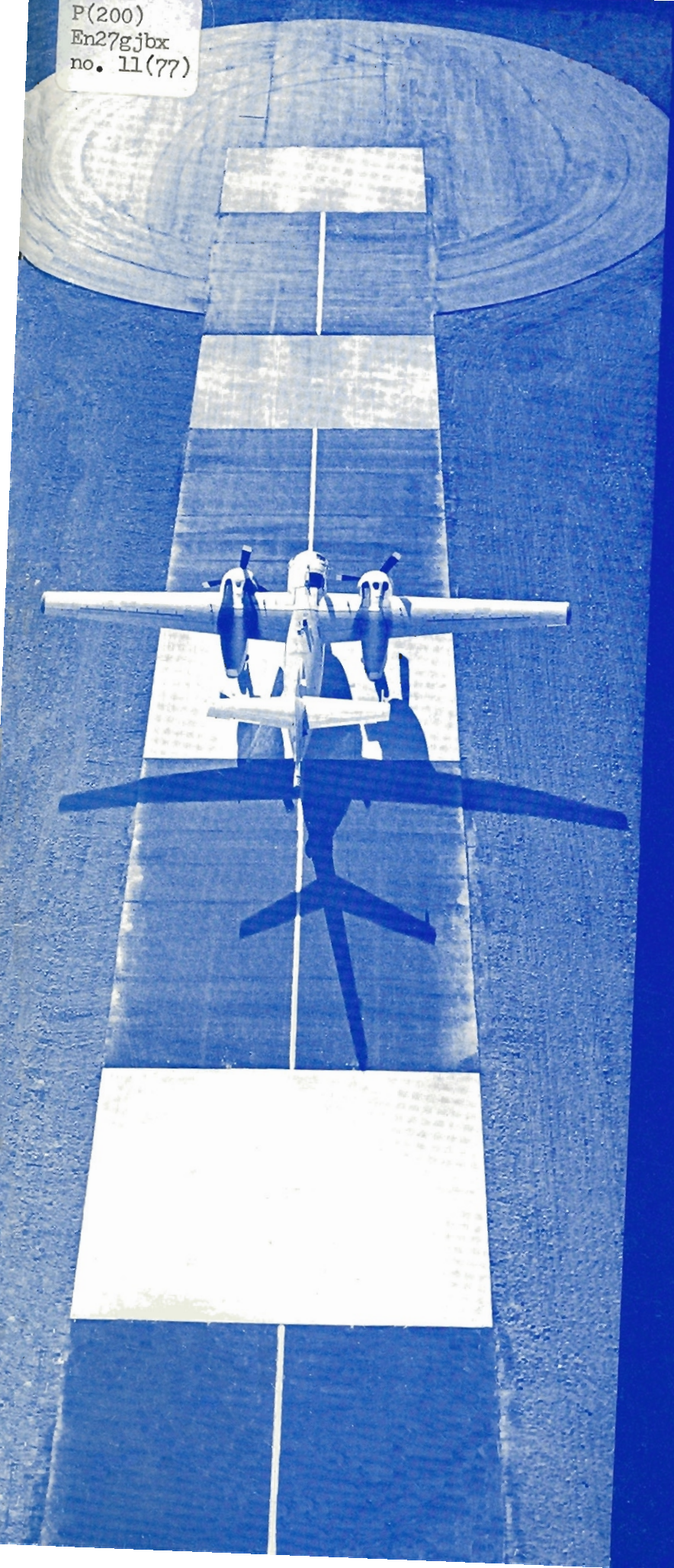
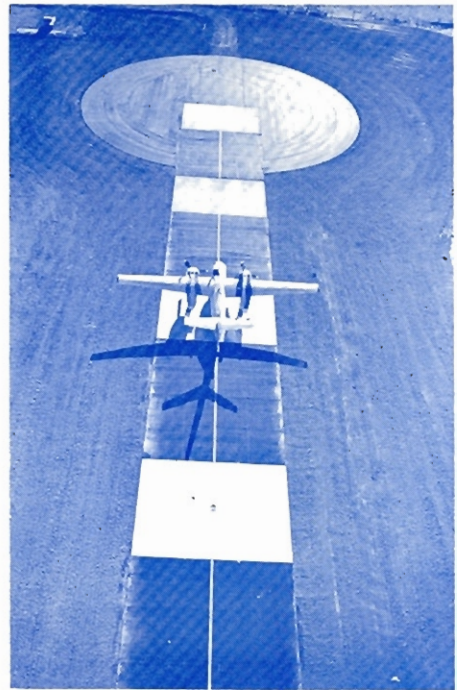
GJBX-11(77



ANNUAL NURE REPORT 1976



An industry Grumman S-2 aircraft is shown parked on ERDA's airborn radiometric calibration facility at Grand Junction's airport. The plane's equipment is being calibrated over five concrete pads containing known quantities of potassium, thorium and uranium. (Axel Kaulisch photograph)

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
GRAND JUNCTION OFFICE
GRAND JUNCTION, COLORADO 81501

ERDA

NEWS
RELEASE

No. 77-37
Contact: Peter Mygatt
Tel: 303/242-8621, Ext. 293

For Release Friday,
May 6, 1977

ANNUAL REPORT OF NURE ACTIVITIES ISSUED

The Bendix Field Engineering Corporation, prime operating contractor for the Grand Junction (Colorado) Office, Energy Research and Development Administration (ERDA), has issued its first annual activities report of the National Uranium Resource Evaluation (NURE).

The 75-page publication, GJBX-11(77), "Annual NURE Report 1976," is a description of work done during calendar 1976 by Bendix and ERDA and their contractors in support of the NURE program. The report does not contain information on the status of uranium resources; this information will be issued about mid-year as GJO-100(77), "Statistical Data of the Uranium Industry."

NURE is an ongoing program of ERDA's Grand Junction Office which includes the development and compilation of 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(77) may be obtained by writing to: Technical Library, Bendix Field Engineering Corporation, P. O. Box 1569, Grand Junction, Colorado 81501, tel: 303/242/8621, Ext. 278.

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Annual NURE Report 1976

National Uranium Resource Evaluation

Bendix Field Engineering Corporation
Grand Junction Operations
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(303) 242-8621

Prepared for the
U.S. Energy Research and Development Administration
Grand Junction Office
Under Contract No. E(05-5)-1664

TABLE OF CONTENTS

FOREWORD

Bendix Field Engineering Corporation, prime operating contractor for the Energy Research and Development Administration's Grand Junction (Colorado) Office, provides management, technical, and total facility services in support of GJO's responsibilities.

This report summarizes technical activities conducted in support of ERDA's National Uranium Resource Evaluation (NURE) program during calendar 1976. Bendix activities were condueted under United States Contract E (05-1) - 1664, and all technical activities were performed under the supervision of the Grand Junction Office of ERDA.

NATIONAL URANIUM RESOURCE EVALUATION

The Energy Research and Development Administration (ERDA) was established under the Energy Reorganization Act of 1974 to bring together federal activities in energy research, development and demonstration, and to assure coordinated and effective development of all energy sources.

Congress, in authorizing ERDA for this purpose, stated as a national goal: ". . . effective action to develop, and increase the efficiency and reliability of use of, all energy sources to meet the needs of present and future generations, to increase the productivity of the national economy and strengthen its position in regard to international trade, to make the Nation self-sufficient in energy, to advance the goals of restoring, protecting, and enhancing environmental quality, and to assure public health and safety."

The National Uranium Resource Evaluation (NURE) is an ERDA-directed program which relates to this task. To develop 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, NURE has been organized into the following elements:

1. Aerial Radiometric Reconnaissance
2. Surface Geologic and Related Investigations
3. Hydrogeochemical and Stream Sediment Reconnaissance
4. Subsurface Geologic Investigations
5. Technology Development

In June of 1976, ERDA published a preliminary estimation of U.S. potential uranium resources, based primarily upon the compilation and evaluation of data in ERDA files and limited reconnaissance-type geologic field work. The NURE programs listed above will expand the data base beyond the 1976 estimate. A comprehensive uranium resources assessment report will be issued in 1981, based upon information gathered and analyzed by the NURE effort.

1976 NURE SUMMARY and HIGHLIGHTS

All National Uranium Resource Evaluation activities were in full swing during 1976. Nearly 80,000 miles of aerial surveys were flown; thousands of square miles were sampled by four ERDA Laboratories for the Hydrogeochemical program; over 50 geologic study projects were under way; in remote sensing,LANDSAT data was being analyzed digitally and by video image enhancement for uranium signatures; the drilling program was initiated with a 2,200-foot granite core hole in Wyoming; and the Technology Development program had more tban two dozen geopbysical and geochemical projects in progress.

NURE information dissemination was highlighted through the installation of a micrographics capability whereby technical reports are now available to the public on microfiche and microfilm. The capability helps facilitate technology transfer, and provides information to the public rapidly and at a reasonable cost.

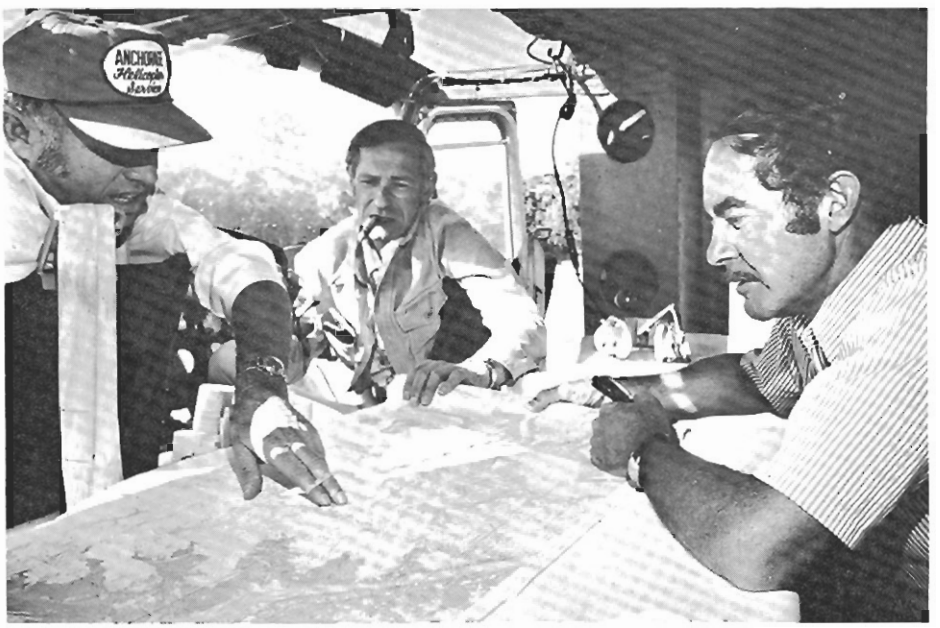
Geophysical Activities

NURE geophysical activity was highlighted by the initiation of the first major aerial radiometric reconnaissance survey using a rotary-wing aircraft. LKB Resources, Inc., under Bendix subcontract, flew more than 12,000 line-miles of survey over rugged mountains of Alaska utilizing a Bell 205 helicopter and a 2,500-cubic-inch spectrometer system. Additional subcontraets to Texas Instruments, Inc., Geodata International, and Geometrics, Inc., accomplished nearly 68,000 more line-miles of aerial surveying during 1976. The year's effort exceeded the total NURE aerial survey line-miles of 1974 and 1975 combined.

Quality control and uniformity of NURE aerial radiometric surveys were enhanced during 1976 through a substantial revision of the Bendix specification PMD-1200, "General Specification for Airborne Geophysical Surveys." Subcontractors now have a common requirements document controlling radiometric and magnetic data acquisition, data reduction, statistical analyses, geologic correlation, and final data presentation.

Normalization of radiometric data from the various subcontractors was also enhanced in 1976 by two "firsts" in the United States: a KUT (potassium, uranium, and thorium) spectrometer calibration pad facility and a dynamic test range for calibrating airborne radiometric survey instrumentation systems. These facilities resulted from two technology development projects. The calibration pads, containing measured amounts of potassium, thorium, and uranium ores, were constructed at Walker Field in Grand Junction. A four-mile-long strip near Lake Mead, Arizona, was selected for the dynamic test range. A new Bendix specification, PMD-1250, defining requirements for the use of both new radiometric system facilities, was released in December.

Uranium geophysical technology development was highlighted in 1976 by the successful demonstration of two different down-hole neutron generator probes developed by Bendix subcontractors for the direct measurement of uranium. Several projects were initiated to identify and evaluate potential methods for locating deeply buried uranium deposits. At year's end, vehicle-mounted data collection systems using the KUT technique were being optimized for surface and subsurface logging; calibration capabilities for emanometry instrumentation and neutron- and gamma-logging systems were being improved or established at the ERDA Grand Junction facility; and, sophisticated electronic equipment was being installed in the ERDA-GJO chemical laboratories to improve the speed, sensitivity, and accuracy of analyzing geologic field samples for uranium and several other elements.



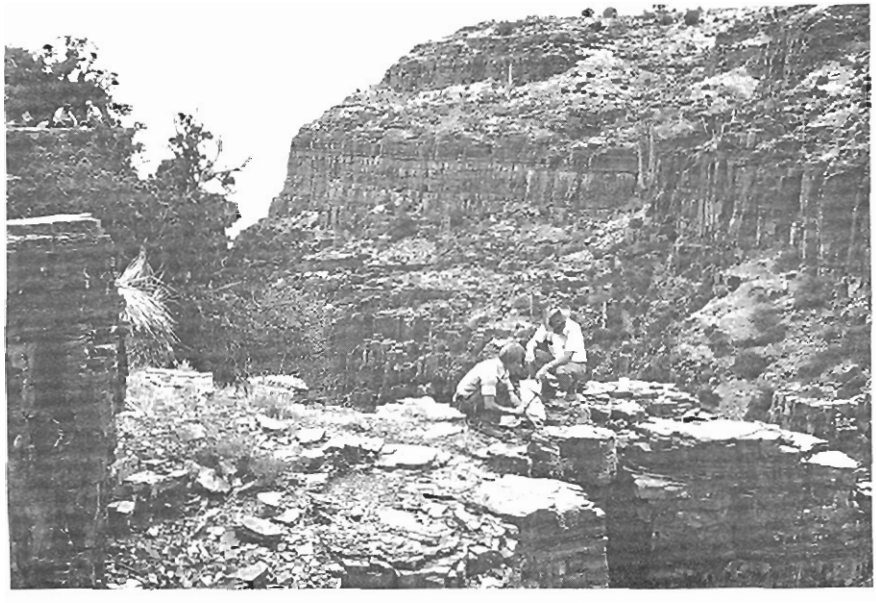
Bendix personnel discuss flight-line layout with Alaskan airborne survey contractor.

Geological Activities

Some 50 geologic projects were active during 1976, reaching from the Connecticut Basin to central Australia and Southwest Africa, from Alaska to Brazil, and studying uranium occurrences in everything from Precambrian crystalline rocks to Quaternary calcrete deposits. Foreign uranium occurrences were studied for geologic modeling to be used in evaluating analagous U.S. environments. Bendix geologists conducted detailed investigations of rock units in the arid terrain of the Southwest, in mountain basins high in the Rockies, across the plains of the midcontinent, through the densely vegetated eastern highlands, and along the coastal plain, back-packing field equipment and sampling outcrops, taking radiation measurements, recording lithologic characteristics, mapping geology, and continually trying to identify uranium favorability characteristics. From these field observations, and from laboratory analyses of more than 4,000 samples, comprehensive geologic reports were prepared and issued to make the results of these investigations available to industry. Regional geologic reports for five uranium favorability assessment projects were placed on open file in 1976.

Bendix regional geologists also initiated 22 preliminary field and literature surveys of potentially promising areas, to determine where further geologic efforts should be concentrated. The findings of several of these preliminary studies are already being used for planning 1978 projects. Besides conducting their own projects, geologists of Bendix regional offices monitored ten subcontracted studies being performed within their respective districts.

In the course of conducting topical geologic studies—those projects which investigate a category of uranium geology rather than make a regional assessment for uranium, Bendix subcontractors traveled many miles outside the United States to study significant economic uranium deposits which occur in rock types not yet found productive here: Australian and South African calcretes, Canadian metasediments, and African Precambrian crystallines. Subcontractors also conducted geostatistical studies to refine the methods of uranium resource appraisal and ore reserve estimation. Statistics were applied to LANDSAT digital data in order to catalog spectral responses and discriminate known uranium occurrences on the Colorado Plateau and in the Basin and Range area.



Bendix geologists collect field samples for laboratory analysis.

Hydrogeochemical Activities

1976 was the first full year for the NURE Hydrogeochemical and Stream Sediment Reconnaissance program, with each of the fonr participating ERDA Laboratories, Livermore, Los Alamos, Oak Ridge, and Savannah River, conducting full-scale stream water, groundwater, and stream sediment sampliug programs from the East Coast to the West Coast and from Georgia to Alaska. Priority of coverage was given to those regions selected according to geologie favorability as potential host areas for uranium.

Reconnaissance surveys were begun during the year; however, most of the effort dnring 1976 was expended on development of field sample collecting techniques, laboratory analysis systems, data management, and internal quality control. During the year, Laboratory personnel and that of their subcontractors executed pilot studies in more than 30 different project areas. Results of these pilot studies were used by each Laboratory to verify or upgrade the sample collecting, processing, and analysis techniques to be employed in reconnaissance surveys in different geologic settings and under varying climatic conditions.

Bendix activity on the Hydrogeochemical program was confined to liaison with the ERDA Laboratories, with emphasis on the results and methods of the various survey pilot studies.

Livermore personnel collect water samples in the Ruby Mountains, Elko County, Nevada.

AERIAL RADIOMETRIC RECONNAISSANCE

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

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

In accomplishing these objectives, the aerial reconnaissance program will survey all states except Hawaii and will fly about a million flight-liue miles by 1981.

The Aerial Radiometric Reconnaissauce program was initiated in 1974 and has expanded to a $3 million effort in 1976.

Ten survey projects have been completed through calendar years 1974-76, totaling some 90,000 line-miles of data; this represents 9 percent coverage of the conterminous United States aud Alaska. The survey

---71,000 miles flown in 1976---

areas completed in the conterminous U.S. and Alaska are shown on the accompanying maps.

There are four planning factors currently controlling the annual aerial survey program:

1. Geographic/geologic priorities
2. Industry survey capability
3. ERDA fiscal year funding
4. Regional seasonal climates

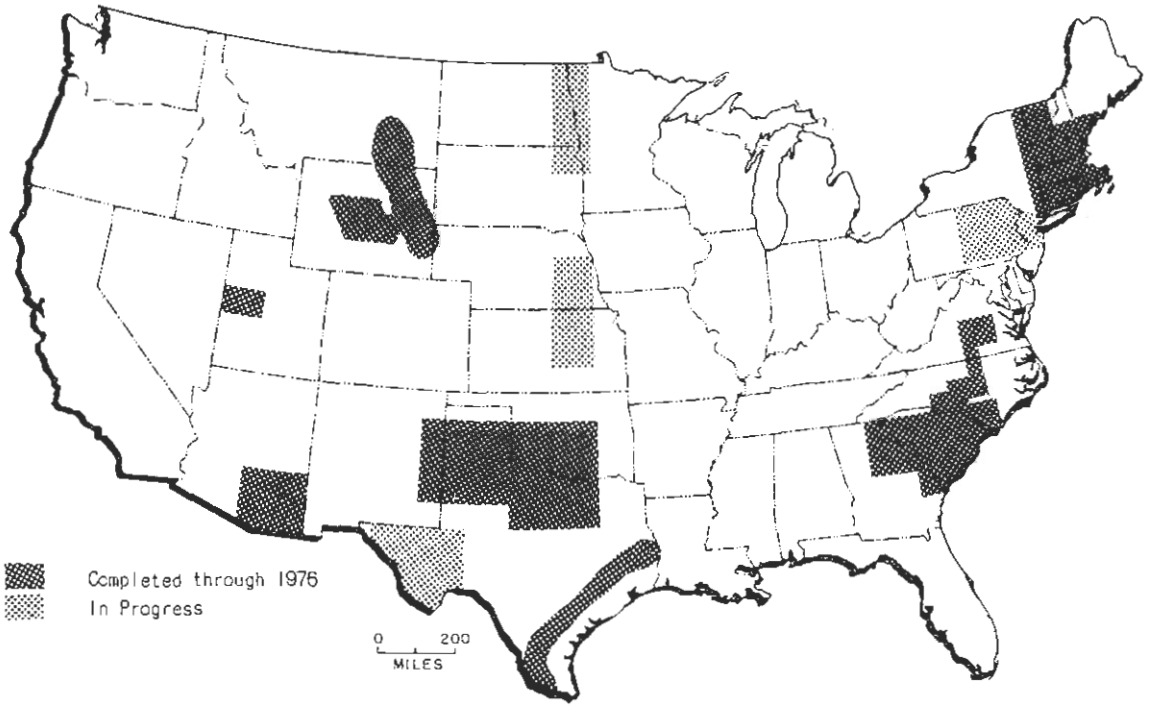
Any one year's survey program must, by necessity, involve trade-offs and compromises of the above-noted factors.

Since the initial two surveys in Texas and Wyoming in 1974, the projects have been flown on the basis of the National Topographic Map Series (NTMS) 1:250,000-scale quadrangles; flight lines and tie lines in east-west or north-south directions only; and at a nominal altitude of 400 feet. Topographic conditions and survey altitude constraints require that specified areas be flown using rotary-wing aircraft.

Results of the aerial survey projects are open-filed by ERDA at preannounced locations. Radiometric data are presented in the form of statistical anomaly maps by geologic unit, histograms, and flight-line stacked profiles of equivalent potassium, thorium, and uranium gamma values and their ratios.

The flying phases of four aerial survey projects were completed during 1976. These four projects totaled just over 71,000 line-miles in Alaska, Utah, Texas, New Mexico and Oklahoma. Three of the areas were surveyed using a DC-3 aircraft system, and one was flown with a new rotary-wing aircraft system. Two additional subcontracts were awarded late in 1976 defining an additional 46,000 line-miles of survey in the conterminous U.S.; 9,000 of these line-miles were completed by the end of 1976.

The aerial reconnaissance program is the responsibility of the Bendix Project Management Division.



Alaska Fixed-Wing Survey

Subcontractor:
TEXAS INSTRUMENTS, INC.
Subcontract Value: $648,333
Start Date: 15 April 1976
Completion Date: 1 February 1977
Line Miles Flown: 20,157
Days Flying: 39
Aircraft: DC-3

Texas Instruments conducted a radiometric and magnetic survey of 23 NTMS quadrangles in southwestern and east-central Alaska. The complete airborne system was successfully checked on-site prior to initiation of data collection on May 27. Data reduction and analysis, started in early June, were complete by December 31.

The aircraft, equipped with a 3,739-cubic-ineh sodium iodide scintillation crystal detection system, flew 20,157 line-miles on a 6.25-mile spacing oriented in an east-west direction, with 25-mile spacing between north-south tie lines. Flying, initially estimated to require 56 days, was completed ahead of schedule in 39 days. Down-time of 28 days was experienced due to poor flying conditions and aircraft problems. Continous inclement weather in the vicinity of St. Lawrence Island necessitated cancelling the planned survey of the island.

Of the 23 quadrangles surveyed, available regional geologic maps for 13 were on scales smaller than the standard NTMS scale of 1:250,000. Therefore, to permit accurate statistical analysis of airborne gamma-ray data, these maps were supplemented by photogeologic interpretation of 1:250,000-scale LANDSAT imagery.

The complete report of this survey will be open-filed in the spring of 1977.

North Central New England Survey

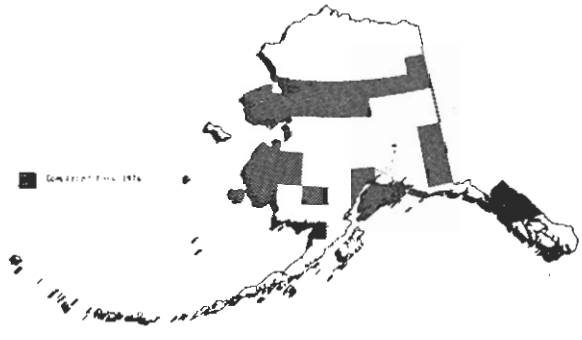
Subcontractor:
TEXAS INSTRUMENTS, INC.
Subcontract Value: $209,646
Start Date: 23 September 1975
Completion Date: 18 May 1976
Line-Miles Flown: 9,160
Aircraft: DC-3 and Alouette III Helicopter

A survey of north-central New England was flown in 1975. However, the final data and report were reviewed by Bendix in early 1976 and the results open-filed by ERDA as GJO-1666-1 in May of 1976.

Carolinas and Georgia Fixed-Wing Survey

Subcontractor:
GEODATA INTERNATIONAL, INC.
Subcontract Value: $369,187
Start Date: 30 August 1975
Completion Date: 1 February 1976
Line-Miles Flown: 15,034
Aircraft: DC-3

A survey of portions of North and South Carolina and Georgia was flown in 1975. However, the final data and report were reviewed by Bendix in 1976, and the results were open-filed by ERDA as GJO-1663-1 in March of 1976.



Aerial survey coverage of the conterminous United States and Alaska through 1976.

The helicopter operated by LKB Resources surveyed over 12,000 line-miles in Alaska.

Alaska Rotary-Wing Survey

Subcontractor: LKB RESOURCES, INC.
Subcontract Value: $1,067,241
Start Date: 12 April 1976
Completion Date: 1 April 1977
Line-Miles Flown: 12,445
Days Flying: 37
Aircraft: Bell 205 Helicopter

The first major rotary-wing radiometric and magnetic survey of the NURE program was conducted in Alaska by LKB Resources. Using an Alouette for logistic support of the Bell 205, LKB surveyed 18 NTMS quadrangles in areas west and south of Anchorage, and in eastern and southeastern Alaska, between June and October 1976. Nominal flight-line spacings were 6.25 miles between east-west traverse lines and 18.75 miles between north-south tie lines.

