LA-7721-PR

Hydrogeochemical and Stream Sediment Reconnaissance of the National Uranium Resource Evaluation Program

Semiannual Progress Report
October 1978—March 1979

Primarily for the Rocky Mountain States of New Mexico, Colorado, Wyoming, and Montana and the State of Alaska

University of California

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Special Distribution
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by

Paul L. Aamodt, Merle E. Bunker,
Glenn A. Waller, and Ray A. Waller

ABSTRACT

During this six-month period, Hydrogeochemical and Stream Sediment Reconnaissance samples were collected by the Los Alamos Scientific Laboratory (LASL) from 623 locations in Colorado for a special study. Additional special studies are planned for nine other areas in the Rocky Mountain states in fiscal year 1979, plus some cleanup reconnaissance sampling in parts of four quadrangles that overlap state borders. Preparations for reconnaissance sampling of the entire North Slope region of Alaska have been made but sampling is contingent upon receiving supplemental funds.

Water samples from 6725 locations were analyzed for uranium by fluorometry or delayed-neutron counting (DNC). Water samples from 9390 locations were analyzed by emission spectroscopy for 12 other elements. Sediment samples from 14 414 locations were analyzed for uranium and 31 other elements by combined DNC and neutron activation analysis. Sediment samples from 9876 locations were analyzed for two additional elements by x-ray fluorescence.

Nine LASL reconnaissance reports, one pilot study data release, one supplemental multielement data release, a multielement data release for three areas in western Alaska, and one quarterly report were open filed by the Department of Energy, Grand Junction Office during the six-month period. Numerous other reports are in various stages of completion and several will be open filed in the near future.

I. INTRODUCTION

This semiannual report highlights the activities and progress of the Los Alamos Scientific Laboratory (LASL) from October 1978 through March 1979 in the Hydrogeochemical and Stream Sediment Reconnaissance (HSSR). The HSSR is sponsored by the Department of Energy (DOE) and managed through the DOE, Grand Junction Office (GJO), Colorado, as part of the National Uranium Resource Evaluation (NURE). The NURE is designed to provide information for estimating the nuclear fuel resources of the United States and to make available to industry information for developing and producing such resources. The LASL is responsible for conducting the HSSR primarily in the Rocky Mountain States of New Mexico, Colorado, Wyoming, and Montana and in the state of Alaska.

II. ACTIVITIES

Sample Collection

During this six-month period field work was limited to sampling four small areas in the northwestern corner of the Pueblo National Topographic Map Series (NTMS) quadrangle, Colorado. A total of 626 locations was sampled by members of the LASL Geochemical Applications Group in October 1978 and provided 62 water and 620 sediment samples. The samples were collected at a nominal density of one location per 0.65 km^2 for a detailed hydrogeochemical study of the four areas, as requested by the DOE GJO, Colorado. The DOE solicited proposals for additional detailed studies in the LASL region of responsibility, and several such proposals were submitted by the LASL during October and November. Of these, the following were deemed to be worthwhile.

- Detailed geochemical study for uranium mineralization in well waters from the Baca formation in a small area around Pie Town, New Mexico.
- Detailed hydrogeochemical survey to evaluate possible uranium mineralization of the Bozeman quadrangle, Montana.
- Investigation of HSSR sampling data in an area near Grants, New Mexico.

Additionally, the DOE Grand Junction Office asked the LASL to conduct detailed HSSR studies in the following geographical areas.

- Oscura Range -- South-central New Mexico
- Vallecito Creek Area -- Southwestern Colorado
- Sawatch Mountains -- Central Colorado
- Vernal/Dutch John Area -- Northeastern Utah
- Craig/Spring Creek Area -- Northwestern Colorado
- Southern Powder River Basin -- Northeastern Wyoming

The sampling for these special studies will be conducted during FY 79.

The HSSR sampling to complete four quadrangles that had been partially sampled by the LASL in previous years will be conducted in the St. Johns, Dubois, Elk City, and Hamilton quadrangles as shown in Fig. 1. Additional HSSR sampling in eight other partially sampled quadrangles is planned for FY 80 and they are also shown in Fig. 1.

Bid specifications, maps, and preliminary planning have been completed for sampling the North Slope area of Alaska, north of 68°N latitude as delineated in Fig. 2. Although preparations have been made to do this work, it can be undertaken only if supplemental funds are made available in time to complete the contracting process prior to the summer sampling season.

Sample Analysis

Fluorometry. During the six-month period, 6655 water samples were analyzed for uranium in the parts per billion (ppb) range by fluorometry. The recent automation of the system is working well, and it is now capable of analyzing over 40 000 samples per year.

Plasma-Source Emission Spectrography. Using an inductively coupled plasma source and a 3.4-m direct-reading spectrograph, 9390 water samples were analyzed for calcium, cobalt, chromium, copper, iron, magnesium, manganese, molybdenum, nickel, lead, titanium, and zinc, all in ppb.

Development of an automatic sample changer for the spectrograph is nearly complete and it has been run unattended successfully. The sample identification numbers are written into a computer program and automatically assigned to the appropriate analysis result as the samples are run. Those samples that require a filter for correct analysis are automatically removed from the data file and their identification numbers are printed separately so that they can run manually later. At the conclusion of an automated run the torch, auxiliary electrical equipment, as well as argon gas and cooling water supplies are automatically shut down and the computer goes to standby status.

