemaha Ridge; the Joplin Quadrangle overlies part of the eastern flank of the Ridge. The Nemaha Ridge, or anticline, consists of Precambrian granitic rocks that were the source for sediments deposited during Paleozoic and Mesozoic time. These sediments may contain uranium derived from the Nemaha granites. Many water wells in the area contain high amounts of radium and some well logs show anomalous radioactivity. Well logs were studied during the year and field work was conducted.

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, which include parts of Missouri, Tennessee, and Kentucky, are underlain by the Ozark Uplift, Nashville Dome, and Mississippi Embayment. Primary targets for uranium resource evaluation are carbonatites and the granites and pegmatites of the basement. Base metals have been mined for many years from the basement rocks and the overlying Paleozoic limestones and dolomites. Secondary targets for uranium investigation are the Cretaceous and younger sediments of the Mississippi Embayment, which may have favorable environments similar to those of the Texas Coastal Plain. Geologic cross sections, which will be important on these projects, were constructed during the year. Field work included logging of a number of water wells.



Atlanta Field Office

The Bendix Atlanta field office is responsible for uranium favorability evaluations in North Carolina, South Carolina, Georgia, Alabama, and Florida; central and eastern Tennessee; and the southern parts of Kentucky, Virginia, and West Virginia. In 1979 Bendix geologists completed their investigations of three quadrangles and began literature search on a fourth, prior to full-scale field work during the 1980 field season. In addition, several Bendix Atlanta geologists were assigned to investigate the high-priority Dickinson and Lemmon Quadrangles in the Casper field office region. Subcontracted work continued on one quadrangle.

Quadrangle Evaluation (BFEC)

Athens Quadrangle

- Start Date: 18 November 1977
- Completion Date: 1 January 1979

Spartanburg Quadrangle

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

Greensboro Quadrangle

- Start Date: 19 October 1977
- Completion Date: 1 August 1979

The Piedmont Province, which includes the greater part of these quadrangles, is composed of Precambrian and Lower Paleozoic metasediments intruded by various granitic plutons. These plutons are the major targets for uranium resource investigations. Other potentially favorable environments for uranium deposits are the Danville, Durham, and Sanford Triassic basins, which underlie parts of the Greensboro and Spartanburg Quadrangles. Field work consisted of data gathering and sample collection. One radon emission survey was performed. Work on these quadrangles was completed in 1979 and folios are now in preparation.

Raleigh Quadrangle

- Start Date: 1 November 1979
- Completion Date: 31 October 1981

Triassic rocks in the Wadesboro Basin constitute the predominant target for uranium resource evaluation in this quadrangle. Other targets include Paleozoic granites and possible roll-type deposits in the Coastal Plain. Work in 1979 consisted of a literature survey in preparation for the 1980 field season.

Dickinson Quadrangle

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

Lemmon Quadrangle

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

Uranium resource evaluation of these two quadrangles in North and South Dakota was conducted by geologists of the Bendix Atlanta field office. Both quadrangles are underlain by Cretaceous and Paleocene siltstones, sandstones, and lignites. Uranium deposits are known in sandstones and lignites; uranium has been produced commercially from lignites in the vicinity of Belfield, North Dakota. Field investigations consisted of outcrop examination and sample collection and included 2,500 miles (4,023 kilometers) of car-borne scintillometer traverses. Field work was completed during 1979 and electric log study and folio compilation have begun.

Quadrangle Evaluation (Subcontractor)

Augusta Quadrangle

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

Ninety-five percent of this quadrangle lies in the Coastal Plain, with the northwestern five percent in the Piedmont Province. In the Coastal Plain, roll-front uranium deposits may occur in Cretaceous sediments; in the Piedmont, Paleozoic fault zones and associated crystalline rocks are being investigated for uranium favorability. Field work consisting of outcrop examination, sample collection, and emanometry surveys was completed in 1979.



Pittsburgh Field Office

Uranium resource evaluations in the entire northeastern section of the United States are the responsibility of the Pittsburgh field office. In 1979 Bendix geologists completed the investigation of three quadrangles in the Pennsylvania-New York-New Jersey area and a subcontractor continued work on two quadrangles in New England. In addition, geologists from the Pittsburgh office conducted uranium favorability studies in three high-priority quadrangles in the western United States: Pittsburgh personnel worked on the Hot Springs Quadrangle in the Casper field region, and on the Marble Canyon and Grand Canyon Quadrangles in the Albuquerque region.

Quadrangle Evaluation (BFEC)

Harrisburg Quadrangle

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

Scranton Quadrangle

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

Williamsport Quadrangle

- Start Date: 1 November 1977
- Completion Date: 31 December 1979

Targets for uranium investigation in these three quadrangles are the Catskill Formation and the Mauch Chunk Formation, which have long been

Working in the Hot Springs Quadrangle near Pringle, South Dakota Bendix geologists examine an outcrop at a radiometric anomaly found by detailed aerial survey.



known to contain significant uranium deposits, and Precambrian metamorphics of the Reading Prong. All geologic units were investigated, outcrops examined, and samples collected for petrologic and chemical analysis. Electric logs were used for interpretation of geologic conditions in the Williamsport Quadrangle. Field studies were completed during 1979 and folio compilation has begun.

Hot Springs Quadrangle

- Start Date: 20 November 1978
- Completion Date: 31 May 1980

Upper Cretaceous and Lower Tertiary sediments underlie most of this Dakota Badlands quadrangle. The Black Hills—intrusive crystallines surrounded by Paleozoic and Mesozoic sediments—are in the northwest quarter. The Edgemont, South Dakota uranium district, which was active in the 1950s, is also in this quadrangle. Resource evaluation has been assigned to geologists from the Bendix Pittsburgh office who examined outcrops in all parts of the project area

and collected samples for petrologic and chemical analysis. A helicopter was used for a radiometric reconnaissance of the intrusive rocks. Field work was completed during 1979 and folio compilation has begun.

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

In these two high-priority quadrangles in Arizona, environments being assessed by Bendix Pittsburgh geologists are primarily in Paleozoic and Mesozoic sediments that are known host rocks for a number of deposits, some of which have had major production. Field investigations consisted of outcrop examination and sample collection for petrologic and chemical analysis. A helicopter was used for radiometric survey of areas thought to be favorable for the occurrence

of uranium deposits and for access to remote areas. Field work was completed during 1979 and folio compilation has begun.

Quadrangle Evaluation (Subcontractors)

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



Anchorage Field Office

The area of responsibility of the Anchorage field office is the entire state of Alaska. During 1979 Bendix geologists conducted uranium favorability investigations of two quadrangles and served as monitors for subcontracted investigations of eight additional quadrangles.

Quadrangle Evaluation (BFEC)

Dixon Entrance Quadrangle

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

In this quadrangle, uranium has been mined 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 uranium occurrences. Field investigations were finished in the summer. Data were compiled and evaluated by year's end and the final report of results is near completion.

Kenai Quadrangle

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

In these two quadrangles, which include portions of New York, Vermont, New Hampshire, and Maine, the underlying rocks 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. Plutons in New Hampshire and Maine are known to contain radioactive dikes and areas of radioactive country rock. Other possible favorable environments being investigated are Lower Paleozoic sediments, where the uranium source may have been fluids from the underlying plutons. The subcontractor's field crews examined outcrops and collected samples for petrologic and chemical analysis.

Land areas in the Kenai Quadrangle lie on opposite sides of Cook Inlet. The focus of the investigation is on Mesozoic plutonic and volcanogenic rocks in the Alaska-Aleutian Range and on continental sedimentary deposits that make up the Tertiary Kenai Group. Preliminary field investigations were completed during the summer and followup work will begin early in 1980.

Quadrangle Evaluation (Subcontractors)

Mt. McKinley Quadrangle

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

Talkeetna Quadrangle

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

Tyonek Quadrangle

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

Lime Hills Quadrangle

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

These quadrangles encompass part of the southern Alaska Range and adjoining lowlands, including the northern part of Cook Inlet. Targets that appear to be favorable for uranium are granitic plutons, felsic volcanogenic rocks, fluvial sandstones, and schists. Final folios and resource evaluation were completed by mid 1979 on these four quadrangles.

Circle Quadrangle

- Subcontractor: C. C. Hawley & Associates, Inc.
- Subcontract Value: \$219,624
- Start Date: 14 May 1979
- Completion Date: 31 May 1980

Charley River Quadrangle

- Subcontractor: C. C. Hawley & Associates, Inc.
- Subcontract Value: \$219,624
- Start Date: 14 May 1979
- Completion Date: 31 May 1980

Black River Quadrangle

- Subcontractor: C. C. Hawley & Associates, Inc.
- Subcontract Value: \$219,624
- Start Date: 14 May 1979
- Completion Date: 31 May 1980

Coleen Quadrangle

- Subcontractor: C. C. Hawley & Associates, Inc.
- Subcontract Value: \$219,624
- Start Date: 14 May 1979
- Completion Date: 31 May 1980

These four quadrangles are in the upper Yukon area of Alaska near the Canadian Border. Granitic plutons of Tertiary age, which are best exposed in the Circle Quadrangle and with which an important uranium deposit is associated in the adjacent Livengood Quadrangle, are the principal rocks under investigation. Additional targets include granitic plutons of Precambrian and Paleozoic ages, sedimentary rocks of Paleozoic and Cenozoic ages, and unconformities found in the Paleozoic-Cenozoic sedimentary sequence. Field investigations were completed in September, compilation and interpretation of results were finished at the end of the year, and report preparation is in progress.

Quadrangle Assessment

Quadrangle assessment uses the results of geologic evaluation to determine the potential uranium resources of each favorable area in

terms of estimated tons and average grade of U_3O_8 . The NURE program imposes two assessment requirements: estimation of the uranium endowment and estimation of the potential uranium resources of a favorable area. The endowment is the total quantity of uranium postulated to exist in concentrations exceeding 100 ppm U_3O_8 . Potential uranium resources are those portions of the endowment estimated to be recoverable at selected forward costs, presently established at \$30, \$50, and \$100 per pound of U_3O_8 .

The resource assessment methodology employed by Bendix requires comparison of areas to be assessed with control areas that have known mineralization, usually producing uranium districts. Estimation of endowment is accomplished by analogy: the favorable area is assumed to contain the same quantity of uranium per unit area, volume, or length as does the control area, subject to modification by factors provided by the field geologist. The potential resources are determined by assuming that the favorable area has the same grade-tonnage distribution as the control area.

A classification of uranium deposits provides the framework for selecting control areas and making comparisons. Consistency and uniformity in geologic interpretation are essential. Preliminary report GJBX-32(79), *Preliminary Recognition Criteria for Uranium Occurrences; A Field Guide* was issued in 1979. This document is a consolidation of GJBX-63(78) and GJBX-67(78). It provides a checklist of the types of information essential to the complete description of favorable environments, and is intended to help the field geologists make standardized classification assignments by comparing the characteristics of favorable areas with those of known uranium-producing areas.

Bendix performs the quadrangle assessments, except for those areas involving company-confidential information; these are assessed by DOE geologists. Final products of the assessments will be released in future NURE reports.

During 1979 assessments were completed for 26 quadrangles. Of these, 18 were part of the 116 quadrangles designated as high priority. These 18 are Athens, Crystal City, Greensboro, Kingman, La Junta, Lamar, Lime Hills, Mt. McKinley, Plainview, Prescott, Sandpoint, Scranton, Seguin, Spartanburg, Spokane, Talkeetna, Tyonek, and Williams. Eight quadrangles from the Seward-

Selawik Peninsula of Alaska were also assessed: Bendeleben, Candle, Kotzebue, Nome, Selawik, Shishmaref, Solomon, and Teller.

NURE Geostatistical Evaluation Study

- Subcontractor: Terradata
- Subcontract Value: \$70,633
- Start Date: 18 July 1979
- Completion Date: 4 January 1980

This geostatistical consulting firm is examining the current assessment methodology from a statistical viewpoint and has made recommendations for minor modifications. An in-depth study of control-area parameters is in progress to provide a population data set for control areas.

Improved Appraisal System for U_3O_8 Endowment

- Subcontractor: University of Arizona
- Subcontract Value: \$288,813
- Start Date: 18 January 1977
- Completion Date: 29 February 1980

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.

The appraisal system is in the final stages of development and is currently undergoing testing.

Work Statement for Preparation of Uranium Deposit Occurrence Models

- Subcontractor: Samuel S. Adams & Associates
- Subcontract Value: \$354,700
- Start Date: 2 April 1979
- Completion Date: 30 September 1980

The objective of this project is to develop descriptive models of six major types of uranium deposits and to provide professional geologic services related to occurrence models and resource assessment methodology.

The subcontractor will develop geologic models for each of the following types of uranium deposits: (1) sandstone—epigenetic carbonaceous material exemplified by the "primary" deposits of the Morrison Formation, San Juan Basin, New Mexico; (2) sandstone—roll front exemplified by the deposits of the Gas Hills, Shirley Basin, and Powder River Basin districts; (3) sandstone—detrital carbonaceous material exemplified by deposits in the Salt Wash Member of the Morrison Formation and in the

Date Creek district, western Arizona; (4) sandstone—gaseous reductants exemplified by the deposits of the Texas Coastal Plain; (5) quartz-pebble conglomerates exemplified by the Blind River, Canada, and the Witwatersrand, South Africa districts; and (6) unconformity-related vein deposits exemplified by the Athabaska, Saskatchewan, and Alligator Rivers, Australia districts.

Related to the prime objective of providing models of six types of uranium occurrences is an additional requirement for professional geological services by the principal investigator. These additional services will serve to fully coordinate the modeling concepts with the USGS (Denver, Colorado and Reston, Virginia), DOE-Bendix (Grand Junction, Colorado), and with Dr. DeVerle Harris, University of Arizona (Tucson, Arizona) for validation work on the San Juan Basin model.

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.

Supply Analysis System

- Subcontractor: Dames & Moore
- Subcontract Value: \$783,770
- Start Date: 20 February 1979
- Completion Date: 13 May 1980

Under this contract, Dames and Moore, along with its subcontractors International Energy Associates and Colorado School of Mines, will develop an integrated computerized system for long-term analysis of domestic U_3O_8 supply. This system will be used by DOE to rapidly evaluate thousands of mineral properties, to allocate resources to more and larger production centers than presently exist, to schedule multilevel production plans, and to perform functional economic analyses.

The system is needed to facilitate frequent and reliable responses to new U_3O_8 demand projections as impacted by updated ore reserve and potential resource estimates, changes in the economic climate, and evolving environmental and institutional constraints.

Aerial Radiometric Reconnaissance and Detail Surveys

The Aerial Radiometric Reconnaissance program has two 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 fly about 1.24 million flight-line miles (2 million flight-line kilometers) with line spacing ranging from 1 to 12 miles (1.6 to 19.3 kilometers).

The Aerial Radiometric Reconnaissance program was initiated in 1974 and funded in 1975 at a level of \$1 million. In 1979 the reconnaissance and detail program expanded to an \$8-million effort.

At the end of 1979 more than 780,000 line miles (1,255,000 kilometers) of reconnaissance survey and 70,000 line miles (112,700 kilometers) of detail survey have been completed; this represents nearly two-thirds of the flying portion of

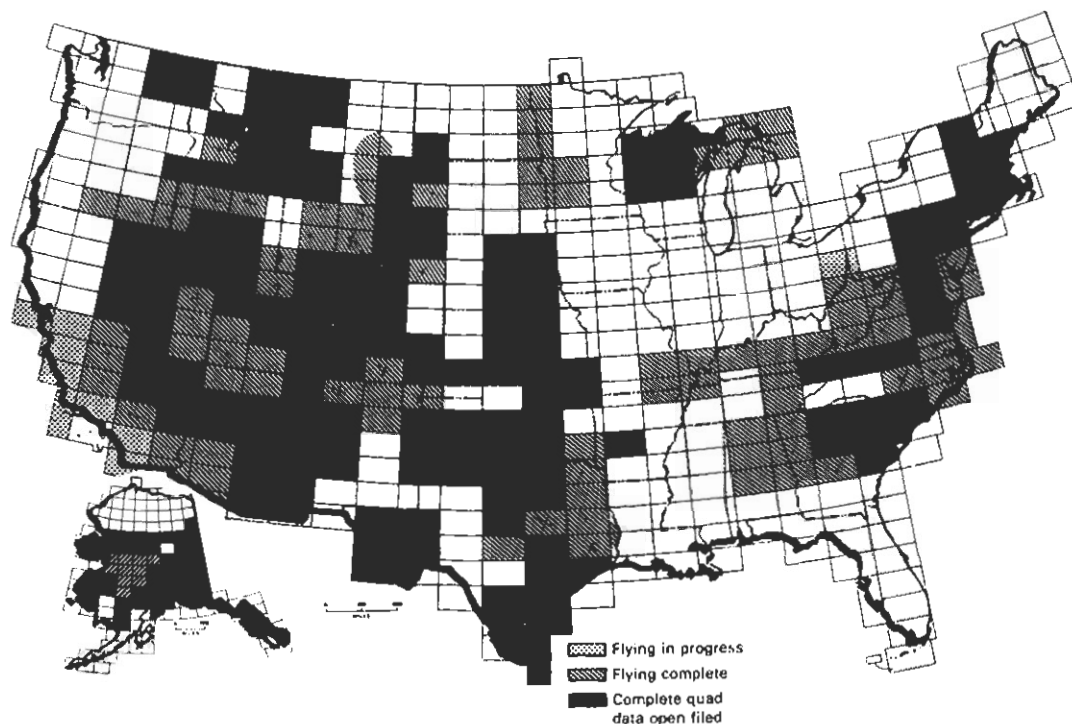
the aerial reconnaissance program. The map presented below shows the areas completed and in progress.

In 1979 contracts were signed for 11 projects and 58 GJBX reports on 112 quadrangles were open filed. Approximately 190,000 line miles (306,000 kilometers) were flown during 1979 in reconnaissance surveys.

A program, to perform detail surveys with line spacing as close as 1/4 mile (0.40 kilometer) that began in 1978, was continued. Detail surveys were carried out in nine areas which were selected on the basis of favorable geology, known occurrences, or other selective criteria. Approximately 48,000 line miles (77,000 kilometers) of detail surveys were completed. One detail survey, the Gillette project, was open filed as GJBX-112(79).

During 1979 seven rotary-wing and three fixed-wing systems, belonging to seven different sub-contractors, were used in the aerial radiometric surveys. To ensure that each airborne system

STATUS OF THE AERIAL RADIOMETRIC RECONNAISSANCE SURVEYS





All the detail survey flying completed during 1979 used helicopters.

and resulting reduced data met surveying specifications, a system qualification program that began in 1977 continued. 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.

A program of magnetic data tape quality control began in 1979. This program requires all subcontractors to submit data tapes which contain radiometric and magnetic data in a common format and to analyze the tapes for correctness and completeness.

Northeast Washington/McDermitt Rotary-Wing/Detail Survey

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: \$1,098,000
- Start Date: 25 July 1979
- Completion Date: 19 July 1980
- Line Miles: 21,127 (33,994 kilometers)
- Aircraft: Sikorsky S-58T

On September 1, 1979 flying began on a 9,105 line-mile (14,650 kilometer) detail survey covering eight areas near Spokane, Washington; flying was completed on November 14, 1979. On November 16, 1979 flying began on the McDermitt/Steens Mountain 13,170-mile (21,191 kilometer) survey in Nevada and Oregon and is scheduled to be completed early in 1980.

Northeast Washington Rotary-Wing Survey

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: \$652,731
- Start Date: 10 August 1977
- Completion Date: 31 January 1979
- Line Miles: 14,754 (23,739 kilometers)
- Aircraft: Sikorsky S-58T

Flying on this survey was conducted between August 10, 1977 and October 3, 1977. An open-file report for the Spokane Quadrangle was released in 1978. The Okanogan and Sandpoint reports were released as GJBX-142(79).

Sweetgrass Rotary-Wing/Fixed-Wing Survey

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: \$945,054
- Start Date: 20 June 1978
- Completion Date: 3 October 1979
- Line Miles: 29,210 (46,999 kilometers)
- Aircraft: Sikorsky S-58T and DC-3

The Sweetgrass survey was described in last year's report. Flying on this survey was conducted between July 31, 1978 and September 28, 1978. Areas covered by this survey are Shelby, Great Falls, Lewistown, Butte, Choteau, Havre, and Cut Bank Quadrangles in Montana; Twin Falls and Pocatello Quadrangles in Idaho; Ritzville Quadrangle in Washington; Hot Springs

Quadrangle in South Dakota; and St. Johns Quadrangle in Arizona and New Mexico. Open-file reports for these quadrangles were released as GJBX-126(79).

Idaho Rotary-Wing Airborne Survey

- Subcontractor: geoMetrics, Inc.
- Subcontract Value: \$581,000
- Start Date: 13 June 1979
- Completion Date: 8 April 1980
- Line Miles: 20,325 (32,723 kilometers)
- Aircraft: Lama

Flying began on July 4, 1979 and was completed October 8, 1979.

Areas covered by this survey were the Boise, Hailey, Idaho Falls, Rapid City, Elk City, Salt Lake City, and Ogden Quadrangles.

The Boise, Hailey, Idaho Falls, and Elk City Quadrangles will be open filed early in 1980; and open filing of the Rapid City, Salt Lake City, and Ogden Quadrangles will follow later in 1980.

Reno/Snake River Basin Rotary-Wing Survey

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

The subcontractor for this survey was a joint venture between High Life Helicopters, Inc., and Geodata International, Inc. The subcontract was handled by DOE/Small Business Administration (SBA), with technical monitoring by Bendix.

Twenty-seven quadrangles were flown; four open filed in 1978, twenty in 1979, and the remaining three will be open filed in 1980. The 20 quadrangles open filed in 1979 were: Winnemucca as GJBX-21(79); Goldfield as GJBX-66(79); Tularosa as GJBX-67(79); Tonopah as GJBX-104(79); Needles as GJBX-114(79); Little Rock as GJBX-115(79); Price as GJBX-117(79); Tooele as GJBX-118(79); Brigham City as GJBX-124(79); Vya as GJBX-136(79); Wells as GJBX-137(79); Millett as GJBX-154(79); Challis as GJBX-156(79); Elko as GJBX-159(79); Richfield as GJBX-161(79); Socorro as GJBX-163(79); Death Valley as GJBX-164(79); Vernal as GJBX-167(79); McDermitt as GJBX-168(79); and McAlester as GJBX-174(79).

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: 66,069 (106,306 kilometers)
- Aircraft: Lama

This project is in the fourth year of a DOE/SBA contract with technical monitoring by Bendix.

The areas assigned in 1979 are for reconnaissance surveys on the Gadsden, Birmingham, Ely, Lund, Mariposa, Fresno, Bakersfield, San Jose, San Francisco, Santa Cruz, San Luis Obispo, San Bernardino, Los Angeles, Santa Maria, Santa Ana, and San Diego Quadrangles, totaling 38,666 miles (62,226 kilometers) of reconnaissance flying. Detailed surveys were assigned for parts of the Prescott, Marfa, Presidio, Fort Stockton, Sonora, Del Rio, Marble Canyon, Escalante, Flagstaff, Durango, and Rawlins Quadrangles, totaling 27,403 line miles (44,100 kilometers).

Data for Gadsden and Birmingham will be open filed in early 1980 and data for the remaining areas will be open filed at intervals during 1980.

Marysvale Rotary-Wing Survey

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

Flying on the Marysvale detail survey in the Richfield Quadrangle, Utah began in October 1978, terminated in November 1978 due to snow in the survey area, and was completed in September 1979. Results of the survey will be open filed in 1980.

Powder River II Rotary-Wing/Fixed-Wing Survey

- Subcontractor: geoMetrics, Inc.
- Subcontract Value: \$339,000
- Start Date: 28 June 1978
- Completion Date: 1 October 1979
- Line Miles: 17,466 (28,103 kilometers)
- 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 were integrated with earlier data covering a portion of the quadrangle that were acquired by

Texas Instruments in 1975 and reported under GJO-1631-1.

Reports for Ekalaka, Gillette, and Newcastle were released as GJBX-82(79). The Casper and Torrington Quadrangles were open filed as GJBX-158(79).

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 kilometers)
- Aircraft: Lama

This survey was described in the 1978 report and covers the Bear Lodge Mountains over portions of the Devil's Tower, Alva, Nefsy, and Sundance 15-minute Quadrangles in northeastern Wyoming. A 1/4-mile (0.40 kilometer) grid, both north-south and east-west, was flown between August 12, 1978 and August 22, 1978. This report was released as GJBX-112(79).

Minnesota Fixed-Wing Survey

- Subcontractor: geoMetrics, Inc.
- Subcontract Value: \$283,000
- Start Date: 7 May 1979
- Completion Date: 3 March 1980
- Line Miles: 14,922 (24,024 kilometers)
- Aircraft: B-65 Queenaire

Flying began August 1, 1979 and was completed on September 22, 1979.

This survey includes the St. Cloud, New Ulm, Watertown, Sault Sainte Marie, Blind River, Escanaba, Cheboygan, Alpena, Milbank, Fargo, Grand Forks, and Thief River Falls Quadrangles in Minnesota and Michigan. The quadrangles in Minnesota are scheduled for a group release early in 1980 and the quadrangles in Michigan soon afterward.

Northern Rockies Rotary-Wing Survey

- Subcontractor: High Life Helicopters, Inc.
- Subcontract Value: \$336,500
- Start Date: 23 June 1978
- Completion Date: 22 August 1979
- Line Miles: 13,370 (21,512 kilometers)
- 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. The Bozeman Quadrangle was released as GJBX-81(79); Billings Quadrangle as GJBX-87(79); White Sulphur Springs Quadrangle as GJBX-96(79); Dillon Quadrangle as

GJBX-107(79); and the Hamilton Quadrangle as GJBX-119(79). Previous coverage of this survey appeared in the 1978 report.

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 kilometers)
- Aircraft: Sikorsky S-58T

Flying was completed on the Yellowstone project in November 1978 and it was reported in the 1978 report. The Cody Quadrangle was open filed as GJBX-105(79); the Ashton Quadrangle as GJBX-106(79); the Durango Quadrangle as GJBX-143(79); and the Dubois Quadrangle as GJBX-155(79).

Uncompahgre Rotary-Wing Survey

- Subcontractor: geoMetrics, Inc.
- Subcontract Value: \$473,921
- Start Date: 28 June 1978
- Completion Date: 12 February 1979
- Line Miles: 13,369 (21,511 kilometers)
- Aircraft: Lama

The Uncompahgre survey was flown during the summer of 1978 and covered the Leadville, Montrose, Moab, and Salina Quadrangles as was reported in the 1978 report. The results of this survey were open filed as GJBX-95(79).

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 kilometers)
- Aircraft: Lama

The Montrose detail survey consists of five separate areas in the Montrose Quadrangle. Flying was completed in the summer of 1978 and final reports are scheduled for open filing in 1980.

Trinidad Project

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: \$155,915
- Start Date: 19 October 1978
- Completion Date: 15 December 1979
- Line Miles: 3,212 (5,168 kilometers)
- Aircraft: Sikorsky S-58T

This survey, reported on last year, covers the Trinidad Quadrangle in Colorado. Flying on this quadrangle began on October 21, 1978 and was temporarily halted due to weather on November 30, 1978 after completing 80 percent of the area.

Flying was resumed on August 27, 1979 and completed on August 30, 1979. An open-file report for this quadrangle will be released in 1980.

Brushy Basin Rotary-Wing Survey

- Subcontractor: High Life Helicopters, Inc.
- Subcontract Value: \$115,523
- Start Date: 7 September 1978
- Completion Date: 30 March 1979
- Line Miles: 3,310 (5,326 kilometers)
- Aircraft: Lama

As reported in 1978 this detail survey was flown at 1/4-mile (0.40 kilometer) 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 Swell in the Price and Salina Quadrangles in Utah. Flying was completed in October 1978; however, due to changes in the contract it will not be open filed until 1980.

Durango Detail Rotary-Wing Survey

- Subcontractor: Litton Aero Service Corp.
- Subcontract Value: \$28,000
- Start Date: 23 June 1978
- Completion Date: 9 May 1979
- Line Miles: 703 (1,125 kilometers)
- Aircraft: Sikorsky S-58T

This survey was reported in the 1978 report. It originally consisted of four areas in the Durango Quadrangle to be flown at 1/4-mile (0.40 kilometer) line spacing; only one area was flown in 1978 before snow forced termination of the survey. Results of the survey for the one area completed will be open filed in early 1980. (The remaining three areas were flown in 1979 by High Life Helicopters, Inc. under contract "High Life/SBA Rotary-Wing Survey" [see p. 35].)

Rocky Mountains Rotary-Wing Survey

- Subcontractor: Geodata International, Inc.
- Subcontract Value: \$577,627
- Start Date: 13 June 1979
- Completion Date: 8 May 1980
- Line Miles: 19,983 (32,153 kilometers)
- Aircraft: Lama

The Rocky Mountains rotary-wing survey consists of Aztec, Cedar City, Jordan Valley, Adel, Thermopolis, Lander, and Arminto Quadrangles. Flying was completed in 1979 and the final reports are scheduled to be open filed in 1980.