The complete instrumentation package, which utilized a 2,474-cubic-inch sodium iodide scintillation crystal system, was installed in the aircraft at Anchorage. Following a successful test-line flight on June 15, production was begun using Anchorage as the first base of operations. As the survey progressed, the base was systematically shifted to locations convenient to the areas being flown. Fuel and supplies were transported to remote sites by truck, barge, and support helicopter in advance of operations by the survey helicopter.

Adverse weather conditions persisted during much of the flying period (64 weather days versus 33 production and 4 transit days). However, average flying was approximately 363 miles per day, well above the initial estimate of 310 miles per day. By October 7, when LKB demobilized from the survey area due to continued bad weather, 12,445 production line-miles had been flown.

Upon completion of data reduetion and analysis in the spring of 1977, the results of this survey will be published in an open-filed report.

Red River Blocks A and B Fixed-Wing Survey

Subcontractor:
GEODATA INTERNATIONAL, INC.
Subcontract Value: $554,402
Start Date: 15 April 1976
Completion Date: 15 September 1976
Line-Miles Flown: 23,674
Days Flying: 37
Aircraft: DC-3

In the course of the Red River Aerial Reconnaissance, 12 NTMS quadrangles in Texas, New Mexico

···eight quadrangles in Texas, New Mexico, Oklahoma···

and Oklahoma were surveyed. Of these, the eight designated Blocks A and B were flown by Geodata International. Block A encompassed the Amarillo, Brownfield, Clovis and Tucumcari quadrangles of Texas and New Mexico; Block B, the Clinton, Lawton, Oklahoma City, and Wichita Falls quadrangles of Texas and Oklahoma.

In the data acquisition phase of the survey, a DC-3 aircraft flew a 3,739-cubic-inch sodium iodide scintillation gamma-ray detection system, multichannel analysers, magnetometer and ancillary electronic equipment. Nominal spacings were 3.125 miles between east-west traverse lines, 18.75 miles between north-south tie lines; sampling interval was one second.

Upon completion of data analysis and interpretation, reports were prepared for each quadrangle. Results are presented as prescribed by Bendix specification PMD-1200. Reports for the individual quadrangles of Block A were open-filed under the single number of GJBX-33(76); for those of Block B, GJBX-34(76).

Red River Block C, and Delta, Utah Fixed-Wing Survey

Subcontractor:
TEXAS INSTRUMENTS, INC.
Subcontract Value: $312,662
Start Date: 19 June 1976
Completion Date: 15 December 1976
Line-Miles Flown: 14,068
Days Flying: 32
Aircraft: DC-3

Flying the same aircraft and instrumentation system used earlier in the summer for the Alaska Fixed-Wing Survey, Texas Instruments conducted an aerial radiometric and magnetic survey of portions of Texas, Oklahoma, aud Utah. Data acquisition began in early August and was completed by the end of September; data reduction was completed in December.

The Texas and Oklahoma portion of the survey, designated Red River Block C, encompassed the four

The DC-3 operated by Texas Instruments surveyed more than 20,000 line-miles in Alaska.

NTMS quadrangles of Abilene, Ardmore, Dallas and Sherman. The Utah portion covered an irregular block near Delta: The northern Delta project area encompassed Ranges 6 to 17 West and Townships 10 to 15 South; the southern project area, Ranges 8 to 12 West and Townships 16 to 20 South.

In the Red River Block C area, T.I. flew approximately 11,500 line-miles at the same traverse and tie-line spacings maintained in the Blocks A and B survey previously described. In the Delta area, where nearly 2,500 line-miles were flown, flight lines were due east-west on 2-mile spacings with north-south tie lines at 6-mile intervals.

Project reports for the areas surveyed will be published by quadrangles and placed on open file early in 1977.

Eastern North Dakota, East Salina Basin, and Big Bend Fixed-Wing Survey

Subcontractor: GEOMETRICS, INC.
Subcontract Value: $548,045
Start Date: 27 October 1976
Completion Date: 15 November 1977
Estimated Line-Miles: 28,150
Aircraft: Grumman S-2

In late 1976 a contract was signed with Geometrics, Inc., to conduct a fixed-wing, high sensitivity gamma-ray and magnetic survey of 10 NTMS quadrangles in three areas designated, respectively, Eastern North Dakota, East Salina Basin, and Big Bend.

The Eastern North Dakota project area lies within the states of North Dakota, South Dakota and Minnesota, and encompasses the four NTMS quadrangles of Thief River Falls, Grand Forks, Fargo and Milbank. The East Salina Basin area covers the Fremont, Lincoln, Manhattan and Hutchison quadrangles of Nebraska and Kansas. All eight quadrangles in these two project areas are to be flown with nominal east-west traverse lines at 3.125-mile intervals, and with tie lines north-south at 18.75-mile intervals, for an estimated 10,197 line-miles in the Eastern North Dakota area and 11,287 line-miles in the East Salina Basin.

In the Big Bend project area, which covers the Van Horn and Pecos quadrangles in the state of Texas, an estimated 6,666 net line-miles are to be flown. Nominal east-west spacing will be 3.125 miles, with north-south tie lines at 12.5-mile intervals.

A Grumman S-2 Tracker, equipped with a 3,072-cubic-inch sodium iodide scintillation crystal detection system, is being utilized for all data collection. The aircraft and instrumentation were checked at the new ERDA calibration pads located at Walker Field, Grand Junction, on November 16. Shortly thereafter, production flying was initiated in North Dakota.

Upon completion of data acquisition, processing, and interpretation, the results of the entire survey will be open-filed in late 1977.

Thorpe and Big Bend Rotary-Wing Survey

Subcontractor: LKB RESOURCES, INC.
Subcontract Value: $504,217
Start Date: 28 October 1976
Completion Date: October 1977
Estimated Line-Miles: 18,500
Aircraft: Sikorsky S-58/S-58T Helicopter

With the 2,474-cubic-inch crystal detector system from their Alaskan survey installed in a Sikorsky S-58 helicopter, LKB Resources is conducting the second major rotary-wing reconnaissance survey of the NURE program. This survey encompasses two separate project areas, designated Thorpe and Big Bend. For the near-sealevel Thorpe project, the aircraft being used is a standard S-58; in the Big Bend area, with topography above 5,000 feet, a turbine-powered S-58T will be used.

The Thorpe project includes the four NTMS quadrangles of Williamsport, Harrisburg, Scranton and Newark in the states of Pennsylvania, New Jersey, and New York. Due to the heavy population density encountered in portions of this area, particularly in the Philadelphia-New York-Delaware Valley corridor, var-

Radiometric equipment aboard Geometrics' S-2 aircraft was checked at the ERDA calibration facility at the Grand Junction airport.

The initial airborne radiometric survey follow-up study was accomplished in the Copper River Basin, Alaska.

---safety restrictions tend to limit survey---

ious legal and safety restrictions exist which tend to limit the areal extent of the survey. However, every effort is being made, such as deviating flight lines from nominal orientation and spacing, to obtain maximum coverage. In the Williamsport and Harrisburg quadrangles, traverse lines will be flown nominally north-south at 3.125-mile spacing, with tie lines east-west at 12.5-mile spacing. In the Scranton and Newark quadrangles, traverse lines will be east-west at 3.125-mile spacing and tie lines north-south at 18.75-mile spacing. It is estimated that between 10,500 and 11,500 line-miles will be flown over the Thorpe area.

The rotary-wing project in the Big Bend area lies entirely within the state of Texas, encompasssing the United States portion of the Marfa, Presidio, and Emory Peak quadrangles as well as the entire Fort Stockton quadrangle. An estimated 7,500 line-miles will be flown at a nominal east-west traverse spacing of 3.125 miles and north-south tie line spacing of 12.5 miles.

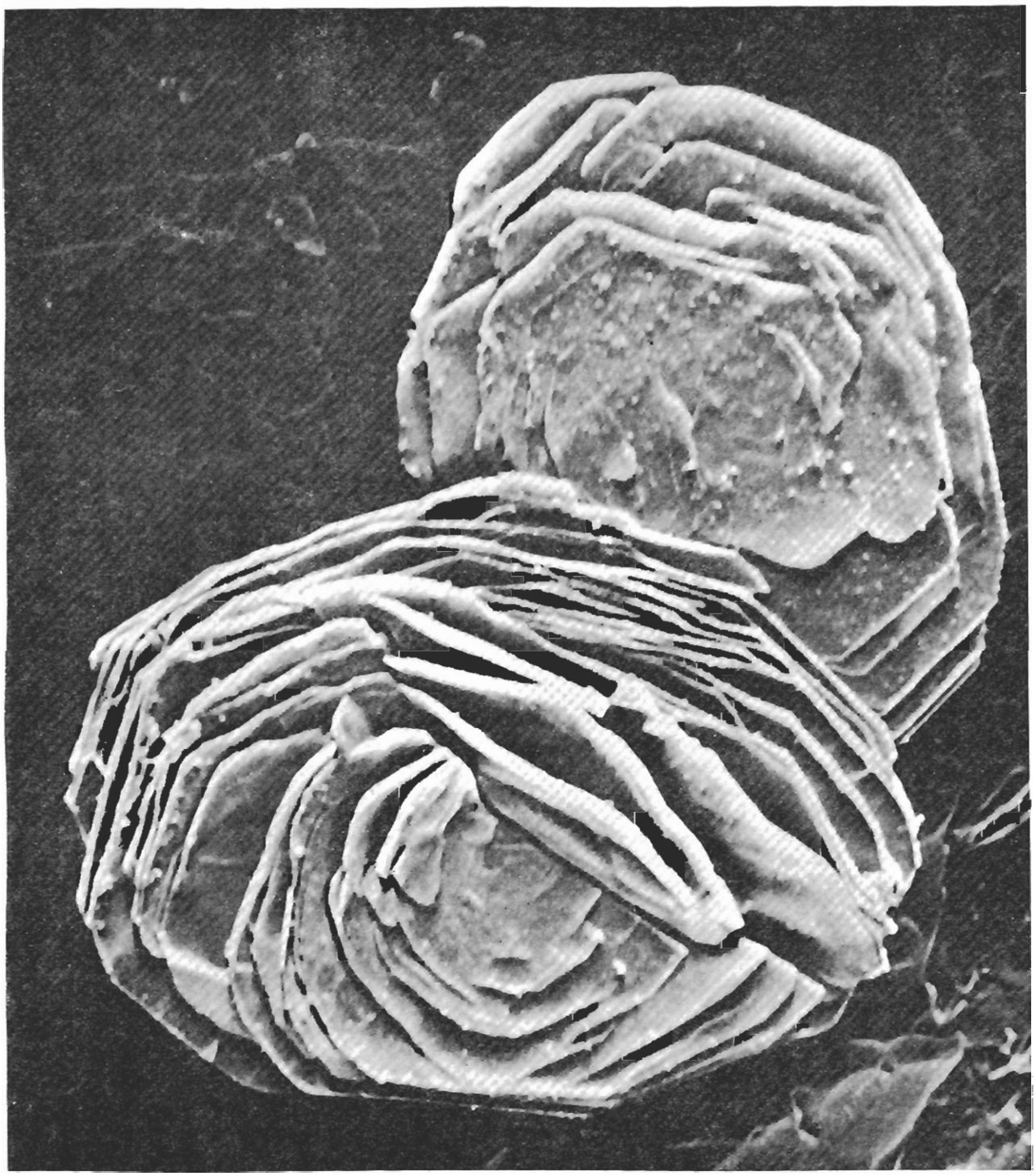
Open-filed reports delineating the results of this project will be published in late 1977.

Copper River Basin Aerial Survey Follow-Up

Subcontractor: UNIVERSITY OF ALASKA
Subcontract Value: $90,000
Start Date: 14 June 1976
Completion Date: 14 March 1977

The University of Alaska Geophysical Institute is conducting a pilot study in the Copper River Basin in Alaska, to follow up the aerial radiometric reconnaissance survey of the area flown in 1975. In attempting to determine the cause of the generally low gamma radiation levels indicated by the survey data, the current investigation is considering three possibilities: that water-saturated ground may attenuate the radiation from lithologic sources; that the rocks of the Copper River Basin may have an innately low content of radioelements; and, that the radioactive minerals may have been mobilized and redeposited elsewhere.

Six areas within the Copper River Basin were identified from the aerial radiometric data as being anomalous. During the summer of 1976 these anomalies were confirmed by ground surveys, and were geologically mapped and sampled for laboratory analyses. Findings and conclusions resulting from this project will be open-filed in the spring of 1977.



REGIONAL GEOLOGIC STUDIES

The Regional Geologic Studies program is the focal point of the entire NURE effort. An updated national uranium resource assessment is the key goal of this program, and all other NURE data sources must be utilized to accomplish this goal. Factors from the hydrogeochemical surveys, the aerial radiometric data, subsurface information, and interpretations from satellite imagery must be integrated with subjective geologic considerations to achieve a comprehensive overall U.S. uranium assessment.

Regional geologic studies continued during 1976 in an attempt to develop the local geologic framework around which the NURE data will be integrated and uranium favorability conclusions drawn. These studies are conducted under the direction of the Bendix Geology Division through its nine regional offices. In 1976, Bendix geologists were engaged in 14 comprehensive regional studies involving literature searches, field mapping, rock sampling, surface radiometric measurements, and detailed laboratory analyses. Of these 14, 10 were completed in 1976 and four are on-going. In addition, 22 preliminary studies of potentially promising areas were conducted during the year by the Bendix field offices to determine where further geologic effort should by concentrated. Of these preliminary studies, which consisted principally of literature searches and limited field work, 13 were completed and 9 are continuing into 1977. This in-house effort was supplemented by 10 subcontracted regional geologic studies, all of which were monitored by Bendix geologists.

The NURE Geologic Drilling program was initiated in 1976 with a 2,200-foot core hole in the Granite Mountains of central Wyoming. This joint project with the United States Geological Survey attempted to core below the zone depleted of uranium to determine what the original uranium concentration of the depleted granite might have been. Planning studies also were initiated of eight other potential drilling areas, as the need for specific subsurface stratigraphic information becomes critical in the ultimate evaluation of uranium potential.

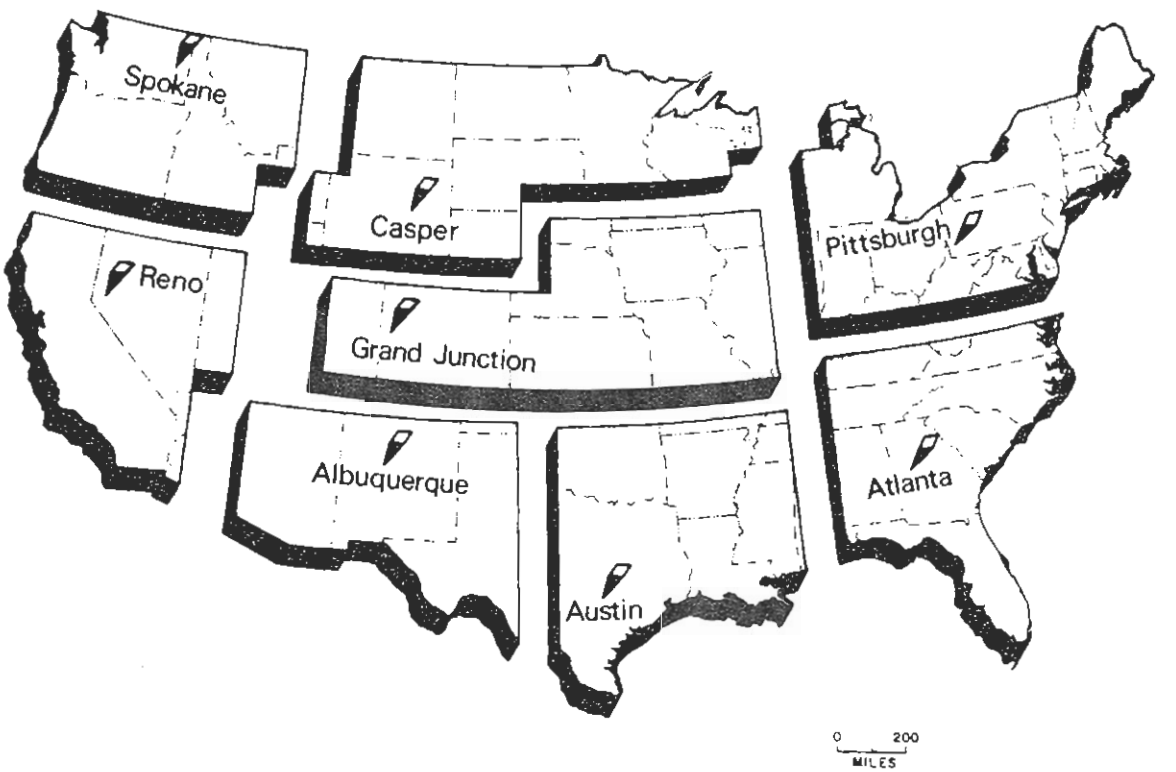
Electron microscope photograph of a "rosette" of the uranium mineral metatyuyamunite.

ERDA/Bendix

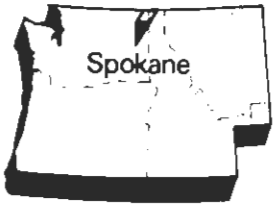
Regional

Geology

Offices



Spokane Office



Bendix geologists of the Spokane office are responsible for planning and conducting geologic projects within the states of Washington and Oregon, the major portion of Idaho, western Montana, and extreme northwestern Wyoming. The physiography of this region is diverse and complex. The Columbia Plateaus and Snake River Plain separate the Basin and Range Province to the south from the Northern Rockies to the northeast; in the western part of the region, the north-trending Coast and Cascade Ranges are partially separated by valley systems in northern Oregon and Washington. Projects are designed to evaluate favorability for uranium in three principal geologic environments: basins filled with Tertiary sedimentary rocks; intrusive bodies and adjacent metamorphic rocks; and silicic volcanic terranes.

In 1976, eight geologists working out of the Spokane office completed three major regional investigations which had been started the previous year, and also conducted three preliminary studies.

Western Snake River Basin, Idaho

Start Date: 15 December 1974
Completion Date: 31 May 1976

Cenozoic formations in the western Snake River Basin of Idaho contain thick sequences of consolidated or partially consolidated sediments. These formations were the subject of a project which was performed in the spring of 1975. The final project report, GJBX-57(76), was placed on open file in December 1976.

Big Meadow, Idaho

Start Date: 1 August 1975
Completion Date: 31 December 1976

Based on the occurrence of radioactive "black sand" placers in the Big Meadow area of Bear Valley, Idaho, a study was undertaken to determine whether a source of uranium might be present in rocks of the Idaho batholith. Work entailed stream-sediment sampling and analyses, and examination of bedrock samples in interfluve areas to identify specific rock types that contributed the radioactive placers.

A summary report of this study will be placed on open file in early 1977.

Typical potential uranium-host sandstone being studied in the Idaho/Oregon/Washington region.

Northeastern Washington Tertiary Sediments

Start Date: 21 September 1973
Completion Date: 31 December 1975

A study of the Tertiary sediments of northeastern Washington, initiated by Bendix's predecessor, involved measurement and sampling of surface sections, chemical and mineralogical analyses of samples, and examination of available water well lithologic logs. A subjective rating system, applicable solely to northeastern Washington, was developed to aid in describing the uranium favorability of the areas investigated. These areas included portions of Spokane, Stevens, Ferry, and Okanogan Counties, as well as that portion of the Pend Oreille River Valley lying within Pend Oreille County.

Results of this study were published by Bendix in May 1976, as a series of three open-filed reports: GJBX-1(76), -2(76), and -3(76).

Southwestern Montana Tertiary Basins

Start Date: 1 June 1975
Completion Date: 31 March 1977

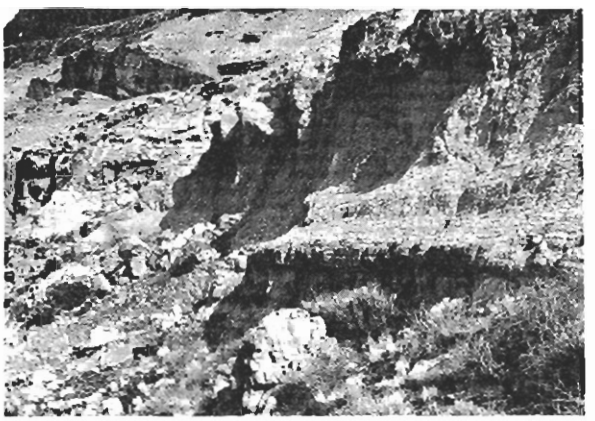
A study of Tertiary sedimentary rocks that fill several basins in southwestern Montana included literature review, extensive field examination and sampling of Tertiary strata, radiometric reconnaissances, and laboratory analyses for uranium content of selected samples. These Tertiary strata are considered potentially favorable principally because many of the basins in which they are found are in close proximity to the Boulder batholith in which numerous uranium occurrences are known.

The project report is to be open-filed in mid-1977.

Boulder Batholith, Montana

Start Date: 1 June 1976
Completion Date: 30 September 1976

A preliminary investigation of the Boulder batholith and assoeiated rocks consisted of an in-depth literature review coupled with field sampling of selected outcrops. Results of this study indicate that further work is necessary to make an accurate estimation of the uranium potential of the batholith.



Typical volcaniclastic sequence being studied in the Idaho area.

Southeastern Oregon

Start Date: 21 June 1976
Completion Date: 31 December 1976

A preliminary study in southeastern Oregon investigated selected volcanic, intrusive, and sedimentary rocks as potential uranium hosts, and evaluated tuffaeeous rocks as a possible uranium source. An inactive uranium mine and several uranium prospects were examined in the Lakeview district in an effort to identify those characteristics of the district which may be useful as indicators of uraninm favorability in the overall project area.

The findings of this preliminary study are providing a basis for planning further work in sontheastern Oregon.

Latah Formation

Start Date: 15 June 1976
Completion Date: 31 December 1976

The Latah Formation of eastern Washington and western Idaho, which is of Miocene age, consists predominately of siltstones and claystones derived from rocks of the Precambrian Belt Supergroup and granitic intrusives of Cretaceous and Eocene ages. Although certain characteristics of the Latah are potentially favorable for uranium accumnlation, there are no identified uranium mineral occurrences. Results of a preliminary study of the Latah are being evaluated to determine if the formation is sufficiently favorable to merit further investigation.

Reno Office

The seven Bendix geologists of this field office, which was relocated from Salt Lake City to Reno in June, 1976, are responsible for a region which encompasses California, Nevada, western Utah, and extreme western Arizona. Although the physiographic environment within this area includes parts of the Pacific Coast and Sierra Nevada Ranges as well as the major portion of the Basin and Range Province, projects to date hve been concentrated in selected parts of the latter. Focus has been on the uranium favorability of Mesozoic granite plutons and Tertiary rhyolitic flows and tuffs exposed in mountain ranges, and on Tertiary sedimentary rocks that occupy intermontane basins.

In 1976, reports were written on two major projects and work was completed on two preliminary studies. A subcontract being performed by the University of Nevada was also monitored by Reno office personnel.

Hallelujah Junction

Start Date: 1 October 1975
Completion Date: 31 December 1976

An area in Washoe County, Nevada, and Lassen County, California, was studied to clarify the complex geology of the area, and to determine the uranium favorability of the Hartford Hill Rhyolite and Truckee Formation, both of Tertiary age. The study involved extensive field work, consisting of rock sampling and detailed mapping of uranium prospects and claims.

The project report will be open-filed in early 1977.

Coso Formation

Start Date: 1 November 1974
Completion Date: 31 August 1976

A study of the low-grade uranium resources of the Tertiary Coso Formation was conducted by Bendix's predecessor as prime contractor to ERDA. The area investigated includes parts of the northern and western flanks of the Coso Range, Owens Valley, Inyo County, California.

The Tertiary Coso Formation consists principally of lake-bed sediments, volcaniclastic rocks, rhyolitic tuffs, dacite flows, and a basal fanglomerate deposited at the flanks of granite intrusives of Cretaceous age. The study was limited to data gathered from surface sampling, field mapping, and literature sources.

The project report was completed by Bendix and open-filed in October, 1976, as GJBX-45(76).

Basin and Range Low Grade

Start Date: 19 July 1976
Completion Date: 31 December 1976

Six areas of Nevada, namely, Virgin Valley, northern Reese River Valley, East Walker River, northwestern Garfield Hills, Coaldale, and Meadow Valley, were investigated in preliminary reconnaissance fashion. Because of the wide separation between areas, a helicopter was used to expedite the project and to gain access to each area for localized radiometric measurements, surface examination, and rock sampling. The units investigated are principally volcanic flows, tuffs, and basin-fill sedimentary deposits, all of Tertiary age.

The findings of this preliminary study are being used to determine where further effort should be concentrated.

Juab County, Utah

Start Date: 1 June 1976
Completion Date: 31 August 1976

A preliminary study was made of the uranium occurrences in Juab County, Utah. Known occurrences were examined in the field, sampled, and the geologic setting identified. The principal geologic unit for which further work is being considered is a beryllium-bearing tuff of Miocene(?) age.