There remain a few problems with the automated system; they are being investigated and should be resolved soon. One of the biggest problems has been to ensure the correct sample number is assigned to each set of results. Extensive rechecking of samples has been necessary to verify results and identify irregularities. Improvements in programming and operational techniques have been made and the amount of rechecking to verify results has been greatly reduced.

Work is underway on the construction and installation of a device to automatically insert the filter when needed in each sample analysis cycle. Modifications to the computer program are planned that will allow it to analyze samples requiring a filter in the automatic mode.

Arc-Source Emission Spectrography. Altogether, 9876 sediment samples were analyzed for beryllium and lithium in the part per million (ppm) range by arc-source emission spectrography during this report period. A change was made in the analysis procedure to correct problems caused by samples rapidly expanding and occasionally even ejecting from the electrode crater. Previously, the samples were arced for 45 s with 17 A across the electrodes. By changing to 6 A for the first 10 s and then to 17 A for 50 s, the sample has a chance to stabilize; even though the total arc time is increased, both the reliability and the precision of the method are improved.

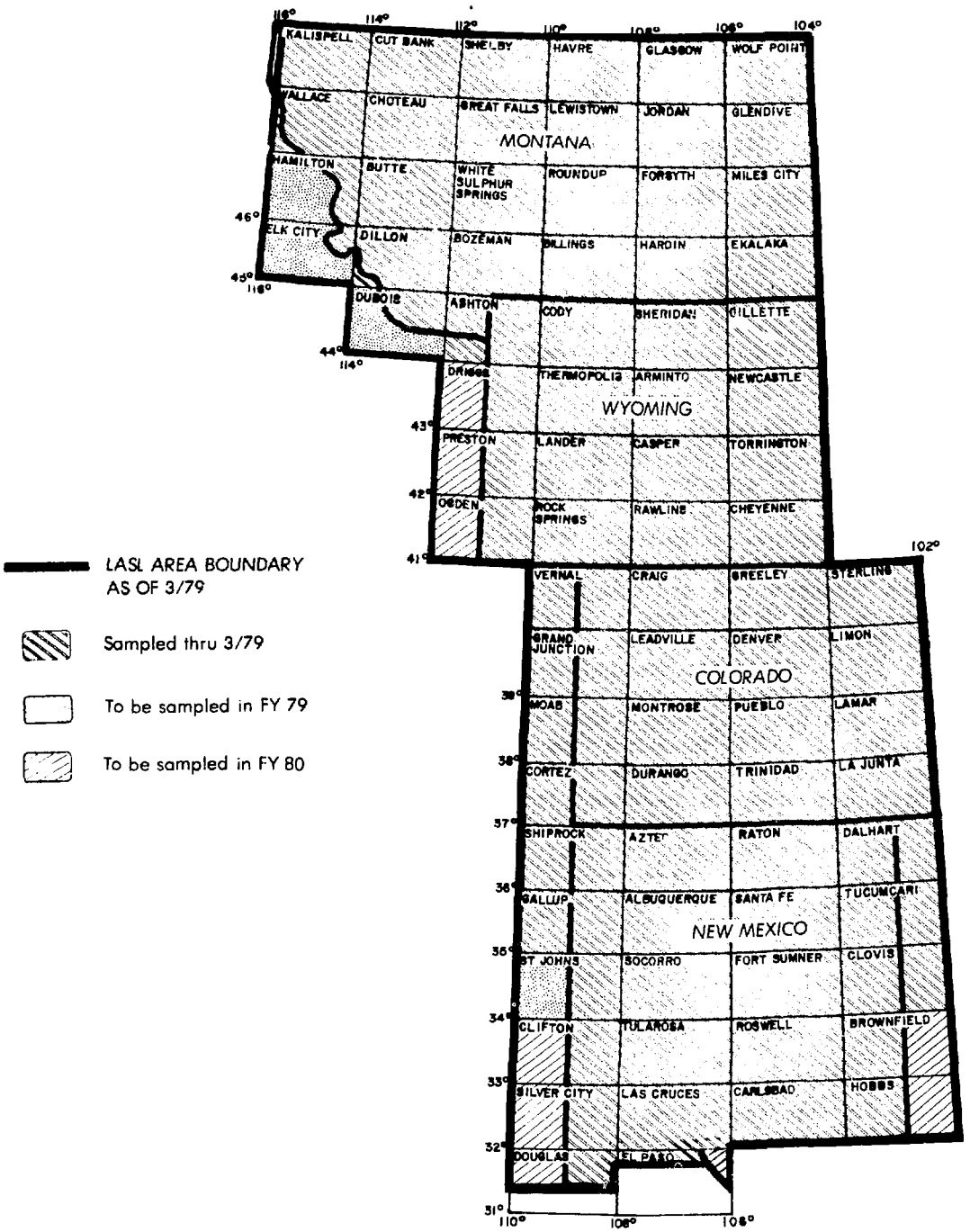

Fig. 1. Status of LASL HSSR sampling in the conterminous Rocky Mountain states as of March 31, 1979.