Raton Basin Rotary-Wing/ Fixed-Wing Survey

- Subcontractor: geoMetrics, Inc.
- Subcontract Value: \$485,000
- Start Date: 28 June 1978
- Completion Date: 18 January 1980
- Line Miles: 15,995 (25,736 kilometers)
- Aircraft: Lama and Grumman S-2

This survey covers the Albuquerque, Shiprock, Gallup, Raton, Santa Fe, and Flagstaff Quadrangles in New Mexico and Arizona. Flying was conducted between October 18, 1978 and December 1, 1979.

The Albuquerque, Shiprock, and Gallup reports were released as GJBX-116(79) and Flagstaff as GJBX-157(79). Raton and Santa Fe will be open filed in 1980.

Utah/Arizona Rotary-Wing/ Fixed-Wing Survey

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: \$664,900
- Start Date: 13 October 1977
- Completion Date: 20 February 1979
- Line Miles: 13,284 (21,374 kilometers)
- Aircraft: Bell-212 and DC-3

This survey completes the 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 and was reported in the 1978 report. The new data were integrated with the previous fixed-wing data and are presented on a complete quadrangle basis. Open-file reports for the Utah/Arizona survey were released as GJBX-23(79) and GJBX-24(79).

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 kilometers)
- Aircraft: Sikorsky S-58T

As described in last year's report, flying on this subcontract began 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. Craig was open filed as GJBX-153(79); the remaining quadrangles are scheduled for open filing in 1980.

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 kilometers)
- Aircraft: DC-3

As reported in 1978 the Llano Uplift project consists of the Llano, Brownwood, Lemmon, and Dickinson Quadrangles. Flying was completed in October 1978. The Brownwood Quadrangle was open filed as GJBX-68(79); Lemmon as

GJBX-138(79); and Dickinson as GJBX-139(79). Llano will be open filed in 1980.

Texas/Kentucky Fixed-Wing Survey

- Subcontractor: Texas Instruments, Inc.
- Subcontract Value: \$350,467
- Start Date: 1 March 1979
- Completion Date: 14 February 1980
- Line Miles: 17,618 (28,348 kilometers)
- Aircraft: DC-3

Dalhart, Poplar Bluff, Dyersburg, Palestine, Beaumont, Rolla, Paducah, and Atlanta Quadrangles are covered in the Texas-Kentucky survey. Flying was completed July 30, 1979 and the final reports are scheduled for release in 1980.

Texas/Nebraska Fixed-Wing Survey

- Subcontractor: geoMetrics, Inc.
- Subcontract Value: \$226,000
- Start Date: 9 July 1979
- Completion Date: 4 May 1980
- Line Miles: 12,022 (19,355 kilometers)
- Aircraft: Queenair

This survey includes the Tyler, Texarkana, Waco, Alliance, and Scottsbluff Quadrangles in Texas and Nebraska.

Flying began on September 24, 1979 and was completed in November 1979. The report is scheduled to be open filed in 1980.

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 kilometers)
- 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, were open filed for Houston, Brownsville, and McAllen Quadrangles in 1978; the Seguin Quadrangle as GJBX-37(79); Beeville and Bay City Quadrangles as GJBX-69(79);



Helicopters are used in ground follow-up investigations of aerial survey data.

Crystal City Quadrangle as GJBX-98(79); Corpus Christi and Laredo Quadrangles as GJBX-99(79); and the Austin Quadrangle as GJBX-148(79).

Southeast United States Fixed-Wing Survey

- Subcontractor: Geodata International, Inc.
- Subcontract Value: \$454,000
- Start Date: 13 June 1979
- Completion Date: 8 May 1980
- Line Miles: 21,120 (34,003 kilometers)
- Aircraft: DC-3

Flying began on this survey on June 23, 1979 and was completed on September 18, 1979.

Quadrangles in this survey are Montgomery, Phenix City, Macon, Evansville, Winchester, Raleigh, Norfolk, Beaufort, Wilmington, Salisbury, Eastville, Manteo, and Rocky Mount. Open-file reports are scheduled for release in mid 1980.

Appalachian Basin Rotary-Wing Survey

- Subcontractor: Carson Helicopters, Inc.
- Subcontract Value: \$555,000
- Start Date: 1 June 1979
- Completion Date: 27 March 1980
- Line Miles: 19,180 (30,880 kilometers)
- Aircraft: Sikorsky S-58T

This survey consists of the Canton, Clarksburg, Cumberland, Charlottesville, Charleston, Jenkins, Roanoke, Bluefield, Corbin, Chattanooga, and Rome Quadrangles.

Flying began on September 5, 1979 and was completed on December 1, 1979. Open-file reports are scheduled for mid 1980.

Thorpe/Big Bend Rotary-Wing Survey

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: \$641,207
- Start Date: 28 October 1976
- Completion Date: 20 July 1979
- Line Miles: 19,000 (30,571 kilometers)
- Aircraft: Sikorsky S-58 and S-58T

The Thorpe portion of this study covered the Williamsport, Harrisburg, Scranton, and Newark Quadrangles in Pennsylvania, New Jersey, and New York. Flying on the Thorpe survey was conducted between November 8, 1976 and April 11, 1977.

In the Big Bend area, the survey covers the Fort Stockton, Marfa, Presidio, and Emory Peak Quadrangles in Texas. Flying on the Big Bend survey was conducted between January 13, 1978 and February 13, 1978. The Marfa, Presidio, Fort Stockton, and Emory Peak Quadrangles were open filed as GJBX-88(79).

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: 5,935 (9,551 kilometers)
- Aircraft: Sikorsky S-58T

The Reading Prong detail survey, reported in the 1978 report, was flown during September and October 1978, with 1/4-mile (0.40 kilometer) line spacing. The final report was scheduled for open filing in 1979 but additional data processing requirements have delayed the report until 1980. The detail survey area lies in the Newark and Scranton Quadrangles.

Central Alaska Rotary-Wing Survey

- Subcontractor: Litton Aero Service Corp.
- Subcontract Value: \$954,000
- Start Date: 1 June 1979
- Completion Date: 26 March 1980
- Line Miles: 13,273 (21,370 kilometers) reconnaissance and 688(1,107 kilometers) detail, total 13,961 (22,477 kilometers)
- Aircraft: Sikorsky S-58T

Flying began in early July 1979 and was completed by the end of September 1979. Ten quadrangles, Sleetmute, Iditarod, McGrath, Unalakleet, Ophir, Medfra, Norton Bay, Nulato, Ruby, and Kantishna River were flown in the reconnaissance survey; an area in the southeast corner of the Ruby Quadrangle and extending into adjacent quadrangles, called the Four Corners survey, was flown in detail with 1-mile (1.6 kilometer) line spacing.

Results of these surveys will be open filed in 1980.



Interior of a helicopter used in 1/4-mile line spacing surveys.

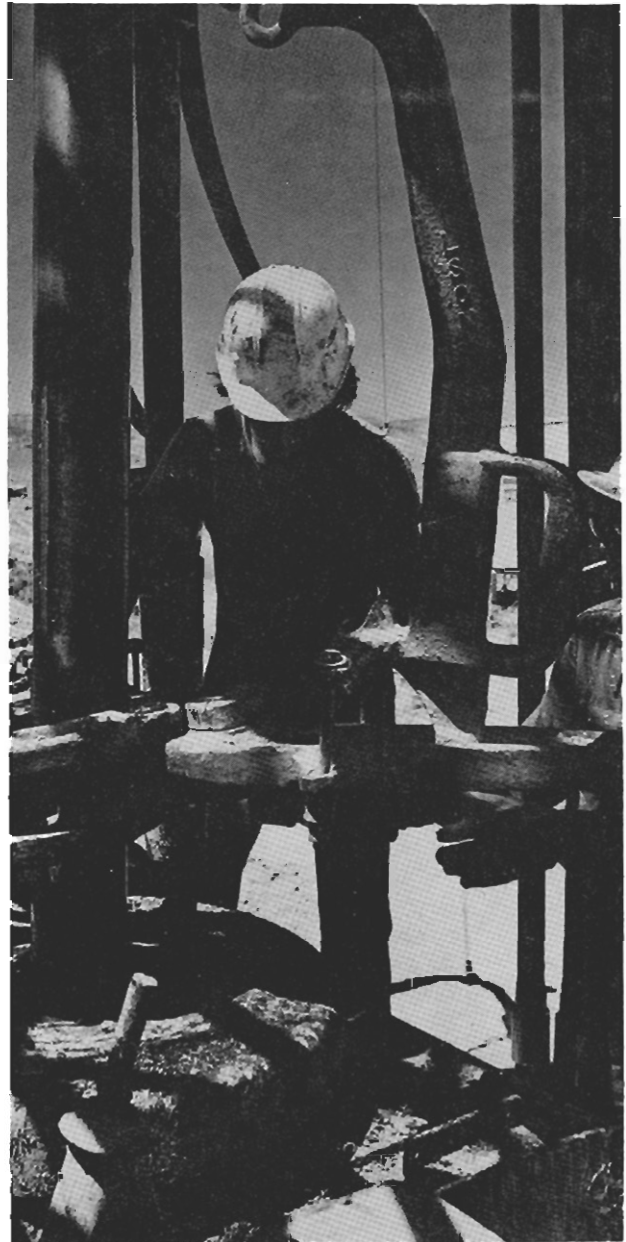
Subsurface Investigations

Subsurface geologic investigations in support of NURE are conducted throughout the United States under the direction of DOE. These investigations obtain subsurface data to reduce the uncertainty of uranium resource estimates in areas of known occurrences, or to help evaluate favorability in areas of suspected occurrences and in areas containing potentially uraniferous host rocks. Subsurface data are generated by drilling, coring, and logging formations with potential for uranium mineralization. Additional subsurface data are obtained by logging holes drilled by industry or other governmental agencies for nonuranium purposes.

Each proposed subsurface project undergoes a geologic study to determine its applicability to NURE objectives. Upon acceptance of the project a detailed drilling plan is prepared that defines all drilling and data acquisition requirements. Drilling operations are subcontracted and are directed by Bendix engineers and geologists. In-house logging operations to provide specialized downhole log data are supplemented by commercial logging. After completion of drilling operations, two reports are written: (1) the engineering report, containing a description of technical aspects of the drilling project, is submitted approximately 2 months after drilling completion, and (2) a geologic report, containing basic geological data and a preliminary evaluation of the results relative to project objectives, is completed about 3 months after the drilling is completed.

During 1979 drilling operations were undertaken for 14 projects. Five of the projects were initiated during 1978 and completed in 1979; seven projects were both initiated and completed during 1979; and drilling of two projects began in 1979 and continued in 1980. A total of 167 holes, having an aggregate total depth of 229,355 feet (69,907 meters), was drilled during 1979. Cores, having a cumulative total length of 42,042 feet (12,814 meters), were cut. Geophysical and lithological logs were obtained from all drill holes.

At the start of 1979 two downhole logging units and one surface survey unit (owned by DOE and operated by BFEC) were operational. During the year, three additional downhole logging units (all with on-board computers) were acquired and equipped with KUT (spectral gamma-ray) probes to support the various NURE projects. A total of 197 holes were logged in 1979; 88 holes



Bendix subcontracted to experienced drillers with proven equipment.

were BFEC drilled and 109 were industry drilled holes located in the various project areas. Just under 1,000,000 feet (304,800 meters) of conventional suite log data and more than 100,000 feet (30,480 meters) of select KUT sampling were performed for projects located in Texas, New Mexico, Arizona, California, Utah, Wyoming, North Dakota, South Dakota, Montana, and Washington. In addition to the in-house logging effort, a new NURE program element called the Quadrangle Logging Program was initiated in 1979 to obtain subsurface information from

holes drilled by industry for purposes other than uranium exploration. The resulting subcontracted logging aggregated 949,500 feet (289,410 meters) logged along the eastern slope of Colorado, eastern Nevada, and the San Joaquin Valley, California. Throughout the year Bendix logging personnel also provided technical support and advice to industry and other government agencies on a routine basis.

During 1979 engineering and geological reports were prepared for drilling projects completed during 1978. These included geological report GJBX-3(79) on the Red River Project in North Dakota and Minnesota; engineering report GJBX-50(79) and geological report GJBX-162(79) for the Michigan Basins Project; engineering report GJBX-103(79) on the Spor Mountain Project in Utah; and engineering report GJBX-101(79) on the East Chaco Canyon Project in New Mexico.

1979 Drilling Projects

Drilling projects completed during 1979 and the Owens Lake, California Project, still in progress, are summarized below. Further discussions of data obtained by projects are included in the Geologic Studies and Technology Applications sections of this report.

Lemhi Pass (Thorium)

- Quadrangle: Dubois
- State: Montana
- Subcontractors: Udy Core Drilling Co.
Wild Cat Drilling Service, Inc.
- Total Subcontract Value: \$115,647
- Start Date: 3 August 1978
- Completion Date: 14 September 1979
- Number of Holes: 4
- Total Feet Drilled: 2,378 (725 meters)

This project was performed in conjunction with USGS which will issue the geologic report. Project holes were 100 percent cored to examine thorium occurrences in veins cutting the Belt Series strata.

Sand Wash Basin

- Quadrangles: Craig, Vernal
- State: Colorado
- Subcontractors: American Drilling Co.
Camp Drilling Co.
Exploration Services, Inc.
Adventures, Inc.
- Total Subcontract Value: \$639,698
- Start Date: 14 May 1979
- Completion Date: 4 November 1979
- Number of Holes: 27
- Total Feet Drilled: 26,084 (7,950 meters)

This project examined the Browns Park sandstone—a Miocene formation with broad surface exposure in northwestern Colorado, south-central Wyoming, and northeastern Utah—which is the host for economic uranium deposits. Some zones of weak uranium mineralization were encountered by project drilling.

Sonora Pass

- Quadrangle: Walker Lake
- State: California
- Subcontractors: Salisbury & Dietz, Inc.
California Division of Mines & Geology
Hosking Exploration Helicopters
- Total Subcontract Value: \$319,174
- Start Date: 4 June 1979
- Completion Date: 19 September 1979
- Number of Holes: 19
- Total Feet Drilled: 6,577 (2,005 meters)

This drilling project was conducted in cooperation with the California Division of Mines and Geology. It examined buried Tertiary stream channels in the central High Sierras of California. The objective was to obtain subsurface data from sediments, thought to be analogous to those of the Juniper channel, which contain moderate uranium reserves.

The data obtained indicate that several channels within the project area have potential for uranium mineralization. Project engineering and geological reports are in preparation.

San Rafael Swell

- Quadrangles: Price, Salina
- State: Utah
- Subcontractors: Chesney Drilling Inc.
Himes Drilling Company, Inc.
Baroid Engineering Division
Exploration Services, Inc.
Century Geophysical Corp.
Adventures, Inc.
- Total Subcontract Value: \$1,083,000
- Start Date: 24 September 1978
- Completion Date: Estimated December 1979
- Number of Holes: 22
- Total Feet Drilled: 39,230 (11,957 meters)

The San Rafael Swell area of southeast Utah contains known uranium occurrences. This project examined the Brushy Basin and Salt Wash Members of the Morrison Formation and the Moss Back and Monitor Butte Members of the Chinle Formation. Some zones of weak uranium mineralization were encountered and substantial new geological information was obtained in areas of limited exploration.



A portable down hole gross gamma-ray probe is used in one of the southeast Wyoming boreholes.

Southwest Prescott

- Quadrangles: Prescott, Williams
- State: Arizona
- Subcontractors: Stewart Brothers Drilling Co.
Century Geophysical Corp.
Exploration Services, Inc.
Adventures, Inc.
- Total Subcontract Value: \$1,557,234
- Start Date: 9 June 1979
- Completion Date: 30 October 1979
- Number of Holes: 18
- Total Feet Drilled: 63,558 (19,372 meters)

This project examined the stratigraphy and uranium favorability of Tertiary sediments in portions of the Date Creek, Big Sandy, Congress, McMullan, Butler, and Sacramento Basins. Some zones of weak uranium mineralization were encountered. The data obtained will greatly increase the geological knowledge and reduce the uncertainty of NURE uranium resource estimates for these areas.

Owens Lake

- Quadrangle: Death Valley
- State: California
- Subcontractors: X-L Drilling Co.
Exploration Services, Inc.
Adventures, Inc.
- Total Subcontract Value: \$1,253,055
- Start Date: 24 June 1979
- Completion Date: Estimated January 1980
- Number of Holes: 5
- Total Feet Drilled: 16,703 (5,091 meters)

The Coso Formation of Tertiary age in Inyo County, California is a complex of coarse continental clastic sediments, volcanoclastic rocks, and lacustrine sediments which contains known uranium deposits. This project is examining the uranium potential and stratigraphy of these sediments in areas and to depths which previously have not been explored.

Missoula/Bitterroot Basins

- Quadrangles: Wallace, Hamilton
- State: Montana
- Subcontractors: X-L Drilling Company, Inc.
Goodwell Inc.
Monaco Engineering Co.
Montana Bureau of Mines and Geology
- Total Subcontract Value: \$802,500
- Start Date: 10 May 1978
- Completion Date: 15 April 1979
- Number of Holes: 7
- Total Feet Drilled: 14,448 (4,404 meters)

This project was conducted in conjunction with the USGS and the Montana Bureau of Mines and Geology. Its purpose was to obtain subsurface data to help assess the uranium potential of southwestern Montana Tertiary basins. Drilling was restricted to the Missoula and Bitterroot valleys. The engineering report, GJBX-127(79), has been open filed. A detailed study of the samples obtained is being made by the University of Montana and the project geological report has been completed.

Black Hills Drilling Project

- Subcontractor: Longyear Company
- Subcontract Value: \$65,146
- Start Date: 3 August 1979
- Completion Date: 7 September 1979

Uranium-bearing Precambrian quartz-pebble Estes conglomerate in the northeastern Black Hills, South Dakota was core drilled to evaluate its uranium content and to solve stratigraphic-structural problems in the area.

Five drill holes totaling 2,211 feet (674 meters) were cored. Engineering information regarding the drilling operation will be open filed in 1980. Geologic information obtained from study of the recovered core will also be open filed in 1980.

Southeast Wyoming Drilling

- Subcontractor: Earth Exploration Drilling of Utah
- Subcontract Value: \$1,030,834
- Start Date: 13 June 1979
- Completion Date: 2 January 1980

This project was a follow-up phase of previous geologic investigations conducted by University of Wyoming researchers. Anomalous amounts of radioactivity had been found in outcrops of Precambrian quartz-pebble conglomerates in numerous localities within the Medicine Bow and Sierra Madre Mountains of southeastern Wyoming. Eighteen core holes totaling 13,037 feet (3,974 meters) were drilled in 1979 to test the

subsurface below weathered outcrops. Additional holes are planned for next year. Data from this coring program will be utilized in substantiating DOE resource estimates and the resource base of this region.

R&D Drilling Program— Red Desert, Wyoming

- DOE Contractor: Hol-Han Drilling
R&R Drilling Co.
- Subcontract Value: \$230,101
- Start Date: September 1978
- Completion Date: October 1979

Twelve holes (5½ inches/13 centimeters diameter) were drilled in support of the Technology Integration project; seven were core and five were rotary holes. The rotary holes averaged 600 feet (183 meters) TD and the fully cored holes averaged about 750 feet (229 meters) to TD. The core recovery ranged between 50-100 percent, averaging about 75 percent. The samples were lithologged and the holes were logged for KUT, total gamma, self potential, resistivity, and density. Borehole water samples were also collected for helium and uranium isotopic studies. The results from this drilling will be integrated with other geophysical, geochemical, and geological studies of the area to meet the Technology Integration objectives described in the Technology Applications section of this report.

R&D Drilling Program— Copper Mountain, Wyoming

- Subcontractor: Longyear Company
- Subcontract Value: \$276,940
- Start Date: September 1978
- Completion Date: October 1979

Seven core holes were drilled in support of the Technology Integration project. Six holes averaged a depth of 600 feet (183 meters) and the seventh hole reached a depth of 2,785 feet (849 meters), providing a total project footage of 6,350 feet (1,935 meters). The core recovery averaged about 98 percent. Samples were lithologged, borehole geophysical logging was completed, and water samples were collected for radon, helium, and uranium isotopic studies. The results from this drilling will be combined with the other geophysical, geochemical, and geological studies to meet the Technology Integration objectives described in the Technology Applications section of this report.

R&D Drilling Program— San Juan Basin, New Mexico

- Subcontractors: Stewart Brothers Drilling Co.
Birdwell Division, Seismograph Service Corporation
Century Geophysical Corp.
- Subcontract Value: Stewart Brothers \$670,000
Birdwell \$27,463
- Start Date: June 1979
- Completion Date: October 1979

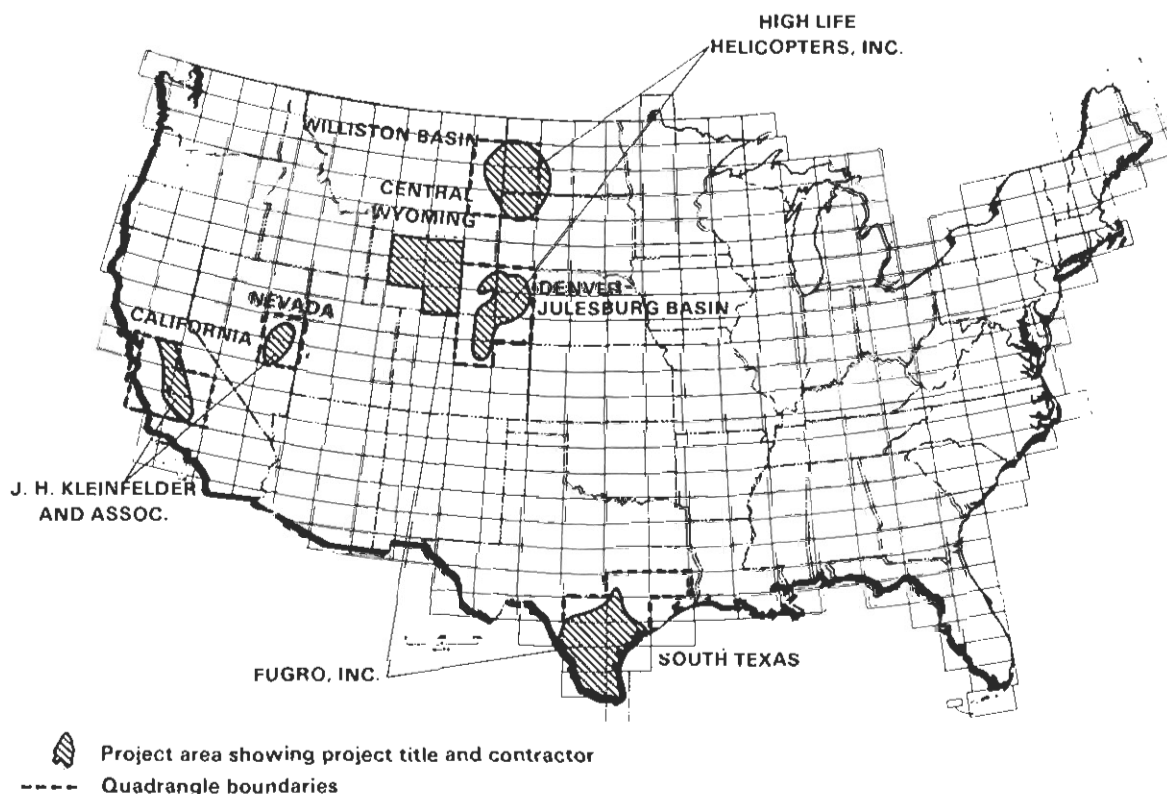
Fourteen holes (4½ to 5½ inches/11.7 to 13 centimeters diameter) were drilled, each with an average TD of 2,400 feet (732 meters). In every hole, the first 1,900 feet (579 meters) or so were rotary drilled and the remaining footage was cored to TD. The core recovery averaged about 90 percent. Subsequent to the drilling, the samples were lithologged, borehole geophysical logging was completed, and ground water samples were collected for radon, helium, and lead isotopic studies. The results from this drilling will be integrated with other geophysical, geochemical, and geological studies of the area to meet the

Technology Integration objectives described in the Technology Applications section of this report.

1979 Quadrangle Logging Program

A quadrangle logging program was conceived and initiated during FY79. Its purpose is to obtain calibrated geophysical logs in designated regions from new and existing holes not drilled for uranium. The areas designated by DOE for assignment to subcontractors are 1° x 2° NTMS quadrangles (see map). The preferred logs are (spectral gamma-ray) KUT, gross gamma-ray, neutron, electrical, and caliper. A maximum density of one hole logged per 9 square miles (23.3 square kilometers) and a maximum depth of 5,000 feet (1,524 meters) have been established as requirements. All acquisition of permits and logging activities are performed by BFEC subcontractors.

QUADRANGLE LOGGING PROGRAM Areas Being Surveyed FY 1979



During 1979 the first year of this new NURE program element, 363 holes were logged, generating 949,500 feet (289,410 meters) of gamma-ray log data. The following subcontracts were in effect:

Planning Study

- Subcontractor: Fugro, Inc.
- Total Subcontract Value: \$84,207
- Start Date: 24 October 1978
- Completion Date: 11 February 1979

This study led to the initiation of the quadrangle logging program.

South Texas and Central Wyoming Logging

- Subcontractor: Fugro, Inc.
- Total Subcontract Value: \$796,180 (ceiling)
- Start Date: 30 April 1978
- Completion Date: Continuing into FY80

These were the first areas to be surveyed under the quadrangle logging program. As of December 31, 1979 production of logs was:

- South Texas: 166 holes, 552,821 feet (168,500 meters) of hole logged
- Central Wyoming: 58 holes, 194,040 feet (59,143 meters) of hole logged

Denver-Julesburg and Williston Basins Logging

- Subcontractor: High Life Helicopters, Inc.
- Total Subcontract Value: \$423,000 (ceiling)
- Start Date: 31 May 1979
- Completion Date: Continuing into FY80

As of December 31, 1979 production of logs was:

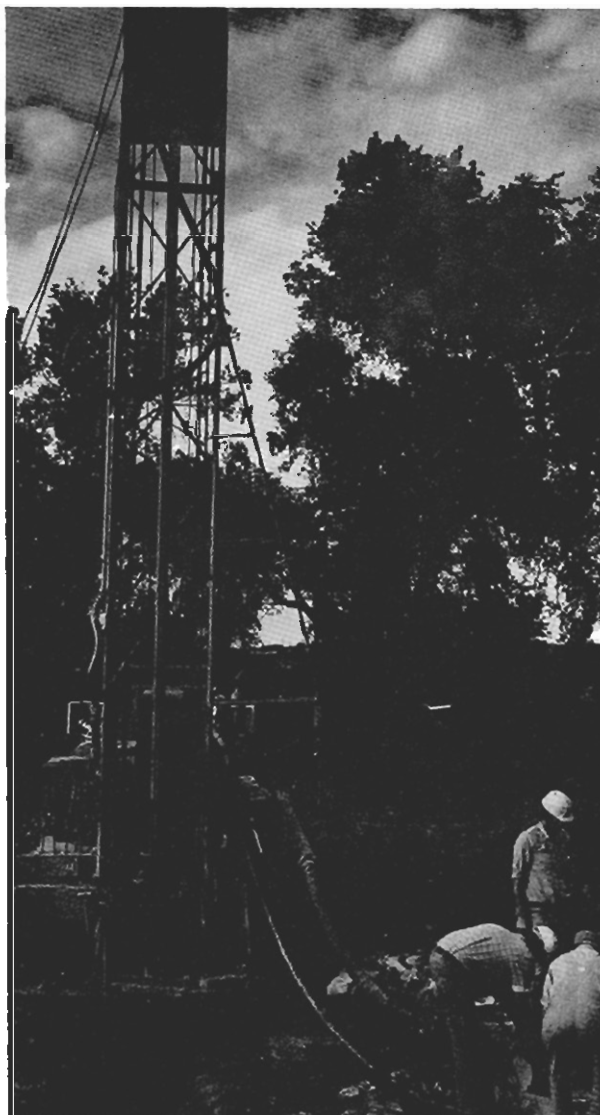
- Denver-Julesburg Basin: 45 holes, 68,948 feet (21,015 meters) of hole logged
- Williston Basin: 40 holes, 71,104 feet (21,672 meters) of hole logged

San Joaquin Valley and Eastern Nevada Logging

- Subcontractor: J. H. Kleinfelder and Associates, Inc.
- Total Subcontract Value: \$240,000
- Start Date: 14 September 1979
- Completion Date: Continuing into FY80

As of December 31, 1979 production of logs was:

- Nevada: 22 holes, 18,911 feet (5,764 meters) of hole logged
- California: 32 holes, 43,674 feet (13,312 meters) of hole logged



The Failing CF1250 drill rig is typical of the type used by subcontractors.