Great Basin Framework and Favorability

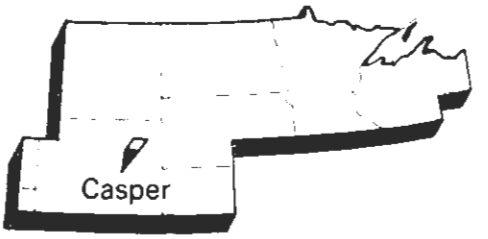
Subcontractor:
MACKAY SCHOOL OF MINES,
University of Nevada, Reno
Subcontract Value: $175,156
Start Date: 18 May 1976
Completion Date: 18 May 1977

Uranium occurs in a wide variety of geologic settings in the Great Basin. The diversity of occurrences and their widespread geographic distribution suggest that this vast region has considerable potential for both conventional grade and low-grade uranium deposits. The purpose of the MacKay School of Mines study is to establish, as accurately as possible, source rock favorability, relative favorability of the various geologic environments, and favorability parameters for evaluating the intermontane basins of the Great Basin.

The approach is to compile from the literature all existing geologic, geophysical, geochemical, and hydrologic information pertaining to uranium occurrences in the project area. A report prepared from the interpretation of all data and criteria generated will rank specific basins, pediments, and lithologic units in order of uranium favorability. This report will be placed on open file upon completion of the project.

Editing regional geologic reports is a critical task for NURE information dissemination.

Casper Office



The geographic area for which the seven geologists of the Bendix Casper office are responsible encompasses the states of Wyoming and North Dakota, as well as portions of South Dakota, Montana, Nebraska, Minnesota, Wisconsin, and Michigan. The varied physiographic environment includes the Wyoming Basins, northern part of the Great Plains, Southern Canadian Shield, and a small portion of the Central Lowlands. Precambrian and Paleozoic rocks crop out extensively throughout the Southern Canadian Shield as well as in the mountains to the west, and underlie the rest of the area. Most of the remainder of the region is an area of Cretaceous outcrops, except in Wyoming and Montana, where Tertiary sediments are the surface units.

In 1976 the geologic objectives of the Casper office were to evaluate the uranium favorability of essentially nonproductive sedimentary basins in Wyoming and Montana and of a Tertiary intrusive mass in the northern Black Hills of South Dakota, and to make a subsurface study of potential host rocks in the Red River Valley of North Dakota and Minnesota in advance of a geologic drilling project.

Two subcontracted studies were conducted to evaluate the uranium possibilities of Precambrian rocks in Minnesota, Wisconsin and Michigan, and a drilling project in central Wyoming was undertaken to ascertain the depth of uranium depletion in a granitic rock.

Northern Powder River Basin

Start Date: 31 May 1973
Completion Date: 30 November 1976

An investigation was conducted of the early Tertiary Fort Union and Wasatch Formations in the northern part of the Powder River Basin of Wyoming and Montana. Emphasis of the study was on mapping subsurface lithofacies in order to identify favorable host-rock trends. Additional work consisted of examination of outcrops, petrographic and chemical analyses of outcrop samples, and literature research.

The initial phase of the investigation, which consisted of well-log analyses and rock sampling, was concluded in late 1974; an extensive re-interpretation of subsurface lithologic information was accomplished the following year. The project final report, GJBX-58(76), was placed on open file in December 1976.

Northern Green River Basin

Start Date: 15 December 1974
Completion Date: 31 December 1976

Both surface and subsurface investigations were conducted in a project to evaluate the Tertiary sedimentary rocks in the Hoback Basin and northern portion of the Green River Basin in western Wyoming. Project procedures included field examination and surface sampling, analysis of drill-hole data, gamma-ray spectrometric analyses of probable granitic source rocks, and laboratory analyses of field samples.

The results of this study are contained in the project report to be placed on open file in early 1977.

Bighorn Basin

Start Date: 15 February 1976
Completion Date: 15 February 1977

A combination of geologic factors has suggested the possibility that concealed uranium deposits may exist in the early Tertiary Polecat Bench and Wildwood Formations in Wyoming's Bighorn Basin. Areas within the basin where these two units crop out were investigated to evaluate these geologic factors and to assess the favorability for the occurrence of uranium.

Work involved the study of well logs and cuttings, field examination and surface sampling, and measuring stratigraphic sections. A report summarizing the results will be placed on open file early in 1977.

Northern Black Hills

Start Date: 1 October 1976
Completion Date: 30 June 1977

A preliminary study is under way in the northern Black Hills near Lead, South Dakota, to examine possible uranium host rocks adjacent to anomalously radioactive Tertiary intrusives. These possible hosts include metamorphic rocks and the Cambrian Deadwood Formation.

Evaluation of the results of the field investigation is in progress, and is prerequisite to any recommendation for future work.

Eastern North Dakota - Upper Cretaceous Overlap

Start Date: 7 July 1976
Completion Date: 30 September 1976

In eastern North Dakota, where permeable sandstones of the Cretaceous Dakota Formation overlie Precambrian crystalline rocks, the situation is somewhat analogous to vein-type uranium deposits in the Lake Athabasca region of Canada. Therefore a preliminary favorability study was conducted in North Dakota along and near the Precambrian-Cretaceous unconformity.

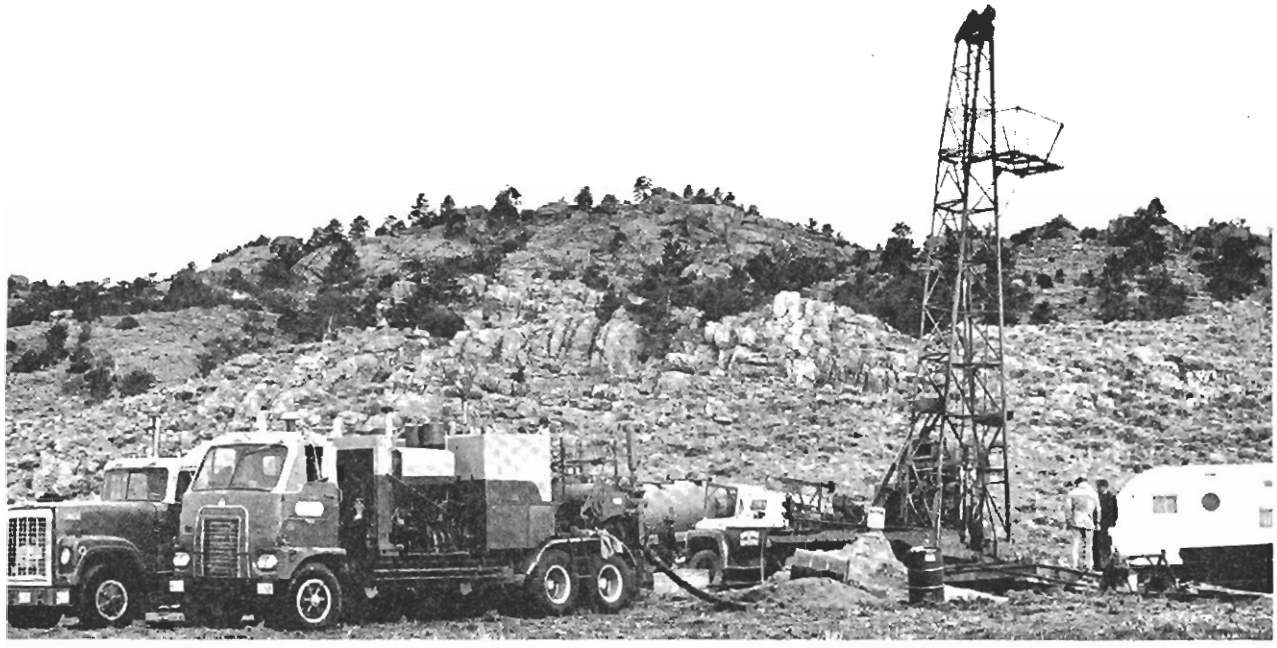
The findings of this preliminary investigation are being used to determine where further effort should be concentrated.

Precambrian of Minnesota

Subcontractor:
UNIVERSITY OF MINNESOTA, Duluth
Subcontract Value: $29,159
Start Date: 1 June 1975
Completion Date: 31 August 1976

In mid-1975, under direct contract with ERDA-GJO, the University of Minnesota initiated a study to ascertain the relative favorability of Minnesota's Precambrian rocks. Phases of the investigation included spot-checking of most rock units in the field with a scintillometer; reviewing the lithologic, stratigraphic, and structural relationships of these units, and comparing these rock units with uranium-bearing units in Canada and elsewhere.

The project report, GJBX-62(76), was placed on open file in December, 1976.



2,200 feet of Precambrian rocks were cored in the Granite Mountains of central Wyoming.

Pedro Mountain Drilling

Start Date: 10 March 1976
Completion Date: 30 September 1976

A cooperative project between ERDA-GJO and the U.S. Geological Survey was undertaken to evaluate the Granite Mountains of central Wyoming as a potential source of the uranium found in Tertiary sandstone in adjacent sedimentary basins. The project consisted of drilling a 2,197-foot core hole in the Precambrian granitic rocks at Pedro Mountain to determine the maximum depth of uranium mobility in the granite.

The hole was drilled by Himes Drilling Company of Grand Junction at a cost of $80,000. Subsequent geophysical logging was performed by Bendix, the U.S.G.S., and Birdwell Corporation; 17 different logs were run in the hole and are now being studied.

The engineering report of this project was placed on open file in December, 1976, as GJBX-56(76); the technical results will be published in a subsequent report to be prepared and issued by the U.S.G.S.

Williston Basin Study

Subcontractor:
UNIVERSITY OF NORTH DAKOTA
Subcontract Value: $29,742
Start Date: 1 June 1974
Completion Date: 30 November 1975

A study of the uranium favorability of Cretaceous and Tertiary rocks in the Williston Basin was undertaken by the University of North Dakota under direct contract with ERDA. In June, 1976, the four reports covering this study were released simultaneously by Bendix and the North Dakota Geological Survey.

The first report, GJBX-21(76), summarizes the geology of the Fox Hills Formation; the second, GJBX-22(76), is basically a broad stratigraphic and depositional environment study of the Cretaceous Hell Creek and Paleocene Ludlow Formations in southwestern North Dakota. GJBX-23(76) summarizes the geology of the Cannonball Formation, and GJBX-24(76) summarizes the stratigraphy of the upper part of the Fort Union Group, which consists of the Tongue River and Sentinel Butte Formations.

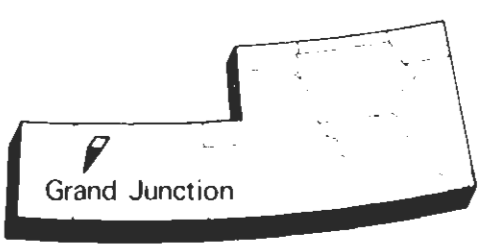
Precambrian of Michigan, Wisconsin and Minnesota

Subcontractor:
MICHIGAN TECHNOLOGICAL UNIVERSITY, Houghton
Subcontract Value: $27,530
Start Date: 31 March 1975
Completion Date: 28 February 1977

Under direct contract with ERDA, Michigan Tech conducted a study to summarize geologic information bearing on favorability for uranium of the Precambrian rocks of Michigan, Wisconsin, and eastern Minnesota. Effort included classification of prospective areas according to geologic characteristics, evaluation of deposits for their uranium and thorium favorability, and limited field work to augment existing literature. The study also considered special relationships of uranium in glaciated terrane, together with abundances in glacial overburden.

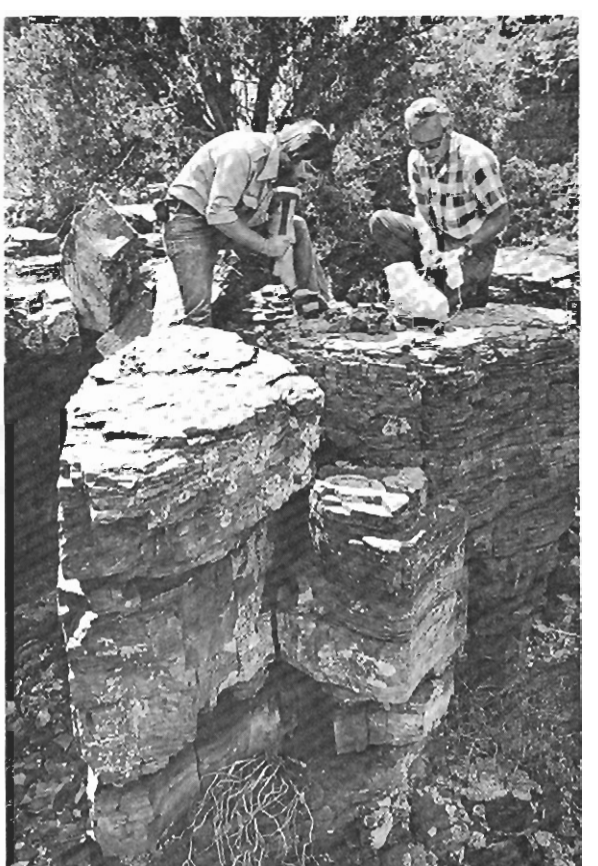
A report on the original portion of this project, GJBX-48(76), was placed on open file in September, 1976; a secondary portion of the project will be reported in mid-1977.

Grand Junction Office

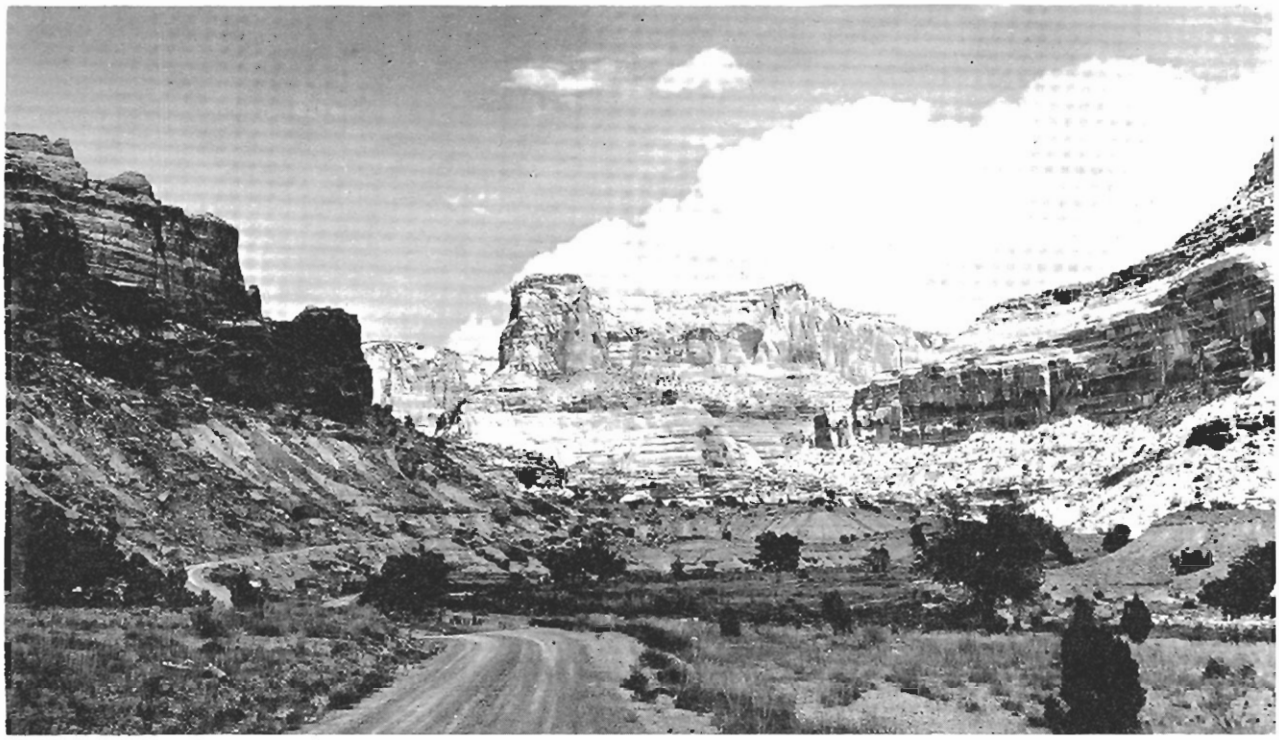


The Bendix Grand Junction district office is responsible for conducting geologic projects within a broad geographic region encompassing eastern Utah, the entire states of Colorado, Kansas and Iowa, most of Nebraska, Missouri and Illinois, and small parts of South Dakota, Minnesota and Wisconsin. The physiographic provinces represented include about half of the Colorado Plateau, a major part of the Southern Rockies, and the middle segments of both the Great Plains and the Central Lowlands. Small areas of Precambrian rocks are exposed in mountainous uplifts; however, most of the region is comprised of Paleozoic and Mesozoic outcrops, with the exception of intermontane basins where Tertiary sediments and volcanics are the surface units.

In 1976, the geologic objectives within this region were to assess the uranium favorability of selected desert and montane basins; to determine the favorability of a newly identified depositional environment and of an area of faulted sedimentary rocks; and to furnish peripheral data for a known mining district. Nine geologists working out of Grand Junction conducted two regional investigations and three preliminary studies during the year.



Bendix geologists determined field criteria for potential host rocks.



The San Rafael Swell, Utah, received detailed examination for uranium favorability.

Badger Flats - Elkhorn Thrust, Colorado

Start Date: 1 May 1975
Completion Date: 30 September 1976

A study of Precambrian and Tertiary rocks was conducted in the Badger Flats-Elkhorn Thrust area of central Colorado. These formations are considered potentially favorable because of known uranium occurrences. Some Precambrian metamorphics and granites in the area contain uranium vein and pegmatite deposits; in the Tertiary strata, most of the known deposits occur in an Eocene alluvium and an Oligocene conglomerate.

The investigation ineluded literature review, extensive field examination and sampling of both Precambrian crystallines and Tertiary sediments, radiometric reconnaissance, and laboratory analyses.

The results of this project were placed on open-file in December, 1976. GJBX-54(76) covers the Tertiary portion; GJBX-55(76), the Precambrian portion.

San Rafael Swell

Start Date: 1 December 1975
Completion Date: 31 March 1977

In the San Rafael Swell area of eastern Utah, uranium has been found in a number of sedimentary formations; however, very little is known of the uranium potential of the Chinle and Morrison Formations at depth in the flanks of the Swell, or of the Coconino Sandstone in any of the area. An investigation was conducted of these three formations, with emphasis on the western and northern parts of the San Rafael Swell.

Effort included a thorough literature review, compilation and analysis of available well logs and drill cuttings, field examination of known uranium deposits and of selected published measured sections, field sampling of potential host rocks, and laboratory analyses.

A project report delineating areas for potential uranium resources in each formation studied will be open-filed in mid-1977.

Brushy Basin

Start Date: 1 July 1976
Completion Date: 30 September 1976

In several localities in east-central Utah, the Brushy Basin Member of the Jurassic Morrison Formation contains relatively large volumes of uranium-bearing mudstones. Some such deposits occur in siltstone facies of an extremely large fan of the Salt Wash Member of the Morrison. A preliminary study was made to investigate known deposits at Last Chance, Cainville Dome, and also at Cedar Mountain at the northwestern San Rafael Swell. Field examination and sample analyses were conducted to determine the possible genetic relationship of these deposits to Salt Wash type fans.

Results of this preliminary work are being used to determine whether further effort is warranted.

Kaiparowits Plateau, Utah

Start Date: 1 October 1976
Completion Date: 31 March 1977

A preliminary study was made of the Kaiparowits Plateau of south-central Utah to determine whether adequate subsurface data is available for a subsequent detailed investigation of the area's uranium favorability. The Jurassic Morrison and Triassic Chinle Formations, both known uranium producers in other areas, were studied as the most probable hosts for uranium mineralization. Effort consisted of a literaure search and interpretation, supported by field checking and analysis of existing well-log data.

A decision regarding any further work in the area will be based upon assessment of the study findings.

Gunnison Area, Colorado

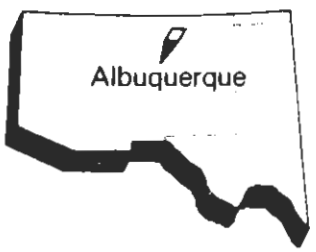
Start Date: 1 October 1976
Completion Date: 31 December 1976

A preliminary investigation was made to evaluate the favorability for vein-type urauium occurrences of the igneous and metamorphic rocks northeast of Gunnison, Colorado. The project area, encompassing about 1,000 square miles, is similar in structure and lithology to the Cochetopa, Powderhorn, and Marshall Pass districts to the south. Effort consisted of a literature search supported by field work in the form of rock and water sampling.

A decision regarding further work in the area will be based upon assessment of the preliminary findings. It is expected that the report of this project will be open-filed in 1977.

Laboratory analyses are critical ingredients in determining uranium favorability.

Albuquerque Office



Bendix geologists working out of the Albuquerque office are responsible for uranium favorability assessment of an area covering most of Arizona, New Mexico, western Texas and the Oklahoma Panhandle. The varied topography represented by segments of the Colorado Plateau, Basin and Range, Southern Rockies, Great Plains and Central Lowlands physiographic provinces indicates the diverse geologic environment. Exposures of Preeambrian rocks are limited to the Grand Canyon and the Southern Rockies, with much of the remaining area consisting of Paleozoic and Mesozoic outcrops. However, Tertiary sediments and volcanics predominate in southern Arizona, southern New Mexico and west Texas.

Geologic investigations conducted in 1976 were aimed at evaluating the uranium favorability of Precambrian and Mesozoic rocks in Arizona, New Mexico and west Texas; studying the stratigraphic distribution of uranium around an ancient volcanie center in New Mexico; and assessing the favorability of portions of sedimentary basins in northern New Mexico. To accomplish these objectives, the seven geologists of the Albuquerque district completed two major regional and two preliminary studies, initiated two additional preliminary studies, and monitored a subcontract to study the geochemistry of the host rocks in the Grants area of New Mexico.

Dripping Spring Quartzite

Start Date: 1 May 1975
Completion Date: 30 September 1976

A study was conducted to assess the uranium favorability of the Precambrian Dripping Spring Quartzite in Gila and Pinal Counties, Arizona. In the course of the project, 25 of the known uranium prospects and mines in the Dripping Spring Quartzite were exanined and sampled. Other project procedures included outcrop, stream sediment and water sampling; and petrographic, radiometric, spectrometric and chemical analyses.

The results of this study will not be open-filed because the contained data and conclusions are not materially different from those of published reports.

High Plains, New Mexico and Texas

Start Date: 1 March 1974
Completion Date: 31 December 1976

In a geologic study conducted by Bendix's predecessor, selected sections of the Triassic Dockum Gronp of eastern New Mexico and northwestern Texas were measured and sampled. The project report, prepared for open filing by Bendix, presents 27 measured sections, many of which are only partial; the intent was to measure only those portions of sections having prominent sandstone/conglomerate beds or uranium deposits.

Locations of the sections, descriptions of the thickness of sample intervals, and modal and spectrometric analyses of the samples are included in the report, which is to be open-filed in early 1977.

Nacimento-Jemez Region New Mexico

Start Date: 1 May 1976
Completion Date: 31 December 1976

In the Nacimiento-Jemez region of north-central New Mexico, uraninm is known in sedimentary and volcaniclastic rocks ranging in age from Pennsylvanian through Tertiary. A preliminary study was conducted to determine the uranium favorability of the Pennsylvanian, Permian, aud Triassic formations in the area. The project involved locating and plotting all known uranium occurrences in formations of these selected

---basis for further work---

ages in the region; and locating, mapping, and projecting geologic features (lithology, folds, faults, channel trends, etc.) which may be favorable for the occurrence of uranium deposits.

The findings of this preliminary study will provide a basis for planning further work in the Nacimiento-Jemez area.

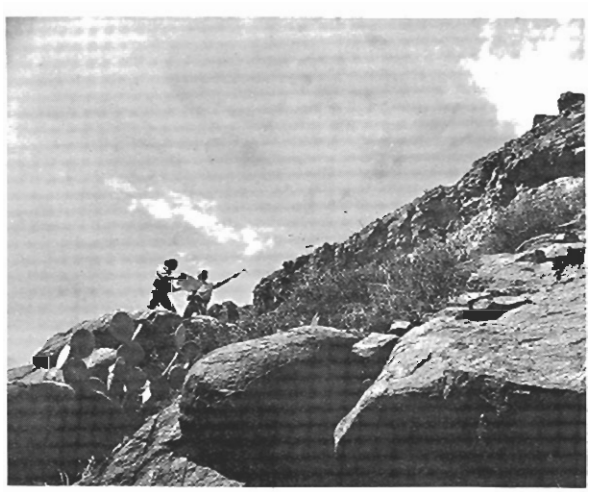
Las Vegas Basin, New Mexico

Start Date: 1 June 1976
Completion Date: 31 December 1976

The Permian and Pennsylvanian Sangre de Cristo Formation in the Las Vegas Basin of northern New Mexico has received very little attention as a potential uranium area because of its depth, although some minor production has come from the region and a few occurrences have been noted at the outcrop. A preliminary study was conducted of the basin, as well as of the New Mexico portion of the Sangre de Cristo Range, where uranium also occurs in outcrops of the Sangre de Cristo Formation.

The project utilized subsurface data to construct cross sections of the area and to describe the geologic environment relative to uranium. Work also involved describing and delineating favorable areas, and summarizing geologic information on the Sangre de Cristo Formation.

Recommendations for any futher work in the area will be based upon assessment of the preliminary findings.



Bendix geologists spent many hours in field-mapping of potential uranium host rocks.

Tertiary of San Juan Basin, New Mexico

Start Date: 15 November 1976
Completion Date: 31 March 1977

In late 1976 a preliminary study was initiated of Tertiary sediments in New Mexico's San Juan Basin. These beds contain fluvial and lacustrine sediments, carbonaceous debris has been reported, and there are known uranium occurrences. The effort under way involves a literature search, review of available well logs, field mapping and sampling of known uranium deposits, and some stratigraphic section measuring.