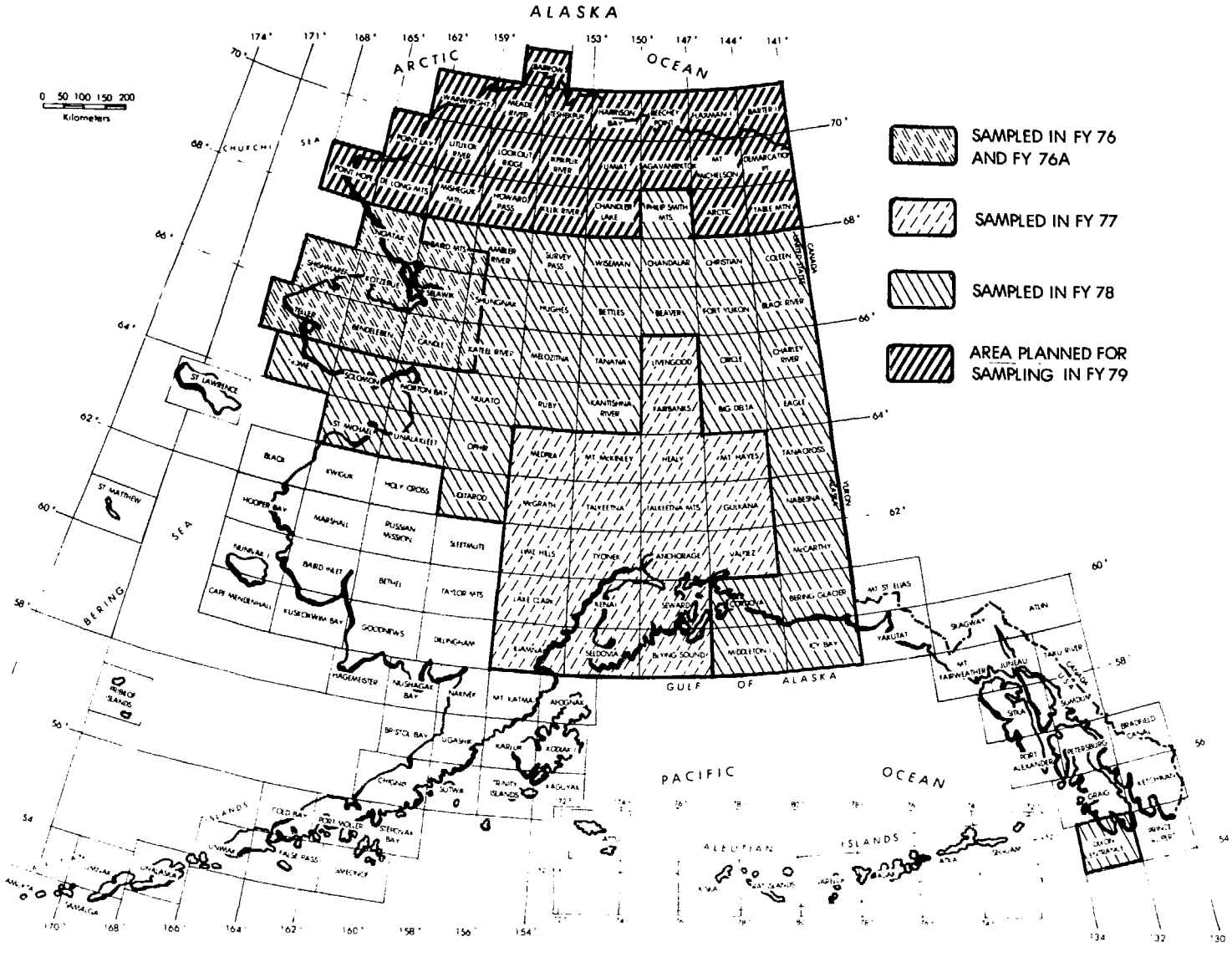

Fig. 2. Status of LASL HSSR sampling in Alaska as of March 31, 1979.

Advanced Multisource Direct-Reading Emission Spectrograph. Construction of the large, dual, direct-reading spectrograph for analyses of liquids and solids is continuing. This spectrograph will determine all metallic elements and possibly some nonmetallic ones with most detection limits in the ppb range.

The new spectrograph consists of a plasma source for liquids with an associated optical system designed to take the light from the top of the plasma on the liquid side and either an arc source or laser-induced plasma source for solids with a 1200 grooves/mm holographic grating optical system on the other side. Tests made on the liquid side have shown that the detection limits in waters for lead and copper are 70 ppb and 3 ppb, respectively. These values are significantly lower than the detection limits achieved using the current system, which are 200 ppb for lead and 4 ppb for copper. Additional testing of the liquid side is planned, specifically to determine if the dynamic range of light spectra taken solely from the top of the plasma is adequate for all elements. A strip chart recorder is being used to record the test results, but a computer system is being readied and will be operational within a few weeks.

On the side of the spectrograph where solids will be analyzed, refinements to the optical system are being made. A temperature regulator has been added that allows independent control of the temperatures of the holographic grating and the vertical mounting plate. With this control, both components can be maintained in-balance a few degrees above room temperature.