Hydrogeochemical and Stream-Sediment Reconnaissance and Detailed Geochemical Surveys

The Hydrogeochemical and Stream-Sediment Reconnaissance (HSSR) and Detailed Geochemical Surveys are directed by the Grand Junction Office of DOE. These surveys are carried out by three DOE national laboratories. The eastern and far western areas are the responsibility of the Savannah River Laboratory at Aiken, South Carolina; the central and plains areas are the responsibility of the Oak Ridge Gaseous Diffusion Plant at Oak Ridge, Tennessee; and the Rocky Mountain area and Alaska are the responsibility of the Los Alamos Scientific Laboratory at Los Alamos, New Mexico. A quality assurance effort is the responsibility of the Ames Laboratory located on the campus of Iowa State University at Ames, Iowa.

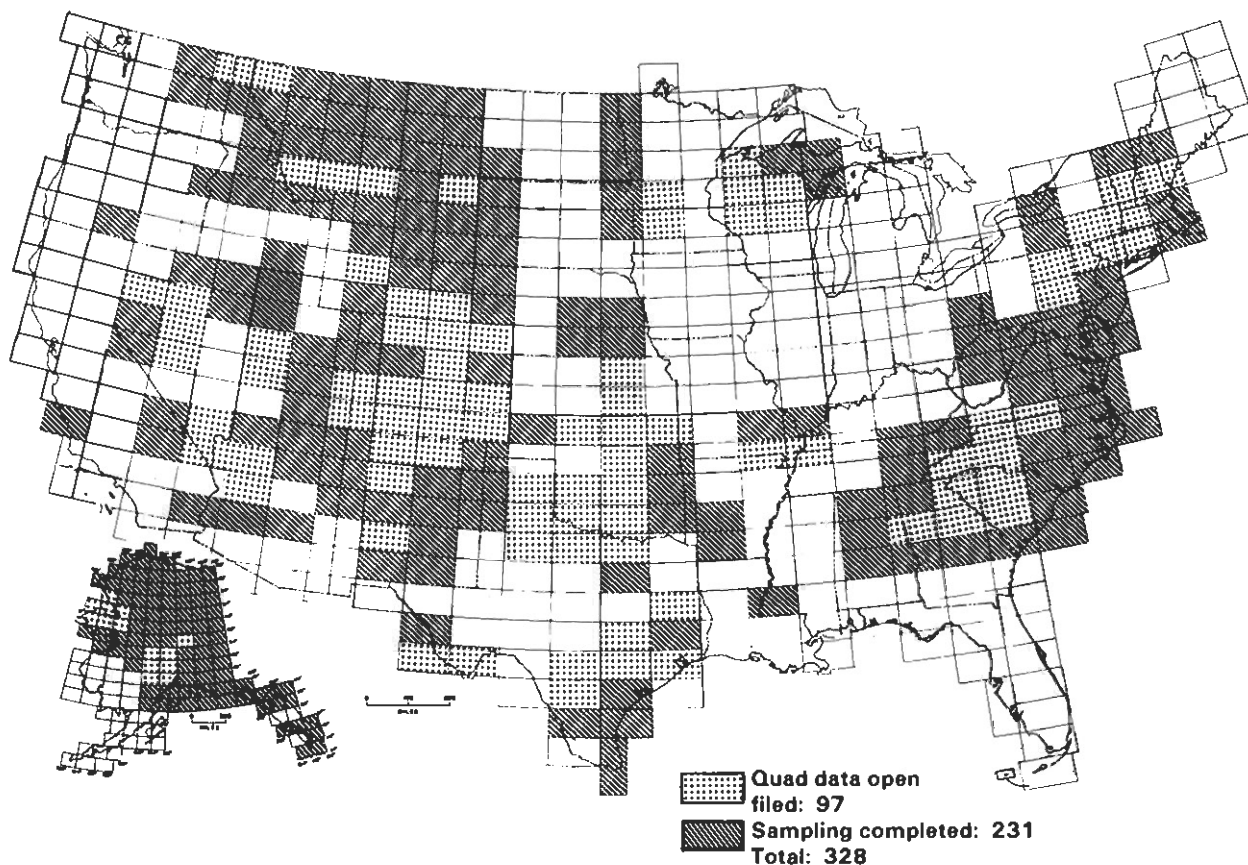
The field reconnaissance program consists of the collection of samples of ground water, stream water, and streambed sediments at a

sample site density of one site per 5 to 10 square miles (13 to 26 square kilometers). The detailed geochemical program involves the collection of selected rock, soil, and vegetation samples as well as those sample types mentioned above. The reconnaissance surveys are reported on the basis of 1:250,000-scale 1° x 2° NTMS quadrangles while the detailed survey areas are selected to meet special needs of the NURE resource assessment.

Bendix conducts the necessary coordination and liaison among the national laboratories and DOE and Bendix resource assessment groups.

During 1979, 100 quadrangles had sampling completed, totaling 328 to date; 58 quadrangle reports were open filed, totaling 97; and 27 detailed studies were initiated, 1 of which was open filed.

STATUS OF THE HYDROGEOCHEMICAL RECONNAISSANCE SURVEYS



In addition to the coordination of reconnaissance and detailed geochemical surveys being conducted by DOE laboratories, Bendix administers subcontracts that support the geochemical surveys. The subcontracts are described in greater detail in the Geologic Studies section. They include studies on the distribution of uranium and related elements in sedimentary and igneous rocks and ground water as well as studies designed to improve data presentation, interpretation, and the direct application of geochemical data to resource assessment.

Lawrence Livermore Laboratory (LLL) published reports on Millet, Williams, Sandpoint, Tonopah, and Lovelock—five high-priority quadrangles of the LLL program; one quadrangle reconnaissance report; and two special reports. These publications completed the LLL responsibility to the NURE program.

Los Alamos Scientific Laboratory

The Los Alamos Scientific Laboratory (LASL) is responsible for the HSSR program throughout 79 quadrangles in the Rocky Mountain region and 136 quadrangles in Alaska. During 1979 nine Rocky Mountain region quadrangles—Driggs,

Preston, Ogden, Clifton, Silver City, Douglas, El Paso, Brownfield, and Hobbs—were added to LASL's region of responsibility while 17 quadrangles, encompassing much of the Aleutian Islands area of Alaska, were dropped by DOE. Altogether the LASL region includes about 1,122,000 square miles (2,906,000 square kilometers) or approximately 30 percent of the total U.S. land area.

Among LASL's noteworthy accomplishments during 1979 were the collection of water and sediment samples from 32,000 locations, approximately half of which were in Alaska, the analyses of some 35,000 water and 35,000 sediment samples, and the publication of reconnaissance reports for 20 quadrangles, including 17 in the 116-quadrangle program. Through 1979 LASL has collected reconnaissance samples from 70 quadrangles in the Rocky Mountain region and 102 quadrangles in Alaska, leaving only parts of the nine newly added Rocky Mountain region quadrangles and 34 Alaska quadrangles to be sampled in 1980 and beyond.

LASL routinely analyzes water samples for 13 elements using fluorometry, plasma-source emission spectrography, and delayed-neutron



The HSSR program requires that many samples be collected in remote areas.

counting at a rate of 400 samples per day. Sediment samples are analyzed for 43 elements using a combination of short- and long-time delay neutron activation analysis (NAA), x-ray fluorescence, and arc-source emission spectrography. The addition of a second complete NAA system at the reactor site during 1979 has doubled the throughput to 400 samples per day. With the increased NAA capability, as many as 80,000 water and 80,000 sediment analyses can now be made each year by LASL.

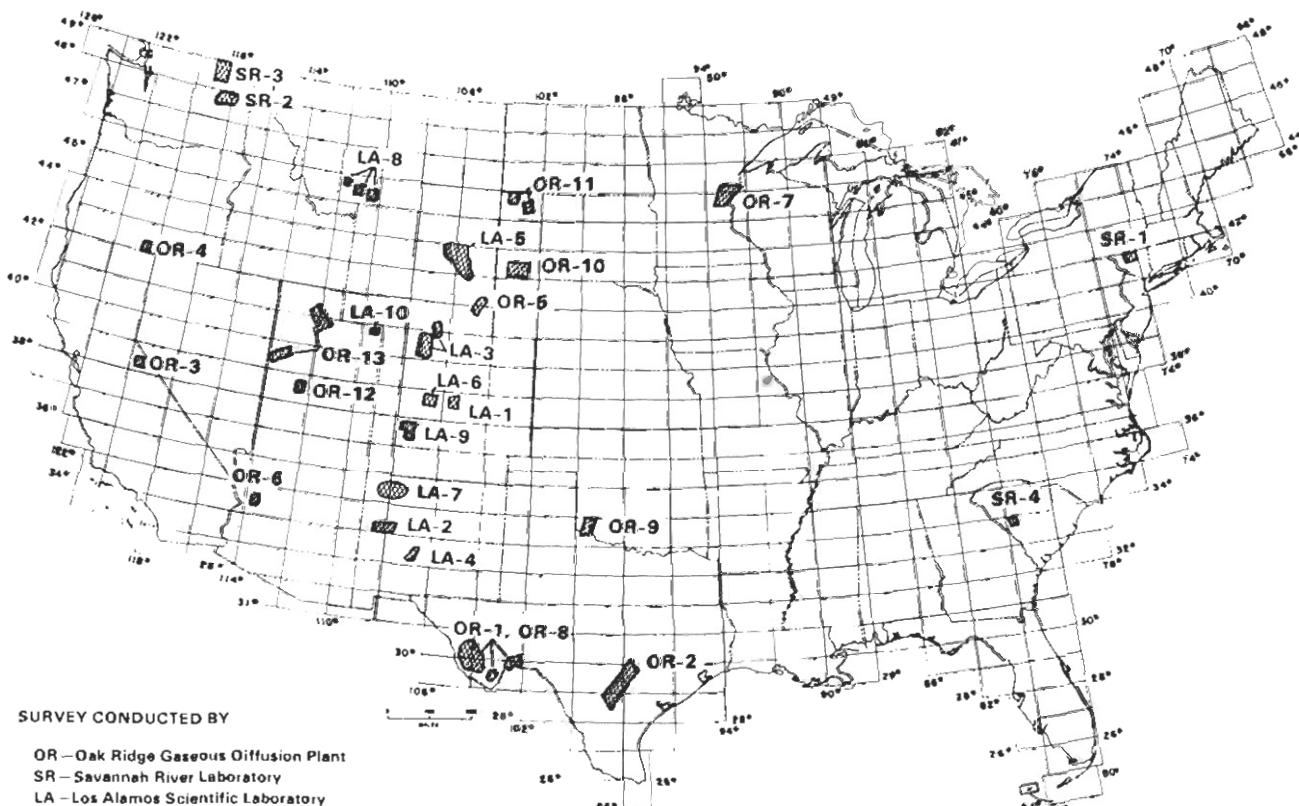
LASL is responsible for reporting on 48 quadrangles in the 116-quadrangle program. Through 1979 reports covering 25 of the quadrangles have been published and 8 others are near completion. Computer tapes of the field and analytical data contained in these quadrangle reports (as well as all other open-file LASL HSSR reports) are made available to the public from: GJOIS Project, Union Carbide Corporation Nuclear Division (UCCND), Computer Applications Department, 4500 North Building, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, TN 37830.

LASL has undertaken 10 HSSR detailed geochemical surveys (at the request of the DOE) (see map): NW Pueblo (LA-1); Pie Town (LA-2);

Spring Creek (LA-3); Oscura Mountains-San Andres Mountains (LA-4); Southern Powder River Basin (LA-5); Sawatch Range (LA-6); Grants (LA-7); Bozeman (LA-8); Needle Mountains-Vallecito Creek (LA-9); and Red Creek Quartzite (LA-10). The NW Pueblo Survey was open filed as GJBX-42(79); sampling for the other nine surveys was completed in 1979 and resulted in the collection of water and/or sediment samples from 12,250 locations. Reports of these surveys are scheduled to be open filed in 1980.

Since the beginning of the HSSR program in 1975 LASL has collected water and sediment samples from approximately 155,000 locations in the Rocky Mountain region and 66,000 locations in Alaska. Analyses have been performed on 85,000 water samples and 96,000 sediment samples. Reconnaissance and special study reports containing the field data and analytical results for water and sediment samples from 82,000 locations in a combined area equivalent to 50 quadrangles have been open filed through the DOE Grand Junction Office. In addition, four topical and progress reports related to LASL HSSR activities were released this year.

DETAILED GEOCHEMICAL SURVEYS CONDUCTED DURING 1979



Oak Ridge Gaseous Diffusion Plant

The Oak Ridge Gaseous Diffusion Plant (ORGDP) is conducting the Hydrogeochemical and Stream-Sediment Reconnaissance (HSSR) program in an area of more than 970,000 square miles (2,512,000 square kilometers) in the central United States (see map). Major accomplishments by ORGDP during 1979 included the collection of 32,455 samples, the analysis of 32,527 samples, and the release of 18 quadrangle reconnaissance reports.

Samples collected for the HSSR studies include surface and ground water and stream sediments. The samples are collected by ORGDP field geologists, state geological surveys, and subcontractors.

Uranium 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 spectrophotometry, and mass spectrometry are used for analysis of 33 additional variables in sediment and water samples.

During 1979 HSSR reports for the following quadrangles of the 116 program were open filed: Enid, Austin, Lawton, Wichita, St. Cloud, Ashland, Clinton, Pratt, Joplin, Palestine, Wichita Falls, Amarillo, New Ulm, Hutchinson, Manhattan, and Lubbock.

Reports were also issued in 1979 for two priority quadrangles, Emory Peak and Presidio. A pilot geochemical survey report in Oklahoma was also issued in 1979. Pilot surveys were planned to sample small but regionally and geologically representative locations as a basis for understanding data from the HSSR program.

Reports for Laredo, Hot Springs, Lemmon, Beaumont, Dickinson, Marquette, Iron River, Corpus Christi, Grand Island, Lincoln, Rapid City, Alliance, Watertown, Scottsbluff, Milbank, Thief River Falls, Brownsville, and Broken Bow Quadrangles are scheduled for release during 1980.

Thirteen detailed geochemical surveys were actively in progress by ORGDP (see map). These include Trans-Pecos (OR-1), South Texas Coastal Plain (OR-2), Lakeview (OR-4), Sonora Pass (OR-3), Laramie Mountains (OR-5), Wichita Uplift (OR-9), Date Creek Basin (OR-6), Duluth-Stillwater Precambrian (OR-7), Edgemont (OR-10), Buffalo Lignite (OR-11), Trans-Pecos Addition (OR-8), Marysville (OR-12), and

Thomas Range-Wasatch (OR-13). Approximately 10,600 samples were collected and 10,200 samples were analyzed. The reports for Trans-Pecos, South Texas Coastal Plain, Wichita Uplift, Date Creek Basin, Duluth-Stillwater Precambrian, Laramie Mountains, and Thomas Range-Wasatch are scheduled for release during 1980. Three semiannual progress reports were issued during 1979.

Two topical reports were issued during 1979. These included *Fitting a Three-Parameter Lognormal Distribution With Applications to Hydrogeochemical Data From the National Uranium Resource Evaluation Program*, GJBX-175(79) and *Application of Discriminant Analysis and Generalized Distance Measures to Uranium Exploration*, GJBX-176(79).

Several papers were presented by the ORGDP Uranium Resource Evaluation Project staff. Two papers were given at the Association of Exploration Geochemists/U.S. Department of Energy Symposium, Geochemical Exploration for Uranium at San Diego, California on November 4, 1979: *Management and Analysis of Regional Geochemical Data and Uranium Exploration—Ground and Surface Water*. One paper was presented at the 1979 Department of Energy Statistical Symposium at Gatlinburg, Tennessee on October 24-26, 1979: *Application of Discriminant Analysis and Generalized Distance Measures to Uranium Exploration*. A paper was given at the Classification Society Annual Meeting in Gainesville, Georgia on April 8-10, 1979: *Results Using an Improved Probabilistic Method for Grouping Data*. Also, a paper was given at the American Statistical Association Annual Meeting in Washington, D.C. on August 13-16, 1979: *Fitting a Three-Parameter Lognormal Distribution With Applications to Hydrogeochemical Data From the National Uranium Resource Evaluation Program*.

Savannah River Laboratory

The Savannah River Laboratory (SRL) is responsible for conducting the HSSR program over an area of more than 1,500,000 square miles (3,885,000 square kilometers), covering 220 quadrangles in all or part of 30 eastern states and 7 western states. Major accomplishments in 1979 included the collection of over 65,000 samples, analysis of over 40,000 samples, and conducting the sampling and analysis of samples from seven western states in support of the 116-priority-quadrangle program.

During 1979 samples collected included ground water, stream water, stream sediment, and vegetation in support of the reconnaissance program. Ground water, stream water, stream sediment, and vegetation samples were collected for detailed studies in four areas. The samples were collected primarily by SRL-trained and supervised contractors.

Thirty-two high-priority quadrangles were assigned to SRL to be included in the NURE resource assessment report for 1980. By the end of 1979 reports were issued for 11 of these quadrangles. HSSH data reports were issued for Spartanburg, Scranton, Athens, Portland, Harrisburg, Glens Falls, Augusta, Dyersburg, and Poplar Bluff in the east. The 23 high-priority quadrangles in the west have been sampled, and of these, Richfield and Delta have been open filed.

Other reports issued in 1979 include data reports for Charlotte, Greenville, Knoxville, Hartford, Atlanta, Albany, and Williamsport Quadrangles. Special reports included the Wolcott, Vermont Orientation Study, a report on uraniferous gor-

ceixite occurrences in Aiken County, South Carolina, three semi-annual reports, and a pilot study on the geology of Birmingham, Gadsden, and Montgomery Quadrangles.

Four detailed geochemical studies were performed in 1979. The reports will be open filed by late 1980 (see map for location of detailed geochemical studies). The studies included two areas in Washington, the Midnite Mine area of the Ritzville Quadrangle (SR-2) and the Kettle Falls Dome area of the Okanogan Quadrangle (SR-3), and a study in the Glen Wild, New York area of the Scranton Quadrangle (SR-1). Of special interest is the detailed study of gorceixite in Aiken County, South Carolina in the Augusta Quadrangle (SR-4). In addition to standard analytical procedures, limited drilling was performed with natural gamma and electric logging. Gorceixite is a barium-aluminum phosphate that contains significant concentrations of uranium. It is a rare mineral in the United States; however, it occurs as a major uraniferous material in Brazil and Africa.

Geologic Studies

The NURE program for 1979 emphasized special projects in the areas of World-Class and Intermediate-Grade uranium studies. Both areas are being considered in the search for additional potential uranium resources which may become economic in the foreseeable future. The World-Class studies emphasized the Quartz-Pebble Conglomerates as an environmental target. The Intermediate-Grade Studies concentrated on extending known deposits to include large resources in the 100 to 500 ppm uranium category. Three studies on low-grade resources (less than 100 ppm uranium) were completed and a fourth study (asphaltite) was initiated.

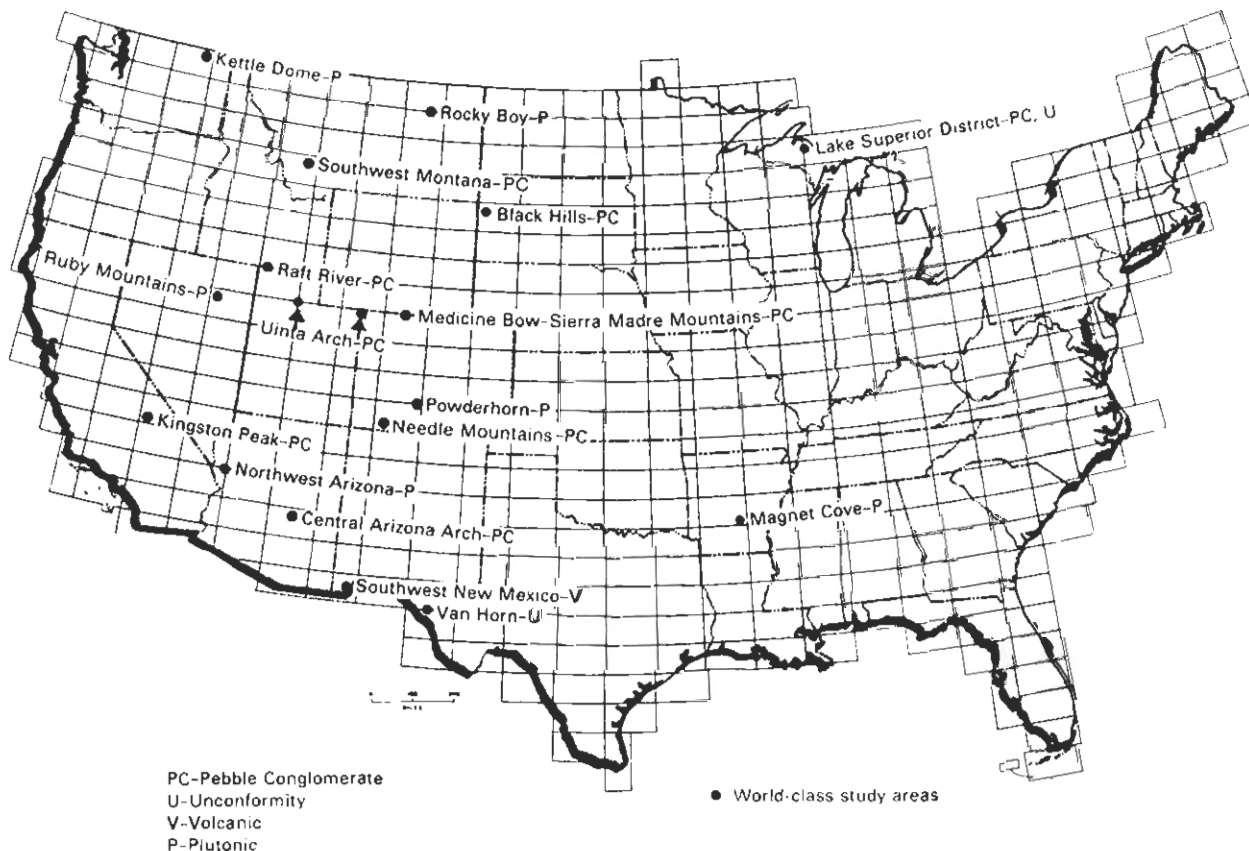
The Geologic Studies initiated during the fiscal year emphasized World-Class environments and Intermediate-Grade resources.

World-Class Deposit Studies

The World-Class Deposit Studies program was established in 1978 to provide complete analyses of 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 results of these studies will guide the evaluation of analogous U.S. geologic environments to broaden the resource base.

Goals of the program are: (1) complete, by October 1980, an evaluation of the Precambrian pebble-conglomerate environment, (2) assess the unconformity-vein and volcanic environments by October 1981, (3) evaluate the plutonic-metamorphic environment by October 1983, and (4) appraise regolith-related environments by October 1984.

POSSIBLE WORLD-CLASS DEPOSIT STUDY AREAS



Program strategy for each environment is to develop occurrence models and then identify areas in the United States fitting the models. Specific areas are then selected for favorability and evaluation studies and the most promising sites are chosen for detailed geologic studies and drilling.

Uranium in Precambrian Quartz-Pebble Conglomerates

- Subcontractor: University of Wyoming
- Subcontract Value: \$217,540
- Start Date: 16 July 1979
- Completion Date: 15 September 1980

Previous NURE-sponsored research by Dr. R. S. Houston and Mr. Karl E. Karlstrom of the University of Wyoming resulted in a considerable compilation of geologic data on uranium-bearing Precambrian quartz-pebble conglomerates throughout the world. These data were used to formulate a general exploration model for uraniferous conglomerate, which was subsequently applied to the Late Archean and Early Proterozoic terrains of the United States to define areas most favorable for this type of uranium mineralization.

In support of the World-Class Studies program, the subcontract to the University of Wyoming was extended to provide direct geologic support to the World-Class drilling project for uraniferous pebble conglomerate in the Medicine Bow and Sierra Madre Mountains. The work revolves around seven major tasks: (1) core logging, (2) detailed geologic mapping, (3) rock-chip sampling, (4) surface radiometrics, (5) mineralogy-petrology studies, (6) geostatistical studies, and (7) consultation services. The end result of the work and research will be a comprehensive geologic report on the surface and subsurface characteristics of uranium-bearing Late Archean and Early Proterozoic pebble-conglomerate and quartzite units in the Sierra Madre and the Medicine Bow Mountains. The report will also provide a preliminary geostatistical evaluation of uranium resources in the project area.

The drilling aspects of these projects are reported in the Subsurface Investigation section of this report.

Geology of the Northeast Black Hills

- Subcontractor: South Dakota School of Mines and Technology
- Subcontract Value: \$53,486
- Start Date: 15 May 1979
- Completion Date: 31 December 1979

The Precambrian Estes conglomerate, exposed in the Nemo district on the northeastern flank of the Black Hills, South Dakota is known to contain uranium and was selected as a target for surface and subsurface geologic investigation to determine its potential as a World-Class-type uranium source.

Detailed field mapping, radiometric and magnetic surveys, logging of cores from five holes in the area, plus chemical analyses of representative samples were carried out under the direction of Dr. J. Redden, South Dakota School of Mines and Technology. Results of the study will be published in an open-file report in 1980.

Tertiary Volcanic Rocks in Southwestern New Mexico

- Subcontractor: University of Kansas
- Subcontract Value: \$34,500
- Start Date: 1 June 1979
- Completion Date: 31 December 1979

The Tertiary volcanics and Cretaceous limestones in southwestern New Mexico were selected for examination and evaluation of their uranium potential because of their similarity with respect to rock types and age to the World-Class type Peña Blanca uranium district in Chihuahua, Mexico. The study, under the direction of Dr. A. Walton, included field mapping, radiometric surveys, and sample collection. A total of 350 samples was collected for chemical and petrographic-mineralogical examinations. The results of the study will be published in 1980.

Proterozoic Unconformity, Van Horn, Texas

- Subcontractor: University of Texas at El Paso
- Subcontract Value: \$37,318
- Start Date: 10 May 1979
- Completion Date: 30 November 1979

Proterozoic rocks in the Van Horn area, Texas show lithologic and structural characteristics favorable for World-Class unconformity-type uranium deposits.

The area, under the direction of Drs. D. Davidson and P. Goodall, was mapped, surveyed radiometrically, and sampled for chemical analyses. Results of the study will be published in an open-file report in 1980.

Geologic Evaluation of Precambrian Metasedimentary Rocks, Uinta Arch, Utah and Colorado

- Subcontractor: Research Associates of Wyoming
- Subcontract Value: \$93,489
- Start Date: 15 June 1979
- Completion Date: 15 March 1980

The prime objective of the project, directed by Dr. Paul J. Graff of Research Associates of Wyoming, is to evaluate selected areas along the flanks of the Uinta Arch in Colorado and Utah for the occurrence of Precambrian metasedimentary rock sequences that could potentially host uranium deposits of the pebble-conglomerate or unconformity-related types. The target metasedimentary rock units chosen for the reconnaissance study are the Red Creek Quartzite, which crops out in the northeastern Uinta Mountains; the Little Willow Series of the west-central Wasatch Mountains; and selected quartzite intervals of the Farmington Canyon Complex in the northern Wasatch Mountains.

The study is field oriented and revolves around literature compilation, reconnaissance mapping, and rock-chip sampling. Attempts will be made to correlate the target metasedimentary rock units with known uranium-bearing Late Archean and Early Proterozoic sequences in southeast Wyoming and elsewhere in the Wyoming Precambrian province. The results of the project will be released in an open-file report.

Geologic-Geochemical Evaluation of Raft River Mountains, Utah and Idaho

- Subcontractor: Meiji Resource Consultants
- Subcontract Value: \$92,104
- Start Date: 9 July 1979
- Completion Date: 15 April 1980

A variety of metasedimentary rocks of probable Precambrian age crop out in the Raft River Mountains, Grouse Creek Mountains, and Albion Range of northwestern Utah and southern Idaho. Some of these units, especially the Elba quartzite, have characteristics that meet the general favorability criteria for the occurrence of uranium-bearing quartz-pebble conglomerate. The project area is of interest because it is the location of a recently recognized metamorphic core complex.

The study, directed by Dr. Alan Black of Meiji Resource Consultants, will concentrate on the basal metasedimentary quartzite, schist, and conglomerate horizons and involves four major tasks: (1) regional mapping and stratigraphic correlation, (2) rock-chip sampling, (3) stream-sediment and water sampling, and (4) sedimentologic studies. The goal of the work is to identify those locations within the project area most favorable for uranium mineralization and most deserving of the follow-up work. All data and results of the work will be released in an open-file report.

Precambrian Plutonic Rocks of Northwest Arizona

- Subcontractor: Loghry-Heinrichs
- Subcontract Value: \$61,000
- Start Date: 5 July 1979
- Completion Date: 16 July 1980

Proterozoic quartz monzonites are being studied in the Hualapai, Cerbat, Peacock, and Aquarius Mountains of northwestern Arizona. Representative geologic and geochemical data are being collected and evaluated on a best-fit basis with previously developed recognition and favorability criteria.

The final report will note the distribution of uranium, thorium, and associated elements in these plutonic rocks as well as discuss the host and source rocks potential of each pluton.