Results of this preliminary investigation will be used to determine the feasibility of a more detailed study of the uranium favorability of the Tertiary formations in the San Juan Basin, or a possible drilling project.

Baca Formation, New Mexico

Start Date: 4 October 1976
Completion Date: 31 March 1977

Several small sandstone-type uranium deposits occur in the Baca Formation south of the San Juan Basin in west-central New Mexico. A surfaee and subsurface study of the Eocene Baca and subjacent Cretaceous sediments is being conducted to determine the stratigraphic correlations, lithology, depositonal environments, and possible solution-front alteration.

Upon completion of this preliminary investigation, the findings will be used to assess the uranium favorability of the area and to determine where further effort should be concentrated.

Uranium of Grants, New Mexico, Mineral Belt

Subcontractor:
UNIVERSITY OF NEW MEXICO
Subcontract Value: $95,000
Start Date: 15 September 1976 [Phase II]
Completion Date: 15 September 1978 [PhaseII]

In 1975 the University of New Mexico, under direct contract with ERDA-GJO, conducted a study of the geochronologic, geochemical, and clay mineralogic aspects of the uranium ore deposits in the Grants, New Mexico, mineral belt. A follow-on to this study, under subcontract with Bendix, was undertaken by the same investigator in the fall of 1976.

The purpose of the second project is to assess, by combining experimental and field data, the role of organic matter as an agent affecting the clay minerals in the Grants mineralized zone, and in rocks both up- and down-gradient from mineralized areas. In addition, the preferential enrichment of trace elements in clay minerals involved in these organic reactions is also being investigated. Work will involve field examination and sampling, and laboratory analyses.

The report on the first phase of the project was open-filed in June 1976 as GJBX-16(76); the results of the second phase will be published in late 1978.

The investigation of known uranium deposits like this Grants Mineral Belt mine plays an important part in extrapolating favorability characteristics in areas of known uranium occurrence.

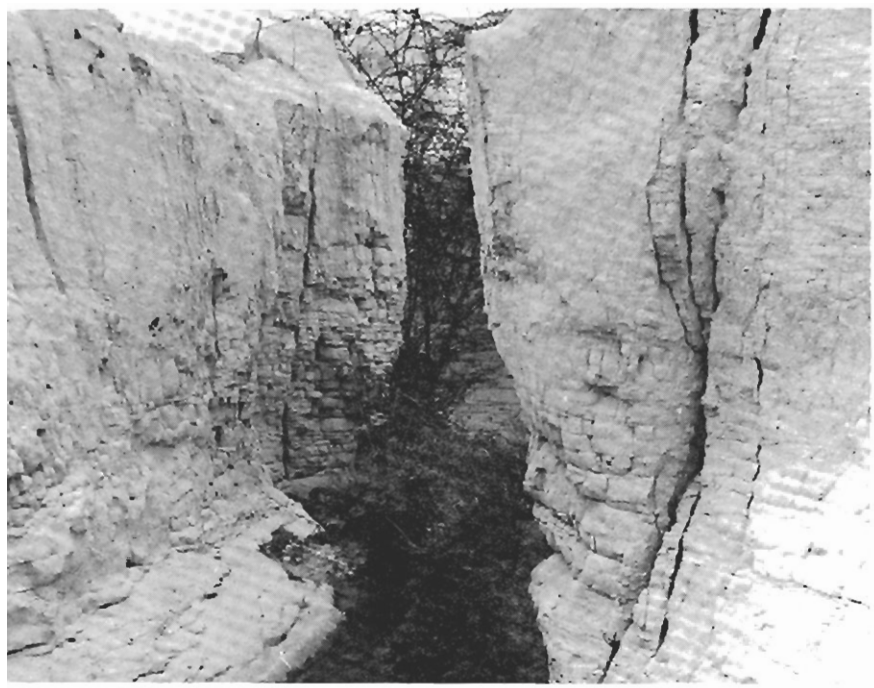
Austin Office

The southern portion of the Central Lowlands and the western portion of the Coastal Plain are the physiographic provinces represented within the region administered by the Bendix Austin office. The Coastal Plain is underlain by a seaward-thickening wedge of Upper Cretaceous, Tertiary, and Quaternary sediments, with poorly consolidated Tertiary strata predominating. At the inner margin of the Plain, and extending into the Central Lowlands, the sedimentary wedge rests unconformably on Mesozoic and Paleozoic strata.

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

Because uranium deposits in the Texas Coastal Plain have been found only in Tertiary strata, geologic projects in this area are aimed at detailed investigation of Tertiary lithologies and favorable trends. These studies involve the collection and interpretation primarily of subsurface data, because of the lack of good surface exposures. In Oklahoma and north-central Texas, where Paleozoic rocks predominate, emphasis is placed on assessing the uranium favorability of stratigraphic sequences ranging in age from Precambrian through Cretaceous.

During 1976, ten Bendix geologists working out of the Austin office were involved with various phases of two major regional and three preliminary studies, and monitored two subcontracted investigations.



The Catahoula Formation in Texas is a prime target of exploration as a uranium host rock.

Permian-Pennsylvanian of Oklahoma

Subcontractor:
OKLAHOMA STATE UNIVERSITY, Stillwater
Subcontract Value: $50,000
Start Date: 1 July 1976
Completion Date: 30 June 1977

Under a previous contract, O.S.U. made a generalized uranium favorability assessment of the various Permian-Pennsylvanian rock units distributed throughout the state of Oklahoma.The University is now conducting a detailed follow-up investigation of specific Permian-Pennsylvanian units and facies, as well as certain basement rocks, in which uranium occurrences are known in southwestern Oklahoma. The current study encompasses field reconnaissance and sampling, petrographic examination, geochemical analysis, and differential spectrometer surveys.

The findings of the initial study were open-filed in June, 1976, in GJBX-20(76); a summary report of the present work will be published upon completion of the project in mid-1977.

Catahoula Formation, Texas

Subcontractor:
BUREAU OF ECONOMIC GEOLOGY, UNIVERSITY OF TEXAS
Subcontract Value: $60,115
Start Date: 20 June 1975
Completion Date: 31 October 1976

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

The results of the regional surface and subsurface analysis and the development of a depositional model for the Catahoula will be detailed in the project report, to be placed on open file in 1977.

Coordinating the regional geologic studies throughout the conterminous United States and Alaska is a monumental task for the Bendix Geology Division.

Fort Worth Basin

Start Date: 1 March 1976
Completion Date: 31 March 1977

In the Fort Worth Basin of north Texas aud southwest Oklahoma, a study is eurrently in progress of those facies in the Pennsylvanian-Permian and Cretaceous systems considered to be favorable for uranium mineralization. These units contain coarse fluvial clastics, including lobes of arkosic and feldspathic debris; a few uranium occurrences have been noted in the area.

The study encompasses field reconnaissance and sampling, radiometric surveying of selected outcrops, laboratory analysis, and subsurface correlation utilizing well logs. Results of this project will he placed on open file in 1977.

Claiborne-Wilcox Belt

Start Date: 1 October 1976
Completion Date: 31 March 1977

A preliminary investigation is under way to study the depositional environments of the Claiborne-Wilcox sediments in Texas in order to establish favorability criteria for uranium mineralization. The Eocene Claiborne-Wilcox group is primarily a fluvial-deltaic system with some shallow marine facies and widespread carbonaceous material.

The findings of this preliminary study will be used to identify areas where more detailed work is warranted.

East Texas-Louisiana Coastal Plain

Start Date: 1 October 1976
Completion Date: 31 March 1977

To determine the geological conditions favorable for uranium emplacement, a preliminary study is being conducted in which geologic trends identified in a previous project are being traced through east Texas into Louisiana. Tbe section of interest consists of Eocene through Pliocene fluvial and deltaic sediments with some shallow marine facies. There is also widespread carbonaceous material in the section and extensive local structural features.

A decision to initiate more detailed investigations in selected areas of the Texas-Louisiana Coastal Plain will be based on the information gencrated by this preliminary work.

South Texas Coastal Plain

Start Date: 1 October 1974
Completion Date: 1 October 1976

In a project initiated by Bendix's predecessor, sedimentary strata of late Eocene through Pliocene age underlying the South Texas Coastal Plain were assessed for uranium favorability. The units investigated were those known to contain uranium deposits or to have lithologies potentially favorable as host rocks; they included the Yegua, Jackson, Frio, Catahoula, Oakville, and Goliad systems. Although attention was given to sandstones that crop out, most of the findings and conelusions of this study apply to sandstones in the subsurface; stratigraphic and structural interpretations were based primarily on data derived from electric logs of 1723 petroleum test wells.

The summary report of this project was prepared by Bendix and will be open-filed in early 1977.

Northeastern Oklahoma and Southeastern Kansas

Start Date: 1 July 1976
Completion Date: 31 December 1976

A preliminary study was conducted to assess the uranium favorability of northeastern Oklahoma and southeastern Kansas, an area of some 30,000 square miles underlain by a stratigraphic sequence that ranges in age from Precambrian to Late Pennsylvanian. Effort was concentrated on a comprehensive literature search and on consultation with individuals familiar with the area, with minimal supporting field work.

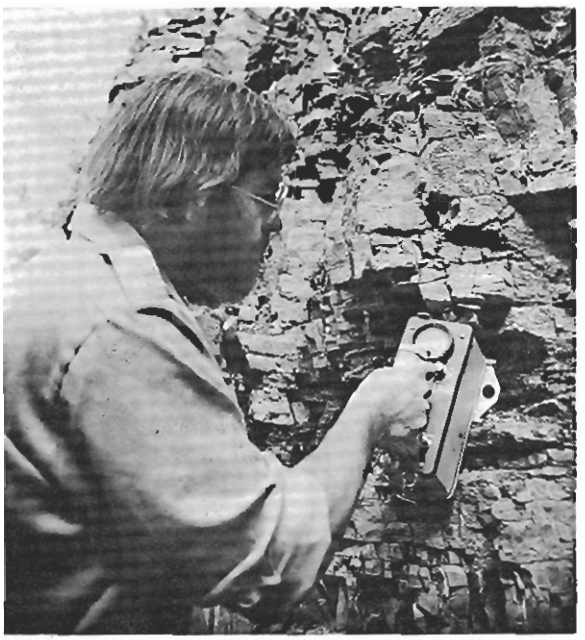
Relatively high concentrations of radium and alpha radiation in the water supplies of some communities, and abnormally high levels of radium found in oil and gas fields in northeastern Oklahoma and southeastern Kansas indicate the desirability for follow-on studies in the region.

The most modern laboratory techniques are utilized in identifying complex uranium minerals.

Atlanta Office

The Bendix Atlanta office was opened in January, 1976, and operates with a staff of six geologists. The regional office is responsible for North and South Carolina, Georgia, Alabama, Florida, central and eastern Tennessee, and the southern portions of Kentucky, Virginia and West Virginia. The geologic environment is that represented by the Coastal Plain, Piedmont, Blue Ridge, and Valley and Ridge physiographic provinces. The Coastal Plain portion is underlain by Cretaceous, Tertiary and Quarternary sediments; in the Piedmont and Blue Ridge areas, plutonic, metamorphic and volcanic rocks predominate. Volcanic and sedimentary rocks fill several downfaulted troughs of Triassic age ("Triassic Basins") in the Piedmont, while tightly folded Paleozoic strata are characteristic of the Valley and Ridge province.

To initiate a uranium favorability assessment of the southeastern United States, Bendix geologists investigated anomalies noted in an earlier aerial radiometric survey, and conducted preliminary studies of two basins and one mountainous area where uranium mineralization appears to be directly related to structural features. In addition, a subcontracted study of selected facies of the Chattanooga Shale was monitored.



Gamma radiation is one of the many types of data acquired in the field by Bendix geologists.

Coosa Basin, Alabama

Start Date: 1 May 1976
Completion Date: 31 December 1976

A preliminary study to assess the uranium favorability of the Hartselle Sandstone and the Pottsville Formation was conducted in the Coosa Basin of northern Alabama. Certain geologic characteristics of these units are considered favorable for the accumulation of uranium deposits. In this area, where 10,000 feet of Pennsylvanian Pottsville sediments have been measured, the strata are principally fluvial and deltaic deposits containing more than 35 coal seams. Moreover, the only redbed sequence in Pottsville is found in the Coosa Basin.

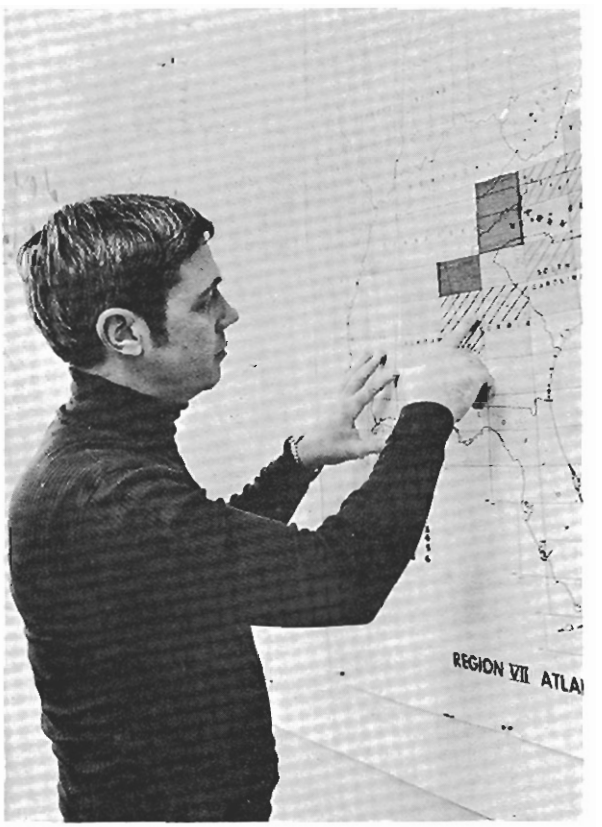
Efforts entailed a literature search, compilation of subsurface data, field examination and sampling, and considerable laboratory analysis. The findings of this preliminary investigation are providing a basis for planning further work in the Coosa Basin.

Chattanooga Shale Facies

Subcontractor:
ENVIRONMENTAL AND REGIONAL RESEARCH ASSOCIATES, INC. [ERRA]
Subcontract Value: $9,853
Start Date: 18 February 1976
Completion Date: 18 February 1977

ERRA is conducting a radiometric reconnaissance study of the Tennessee and Virginia clastic equivalents of the Chattanooga Shale, to assess their favorability for uranium resources. The study includes surface gamma-ray measurements of the Chattanooga and Millboro Shales, and of the Price and Grainger Formations. Emphasis is being placed on any structural and lithologic features which appear to correlate with the areas of highest gamma radiation.

Upon completion of the project, a report is to be prepared and open-filed in the spring of 1977.



Appalachian Plateau Shear Zones

Start Date: 1 October 1976
Completion Date: 15 February 1977

A direct relationship appears to exist between shear zones and uraninm mineralization in the southern Appalachians. A preliminary project, employing gamma-ray spectrometry, LANDSAT imagery, and statistical analysis, is nnder way to study known uraninm occurrences and areas of anomalous radioactivity. Genetie models explaining the origin and oceurrence of uranium minerals in the shear zones are being prepared.

A decision to implement more detailed investigations in selected areas of the Appalachian Plateau will be based on the information generated by this preliminary work.

Sanford Basin-Colin Arch

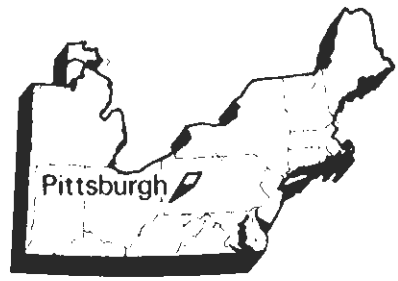
Start Date: 1 October 1976
Completion Date: 31 March 1977

The Triassic redbeds in the Deep River Basin of North Carolina consist of continental conglomerates, sandstones, and shales weathered from Appalachian piedmont metamorphies. These redbeds, which contain abundant organic matter and pyrite, could be favorable hosts for uranium derived from solutions migrating from adjacent granitic rocks through shear zones and faults around the basin. For a preliminary assessment of uranium favorability, the Deep River Basin has been subdivided into three project areas, namely, thc Sanford, Wadesboro, and Durham Basins.

The portion of the study currently under way in the Sanford Basin-Colin Arch area is evaluating the uranium favorability and surface radioactivity of the Triassic sediments and of adjacent pre-Triassie igneous and metamorphic rocks. Work in thc Wadesboro and Durham Basins is scheduled for a later date. A decision to conduct further work in the Deep River Basin will be based upon the results of these three preliminary investigations.

Regional geologists are responsible for setting priorities for supporting surveys such as airborne radiometric and hydrogeochemical reconnaissance.

Pittsburgh Office



The Bendix Pittsburg office, which was established in the spring of 1976 with a staff of three geologists, is responsible for an area that includes highly diverse physiography and geology associated with the Appalachian Highlands and the Central Lowlands. Eight physiographic provinces are involved, with outcrops ranging in age from Precambrian to Recent. Geographically, the area encompasses all of the New England states, New York, New Jersey, Maryland, Delaware, Pennsylvania, Ohio and Indiana, as well as most of Michigan and West Virginia and portions of Virginia, Kentucky, and Illinois.

Initial efforts of the Pittsburgh staff were concentrated on preliminary studies of two New England basins. In addition, two subcontracts involving studies of Precambrian and Paleozoie formations in the Central Lowlands were monitored.

Connecticut Basin

Start Date: 18 March 1976
Completion Date: 30 September 1976

In a preliminary study of thc Connecticut Basin of Massachusetts and Connecticut, the Triassic-Jurassic formations in the area were investigated. Each sedimentary unit within the basin was examined and sampled as a possible uranium host rock. Samples were also taken from several prospective source rocks within thc basin and in the adjacent highlands.

Analytical results and a ground radiometric survey indicate that,while geologic characteristics of the basin are favorable for uranium accumulation, further study of the area will be neccessary to define the uranium potential.

Responsibility of the Pittsburgh office is to unravel the complex uranium potential of the northeastern United States.

Narragansett Basin

Start Date: 1 October 1976
Completion Date: 31 March 1977

A preliminary favorability study is being conducted of rocks in the Narragansett Basin of Rhode Island and Massachusetts. The units of interest are several thousand feet of Pennsylvanian non-marine coarse clastics with coal beds, as well as various mafic dikes and quartz veins. The section has been folded, faulted, and intruded by the Narragansett Pier Granite and Westerly Granite; there is also evidence of extensive hydrothermal activity in the area.

The findings of this preliminary study will be used in deciding if further work is warranted.

Michigan and Illinois Basins

Subcontrator:
UNIVERSITY OF ILLINOIS
Subcontract Value: $16,687
Start Date: 1 May 1974
Completion Date: 29 February 1976

Under direct contract with ERDA, the University of Illinois undertook a project to prepare basic geologic information to be used to evaluate the favorability for uranium of Upper Precambrian through Lower Mesozoic rocks in the Forest City, Illinois, and Michigan basins and adjacent shelves. The study area includes all of Wisconsin, Nebraska, Missouri, Kentucky and Ohio.

The results of this study are still being compiled and should be ready for publication sometime in early 1977.

Devonian Black Shales, Central Appalachian Basin

Subcontractor:
UNIVERSITY OF CINCINNATI
Subcontract Value: $8,280
Start Date: 1 April 1975
Completion Date: 31 December 1976

Black shales of Devonian age are geographically widespread and highly radioactive. A project conducted by the University of Cincinnati, under direct contract with ERDA and monitored by Bendix, compiled stratigraphic and sedimentologic models of the most radioactive units in the Central Appalachian Basin.

The study included the examination of well logs and cuttings, limited field sampling, laboratory analysis, and review of world literature on black shales to develop favorability criteria and possible guides for future exploration.

The report of this investigation will be open filed early in 1977.

Anchorage Office

The Bendix Anchorage office was established in September, 1976, and from it all Alaskan geologic investigations are conducted. Alaska's huge size, climatic conditions, and complex geology present a significant challenge to the collection of data. The state consists of subparallel extensions of the Pacific Coast Ranges and the Rocky Monntains, separated by large intermontane basins. Cenzoic and Mesozoic rocks are most widespread, with older rocks confined to the principal mountain ranges. Favorability investigations will be concentrated mainly on Tertiary and Mesozoic sedimentary rocks and on Tertiary intrusives.

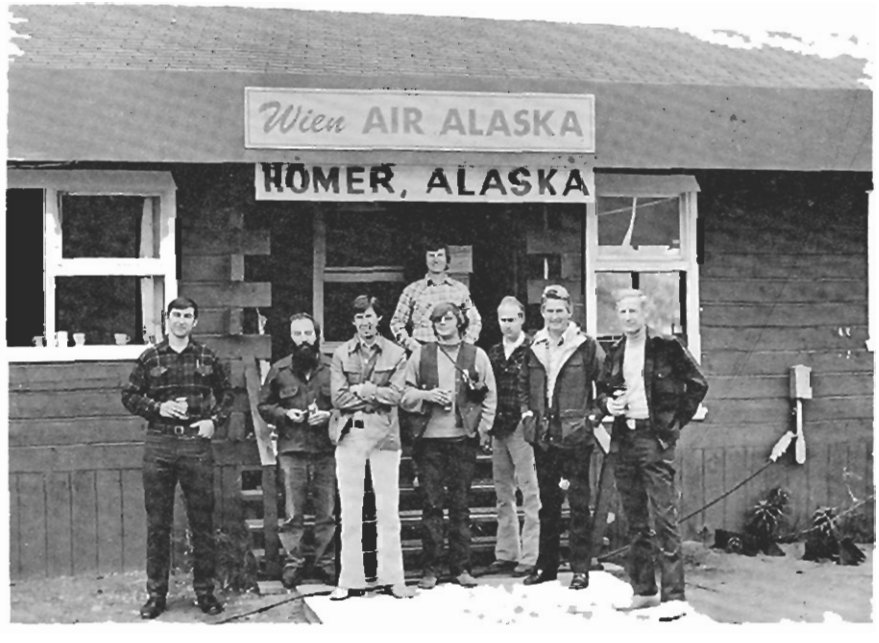
One Bendix geologist is presently assigned to tbe Anchorage office; his initial project has been to monitor a subcontracted study of the Cook Inlet area. Meanwhile, planning of in-house investigations is in progress, including utilization of NURE airborne radiometric data already available as a result of contract flying in Alaska.

Cook Inlet

Subcontractor: WGM, INC.
Subcontract Value: $98,000
Start Date: 17 May 1976
Completion Date: 31 March 1977

Under subcontract to Bendix, an Anchorage firm is conducting a geologic evaluation for uranium favorability of the Cook Inlet and Susitna Basin in Alaska. The principal rock units under consideration are of Jurassic, Cretaceous and Tertiary age.

The work being done is basically a compilation of all available information useful in determining the uranium favorability of the project area. Well logs, hydrologic data, published maps, cross sections and reports, as well as minimal field checking of selected data and reported uranium occurrences, are to be the basis for writing a report on the favorability assessment of the area. Upon completion of the project, the results will be placed on open file.



Close coordination involving both aerial survey and ground examination occurred between Bendix geoscientists and WGM, the subcontractor for the Cook Inlet, Alaska, geologic study.

TOPICAL GEOLOGIC STUDIES

"Topical" is the term used to organize and generate those geologic projects which are distinctly non-regional in nature. Uraninm favorability assessment of a specific area is not the goal of the topical geologic projects; rather, these projects investigate a *specific type of known geologic occurrence* of uranium with the intent to define the parameters that are responsible for the uranium concentration.

Non-sandstone host rocks that represent the major portion of the world's uranium resources are emphasized in the topical projects. Favorability criteria developed through the study of economic foreign uranium deposits are being used to evaluate similar geologic environments in the United States. The organization of topical studies also arbitrarily includes subcontracted geostatistical projects and geology compilation projects such as bibliographic, well-log data, or geologic map compilations.

Topical geologic studies are the responsibility of the Bendix Project Management Division.

Calcrete environments of the southwestern United States are under investigation for uranium potential.

Statistical Analysis of Uranium Production and Geochemical Distribution

Subcontractor:
PRINCETON UNIVERSITY
Subcontract Value: $49,692
Start Date: 1 January 1976
Completion Date: Spring 1977

To try to predict the magnitude of U.S. uranium resources and their future availability, Princeton University conducted a statistical study which compared the geochemical distribution and mining history of uranium with the distribution and history of copper, silver, and zinc.

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

A report on this work will be open-filed upon completion of the project.

Uranium Favorability of Calcretes

Subcontractor:
UNIVERSITY OF CALIFORNIA AT LOS ANGELES
Subcontract Value: $96,004
Start Date: 21 June 1976
Completion Date: 20 June 1977

The occurrence of uranium in calcrete deposits in South Africa and western Australia indicates the desirability of assessing the uranium potential of similar calcrete and gypcrete horizons in the southwestern United States. UCLA has undertaken such a study, the purpose of which is to identify those particular types of calcrete/gypcrete deposits which could become U.S. objectives of more detailed study as potential uranium hosts, and also to determine their relationships to surrounding geology.

The project includes evaluation and comparison of known uraniferous calcrete deposits in western Australia and South Africa. About 135,000 square miles in the southwestern United States are being investigated to define areas favorable for uranium resources due to similarity with the foreign deposits.

Upon completion of the study in mid-1977, the findings will be published in an open-filed report.

Uranium Associated with Alkaline Rocks

Subcontractor:
LAWRENCE BERKELEY LABORATORY
Subcontract Value: Approximately $90,000
Start Date: Early 1977
Completion Date: Late 1978

Alkaline rocks as a potential source of nominal to high-grade actinide minerals including uranium are little understood, and the distribution of potentially mineralized alkaline environments in the United States is not currently documented. Therefore, in late 1976 a study was defined to determine the distinguishing parameters of uranium-bearing alkaline environments in Greenland, South America, and Africa; further, to prepare a distribution map of alkaline rocks in the United States, categorizing them by comparison with lithology, geochemistry, age, and structure with the known uranium-bearing foreign occurrences.