The laser-ICP source used for the initial testing does not have the required power and the exact power conditions needed are not yet known. Additional experiments with the existing laser or a borrowed one are planned for the near future, since this method appears to be superior for the analysis of all types of powder samples.

X-Ray Fluorescence. A computer-controlled, energy dispersive, automated x-ray fluorescence method is routinely used to determine the concentrations in ppm of nickel, copper, tungsten, lead, bismuth, niobium, silver, cadmium, and tin in sediments. The samples are ground in a Spex shatterbox to produce a powder, 90% of which will pass a 325-mesh sieve. Twenty such samples can be loaded and automatically analyzed on each of two systems presently available. During the report period 12 400 samples were analyzed with the two x-ray fluorescence systems.

Delayed-Neutron Counting. During this six-month report period, 70 water samples found by fluorometry to have more than 40 ppb uranium or to exhibit interference problems were analyzed for uranium by delayed-neutron counting (DNC). The data were acquired and processed with an LSI-11 microcomputer system.

The accuracy and linearity of the sediment DNC system has been tested using several standards certified by other laboratories. Original calibration of the LASL DNC system was based on analysis of National Bureau of Standards Reference Material SRM-1633, certified to contain 11.6 $\pm$ 0.2 ppm uranium. New standards were run "blind" along with routine HSSR samples over a period of several weeks, and typical results are given in Table I.

Neutron Activation Analysis. Some 14 414 sediment samples were analyzed for uranium and 31 other elements during this six-month period, using the neutron activation analysis system. All of the data were processed with

TABLE I

TYPICAL DNC RESULTS OF CERTIFIED STANDARDS

Reference Material	No. of Analyses	LASL DNC (ppm)	Certified Value (ppm)	LASL/Certified Ratio
CRM[a]:DL-1	48	41 ± 2	41	1.00
CRM:BL-1	21	222 ± 3	220	1.01
CRM:BL-4	3	1700 ± 100	1730	0.98
IAEA[b]:S-4	3	3100 ± 20	3180	0.97

[a] Canadian Certified Reference Material.
[b] International Atomic Energy Agency Reference Material.

a PDP-11/60 computer at the analytical facility prior to being transmitted to the main HSSR data base computer.

Installation of a second complete analytical system, including one DNC counter and four Ge(Li) detectors, is underway. Most of the necessary components have been delivered, the required pneumatic sample transfer facilities have been constructed, and the associated computer facilities will soon be operational. Once the second system is working, data acquisition for both systems will be independently controlled by a PDP-11/34 computer with final data analysis completed by a PDP-11/60 computer. The two computers are being set up so either one can function as the data acquisition computer in the event of hardware failures.

The reliability of the existing pneumatic system has been improved through modifications of the delay-loader sample changer and sample clips for the automatic loader. Also, the photo detectors that sense the position of the samples in the pneumatic lines have been modified to improve their stability and reliability.

Data Management

During this period approximately 28 000 field data forms were keypunched and loaded into 19 data bases. All existing data bases were redefined to accept multielement results for both water and sediment samples. Codes were written to load the multielement results and to produce the desired output for inclusion in LASL reports. Additional codes have been developed to check the validity of the field and analytical data and to make changes when necessary. Refinements to existing codes used to make graphical output such as histograms and concentration plots continue to be made so that they can be used in the reports with only minimum modification.

Reporting

Nine LASL HSSR reports were open filed by the DOE GJO during the six-month period; each is summarized in the appendix. These reports cover quadrangles in the Rocky Mountain states (Fig. 3) and in Alaska (Fig. 4) and provide uranium and, in some cases, multielement analyses of water and sediment samples along with field data recorded at each sample location. Other