Uranium in Precambrian Conglomerates, Southwest Montana

- Subcontractor: Robert E. Cohenour & Associates
- Subcontract Value: \$113,000
- Start Date: 2 July 1979
- Completion Date: 2 March 1980

In southwestern Montana, older Precambrian rocks generally referred to as pre-Beltian show evidence of a period of sedimentation followed by high temperature metamorphism. Rapid erosion of the topographically high Pony and Cherry Creek series rocks has given rise to the coarse clastics of the Beltian LaHood Formation conglomerate.

Both the older and younger Precambrian rock units exhibit similarities to Precambrian quartz-pebble conglomerates of the Medicine Bow-Sierra Madre type and are included in this regional reconnaissance study.

Geologic Study of Precambrian Pebble Conglomerates, Needle Mountains, Colorado

- Subcontractor: Colorado State University
- Subcontract Value: \$73,705
- Start Date: 7 May 1979
- Completion Date: 1 February 1980

Precambrian quartz-pebble conglomerates with characteristics similar to those of the Witwatersrand and Medicine Bow Mountains have been noted in the Needle Mountains of southwestern Colorado. This study was undertaken to test the uranium favorability of this thick rock (5,000 feet/1,524 meters) sequence and to compare the resultant data with the general quartz-pebble conglomerate model on a best-fit basis.

Detailed stratigraphic sections have been measured and sampled both geochemically and radiometrically.

Geologic Study of Kettle Dome, Northeast Washington

- Subcontractor: Cruson and Pansze, Geologists
- Subcontract Value: \$60,000
- Start Date: 1 June 1979
- Completion Date: 15 February 1980

The goal of this geologic study is to evaluate the uranium potential of the plutonic and metamorphic rocks of Kettle Dome in northeastern Washington. Chemical and radiometric analyses of samples, local detailed mapping, studies of mineral paragenesis, and uranium mineralization modeling will assist in evaluating the uranium potential of Kettle Dome and will provide a comparison of this geologic environment with similar World-Class environments and uranium deposits. There are numerous small uranium-bearing simple pegmatites in amphibolitic rocks on the margins of the dome. Many of the pegmatites show both metasomatic and injection features.

Geologic Study of Kingston Peak Formation, Southeast California

- Subcontractor: University of California at Los Angeles
- Subcontract Value: \$91,221
- Start Date: 4 May 1979
- Completion Date: 31 March 1980

Late Precambrian quartz-pebble conglomerates of the Kingston Peak Formation are exposed along the west side of the Panamint Range and in nearby ranges of southeastern California. The conglomerates are locally radioactive and are being studied to determine the amount and extent of uranium mineralization and to determine if the geologic conditions associated with Precambrian uranium-bearing conglomerates elsewhere in the world are present in the Kingston Peak Formation. Three field crews under the direction of Dr. Don Carlisle are doing sampling and detailed stratigraphic studies of the conglomerates. The final report will evaluate the uranium potential of the Kingston Peak Formation and recommend additional studies and drilling if warranted.

Precambrian Conglomerates of the Central Arizona Arch

- Subcontractor: Wallaby Enterprises
- Subcontract Value: \$93,985
- Start Date: 1 August 1979
- Completion Date: 1 April 1980

This project includes the evaluation of the uranium potential of the Precambrian conglomerates of the central Arizona Arch in Gila County and parts of adjacent counties. Extensive rock sampling and locally detailed stream and sediment sampling are being conducted to evaluate areas which have uranium potential. There are several stratigraphic intervals which have quartz-pebble conglomerates and the conglomerates are being studied in terms of environments of deposition to compare them with Precambrian rocks known to produce uranium. Uranium has been mined in this area in nonconglomeratic rocks and the current study also seeks to determine if Precambrian conglomerates may have been source rocks.

Uranium in Metamorphic Core Complexes

- Subcontractor: University of Arizona
- Subcontract Value: \$109,000
- Start Date: 19 July 1979
- Completion Date: 19 August 1980

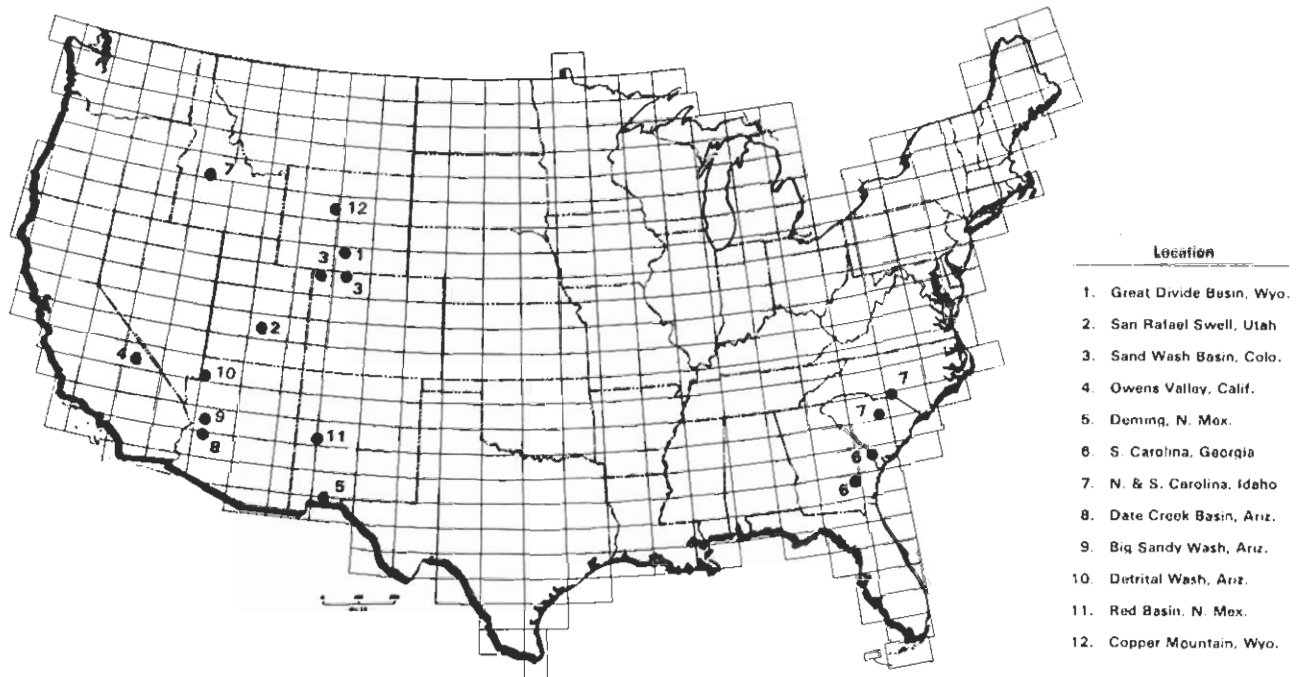
The goal of this project is to determine how uranium is mobilized, partitioned, and deposited in and around metamorphic core complexes. This modeling study entails literature review, study of uranium occurrences in core complexes, regional map compilations, and detailed sampling and field study of two core complexes. Geologists under the direction of Dr. Peter Coney have been studying uranium in core complexes in the Ruby Mountains of Nevada and the Rincon Mountains of Arizona. A genetic model and uranium recognition criteria plus recommendations for detailed study and drilling at selected sites will be the final product.

Uranium in Carbonatites in the United States

- Subcontractor: Powell and Associates
- Subcontract Value: \$93,405
- Start Date: 2 July 1979
- Completion Date: 2 July 1980

The objective of the project is to prepare genetic models for uranium in carbonatites using worldwide geologic, geochemical, and geophysical data from carbonatites and associated alkaline rocks and to use these models in evaluating the uranium potential of selected carbonatites in the United States. Carbonatites at Rocky Boy, Montana; Powderhorn, Colorado; and Magnet Cove, Arkansas have been studied in the field and sampled. Genetic models have been completed, and evaluation of the models is in process.

LOCATION OF POSSIBLE INTERMEDIATE-GRADE STUDY AREAS



Intermediate-Grade Studies

The Intermediate-Grade Resource Studies began in 1978 to develop, evaluate, and expand that category of uranium resources between 0.01 and 0.05 percent U_3O_8 which normally are not recoverable at costs under \$50/per pound.

The targets chosen for detailed study in 1979 were largely in sandstone environments, geographically centered in producing areas. Facies previously considered marginal were given special attention.

Other environments are being considered and priorities for their test and evaluation will be set by DOE.

Work progressed on four areas, two of which reached the preliminary report stage in 1979. Additional potential locations have been subjected to preliminary analysis to develop priorities for 1980.

Copper Mountain Drilling Project

- Subcontractor: Bendix plus drilling contractor not yet determined
- Subcontract Value: Not Yet Determined
- Start Date: 1 August 1979
- Completion Date: 1 August 1980

Subsurface and surface studies are being con-

ducted at Copper Mountain, Wyoming by Bendix personnel in order to outline a drilling program intended to determine intermediate-grade uranium resources outside the area of current industry exploration. Selected boreholes are being logged for KUT data, and use is being made of extensive geophysical and geochemical studies at Copper Mountain completed by Bendix.

Cedar Mountain Drilling, San Rafael Swell

- Subcontractor: Himes Drilling Company, Inc.
- Subcontract Value: \$78,100
- Start Date: 15 June 1979
- Completion Date: 28 July 1979

The drilling project examined the Brushy Basin Member of the Morrison Formation in the area of Cedar Mountain, Utah.

The data obtained from the drilling program increased subsurface knowledge of the Brushy Basin Member. The known reserves of the Cedar Mountain area were confirmed. These are confined to the Mountain itself and have no lateral continuity due to the faulting, leaching, and erosion of the region. There were no additional resources identified in the Brushy Basin Member. Results of this project will be published in an open-file report in 1980.

Red Desert, Great Divide Basin

- In-house project—Intermediate Grade
- Start Date: July 1979
- Completion Date: September 1980

The Great Divide Basin of Wyoming has several depositional environments grading from piedmont slope through flood plain to lacustrine and swamp facies. The lacustrine paludal facies exhibit what appear to be large volume, low-grade uraniferous potential with possible relatively uniform continuity. The objective of the project is to define and quantify that area containing mineral reserve potential in the 0.01-0.05 percent U_3O_8 category.

Six rotary holes were completed during FY79 for 4,697 feet (1,432 meters) of drilling.

Sand Wash Basin

- Start Date: July 1979
- Completion Date: September 1980
- In-house project—Intermediate Grade

Uranium mineralization in the sandstones of the Browns Park Formation of Miocene age has been widely recognized. The formation consists of a basal fluvial conglomerate and lacustrine-eolian tuffaceous sands. The host rock is widespread in the basin and is potentially a viable uranium resource.

The objective of this project is to evaluate and assess the formation for its potential as an intermediate-grade (0.01-0.05 percent U_3O_8) uranium resource. Data compilation and evaluation coordinated with geologic, geochemical, and geophysical surveys have been conducted. Recently, a detailed aerial resistivity and VLF-EM survey was performed for the purpose of delineating favorable structural features. A rotary and core drilling program is scheduled for the spring of 1980.

Topical Geologic Studies

Topical Geologic Studies that were part of the NURE program through 1979 have been winding down. These specialized studies in the future will be directed toward broadening the target base for World-Class and Intermediate-Grade Studies.

Geochemical Exploration for Sandstone-type Uranium Deposits

- Subcontractor: Pennsylvania State University
- Subcontract Value: \$58,475
- Start Date: 2 January 1978
- Completion Date: 31 December 1979

The investigation included the Devonian Catskill Formation in eastern Pennsylvania and the Uravan mineral belt in western Colorado. The objectives were: (1) to find if sandstone-type uranium deposits are accompanied by regional uranium anomalies in the host rocks, (2) to find the relations of uranium to thorium and other major and trace elements, and how these relations can be used in exploration, (3) to see if the ground-water conduits through which uranium was transported to form orebodies are enriched or depleted in uranium, and (4) to find if U and Th contents of zircon are useful to explore for uranium deposits in sedimentary rocks.

Results in Pennsylvania indicate regional anomalies in uranium and thorium probably arose during sedimentation. During diagenesis, uranium was apparently mobilized into aquifers. Paleo-aquifers through which uranium was transported are enriched in U and Fe_2O_3 .

Detailed discussion of this project will be open filed in 1980.

Development of Data Enhancement and Display Techniques

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

Significant amounts of highly reliable geochemical data, consisting of multi-element 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, Dr. George S. Koch, Jr. of the University of Georgia with the assistance of Dr. Richard J. Howarth (Imperial College, London), Dr. John Schuenemeyer (University of Delaware), and Dr. Robert H. Carpenter (University of Georgia) are studying appropriate statistical methods for enhancing HSSR data and bringing out anomalous signals from the background noise. Geochemical mapping and graphic display techniques are being developed to optimize portrayal of the statistically treated parameters for visual interpretation of uranium favorability.

The group selected stream-sediment data from three geologically, geographically, climatologically, and hydrologically distinct areas—the Pueblo, Colorado Quadrangle; the Seguin, Texas Quadrangle; and a four-quadrangle (Winston-Salem, Charlotte, Spartanburg, and Greenville)

region in the southeastern United States—for analysis by statistical and graphic methods.

A major portion of the research was devoted to identification and resolution of genuinely significant uranium anomalies by initially grouping samples according to source-rock type and then using mineralogical models to remove the uranium associated with heavy minerals, leaving residual uranium values thought to represent mobile uranium.

Results of this project will be open filed in 1980.

Involvement of HSSR Data in Uranium Resource Assessment and Identification of Areas Favorable for Uranium Deposits

- Subcontractor: University of Georgia Research Foundation, Inc.
- Subcontract Value: \$139,973
- Start Date: 1 August 1979
- Completion Date: 1 August 1980

Dr. George S. Koch, Jr. (University of Georgia), in association with Dr. Richard J. Howarth (Imperial College, London) and Dr. Robert H. Carpenter (University of Georgia), has undertaken this study. The team has chosen the four-quadrangle block comprising the Pueblo, Montrose, Durango, and Trinidad Quadrangles in Colorado as the training and test areas.

The HSSR data from those four quadrangles will be combined with published grade-tonnage-production data to generate and test mathematical models for estimation of uranium resources. Results will be compared with resource estimates derived by other methods and conclusions will be drawn concerning whether the HSSR data-based estimate can be combined with the other estimates to establish a more reliable final number for the uranium endowment of an area.

Results of this project will be published in an open-file report in 1980.

Geochemical Interpretation of Ground-Water Data in the NURE Program

- Subcontractor: Colorado School of Mines
- Subcontract Value: \$93,850
- Start Date: 1 May 1979
- Completion Date: 1 October 1980

Bendix geologists use a scintillometer to study a mineralized outcrop in the Copper Mountain area.

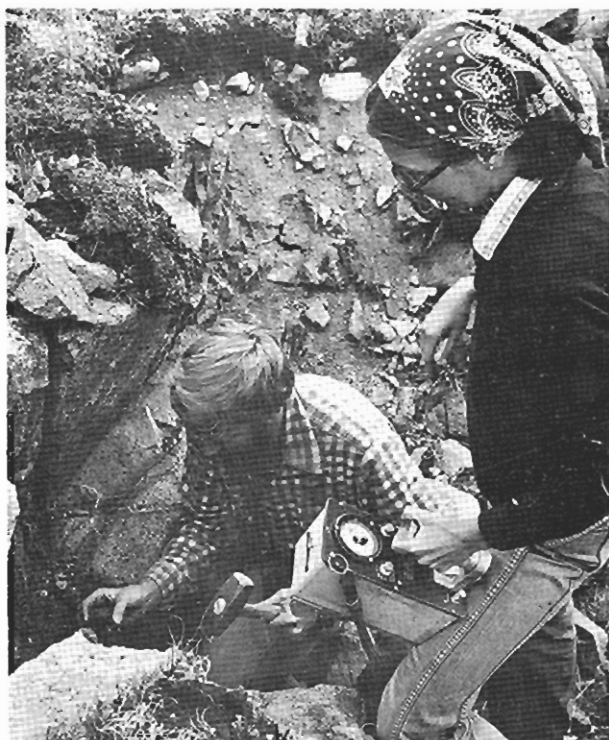
Dr. Donald Langmuir of the Colorado School of Mines will study in detail the chemistry and radiochemistry of ground waters from two known uranium districts in the western and southwestern United States. The chemical data, along with measurements of physico-chemical parameters such as Eh, pH, and temperature, will be fed into a computer program to determine what solution-mineral equilibria may be controlling transport and deposition of uranium in each area and the extent to which the waters are saturated with respect to uranium minerals. This thermodynamic approach may lead to markedly improved detection of blind uranium deposits from ground-water data.

Results of this project are to be published in an open-file report in 1980.

Uranium Distribution in Fluorine-Enriched Volcanic Rock

- Subcontractor: Arizona State University
- Subcontract Value: \$78,786
- Start Date: 1 January 1979
- Completion Date: 29 February 1979

Fluorine-enriched silicic volcanic environments in the western United States generally show uranium enrichment when compared to other volcanic terrains. As such, fluorine-enriched volcanic environments provide excellent source rocks for secondary uranium mobilization into



peripheral volcanoclastic and sedimentary environments. With primary petrochemical enrichment, various depositional facies of the volcanic terrain 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 have been studied where there are known occurrences of fluorine-enriched volcanics and (or) topaz-bearing rhyolite.

At Spor Mountain, the principal investigators, Drs. D. M. Burt and M. F. Sheridan, will integrate pre-existing 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 fluorine-enriched volcanic rocks. 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 Proterozoic Metamorphic Rocks

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

Sedimentation of the basal Kombolgie Formation (Upper Precambrian-Carpenterian), Northern Territory, Australia has possible significance in the genesis of the underlying Alligator Rivers unconformity-type uranium deposits.

Dr. R. W. Ojakangas of the University of Minnesota (Duluth) synthesized current data collected in Australia during field studies for the original contract.

The controversy surrounding the genesis of the major Australian deposits in the Northern Territory made these data important. A definitive position on their genesis cannot yet be made. Dr. Ojakangas has determined that paleocurrents, as indicated by sedimentary structures, Lower Kombolgie sandstone, and conglomerate, flowed down a paleoslope from west and northwest to east and southeast. The sediments reflect the tectonics to which the Kombolgie was subjected.

These facts are related by Ojakangas to the genetic theories.

Uranium in Accessory Minerals

- Subcontractor: Colorado School of Mines Research Institute
- Subcontract Value: \$82,296 (Amended: \$55,100)
- Start Date: 27 September 1978
- Completion Date: 31 January 1980

The analytical work on whole rock samples relating to known uranium occurrences has been completed and the Colorado School of Mines Research Institute has entered into the interpretive phase.

The study is part of the U.S. effort in collaboration with IAEA to answer in part the hypothesis that certain trace elements other than thorium may be reliable indicators of uranium districts.

CSMRI will conduct additional sampling and analyses when synthesis of the existing material indicates these efforts are warranted.

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 March 1980

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 will provide funds for Dr. R. S. Houston, University of Wyoming, and various team members of the Structural Union of Geophysical Societies Working Group on the Precambrian for the United States and Mexico to complete the work on chronometric relationships of Precambrian rocks started 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* in mid 1980.

Uranium Favorability of Calcretes

- Subcontractor: University of California at Los Angeles
- Subcontract Value: \$111,300
- Start Date: 21 June 1976
- Completion Date: 31 January 1980

The original model study was open filed as GJBX-29(79). Further work has been done in South Africa to update the model, and this will be open filed in 1980.

Lacustrine Uranium Distribution

- Subcontractor: Lamar-Merrifield
- Subcontract Value: \$20,600
- Start Date: 18 October 1978
- Completion Date: 18 October 1979

The Kern Lake, California study produced a number of surprising results in regard to uranium and thorium deposition in the lacustrine environment. Contrary to expectations, thorium highs were encountered in mid lake. Uranium dissemination does not follow expected patterns with relation to solutions entering the lake via the Kern River with its relatively rich source rocks, such as those found at the Miracle Mine.

The report, to be open filed in 1980, will give the results of a detailed geochemical survey of the lake and its environs. The investigators were able to utilize trenches opened up by the USGS in the course of its Microseismic Studies.

Uranium in Red Muds

- Subcontractor: Zellars-Williams
- Subcontract Value: \$44,500
- Start Date: 12 September 1978
- Completion Date: 12 April 1980

The Red Mud residues from aluminum production have been analyzed for uranium and thorium content.

The results of this program indicate, by reason of the tremendous volumes of material and a possible 30 ppm uranium content, that these residues are a potential low- to intermediate-grade uranium resource. The study indicates that there is a by-product potential with aluminum production not unlike that of phosphates. The study, to be open-filed in 1980, will assess the by-product potential and indicate the resources contained in the muds.

Regional Geology and Uranium Favorability in Alaska

- Subcontractor: Geophysical Institute, University of Alaska
- Subcontract Value: \$74,677
- Start Date: 3 August 1978
- Completion Date: 3 February 1980

Metamorphic terrains in the Seward Peninsula are included in a study of the tectonic evolution of Alaska. A total of 14 areas are being tested to ascertain if variations in uranium and thorium content have a correlative relationship between tectonic events.

Enriched and/or depleted uranium/thorium provinces, therefore, can be identified and rank ordered on the basis of developed uranium favorability criteria.

Study of Uranium- and Thorium-Bearing Pegmatites

- Subcontractor: Derry, Michener & Booth
- Subcontract Value: \$83,000
- Start Date: 1 October 1978
- Completion Date: 30 April 1980

In order to assess the uranium/thorium potential of individual pegmatites within the several pegmatite provinces in the U.S., a minimum of eight radioactive pegmatite localities are being sampled and studied in detail. From these studies favorability criteria are being developed which may be utilized in future economic studies of additional pegmatite localities within the U.S. and Canada.

Radioactive Mineral Deposits in Arizona

- Subcontractor: University of Arizona
- Subcontract Value: \$59,270
- Start Date: 1 September 1979
- Completion Date: 30 November 1980

The Arizona Bureau of Geology and Mineral Technology, a division of the University, is conducting a detailed inventory of the radioactive mineral occurrences in Arizona. The goal is to provide a complete synthesis of all available data and to locate and describe all known radioactive occurrences in Arizona. A complete report, to be published by the Bureau in late 1980, will summarize the present widely scattered data so that they will be more useful in the exploration for, and the development of, the radioactive minerals in Arizona.

Uranium in Granites of Southwestern North America

- Subcontractor: California Institute of Technology
- Subcontract Value: \$108,180
- Start Date: 20 August 1979
- Completion Date: 19 August 1980

Dr. Leon T. Silver of California Institute of Technology, is studying the systematics of the distribution of uranium, thorium, and radiogenic lead among the major, minor, and trace minerals of uraniferous and nonuraniferous plutonic suites of igneous rocks in southwestern North America. These studies will include petrogenetic, tectonic, and chemical characterization of and comparisons between high uranium (greater than 8 ppm) and low uranium (less than 4 ppm) plutons of similar geologic provenance. Representative plutonic rock suites will be identified from

middle Proterozoic and Cretaceous-Tertiary assemblages.

The final report will specifically highlight the geochemical behavior of uranium in both the primary and secondary portions of the geochemical cycle. The emphasis will be on those characteristics of plutonic rocks that indicate favorable uranium source- and host-rocks.

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 resource program is to confirm the location and apparent extent of such deposits and to develop basic information required to estimate their general magnitude and economics or practicability of uranium recovery.

Three studies were completed in FY79; all were related to the Chattanooga Shale, phosphates, and sea water.

Chattanooga Shale

- Subcontractor: Mountain States Mineral Enterprises, Inc.
- Subcontract Value: \$270,732
- Start Date: September 1977
- Completion Date: June 1979

As a follow-up to the work open filed as GJBX-4(79), a conference was held at Oak Ridge, Tennessee in order to discuss the referenced Mountain States report and to solicit recommendations relative to additional work. Proceedings of this conference were open filed as GJBX-170(79).

As a final phase of the Chattanooga Shale study, Mountain States identified immediate, short- and long-range programs, and/or strategies for the development and commercialization of the resource.

Phosphate Studies

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

Phosphates and phosphate rocks have been of continuing interest as a source of uranium and particularly in recent years with improvements in the technology for extraction. A resource evaluation of the uranium contained in these phosphate units in the United States and in the free world was completed and open filed as GJBX-110(79).

Seawater Project

- Subcontractor: EXXON Nuclear Co. Inc.
- Subcontract Value: \$309,307
- Start Date: 6 September 1978
- Completion Date: 10 March 1979

The Seawater project was conducted by EXXON Nuclear Co., Inc. It was completed in March 1979 and was reported in the NURE 1978 Annual Activity Report.

Asphaltite Project

A review of the USGS Professional Paper #454-G, *Uranium and Helium in the Panhandle Gas Field, Texas and Adjacent Areas*, published in 1964, has created renewed interest in asphaltite as a potential low-grade uranium resource. Late in 1979 DOE directed Bendix, using both Bendix geologists and subcontractor specialists, to make a preliminary evaluation of asphaltite in the Panhandle gas field.

The Texas Bureau of Economic Geology, working under an amendment to an existing subcontract from Bendix, has provided a report on stratigraphic occurrences of the asphaltite in the Texas Panhandle.

Geologic Map Compilation Program

- Subcontractors: approximately 20
- Subcontract Value: \$1,509,000
- Start Date: October 1977
- Completion Date: September 1981

The Geologic Map Compilation Program is designed to provide 1:250,000-scale geologic maps, not available from the USGS or state surveys, for use as data bases for all NURE program elements; 189 of the 621 NTMS NURE quadrangles were covered by acceptable published surface geologic maps with a scale of 1:250,000. The remaining 432 quadrangle maps are being compiled.

Through 1979, 232 maps have been delivered via NURE subcontractors. Of these, 101 were delivered during 1979, and 22 additional maps remain with subcontractors.

The major sources for the production of new 1:250,000-scale maps are previously published maps of various scales. These are checked for specification compliance, reduced or enlarged to 1:250,000 scale, and compiled. Geology is generated by aerial photography interpretation where gaps occur in the published sources. Field studies have not been used to produce or supplement map generation because of the tight schedule required by NURE.

Technology Applications

The Technology Applications element of NURE provides technical development, evaluation, and integration of new and improved techniques, methodologies and instrumentation for uranium exploration and resource assessment. Technology Applications encompasses the disciplines of geophysics, geology, physics, geochemistry, computer science, and electrical engineering. Bendix pursues this program with in-house professional specialists and subcontractor back-up services and experience. Continuing development and improvement in testing and evaluation of geophysical and logging instrumentation used in uranium exploration is one of the key program objectives. Technology integration, another key objective, is achieved by geophysicists, geologists, physicists, and geochemists combining to produce research and developmental data concerning: exploration and resource assessment strategies; ore genesis models; and definition and identification of uranium-associated halos. This research is carried out using evaluations of identified deposits in known geological environments having a variety of geological conditions.

In addition, technical support is furnished in electronics and geochemical analyses for the entire NURE program. Technical products of the program are transferred to the public via open-file reports, professional journals, and presentations at professional meetings and forums. The resultant program and budgetary categories for Technology Applications are identified as Technology Development and Evaluation, Technology Integration, and Technology Support.

Technology Development and Evaluation

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

Areas of broad interest in Technology Development and Evaluation include prompt and delayed fission neutron logging, gamma-ray spectral logging, radon and helium emanometry, and aerial radiometrics.

Technology resulting from these projects is made available to industry, other government agencies, and the general public via open-file reports, seminars, professional forums, and journal publications.

Uranium Borehole Logging with PFN

- DOE Contractor: Sandia Laboratories
- Subcontract Value: \$560,000
- Start Date: September 1978
- Completion Date: September 1979

Activity continued in two major areas: commercialization of the neutron generating tube technology and prompt fission neutron system refinement along with field work.

A subcontract issued by Sandia to Kaman Sciences Corporation, Colorado Springs, Colorado in mid 1978 continued with the objective of transferring Sandia's tube technology to the commercial sector. Phases I and II required the construction of 10 Controlatron tubes and five transformers with three tube transformer assemblies (TTA), respectively, and were successfully concluded. Phases III and IV, which are tied to the Zetatron tube (an improved version of the Controlatron) development, were deferred pending studies by Sandia and General Electric Neutron Devices on the system handling procedures for preloaded reservoirs. It is planned that Phase III work by Kaman to build 20 of the high output Zetatron tubes will resume in January 1980.

Improved prompt fission neutron (PFN) probes were completed and successfully tested. Of particular note was the elimination of a troublesome noise problem and the increase in epithermal neutron sensitivity. Late in the year, life testing of the neutron generating tube was initiated. Results of the testing will be available in early 1980.

Field work during the year using the PFN system was conducted in Texas, New Mexico, and Washington. The latter was by special arrangement with DOE's Hanford facility contractor Rockwell for PFN logging (for plutonium) at a waste disposal site near Richland. Also of note from the year's field work was the logging of mill settling ponds by dragging the PFN probe along the bottom of the ponds.