At the end of 1976 Bendix was working out the final details of the subcontract with Dr. Harold Wollenburg at LBL, who will be the principal investigator.

Uranium in Proterozoic Metamorphic Rocks

Subcontractor: To be selected
Subcontract Value: To be determined
Start Date: Early 1977
Completion Date: Late 1978

Significant uranium reserves have been established in Precambrian metamorphic rocks in several foreign localities. However, metamorphic rocks in the United States have not been systematically explored for uranium and consequently no major occurrences are known. Identifying the key criteria for uranium in foreign Proterozoic metamorphic occurrences should permit a realistic evaluation of the Precambrian metamorphic sequences in the United States.

In December 1976, ERDA approved a project of national scope to evaluate Proterozoic metamorphic rocks which bear chemical and provincial similarities to uranium-bearing Proterozoic metamorphics recently discovered in Europe, Canada and Australia. Bendix prepared a work statement and issued an RFP in December 1976, planning for a subcontract award to be made in early 1977.

Uranium in Igneous Rocks

Subcontractor:
UNIVERSITY OF NORTH CAROLINA
Subcontract Value: $55,940
Start Date: 15 June 1975
Completion Date: 31 December 1976

To determine the favorability of certain uranium-bearing granites in the United States as uranium host rocks, the University of North Carolina has compiled information on the distribution of uranium in felsic igneous rocks in select occurrences in the free world. The aim of this study was to catalog known areas of uranium concentration in plutonic igneous rocks from high-grade deposits down to approximately 50 ppm; to survey the present status of development of major uranium deposits in granitic and related rocks; to provide preliminary information on the reasons for the occurrence of very high concentrations of uranium in some plutonic igneous rocks; and to develop criteria for predicting uranium abundances in plutonic terranes.

Effort encompassed an exhaustive literature search of domestic and foreign publications, as well as personal contacts and correspondence to obtain unpublished information; field examination of uranium deposits in granitic and related rocks now being mined or developed, particularly deposits in Southwest Africa and Canada; and a survey of all known significant deposits of uranium in plutonic igneous rocks.

Results of this study will be placed on open file early in 1977.

Geostatistical Ore Reserve Estimation

Subcontractor:
UNIVERSITY OF ARIZONA
Subcontract Value: $24,992
Start Date: 15 April 1976
Completion Date: 15 December 1976

In 1975 the University of Arizona conducted a study to test the practicality of a geostatistical ore reserve estimation method, as well as its superiority over conventional methods, by means of a comparative study of a porphyry copper mine. Results indicated that the geostatistical method was practical and indeed superior to "conventional methods" under some circumstances. In 1976 the University undertook a follow-on project to develop procedures and to conduct a similar case study for a sandstone roll-front type uranium deposit.

This second project included constructing a representative model for implementing the geostatistical method in the uranium ore reserve estimation procedures used by ERDA. Programs to display the results of the geostatistical study were also developed.

Results of the initial study were open-filed in September 1975, as GJO-1649; those of the follow-on, in January 1977, as GJBX-3(77). In late December 1976, a third contract was signed with the University of Arizona to expand the geostatistical analysis and to make additional comparisons. It is anticipated that the third project report will be placed on open file before the end of 1977.

Precambrian metamorphic rocks such as those exposed in Unaweep Canyon in the Uncompahgre Uplift of Colorado are receiving intense examination for uranium host/source rock potential.

Uranium in Veins

Subcontractor: HARVARD UNIVERSITY
Subcontract Value: $69,610
Start Date: 1 November 1975
Completion Date: 31 October 1976

In an ERDA-conducted study completed in 1975, an investigative team from Harvard concluded that some vein-type uranium deposits are the result of reconcentration of uranium from various scattered sources by highly oxidized ground waters moving through a variety of source rocks. Under a follow-on contract, the Harvard team has conducted further research to determine the validity of this concept.

Methods of investigation included research into the hydrology of vein-type uranium deposits; collection of fluid inclusion data to determine the nature of ore-forming fluids; determination of the isotopic composition of oxygen in uraninite; and measurements of the solubility of uraninite in hydrothermal solutions over a wide range of temperatures.

The results of the initial study were open-filed in January 1976, as GJO-1640. Although the follow-on contract was scheduled for completion by October 31, the final report is still is preparation and is not expected to be available for open-filing until early 1977.

Geologic Map Compilations

Subcontractor: To be selected
Subcontract Value: To be determined
Start Date: Early 1977
Completion Date: Late 1977

Accurate geologic maps of the 1:250,000-scale NTMS quadrangles are essential to correlate data from the aerial radiometric survey program and the hydrogeochemical surveys. Only about 30 percent of the 621 NTMS quadrangles in the conterminous United States and Alaska are published with geology. A project to compile various sources of published geology and do photogeology was authorized by ERDA in December 1976.

At the close of 1976, Bendix initiated efforts to identify potential subcontractors who would do both photogeology and compilation work to support the FY77 and FY78 aerial survey program.

LANDSAT Data Analysis

Subcontractor:
DENVER MINERAL EXPLORATION CORP. [DEMEX]
Subcontract Value: $58,830
Start Date: 7 April 1976
Completion Date: 7 February 1977

Recent investigations of spectral responses, utilizing LANDSAT Multispectral Scanner (MSS) digital data, have indicated that certain mineral alteration zones can be routinely detected and displayed. Alteration zones specifically associated with known uranium occurrences have similarly been detected. DEMEX has undertaken a Bendix subcontract to analyze the spectral responses and develop the recognition discriminants of known uranium districts in the Colorado Plateau, northeastern Washington, northwestern Idaho, and the Front Range of Colorado.

LANDSAT MSS data, SKYLAB imagery, and aircraft photography are being used to catalog indicators of favorability for identifying other possible areas of uranium occurrence.

The report of this project, including color illustrations showing the ground surface extent of the signatures for each district, is to be placed on open file in the spring of 1977.

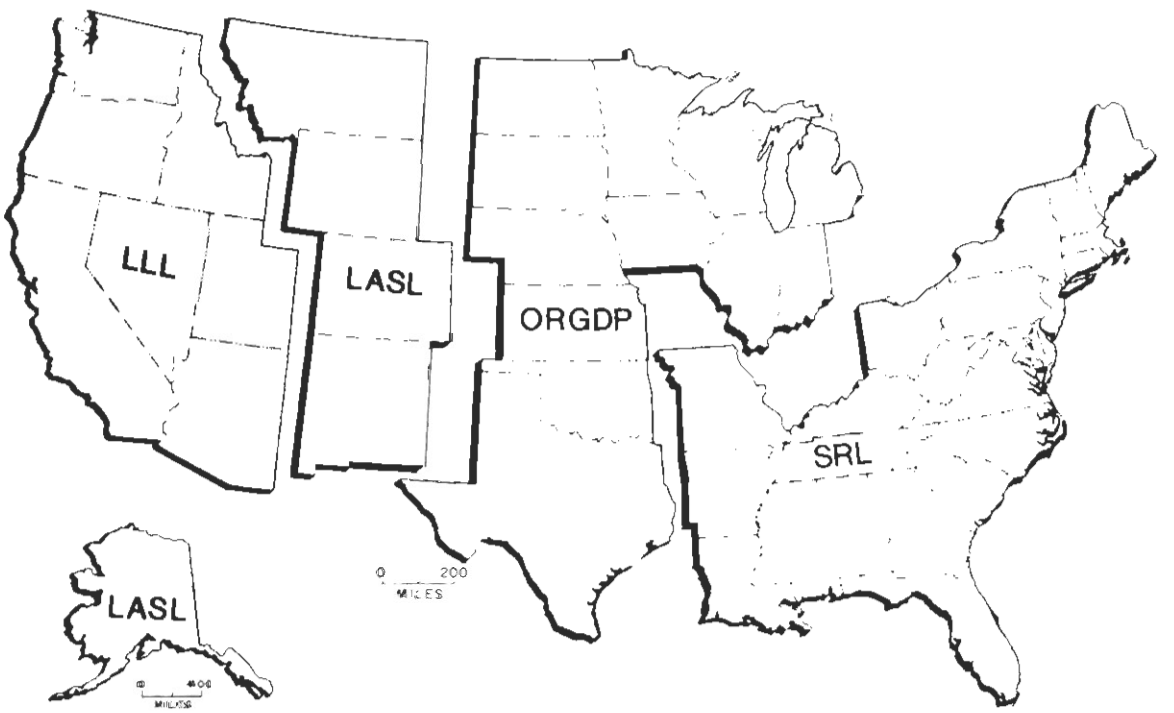
Spectral responses from LANDSAT of known uranium occurrences in the Uravan Mineral Belt were cataloged for uranium signature analysis.

HYDROGEOCHEMICAL and STREAM SEDIMENT RECONNAISSANCE

The Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) was initiated in 1975 as a major element of the National Uranium Resource Evaluation. The objective of the HSSR is to complete, by 1981, a systematic reconnaissance survey of the nation's surface waters, groundwaters, and stream sediments and to determine the importance of uranium and associated elements as guides for uranium search. The HSSR is also intended to assist private exploration efforts by furnishing information on new areas favorable for uranium occurrence.

Uranium is a mobile element geochemically, and commonly is disseminated in varying degrees in rocks surrounding an ore body. Groundwaters and streams redistribute the uranium which in places results in anomalously high concentrations in water and in stream sediments outward or downstream for some distance from the source. A systematic sampling of the nation's streams is expected to provide evidence of uranium occurrences not currently known.

The HSSR program is being conducted by four



Hydrogeochemical & Stream
Sediment Reconnaissance Regions

---HSSR activities based on priorities-----

ERDA laboratories (see accompanying map) under the overall management coordination of the ERDA Grand Junction office. The Lawrence Livermore Laboratory (LLL), Livermore, California, is conducting the survey in the Pacific Coast and Basin and Range states. The Los Alamos Scientific Laboratory (LASL), Los Alamos, New Mexico, is responsible for the Roeky Mountain states and Alaska. The Oak Ridge Gaseous Diffusion Plant (ORGDP), Oak Ridge, Tennessee, is responsible for the Great Plains area of the central United States. The Savannah River Laboratory (SRL), Aiken, South Carolina, is conducting the survey in the easten United States, including the Appalachian, New England, and southeastern states. Scheduling of activities in each laboratory is based on priorities designated by ERDA Grand Junction. The U.S. Geological Survey is cooperating in the program in an advisory capacity.

The hydrogeochemical reconnaissance program includes collection of water and stream sediment samples at various spacings throughout the country. The samples are then analyzed at the laboratories and the data plotted on NTMS 1:250,000-scale maps. As completed, these maps will be placed on open file at various locations aeross the United States.

Each of the four regions is divided into smaller study areas according to hydrologic, geologic, and physiographic characteristics. Initially, field investigations are eonducted in select stndy tracts for orientation purposes. These preliminary pilot studies provide information concerning the optimum type and size of samples, sample spacing, techniques of sample storage and transportation, effects of seasonal change, and the most appropriate analytical methods to be used.

During 1976, field orientation studies were conducted and reconnaissance sampling was initiated by all four laboratories. During the year, reports on 13 pilot studies were open-filed; another 9 were completed, but the reports have not yet been open-filed, and another 18 were in progress. Of the 35 reconnaissance studies in progress, work on one was completed; no reconnaissance reports have yet been open-filed.

Correlation of HSSR results with those of aerial radiometric reconnaissance surveys is a key step in regional uranium assessment.

Lawrence Livermore Laboratory

Lawrence Livermore Laboratory (LLL) is responsible for conducting the national Hydrogeochemical and Stream Sampling Reconnaissance survey in seven western states (see map). To date, subcontractors have sampled 3,000 sites representing an area of 42,000 square miles, and returned the samples to LLL for analysis. Elemental analysis is performed by delayed neutron counting, neutron activation, and optical emission spectrometry. In addition, temperature, pH, alkalinity, bicarbonate, conductivity, sulfate, and chloride are measured for the water samples. Results of the survey are published in raw data reports, listing uranium and associated trace-element concentrations for each sample type and location. Separate evaluation reports relate the raw data to base-map geology and include discussions of background and anomalous uranium values, geochemical relations, and other interpretations of the data in terms of favorability for uranium occurrence.

Stream sediments are taken dry in the semi-arid and arid West.

---high-throughput system---

In 1976, samples were collected in seven pilot study areas in Nevada, Washington, and Idaho. Samples from the five Nevada areas were processed and analyzed, and the data have been open-filed. In addition, approximately 2,500 reconnaissance-survey samples were collected in the Humboldt River Basin and in six adjacent basins in northern Nevada. Planning and site selection were completed for four projects to be conducted early in 1977: a reconnaissance sampling survey in west-central Utah and three pilot studies in Arizona.

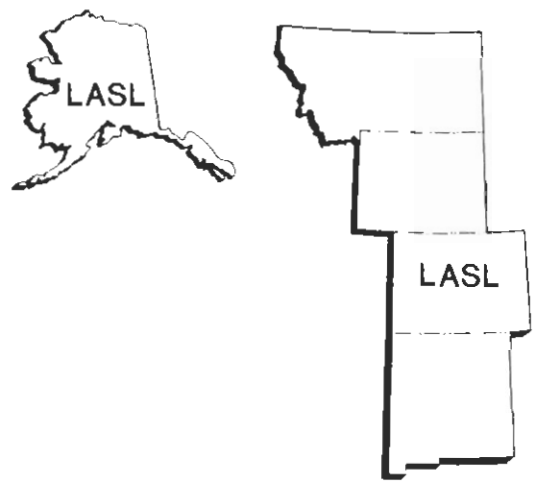
Data obtained from the pilot studies were used to investigate the best sediment-size fraction for detecting uranium anomalies in arid regions; methods for normalizing seasonal variations in the uranium content of streams; and, the use of multielement analysis for defining the geologic/geochemical setting from which a sample was derived. Based on these results, sample acquisition, processing, and analysis techniques have been selected for reconnaissance surveys covering a large portion of the Basin and Range Province.

To facilitate sample analysis, LLL initiated the design and installation of a high-throughput (27,000 samples per year) analytical system that will be fully operational in 1977. Key components of the system include a delayed-neutron counter, a neutron activation analysis (NAA) facility with four Ge(Li) detectors, and an optical-emission spectrometer with dc-arc and inductivity coupled plasma sources. A clean room was constructed to house the emission spectrometer, NAA sample ("rabbit") preparation, and automated anion-chemistry equipment. Other laboratories were modified to provide a sediment preparation room, counting room, rabbit-receiving station, and computer center.

A PDP 11/70 computer system was installed to provide on-line data reduction for several analytical systems and to perform all data base management and reporting tasks. Information-management activities in 1976 included development of data bases for site and field measurements, sample analysis, archives, and sample tracking. Five open-file reports and their associated computer-readable magnetic tapes were prepared from these data files.

In all, LLL released 10 reports pertinent to the HSSR program for open filing in 1976. The complete list is contained in the final section of this Bendix report.

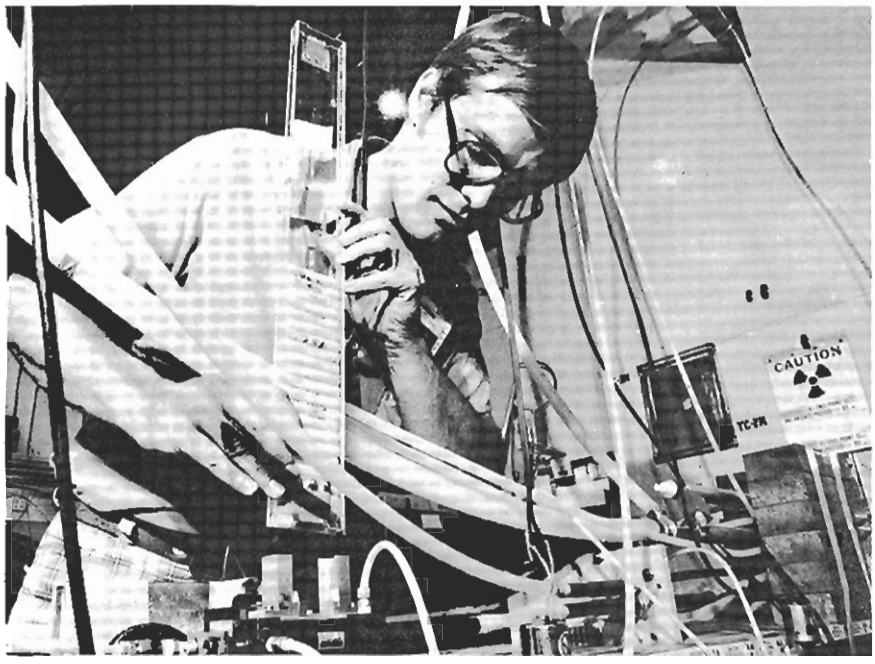
Los Alamos Scientific Laboratory



Alaska and the four Rocky Mountain states of Montana, Wyoming, Colorado and New Mexico constitute the sampling region for which the Los Alamos Scientific Laboratory (LASL) is responsible in participating in the HSSR survey. To date, water and sediment samples have been collected from approximately 46,000 locations covering more than 200,000 square miles, or about 20 percent of the total area assigned to LASL.

In 1976 subcontractors completed sample collection in 21 areas, using the methodology developed during 1975. The first of these surveys in Alaska was conducted on the Seward Peninsula, where 4,468 lakes and streams were sampled over an area of 36,000 square miles in 38 working days, using LASL-developed helicopter sampling procedures.

LASL's approach to the HSSR program has been to continually evaluate and improve field sampling methodology and analytical procedures by contracting detailed pilot studies to specifically selected individuals at state universities. During 1976 the University of Montana completed such a study in the Boulder Batholith area, to evaluate climatic variations on LASL sampling techniques in mountainous areas. Five other pilot-study contracts were initiated to further verify the LASL sampling methods in arid lands (University of New Mexico), river basins (University of Colorado),



Neutron activation analysis is being used to determine uranium concentration in HSSR samples.

---multi-element capabilities---

Precambrian environments (University of Wyoming), mountains (University of Montana), and lakes (University of Alaska).

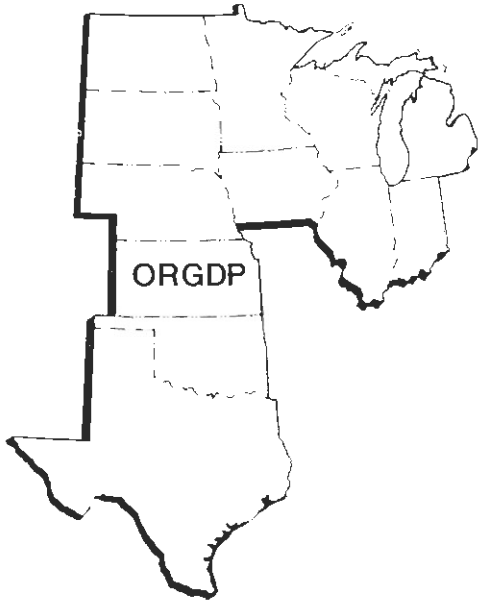
The LASL analytical laboratories have been expanded and automated to increase the sample-throughput capabilities to the level required for the HSSR. With two fluorometers in operation, the chemistry laboratory can make uranium determinations for 875 water samples per week. A sustained average of 1,000 sediment samples per week can be run for uranium at the reactor site using delayed neutron counting. Additional improvements to the reactor sample and data-handling systems are being made to increase the average sample throughput still further. Operating under ideal conditions, a single-day run of 700 samples has been achieved. During 1976, uranium determinations were made for more than 26,000 sediment and 22,000 water samples.

Although LASL does not routinely perform multielement analyses of the HSSR samples, the multielement capabilities at both the chemistry laboratory and the reactor site are being developed. Chemical techniques under investigation are the energy dispersive x-ray fluorescence method for determining several trace elements in water and sediment samples, and the plasma jet-emission spectrographic method for determining a number of elements in water. In anticipation of running all sediment samples (now being placed in archival storage) for 27 different elements, LASL has expended considerable effort on developing its neutron activation analysis (NAA) facilities. Because NAA techniques were initially slow and expensive, only 450 sediments from pilot studies have been run manually by this method. But, with improved sample handling facilities, more detectors, and computerized sample and data controls, the multielement throughput for NAA is expected to reach 200 samples per day.

A computer data base is being established for each contract area, with 16 areas currently operational. From these, sample location overlays can be made at any map scale, data listings can be printed, and graphic uranium concentration overlays can be produced for the 2° NTMS maps. Statistical studies have been made and partially reported on sample treatment, sieve analysis, and the variabilities of analytical and sampling methods. Additional reports on these aspects of the LASL program are nearing completion.

During 1976, LASL released six reports for open filing on various aspects of its HSSR activities; reports for nearly half the contract areas are expected to be open-filed early in 1977.

Oak Ridge Gaseous Diffusion Plant



The Oak Ridge Gaseous Diffusion Plant(ORGDP) is responsible for conducting the HSSR survey program in a 12-state area (see map) encompassing some one million sqnare miles of the central United States. Reconnaissance sampling was started in early 1976, with approximately 70,000 square miles sampled in thc first phase and 27,500 square miles in the second phase. A reeonnaissance survey of the Crystal City and Beeville quadrangles of sonth Texas demonstrates the relation of the widely-spaced sampling of the first phase to the more closely-spaced sampling of the second.

Sampling was also completed in eight pilot studies which were condncted in the Llano area of Texas, northwest Texas, Oklahoma, Kansas, the Dakotas, Minnesota, Wisconsin, and upper Michigan. In these pilot studies, stream- and well-water samples, stream sediments, and plant ash were analyzed for approximately 25 elements and investigated for several chemical properties.

In the field-sampling stages of pilot and reconnaissance surveys, groundwater and stream water are collected directly in polyethylene bottles; groundwater samples from domestic wells are taken as close to the well head as possible. Stream sediments are collected as composite samples, generally along a traverse parallel to the axis of the stream; in every case, the most recently deposited sediments are collected with a polyethylene scoop to avoid possible contamination with the hand or with anything metallic, and are placed in paper envelopes. Botanical samples are taken as near to stream sediment and stream water sample locations as possible, to evaluate the usefnlness of this material as a substitute when other surface samples are not available.

All water, sediment, and plant samples are shipped to the ORGDP laboratories for ehemical analysis. Water samples are processed in a clean room facility as soon as possible after receipt, with the uranium measurement being made within 5 to 10 days. Sediment samples are dried, disaggregated, and sieved prior to analysis; botanical samples are ignited and the ash processed for analysis.

Uranium is determined in water, sediment, and plant ash by fluorescence spectroscopy. Stream sediments are also analyzed by neutron activation, using delayed-nentron counting. For water samples with uranium concentrations below the reporting limit of flnorometric analysis, isotope dilntion thermal emission (IDTE) mass spectrometry is used.

During 1976, the HSSR clean room laboratory at Oak Ridge was modified, all equipment installed, and made operational. Necessary analytical procedures were developed, quality control programs established, and a project procedures manual drafted. A data management program and a retrievable sample-storage system were designed and implemented. HSSR project data were placed on computer tapes and forwarded to ERDA-Grand Junction for insertion in a GJO Information Storage data base.

Currently, base stations are being established in each of the 12 states in ORGDP's area of responsibility. These installations will measure temporal variations in uranium content at U.S. Geological Survey gaging stations. Samples are now being received from samplers in Texas, and discussions are under way in the remaining states with state ageneies and the U.S.G.S. for establishment of base stations.

ORGDP reports open-filed in 1976 in relation to the hydrochemical program include six quarterly reports, covering the period from April 1975 through September 1976, and two pilot snrveys. A report of the reconnaissance survey in the Crystal City and Beeville quadrangles of Texas is in preparation for release carly in 1977.

Savannah River Laboratory

The Savannah River Laboratory (SRL) is responsible for conducting the national HSSR survey in the eastern United States (see map), over an area extending from Maine to Florida and from the Atlantic Coast to the Mississippi. In 1976, orientation studies were completed or under way in Georgia, North and South Carolina, Pennsylvania, New York, New Jersey, and New England. Reconnaissance sampling of stream bottom sediments was completed in approximately 90,000 square miles of the southern Appalachian, Blue Ridge and Piedmont provinces. Some sampling was also conducted in the Valley and Ridge and Upper Coastal Plain provinces to provide a basis for future sampling programs in these areas. Evaluation of seasonal effects on the hydrogeochemistry of uranium was in progress in North and South Carolina, and a well-sampling feasibility study in western New York was completed.

Orientation data from the pilot studies provided much useful information: Sediment size of -100 U.S. standard mesh was selected as the most effective for reconnaissance in crystalline rock areas in the southeast; coarser sediment seems to be useful in identifying areas less than a half mile from uranium deposits. A study of data from sandstone areas indicates that sediment analysis alone will not be adequate for reconnaissance there. Surface water seems to integrate the geology of an area better than sediment; ground water samples reflect subsurface conditions in the immediate vicinity of sample sites and therefore may be useful for detailed exploration. Using data from the Williamsport, Pennsylvania area it can be implied that ground water samples may be an excellent indicator of regional trends in uranium mineralization. Extractable uranium in sediments and the uranium content of stream water seem to provide comparable information regarding known uranium deposits in the Devonian Catskill Formation of Pennsylvania.

Data from 6,000 stream sediment samples collected from western and central Maine by the U.S. Geological Survey, including emission spectrographic results for 28 elements, were provided to SRL. The samples are to be analyzed for uranium using neutron activation techniques.