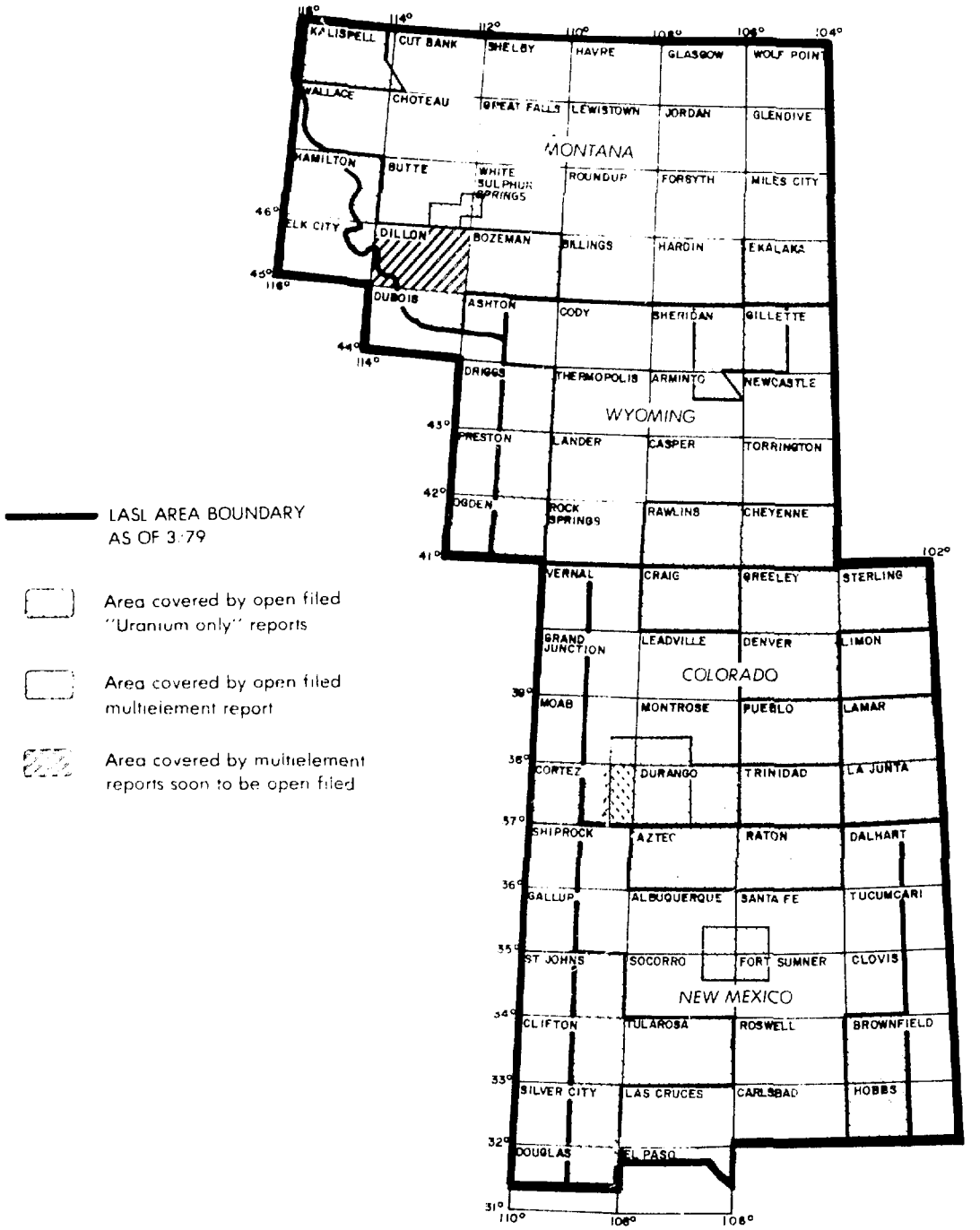

Fig. 3. Status of LASL HSSR reports for the conterminous Rocky Mountain states as of March 31, 1979.

