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ELKO 1° x 2° NTMS AREA NEVADA AND UTAH

MASTER

DATA REPORT

NATIONAL URANIUM RESOURCE EVALUATION PROGRAM

HYDROGEOCHEMICAL AND STREAM SEDIMENT RECONNAISSANCE

W. M. FAY

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ABSTRACT

This data report presents results of ground water and surface sediment reconnaissance in the National Topographic Map Series (NTMS) Elko 1° x 2° quadrangle. The target sampling density was one site per 12 square kilometers. This resulted in 1713 sediment samples being collected; however, dry conditions and sparse population contributed to the relatively small number of ground water (154 samples) collected. Neutron activation analysis (NAA) results are given for uranium and 16 other elements in sediments, and for uranium and 9 other elements in ground water. Mass spectrometry results are given for helium in ground water. Field measurements and observations are reported for each site. Analytical data and field measurements are presented in tables and maps. Statistical summaries of data and a brief description of results are given. A generalized geologic map and a summary of the geology of the area are included.

Data from ground water sites (on microfiche in pocket) include (1) water chemistry measurements (pH, conductivity, and alkalinity), (2) physical measurements where applicable (water temperature, well description, and scintillometer reading), and (3) elemental analyses (U, Al, Br, Cl, Dy, F, He, Mg, Mn, Na, and V).

Data from sediment sites (also on microfiche in pocket) include (1) stream water chemistry measurements (where available) for pH, conductivity, and alkalinity, and (2) elemental analyses (U, Th, Hf, Al, Ce, Dy, Eu, Fe, La, Lu, Mn, Sc, Sm, Na, Ti, V, and Yb). Sample site descriptors (coordinates, vegetation, etc.) are also tabulated. Areal distribution maps, histograms, and cumulative frequency plots for most elements, U/Th and U/Hf ratios, and scintillometer readings for sediment samples are included on the microfiche.

CONTENTS

Introduction	7
Geologic Summary and Mineral Occurrences	10
Hydrology	23
Factors Affecting the Data	27
Quality Assurance	27
Description of Data Tables	27
Results and Discussion of the Data	35
Acknowledgments	40
References	41

LIST OF FIGURES

- 1 Location Map for the Elko 1° x 2° NTMS Quadrangle 9
- 2 Location of the Elko Quadrangle on a Physiographic Province Map 11
- 3 SRL Field Data Form for Western Quadrangles 28

LIST OF TABLES

- 1 Summary of Tertiary Igneous Events in the Elko Quadrangle 14
- 2 Radiometric Ages of Rocks in the Elko 1° x 2° NTMS Quadrangle 15
- 3 Precipitation Totals for 1979 at Selected Weather Stations in the Elko Quadrangle 24
- 4 Accuracy and Precision of Analyses of SRL Sediment Standards 29
- 5 Statistical Summary of Elemental Analyses - Sediment; Elko 36
- 6 Statistical Summary of Field Measurements and Elemental Analyses - Ground Water; Elko 39

MAPS

(On Microfiche)

- PLATE 1A Geologic Map of the Elko Quadrangle
- PLATE 1B Mineral Resources in the Elko Quadrangle
- PLATE 2 Ground Water Sample Site Locations in the Elko Quadrangle
- PLATE 3 Sediment Sample Site Locations in the Elko Quadrangle
- PLATE 4 Uranium Distribution in Surface Sediments of the Elko Quadrangle
- PLATE 5 Thorium Distribution in Surface Sediments of the Elko Quadrangle
- PLATE 6 Uranium Distribution in Ground Waters of the Elko Quadrangle
- PLATE 7 Conductivity Distribution in Ground Waters of the Elko Quadrangle

ELKO TABLES

Tabulated reconnaissance data and elemental concentrations in surface sediment samples and ground water samples (Tables A and B).

ELKO PLOTS

Areal distribution maps, histograms, and cumulative frequency plots for elemental U, Th, Hf, La, Ce, Sm, Eu, Dy, Yb, Lu, Al, V, Ti, Mn, Fe, Sc, Na; U/Th and U/Hf ratios; and scintillometer readings for sediments.

ELKO GROUND-WATER PLOTS

Areal distribution maps, histograms, and frequency distribution plots for U, F, Na, Mg, Al, Cl, Mn, Br, Dy, V, conductivity, alkalinity, pH, $U \times 1000/\text{conductivity}$, He, and scintillometer readings for ground water samples.