At year's end, the weekly capacity of the neutron activation analysis (NAA) facility was 750 sediment samples or 375 water samples. Design criteria have been defined to upgrade the facility for full-scale operation of 60,000 samples per year. Techniques for emission spectrographic analysis of sediments were developed for backup and cross-checks of NAA. In addition, procedures were implemented for more efficient entry, correlation, and compaction of raw neutron activation data from the Pilot Scale Reactor Activation Facility (PSRAF) into the IBM-360/195 computer. Sample handling equipment and control software were modified to increase the sample throughput of the PSRAF.

Inductivity coupled, plasma-emission spectroscopy (ICPES) was evaluated for supplementary elemental analysis. Late in 1976, a subcontractor began routine preparation of ion-exchange resins from water samples for ICPES.

During the year the SRL data management system was modified to allow processing of orientation and reconnaissance data as independent files. A computer program to inventory and manage samples and a program to place inventory data in retrievable archives were completed. Records for approximately 16,000 samples were successfully processed by the sample inventory system. The capability to prepare computer-generated maps for raw data releases was also developed.

Twelve reports pertinent to the HSSR program

---SRL issued 12 HSSR reports during 1976----

were released by SRL for open filing in 1976; these include seven quarterly reports covering the period from January 1975 through September 1976, four raw data releases from orientation studies, and one data management system report. Open-file numbers and titles of these reports are contained in the final section of this Bendix report.

Water Sample Compilation

Start Date: 1 September 1975
Completion Date: 31 October 1976

During the period 1956-1975, personnel of the Grand Junction Office of the Atomic Energy Commission, the Energy Research and Development Administration, and their contractor personnel collected water samples as part of the agencies' uranium resource appraisal program. Bendix has compiled field and analytical data from 1,865 of these samples, in order to make the information available to the public.

The sources of information on which this compilation is based consist principally of original field notes and maps prepared by the sample collectors and of the related analytical results. The procedure employed was to transcribe data onto computer coding forms from the original materials, then to generate a computer listing, using a standard reporting format.

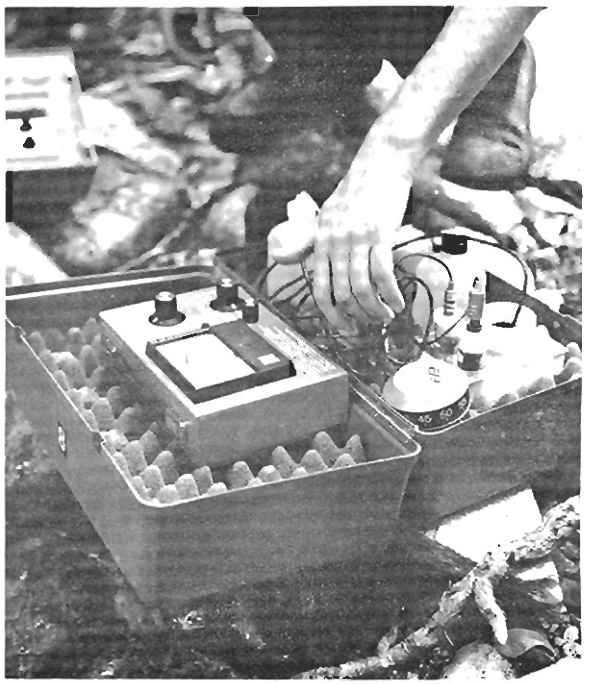
The compilation was placed on open file in December 1976, as GJBX-51(76).

Groundwater Sampling Network

Subcontractor:
UNIVERSITY OF MINNESOTA
Subcontract Value: $30,000
Start Date: 1 August 1976
Completion Date: 31 December 1976

A project was initiated under subcontract with the University of Minnesota to design a groundwater sampling network for hydrogeochemical investigations to determine the distribution of uranium in groundwater. This study is to provide a hydrogeochemical map of Minnesota which will delineate known and definable aquifers, and provide a base for locating a network of wells to evaluate the uranium potential of rocks masked by glacial drift.

Results of this project will be placed on open file early in 1977.



The latest water sample test equipment is being used by field personnel performing hydrogeochemical surveys.

Northeastern Pennsylvania Geochemical Study

Subcontractor:
PENNSYLVANIA STATE UNIVERSITY
Subcontract Value: $34,000
Start Date: 1 December 1974
Completion Date: 31 May 1976

Under direct contract with ERDA, Pennsylvania State conducted a project to investigate certain aspects of drainage surveys for uranium by using the uranium occurrences of northeastern and north-central Pennsylvania as test sites. The work involved three phases: (1) Stream sediment and water samples were collected near known uranium occurrences to determine if usable anomalies exist; (2) a stream-sediment and water survey of two 15-minute quadrangles was conducted to test the preferred methods and to identify geochemical characteristics of background samples; and (3) the possibility of using other elements as pathfinders was investigated by sampling rocks near uranium occurrences.

The project report, GJBX-28(76), was placed on open file in July 1976.

TECHNOLOGY DEVELOPMENT

The major goals of the Technology Development program in support of the NURE are:

1. To improve existing uranium surveying and exploration instrumentation and methods; and
2. To design aud implement new techniques for geophysical and geochemical surveying and exploration, data collection and analysis for uranium resources and methods for exploitation.

The program is therefore structured to encompass a number of geoscience technology areas including geophysics, geochemistry, chemical aualysis, remote sensing, mining, metallurgy and drilling. At the close of 1976, the geophysical program was furthest advanced.

Technology development activities are conducted by Bendix through a combination of in-house and subcontracted projects, many of which are initially small-scale investigations undertaken to evaluate a particular technique or approach. The mix of activities contains some high risk, low cost projects which if successful could have a significant programmatic impact, as well as a number of moderate cost projects which carry a high success probability and a predictable programmatic impact. There were 17 subcontracted and 9 in-house projects under way during 1976; of these 4 were in geochemistry; 1 in remote sensing, and 21 in geophysical technology. These geophysical activities are subdivided into four categories: airborne, borehole, emanometry, and other.

The Technology Development program is the responsibility of the Bendix Advanced Technology Division.

Airborne Technology

The purpose of the airborne technology program is to optimize airborne collection and interpretation of radiometric data. Within the scope of this program are sensor improvement, development of calibration methods for aerial sensor arrays, and improvements in the mode of data collection, processing, interpretation and storage.

Airport Calibration Pads

Start Date: 7 January 1976
Completion Date: 1 April 1977

An airport spectrometer calibration facility, the first such installation for normalization of radiometric data in the United States, has been constructed at Walker Field, Grand Junction, Colorado. This ERDA facility, built to Bendix design specifications by Corn Construction Company at a cost of $164,500, consists of five concrete pads containing measured amounts of potassium, uranium, and thorium. The pads are interconnected by a taxiway to the main airport facility.

Use of the facility is available without charge to firms and organizations wishing to calibrate airborne and vehicle-borne spectrometer equipment over known elemental concentrations. Access by instrumented aircraft is under airport control. The first aircraft to use the new ERDA calibration pads was the S-2 Tracker operated by Geometrics, Inc. On November 16 the aircraft and instrumentation were checked out prior to initiation of the Eastern North Dakota aerial survey project.

Present effort is being expended on analysis of samples taken at several stages of pouring the radioactive concrete mixtures, in order to confirm the calculated elemental concentration levels.

Bendix specification PMD-1250, defining requirements for the use of this facility and of the dynamic test range in Arizona, was released in December 1976. A report on construction of the pads and verification of elemental concentrations will be open-filed in 1977.

Potassium, uranium, and thorium calibration pads for radiometric measurement equipment were completed at Grand Junction's Walker Field airport.

Dynamic Test Range

Subcontractor:
GEODATA INTERNATIONAL, INC.
Subcontract Value: $78,586
Start Date: 28 May 1976
Completion Date: 28 November 1976

Geodata International is developing the first dynamic test range in the United States for calibrating airborne radiometric survey instrumentation systems. This facility will permit development of correction factors for normalizing to standard bases the radiometric data collected by various subcontractor systems.

Initial effort was concentrated on selection and evaluation of several potential sites for the test range. Consideration of such factors as year-round favorable flying weather, relatively uniform radiation background, proximity to a sizeable body of fresh water, minimum vegetation and soil moisture, and ground accessibility for sample collection and for installation of ground monitor facilities, led to the ultimate selection of a 4-mile-long strip near Lake Mead, Arizona. In December 1976 Bendix issued Specification PMD-1250, which defines requirements for use of this range.

Additional phases of this project are being planned to make the dynamic test range fully operational for industry use.

Soil Moisture Measurements

Subcontractor:
GEODATA INTERNATIONAL, INC.
Subcontract Value: $32,272
Start Date: 1 October 1976
Completion Date: 31 March 1977

Under a follow-on to the dynamic test range development contract, Geodata International is investigating the feasibility of a technique, using aerial radiometric data, to correct for attenuation of gamma radiation due to soil moisture and surface vegetation conditions. In order to make reliable radioelement concentration measurements, aerial survey data should be corrected or at least normalized to some standard condition of moisture and vegetation attenuation. Such corrections may be possible using a portion of the radiometric data itself: The effect of gamma attenuation is strongest for low energy gamma photons; thus, if the high energy portions of the composite spectrum can be reconstructed with sufficient accuracy, the low energy residual spectrum may be used for correction of soil moisture and vegetation attenuation.

The Geodata study is testing the feasibility of the low energy residual technique. The current phase involves, first, performance of a series of experiments under controlled conditions to determine whether effects of distributed-source attenuation can be identified in the low energy region of the spectrum; next, performance of detailed calculations to explain the experimental results observed, whether positive or negative; and finally, examination of data collected over the dynamic test range, with particular attention to the statistical significance of the residual spectral data.

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

Optical Detection Methods

Subcontractor:
NAVAL UNDERSEA CENTER
Subcontract Value: $115,000
Start Date: 1 June 1976
Completion Date: 30 March 1977

Current aerial survey techniques use the gamma spectrum of bismuth-214 as an indication of ground surface uranium concentrations; however, radiation due to airborne Bi-214 between the survey aircraft and the ground limits the sensitivity of this method. Since airborne Bi-214 results from the decay of atmospheric Rn-222, a technique for the detection of atmospheric radon would permit removal of the airborne Bi-214 background from radiometric survey data.

The Naval Undersea Center, assisted by San Diego State University, is conducting a study to determine the applicability of optical methods to detection of ambient levels of airborne Rn-222 or Bi-214. Phase I of this project considered the feasibility of remote detection, by laser-probing techniques, of very low concentrations of these uranium-238 daughter products in the atmosphere. Phase II is using the results of the feasibility study to perform necessary laboratory measurements to verify the calculated predictions. In addition, a laboratory prototype system is being constructed, using commercially available components; the sensitivity of this system will be measured under laboratory and controlled field conditions to evaluate the ultimate operational performance.

A report outlining methods and results of this project will be placed on open file in 1977.

Analytical chemists prepare geologic samples by a fusion technique at the ERDA/Bendix Grand Junction laboratories.

Airborne Detector Improvement

Subcontractor:
GRUMMAN AEROSPACE CORPORATION
Subcontract Value: $51,037
Start Date: 27 April 1976
Completion Date: 30 September 1976

To improve the accuracy of airborne radiometric survey data, increasing the sensitivity of the radiation detector is necessary. Grumman Aerospace, under subcontract with Bendix, conducted a project to develop an airborne detector system employing an optimized phoswich configuration, which would be twice as sensitive to ground-level potassium, uranium, and thorium concentrations as conventional sodium iodide sensors of the same size.

The phoswich configuration was tested using a 12-inch by 4-inch sodium iodide detector wrapped on three sides with a 1-inch thick cesium iodide blanket, a method which in previous tests had shown significant improvement in effective sensitivity.

Results of this development project will be published in a report to be open-filed early in 1977.

Development of a Flight-Path Recovery System

Subcontractor: SYSTECH, INC.
Subcontract Value: $61,977
Start Date: 26 August 1976
Completion Date: 1 June 1977

To correlate aerial survey radiometric data with survey aircraft position, current practice is to develop and visually scan continuous strip photographs. A system which could store radiometric and flight path position data on the same record would permit computer processing of both sets of information, resulting in a substantial cost benefit.

SysTech is developing an engineering design for relative flight path position recovery of better than 100 feet within a survey grid of 10,000 square miles. When a feasible system design has been completed and a favorable assessment made of its utility to survey data reduction, the necessary equipment will be acquired and software generated to conduct a flight demonstration.

A report on this project will be published in the summer of 1977.

Airborne Temperature Profiler

Subcontractor:
SCIENCE APPLICATIONS, INC.
Subcontract Value: $16,788
Start Date: 21 May 1976
Completion Date: 30 September 1976

To increase the accuracy of interpreting aerial radiometric survey data, a downward-looking sensor system which could measure temperature variations in the atmosphere would be highly desirable. In theory, such a system could detect the presence of inversion layers which trap radon gas between the aircraft and the ground, thus giving erroneous indications of the ground surface radiation levels. Detection of a temperature inversion would enable flagging the possibly faulty data.

The feasibility of developing a downward-looking airborne temperature profiler has been the subject of a computer simulation study conducted by SAI. Effort entailed development of a procedure using spectral radiance measurements to determine temperature profiles of the atmosphere below an aircraft flying at nominal survey altitude of 400 feet. It was felt that these measurements would identify the temperature inversion conditions which lead to an unacceptably large background of gamma rays from the atmospheric radon.

The project report, delineating the procedure used and the conclusions of the study, will be placed on open file early in 1977.

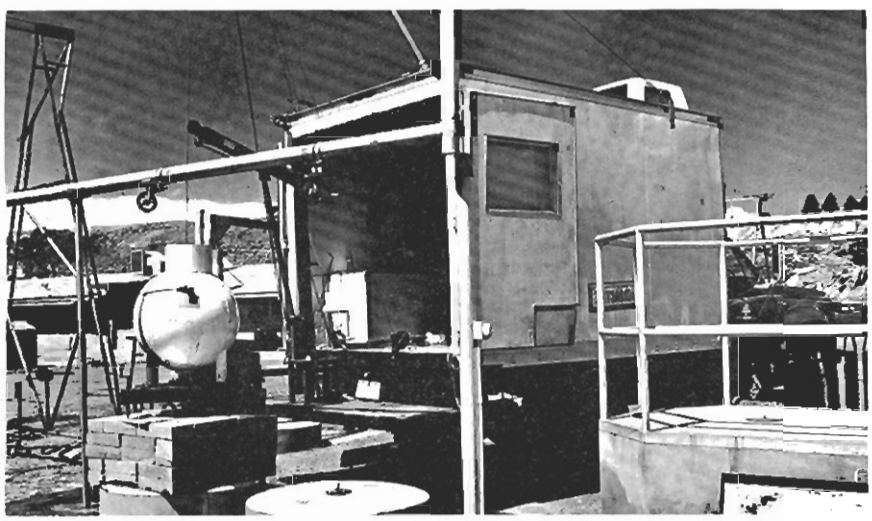
Airborne Data Procedures

Subcontractor:
TEXAS INSTRUMENTS, INC.
Subcontract Value: $157,000
Start Date: 1 October 1976
Completion Date: 1 September 1977

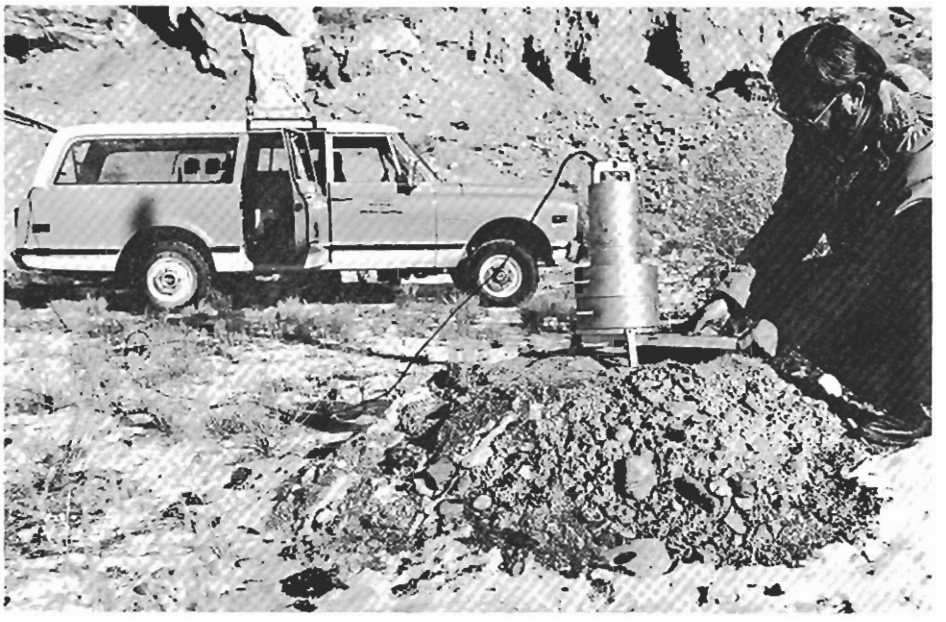
To determine the optimum specifications and procedures for conducting an airborne radiometric survey of a particular geologic environment, Texas Instruments is performing an extensive follow-up study of their 1974-75 aerial survey of the Casper (Wyoming) quadrangle. The Casper quadrangle is particularly suited to this study for several reasons: It contains known economic uranium deposits in Tertiary sandstone, as well as two potential sources of the uranium - crystalline rocks and volcanic tuffs; considerable geological, geochemical and remote sensing data are available; and, data collected during the 1974-75 survey using state-of-the-art techniques and instrumentation are available and already interpreted to some degree.

This study encompasses compilation of all available and pertinent ground truth data, evaluation of aerial survey operational parameters relative to the Casper quadrangle, evaluation of data analysis procedures and data display formats, and limited supportive field work.

A report describing the procedures and results of this study will be placed on open file upon completion of the project.



A californium delayed fission neutron probe was calibrated at ERDA's Grand Junction facility.



Experimentation is carried out on a continuing basis on surface radiometric measurement instrumentation.

Spectrum Enhancement

Subcontractor:
SCIENCE APPLICATIONS, INC.
Subcontract Value: $76,855
Start Date: 5 May 1976
Completion Date: 30 September 1976

A study was conducted by SAI to demonstrate the applicability of the spectrum enhancement technique to data acquired by sodium iodide detector systems currently used in aerial radiometric surveys. The technique treats spectral data mathematically to extract information on the potassium, thorium, uranium, and gamma-ray lines with greater accuracy, as well as to reveal previously hidden spectral features which may be helpful in making corrections for the presence of airborne bismuth-214.

Effort involved application of the MAZE II computer code to spectra in the 0.5- to 3.5-MeV energy range; the enhanced accuracy thus obtained was compared to the spectral determination obtained without use of the MAZE program. In addition, lower energy gamma-ray lines were similarly treated to determine their usefulness in making soil moisture and atmospheric Bi-214 corrections.

Results of this study are contained in a summary report to be open-filed early in 1977.

Borehole Technology

Borehole technology is a broad scope program to develop both active and passive techniques for subsurface detection of uranium and associated trace elements or physical parameters. Included are methods for direct and indirect measurement of uranium, as well as nuclear and non-nuclear detection methods.

Surface and Subsurface KUT Sytems

Start Date: 1 March 1976
Completion Date: 1 December 1979

The KUT gamma spectrometric technique utilizes distinctive gamma spectral emissions of potassium, "K", uranium, "U", and thorium, "T", to determine the concentrations of these elements and their ratios, and to distinguish lithologic signatures based upon these concentrations and ratios. Thus, KUT data are useful in identifying areas of radiologic anomalies. Bendix geophysicists are engaged in a multiphase program to develop integrated field systems for surface and subsurface logging using the KUT technique.

Current effort on the surface-logging portion of this project involves design and construction of an optimized vehicle-mounted data collection system which employs a large volume NaI(Tl) detector and appro-

---various methods of data transmission being evaluated---

priate shielding to measure KUT radiation near the ground surface. Particular emphasis is being placed on detector position and spacial configuration to maximize long range detection sensitivity. In addition, all equipment must be designed to withstand such field conditions as mechanical shock and dirt.

The subsurface-logging portion of this project requires fabrication of an optimized, high sensitivity NaI (Tl) borehole sonde and supporting electronics, as well as fabrication of a vehicle to accommodate the complete instrumentation package. Various methods of data transmission from the sonde up the borehole are being evaluated.

For both the surface and subsurfaec KUT logging systems, investigations are under way to determine the most suitable method for extracting maximum information from the KUT spectrum, optimal data format and storage, real-time data analysis and display, and system calibration. Upon completion of the project, a report discussing procedures and results will be placed on open file.

Test of A Neutron Logging Tool

Subcontractor:
KAMAN SCIENCES CORPORATION
Subcontract Value: $83,434
Start Date: 22 July 1976
Completion Date: 31 January 1977

Under a previous contract with ERDA, Kaman Sciences developed a delayed fission neutron (DFN) logging tool for actively measuring the DFN response to a pulsed neutron source in a uranium-bearing borehole environment. Under a follow-on subcontract with Bendix, Kaman has undertaken to optimize, calibrate, and field-test the tool. To accomplish these objectives, it was necessary to decrease the system-generated noise to a level of no more than one count per second detected at the receiver. The probe with its supportive surface equipment was subsequently calibrated, then taken into the field for testing at selected boreholes in New Mexico and Texas.

A report on the development of the tool was placed on open file in December 1976, as GJBX-18(76); the results of the follow-on project will be open-filed early in 1977.

The borehole calibration facility at the ERDA Grand Junction site is used by both industry and ERDA logging units.

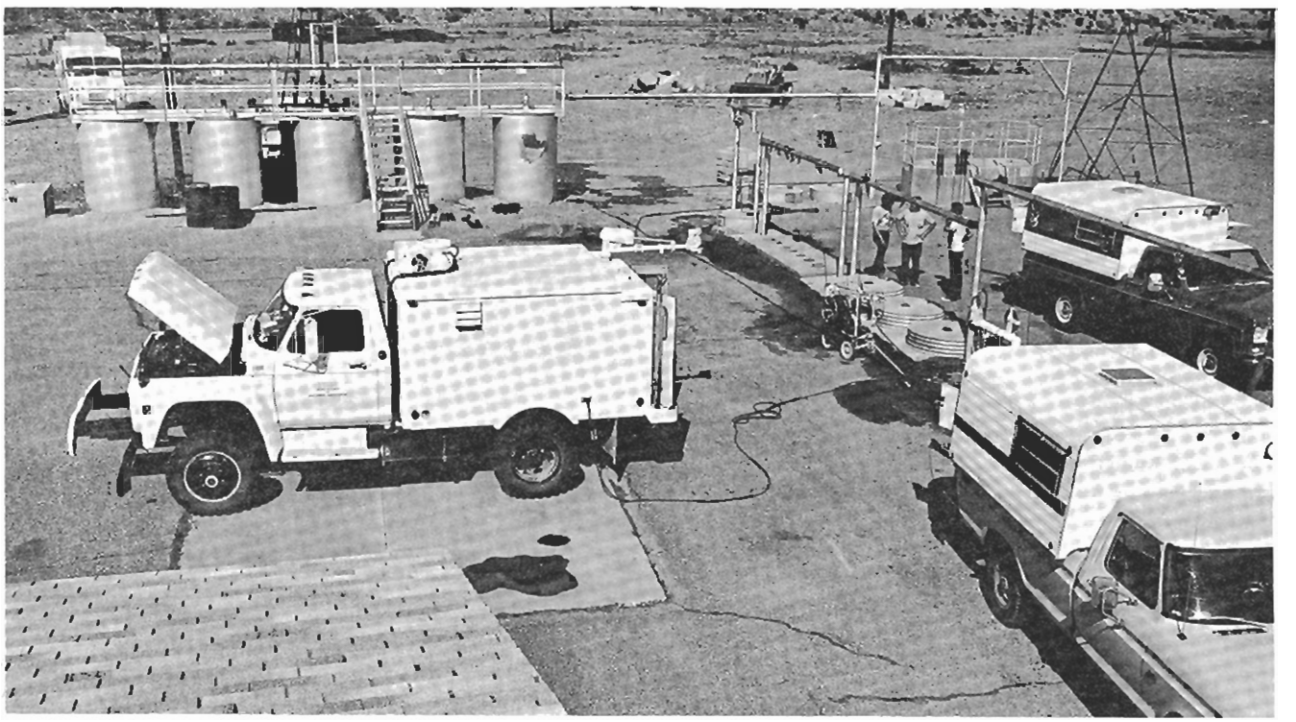
Test Models: Calibration and Test Facilities

Start Date: 1 July 1975
Completion Date: Open

Bendix is conducting a project to develop more useful and accurate information about the calibration and test models located at the ERDA-GJO facility. These 20 models are used by ERDA, Bendix, and private industry to calibrate a variety of different gamma logging systems for uranium exploration. The calibration models have several assigned ore grades necessary in interpreting field logs.

Current effort on this project includes the following tasks: compilation of all available data for each logging test model; review of the ore grades assigned to the calibration test models, making additional chemical and radiometric assays of model samples, and measuring the physical parameters of the models to ascertain their possible effects on assigned grades; evaluation of a new computer program for estimating uranium ore grade from gamma logs; determination of a method to optimize use of the existing models for calibration of gamma logging equipment; and, definition of a calibration logging model for future construction.

GJBX-49(76), a report on the construction of the KUT test pits, was open-filed in November 1976; a brief review of the procedures used in gross gamma log calibration, GJBX-61(76), was open-filed in December.