²⁵²Cf-Based Direct Uranium Logging System

- Subcontractor: IRT Corporation
- Subcontract Value: \$240,464 (Phase I)
\$531,329 (Phase II)
- Start Date: 1 June 1977 (Phase I)
- Completion Date: December 1979

Efforts during the year were directed at bringing the prototype development and field testing to an end. Costs incurred during the year amounted to \$32,342.

In summary the activities for the year included the completion of reduction/analysis of all remaining unanalyzed data and the delivery of the equipment and final report to Grand Junction.

During the latter part of 1978, field work was conducted in Texas and Wyoming and by special arrangement on DOE's Hanford facility located near Richland, Washington. These data were reduced, analyzed, and disseminated to the principals involved.

The first draft of the final report was received in late September and after some revision is scheduled for open filing in 1980. The system drawings were accepted in an "as is" condition and are available for inspection at GJO.

Based on this work, IRT designed and built a system for use in mineral exploration and announced the availability of a commercial "Delayed Neutron Logging" service late in 1979. The photo on page 65 shows the commercial system at the time it was calibrated in the fission neutron models in Grand Junction

Borehole Neutron Activation Analysis (NAA) for Uranium Associated Elements

- DOE Contractor: Sandia Laboratories
- Contract Value: \$220,000
- Start Date: 1 January 1979
- Completion Date: February 1983

The goal of this work is to develop a gamma-ray spectroanalysis probe that assays for elements which are associated with uranium deposits. It is envisaged that this probe, when developed, will be used in concert with other prospecting techniques in a systems approach for the identification of locations favorable to uranium mineralization. The principles involved in the probe concept include the generation of 14 MeV neutrons, the resulting propagation and subsequent capture of these neutrons by formation elements, the time and spectrally resolved detection of both capture and delayed gamma-rays emitted by the capturing atoms, and a reduction of the data culminating in an elemental analysis of the formation.



Chemist inserting boat in LECO sulphur analyzer at the Grand Junction laboratory.

After consulting with experts from the U.S. Geological Survey and the National Aeronautics and Space Administration, a specification was put together and a request for proposal (RFP) was issued. The basis of the RFP was a cooled high purity germanium detector with a preamplifier, amplifier, and high voltage circuits, all to be housed in a 2.5-inch (63.5 millimeter) outer diameter probe. Subcontract award was made to Ortec Inc. in Oak Ridge, Tennessee.

Borehole Neutron Experiments

- Subcontractor: Science Applications, Inc.
- Subcontract Value: \$44,350
- Start Date: December 1977
- Completion Date: October 1979

The measurement program for this project, a joint effort with Science Applications and BFEC personnel, is now complete and the report, GJBX-165(79), was open filed in December 1979.

The first phase was an experimental evaluation of a fast fission source monitor that measures the pulsed 14 MeV neutron output from direct uranium borehole logging probes. The ^{238}U -lined proportional counters used as the monitor detect only neutrons with energies above the fast fission threshold at about 1.5 MeV. Results indicate that the fast fission counter functions well as a 14 MeV neutron monitor and is relatively insensitive to variations in borehole conditions and to other variations in the surrounding neutron scattering medium. Additional tests are required to further evaluate this source monitor concept.

The second phase of the project required a series of benchmark neutron flux measurements to verify results of a previous calculative study on the performance of fission neutron direct uranium logging probes. Absolute neutron flux measurements for both ^{252}Cf and 14 MeV sources are in agreement with the calculative results reported previously in GJBX-44(77) and GJBX-52(79).

Borehole Neutron Correlation, Phase II

- Subcontractor: Consolidated Controls Corporation
- Subcontract Value: \$53,350
- Start Date: 17 May 1979
- Completion Date: 17 August 1980

Experiments are being conducted to test the associated particle technique for uranium exploration with probes containing neutron generators. Utilizing this technique, the alpha particle, emitted as a result of the reaction in the generator, is monitored to provide information on

the time and direction of neutron emission. Gamma rays and neutrons from the neutron-induced reactions in the formation are subsequently detected and correlated with the initial neutron emission.

The experiments are being conducted in a laboratory using simulated sandstone formations containing known amounts of uranium. The results will be used to test theoretical calculations from Phase I of the project and to determine the feasibility of the technique for uranium exploration.

Gamma-Gamma Transport Calculations

- Subcontractor: Science Applications, Inc.
- Subcontract Value: \$69,833
- Start Date: April 1979
- Completion Date: May 1980

This calculative study by Science Applications employs state-of-the-art Monte Carlo radiation transport techniques to investigate the gamma-ray backscatter principle as a direct uranium logging method. With this technique the study will also determine the sensitivity of formation density measurements to variations in borehole diameter, fluid, rugosity, and mud cake conditions and will determine probe design parameters.

Four of the eight Monte Carlo calculations are complete. Each calculation models the probe and borehole geometry in great detail and predicts the probe signal as a function of source-detector spacing, uranium ore grade, detected gamma-ray energy, source emission angle, detector incident angle, and formation sampling depth.

When complete, the data base of results will be implemented on the GJO CDC 6600 computer system. A user's program will permit the use of this data base in solving calibration and design problems for gamma-ray backscatter borehole probes.

A final report for this project will be open filed in 1980.

Spectral Gamma Evaluation/Refinement

- Ongoing in-house project

Bendix has a continuing project to improve data-reduction and correction procedures for spectral gamma-ray logs. This project also seeks to improve hardware used for collecting borehole data.

The Grand Junction calibration models are used in conjunction with borehole probes to provide

data for the studies. Results have helped to better characterize these models and to provide understanding of data collected in the field by the Bendix logging personnel.

The work this year was concentrated in the following areas: energy stabilization methods, tests of commercial portable spectrometers, log deconvolution with the inverse digital filters, and interpretations of high resolution gamma-ray transport calculations.

A gamma-ray logging workshop is planned for 1980 to discuss the results of the investigations and to confer with industry representatives. After the workshop a report on the studies will be open filed.

Intrinsic Germanium Probe Evaluation

- Ongoing in-house project in cooperation with the USBM, Princeton Gamma-Tech, and CONOCO

This project to evaluate high resolution intrinsic germanium probes for direct uranium logging began in 1978 as a cooperative effort between the DOE/GJO and the USBM/Denver. The germanium probe fielded by Princeton Gamma-Tech and the fission neutron probes developed by IRT, Sandia, and Century Geophysical logged a set of 30 test holes in south Texas.

The test holes exhibited a wide range of uranium grades and uranium/radium disequilibrium conditions. Extensive core analyses were performed by BFEC to characterize the composition and physical properties of the test holes. All core and logging results have been written to a computerized data base. The data base was then exercised to produce various comparison plots and other forms of data evaluation for the several direct uranium probes.

Calculation of the grade-thickness product for each ore zone and sonde type shows that the logging results are widely dispersed about the values obtained from the core assays. Results for the IRT sonde are systematically lower than core results, the Century sonde severely overestimates the grade thickness product for very low grade zones, and the PGT sonde exhibits a systematic trend toward underestimating grade thickness for higher grade (>1,000 ppm) ore zones. The Sandia sonde shows no such systematic trends but seems to agree better with core results at the higher grades (1,000 to 2,500 ppm range). Neglecting the very large discrepancies observed, for example, with Century's sonde at low grades, or with IRT's sonde when malfunction was suspected, the four direct

uranium logging sondes exhibited similar dispersions about the core results.

Approximately 50 percent of the time the logging sondes are within ± 30 percent of the core results while about 75 percent of the time they are within ± 50 percent. A certain amount of this dispersion is due to the unfavorable borehole conditions and to the variety of host environments sampled.

Complete project results will appear in an open-file report to be published early in 1980.

Intrinsic Germanium Probe

- Subcontractor: Princeton Gamma-Tech
- Subcontract Value: \$44,374
- Start Date: 13 June 1979
- Completion Date: 15 December 1979

A borehole probe for use in the DOE calibration models was built by the subcontractor for use by Bendix. The probe contains an intrinsic germanium detector which is cryogenically cooled during operation and warmed to room temperature during storage.

The germanium detector provides high resolution gamma-ray spectra from the calibration models. The spectra are superior to those collected by scintillation detectors such as sodium iodide because there is much less overlapping of gamma-ray signals from the various radioactive elements in the models. Data from this probe will be used to obtain correlations of the grades in the calibration models.

Computation and Nondestructive Assay Methods

- Subcontractor: Los Alamos Scientific Laboratory
- Subcontract Value: \$200,000
- Start Date: October 1976
- Completion Date: December 1980

In 1979 the Los Alamos Scientific Laboratory (LASL) completed a program of theoretical spectral gamma-ray flux calculations for three distributions of rock with gamma-ray source material: (1) an infinite, homogeneous rock medium, (2) two "semi-infinite," homogeneous media, air and rock, separated by a plane interface (airborne model), and (3) an infinite, homogeneous rock medium which is penetrated by a borehole (borehole model). In each case, the simulated gamma-ray fluxes were generated in the rock by uniform concentrations of potassium-40, uranium-235, uranium-238, thorium-232, and radioactive elements in the decay chains. Secular equilibrium was assumed for all decay series.



Commercial version of IRT delayed neutron logging system.

Previously developed sodium iodide detector response calculations were refined and convolution methods were formulated to enfold the calculated detector responses with the calculated gamma-ray flux spectra. With these results, pulse-height spectra can be calculated for simulated airborne surveys or logging runs. The borehole model calculations allow for variations in borehole diameter, borehole fluid (air or water), borehole casing composition and thickness, sonde wall thickness, and rock bulk density, porosity, and saturation. The calculations can therefore be used to predict the effects of these parameter variations on gamma-ray logs. In the airborne model, the effect of aircraft height on the survey can be investigated.

Comparisons between calculated results and experimental data demonstrated the accuracy of the borehole calculational methods. Flux calculations, detector response calculations, and enfolding calculations were performed for potassium, uranium, and thorium source material surrounding a 1.5-inch by 9.0-inch (3.8 centimeter by 22.9 centimeter) sodium iodide detector in a borehole. The calculations utilized source and borehole parameters from the DOE K, U, and T borehole calibration models at Grand Junction. The calculated pulse-height spectra were in excellent agreement with data collected by BFEC with a 1.5-inch by 9.0-inch (3.8 centimeter by 22.9 centimeter) sodium iodide detector in the K, U, and T borehole calibration models.

LASL completed a series of gamma-ray transport calculations for a gamma-gamma-type sonde in a borehole. This sonde was designed to obtain accurate uranium assays in formations characterized by uranium/radium disequilibrium. The calculations imply that the uranium K-shell x-ray fluorescence signal can be utilized

to detect disequilibrium and obtain the desired uranium assay.

A sonde that employs a photoneutron source has been designed and is being evaluated for direct uranium detection through fission neutron logging. Photoneutrons will be generated in the sonde by gamma-ray bombardment of beryllium. This is accomplished through the mechanical coupling of an antimony-124 gamma-ray source with a beryllium target. Neutron radiation safety problems are alleviated by the fact that neutron generation terminates upon separation of the gamma-ray source from the target. A prototype sonde is now undergoing borehole tests.

In 1979 a report entitled *Nondestructive Assay Technology for Uranium Resource Evaluation: Infinite Medium Calculations Final Report*, GJBX-85(79), was placed on open file. It describes gamma-ray flux calculations for infinite, homogeneous rock media.

R&D Logging Vehicle

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

The purpose of this project is the construction of an R&D logging vehicle. Fabrication of the vehicle's logging cabin, draw works, and boom was completed by Energy Products, Ltd., of Fort Worth, Texas. The installation and checkout of electronics systems, including a Data General Nova 3/12 minicomputer, was completed by Bendix personnel. The vehicle will support Bendix R&D work in borehole logging techniques and geophysics. Major projects that make use of the vehicle are gamma-ray spectral logging (including KUT), prompt fission neutron (PFN) logging, and magnetic susceptibility (MS) logging. It also provides caliper, total gamma-

ray, neutron-neutron, resistivity, self potential, and gamma-gamma density measurements for ancillary information.

With the on-board minicomputer, the vehicle will support borehole instrumentation R&D with exceptional data taking and processing capabilities. It has supported gamma-ray spectral studies and MS work in Colorado, Wyoming, and Utah. PFN demonstrations began in December 1979.

Fiber-Optic Logging Cable Development

- Subcontractor: Optelecom Inc.
- Subcontract Value: \$91,306
- Start: October 1978
- Completion Date: 1 March 1980

A fiber-optic borehole logging cable will increase the data-transmission capabilities of logging systems many times over the industry standard, four-conductor, logging cable. The objective of this project is to develop a fiber-optic logging cable system that includes a 1,000-foot (305 meter) length of fiber-optic cable containing three optical fibers, three copper conductors, and two armored layers, having the same mechanical characteristics as a standard four-conductor logging cable. Cable termination assemblies and interface electronics are provided to: transmit digital data through the optical fibers from borehole electronics to the surface, transmit control data from the surface to borehole electronics via an optical fiber, and power the probe using the copper conductors.

Construction of a 400-foot (122 meter) 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 scheduled for open filing.

Borehole Data Transmission and Acquisition System (BDATS)

- Subcontractor: Science Applications, Inc.
- Subcontract Value: \$100,000
- Start Date: 17 December, 1979
- Completion Date: November 1980

Digital data transmission of borehole probe signals will provide a much needed improvement over analog data transmission techniques. This is especially true when pulse-type signals and large quantities of data are to be transmitted across long lengths of standard logging cable.

This subcontract provides for construction of a prototype BDATS that utilizes digital data transmission and acquisition techniques.

The system will include a downhole electronics package that contains a 16-channel analog-to-digital converter, six pulse counters (scalers), two multichannel scalars (MCS), a four-bit digital I/O interface, a high speed serial interface (for a pulse height analyzer), and a high speed modem to transmit data from the above mentioned acquisition components to the surface. At the surface, a mating modem and minicomputer interface will be provided and placed in the Bendix/DOE R&D logging vehicle.

A report and documentation will be provided by the subcontractor.

Phoswich Airborne Detector

- Subcontractor: Grumman Aerospace Corporation
- Subcontract Value: \$253,492
- Start Date: 27 April 1976
- Completion Date: February 1980

Based on a study of possible Phoswich detector configurations, Grumman Aerospace has fabricated a hybrid Phoswich detector that is expected to have a greater sensitivity for uranium than a sodium iodide detector by about 50 percent for equal volume or weight systems. The configuration selected should also provide information concerning atmospheric radon and topographic changes. The hybrid detector has a sodium iodide main crystal, a cesium iodide back crystal, and a sodium iodide annulus. Testing of the detector in the laboratory and in flight has been accomplished. The flight program consisted of collecting data on: the Walker Field Pads, the Dynamic Test Range, and a portion of the Lubbock Quadrangle. Preliminary results indicate that each of the two Phoswich detectors tested have a spectrum with a reduced background level in the region of the uranium peak that gives an effective sensitivity improvement of approximately 50 percent. The testing also established the directionality of the detector system since a nonuniform radiation field can readily be ascertained by the ratio of the total counts from the annulus crystal to the total counts from the central crystal. The results of this project are scheduled for open filing in 1980.

Spectrum Enhancement (Phase II)

- Subcontractor: Science Applications, Inc.
- Subcontract Value: \$141,149
- Start Date: 1 February 1977
- Completion Date: 31 May 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. Also, the technique is capable of revealing previously hidden spectral features which will be helpful in making corrections for the presence of airborne bismuth-214, vegetation, and overburden.

As announced in the NURE 1978 Annual Activity Report, results of the study were published in report GJBX-169(79) which includes: (1) an evaluation of the technique, as a function of counting statistics, (2) an investigation of the ground moisture and ground cover effects on the aerial gamma-ray spectrum, (3) an analysis of corrections for nonlinearities in sodium iodide (thallium drifted) data, (4) a fast running version of the computer code, (5) the conceptual design of a new data-filtering technique for aerial data, and (6) a comparison of MAZE techniques to conventional processing methods.

Subcontractor's MAZE Code

- DOE Contractor: Science Applications, Inc.
- Subcontract Value: \$212,398
- Start Date: 4 June 1979
- Completion Date: June 1980

With the successful conclusion of the Spectrum Enhancement Phase II Project, this effort was begun in order to prepare for implementation of the spectrum enhancement (MAZE) technique. The study is organized into two tasks. First is the final development and demonstration of a temporal filtering technique conceptually developed under the Phase II project. Second is to assemble computer codes for determining detector response functions of typical aerial radiometric detectors into a user oriented package.

Both tasks are required to transfer all codes to a minicomputer. The HP 1000/45 has been chosen as the representative minicomputer since one is available to BFEC. Converting codes of tasks one and two to the HP 1000/45 is still in progress. The planned code performance tests and demonstrations toward code evaluations and processing of radiometric data should begin in early 1980.

Vertical Radon Propagation

- Subcontractor: Radiation Research Associates, Inc.
- Subcontract Value: \$168,488
- Start Date: 31 January 1978
- Completion Date: 30 November 1979

Data acquisition under this subcontract has been completed. A relative cost advantage was realized by locating the radon detectors at

various levels on a commercial 1,500 foot (457 meter) tall RF transmission tower and using local labor to maintain the instrumentation over the 3-month emplacement period.

When open filed in early 1980, the final report will provide knowledge of the near-earth distribution of radon during seasonal variations as well as the effect of microscale weather patterns on its concentration and stay time.

In addition, the report will promulgate much needed information for developing more accurate techniques to account for radon daughters and further improve subsequent model calculations. A data summary from current literature has been prepared and will be included in the final report.

Effect of Vegetation

- Subcontractor: Radiation Research Associates, Inc.
- Subcontract Value: \$25,657
- Start Date: 29 September 1978
- Completion Date: 30 November 1979

This effort examined the magnitude of the vegetation effect on natural gamma transport. Ground cover biomass and tree/tree-root biomass were modeled using both one and three dimensional analyses. Their effect on the angular distribution of ground emanating gamma-rays was also quantified. Preliminary results verify that vegetation reduced the field of view of aerial spectrometers and that the sensitivity can be reduced by a factor of two. Complete results of this study will be open filed in 1980.

Statistical Techniques Applied to Aerial Radiometric Surveys (STAARS)

- Ongoing in-house project

STAARS is an in-house project designed to develop independent computational tools for the interpretation of NURE aerial radiometric survey data. Techniques such as principal components analysis, discriminant analysis, trend surface generation, robust outlier evaluations, and maximum sequential variance analysis are some of those now in operation. Additional techniques including regression analysis, nonparametric analysis, and various forms of spatial filtering are being evaluated. Both binary and dynamic clustering algorithms are also under development. Publications of software developed under this project will be produced as each method completes test and evaluation; also, publications illustrating each technique applied to geological interpretation will be prepared.

Training Area Studies

- Ongoing in-house project

The Training Area Studies project is designed to provide a case study vehicle by which interpretation methods developed under the STAARS project will be applied to specific uranium depositional environments. Training area sites now include Copper Mountain, Wyoming, the Bear Lodge Mountains area of Wyoming, the central portion of the Powder River Basin, Wyoming, and the southeast Texas Gulf Coast area. Additional training area sites will include the Big Bend region, Texas, the McDermitt Caldera area of Nevada, and the Date Creek area of Arizona. The first of several reports on this work is scheduled to be completed late in the summer of 1980.

Airborne Data Evaluation

- Subcontractor: G-Cubed, Inc.
- Subcontract Value: \$156,000
- Start Date: 1 August 1978
- Completion Date: 15 October 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 hydrochemical and stream-sediment reconnaissance data for the quadrangle and correlation of the results with the survey interpretation. Open-file report GJBX-135(79) is a result of this study.

Two exploration models are proposed. The first and most obvious involves the basal Dockum (Triassic) sandstone while a second more speculative model was derived from the NURE data by integrating NURE aerial radiometric, NURE HSSR, subsurface geologic, and ground geologic and geochemical data.

The report concludes that the NURE data sets, when coupled with that normally integrated into exploration programs, can be used in this area to generate exploration models.

Crystal City/Beeville Geochemical Analysis Models

- Subcontractor: Rice University
- Subcontract Value: \$70,341
- Start Date: 1 June 1979
- Completion Date: 31 March 1980

The objective of this project is to: (1) obtain an independent expert assessment of the utility of the NURE aerial survey open-file report, (2) obtain an independent expert assessment of the utility of the NURE aerial survey data, and (3) investigate various techniques by which NURE aerial reconnaissance survey data may be used to characterize the radioelement distribution of six formations from the study area.

Completion of this project will lead to an open-file report in 1980 that will include a map showing relative uranium favorability in the Crystal City and Beeville, Texas NTMS Quadrangles. This favorability may be expressed in terms of dollars per square kilometer of exploration costs and will be based on aerial radiometric data, hydrogeochemical data, formation characterization, and drilling depths involved. Also in the report will be a geochemical model which fits the radiometric characterizations developed. This model will be validated through "ground truth." Hydrogeochemical, stream-sediment, and aerial reconnaissance data will be included in the model and any inconsistencies between the model and the aerial radiometric data will be addressed.

Preliminary results indicate that the data in the open-file reports have identified, on a relative basis, the granitic provenance factor in the Quaternary alluvium and barrier island part of the Beaumont Formation and even in the Beaumont proper, assuming that almost all of the Beaumont in the study quadrangles is radiometrically dominated by clastics from the Precambrian of central Texas.

Geophysical Interpretation, Big Bend Area, Texas

- Subcontractors: University of Texas at El Paso
Purdue University
University of Texas at Dallas
- Subcontract Value: \$111,161
- Start Date: 19 September 1978
- Completion Date: 19 September 1980

The major objective of this study is to prepare a geological interpretation of geophysical data in the area of the Marfa, Emory Peak, Presidio, and Fort Stockton Quadrangles in west Texas for controls on the distribution of observed uranium and thorium resources. A secondary objective of this study is to evaluate and illustrate the use of geophysical data derived from the NURE aerial radiometric and magnetic surveys. Special emphasis is placed on the utility of analytical methods to derive magnetic maps from the original magnetic anomaly data by computer processing.

A major product of this study will be regional gravity and magnetic maps of the area as well as an integrated analysis of geochemical sampling from NURE HSSR surveys and other ground truth sampling. This study will provide a regional geophysical and geochemical interpretation as background for detailed aerial radiometric and HSSR surveys now being conducted in the Big Bend area of Texas. A report will be open filed in late 1980.

Reconnaissance Magnetics Interpretation

- Subcontractor: QEB, Inc.
- Subcontract Value: \$54,849
- Start Date: 23 October 1978
- Completion Date: 15 November 1979

The aerial gamma-ray spectrometer surveys subcontracted under the Aerial Radiometric Reconnaissance element of the NURE program include a collection of aeromagnetic data. The surveys are designed for the collection of high quality radiometric data and are not limited by some of the normal constraints of 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 for possible use in evaluating uranium resource potential. As part of the study the quality of NURE-collected aeromagnetic data will be assessed and calibration procedures and checks recommended.

An open-file report on this study is planned for 1980.

Video Image Enhancement

- Subcontractor: University of Wyoming
- Subcontract Value: \$119,925
- Start Date: 1 April 1975
- Completion Date: 15 December 1979

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

As a result of the first modification, LANDSAT imagery was analyzed and interpreted for nine areas in the southern and western United States, selected by Bendix and DOE geologists. Different procedures were used in each area, depending on specific problems and objectives.

Lithologic distinctions and detection of altered zones were accomplished with spectral processing; edge enhancement and contrast stretching were used as aids for structural interpretation. A detailed presentation of this work is available in open-file report GJBX-137(78).

As a result of the second modification, LANDSAT imagery and aerial photography were shown to be useful for mapping areas of altered sandstone associated with roll-front uranium deposits. Image data must be enhanced so that spectral contrasts related to alteration can be seen through masking contrasts of soil moisture and vegetation. For LANDSAT data, the ratio of band 7 to band 4 produces the best enhancement of altered sandstone. The ratio of 6 to 4 is most effective for color infrared aerial photography.

Samples collected at the Pumpkin Buttes uranium district show that iron, in the form of an oxide stain on sand grains, is the primary coloring agent which makes alteration visually detectable. Statistical analyses show that the detectability of geochemical and color zonation in host sands is weakened by soil-forming processes. When alteration can be mapped in areas of thin soil cover and moderate to sparse vegetative cover, it often is a good indicator for roll-front uranium deposits. These results are presented in GJBX-171(79).

Imagery Pattern Recognition

- Subcontractor: Earth Satellite Corporation
- Subcontract Value: \$108,700
- Start Date: July 1978
- Completion Date: December 1979

The purpose of this subcontract was to investigate the application of texture measures and displays to uranium exploration, using data from the LANDSAT series of spacecraft as the primary information source.

Six training sites were selected, consisting of Copper Mountain (Wyoming); Pumpkin Buttes/Kaycee (Wyoming); Grants (New Mexico); Rössing (Namibia); Marysville (Utah); and Beaverlodge (Saskatchewan). For each of these sites, texture measures and/or texture displays were generated, and where possible, discrimination functions were developed to separate known uraniumiferous areas from areas of unknown uranium content.

The analysis was applied to the original LANDSAT spectral bands, to all eigenbands (linear combinations of the original bands), and to band ratios (visual inspection only). The basic data sources for all analyses were the LANDSAT Computer Compatible Tapes.

Of all data and all texture measures, the most successful results were obtained by plotting measure pair, Inverse Difference Moment against Angular Second Moment applied to the third eigenband of the LANDSAT data. Use of this measure pair permitted separation of uranium from nonuranium in certain geological settings (particularly Pumpkin Buttes/Kaycee) but was unsuccessful in others.

Attempts to develop general discriminants by extending calculated discrimination curves across LANDSAT frame boundaries were unsuccessful. This lack of success in jumping boundaries is attributed to variations in LANDSAT images caused by changes in sun angle, atmosphere, and season from one frame to another.

The use of texture displays as a tool for analysis showed hints of correlation with uranium occurrences but the resolution of available data limited the strength of this inference. Generally speaking, texture and enhanced lineament displays are still too crude to enable any real correlation with uranium to be demonstrated or denied.

Although the results cannot be described as providing a new tool for uranium exploration, it is evident that computed texture measures are describing some element of the LANDSAT data source that cannot be readily observed or analyzed by visual interpretation. The success of eigenband-3 is less surprising, since other evidence exists suggesting that such a band should be relevant to image textures.

It is concluded that the experiments would be worth pursuing further only in areas with selected geological settings, such as that of Pumpkin Buttes. In addition, portions of this work should definitely be repeated as soon as the higher resolution data of LANDSAT-D becomes available. There were sufficient data to indicate that texture cannot be discounted as a basis for classifying terrain in terms of uranium-bearing potential.

A detailed presentation of this work, including LANDSAT imagery in microfiche format, is scheduled for open filing in 1980.

Emanometry

- Ongoing in-house project

Emanometry is defined as the measurement of the gases, radon and helium, which are produced by uranium. It is expected that radon and helium gases can migrate from their source to provide broader exploration or assessment tar-

gets than uranium itself. Bendix is conducting a program to determine the relationship between these gases and mineralization. The influence of geologic controls, environmental conditions, and migration processes on the emanometric patterns measured will also be determined.

Detailed surface sampling programs at three known uranium occurrences (Red Desert and Copper Mountain in Wyoming and Spokane Mountain in Washington as covered in detail in the Technology Integration section) indicated that both radon and helium concentrations in soil correlated with the known mineralization at depth, and that these gases may be used to locate drilling targets. Subregional sampling programs at the three sites demonstrated that a major component of a radon or helium signal is related to lithology and/or structure. Due to physical differences between radon and helium, these gases are affected differently by the same geologic environment and exhibit different spatial patterns. Areas of overlap between anomalous radon and helium signals may be a more successful approach to indicating areas for detailed follow up than either single gas measurement.

Ground water samples collected from boreholes at the same three sites indicated that radon can provide a strong indication of mineralization, both vertically and horizontally, sufficient to distinguish a near-miss drill-hole condition. The helium concentration in the ground water samples was more subtly indicative of near mineralization. An elevated helium concentration was usually found in ground water down dip from an accumulation. Thus, the helium concentration in ground water may provide information concerning updip mineralization. Further sampling at these sites has been performed to confirm these observations. Also, ground water samples have been collected for radon and helium analysis from boreholes near a known deep deposit in the Grants Mineral Belt, New Mexico.

Reports on the results of this project will be submitted for open filing during 1980.

Helium Surveying

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

Helium surveys have been performed over three areas of known 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. (These test sites are also discussed in the Technology Integration section.) Sampling was repeated over the Red Desert site during the winter months of 1978 and early spring of 1979 to determine the seasonal effects on the helium surveys.

Results of the two Red Desert surveys indicate that the helium in soil values obtained from samples collected during early spring were much lower than the identical survey completed during the previous summers. Correcting the soil helium for biogenic effects and residual soil gases indicated results of both surveys correlated to the known uranium occurrence.

The helium anomalies found in soil samples reflected the presence of the known deposits at both the Red Desert and Copper Mountain sites. At Spokane Mountain, the pattern of soil helium values was ambiguous although the presence of a fault that transects the mineralization was highlighted by the helium values.