USER'S GUIDE

INTRODUCTION

The National Uranium Resource Evaluation (NURE) program was established to evaluate domestic uranium resources in the continental United States and to identify areas favorable for uranium exploration. The Grand Junction Office (GJO) of the Department of Energy (DOE) is responsible for administering and coordinating NURE program efforts. The Savannah River Laboratory (SRL) has responsibility for hydrogeochemical and stream/surface sediment reconnaissance (HSSR) of 3.9 million square kilometers (1,500,000 square miles) in 37 eastern and western states. Other DOE laboratories are responsible for similar reconnaissance in the rest of the continental United States, including Alaska. The significance of the distribution of uranium in natural waters and sediments will be assessed as an indicator of areas favorable for the location of uranium deposits.

The principal objectives of the NURE program are:

- Increase geologic knowledge of U.S. uranium resources in regions where uranium ore bodies are known to exist and are candidate supplies under present and near-term market conditions.
- Complete assessment of lower cost potential uranium resources in the conterminous U.S. and Alaska.
- Improve reliability and validate resource estimates and increase confidence levels.
- Expand scope of uranium assessment to include higher cost and relatively unknown domestic resources that may be feasible uranium supply alternatives.
- Apply advanced technologies for detection and assessment of uranium resources.

DOE-GJO is responsible for administering and coordinating efforts to meet these objectives, including distribution of reports. Inputs to the NURE program come from DOE prime

contractors, DOE-sponsored research and development, the uranium industry, U.S. Geologic Survey, U.S. Bureau of Mines, other federal and state government agencies, and independent sources.

The NURE program consists of six parts:

1. Hydrogeochemical and Stream Sediment Reconnaissance Survey
2. Aerial Radiometric Survey
3. Intermediate Grade Resource Studies
4. World Class Geologic Studies
5. Subsurface Geologic Investigation
6. Technology Application

The data presented here are reconnaissance data intended for use in identifying broad areas for further study. While care has been taken to provide reliable sampling and analyses, verification of individual analyses is beyond the scope of this report. The data should be viewed statistically because "one-point anomalies" may be misleading. Regional trends, however, should be reliable. With careful consideration of regional geology, these data should provide reliable guides to areas warranting further study.

This report is one of a series presenting basic data obtained by SRL reconnaissance. In the interest of disseminating available data as soon as possible, only neutron activation analyses are reported here. Supplementary reports will be issued later. All data will be available on magnetic tape from:

GJOIS Project
UCC-ND Computer Applications Department
4500 North Building
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, Tenn. 37830

A brief description of sampling and analytical procedures and a detailed description of the maps, tables, and figures contained in this report are presented in the SRL document **USER'S GUIDE** included on microfiche in the pocket on the inside back cover of this report. A summary of the SRL development program in support of the reconnaissance is available in SRL-NURE progress reports (SRL-138). SRL data reports (SRL-146) have been open-filed for other western quadrangles (Figure 1).

FIGURE 1. Location Map for the Elko 1° x 2° NTMS Quadrangle

GEOLOGIC SUMMARY AND MINERAL OCCURRENCES

General Features

The Elko 1° x 2° NTMS quadrangle lies in the Basin and Range Province, known also as the Great Basin (Figure 2). The Great Basin is characterized by isolated, nearly parallel, mountain ranges (commonly fault blocks) and intervening plains filled with detrital material. The area has been orogenically active from at least Precambrian time (Nolan, 1943). The area experienced a series of geosynclines and orogenic interruptions throughout the Paleozoic and most of the Mesozoic Eras, culminating in the orogeny which formed the present Great Basin and which is continuing at present (Roberts and others, 1967).

The rocks of the Paleozoic Era consist principally of sediments formed in a geosynclinal sea. Paleozoic orogenies include the Ordovician Ruby disturbance, the Devonian Antler orogeny, and the Permian Sonoma orogeny. Uplift of the area became general in the Mesozoic Era with only localized sedimentation. Uplift was culminated in the Tertiary Period with a series of volcanic eruptions related to block faulting.

Structural History

Precambrian rocks of the Elko 1° x 2° NTMS quadrangle are represented by the McCoy Creek Group (Misch and Hazzard, 1962) and by unnamed Precambrian metamorphic rocks of the Ruby Mountains and East Humboldt Range. Precambrian orogenic cycles are not clearly defined, but at least one orogeny (Misch, 1960) and possibly three orogenies (Misch and Hazzard, 1962) have affected Precambrian rocks of the Great Basin.