Support of Neutron Logging Tool Development

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

Three neutron logging tools are currently being developed and tested under ERDA contracts with Sandia, Kaman Sciences, and IRT. These tools are borehole sondes that, by various techniques, directly interrogate for uranium in the rocks adjacent to the borehole. The two basic neutron assay techniques being used are the eipthermal die-away, "PFN" technique (Sandia) and the delayed fission neutron, "DFN" technique. The latter is further subdivided by source: a pulsed 14-MeV neutron generator (Kaman) and a californium-252 neutron source (IRT).

Bendix is participating in the development of these probes by providing laboratory and field support, coordinating field logging aetivities, and providing personnel and equipment as necessary to evaluate the utility of the tools in borehole uranium exploration.

The development report of the Kaman probe, GJBX-18(76), was placed on open file in December 1976. The IRT report will be published early in 1977.

Borehole Model Neutron Calculations

Subcontractor:
SCIENCE APPLICATIONS, INC.
Subcontract Value: $48,998
Start Date: 1 July 1976
Completion Date: 1 December 1976

To aid in the interpretation of borehole logging data provided by various neutron tools being developed, as well as to intercalibrate these tools, a computer modeling study of neutron transport calculations has been performed by SAI. A detailed knowledge of the time and energy distributions of the returning neutrons, as a function of the energy of the neutrons gencrated by the tool, is neeeded to optimize performance.

The results of this study are in the form of an evaluation matrix that provides returning neutron distributions as a function of the density and moisture content of the host rock, diameter of the borehole, and uranium concentration. The project report, including the computer program, will be placed on open file in early 1977.

Computation and Nondestructive Assay Methods

Subcontractor:
LOS ALAMOS SCIENTIFIC LABORATORY
Subcontract Value: $280,000
Start Date: 6 April 1976
Completion Date: 30 August 1977

For quantitative interpretation of the various gamma logs used in uranium exploration, corrections should be made for variations in borehole and host rock parameters. LASL is developing a computer model of natural gamma-ray transport in the subsurface to establish the types and methods of corrections necessary. The model uses a specified approximation of the natural gamma flux in a borehole as a function of such pertinent parameters as hole diameter and water content, density and moisture content of the host rock, and casing effects. Upon completion of the computer model, the flux results are to be applied to sonde detector systems in order to improve probe design parameters.

LASL is also performing feasibility studies for the use of a ^{124}Sb-Be photoneutron source in direct uranium borehole logging. Upon completion of Monte Carlo calculations to determine optimum tool design, a prototype will be constructed to verify expected performance. Other isotopic sources in addition to ^{124}Sb-Be are to be considered, and a new fast neutron detector with low gamma-ray sensitivity will be developed.

A detailed report on the methods and results of this project will be published for open filing in the fall of 1977.

New instrumentation such as this industry-developed radon gas detector is evaluated by Bendix research engineers.

Emanometry Techniques

Emanometry techniques are used to detect the gaseous products of uranium decay, such as radon and radiogenic helium. The emanometry technology program includes development of methods to detect these emissions in high and low concentrations, close to their source as well as at considerable distance, in ground water, in air samples, and in subsurface environments.

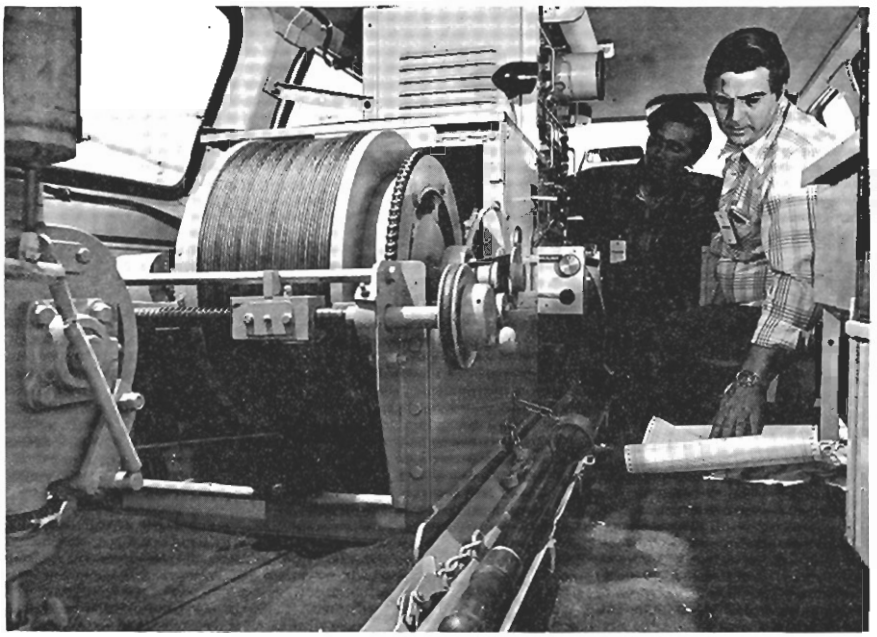
Emanometry

Start Date: 1 June 1975
Completion Date: 1978

Emanometry, the measurement of radon and helium decay products from the uranium chain, is a promising method of discovering subsurface uranium deposits. Uranium exploration instrumentation systems utilizing this technique require an emanometric calibration unit to substantiate their accuracy aud integrity and to provide a standard method of calibration.

A projeet is currently under way at Bendix to establish such a calibration capability at Grand Junction and to evaluate existing radon detector systems. Work effort entails delineation of specifications and design criteria for subcontracting the design and construction of a calibration unit which allows the extraction of known radon concentrations in the range of 0.1 to 100 picoCuries per liter; and, test and evaluation of available emanometry systems as well as recommendations for modifieations to achieve desired detection sensitivity and/or operational characteristics.

A report on the laboratory test phase of this project is expected to be placed on open file in mid-1977.



Industry logging units such as this gamma-ray probe make use of the calibration facilities at the ERDA/ Grand Junction site.

$^{4}He/^{36}Ar$ Ratios

Subcontractor:
TELEDYNE ISOTOPES
Subcontract Value: $36,983
Start Date: 1 April 1976
Completion Date: 30 September 1976

Among the many radioactive decay products of uranium are alpha particles which readily attract free electrons, forming various gases. Presumably, gas-permeable paths to the surface exist in the environment surrounding buried uranium deposits. Therefore, developing a methodology for using the detection of certain such gases, and their ratios to stable reference gases, when combined with a knowledge of favorable geologic characteristics hopefully will aid in locating subsurface uranium ore bodies.

Teledyne Isotopes, under subcontract to Bendix, conducted a study to develop a methodology for uranium prospecting by measuring the ratio of helium-4 to argon-36. Soil-gas test samples were collected from boreholes over known uranium deposits, then 10 percent of the holes were re-sampled. The samples were analyzed for $^{4}He/^{36}Ar$ ratios, and the ratios compared to radon gas (^{222}Rn) concentrations collected in the same location.

Results of this project will be placed on open file early in 1977.

$^{4}He/^{3}He$ Ratios

Subcontractor:
MARTIN MARIETTA
Subcontract Value: $61,941
Start Date: 1 April 1976
Completion Date: 31 January 1977

As part of a cooperative program involving the Westinghouse Corporation, the Colorado School of Mines Research Foundation, the Electric Power Research Institute and ERDA, Martin Marietta is conducting a program under a Bendix subcontract to develop a technique for detecting the helium-4 isotope as a signature of uranium deposits. The technique involves comparison of helium-4 to helium-3, and evaluation of the sensitivity and reliability of the comparison ratio as a uranium indicator.

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

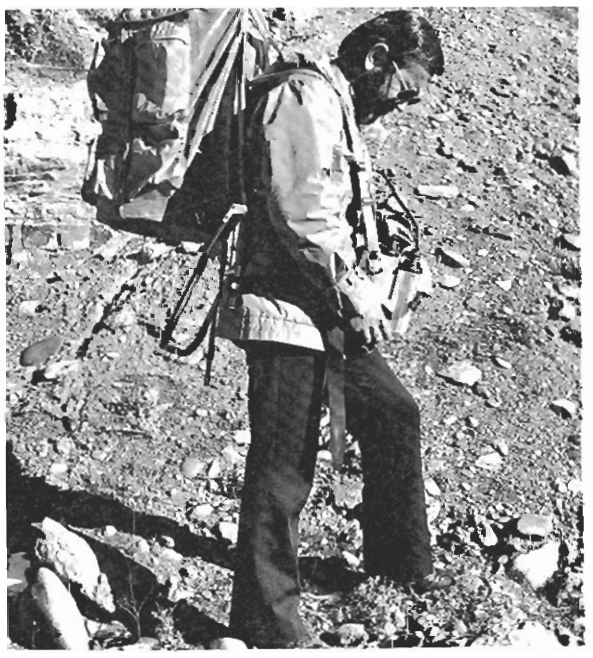
Results of the investigation will be open-filed early in 1977.

Numerical Modeling of Radon-222 Distribution

Subcontractor:
TELEDYNE ISOTOPES
Subcontract Value: $27,192
Start Date: 29 September 1976
Completion Date: 30 March 1977

As a follow-on to the $^{4}He/^{36}Ar$ study, Teledyne Isotopes has undertaken the development of methodology for numerical modeling of the distribution and concentration of radon-222 and its daughter products generated by a uranium ore body as a function of depth below the surface. The half-life of Rn-222 allows its migration through soil for distances up to a few hundred meters. Solid daughter decay products of the radon can be radiometrically identified and their concentrations compared to that of their parent precursor; that is, the ratios of their intensities to Rn-222 may provide an indication of the subsurface location of the uranium deposit.

The computer program being developed incorporates such variables as uranium content of the ore, depth of the ore deposit, radon emanation rate, and permeability of the soil. Upon completion of the project, the summary report will be placed on open file.



A recently developed field-portable spectrometer system was purchased from industry for detailed evaluation by Bendix engineers.

Other Methods

This category of the geophysical technology development program encompasses the improvement of existing geophysical tools and the development of new instrumentation and techniques for surface investigations.

Evaluation of Pulsed Radar for Uranium Exploration

Subcontractor:
STANFORD RESEARCH INSTITUTE
Subcontract Value: $18,000
Start Date: 18 May 1976
Completion Date: 30 September 1976

Applicability of radar reflection methods to geophysical problems is dependent upon the dielectric constant contrast between the geological structure to be located and the surrounding material, and also upon the electrical conductivity of the material along the path of the radar pulse. Stanford Research Institute conducted a study to determine whether the pulsed radar technique is useful for uranium exploration. In sandstones typical of the uranium roll-front environment, the useful depth of radar energy penetration is less than 25 meters; the principal targets of interest that may have sufficient contrast in dielectric constant would be paleostream channels or an actual roll-type uranium deposit. However, in hardrock areas, radar penetration is significantly greater than in sandstones, and targets such as mineralized fracture zones offer a greater contrast in dielectric constant.

SRI performed radar profiling surveys over a known paleostream channel at depths of less than 25 meters. Effort included reconnaissance to establish sites for detailed stratigraphy, collection of rock samples for laboratory measurements to determine electrical conductivity and dielectric constant, and computer processing of the pulse reflection data. Investigation of a hardrock uranium area included profiling surveys in mine tunnels to detect known, but unexposed, fracture zones, and to trace exposed deposits to the limit of detection. Sample collection, laboratory analyses, and data processing were similar to the sandstone study.

The report on this project will be open-filed early in 1977.

Ge(Li) Lab Assay

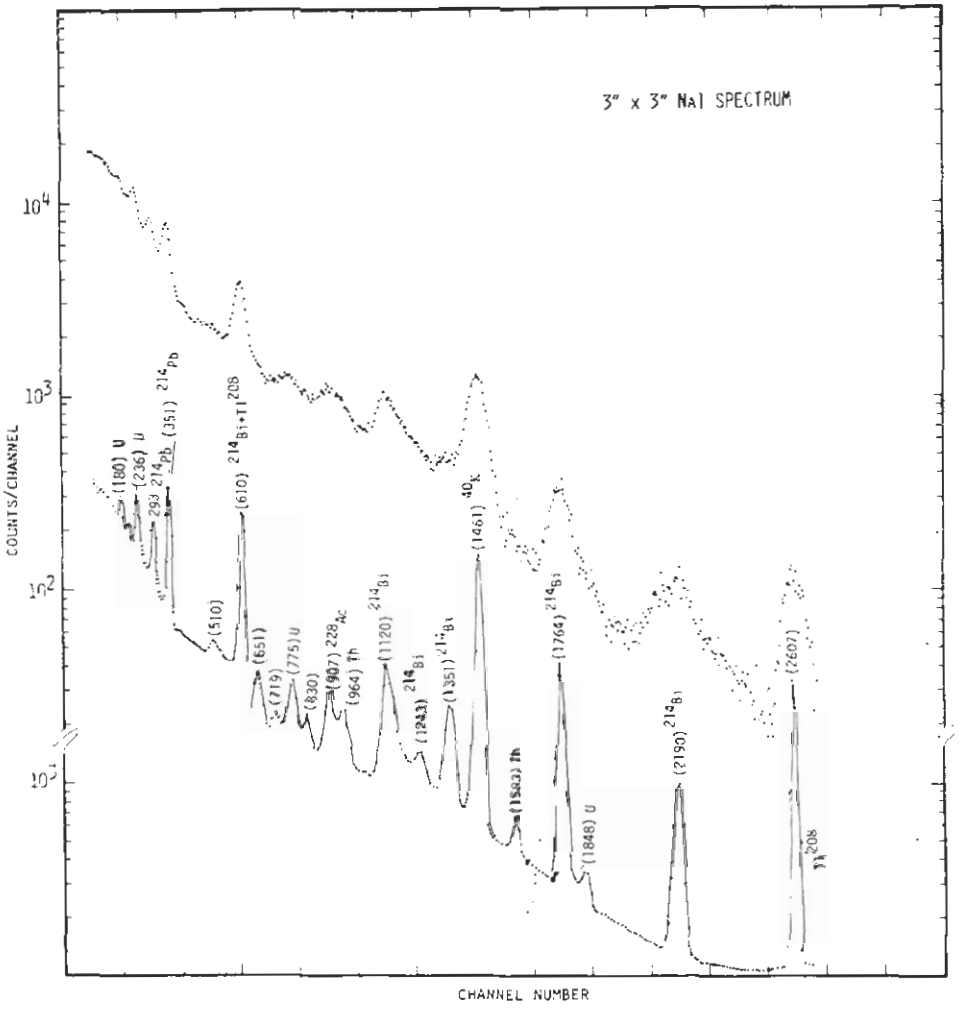
Start Date: 1 January 1975
Completion Date: 1 October 1977

Bendix geochemists are adapting a high resolution Ge(Li) detector system for routine radiometric counting of geologic samples. The potential advantages of this system include more accurate determination of potassium, uranium, and thorium values, direct measurement of uranium concentrations, and reduced sample turnaround time.

The currently accepted method for analysis of bulk samples in the laboratory employs a NaI(Tl) detector from which uranium content is inferred from the measurement of certain radioactive decay products. The implementation of a high resolution Ge(Li) detection system would not only enable a direct measurement of uranium concentration, but also eliminate the need to correct mathematically for interferences from other radionuclides.

This development project involves assembling a low background Ge(Li) spectrometer suitable for bulk sample analysis; developing and implementing a Ge(Li) analysis scheme to meet the goals of the project; and, evaluating the present NaI(Tl) system.

A report describing the procedures used and results obtained will be placed on open file in late 1977.



Energy spectrum is significantly enhanced by the germanium detector (solid lines) as compared to that of a sodium-iodide detector (dotted).

Geochemistry and Chemical Analysis

The purpose of the geochemistry program is to improve existing geochemical analysis techniques and develop new laboratory and field procedures, instrumentation, and data interpretation technologies.

Spectrophotometer

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

A project has been initiated to improve the accuracy and sensitivity of in-house low level uranium analysis procedures by replacing the fluorometer in current use with a more sensitive and efficient fluorescence spectrophotometer. Present low level uranium analyses are performed with a broad band filter photometer (fluorometer). The samples are prepared with a time-consuming solid state fluxing procedure following chemical separation. By substituting a speetrophotometer which is equipped to handle both liquid and solid samples, solution phase techniques can be adapted to improve the speed, sensitivity, and accuracy of uranium analyses.

As a first step toward accomplishing this improvement, a dual beam spectrophotometer has been installed in the Bendix Chemical Laboratory at Grand Junction, Colorado. New analytical procedures are uow being implemented for routine analysis of uranium, and procedures for analysis of trace elements, including selenium, arsenic, vanadium, and molybdenum are under development.

A users' guide and report evaluating system capabilities and performance will be published in late 1977.

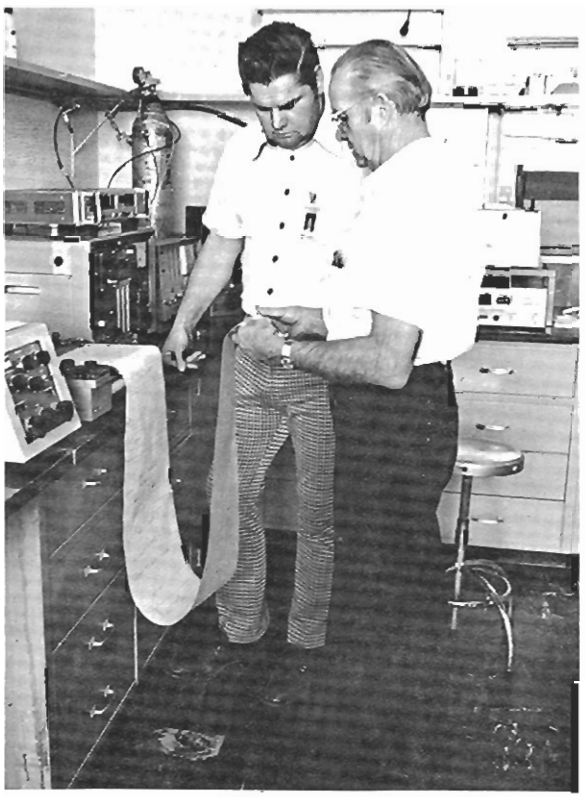
X-Ray Fluorescence

Start Date: 1 April 1975
Completion Date: Open

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

Long-term effort on this project entails testing of the equipment; formulation of analytical proeedures, including sample preparation methods and qualitative and qnantitative analyses techniques; implementation of these procedures by developing softwarc and compiling and testing integrated programs; and finally, initiation of analysis production.

Upon completion of the project, a report on system capabilities and ou the utility of energy dispersive x-ray fluorescence for rock analysis will be published.



Newly developed fluorimetric selenium procedures are used to compare laboratory detection limits.

Automated Techniques and Methods Development

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

A project to develop automated techniques and laboratory methods has been initiated to provide new geochemical analytical capabilities, increase production capacities of existing procedures, and replace unreliable hardware with dependable equipment. Effort is being directed toward four discrete activity areas: design of an automated system to collect and collate geochemical analysis data; acquisition of an atomic absorption analyzer with microprocessor electronics and heated graphite accessory; development of semi-automated batch sample preparation methods; and, acquisition of certain capital equipment improvements which could significantly benefit the geochemical analysis facility.

Geochemical Relationship of Organic Matter and Uranium Deposits

Subcontractor:
DENVER RESEARCH INSTITUTE
Subcontract Value: $63,201
Start Date: 30 September 1976
Completion Date: 30 September 1977

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

This project is primarily a laboratory study of previously obtained and readily accessible samples, supplemented by a computer-assisted literature search of publications from non-ERDA sources. Effort is being concentrated on investigation of ehemical properties of organic matter associated with uranium deposits; determination of significant changes in chemical properties of organic-bearing rocks as a function of age; determination of plausible reaction mechanisms possibly involved in organic-associated uranium deposits; and, definition of the physical and chemical conditions which are most favorable for uranium deposition and remobilization in the presence of naturally occurring organic matter.

A detailed report will be placed on open file in late 1977.

Remote Sensing

The purpose of the Remote Sensing program is to investigate the possibility of using techniques for the interpretation of the remotely sensed data, such as that obtained from LANDSAT, with the objective of delineating favorable uranium districts.

Video Image Enhancement

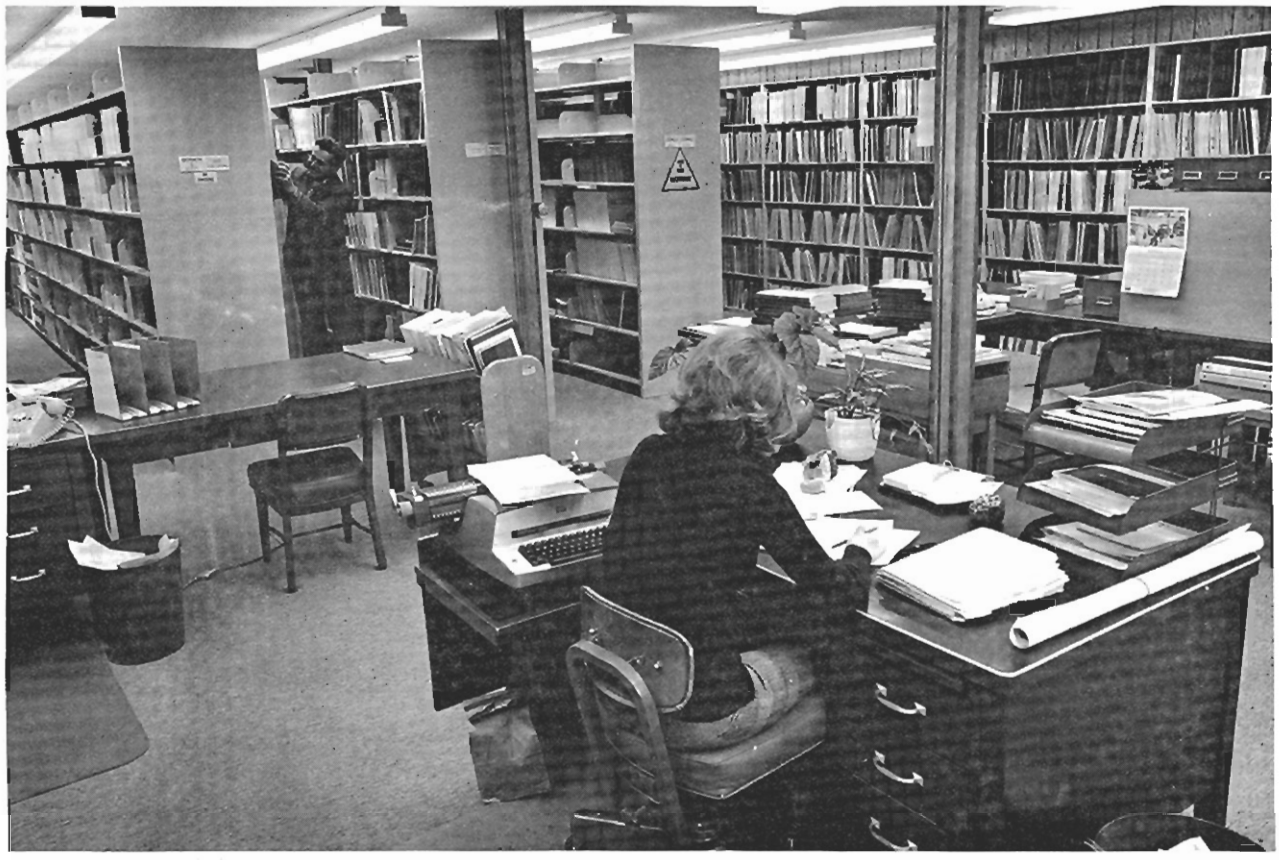
Subcontractor:
UNIVERSITY OF WYOMING
Subcontract Value: $70,762
Start Date: 1 April 1975
Completion Date: 30 September 1977

Under direct contract with ERDA, the University of Wyoming developed a video image enhancement/analysis system which provides image enhancement of a type and quality comparable to that of present digital systems. Video capabilities include: color separation, color addition and subtraction, contrast stretching, dark level adjustment, density analysis, edge enhancement, scale matching, image mixing, image ratioing, and construction of false-color composite images.

The video system has undergone extensive testing, comparison to other systems, and has been used successfully in practical applications ranging from analysis of x rays and thin seetions to production of color composite ratios of multispectral imagery. The equipment was tested in several areas of known uranium occurrences for its utility in field investigations.

In late 1976, Bendix initiated a follow-on contract under which the University of Wyoming is to provide instrument and personnel support so that technology transfer may be facilitated. Current effort is providing laboratory support, on an appointment basis, to work on ERDA-sponsored field problems.

A detailed report, GJBX-37(76), on the functional capabilities and operation of the video system was placed on open file in November 1976.



The GJO Technical Library is the central distribution point for all NURE-related reports.

NURE INFORMATION DISSEMINATION

A major objective of NURE is to provide industry with data and technology which could lead to increased activity in exploration and development of new uranium districts. Therefore, results of NURE-oriented activities described in previous sections are made public as soon as they become available, primarily through the publication of open-filed technical reports. Other methods of NURE information dissemination include ERDA-sponsored technical meetings, demonstrations of new hardware, the annual release of updated statistical data of the uranium industry, and the development of a NURE data bank.

Information activities during 1976 included the first in a planned series of technical symposia to describe ERDA-funded activities withing specific uranium-related technological areas, the annual Uranium Industry Seminar, open-filing and distribution of 66 NURE-related reports, issuance of 114 news releases, participation in community functions, and conducting tours of the Grand Junction facility.

Technical Meetings

Face-to-face dissemination of information is accomplished through technical symposia and seminars. These meetings not only reduce the lead times associated with the publication of printed material, but also provide the opportunity for an exchange of ideas between industry and ERDA/Bendix representatives concerning key issues in specific technical areas of interest.