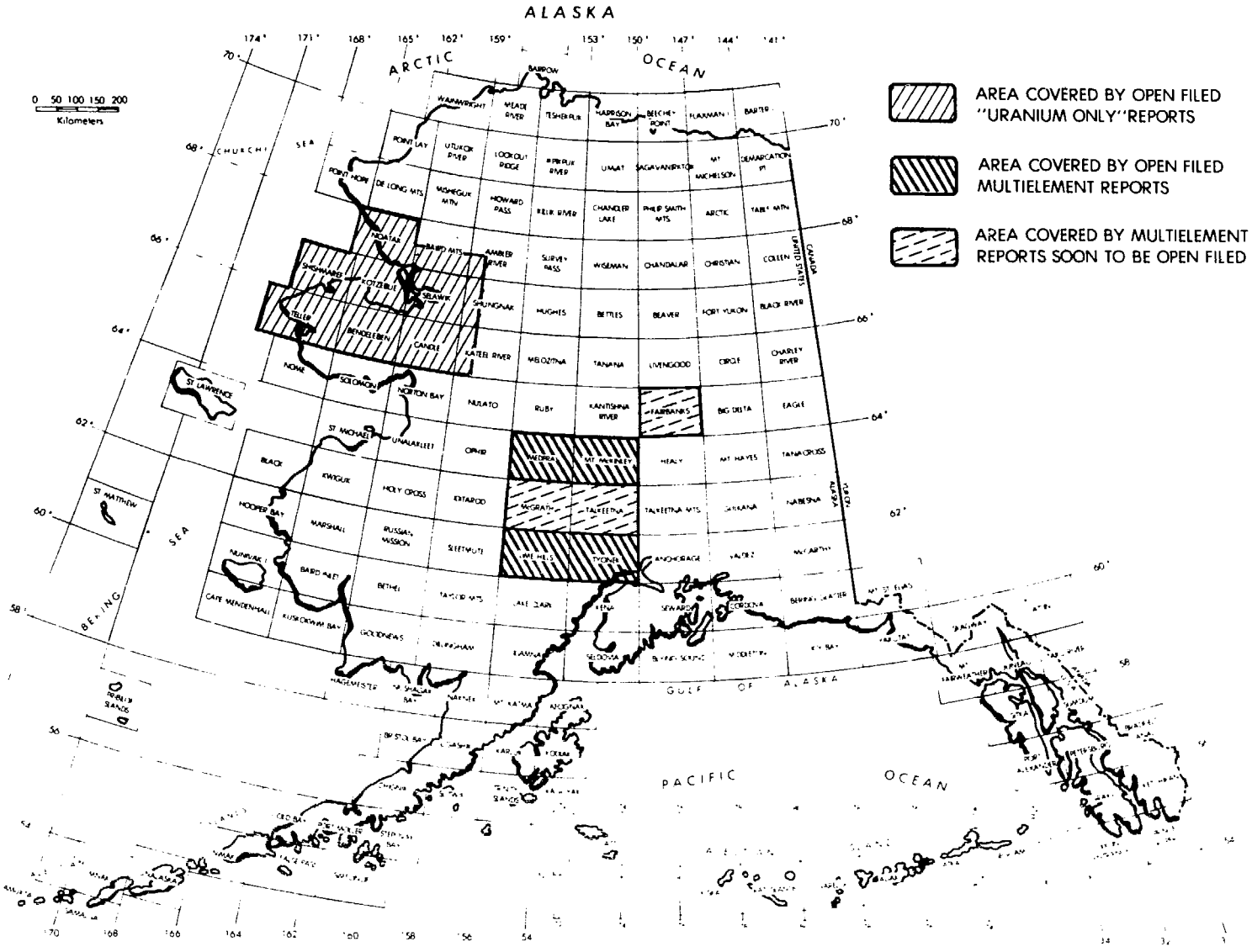

Fig 4. Status of LASL HSSR reports for Alaska as of March 31, 1979.

reports open filed during this period include a data release for a pilot study conducted by investigators from the University of Colorado in two small areas in the Sterling and Greeley quadrangles, Colorado; a report of multielement results for samples collected in three areas of western Alaska; and a quarterly progress report for the January-March 1978 period. Numerous other reports are in various stages of completion and, as indicated in Figs. 3 and 4, several will be open filed in the near future.

The field and elemental data for each of the open-filed LASL HSSR reports are available on magnetic tape from: GJOIS Project, Union Carbide Corporation National Depository (UCC-ND), Computer Applications Department, 4500 North Building, Oak Ridge National Laboratory, P. O. Box X, Oak Ridge, Tennessee 37830.

APPENDIX

ANNOTATED BIBLIOGRAPHY OF LASL HSSR REPORTS OPEN FILED BY THE US DEPARTMENT OF ENERGY, GRAND JUNCTION OFFICE, COLORADO, BETWEEN OCTOBER 1, 1978, AND MARCH 31, 1979

Bolivar, S. L., 1978, Uranium hydrogeochemical and stream sediment reconnaissance of the Aztec NTMS quadrangle, New Mexico, GJBX-129(78), 75 p.

Totals of 338 water and 1744 sediment samples were collected from 1876 locations over a 20 200-km^2 area at a nominal density of one location per 10 km^2. The uranium concentrations in waters collected in the Aztec quadrangle range from below the detection limit of 0.2 ppb to 67.3 ppb. Lack of available surface waters and the uneven distribution of wells made interpretation of water data difficult. One small cluster of three water samples containing anomalous uranium concentrations is noted about 50 km north of Cuba in drainages that cut the San Jose formation. Several individual water samples with anomalous uranium concentrations are associated with fault zones. Sediments have uranium concentrations that range between 0.3 ppm and 30 ppm. Most anomalous sediment samples were collected from areas underlain by either the Nacimiento or San Jose formations in the San Juan basin. Northwest of Cuba, a small cluster of sediment samples with anomalous uranium concentrations occurs near several known uranium deposits.

Bolivar, S. L., 1978, Uranium hydrogeochemical and stream sediment reconnaissance of the Bozeman NTMS quadrangle, Montana, GJBX-8(79), 98 p.

Totals of 1251 water and 1536 sediment samples were collected from 1586 locations over a 17 400-km^2 area. The uranium concentrations in waters range from below the detection limit of 0.20 ppb to 41.35 ppb, with a mean concentration of 1.17 ppb. The uranium concentrations in sediments range from 0.90 ppm to 94.30 ppm, with a mean concentration of 3.71 ppm. Arbitrary anomaly thresholds of nominally two standard deviations above the mean were chosen for both water and sediment sample populations. Waters with anomalous uranium concentrations were found in tributaries of the Boulder River, which drain Precambrian rocks in the Beartooth Mountains, and in tributaries of the Three Forks basin, which are underlain predominantly by Tertiary-Quaternary sediments. Areas appearing favorable for future exploration are in the Three Forks basin, a district about 20 km due west of Three Forks, tributaries of the Boulder River in the Beartooth Mountains, the northern part of the Madison Range, and the Tobacco Root Mountains just north of Virginia City.

Dawson, H. E., and Weaver, T. A., 1979, Uranium hydrogeochemical and stream sediment reconnaissance of the Durango NTMS quadrangle, Colorado, GJBX-10(79), 107 p.

During the spring and summer of 1976, 1518 water and 1604 waterborne sediment samples were collected from 1804 locations in the Durango NTMS quadrangle, Colorado. Uranium concentrations in waters ranged from less than the detectable limit of 0.2 ppb to 25.7 ppb, with a mean value of 0.84 ppb.