The Paleozoic Era was host to at least three orogenic episodes (Erickson and Marsh, 1974); the Ruby disturbance which is an Ordovician tectonism (Willden and Kistler, 1967), the Late Devonian to Early Pennsylvanian Antler Orogeny (Roberts and others, 1958; Roberts, 1964a; 1964b; 1966), and the Late Permian Sonoma orogeny (Silberling and Roberts, 1962). The Sonoma orogeny may be reflected in this quadrangle by Latest Permian deformation of Permian rocks in the Diamond Range (Brew, 1961b; Larson and Riva, 1963; Brew, 1963). The earliest Paleozoic tectonic episode, the Ruby disturbance, occurred between Early Ordovician and Silurian times (Willden and Kistler, 1967) and is displayed in the Cambrian and Lower Ordovician rocks of the southern Ruby Mountains. These rocks are folded and show effects of regional metamorphism. The Lower Paleozoic rocks are unconformably overlain by Devonian rocks with a different structural regime. In areas outside the southern Ruby Mountains, this tectonic episode

FIGURE 2. Location of the Elko Quadrangle on a Physiographic Province Map

may be represented by an unconformity at the base of the Eureka Quartzite (Roberts and others, 1967; Nolan, 1943).

Nolan (1943) notes that the Great Basin during the Paleozoic was part of the Cordilleran geosyncline. The Cordilleran geosyncline was split by the emergence of a geanticline in western Nevada at the end of the Devonian Period (Nolan, 1943). This geanticline was eroded by Permian time. A second geanticline formed about 160 km (100 miles) east of the earlier one in southern Nevada and gradually extended northward throughout the rest of Permian and most of Mesozoic time. Eventually this geanticline extended throughout the Great Basin area, creating an erosional, volcanic highland by Tertiary time.

The Antler orogeny peaked during Early Mississippian time. The Roberts Mountains thrust, which outcrops in the western part of the Elko quadrangle, was likely active during Late Devonian to Early Mississippian time (Smith and Ketner, 1968). Clastics from the Antler orogenic belt west of the Elko quadrangle pulsed into the seaway; forming, among others, the Chainman Shale (Roberts and Lehner, 1955; Brew, 1963), the Diamond Peak Formation (Roberts and others, 1967), and the Tonka Formation of Dott (1955). The Antler orogeny continued with intermittent movements into Late Pennsylvanian time. The highlands were effectively eroded to low relief by Early Pennsylvanian time with calcareous facies extending westward across the foreland basin into the marginal areas of the uplift (Gilluly and Masursky, 1965) into the area known as the Ely basin (Bissell, 1967). Mudstone, siltstone, sandstone, conglomerate, and impure limestone (Antler flysch) were deposited within the foreland basin during Mississippian time (Poole, 1974; Poole and Sandberg, 1975).

The Humboldt orogeny of mid-Permian time (Ketner, 1977) created some local flysch deposits in central Nevada (Poole and Wardlaw, 1978). The deposits of the Humboldt orogeny were disrupted by the Sonoma orogeny which extended from Late Permian to Early Triassic time (Roberts, 1964; Silberling, 1973; Silberling and Roberts, 1962). Deformation of Permian rocks in the Diamond Range is attributed to the Sonoma orogeny (Brew, 1961b; Brew, 1963; Larson and Riva, 1963). Sonoma epeirogenic movements ended during the Triassic Era with a resultant low relief of the old orogenic belts.

During Triassic and Jurassic time, volcanism erupted from an island arc in California, Oregon, and Washington (Shawe and others, 1978), creating a depositional inner-arc basin in western Nevada (Silberling and Roberts, 1962). In the Elko quadrangle, principally marine sediments were laid down during the Triassic Era, followed by continental clastic sedimentation and volcanic deposits during the Jurassic Era. The volcanic deposits may be related to volcanism from orogenic disturbances in the area of the

Cortez Mountains just west of the Elko quadrangle (Muffler, 1964; Gilluly and Masursky, 1965). Igneous activity began at this time and continued into Early Cretaceous time (Nolan, 1962; Ferguson and Muller, 1949; Carlson and others, 1975).

By Cretaceous time, most of the Great Basin had developed into an area of moderate highland and the Basin and Range topography of modern times began to form. The epicontinental sea of the Rocky Mountain geosyncline was located just east of the Elko quadrangle during Cretaceous time, and only rocks of the Newark Canyon Formation of terrestrial clastic origin were deposited in this quadrangle. Cretaceous-age, large-scale, eastward overthrusting took place in western Utah, just east of the Elko quadrangle in the Sevier orogenic belt (Armstrong, 1968). Cretaceous plutonism may be marginally related to a subduction zone that had formed along the west margin of the continent (Shawe and others, 1978).