In mid-September, Bendix conducted the Uranium Geophysical Technology Symposium to consider various aspects of aerial radiometric surveys, with emphasis on data acquisition, reduction, and interpretation; and to delineate current research and development efforts in airborne radiometrics, emanometry, and uranium measurement instrumentation. This three-day meeting attracted over 450 attendees representing 151 different organizations. Approximately 50 speakers from ERDA, Bendix, and NURE subcontractors presented papers on the national aerial radiometric survey and the most recent geophysical technology developments, and participated in panel discussions on exploration research and development needs. Summaries of the papers presented were handed out during the meetings; the full text and reprints of slides which accompanied the papers are being compiled and will be published as an ERDA open-filed report early in 1977. The symposium agenda is shown on page 68.

ERDA's 1976 Uranium Industry Seminar, held at Grand Junction on October 19 and 20, was attended by 547 people. During the seminar, ERDA staff members from the Grand Junction Office and ERDA headquarters, Washington, D.C., presented 14 papers on the current and probable future status of the uranium industry. In addition, a paper on uranium mill licensing activities was presented by a member of the staff of the Nuclear Regulatory Commission, Washington, D.C. Topics of discussion included nuclear fuel planning, uranium market activities and requirements, the NURE program, uranium reserves and exploration, uranium supply, regulatory considerations, and the foreign uranium situation. A report on the seminar, incorporating the papers presented, was open-filed in December as GJO-108(76). The seminar agenda is shown on page 69.

URANIUM GEOPHYSICAL TECHNOLOGY SYMPOSIUM

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
Grand Junction Office, Colorado

September 14, 15, 16, 1976

September 14

GENERAL SESSION

Welcome	ERDA Manager BFEC Manager
Uranium Technology Development: An Overview	C. Roach, ERDA
Airborne Radiometric Reconnaissance: The Why's and Wherefores	P. Dodd, ERDA
Geophysical Technology Development Program	P. Alexander, BFEC

AIRBORNE RADIOMETRIC RECONNAISSANCE

The Airborne Geophysical Reconnaissance Program	S. Mitchell, BFEC
Airborne Survey Requirements: Planes and Parameters	J. Nienaber, BFEC
Data Acquisition: High-Sensitivity Multichannel Spectrometer	J. Lindow, Geometrics
The Airborne System: Fixed-Wing Aircraft	J. Alliger, Texas Instruments (T.I.)
Rotary-Wing Aircraft	F. Navazio, LKB, Inc.
Radiometric Data Processing	M. Potts, T.I.
Radiometric Data Presentation	R. Foote, Geodata
Data Dissemination: The ERDA Open File Report	R. Falconer, BFEC
The ERDA Data Bank	F. Eckerson, ERDA
Post-Reconnaissance Survey Activities	W. Farley, BFEC
The Canadian Uranium Program: An Overview	K. Richardson, Geol. Survey of Canada (G.S.C.)
An Uranium Industry Viewpoint	L. Miller, Texasgulf
Panel Response to Industry Questions/Recommendations	P. Dodd, ERDA; R. Foote, Geodata; J. Nienaber, BFEC; M. Potts, T.I.

September15

The ERDA/BFEC Technology Development Program	P. Alexander, BFEC

AIRBORNE TECHNOLOGY DEVELOPMENT

Development of a Dynamic Test Range	R. Foote, Geodata
Development of Airport Test Pads	D. Ward, BFEC, and K. Kosanke, BFEC
Airborne Radiometric Calibration in Canada	R. Grasty, G.S.C.
Airborne Phoswich Gamma-Ray Detector	E. Schneid, Grumman Aerospace Corp.
Other Airborne Radiometric Detectors	P. Alexander, BFEC
Radiometric Data Analysis and Graphic Display	K. Zeigler, LASL
Optical Detection of U Decay Products in the Atmosphere	J. Solomon, Naval Undersea Center
MAZE Code for Airborne Data	J. Reed, Science Applications, Inc. (SAI)
Airborne Temperature Profiler	W. Malkmus, SAI
Aircraft Position Location	D. Lightbody, SysTech
ERDA/EG&G Airborne Measuring System (AMS)	J. Lackey, EG&G
Panel Discussion: Value of Airborne Radiometric Surveys and Technological Improvements	P. Dodd, ERDA; R. Foote, Geodata; R. Grasty, G.S.C.; K. Kosanke, BFEC; R. Pliler, Exxon; M. Potts, T.I.

EMANOMETRY TECHNOLOGY DEVELOPMENT

Emanometry Overview	J. Pacer, BFEC
$^4He/^3He$ Ratios	L. Bergquist, Martin Marietta Aerospace
$^4He/^{36}Ar$ Ratios	D. Schutz, Teledyne Isotopes
Radon Track Etch	J. Gingrich, Terradex
Panel Discussion: Emanometry As An Exploration Tool	R. DeVoto, Colo. School of Mines; H. Evans, BFEC; J. Gingrich, Terradex; D. Hansen, ScienTerra; J. Pacer, BFEC; R. Rodriguez, Wyoming Mineral Corp.

September 16

DIRECT U MEASUREMENT TECHNOLOGY DEVELOPMENT

Direct U Measurement Overview	J. Duray, BFEC
Direct Measurement of Uranium	P. Dodd, ERDA
Downhole 14-MeV DFN System	J. Reichardt, Kaman Sciences, Inc.
Downhole 14-MeV PFN System	H. Bivens, Sandia Labs.
Cf-252 Logging System	D. Steinman, IRT Corp.
Borehole Model Calculations	W. Woolson, SAI
Other Direct U Techniques	R. Wilson, BFEC
DFN U Assay Logging Using A Pulsed 14-MeV Neutron Source	R. Caldwell, Mobil Research Labs.
Panel Discussion: The Future of Direct U Measurement	H. Bivens, Sandia Labs.; R. Caldwell, Mobil; C. Collins, Rky Mtn. Energy J. Duray, BFEC J. Shreve, Jr., Kerr-McGee Corp.; D. Steinman, IRT Corp.

KUT TECHNOLOGY DEVELOPMENT AND NON-NUCLEAR METHODS

KUT and Non-Nuclear Overview	D. Emilia, BFEC
In-House KUT Projects	K. Kosanke, BFEC
Non-Nuclear Methods	D. Emilia, BFEC
Pulsed RF Techniques	R. Vickers, Stanford Research Institute
The Utility of Electric Logs In Uranium Exploration	J. Hallenburg, Century Geophysical Corp.
Log Measurements: Possibilities and Problems	H. Evans, BFEC
U.S.G.S. Non-Nuclear Geophysics R & D Projects	J. Scott, U.S.G.S.
Panel Discussion: What Kind of Tools Are Needed for U Exploration?	A. Atkinson, Birdwell; D. Emilia, BFEC; H. Evans, BFEC; J. Hallenburg, Century; J. Scott, U.S.G.S.
An Industry View of the Conference	S. Adams, Anaconda
Technology Development Wrap-Up and Conference Summary	P. Dodd, ERDA

URANIUM INDUSTRY SEMINAR

October 19 & 20, 1976 Two Rivers Plaza

Grand Junction, Colorado

Seminar Chairmen: E.W. Grutt, Jr. and Ben Bowyer

Tuesday, October 19

Introductory Remarks	E.W. Grutt, Jr.
NUCLEAR FUEL PLANNING	
Overview of the Nuclear Fuel Cycle	J.L. Schwennesen
Plans for Operation of ERDA Enrichment Plants	D.C. Thomas and J.W. Parks
URANIUM MARKET	
Uranium Market Activities	J.A. Patterson
Domestic and Foreign Uranium Requirements	E.J. Hanrahan
NATIONAL URANIUM RESOURCE EVALUATION	
Status and Progress of the NURE Program	R.C. Malan
Discussion of Preliminary NURE Report and Potential Resources	D.L. Hetlund
Uranium Geophysical Technology Development	C.H. Roach

Wednesday, October 20

URANIUM RESERVES AND EXPLORATION	
Uranium Ore Reserves	R.J. Meehan
Exploration Activities	W.L. Chenoweth
URANIUM SUPPLY	
Production Statistics	J.F. Facer, Jr.
Cost Model for Solution Mining of Uranium	J.N. Frank
Trends in Uranium Supply, Discovery Rates, and Costs	John Klemenic
REGULATORY CONSIDERATIONS	
NRC Uranium Mill Licensing Activities	John B. Martin
FOREIGN URANIUM SITUATION	
Foreign Uranium Developments	R.J. Wright

Almost 350 people attended the 1976 Uranium Industry Seminar.

Computerized Information

ERDA's Grand Junction Office has entered into a contractual agreement through the Oak Ridge Operations Office with Union Carbide Company - Nuclear Division, to establish an ERDA data bank in support of the NURE and any other operating programs assigned to Grand Junction. This data bank is to provide a permanent consolidated repository for technical information generated by those programs.

The large scale computer-oriented system being established is known as the Grand Junction Office Information System (GJOIS). Designed to maximize the use of existing hardware and software available to ERDA through its prime contractors, the system will permanently store NURE data, and can utilize procedures when developed for resource calculations, prediction models, data integration techniques, and favorability evaluations. The single major current goal is to facilitate the compilation and synthesis of NURE data in support of a comprehensive 1981 uranium resource assessment.

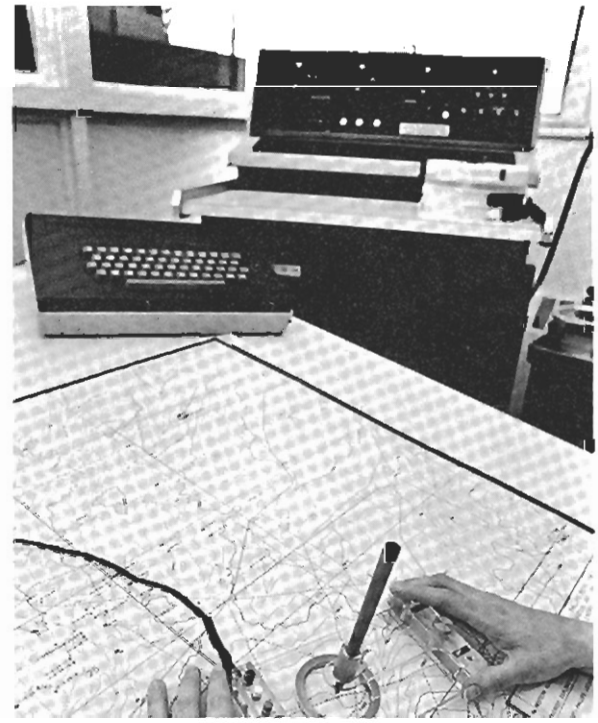
When GJOIS is operational, it will enable ERDA-GJO and Bendix to access certain data bases through a variety of computer terminals; other capabilities, such as computer-generated overlays of various types of data (e.g., hydrogeochemical and airborne), will be available at Oak Ridge.

Long-range plans are that interested users will be able to access the system through local computer terminals or to obtain printed copy from Oak Ridge. Specific details concerning user access to the ERDA data bank, and the types of information and data formats available, will be published when the system is operational.

Printed Material

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

Microfiche copies of GJO reports in the Bendix Library collection are available at nominal cost. Microfiche reports are at a 24:1 reduction; accompanying maps and oversize charts are on 35-mm film. Any individual or organization wishing to receive all future GJO open-file publications automatically may do so by establishing a deposit account with the Bendix Library in Grand Junction.



Geologic map positioning is accomplished using an electronic plotter.

Reports Issued in 1976

The identification numbers and titles of the reports placed on open file during 1976 by ERDA-GJO/Bendix are listed below.

GJBX-1(76) Uranium Favorability of Tertiary Sedimentary Rocks of the Lower Spokane Valley and of Northern Spokane County, Washington. (Lucius Pitkin, Inc. - LPI)

GJBX-2(76) Uranium Favorability of Tertiary Sedimentary Rocks of the Western Okanogan Highlands and of the Upper Columbia River Valley, Washington. (LPI)

GJBX-3(76) Uranium Favorability of Tertiary Sedimentary Rocks of the Pend Oreille River Valley, Washington. (LPI)

GJBX-4(76) Selected References on Alkalic Igneous Rocks of the United States.(ERDA)

GJBX-5(76) Hydrogeochemical and Stream Sediment Reconnaissance - Eastern United States, January - March 1975. (SRL)

GJBX-6(76) Hydrogeochemical and Stream Sediment Reconnaissance - Eastern United States, April - June 1975. (SRL)

GJBX-7(76) Hydrogeochemical and Stream Sediment Reconnaissance - Eastern United States, July - September 1975. (SRL)

GJBX-8(76) Hydrogeochemical and Stream Sediment Reconnaissance - Eastern United States, October - December 1975. (SRL)

GJBX-9(76) Raw Data from Orientation Studies in Crystalline Rock Areas of the Southeastern United States. (SRL)

GJBX-10(76) Hydrogeochemical and Stream Sediment Survey - Western United States, April - June 1975. (LASL)

GJBX-11(76) Survey of Lands Held for Uranium Exploration, Development and Production in Fourteen Western States, for six-month period ending December 31, 1975. (BFEC)

GJBX-12(76) A Survey and Critique of Quantitative Methods for the Appraisal of Mineral Resources. (Univ. of Arizona)

GJBX-13(76) Report on Airborne Radioactivity Surveys and the Uranium Deposits in the Red River Region of Texas and Oklahoma, 1955-1956. (AEC)

GJBX-14(76) Uranium Hydrogeochemical Survey (NURE) - Western States, July - September 1975.(LLL)

GJBX-15(76) Uranium Hydrogeochemical Survey (NURE) - Western States, October - December 1975. (LLL)

GJBX-16(76) Uranium Deposits of the Grants, New Mexico, Mineral Belt. (Univ. of New Mexico)

GJBX-17(76) Hydrogeochemical and Stream Sediment Reconnaissance - Eastern United States, January - March 1976. (SRL)

GJBX-18(76) Development of a Neutron Logging Tool for Uranium Exploration. (Kaman Sciences Corp.)

GJBX-19(76) Hydrogeochemical and Stream Sediment Survey of the National Uranium Resource Evaluation Program - Alaska, Montana, Wyoming, Colorado, and New Mexico, April - June 1975. (LASL)

GJBX-20(76) Summary of the Stratigraphy, Sedimentology, and Mineralogy of Pennsylvanian and Permian Rocks of Oklahoma in Relation to Uranium-Resource Potential. (Oklahoma State U.)

GJBX-21(76) Geology of the Fox Hills Formation (Late Cretaceous) in the Williston Basin of North Dakota, with Reference to Uranium Potential. (Univ. of North Dakota)

GJBX-22(76) The Stratigraphy and Environments of Deposition of the Cretaceous Hell Creek Formation (Reconnaissanee) and the Paleocene Ludlow Formation (Detailed), Southwestern North Dakota. (Univ. of North Dakota)

GJBX-23(76) Geology of the Cannonball Formation (Paleocene) in the Williston Basin, with Reference to Uranium Potential. (Univ. of North Dakota)

GJBX-24(76) Geology of the Upper Part of the Fort Union Group (Paleocene), Williston Basin. with Reference to Uranium. (Univ. of North Dakota)

GJBX-25(76) Hydrogeochemical and Stream Sediment Survey of the National Uranium Resource Evaluation Program, Alaska, Montana, Wyoming, Colorado, and New Mexico, July - September 1975. (LASL)

GJBX-26(76) Hydrogeoehemical and Stream Sediment Survey (NURE) - Western United States, January - March 1976. (LLL)

GJBX-27(76) Hydrogeochemical and Stream Sediment Reeonnaissance - Eastern United States, April - June 1976. (SRL)

GJBX-28(76) Geologieal Drainage Surveys for Uranium: Sampling and Analytical Methods Based on Trial Surveys in Pennsylvania. (Penn. State U.)

GJBX-29(76) Hydrogeoehemical and Stream Sediment Survey - Central United States, April - June 1975. (ORGDP)

GJBX-30(76) Hydrogeochemical and Stream Sediment Survey - Central United States, July - September 1975. (ORGDP)

GJBX-31(76) Hydrogeochemical and Stream Sediment Survey - Central United States, October - December 1975. (ORGDP)

GJBX-32(76) Hydrogeochemical and Stream Sediment Survey - Central United States, January - March 1976. (ORGDP)

GJBX-33(76) Aerial Radiometric and Magnetic Survey (Amarillo, Tucumcari, Clovis and Brownfield) National Topographic Map. (Geodata International)

GJBX-34(76) Aerial Radiometric and Magnetic Survey (Clinton, Oklahoma City, Lawton, Wiehita Falls) National Topographic Map. (Geodata International)

GJBX-35(76) Uranium Concentrations in Natural Waters, South Park, Colorado. (LASL)

GJBX-36(76) Hydrogeochemical and Stream Sediment Pilot Survey of Llano Area, Texas. (ORGDP)

GJBX-37(76) Rapid, Low-Cost Image Analysis through Video Procession. (Univ. of Wyoming)

GJBX-38(76) Hydrogeochemical and Stream Sediment Survey of the National Uranium Resource Evaluation Program, Alaska, Montana, Wyoming, Colorado and New Mexico, October - December 1975. (LASL)

GJBX-39(76) Hydrogeochemical and Stream Sediment Survey of the National Uranium Resource Evaluation Program, Alaska, Montana, Wyoming, Colorado and New Mexico, January - March 1976. (LASL)

GJBX-40(76) Hydrogeochemical and Stream Sediment Survey (NURE) - Preliminary Report of the Walker River Basin Study. (LLL)

GJBX-41(76) Hydrogeocheuical and Stream Sediment Survey (NURE) - Preliminary Report on the Winnemucca Dry Lake Basin Pilot Study. (LLL)

GJBX-42(76) Hydrogeochemical and Stream Sediment Survey (NURE) - Preliminary Report on the Smoke Creek Desert Basin Pilot Study. (LLL)

GJBX-43(76) Hydrogeochemical and Stream Sediment Survey (NURE) - Preliminary Report on the Cave Valley Basin Pilot Study. (LLL)

GJBX-44(76) Hydrogeochemical and Stream Sediment Survey (NURE) - Preliminary Report on the Roach Lake Basin Pilot Study. (LLL)

GJBX-45(76) Study of Low-Grade Uranium Resources of the Coso Formation, Owens Valley, California. (LPI)

GJBX-46(76) Hydrogeochemical and Stream Sediment Reconnaissance - Raw Data Release II; Orientation Studies in Alabama. (SRL)

GJBX-47(76) Savannah River Laboratory - NURE Hydrogeochemical Data Management System. (SRL)

GJBX-48(76) Uranium and Thorium Occurrences in Precambrian Rocks, Upper Peninsula of Michigan and Northern Wisconsin, with Thoughts on Other Possible Settings. (Michigan Tech. Univ.)

GJBX-49(76) Construction of the KUT Test Pits. (BFEC)

GJBX-50(76) Development of a Portable Radon Detection System. (BFEC)

GJBX-51(76) Chemical Analysis of Ground and Surface Water Samples from Parts of the United States, 1956-1975. (BFEC)

GJBX-52(76) Hydrogeochemical and Stream Sediment Reconnaissance Program in the Central United States, April - June 1976. (ORGDP)

GJBX-53(76) Hydrogeochemical and Stream Sediment Reconnaissanee - Raw Data Release III; Orientation Study in the Williamsport, Pennsylvania, Area. (SRL)

GJBX-54(76) Uranium Favorability of Tertiary Rocks in the Badger Flats - Elkhorn Thrust Area, Park and Teller Counties, Colorado. (BFEC)

GJBX-55(76) Uranium Favorability of Precambrian Rocks in the Badger Flats - Elkhorn Thrust Area, Park and Teller Counties, Colorado. (BFEC)

GJBX-56(76) Pedro Mountain Drilling Project, Carbon County, Wyoming. (BFEC)

GJBX-57(76) Uranium Favorability of Cenozoic Sedimentary Rocks of the Western Snake River Basin, Idaho. (BFEC)

GJBX-58(76) Uranium Favorability of the Fort Union and Wasatch Formations in the Northern Powder River Basin, Wyoming and Montana. (BFEC)

GJBX-59(76) Hydrogeochemical and Stream Sediment Survey of the National Uranium Resource Evaluation (NURE) Program - Western United States, April - June 1976. (LLL)

GJBX-60(76) Northwest Texas Pilot Geochemical Survey. (ORGDP)

GJBX-61(76) A Brief Review of the Basis for, and the Procedures Currently Utilized in, Gross Gamma-Ray Log Calibration. (BFEC)

GJBX-62(76) Uranium Potential in Precambrian Rocks in Minnesota. (Univ. of Minnesota)

GJBX-63(76) Hydrogeochemical and Stream Sediment Reconnaissance - Eastern United States, July - September 1976. (SRL)

GJBX-64(76) Hydrogeochemical and Stream Sediment Reconnaissance Program - Central United States, July- September 1976. (ORGDP)

GJBX-65(76) Hydrogeochemical and Stream Sediment Reconnaissance of the National Uranium Resource Evaluation Program, Alaska, Montana, Wyoming, Colorado and New Mexico, April - June 1976. (LASL)

GJBX-66(76) Hydrogeochemical and Stream Sediment Reconnaissance - Raw Data Release IV; Orientation Study in the Kings Mountain, North Carolina Area. (SRL)

GJO-100(76) Statistical Data of the Uranium Industry. (ERDA-GJO)

GJO-103(76) Uranium Exploration Expenditures in 1975 and Plans for 1976 and 1977. (ERDA-GJO)

GJO-108(76) Uranium Industry Seminar, October 19-20, 1976. (ERDA-GJO)

GJO-109(76) Survey of Lands Held for Uranium Exploration, Development and Production in Fourteen Western States in the Six-month Period Ending June 30, 1975. (BFEC)

GJO-110(76) A Subjective Probability of Uranium Resources in the State of New Mexico. (ERDA/Univ. of Arizona)

GJO-111(76) National Uranium Resource Evaluation, Preliminary Report, June 1976. (ERDA-GJO)

GJO-112(76) The Estimation of Uranium Resources by Life-Cycle or Discovery-Rate Models - A Critique. (Univ. of Arizona)

GJO-1640 Vein-Type Uranium Deposits. (Harvard University)

GJO-1642 Potential Uranium Host Rocks and Structures in the Central Great Plains. (Univ. of Kansas)

GJO-1661 Airborne Geophysical Survey of a Portion of New England; Lake Champlain, Glen Falls, Portland, Albany, Boston, Hartford, and Providence National Topographic Map Series Quadrangles. (Texas Instruments)

GJO-1663 Aerial Radiometric and Magnetic Survey (Greenville, Spartanburg, Florence, Athens, Augusta, Georgetown, and Savannah) National Topographic Maps. (Geodata International)

RME-1077 Economic Geology of Uranium Deposits in the Ralston Creek Area, Jefferson County, Colorado, January 15, 1957. (AEC)

RME-3032 A Sampling and Radiation Analysis of the Precambrian Rocks of Michigan, Minnesota, and Wisconsin, February 1953. (AEC)

RMO-984 Radioactive Mineral Deposits in Dickinson County, Michigan, August 1952. (AEC)

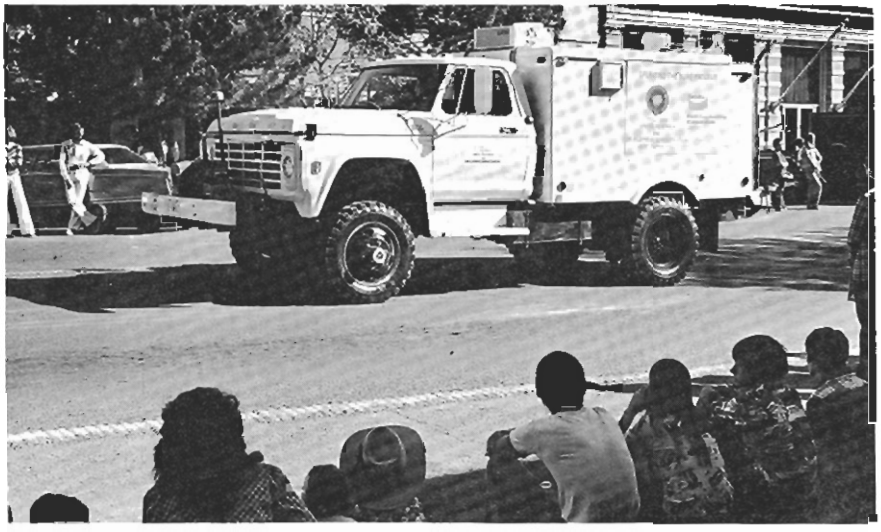
ERDA 76-46 Survey of United States Uranium Marketing Activity, April 1976. (ERDA)

Preliminary Map No. 21, An Electric Log Cross Section Showing the Lithology of the Wasatch and Fort Union Formations, Sheridan to Wyodak, Powder River Basin, Wyoming.

Preliminary Map No. 22, Distribution of Known Uranium Occurrences in New Mexico (two sheets).

Preliminary Map No. 23, Mine Location Map of the Carrizo Mountains Uranium Area, Apache County, Arizona, and San Juan County, New Mexico.

Preliminary Map No. 24, Nine Sheets of Electric Log Cross Sections Showing Lithology of Wasatch and Fort Union Formations, Powder River Basin, Wyoming.



ERDA and Bendix joined the community in celebrating the annual Mining and Petroleum Days in Grand Junction by participating in the parade and setting up a public display booth describing the NURE program.

BENDIX FIELD ENGINEERING CORPORATION

Bendix Field Engineering Corporation (BFEC) was selected by ERDA in June of 1975 to become the new on-site contractor in Grand Junction, Colorado, with responsibilities to conduct, under ERDA direction, the National Uranium Resource Evaluation effort. Bendix commeneed operation in Grand Junction in August of 1975.

The Grand Junction Operations of Bendix are organized into eight divisions comprised, at the end of 1976, of some 280 employees. NURE technical activities are the responsibility of the Project Management, Geology, aud Advanced Technology Divisions.