The concentrations in sediments ranged from 1.0 ppm to 71.6 ppm, with a mean value of 4.2 ppm. Thirty-four water samples (approximately 2.2% of the total water population) had uranium concentrations above 5.0 ppb, the highest of which were well water samples from the San Luis Valley. Thirty-seven sediment samples (approximately 2.3% of the total sediment population) had uranium concentrations above 12.0 ppm. The majority of these were taken from sites in Precambrian rocks, but several came from Paleozoic and Mesozoic strata and Tertiary volcanics. The uranium concentrations in sediment samples from areas of Precambrian rock were especially high and these areas may warrant further, more detailed investigations.

Jacobsen, S. I., Aamodt, P. L., and Sharp, R. R., Jr., 1979, Uranium hydrogeochemical and stream sediment reconnaissance of the Lime Hills and Tyonek NTMS quadrangles, Alaska, including concentrations of forty-three additional elements, GJBX-29(79), 224 p.

Water and sediment samples were collected from 1250 streams and small lakes at a nominal density of one each per 23 km^2 over the combined 35 750-km^2 area. The water samples were analyzed for uranium and 12 additional elements, while the sediment samples were analyzed for uranium and 42 other elements. All data are presented in this report, but only uranium and thorium are specifically addressed. The uranium contents of the 671 waters from the Lime Hills quadrangle range from below the detection limit of 0.02 ppb to a high of 11.29 ppb. Uranium contents of the 667 sediments from this quadrangle range from a low of 0.1 ppm to a high of 94.9 ppm. Both waters and sediments containing relatively high uranium concentrations are found to cluster in association with plutonic rocks in the Alaska Range, and particularly so in the vicinity of the Tired Pup batholith and Mount Estelle pluton. The uranium contents of 575 waters from the Tyonek quadrangle range from below the detection limit to 13.13 ppb. Relatively high uranium concentrations in waters were found to cluster near the Mount Estelle pluton and undifferenitated igneous, metasedimentary, and volcanic rocks in the Alaska Range and in Pleistocene deposits along the Castle Mountain fault. Uranium contents in 502 sediments from the Tyonek quadrangle range from 0.1 ppm to 58 ppm. Sediment samples having high uranium concentrations are from locations near the Mount Estelle pluton and Styx River batholith in the Alaska Range. The HSSR results correlate well with the NURE airborne radiometric surveys of the two quadrangles, particularly so in the Alaska Range.

Morgan, T. L., and Broxton, D. E., 1978, Uranium hydrogeochemical and stream sediment reconnaissance of the Raton NTMS quadrangle, New Mexico, GJBX-138(78), 84 p.

Totals of 824 water and 1340 sediment samples were collected from 1844 sample locations in the Raton NTMS quadrangle. Notably high uranium values were found in both water and sediment samples collected from tributaries of Costilla Creek in the Culebra Range. Numerous groups of ground waters with high uranium concentrations come from locations along the Cimarron and Sierra Grande Arches in the eastern part of the quadrangle. The Cimarron Arch is the locus of the largest group of uraniferous ground waters, with concentrations ranging between 5.2 and 103.3 ppb. Stream sediment samples with high uranium concentrations (10.1 to 51.4 ppm) were found in several drainages from the

western front of the Taos Range. One group of locations providing high uranium sediments is near a known uranium occurrence in the vicinity of Cabresto and Latir Peaks.

Morris, W. A., LaDelfe, C. M., and Weaver, T. A., 1978, Uranium hydrogeochemical and stream sediment reconnaissance of the Trinidad NTMS quadrangle, Colorado, GJBX-139(78), 79 p.

During 1976 and 1977, 1060 natural water and 1240 waterborne sediment samples were collected from 1768 locations in the Trinidad NTMS quadrangle, Colorado. The uranium concentrations in waters ranged from less than the detection limit of 0.02 ppb to 88.3 ppb, with a mean value of 4.05 ppb. The concentrations in sediments ranged from 1.3 ppm to 721.9 ppm, with a mean value of 5.55 ppm. Anomaly thresholds based on simple statistical analyses were set at 20 ppb for water samples and 12 ppm for sediment samples. At least five areas delineated by the data appear to warrant more detailed investigations. Twenty-six anomalous water samples outline a broad area corresponding to the axis of the Apishapa uplift, seven form a cluster in Huerfano Park, and five outline a small area in the northern part of the San Luis Valley. Twenty-three anomalous sediment samples outline an area corresponding generally to Precambrian metamorphic rocks in the Culebra Range, and seven anomalous sediment samples form a cluster near Crestone Peak in the Sangre de Cristo Mountains.

Nunes, H. P., 1978, NURE Hydrogeochemical and stream sediment data release for pilot study samples from portions of the Sterling and Greeley NTMS quadrangles, Colorado, GJBX-140(78), 105 p.

During four distinct time periods between December 1976 and August 1977, samples were collected from two study areas to determine the effect of seasonal variations upon the elemental concentrations, particularly uranium, in the samples. Totals of 529 water samples and 267 sediment samples were taken from 264 locations. Uranium and other elemental concentrations were determined at the LASL using standard analytical procedures. Analytical data for alkalinity, calcium, chloride, iron, magnesium, nitrate, nitrite, phosphate, and total hardness are also presented. This report is a data release, intended to make the data available to the University of Colorado, DOE, and the public as quickly as possible, and no discussion of the geology, uranium occurrences, or data is included. An evaluation of the data to be prepared by the University of Colorado will be reported through the DOE Grand Junction Office at a later date.