Helium contained in soil samples proved to be the best method for surveying. The helium anomalies measured in soil gas were found to be weaker than the helium in soil. Helium signals in water showed higher anomaly contrast except at Spokane Mountain but sources of water samples are not as readily available as the soil samples along a systematic grid pattern.

Copies of the open-file report will be available in 1980.

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

- Subcontractor: Teledyne Isotopes
- Subcontract Value: \$141,000
- Start Date: 19 August 1977
- Completion Date: March 1980

Radon and helium gases are produced via the decay of uranium. Presumably these gases, created by an orebody at depth, migrate to the surface where they can be detected, and when combined with a knowledge of favorable geologic characteristics, will aid in locating the orebody. The primordial gas argon-36 is assumed to be stable in abundance throughout the earth. Thus, the concentrations of argon should reflect the local variations in soil gas and the ratio helium-4/argon-36 should not be sensitive to meteorological conditions or changes.

This project includes sampling three different areas of known mineralization. They include a

sandstone environment at the Red Desert in Wyoming, a granitic environment at Copper Mountain, Wyoming, and a metamorphic environment at Spokane Mountain in Washington. (These test sites are discussed in the Technology Integration section.)

Results indicated the helium-4/argon-36 ratio did eliminate local variations in the soil-gas values.

At the Red Desert site radon showed minimal excess in surface gas samples but excess ^{210}Pb was present and correlated with ore location. In vertical profiles most of the gas and water samples were deficient in ^{222}Rn but excess was found 46 feet (14 meters) above the ore zone at a level 230 times that expected from in-situ emanation.

Dissolved ^{222}Rn in ground water was mobilized by induced pumping of fluids in a drill hole, thus suggesting a technique for enhancing the effective sampling radius at chosen depth.

The presence of excess ^{210}Pb in surface samples and in vertical profiles suggests that it may be an ore indicator although statistical variation at low concentrations and absence of measurements in true background locations limit a conclusive interpretation. The ^{210}Pb values from soil samples correlate well with near surface uranium concentrations at all the sites.

Complete results of this study are scheduled for open filing early in 1980.

Numerical Modeling of Radon and Helium Migration

- Subcontractor: Teledyne Isotopes
- Subcontract Value: \$95,750
- Start Date: 26 September 1976
- Completion Date: January 1980

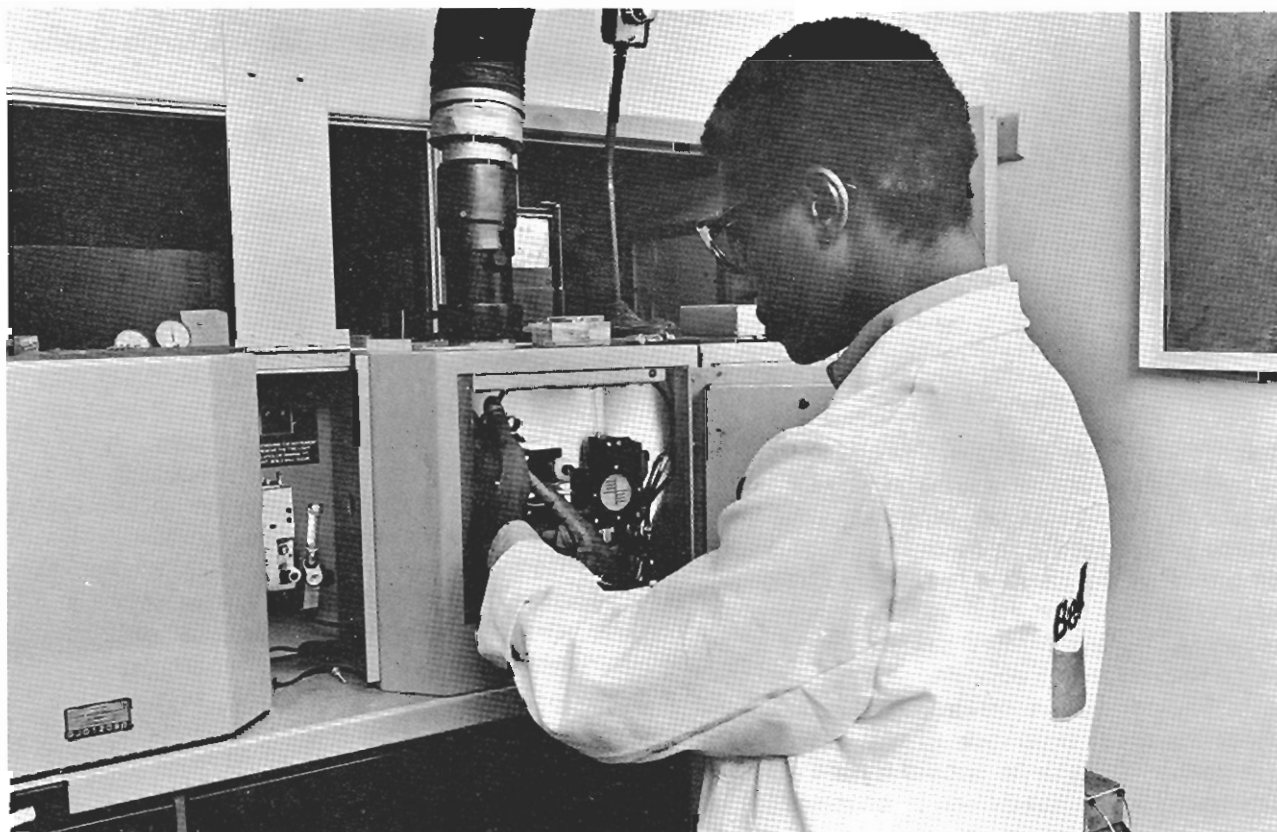
Phase I of this project was reported in the 1978 NURE Annual Activity Report and in GJBX-67(79). Phase II started in late 1978 and will be completed in FY80 with an open-file report. The project involves the development of one-dimensional mathematical models to simulate the transport of the radon and helium gases away from uranium mineralization. The resulting concentrations of indicator nuclides in the soil are used to infer the detectability of buried uranium deposits by emanation methods.

In the case where there is a nonradioactive overlying formation, radon and some of its daughter products are calculated to be detectable at distances of several tens of meters from a planar uranium deposit. When the overlying rock-sediment column is assumed to contain 4 ppm

uranium, the masking effect of locally produced radon reduces the detection range to less than 33 feet (10 meters). Models of helium diffusion in rock yield highly uncertain results because measurements of diffusion coefficients in actual rock types are lacking and because the flux of helium from deep within the earth is generally unknown.

Inhomogeneity in a rock-sediment column is simulated by multiple-layer models. Each horizon may be assigned uranium and thorium concentrations as well as a diffusion coefficient and physical properties. Results are in reasonable agreement with the subsurface distribution of radon and some of its daughter products at a site of known mineralization in central Wyoming.

Barometric influences on gas transport are simulated by time-dependent numerical models. Sinusoidal variations in atmospheric pressure cause sinusoidal changes in gas concentrations which are attenuated with increasing depth. The effect is less than ± 15 percent near the soil surface for radon while helium exhibits a maximum variation of 0.4 percent.



This new emission spectrometer is capable of analyzing up to 64 elements per analysis.

Radon Emanation Studies

- DOE Contractor: General Electric Co.
- Subcontract Value: \$159,940
- Start Date: 1 April 1977
- Completion Date: July 1979

In order to determine the nature of radon signals, field and laboratory experiments were performed by General Electric. The field work was carried out at a known occurrence at a depth of 328 feet (100 meters) in New Mexico. Extensive monthly near-surface integrated radon measurements were made. These measurements, which were made insensitive to thoron, moisture, and heat, can be reproduced within 22 percent. The median radon value was remarkably constant and no seasonal effect was perceivable. Monthly variations of the high and low radon values do not correlate with large-scale weather variations. An interpretation of these temporal variations acknowledges that they are produced by upflows and downflows of gas from unknown depths. The observations are compatible with vertical velocities in the range of 1 to 2×10^{-3} centimeters/second, which would be sufficient to transport significant radon signals from ore at 98 to 164 feet (30 to 50 meters) below the surface. Downhole radon and permeability measurements were made at the field site. One region near the orebody was found to have very high permeability, such that if the orientation and extent of the region were favorable, flow from the ore to the surface might be possible.

Results of this study were open filed in report GJBX-97(79).

Uranium and Radon Daughters by Nuclear Emulsions

- Subcontractor: Stieff Research and Development Co., Inc.
- Subcontract Value: \$51,227
- Start Date: May 1979
- Completion Date: April 1980

The interpretation of ^{222}Rn concentration data in soil gas has generally proceeded from the assumption that the processes of emanation and diffusion are responsible for the presence of radon at the mineral grain boundaries and interstitial pore spaces near the uranium source area. It is also assumed that the radon migrated to the surface under the influence of various transport mechanisms, and that the diffusion process is not significant at long distances. Therefore, the relatively short half-life of 3.8 days for ^{222}Rn has placed an uncertainty on the geologic processes which could account for the observed surface data. In order to evaluate the radon gradient

data, the radon concentration measurements should be directly correlated not only with quantitative measurements for uranium and radium in related soil or core samples but also with the longer lived daughter products such as ^{210}Pb .

The major objective of this investigation is to obtain data on the systematic distribution and concentration of uranium (^{238}U) and its daughter products (^{226}Ra , ^{210}Pb , and ^{234}U) from drill-hole and geochemical samples collected over or near known uranium orebodies via nuclear emulsion techniques. Also, it will be determined whether leachable ^{210}Pb values represent an enhanced ^{222}Rn signal.

This project may determine the feasibility of the nuclear emulsion as a uranium exploration tool and obtain information concerning the vertical migration and the subsurface distribution of radon and its precursors.

A report on this project is scheduled for open filing in 1980.

Ruggedized Radon Emanometer

- Subcontractor: TSA Systems, Inc.
- Subcontract Value: \$58,120
- Start Date: 1 December 1977
- Completion Date: December 1979

Sixteen ruggedized radon emanometers were procured and distributed to Bendix field personnel for evaluation of radon in near-surface soil gas and ground waters.

These units are being tested side by side with other commercially available emanometers and the test results then compared to the data from alpha-track integration surveys of the same sites.

An evaluation report on these instruments is expected to be open filed in FY80.

Drilling Mud Emanometer

- Subcontractor: Overhoff and Associates, Inc.
- Subcontract Value: \$19,800
- Start Date: 18 August 1978
- Completion Date: December 1979

Radon gas emanating from deeply buried uranium orebodies may not be readily detected at the surface using current emanometric techniques. If, however, some of the migrating gas is intersected by a borehole, some of the gas may be rapidly carried to the surface in the circulating mud used to clean and lubricate the drill bit.

Overhoff and Associates has developed and built a prototype instrument which separates the

trapped gases from the drill mud and provides a real-time record of radon concentration which can be correlated with drilling depth. This prototype instrument is currently undergoing laboratory testing by Bendix at Grand Junction and will be evaluated in the field during FY80.

Thermoluminescence Techniques for Uranium Ore Exploration

- DOE Contractor: Brookhaven National Laboratory
- Subcontract Value: DOE/Brookhaven interagency agreement
- Start Date: October 1978
- Completion Date: September 1979

The use of the thermoluminescence properties of the quartz component of sandstone is being studied for its ability to "remember" past exposures to radiation. This exposure could indicate the flow of uranium-bearing solutions through a sandstone bed or the flow of radon through a rock column. Core and near-surface soil samples from areas with known deposits are being analyzed for their thermoluminescence response. The results from this study are scheduled for open filing in 1980.

Geochemical Relationship of Organic Matter and Uranium Deposits

- Subcontractor: Denver Research Institute
- Subcontract Value: \$63,201
- Start Date: 30 September 1976
- Completion Date: 10 September 1979

The association of uranium with organic matter in several major mining districts is well known and studies of this association have demonstrated that 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.

A final report, GJBX-130(79), open filed in September 1979, presents the results of a detailed literature search and preliminary experimental results on the possible interactions of uranium with humic and fulvic acids.

Ge(Li) Spectrometer Calibration and Software

- Subcontractor: Science Applications, Inc.
- Subcontract Value: \$15,000
- Start Date: November 1978
- Completion Date: February 1980

A project to develop new and improved data reduction techniques for the radiometric survey

assay of bulk uranium samples was successfully completed in October 1978 and is documented in open-file report GJBX-124(78). The techniques were developed for the GJO high resolution Ge(Li) gamma-ray spectrometer. They correct for the effects of sample self absorption and permit radiometric bulk sample assays for potassium, direct uranium, equivalent uranium, radium, and thorium.

On the current project, Science Applications is developing the computer software necessary to perform these radiometric assays with the GJO Ge(Li) system and associated DEC 11/20 computer.

Technology Integration

Technology Integration projects have the following major objectives: (1) establishment of integrated approaches for uranium exploration and resource assessment, (2) characterization of uranium occurrences by suites of geochemical, geological, and geophysical parameters, and (3) development of ore genesis models. These objectives are being pursued with state-of-the-art and developing technologies in varying geologic environments favorable for uranium accumulation.

Results of this work will enhance the NURE resource assessment data and should assist in exploration for new deposits. Such studies may be most important in development of intermediate- or low-grade resources.

Bendix personnel are in the process of integrating data sets from four research sites, each having a specific uranium development environment: Spokane Mountain, Washington; Copper Mountain, Wyoming; Red Desert, Wyoming; and San Juan Basin, New Mexico.

Spokane Mountain Technology Integration Site

- Ongoing in-house project

The Spokane Mountain, Washington research site was chosen as a part of the Technology Integration project to identify and characterize primary and secondary geological, geochemical, and geophysical halos associated with uranium mineralization along a contact between igneous and metasedimentary rocks.

The research area is located northwest of Spokane and is within the Deer Trail anticline.

The area is made up of pelitic and calc-silicate Precambrian rocks underlying the Tertiary quartz monzonite, dacite, and dacitic flows.

Regional and detailed geochemical, radiometric, emanometric, and geophysical surveys were conducted in the area.

Analyses of various samples and data and their interpretation and compilation are in progress. Preliminary results of the geochemical and emanometric surveys indicate anomalies in close proximity to the known mineralized zones. VLF-EM and magnetic surveys indicate north-east-trending regional structures and reflect the different lithological units in the area. Magnetic survey data were particularly useful in the recognition of remanent magnetism that might indicate the time of intrusion and perhaps mineralization.

A detailed presentation of the results of work at this site will be open filed in 1980.

Red Desert Technology Integration Site

- Ongoing in-house project

The Red Desert, Wyoming research site was chosen to identify and characterize primary and/or secondary geological, geochemical, and geophysical halos associated with uranium mineralization in a Tertiary sandstone-type sedimentary environment.

The research area, within the Great Divide Basin of south central Wyoming, is made up of Tertiary sediments that were derived from the erosion of surrounding Precambrian granitic rocks. The uranium deposits are found in fluvial arkosic sedimentary rocks. The source for uranium is either the granitic rocks, the volcanic ash, or both.

Regional and detailed geophysical, geochemical, radiometric, and emanometric surveys were conducted in and around the main orebody being studied. Altogether 12 holes (7 core and 5 rotary) were drilled and borehole geophysical logging was completed. The drilled samples are being composited for various geochemical and geophysical analyses. In support of the study, aerial EM evaluation, complex resistivity surveys, and uranium isotopic study subcontracts were awarded; each of these projects is described elsewhere in the Technology Integration section of this report.

Analyses of various samples and data and their interpretation and compilation are in progress. Preliminary results of regional geochemical sur-

veys indicate helium, radon, and soil trace-element anomalies in and around the deposit. These anomalies have also indicated new local targets of interest. The $^{234}\text{U}/^{238}\text{U}$ ratios and total uranium in ground water were found to be good indicators of uranium deposits.

A detailed presentation of the results of work at this site will be open filed during 1981.

Copper Mountain Technology Integration Site

- Ongoing in-house project

The Copper Mountain, Wyoming research site was chosen because of its recent emergence as an important type of granitic uranium occurrence. It is located along the southeastern edge of the Owl Creek Mountains in north-central Wyoming. The area is made up of a Precambrian interbedded sequence of metasedimentary rocks and amphibolitized extrusive and intrusive rocks. Subsequent felsic granitic rocks and late-stage complex pegmatites are also present. Uranium is found within the granitic rocks and is spatially related to the complex structure developed during Laramide tectonism.

Aerial and surface radiometrics, magnetics, electromagnetics, and geochemical surveys were conducted. Seven core holes were drilled and borehole geophysical logging was completed. Borehole samples are being composited for geochemical and geophysical analyses. In support of the study, subcontracts for aerial EM application and aerial geochemical evaluation were awarded and are described elsewhere in this section.

Preliminary results of regional geochemical surveys indicate trace-element and radionuclide halos associated with the principal economic deposits. Subregional magnetics, VLF-EM, and complex resistivity data are used to map favorable fracture zones and local targets of interest.

A detailed presentation of the results of work at this site will be open filed during 1981.

San Juan Basin Technology Integration Site

- Ongoing in-house project

The San Juan Basin, New Mexico research site was chosen because of its prominence as the most important sandstone-type sedimentary environment uranium district in the United States and because it is significantly different from that of the Red Desert, Wyoming site.

The research area, located in the southern part of the San Juan Basin, is made up of Triassic to Cretaceous sedimentary rocks where the uranium deposits are associated with the Jurassic sandstones.

Altogether 14 holes (rotary and core) were drilled. Drilling samples were lithologged, borehole geophysical logging was completed, and borehole ground water samples were collected for helium, radon, lead, uranium isotopic, and trace-element studies. The drilling samples are being composited for geochemical and geophysical analyses. Subcontractor-conducted studies of lead isotopes in ground water, uranium isotopes, and selective extraction evaluation are described elsewhere in this section.

Further geophysical surveys are planned for the area during the summer of 1980 and the integrated study findings will be presented in an open-file report during 1982.

Aerial EM Evaluation

- Subcontractor: Geotrex Limited
- Subcontract Value: \$66,170
- Start Date: 13 November 1978
- Completion Date: 30 November 1979

It has become increasingly evident that the proper utilization of nonradiometric geophysical methods is a cost effective tool in uranium exploration. For certain conceptual models used in exploration, measurements of various electrical parameters will yield such information as porosity, fracturing, alteration, and clay and metallic mineral content. Such information may result in defining sedimentary channels by using a low-frequency airborne EM system.

A study was undertaken to evaluate the effectiveness of the Barringer INPUT system to map resistivity of the sedimentary environments of the Red Desert Technology Integration site and the Powder River Basin study area. To make the airborne survey program as complete as possible, spectrometer and magnetic surveys were included. Such a combined survey may permit more detailed evaluation of an exploration target.

Preliminary results from both study areas indicate that the INPUT system was able to map gross variations of the subsurface resistivity structure but was not sufficiently detailed to map stream channels. Survey results will be integrated with other data in an open-file report in early 1981.

Aerial EM Application

- Subcontractor: Dighem Limited
- Subcontract Value: \$42,800
- Start Date: 1 November 1979
- Completion Date: 1 February 1980

Conceptual models of particular exploration targets of interest should indicate which geophysical tools are likely to be most effective. For the Copper Mountain research site in Wyoming, the favorable geological conditions associated with major fracture systems are considered an essential part of the conceptual model for exploration. The environment appears to be a favorable target for utilizing a combined airborne EM/resistivity/magnetic/VLF-EM survey to map near-surface lithology changes and fractures. Borehole studies, in conjunction with other geological and geochemical data, are aimed at halo identification tasks around the known orebody. Survey results will be integrated with other geological and geochemical data in an open-file report on the Copper Mountain uraniumiferous deposit in 1981.

Complex Resistivity Survey

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

Uranium deposits are known to contain certain unique spatial distributions of pyrite, molybdenum, selenium, and calcite. The distribution of these provides an 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 met with success in exploration for base metals and their associated minerals. Such a survey was conducted over the Red Desert and Copper Mountain research sites in Wyoming to determine how this system might be used in uranium exploration.

Results from the Red Desert (sandstone) research site indicate that a small amount of polarization is produced by the pyrite and carbonaceous matter associated with the uranium deposit. The Copper Mountain (granitic) research site, on the other hand, did not produce any appreciable polarization. The resistivity portion of the survey resulted in delineating areas of favorable geological conditions. Survey results will be integrated with other data in an open-file report on both sites in the early part of 1981.

Stable Isotopes and Geochemical Halos

- Subcontractor: Global Geochemistry Corporation
- Subcontract Value: \$85,000
- Start Date: October 1979
- Completion Date: June 1980

NURE drill core obtained from the San Juan Basin, New Mexico research site will be selected for sulfur and carbon isotope determinations and for neutron activation analysis on whole rock samples and leachates for a large suite of elements. Both isotopic and trace-element studies on the core samples in and around the known ore deposit are underway. These studies are aimed at delineating the halos around a known deposit and at developing an exploration model. The genesis of the trend ore deposit being investigated will be considered and the isotopic and trace-element halos around the deposit will be mapped. The data will be interpreted and incorporated into the case study report for this site. A report of the complete case study will be open filed in early 1982.

Lead Isotopes in Ground Water

- Subcontractor: California State University at Los Angeles
- Subcontract Value: \$56,764
- Start Date: September 1979
- Completion Date: September 1980

This project was initiated for the San Juan Basin research site to study the U/Pb variations in and around the known mineralization for halo identification study. Ground water was collected at different levels from seven BFEC/DOE holes and additional samples will be collected from leaching the core samples collected from the same site. Initially, the investigations of the subcontractor have attempted to sample enough levels within boreholes to identify U/Pb variations in the various geologic formations. Samples of all known contaminants were acquired in order to place constraints on their contribution, if any, to the U/Pb analyses associated with the aquifer. This study will be completed with an open-file report in 1980.

Selective Extraction Evaluation

- Subcontractor: Uranium-West Labs.
- Subcontract Value: \$42,000
- Start Date: September 1979
- Completion Date: June 1980

This project is a combined in-house and subcontracted effort. Rock, core, sediment, and soil samples with anomalous and background concentrations of uranium were obtained from the Technology Integration research sites. Bendix geoscientists and the subcontractor will leach

these samples with various weak leaching solutions. The leachates will be analyzed for a large suite of elements by both neutron activation and atomic absorption techniques.

The data obtained will be used in a detailed evaluation of the ability of each wet digestion technique to improve the contrast of anomalous samples to background. Both petrography and electron microscopy will be used to study the specific minerals being dissolved by each leaching agent. The final results will be incorporated into the Technology Integration case study open-file reports.

Uranium Isotope Studies

- DOE Contractor: Florida State University
- Subcontract Value: \$122,000
- Start Date: 1 April 1978
- Completion Date: June 1980

Phase I of the project involved an evaluation of the $^{234}\text{U}/^{238}\text{U}$ activity ratio as a prospecting tool in three uranium districts: (1) Red Desert, Wyoming; (2) Copper Mountain, Wyoming; and (3) south Texas Gulf Coast. Activity ratios and accurate uranium concentration determinations were evaluated on borehole ground water samples collected around known uranium occurrences in each district. Phase I noted high activity ratios for samples collected downdip from several accumulations. The activity ratio is considered an effective ground water indicator for updip accumulations.

Along with the data for the first three districts investigated, the basic methods and principles of the technique are discussed in the final report for Phase I, scheduled for open filing early in 1980. Phase II of the project, which is now underway, involves an in-depth evaluation of the technique with ground water samples from deep holes in the Grants Mineral Belt, New Mexico.

Aerial Geochemical Evaluation

- Subcontractor: Barringer Research, Inc.
- Subcontract Value: \$164,000
- Start Date: August 1977
- Completion Date: December 1979

The aerial geochemical sampling techniques developed by Barringer Research include AIRTRACE and SURTRACE. The SURTRACE survey over the Copper Mountain, Wyoming site revealed meaningful multielement patterns related to residual soil anomalies adjacent to a major deposit but the AIRTRACE data are, as yet, inconclusive. A correlative study between SURTRACE, AIRTRACE, and residual soil-element anomalies is underway. A complete evalua-



Drilling and logging of boreholes in areas of southeast Wyoming were accomplished by transporting equipment with helicopters.

tion of the data from these systems will be open filed with the case study report on Copper Mountain in 1981.

High-Resolution Seismic Reflection

- Subcontractor: Boise State University
- Subcontract Value: \$78,218
- Start Date: 12 August 1977
- Completion Date: 1 July 1979

A study was undertaken to evaluate the 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 two energy sources—a high-frequency vibrator (40–350 hz) and 1-pound (0.45 kilogram) dynamite charges shot in 10-foot (3 meter) holes. A limited amount of data was acquired utilizing detonating cord on the surface. Some 3-D reflection and passive seismic data were also acquired.

As reported in the NURE 1978 Annual Activity Report, the 2-D 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 the study. Several areas were delin-

eated 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.

The passive seismic data appeared to show the approximate top of the Wind River Formation but failed to give any indication of the existence of the unconformity. The 3-D reflection data, although very limited in spatial extent and multiplicity of stack, demonstrated a capability for detailed mapping of both the Tertiary section and the unconformable surface.

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 available as open-file report GJBX-100(79).

Technology Support

Technology support to the NURE program is provided through ongoing in-house activities, in-house projects, and subcontracted projects.

Ongoing in-house activities include geochemical analysis of samples for Bendix and DOE geoscientists; reduction of borehole and surface geophysical data; calibration of borehole, surface, and aerial data systems for NURE and the uranium industry; maintenance and improvement of borehole calibration and airborne radiometric standardization facilities at GJO and remote sites; continued evaluation, upgrading, and maintenance of geophysical and geochemical instrumentation systems for Bendix and DOE technical divisions; and aerial survey data standardization and quality assurance.

In-house projects include the development and evaluation of new geophysical and geochemical instrumentation systems such as borehole logging systems and probes.

Subcontractors are developing new instrument systems and facilities needed to enhance in-house support capabilities.

Geochemical Analysis Support

- Ongoing in-house project

The geochemical analysis laboratory continues to provide timely and effective analytical support

of field programs by meeting analysis requirement schedules and constantly improving and expanding analytical capabilities. During this past year a new analytical procedure was developed for two important uranium pathfinders, arsenic and selenium. These elements are analyzed by carbon furnace atomic absorption after using a block digester for sample dissolution. This procedure permits up to five times more arsenic and selenium determinations than was previously possible while actually decreasing the personnel required. Similarly, an ion selective electrode procedure for fluoride analysis has been streamlined to yield twice as many analyses without additional manpower or equipment.

Analytical capabilities have been expanded in several areas. Some significant examples include the addition of analytical procedures for elements such as antimony and tellurium whose determination was not previously possible. Also developed was an analytical procedure for the analysis of silver and gold at concentrations as low as five parts per billion. The laboratory has given direct support to Bendix field offices by evaluating the Scintrex UA-3 uranium analyzer and presenting a training course on its use. Other such projects are expected to further reduce costs and increase the efficiency of operation in the next year.

In addition to providing in-house determination, the geochemical analysis laboratory supported quadrangle evaluation by monitoring the quality control of the outside laboratories used by Bendix field offices.

Emission Spectrophotometer Implementation

- In-house project
- Start Date: 1 January 1978
- Routine production started September 1979

A direct-reading emission spectrophotometer with d.c. arc sample excitation was installed at GJO. This instrument combined present technology of direct readers and a standard geologic survey technique using powdered samples diluted with graphite for semi-quantitative determination of 35 elements. Bendix developed computer techniques for the standardizing, multi-element interference correcting, and polynomial analyzing to adapt the instrumentation to the analysis of geologic samples. The system was implemented into routine analysis in September 1979.

XRF Laboratory Development

- Ongoing in-house project
- Start Date: 1 April 1975
- Routine production started October 1979

An energy dispersive x-ray fluorescence (EDX) system is being developed by Bendix for multi-element analysis of geologic samples. Various sample preparation and data reduction methods have been evaluated. A modified Compton-backscatter matrix-correction routine looks promising for most elements in geologic matrices.

A Compton-backscatter method with a loose-powder sample-preparation technique for routine quantitative analysis of rubidium, strontium, yttrium, and zirconium has been developed and implemented on the EDX. This procedure should be applicable for elements with atomic numbers greater than 26. Currently of interest to the project are arsenic, selenium, niobium, molybdenum, tin, lanthanum, hafnium, tungsten, mercury, the rare earths, and thorium. Methods of analysis for these elements are being investigated. For example, an existing wavelength dispersive (WDX) x-ray fluorescence system was incorporated into the XRF lab development project early in 1979 for routine analysis of low levels of thorium. The WDX uses a modification of the Compton-backscatter matrix-correction method.

Gamma Spectrometer Implementation

- In-house project
- Start Date: January 1978
- Completion Date: April 1980

The gamma analysis laboratory at GJO is being expanded to meet the increased demand for radiometric, potassium, uranium, and thorium analyses by gamma spectroscopy. At present, one sodium iodide (NaI) spectrometer and one lithium drifted germanium [Ge(Li)] spectrometer are in routine operation. The new facility includes a room to be used exclusively for gamma spectroscopy that will house three NaI spectrometers and one Ge(Li) spectrometer together with conveyor systems, sample changers, and lead caves to shield the detectors.