Cenozoic orogenic movements consist principally of high-angle faulting and tilting of Basin and Range blocks, and intermittent volcanism (Table 1). Most of the ranges of the Elko quadrangle are tilted eastward or southeastward.

At least two stages of glaciation were present in the Elko quadrangle; the Lamoille (early Wisconsin to Iowan), and the Angel Lake (later Wisconsin - Blackwelder, 1931; Sharp, 1938; and Sharp, 1942). The orographic snow-line was at about 3000 m (10,000 ft) during Wisconsin time with a southward gradient of 60 to 90 m per 160 km (200 to 300 feet per 100 miles) (Sharp, 1942).

Current radiometric age dates of the quadrangle are summarized in Table 2.

Stratigraphy

Precambrian Era

Precambrian rocks of the Elko 1° x 2° NTMS quadrangle consist of unnamed metamorphic rocks, the McCoy Creek Group, and possibly the lower part of the Prospect Mountain Quartzite (Misch and Hazzard, 1962). The McCoy Creek Group is exposed in the Ruby Mountains and in the Pilot Range just north of this quadrangle. Metamorphosed rocks of the Ruby Mountains and East Humboldt Range may be of an older Precambrian basement, though evidence is inconclusive (Misch and Hazzard, 1962). The McCoy Creek Group consists of thick successions of quartzose and argillaceous metasediments and is overlain by the Prospect Mountain Quartzite (Misch and Hazzard, 1962). The McCoy Creek Group and Prospect Mountain Quartzite have undergone synkinematic, orogenic metamorphism of post-Cambrian age (Misch, 1960).

TABLE 1

Summary of Tertiary Igneous Events

<u>Age*</u>	<u>Activity**</u>
5 to recent	Eruption of alkaline andesites and dacites
16-5	Basalt and rhyolitic flows
34-20	Widespread ash-flow sheets of rhyolitic eruptions
40	Emplacement of small igneous bodies and eruption of andesite lavas

* Age in millions of years before the present (Myr BP).

** Sequence from Silberman and McKee (1973).

TABLE 2

Radiometric Ages of Rocks in the Elko 1° x 2° NTMS Quadrangle

Site	Formation	Rock Type	Mineral	Age	Method/ Reference
1	Silver Zone Pluton	Granite	Biotite	124(5)	1/1
2	Humboldt Fm.	Tuff	Biotite	36.6(0.8)	1/2
3		Tuff	Biotite	36.2(0.7)	1/2
4a	Humboldt Fm.	Tuff	Sanidine	33.2(0.7)	1/2
4b	Humboldt Fm.	Tuff	Biotite	34.9(0.7)	1/2
5	Humboldt Fm.	Tuff	Biotite	33.9(0.9)	1/2
6	Humboldt Fm.	Tuff	Biotite	39.2(0.8)	1/2
7		Rhyolite	Biotite	35.5(1.4)	1/2
8		Rhyolite	Biotite	34.6(1.9)	1/2
9		Quartz Monz.	Biotite	26(4)	1/3
10		Quartz Monz.	Biotite	29-36(3.3)	1/3
11	Harrison Stack Pass	Quartz Monz.	Biotite	35	2/3
12		Quartz Monz.	Zircon	30(3)	2/3
13		Quartz Monz.	Zircon	40(4)	2/3
14		Pegmatite		41.5	1/3
15		Pegmatite		29.8	1/3
16		Syenite	Biotite	125(19)	1/3
17		Quartz Monz.	Biotite	140(21)	1/3
18		Quartz Monz.	Biotite	35(5)	1/3
19		Quartz Monz.	Zircon	41	2/3
20		Tuff	Biotite	22(3)	1/3
21	Dead Horse Tuff	Tuff	Biotite	39.9	1/3
22		Gneiss	Biotite	25(4)	1/3
23		Gneiss	Biotite	29(4)	1/3
24		Granite	Zircon	45(10)	2/3

Explanation of columns: SITE - key to Plate 1B; AGE, in Myr BP, (--) is numerical value of uncertainty; METHOD/REFERENCE, (METHOD) 1 is K/Ar, 2 is Pb/A, (REFERENCE) 1 is McDowell (1971), 2 is McKee and others (1971), 3 is Schilling (1965).