Shannon, S. S., Jr., 1978, Uranium Hydrogeochemical and stream sediment reconnaissance of the Pueblo NTMS quadrangle, Colorado, GJBX-135(78), 77 p.

Totals of 861 water and 1060 sediment samples were collected from 1402 locations at a nominal density of one sample location per 10 km^2 over a 19 700-km^2 area. For water samples, an arbitrary anomaly threshold of 36 ppb was chosen. The major clusters of anomalous water samples are from

locations in Quaternary sediments, the Pierre shale, and the Niobrara formation in the Arkansas River valley and in faulted Precambrian granodiorite along Fernleaf Gulch near Cotopaxi. For sediment samples, the arbitrary anomaly threshold is 25 ppm uranium. Most anomalous sediment samples were collected in areas of the Front Range underlain by Precambrian igneous rocks, specifically the Pikes Peak granite, the Cripple Creek quartz monzonite, and the Boulder Creek granodiorite. Most anomalous sample locations are associated with fault zones and known uranium occurrences.

Shannon, S. S., Jr., 1978, Uranium hydrogeochemical and stream sediment reconnaissance of the Pueblo NTMS quadrangle, Colorado, including concentrations of forty-three additional elements, GJBX-14(79), 141 p.

This report is a supplement to the HSSR uranium evaluation report for the Pueblo NTMS quadrangle, Colorado, which presented the field and uranium data for the 861 water and 1060 sediment samples collected from 1402 locations in the quadrangle. This supplement presents the results of multielement analyses of those HSSR samples. In addition to uranium, the concentrations of 12 elements are presented for the waters and 42 elements for the sediments. No evaluation of the multielement data is presented.

Sharp, R. R., Jr., 1978, Results of elemental analyses of water and waterborne sediment samples from areas of Alaska proposed for the Chukchi Imuruk National Reserve, Selawik National Wildlife Refuge, and Cape Krusenstern National Monument, GJBX-26(79), 155 p.

During July-August 1976, waters and sediments were collected from streams and lakes over an area of 100 000 km^2 around Kotzebue, Alaska. The approximate 10 900-km^2 proposed for the Chukchi Imuruk National Reserve, the approximate 5640-km^2 area proposed for the Selawik National Wildlife Refuge, and the 1400- to 1900-km^2 area proposed for the Cape Krusenstern National Monument were included in the sampling area. This work, done with funds from the US Bureau of Mines, Anchorage, provides multielement results for 949 waters and 886 sediments from 979 locations. Of these, 492 waters and 452 sediments are from 517 locations in the proposed Chukchi Imuruk Reserve; 447 waters and 423 sediments are from 451 locations in the proposed Selawik Wildlife Refuge; and 10 waters and 11 sediments are from 11 locations in the proposed Cape Krusenstern Monument. The field data, with concentrations of 13 elements in the waters and 43 in the sediments, are presented in appendixes.

Van Eeckhout, E. M., Warren, R. G., and Hill, D. E., 1979, Uranium hydrogeochemical and stream sediment reconnaissance of the Medfra and Mt. McKinley NTMS quadrangles, Alaska, including concentrations of forty-three additional elements, GJBX-30(79), 210 p.

During the summer of 1977, 1278 water and 1216 sediment samples were collected from 1300 streams and small lakes within the 33 400-km^2 area defined by the Medfra and Mt. McKinley NTMS quadrangles in central Alaska. Each water sample was analyzed for 13 elements, including uranium, and each sediment sample was analyzed for 43 elements, including uranium and thorium.

Uranium values in water samples from the combined Medfra and Mt. McKinley quadrangles range from below the detection limit of 0.02 ppb to 8.11 ppb, with a mean of 0.31 ppb. Relatively high uranium concentrations in water are associated with four reconnaissance airborne radiometric anomalies reported for the Mt. McKinley quadrangle. Uranium values in sediment samples range from 0.35 ppm to 33.32 ppm, with a mean of 2.89 ppm. Three areas of high uranium concentrations in sediment are granitic rocks of the Sunshine Hills, Paleozoic metamorphic rocks marginal to the Kantishna Hills mining district, and exposures of the Mt. Foraker granodiorite in the Alaska Range.

Weaver, T. A., Bunker, M. E., and Hansel, J. M., Jr., 1978, Hydrogeochemical and stream sediment reconnaissance of the National Uranium Resource Evaluation program, January-March 1978, Rocky Mountain states of New Mexico, Colorado, Wyoming, and Montana and the state of Alaska, GJBX-136(78), 28 p.

To date, approximately 57% of the total area assigned to the LASL in the Rocky Mountain region and Alaska has been sampled and plans are well underway to sample an additional 28% during FY 78. Contracts have been let to complete the sampling of the LASL area in the lower states and bids to sample an additional 33% of Alaska are being evaluated. Numerous reports and data releases are being prepared for open filing. By the end of the quarter, all multi-element analysis systems were operational. Water samples from 7780 locations and sediment samples from 4170 locations were analyzed for uranium. Samples from approximately 6500 locations were analyzed by one or more of the multi-element methods.

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