The conveyor system is designed to handle samples for up to 4 days continuous analysis. Total automation of the sample changers and the use of an uninterrupted power supply allow unattended, continuous operation. The facility is designed so that the NaI detectors can be upgraded to Ge(Li) detectors at any future time.

Presently two new lead caves, sample changers, and conveyor systems have been built and

installed. One of these systems has all electronic apparatus installed and is operational. After both new systems are operating routinely, the present NaI system and Ge(Li) system will be moved and incorporated in the new facility.

Electronics Support Activities

- Ongoing in-house project

The electronics laboratory 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, and performance evaluation services to DOE and Bendix divisions.

Some 1979 activities included testing and evaluation of 16 newly developed radon emanometers procured from TSA Systems, Inc. Ten dual crystal KUT probes and four new KUT logging systems were designed, fabricated, and tested. Electronics and mechanical subsystems for the new NaI gamma-ray spectroscopy system in the geochemical analysis laboratory were designed, fabricated, and installed by electronics laboratory personnel.

Existing Calibration Facilities and Services

Through Bendix, DOE provides to 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, Colorado; Casper, Wyoming; Grants, New Mexico; and George West, Texas. Including the models installed during 1979 each facility outside Grand Junction has four borehole models for calibration of borehole probes and two models (blocks) for calibration of portable scintillometers and spectrometers. All four borehole models have a run tube extending 13 feet (3.9 meters) below the model bottom to accom-

moderate the newer long probes; two models are for gross count gamma ray, one is for KUT (potassium, uranium, and thorium) spectrometer gamma ray (1979 installation), and one is for fission-neutron (1979 installation) borehole probes.

Grand Junction facilities for routine calibration of gross count gamma-ray probes consist of four models featuring ore grades from 0.24 percent to 2.0 percent U_3O_8 , and one model featuring four holes ranging in size from 2½ inches (6 centimeters) to 8½ inches (21.9 centimeters). There are four models for routine calibration of KUT (spectrometer gamma ray) probes: three, each with one element high relative to the other two elements. The fourth is a water factor model for calibrating and testing hole size/fluid effects in 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 five boreholes ranging in size from 3 inches (7.6 centimeters) to 12 inches (30 centimeters).

Six borehole models, installed during 1978 at the Grand Junction facility, are now available for use in calibrating and testing fission neutron logging systems. These models are 6 feet (1.8 meters) in diameter and 15 feet (4.6 meters) deep, each with a 15-foot (4.6 meter) run tube. They feature eight ore zones having characteristics needed to study tool responses versus ore grade (four values), density (two values), porosity or moisture (three values), and thermal neutron cross section (two values). A seventh borehole model (water factor) for calibration and testing of fission neutron logging systems in different size holes was completed in 1979. The model features a single ore zone penetrated by seven boreholes, ranging in size from 3 inches (7.6 centimeters) to 13 inches (33 centimeters). A 300-foot (91 meter) test borehole was another important addition to the Grand Junction complex in 1979. Several other borehole models are available for specialized calibration or research measurements including those related to thin dipping beds, granite (block), and magnetic (susceptibility) materials.

A set of five surface models for calibration and testing of portable gamma-ray spectrometers is available. The models are cylindrical blocks, 4 feet (1.2 meters) in diameter by 1.5 feet (0.46 meters) in length, featuring radioelement concentrations of potassium, uranium, thorium, a mixture, and one with nominal natural radioelement materials (barren).

All standardization and calibration effort undertaken by industry using these government-supplied facilities is done voluntarily in order to obtain a consistent, reliable data base for establishing the uranium resources of the nation.

Field Calibration Sites— Construction and Up-grade

- Ongoing in-house project

The field calibration facilities at Casper, Wyoming; Grants, New Mexico; and George West, Texas were all upgraded so that spectral gamma ray and fission neutron logging equipment can be calibrated.

At each site, two calibration models were installed for use with spectral gamma-ray logging probes. Each of these spectral gamma-ray calibration models has two ore zones. Together they provide zones of potassium, uranium, thorium, and a mixed zone making it possible to compute the elemental response of logging probes, from which logs of the potassium, uranium, and thorium (KUT) concentration can be derived.

At each site, one calibration model was installed for the use of fission neutron logging probes. The model has two ore zones with different grades of uranium, making it possible to calculate both the K-factor and the "dead time" for fission neutron logging probes.

New calibration facilities, which will be comparable to these up-graded field facilities, have been approved for installation at Spokane, Washington; Pittsburgh, Pennsylvania; and Reno, Nevada. Plans call for the completion of these new facilities in 1980.

Fission Neutron Water Factor Model

- In-house project
- Start Date: September 1977
- Completion Date: December 1979

In 1979 a fission neutron water factor model was constructed, under BFEC supervision, and made available for NURE and industry use at the DOE Grand Junction facility. This model is a right circular concrete cylinder having a 16-foot (4.88 meter) diameter and a depth of 15 feet (4.57 meters). There are three zones of uniform thickness and composition: 5-foot (1.52 meter) thick upper barren zone, a 6-foot (1.83 meter) thick ore zone with a uranium grade of 0.0797 percent U_3O_8 , and a 4-foot (1.22 meter) thick lower barren zone. Seven uncased, water-filled boreholes, with diameters of 3 inches (7.6 centimeters), 4½ inches (11.43 centimeters), 6 inches (15.24 centimeters),

7⁹/₁₆ inches (19.21 centimeters), 9 inches (22.86 centimeters), 11 inches (27.94 centimeters), and 13 inches (33 centimeters) penetrate the zones. Each borehole has a 14-foot (4.27 meter) run tube below the lower barren zone. The boreholes are oriented approximately 2 degrees from the vertical to ensure that probes will be sidewalled during logging runs.

Because of the ability of water to moderate neutrons, the response of a fission neutron-based logging probe in a water-filled borehole will in general be strongly dependent on the diameter of the borehole. The determination of borehole size-dependent correction factors, or water factors, is an essential part of the calibration procedure for any fission neutron-based logging probe. Since the seven fission neutron water factor model boreholes differ only in borehole size, water factor corrections can be calculated from logs run in each of the model boreholes.

300-Foot Borehole

- Subcontractor: Himes Drilling Company, Inc.
- Subcontract Value: \$28,364
- Start Date: 1 May 1979
- Completion Date: 21 November 1979

The 300-foot (91 meter) borehole was constructed as part of the Grand Junction facility primarily to provide for testing the draw works of logging trucks, their instrumentation, and the hydraulic seals of logging probes under close to normal field conditions.

The hole is cased to the bottom with 4-inch (10.1 centimeter) I.D. schedule 40 ABS plastic pipe. The pipe intersects coarse aggregate for the first 20 feet (6.1 meters) and then penetrates the Morrison Formation. The water level in the pipe is 18 inches (45.7 centimeters) from the top.

Grade Assignment Studies

- Ongoing in-house project

Bendix and DOE provide calibration models that are used by industry as standards. Because these models are standards, the values assigned to them are fundamental.

The purpose of this project is to devise and improve methods used for calibration of borehole logging systems. Present efforts have focused on improving grade assignments for models used for calibration of total-count gamma-ray logging systems. There are four total count gamma-ray calibration models at Grand Junction and two at each of the field sites: Casper, Wyoming; George West, Texas; and Grants, New Mexico.

Calibration Facilities Monitoring System

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

A special system has been developed to monitor and better characterize models at Grand Junction and field locations. The system contains three spectral gamma-ray probes: one gamma-gamma density probe and two neutron-neutron probes. It is automated to allow collection of long-term, statistically precise data.

A novel problem in design of the system was that of insuring stability. Because the calibration models are standards, it is difficult to determine whether the model or the monitoring system has changed between two sets of measurements. To define limits of stability, precision (highly stable) references are being used before, during, and after measurements in calibration models. Preliminary data are now being collected with the system and show the system to be performing according to design specifications.

Radon Calibration Unit and Instrument Evaluation

- Ongoing in-house project

The use of radon to remotely detect the presence of buried uranium deposits has brought about the development of a number of radon measurement instruments. These newly developed instruments are being tested both in the laboratory and in the field to determine their sensitivity, variability, integrity, and accuracy.

The testing in the laboratory includes the use of the calibration unit which was delivered by a subcontractor in December 1978. The radon concentration in the unit is variable and can be set automatically. The radon concentration, humidity, temperature, and operating conditions are continuously monitored and automatically adjusted to remain constant. The unit is also used to standardize, in absolute radon units, any radon measurement instruments, making it possible to compare radon measurements obtained using different instruments.

Reports on these evaluations will be placed on open file as they are completed. A report on the field testing of several instruments is scheduled for open filing early in 1980. A report on the radon calibration unit is also scheduled for open filing in 1980.

Dynamic Test Range I Follow-on

- Subcontractor: LKB Resources, Inc.
- Subcontract Value: \$130,822
- Start Date: 6 September 1978
- Completion Date: 29 February 1980

Detailed radiometric and aeromagnetic data of DTR-I was obtained and the project is complete except for acceptance and publication of the final report.

The immediate benefit to NURE aerial radiometric subcontractors is the concentration-contour maps which will allow these range users, for the first time since the range became operational in 1977, to find both altitude and location-dependent concentration variations and apply this information to improve their airborne calibration coefficients.

Dynamic Test Range II

- Subcontractor: Golder Associates, Inc.
- Subcontract Value: \$196,287
- Start Date: 1 December 1978
- Completion Date: 1 April 1979

The search for a candidate test site having different radiometric characteristics from already operational DTR-I, is in process.

DTR-II will complement the effectiveness of the original calibration facility (DTR-I) by providing

a second aerial radiometric calibration data set with which to cross check established NURE aerial radiometric subcontractors' system calibration coefficients. This cross check, not possible with DTR-I alone, will greatly increase the numerical confidence in the ultimate accuracy of NURE aerial radiometric data.

DTR-II Ground Support Vehicle

- Subcontractor: Radiation Management Corporation
- Subcontract Value: \$64,836
- Start Date: 5 July 1979
- Completion Date: 5 January 1980

The possibility of normalizing aerial system calibration data using a mobile radiometric surveillance system, correlating realtime ground and weather conditions with calibration over flights, was established during the past 2 years since DTR-I became operational. With the establishment of a second dynamic test range, a similar dedicated mobile system is being acquired.

Drawing on the practical experience gained from field operations with the DTR-I system, minor design improvements are being incorporated into



By using an auxiliary boom truck, an industry logging vehicle was able to use the Grand Junction KUT models to calibrate a petroleum spectral logging probe.

this new vehicle. The major radiometric electronics and meteorological components have been duplicated to take advantage of the dual operational reliability afforded by redundant systems.

Aerial Product Quality Assurance

- Ongoing in-house project

This project is a continuation and expansion of the "Support for Operational Aerial Surveys" program. Activities are designed to assure the quality of survey data acquired by the subcontractors on the Aerial Radiometric Reconnaissance program.

Quality checks are made at two critical points in an aerial survey. First, prior to a survey, the calibration of each aircraft is carefully evaluated to insure compliance with BFEC specifications 1200-C and 1250-A, which set minimum standards for hardware and data reduction. Second, prior to accepting data acquired by a subcontractor, all survey data (raw and reduced)

digitally recorded on magnetic tape, are played back to assure proper format and completeness. Data records from each tape are then randomly sampled and analyzed for reasonable physical meaning.

Aerial Data Reduction Standardization

- Ongoing in-house project

A standardized magnetic data tape format for aerial survey data was completed in February 1979 and incorporated in specification BFEC 1200-C, to eliminate intra-subcontractor format differences and greatly enhance computer usage of aerial survey data.

Work continues to develop a standardized calibration and data reduction specification for the aerial survey program which will eliminate intra-subcontractor processing biases and will ensure usage of state-of-the-art calibration analysis techniques. Completion is expected in early 1980 for use in the 1980 surveys.

Information Dissemination

Information generated from NURE-related activities is published as technical papers, 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 statistical data of the uranium industry, and the NURE data bank.

Activity highlights in 1979 were the annual Uranium Industry Seminar, the issuance of 157 press releases, the open filing of 176 NURE-related technical reports, 213 other miscellaneous reports and 253 technical memoranda, and the participation in community affairs.

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 lead time 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 Bendix and subcontractor personnel at various national and international meetings.

National Uranium Resource Evaluation (NURE) Program in Alaska; J. R. Anderson, Bendix; Alaska Geological Society, Anchorage, Alaska; April 23-25, 1979.

Total Sulfur Content and Morphology of Iron-disulfide Minerals in the Parachute Creek Member of Green River Formation, Piceance Creek Basin, Colorado; R. D. Cole, Bendix; Geological Society of America (GSA), Rocky Mountain Section, Fort Collins, Colorado; May 25-26, 1979.

A Borehole Spectrometer for Uranium Exploration; D. C. George, Bendix; Society of Professional Well Log Analysts (SPWLA), Tulsa, Oklahoma; June 3-6, 1979.

Spectral Gamma-ray Logging I: Energy Stabilization Methods; D. C. Stromswold, Bendix; SPWLA, Tulsa, Oklahoma; June 3-6, 1979.



Advance registration for the 1979 DOE Uranium Industry Seminar exceeded 900.

Dr. Donald Everhart, Manager, DOE/GJO, welcomed participants to the seminar held in Grand Junction's Two Rivers Plaza.



Spectral Gamma-Ray Logging II: Borehole Correction Factors; D. C. Stromswold, Bendix; SPWLA, Tulsa, Oklahoma; June 3-6, 1979.

Spectral Gamma-Ray Logging III: Formation and Thin Bed Effects; D. C. Stromswold, Bendix; SPWLA, Tulsa, Oklahoma; June 3-6, 1979.

Evaluation Models for Uranium Exploration by Active Neutron Logging; W. Woolson and M. Gritzner, Science Applications Inc.; SPWLA, Tulsa, Oklahoma; June 3-6, 1979.

Nonmarine Depositional Environments and Uranium Exploration in the Lower Cretaceous Antlers Formation, North Texas; D. Hobday, University of Texas at Austin; American Association of Petroleum Geologists (AAPG), Casper, Wyoming; June 3-6, 1979.

Definition of Depositional Facies of the Parachute Creek Member of Green River Formation, Colorado: Evidence from Sulfur Isotopes and Whole-Rock Mineralogical Data; R. D. Cole, Bendix; AAPG, Society of Economic Petroleum Geologists (SEPG), Casper, Wyoming; June 3-6, 1979.

Petrology of Tertiary Sandstones of the Southern Piceance Creek Basin, Colorado: Implications for Provenance and Depositional Processes; R. D. Cole, Bendix; AAPG, Society of Economic Paleontologists and Mineralogists (SEPM), Casper, Wyoming; June 3-6, 1979.

Execution of the National Uranium Resource Evaluation Program; R. C. Horton, Bendix; International Atomic Energy Agency, Nuclear Energy Agency, International Symposium on Uranium Evaluation and Mining Techniques; Buenos Aires, Argentina; October 1-3, 1979.

Uranium Geophysics, Copper Mountain, Wyoming; D. A. Emilia, Bendix; American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), Tucson, Arizona; October 17-19, 1979.

World Class Program of Department of Energy; R. G. Young, Bendix; Wyoming Geological Association, Casper, Wyoming; October 26, 1979.

Geochemical Exploration: Technique Integration in the Red Desert, Wyoming; L. Bramlett, Bendix; Association of Exploration Geologists (AEG), San Diego, California; November 5, 1979.

Radon and Helium Surveys at Three Known Uranium Occurrences; J. C. Pacer, Bendix; Society of Exploration Geologists, (SEG), New Orleans, Louisiana; November 5-9, 1979.

Characteristics of Radon Techniques for Uranium Exploration; J. C. Pacer, Bendix; SEG, New Orleans, Louisiana; November 5-9, 1979.

Calibration Facility Monitoring System; M. Dale, Bendix; SEG, New Orleans, Louisiana; November 5-9, 1979.

Geochemical Characterization of Stream Sediment and Soil in the Midnite Uranium District, Eastern Washington; L. Bramlett, Bendix; GSA, San Diego, California; November 5-9, 1979.

Stream Sediment in Regional Uranium Reconnaissance, V. Price, SRL; GSA Annual Conference, San Diego, California; November 5, 1979.

Production, Control and Retrieval of Well Log Microfilm Records, R. W. Smith, Bendix; Department of Energy Contractors Micrographics Association, Las Vegas, Nevada; November 7-9, 1979.

Uranium Industry Seminar

This annual seminar was held in Grand Junction on October 16-17, 1979. DOE and BFEC staff members from GJO and DOE staff from headquarters in Washington, D.C., presented 14 papers on the current and probable future status and activities of the uranium industry. Two additional papers were presented, the first of which dealt with the International Nuclear Fuel Cycle Evaluation (INFCE) program, presented by a DOE coordinator for INFCE; and the second paper, presented by a member of the Branch of Uranium and Thorium Resources, USGS, Denver, dealt with the status of the USGS uranium and thorium resource assessment and exploration research program.

DOE's 1979 seminar was attended by 830 people representing various organizations, including energy-related 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(79) released in January 1980. The agenda included:

Uranium Enrichment Policies, W. R. Voigt, Jr.

Uranium Enrichment Plans, R. H. Smith

Uranium Issues and Policies: An Overview, J. A. Patterson

The U.S. Uranium Market 1978-1979, G. F. Combs

Uranium Market Forecast, R. G. Clark and A. W. Reynolds

Overview of NURE Progress, Fiscal Year 1979, C. H. Roach

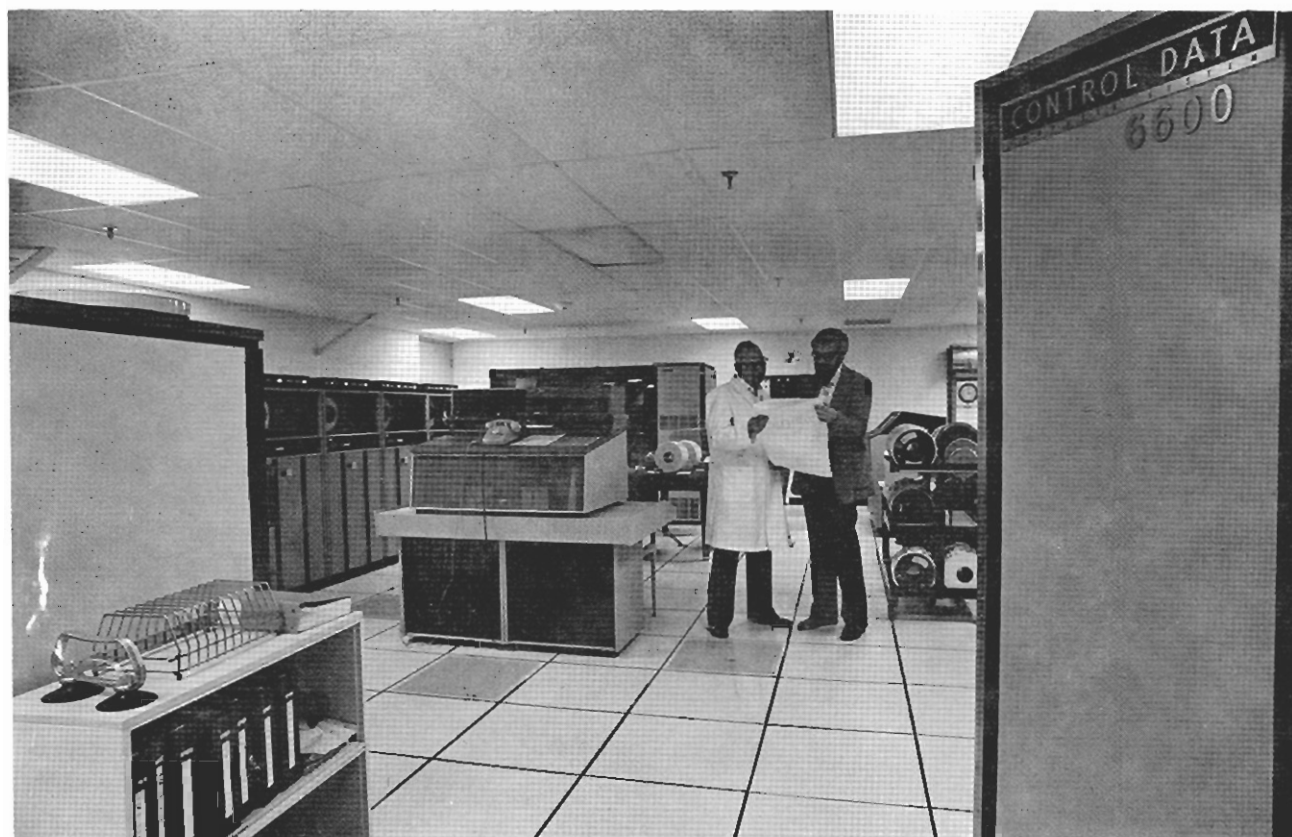
USGS Uranium and Thorium Resource Assessment and Exploration Research Program, Fiscal Year 1980, T. W. Offield
NURE Quadrangle Evaluation and Assessment, R. C. Horton
Foreign Exploration and Uranium Supply, R. J. Wright and R. K. Pitman
INFCE Nearing Conclusion, E. S. Beckjord
Uranium Reserves, R. J. Meehan
Potential Uranium Resources, D. L. Hetland
Industry Exploration Activities, W. L. Chenoweth
Results of Low-Grade Uranium Studies, F. E. McGinley
Uranium Production, J. F. Facer, Jr.
Uranium Production Capability in the United States, J. Klemenic

Computerized Information

The large quantities of data that must be processed and analyzed in the course of the NURE program require processing by computer. The facilities currently available for processing these data at Grand Junction include an on-site CDC 3100 computer, a CDC 6600 computer, and a

remote access link to the Oak Ridge National Laboratory. During 1979 the CDC 6600 computer was installed to replace the CDC 3100 computer system in order to provide adequate capacity for satisfying the needs of the program. This large-scale computer system was received in December 1978 and became operational in March 1979. The CDC 3100 will be phased out during 1980.

The CDC 6600 computer provides on-site batch as well as local and remote interactive operations. 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. Parts of this system are now in use and much of the data editing for ore reserves is being performed interactively. Systems design for quadrangle analysis and laboratory bookkeeping for samples, which have been temporarily implemented at Oak Ridge, has begun in order to provide a permanent and adequate capability in Grand Junction for handling these data. In addition to applications directly related to the technical aspects of the



The recently installed CDC 6600 computer provides support for local and remote interactive as well as batch operations.

NURE program, Grand Junction accounting applications for both Bendix and DOE are being implemented on this system, with DOE accounting in operation during 1979.

The remote access link to the computer center at Oak Ridge National Laboratory includes a remote batch terminal, a multiplexer, and two leased lines. In addition to providing access to interim computer capability for analyzing and processing NURE data, the link provides access to a bank of technical data collected under the NURE program. Currently data from aerial radiometric reconnaissance and hydrogeochemical surveys on approximately 180 quadrangles are archived at Oak Ridge; additional data will be included in this data bank as they become available.

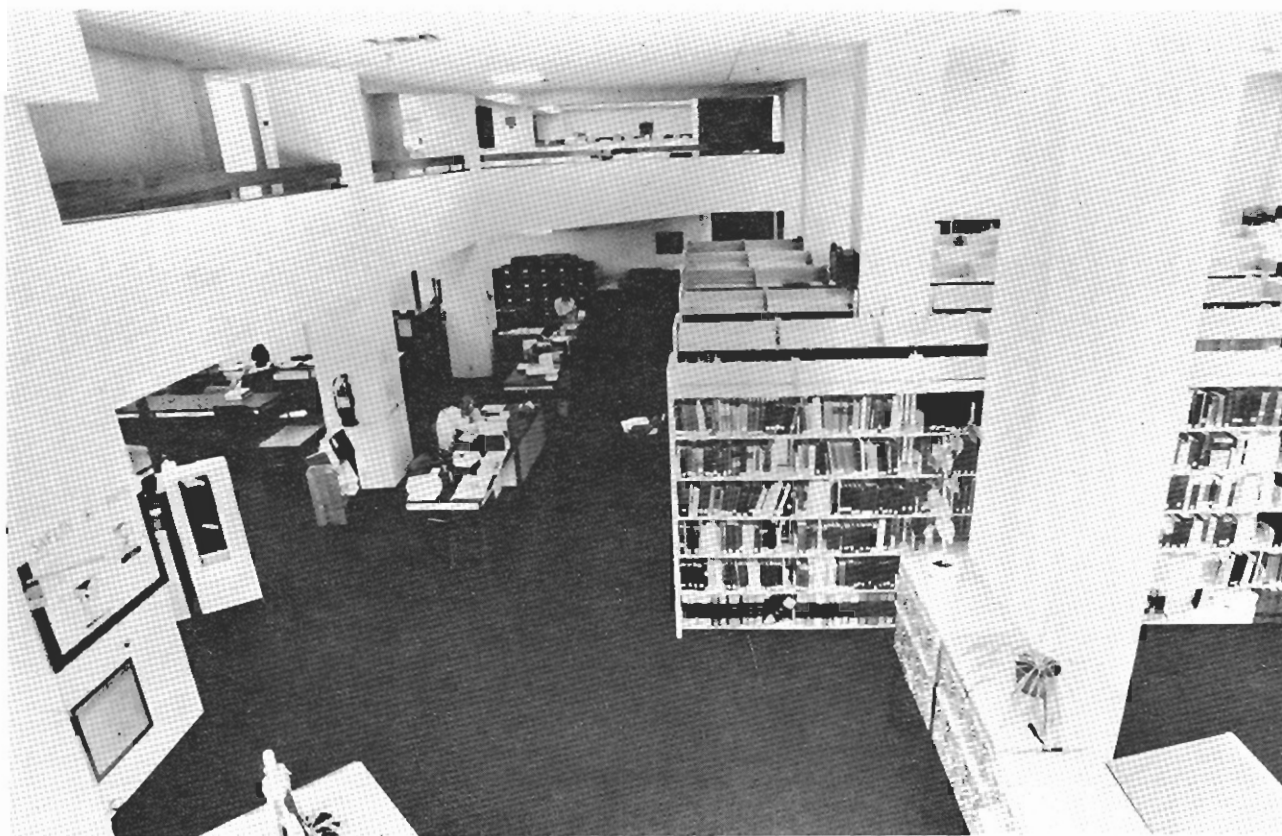
Copies of these technical data sets are available from DOE on a cost-to-copy basis. Computerized evaluation models used in support of the NURE program assessment rely heavily on these data sets.

Since May the Oak Ridge link has been housed with the CDC 6600 system and in December the remote batch portion was modified to allow use

for communication with the Bendix Data Center in Ann Arbor, Michigan and to allow simultaneous operation as a key disk system for the purpose of interactive entry of laboratory analysis data. An interactive digitizer system has been installed to provide better and faster processing. The output of all computing systems can be displayed on sophisticated color and line plotting equipment located in the CDC 6600 facility.

Technical Library Services

The DOE Technical Library, now located in the new library facility at the Grand Junction Office, maintains a collection of more than 100,000 volumes of uranium-related books, periodicals, legal references, maps, and drilling information, which is used daily by industry, the public, and Grand Junction personnel. Reference services include answering written and telephone inquiries and assisting library visitors. The technical library is also the local open-file report repository and houses almost 600 current NURE-related open-file reports and several thousand reports dating back to 1948, which deal with uranium exploration, mining, and milling activities.



The new library at the GJO facility houses more than 100,000 volumes of material related to uranium.

The library has microfiche copies of GJO open-file reports available for sale to the public at a nominal charge. At present, more than 1,550 reports are available on microfiche. In 1979, more than 9,600 microfiche copies of reports were sold, an increase of 50 percent over 1978 microfiche sales of 6,223 copies, and nearly three times the combined 1976 and 1977 sales of 3,283 copies.

Microfiche copies of reports are at a 24:1 reduction; accompanying maps and oversize charts are on 35mm 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.

Bibliography of GJO Reports

- Subcontractor: Mesa College
- Start Date: October 1978
- Completion Date: January 1980
- Subcontract Value: \$38,000

The bibliography will include all GJO reports open filed through December 1978. It is intended that this subcontract will be extended for annual updates to include reports open filed each year. This bibliography will be available on magnetic tape with access to the data base by report number, title, author, subject, and 1° x 2° quadrangle name.

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-filing system requires the distribution of printed materials to selected open-file repositories throughout the United States. At present there are 16 open-file locations which receive all reports except aerial radio-metric reconnaissance volumes, and 18 open-file locations which receive technical reports on a case-by-case exception basis. (See map.)

1979 Open-File Reports

In the listing that follows, a GJBX prefix designates reports of current projects by DOE, Bendix, or subcontractors; a GJO prefix designates reports developed by DOE staff members; a GJQ prefix designates NURE quadrangle assessment folios; and a DAO, DBO, DEB, RME, or TM-D prefix designates reports on uranium investigations carried out in the 1950s and 1960s. The section listing 13 miscellaneous reports contains three reports produced annually by DOE at GJO, two of which deal with statistical data and exploration expenditures of the uranium industry; the third is the Uranium Industry Seminar Proceedings.

The prices in the following list refer to microfiche unless otherwise noted and are to be prepaid.