The Prospect Mountain Quartzite has been noted as latest Precambrian by Hope and Coats (1976) in their stratigraphic column. However, Wheeler and Lemmon (1939) note that the upper 30 m (100 ft) of the Prospect Mountain Quartzite are Lower Cambrian based on fossil evidence. The formation is at least 450 m (1500 ft) thick (Wheeler and Lemmon, 1939) and may possibly bridge the time zones. The Prospect Mountain Quartzite consists of quartzite with a few percent feldspar and shale partings (Hose and Blake, 1976). This quartzite has undergone low-grade metamorphism which has produced sericite; the shale partings have changed locally to phyllite (Hose and Blake, 1976).

Paleozoic Era

The Cambrian system of the Elko quadrangle is represented by the Prospect Mountain Quartzite and by unnamed units of carbonate rocks (limestone and dolomite) and detrital rocks (shale and quartzite). These may correlate to the Eldorado Dolomite (Walcott, 1908) of Lower Cambrian age, the Geddes Limestone (Wheeler and Lemmon, 1939), Pole Canyon Limestone (Kellogg, 1963), Secret Canyon Shale (Hague, 1892), Lincoln Peak Formation (Whitebread, 1959), the Johns Wash Limestone (Drewes and Palmer, 1957), the Dunderberg Shale (Walcott, 1908), and the Corset Spring Shale (Drewes, 1958).

The Pogonip Group is of Middle to Lower Ordovician age (Hintze, 1951; Ross, 1949; 1951). Wheeler and Lemmon (1939) note fossils of Upper Cambrian age in the lower part of the "Pogonip Limestone." Nolan and others (1956) redefined the Pogonip, restricting it to the Ordovician portion only, differentiating the lower portion into the Windfall Formation of Upper Cambrian age.

The Eureka Quartzite (Hague, 1883) is a white quartzite exposed in the Ruby Mountains and Cherry Creek Range (Woodward, 1964). The Eureka Quartzite is of Middle Ordovician age (Roberts and others, 1967). Other references on the Ordovician rocks of the quadrangle include Chamberlin (1975), Christensen (1975), Hintze (1950), Ketner (1968), and Webb (1960).

Silurian rocks of the Elko quadrangle are made up principally of the Laketown Dolomite which is combined with the Ordovician Ely Springs Dolomite (Plate 1-A). Previous work in the area has combined the above two units with the Fish Haven Dolomite (Woodward, 1964; Fritz, 1960; Dechert, 1967).

The Devonian system was affected by the Antler orogeny of Late Devonian and Mississippian time, when an orogenic highland developed along the western margin of the Cordilleran miogeosyncline. Poole (1974) and Poole and Sandberg (1975) note the

westward source for sediments that formed the Antler flysch during this time. Devonian units of the Elko quadrangle include the Guilmette Formation (Nolan, 1935), Devils Gate Formation (Merriam, 1940), Woodruff Formation, and Pilot Shale (Spencer, 1917).

Mississippian units include the Joanna Limestone (Spencer, 1917), the Chainman Shale (Spencer, 1917), and the Diamond Peak Formation (Hague, 1883; Brew, 1961a). The Pennsylvanian system consists of rocks of the Ely Limestone (Lawson, 1906; Spencer, 1917), and the equivalent Moleen and Tomera Formations (Dott, 1955). References on the Mississippian and Pennsylvanian systems include Addison (1929), Blomquist (1971), Christensen (1975), Coogan (1962), Marcantel (1973), and Steele (1959).

The Permian system is represented by the Strathearn Formation (Dott, 1955), Sunflower Formation, Winecup Formation, Rib Hill Sandstone (Brokaw and Heidrick, 1966), Pequop Formation (Steele, 1960), and Park City Group (Hose and Repenning, 1959). Other references on the Permian rocks in the Elko quadrangle include Poole and Wardlaw (1978), Stevens (1963), Knorr (1967), and Barosh (1965).

Mesozoic Era

The Triassic Period of the Elko quadrangle is represented by marine sedimentary rocks equivalent to the Moenkopi and Thaynes Formations and by sandstone and shale equivalents of the Aztec Sandstone and Chinle Formation (Hope and Coats, 1976).

The Jurassic and Cretaceous Periods are represented by Jurassic age intrusives, Cretaceous age intrusives, and by the Cretaceous Newark Canyon Formation (Nolan and others, 1956).