Reports Issued in 1979

- GJBX-1(79) "Uranium Distribution in Mined Deposits and in the Earth's Crust," K. Deffeyes and I. MacGregor, Princeton University Department of Geological and Geophysical Sciences, August 1978, 480 p., \$3.00.
- GJBX-2(79) "Scranton 1° x 2° NTMS Area, New Jersey, New York, and Pennsylvania, Preliminary Basic Data Report, NURE Hydrogeochemical and Stream Sediment Reconnaissance," R. B. Ferguson, P. L. Jones, Savannah River Laboratory, November 1978, 226 p., 10 illus., 3 fiche, \$5.00.
- GJBX-3(79) "A Preliminary Report on the Uranium Geology of the Red River Valley Drilling Project, Eastern North Dakota and Northwestern Minnesota," Walter L. Moore, University of North Dakota, August 1978, 301 p., \$3.00.
- GJBX-4(79) "Engineering Assessment and Feasibility Study of Chattanooga Shale as a Future Source of Uranium," Mountain States Research and Development and PRC Toups Corp., June 1978, 951 p., \$9.00.
- GJBX-5(79) "Radioactive Mineral Occurrences of Colorado and Bibliography," J. L. Nelson-Moore, et al., Colorado Geological Survey, 1978, 1,061 p., 12 illus., \$5.00.
- GJBX-6(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Emory Peak NTMS Quadrangle, Texas," Oak Ridge Gaseous Diffusion Plant, December 1978, 105 p., 7 illus., 1 fiche, \$5.00.
- GJBX-7(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Enid NTMS Quadrangle, Oklahoma," Oak Ridge Gaseous Diffusion Plant, December 1978, 130 p., 7 illus., 2 fiche, \$5.00.
- GJBX-8(79) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Bozeman NTMS Quadrangle, Montana," S. L. Bolivar, Los Alamos Scientific Laboratory, November 1978, 103 p., 4 illus., \$4.00.
- GJBX-9(79) "Flight Path Recovery System (FPRS) Design Study," SysTech Inc., September 1978, 253 p., \$3.00.
- GJBX-10(79) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Durango NTMS Quadrangle, Colorado," H. E. Dawson, T. A. Weaver, Los Alamos Scientific Laboratory, January 1979, 111 p., 3 illus., \$4.00.
- GJBX-11(79) "NURE, 1978, Annual Activity Report," Bendix Field Engineering Corporation, May 1979, 112 p., Free.
- GJBX-12(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Presidio NTMS Quadrangle, Texas," Oak Ridge Gaseous Diffusion Plant, December 1978, 88 p., 7 illus., 1 fiche, \$5.00.
- GJBX-13(79) "Hydrogeochemical and Stream Sediment Reconnaissance, Semi-Annual Report, Eastern United States, April-September 1978," Savannah River Laboratory, 57 p., \$3.00.
- GJBX-14(79) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Pueblo NTMS Quadrangle, Colorado, Including Concentrations of Forty-Three Additional Elements," S. S. Shannon, Jr., Los Alamos Scientific Laboratory, December 1978, 144 p., 3 illus., \$4.00.
- GJBX-15(79) "Modes of Uranium Occurrences in the Colorado Front Range," Dr. Robert H. Carpenter, et al., July 1978, 294 p., 4 fiche, \$20.00.
- GJBX-16(79) "NURE Aerial Gamma-Ray and Magnetic Reconnaissance Survey, Blue Ridge Area, Greensboro NJ 17-12, Winston-Salem NJ 17-11, Johnson City NJ 17-10 Quadrangles," LKB Resources Inc., December 1978, 643 p., 50 fiche, \$15.00.
- GJBX-17(79) "Aerial Gamma Ray and Magnetic Survey, Rock Springs, Rawlins, and Cheyenne Quadrangles, Wyoming, and the Greeley Quadrangle, Colorado," geoMetrics, December 1978, 843 p., 93 fiche, \$20.00.
- GJBX-18(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Austin NTMS Quadrangle, Texas," Oak Ridge Gaseous Diffusion Plant, December 1978, 140 p., 7 illus., 2 fiche, \$5.00.
- GJBX-19(79) "Helicopter-Assisted Radiometric Survey of the Dixon Entrance Quadrangle, Alaska," W. A. Burgett, K. J. Krause, Bendix Field Engineering Corporation, February 1979, 11 p., 2 fiche, \$5.00.
- GJBX-20(79) "Athens 1° x 2° NTMS Area Georgia and South Carolina, Preliminary Basic Data Report, Hydrogeochemical and Stream Sediment Reconnaissance," R. B. Ferguson, Savannah River Laboratory, December 1978, 169 p., 8 illus., 3 fiche, \$5.00.
- GJBX-21(79) "Aerial Radiometric and Magnetic Survey, Winnemucca National Topographic Map, Nevada," Geo-Life, September 1978, 339 p., 62 fiche, \$10.00.
- GJBX-22(79) "Formation of Uranium Ores by Diagenesis of Volcanic Sediments, Final Report," C. D. Henry, A. W. Walton, University of Texas Bureau of Economic Geology, 1978, 443 p., \$3.00.
- GJBX-23(79) "Aerial Radiometric and Magnetic Reconnaissance Survey of Portions of Arizona—New Mexico, Mesa, Clifton, Tucson, Silver City, Nogales, and Douglas Quadrangles," Texas Instruments, Inc., November 1978, 1,167 p., 99 fiche, \$30.00.
- GJBX-24(79) "Aerial Radiometric and Magnetic Reconnaissance Survey of the Delta Quadrangle, Utah," Texas Instruments, Inc., November 1978, 576 p., 28 fiche, \$10.00.
- GJBX-25(79) "Study to Integrate NURE Data," K. Golabi, A. Lamont, Woodward-Clyde Consultants, September 1978, 92 p., \$3.00.

- GJBX-26(79) "Results of Elemental Analyses of Water and Waterborne Sediment Samples from Areas of Alaska Proposed for the Chukchi Imuruk National Reserve, Selawik National Wildlife Refuge, and Cape Krusenstern National Monument," R. R. Sharp, Jr., Los Alamos Scientific Laboratory, October 1978, 151 p., 3 illus., \$4.00.
- GJBX-27(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data For Lawton NTMS Quadrangle, Oklahoma: Texas, Uranium Resource Evaluation Project," Oak Ridge Gaseous Diffusion Plant, December 1978, 128 p., 7 illus., 2 fiche, \$5.00.
- GJBX-28(79) "Portland 1° x 2° NTMS Area, Maine and New Hampshire, Data Release, Hydrogeochemical and Stream Sediment Reconnaissance," G. R. Koller, Savannah River Laboratory, February 1979, 214 p., 10 illus., 3 fiche; \$5.00.
- GJBX-29(79) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Lime Hills and Tyonek NTMS Quadrangles, Alaska, Including Concentrations of Forty-Three Additional Elements," S. I. Jacobsen, et al., Los Alamos Scientific Laboratory, January 1979, 227 p., 12 illus., \$5.00.
- GJBX-30(79) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Medfra and Mt. McKinley NTMS Quadrangles, Alaska, Including Concentrations of Forty-Three Additional Elements," E. M. Van Eeckhout, et al., Los Alamos Scientific Laboratory, February 1979, 211 p., 11 illus., \$5.00.
- GJBX-31(79) "Harrisburg 1° x 2° NTMS Area, Pennsylvania, Data Release, Hydrogeochemical and Stream Sediment Reconnaissance," J. D. Heffner, Savannah River Laboratory, February 1979, 227 p., 11 illus., 3 fiche, \$5.00.
- GJBX-32(79) "Preliminary Recognition Criteria for Uranium Occurrences; A Field Guide," G. Mathews, C. Jones, R. C. Pilcher, R. D'Andrea, Jr., Bendix Field Engineering Corporation, February 1979, 47 p., \$3.00.
- GJBX-33(79) "Uranium Potential and Geology of the Challis Volcanics of the Basin Creek-Yankee Fork Area, Custer County, Idaho," P. L. Siems, et al., University of Idaho, June 1978, 205 p., 1 fiche, \$4.00.
- GJBX-34(79) "Geostatistics Project of the National Uranium Resource Evaluation Program," T. R. Bement, D. E. Whiteman, Los Alamos Scientific Laboratory, July-September 1978, 13 p., \$3.00.
- GJBX-35(79) "Extraction of Uranium from Seawater: Evaluation of Uranium Resources and Plant Siting," S. E. Binney, et al., Exxon Nuclear Company, February 1979, Vol. I, 157 p., Vol. II, 276 p., \$6.00.
- GJBX-36(79) "Extraction of Uranium from Seawater: Chemical Process and Plant Design Feasibility Study," S. E. Binney, et al., Exxon Nuclear Company, February 1979, Vol. I, 172 p., Vol. II, 322 p., \$6.00.
- GJBX-37(79) "Aerial Radiometric and Magnetic Survey, Seguin National Topographic Map, Texas Gulf Coast," Geodata International, Inc., 226 p., 144 fiche, \$5.00.
- GJBX-38(79) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Dillon NTMS Quadrangle, Montana/Idaho, Including Concentrations of Forty-Three Additional Elements," D. E. Broxton, Los Alamos Scientific Laboratory, March 1979, 232 p., 6 illus., \$4.00.
- GJBX-39(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data Report for Millett NTMS Quadrangle, Nevada," J. L. Wagoner, Lawrence Livermore Laboratory, December 1978, 84 p., 7 illus., 4 fiche, \$5.00.
- GJBX-40(79) "Study of Airborne Gamma-Ray Spectrometer Data Procedures, Wind River Basin, Wyoming, Casper Quadrangle," Texas Instruments, Inc., January 1979, 473 p., \$30.00.
- GJBX-41(79) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the La Junta NTMS Quadrangle, Colorado, Including Concentrations of Forty-Three Additional Elements," J. D. Purson, R. G. Warren, Los Alamos Scientific Laboratory, February 1979, 146 p., 5 illus., \$4.00.
- GJBX-42(79) "Detailed Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Tallahassee Creek, Badger Creek, Castle Rock Gulch, and Buffalo Gulch Areas in the Northwestern Part of the Pueblo NTMS Quadrangle, Colorado," S. S. Shannon, Jr., Los Alamos Scientific Laboratory, February 1979, 108 p., 6 illus., \$4.00.
- GJBX-43(79) "Orientation Study Data Release VII, Wolcott, Vermont, Area," P. L. Jones, V. Price, Savannah River Laboratory, February 1979, 30 p., 1 illus., \$3.00.
- GJBX-44(79) "Glens Falls 1° x 2° NTMS Area, New Hampshire, New York, and Vermont; Data Release," G. R. Koller, Savannah River Laboratory, March 1979, 226 p., 10 illus., 3 fiche, \$5.00.
- GJBX-45(79) "Augusta 1° x 2° NTMS Area, Georgia and South Carolina, Data Release," P. L. Jones, Savannah River Laboratory, March 1979, 174 p., 8 illus., 3 fiche, \$5.00.
- GJBX-46(79) "Oklahoma Pilot Geochemical Survey," C. S. Bard, et al., Oak Ridge Gaseous Diffusion Plant, February 1979, 237 p., 12 illus., 1 fiche, \$5.00.
- GJBX-47(79) "Uraniferous Gorceixite Occurrences in Aiken County, South Carolina," R. B. Ferguson, V. Price, W. C. Mosley, Jr., Savannah River Laboratory, March 1979, 22 p., 1 illus., \$3.00.
- GJBX-48(79) "NURE Aerial Gamma-Ray and Magnetic Reconnaissance Survey, Southeastern Area—Alaska, Skagway, Atlin, Mt. Fairweather, Juneau, Taku River, Sitka, Sumdum, Port Alexander, Petersburg, Bradfield Canal, Craig, Ketchikan, Dixon Entrance, and Prince Rupert Quadrangles," LKB Resources, Inc., January 1979, 1,094 p., 40 fiche, \$70.00.

- GJBX-49(79) "Aerial Gamma Ray and Magnetic Survey, Rockies/Laramie Range Project, Denver and Pueblo Quadrangles, Colorado," geoMetrics, March 1979, 718 p., 39 fiche, \$10.00.
- GJBX-50(79) "Engineering Report on the Drilling in the Upper Michigan Precambrian Basins," J. Trow, Michigan Department of Natural Resources, Geological Survey Division, April 1979, 84 p., 13 fiche, \$3.00.
- GJBX-51(79) "Survey of Lands Held for Uranium Exploration, Development, and Production in Fourteen Western States in the Six Month Period Ending December 31, 1978," Bendix Field Engineering Corporation, May 1979, 22 p., \$3.00.
- GJBX-52(79) "Evaluation Models of Active Neutron Logging Tools for Direct Uranium Measurement," W. A. Woolson and M. L. Gritzner, Science Applications, Inc., September 1978, 220 p., \$3.00.
- GJBX-53(79) "Hydrogeochemical and Stream Sediment Reconnaissance Program in the Central United States, Semiannual Progress Report, April 1 through September 30, 1978," J. W. Arendt, Oak Ridge Gaseous Diffusion Plant, October 1978, 9 p., \$3.00.
- GJBX-54(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Wichita NTMS Quadrangle, Kansas," Oak Ridge Gaseous Diffusion Plant, March 1979, 119 p., 7 illus., 3 fiche, \$5.00.
- GJBX-55(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for St. Cloud NTMS Quadrangle, Minnesota," Oak Ridge Gaseous Diffusion Plant, March 1979, 119 p., 9 illus., 3 fiche, \$5.00.
- GJBX-56(79) "Uranium in Coal," J. Fred Facer, Jr., U.S. Department of Energy/Grand Junction Office, May 1979, 73 p., \$3.00.
- GJBX-57(79) "NURE Aerial Gamma-Ray and Magnetic Reconnaissance Survey, Blue Ridge Area, Knoxville and Charlotte Quadrangles," LKB Resources, Inc., March 1979, 366 p., 30 fiche, \$10.00.
- GJBX-58(79) "Dyersburg 1° x 2° NTMS Area Kentucky, Missouri, Tennessee, and Illinois—Data Release," P. L. Jones, Savannah River Laboratory, April 1979, 205 p., 10 illus., 3 fiche, \$5.00.
- GJBX-59(79) "Airborne Gamma-Ray Spectrometer and Magnetometer Survey, Las Vegas Quadrangle (Arizona, California, Nevada), Williams Quadrangle (Arizona), Prescott Quadrangle (Arizona), and Kingman Quadrangle (Arizona, California, Nevada), Final Report," Aero Service Division, Western Geophysical Company of America, February 1979, 993 p., 148 fiche, \$20.00.
- GJBX-60(79) "Hydrogeochemical and Stream Sediment Reconnaissance Program in Central United States, Semiannual Progress Report, October 1, 1978 through March 31, 1979," J. W. Arendt, Oak Ridge Gaseous Diffusion Plant, April 1979, 22 p., \$3.00.
- GJBX-61(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Ashland NTMS Quadrangle, Wisconsin; Michigan; Minnesota," J. W. Arendt, Oak Ridge Gaseous Diffusion Plant, March 1979, 130 p., 8 illus., 2 fiche, \$5.00.
- GJBX-62(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Clinton NTMS Quadrangle, Oklahoma," J. W. Arendt, Oak Ridge Gaseous Diffusion Plant, March 1979, 147 p., 7 illus., 3 fiche, \$5.00.
- GJBX-63(79) "Poplar Bluff 1° x 2° NTMS Area, Missouri and Arkansas, Data Release, NURE Program Hydrogeochemical and Stream Sediment Reconnaissance," J. D. Heffner, Savannah River Laboratory, April 1979, 210 p., 10 illus., \$5.00.
- GJBX-64(79) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Lamar NTMS Quadrangle, Colorado, Including Concentrations of Forty-Three Additional Elements," S. S. Shannon, Jr., Los Alamos Scientific Laboratory, April 1979, 155 p., 5 illus., \$4.00.
- GJBX-65(79) "Aerial Radiometric and Magnetic Survey, Trona National Topographic Map, California," Geo-Life, Inc., December 1978, 204 p., 126 fiche, \$5.00.
- GJBX-66(79) "Aerial Radiometric and Magnetic Survey, Goldfield National Topographic Map, California and Nevada," Geo-Life, Inc., December 1978, 339 p., 116 fiche, \$5.00.
- GJBX-67(79) "Aerial Radiometric and Magnetic Survey, Tularosa National Topographic Map, New Mexico," Geo-Life, Inc., December 1978, 184 p., 66 fiche, \$5.00.
- GJBX-68(79) "Aerial Radiometric and Magnetic Survey, Brownwood National Topographic Map, Texas," Geodata International, Inc., February 1979, 293 p., 62 fiche, \$10.00.
- GJBX-69(79) "Aerial Radiometric and Magnetic Survey Beeville/Bay City National Topographic Map, Texas Gulf Coast," Geodata International, Inc., January 1979, 256 p., 114 fiche, \$15.00.
- GJBX-70(79) "Hydrogeochemical and Stream Sediment Reconnaissance Raw Data Report for Sandpoint NTMS Quadrangle, Washington, Idaho, and Montana," F. J. Ciminesi, Lawrence Livermore Laboratory, February 1979, 122 p., 6 illus., 8 fiche, \$4.00.
- GJBX-71(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data Report for Williams NTMS Quadrangle, Arizona," J. L. Wagoner, Lawrence Livermore Laboratory, February 1979, 77 p., 6 illus., 5 fiche, \$4.00.

- GJBX-72(79) "Artillery Peak Orientation Study, Mohave County, Arizona," K. P. Puchlik, et al., Lawrence Livermore Laboratory, March 1979, 28 p., 3 illus., 1 fiche, \$4.00.
- GJBX-73(79) "Athens, Charlotte, Greenville, and Spartanburg NTMS 1° x 2° Quadrangle Areas, Supplemental Data Release," R. B. Ferguson, Savannah River Laboratory, March 1979, 126 p., \$3.00.
- GJBX-74(79) "Results of Elemental Analyses of Water and Waterborne Sediment Samples from the Fairbanks NTMS Quadrangle, Alaska," R. R. Sharp, Jr., et al., Los Alamos Scientific Laboratory, April 1979, 211 p., 5 illus., \$4.00.
- GJBX-75(79) "Knoxville 1° x 2° NTMS Area North Carolina, South Carolina and Tennessee, Data Release," E. I. Baucom and R. B. Ferguson, Savannah River Laboratory, May 1979, 136 p., 8 illus., 3 fiche, \$3.00.
- GJBX-76(79) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Craig NTMS Quadrangle, Colorado, Including Concentrations of Forty-Three Additional Elements," S. L. Bolivar and D. E. Hill, Los Alamos Scientific Laboratory, May 1979, 238 p., 5 illus., \$4.00.
- GJBX-77(79) "Uranium Hydrogeochemical and Stream Sediment Reconnaissance of the Cortez NTMS Quadrangle, Colorado/Utah, Including Concentrations of Forty-Three Additional Elements," R. G. Warren, Los Alamos Scientific Laboratory, May 1979, 201 p., 5 illus., \$4.00.
- GJBX-78(79) "Geology of the Birmingham, Gadsden, and Montgomery 1° x 2° NTMS Quadrangles, Alabama," C. W. Copeland and M. A. Beg, Savannah River Laboratory, April 1979, 88 p., 10 illus., \$5.00.
- GJBX-79(79) "Automated Data Handling of Uranium Analyses for the NURE Program," S. T. Kosiewicz, Los Alamos Scientific Laboratory, February 1979, 16 p., \$3.00.
- GJBX-80(79) "Calculated Time-Correlated Neutron-Induced Radiations in a Sandstone Formation," C. W. Peters and E. I. Karaoglan, Consolidated Controls Corporation, March 1979, 98 p., \$3.00.
- GJBX-81(79) "Aerial Radiometric and Magnetic Survey, Bozeman National Topographic Map, Montana," High Life Helicopters, Inc., and Geodata International, Inc., April 1979, 300 p., 128 fiche, \$5.00.
- GJBX-82(79) "Aerial Gamma Ray and Magnetic Survey, Powder River II Project, Newcastle, Gillette, Wyoming and South Dakota, Ekalaka, Montana, South and North Dakota Quadrangles," geoMetrics, April 1979, 472 p., 54 fiche, \$15.00.
- GJBX-83(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Pratt NTMS Quadrangle, Kansas," J. W. Arendt, Oak Ridge Gaseous Diffusion Plant, April 1979, 111 p., 7 illus., 2 fiche, \$5.00.
- GJBX-84(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Joplin NTMS Quadrangle, Kansas; Missouri," Oak Ridge Gaseous Diffusion Plant, April 1979, 137 p., 7 illus., 3 fiche, \$5.00.
- GJBX-85(79) "Nondestructive Assay Technology for Uranium Resource Evaluation, Infinite Medium Calculations, Final Report," M. Jain, et al., Los Alamos Scientific Laboratory, March 1979, 74 p., \$3.00.
- GJBX-86(79) "Savannah River Laboratory Semi-Annual Report, Hydrogeochemical and Stream Sediment Reconnaissance, National Uranium Resource Evaluation Program, October 1978-March 1979," Savannah River Laboratory, May 1979, 51 p., \$3.00.
- GJBX-87(79) "Aerial Radiometric and Magnetic Survey, Billings National Topographic Map, Montana," High Life Helicopters, Inc., and Geodata International, Inc., April 1979, 237 p., 6 illus., 127 fiche, \$5.00.
- GJBX-88(79) "NURE Aerial Gamma-Ray and Magnetic Reconnaissance Survey, Big Bend area, Marfa MH 13-5, Fort Stockton MH 13-6, Presidio MH 13-8, and Emory Peak MH 13-9 Quadrangles," LKB Resources, Inc., February 1979, 578 p., 39 fiche, \$20.00.
- GJBX-89(79) "Hydrogeochemical and Stream Sediment Reconnaissance Report for the Tonopah NTMS Quadrangle, Nevada," B. Qualheim, Lawrence Livermore Laboratory, March 1979, 58 p., 6 illus., 3 fiche, \$4.00.
- GJBX-90(79) "Hydrogeochemical and Stream Sediment Reconnaissance Report for the Lovelock NTMS Quadrangle, Nevada," B. Qualheim, Lawrence Livermore Laboratory, March 1979, 58 p., 6 illus., 3 fiche, \$4.00.
- GJBX-91(79) "Mining and Processing Methods and Cost Models for the Recovery of Thorium from Domestic Occurrences," J. F. Lemons, Jr., and L. V. Coppa, U.S. Bureau of Mines, May 1979, 75 p., \$5.00.
- GJBX-92(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Palestine NTMS Quadrangle, Texas," Oak Ridge Gaseous Diffusion Plant, May 1979, 123 p., 7 illus., 3 fiche, \$5.00.
- GJBX-93(79) "Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for the Wichita Falls NTMS Quadrangle, Texas," Oak Ridge Gaseous Diffusion Plant, May 1979, 144 p., 7 illus., 2 fiche, \$5.00.
- GJBX-94(79) "Hartford 1° x 2° NTMS Area, Connecticut, New Jersey and New York, Data Release, Hydrogeochemical and Stream Sediment Reconnaissance," P. L. Jones, Savannah River Laboratory, May 1979, 226 p., 10 illus., 3 fiche, \$5.00.
- GJBX-95(79) "Aerial Gamma Ray and Magnetic Survey, Uncompahgre Uplift Project, the Salina, Utah; Moab, Utah and Colorado; Montrose and Leadville, Colorado Quadrangles," geoMetrics, April 1979, 826 p., 128 fiche, \$20.00.
- GJBX-96(79) "Aerial Radiometric and Magnetic Survey, White Sulphur Springs, National Topographic Map, Montana," High Life Helicopters, Inc., and Geodata International, Inc., May 1979, Vol. I: 224 p., Vol. II: 72 p., 124 fiche, \$5.00.

- GJBX-97(79) "Anomalies in Concentrations of Radon in the Earth," R. L. Fleischer, et al., General Electric Research and Development Center, October 1978, 127 p., \$3.00.
- GJBX-98(79) "Aerial Radiometric and Magnetic Survey, Crystal City National Topographic Map, Texas Gulf Coast," Geodata International, Inc., May 1979, Vol. I: 147 p., Vol. II: 78 p., 104 fiche, \$5.00.
- GJBX-99(79) "Aerial Radiometric and Magnetic Survey, Corpus Christi/Laredo National Topographic Map, Texas Gulf Coast," Geodata International, Inc., January 1979, Vol. I: 154 p., Vol. II: 104 p., 140 fiche, \$5.00.
- GJBX-100(79) "High Resolution Seismic Study in the Gas Hills Uranium District, Wyoming," J. K. Applegate, et al., Boise State University Department of Geology and Geophysics, 104 p., 1 illus., \$3.00.
- GJBX-101(79) "Engineering Report on the Drilling in the East Chaco Canyon of New Mexico," Bendix Field Engineering Corporation, July 1979, 47 p., \$3.00.
- GJBX-102(79) "Papago Indian Reservation Water Sample Analyses," G. H. Higgins, Lawrence Livermore Laboratory, May 1979, 21 p., \$3.00.
- GJBX-103(79) "Engineering Report on the Drilling in the Spor Mountain Area of Utah," Bendix Field Engineering Corporation, July 1979, 108 p., \$3.00.
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Technical Memoranda

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- DAO-4-TM-1 "Thorium Occurrences in the Capitan Mountains Area, Lincoln County, New Mexico," G. E. Collins, August 1956, 11 p., 2 illus., \$3.00.
- DAO-4-TM-4 "Uranium Occurrences on the Empire Claims, Iron Mountain Mining District, Sierra County, New Mexico," F. S. Boyd, Jr., November 1957, 13 p., 3 illus., \$3.00.
- DAO-4-TM-11 "A Report on Auger Drilling Project Conducted on the Harte-Mansfield Ranch, Oldham County, Texas," J. W. Allison, December 1956, 23 p., 2 illus., \$3.00.
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- DBO-4-TM-5 "Preliminary Reconnaissance for Uranium in the Cornudas Mountains, Otero County, New Mexico, and Hudspeth County, Texas," G. E. Collins, February 1958, 16 p., 2 illus., \$3.00.
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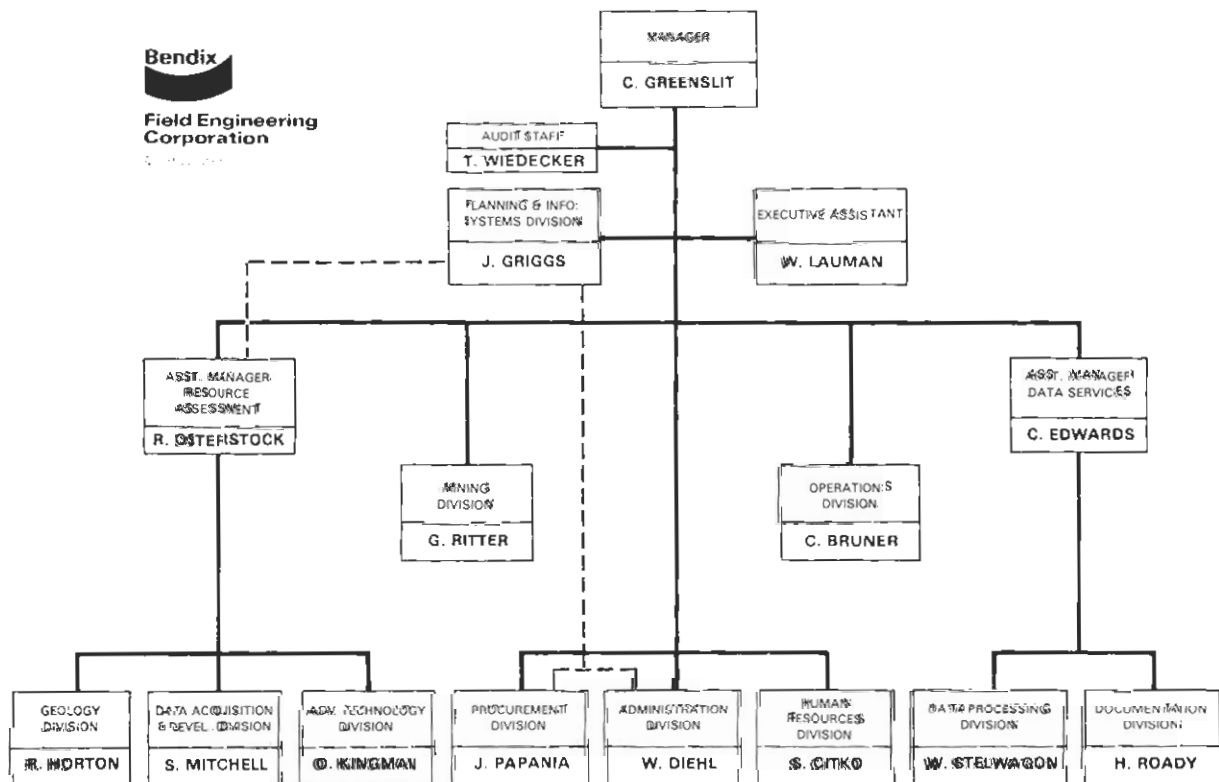
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