Cenozoic Era

Tertiary units consist of volcanic deposits and associated volcanic sedimentary deposits erupted at intermittent times (Table 2).

Geology of the Ranges (Brief Summary)

Adobe Range and Elko Hills

The area of the Adobe Range and Elko Hills in the northwest section of the Elko 1° x 2° NTMS quadrangle is made up of low, desert hills separated by the Humboldt River valley. Rocks of the

area consist principally of sedimentary and volcanic rocks of Miocene to Recent age and tightly folded Paleozoic rocks. The Adobe Range contains rocks of the Diamond Peak Formation, Chainman Shale, Strathearn Formation, and the Park City Group (Ketner, 1970). The rocks of the Elko Hills consist of the Chainman Shale, Diamond Peak Formation, and Park City Group.

Structural relations of the area indicate two episodes of thrusting and one of folding (Ketner, 1970). The oldest thrust-faulting is of Paleozoic age and the youngest is of post-Early Triassic age (Ketner, 1970). References of interest in the area include Evans and Ketner (1971), Ketner (1973 and 1974), and Silitonga (1974).

Pinon Range

The Pinon Range lies along the west border of the Elko quadrangle and displays a diverse geological character. Among the units found here are: the Western facies, a Paleozoic overthrust sheet associated with the Roberts Mountain thrust; unnamed Paleozoic dolomitic rocks; Guilmette and Devils Gate Formations of Devonian age; Chainman Shale and the Diamond Peak Formation; Ely Limestone; Strathearn Formation; Newark Canyon Formation; Newark Canyon Formation; and volcanic rocks of Oligocene and Miocene ages. The Carlin area lies to the west of the Pinon Range where extensive studies have been made owing to mineral deposit (gold) interests.

The principal structural feature of the Pinon Range is the Roberts Mountain thrust, an eastward thrust of Late Tertiary age (Smith and Ketner, 1968). References of interest in the area include Carlisle and others (1957), Gilluly and Masursky (1965), Gordon and Duncan (1961), Noland and others (1956), Roberts and Lehner (1955), Regnier (1960), Smith and Ketner (1975), Radtke (1976), Jones and others (1978), and Flynn (1957).

Diamond Mountains

The Diamond Mountains, located in the southwestern area of the Elko quadrangle consist of Joanna Limestone and Pilot Shale of the White Pine Group (Misch, 1960) of Devonian and Mississippian age, Ely Limestone, and Fegroup Formation. These marine sedimentary rocks have been invaded by a Tertiary granitoid pluton. References of interest to this area include Dott (1955), Brew (1961b), Hose and Blake (1976), Vanderburg (1936), Larson and Riva (1963), and Roberts and others (1967).

Ruby Mountains

The Ruby Mountains of the west-central area of the Elko quadrangle are the highest and most extensive range in the quadrangle. The geology of the Ruby Mountains is considerably more complex than that shown on Plate 1-A, but this complexity could not accurately be shown at the scale (1:250,000). The Ruby Mountains generally consist of Paleozoic and Precambrian metasediments intruded by Mesozoic-to-Tertiary granitoid plutons. Alpine glaciation of Wisconsin age left deposits throughout the central and northern areas of the range. A large group of metamorphosed lower Paleozoic and Precambrian rocks, located in the northwest Ruby Mountains (Plate 1A), is actually a complex section which has been reasonably well-defined and displayed at a scale of 1:100,000 by Hope and Cates (1976). The Ruby Mountains are one of the principal areas displaying Ordovician age tectonism (Willden and Kistler, 1967). Studies in the Ruby Mountains have been important to an understanding of the history of the Cordilleran geosyncline. A summary of important references on the area includes Armstrong and Hansen (1966), Howard (1966), Sharp (1942), Willden and others, (1966), Willden and Kistler (1967), Blackwelder (1934), Willden and Kistler (1969), Snelson (1957), Ketner (1973), Sharp (1938, 1939, 1940), and Dudley (1967).

East Humboldt Range

The East Humboldt Range, located in the north-central section of the Elko quadrangle, consists principally of metamorphosed lower Paleozoic and Precambrian sediments. Glacial deposits are common in the East Humboldt Range. Pertinent references on the area include many of those of the Ruby Mountains.

Wood Hills and Pequop Mountains

The Wood Hills and Pequop Mountains, situated in the north-central part of the Elko quadrangle, consist of a wide range of Paleozoic rocks with a substantial amount of Triassic marine sedimentary rocks in the southern part of the Pequop Mountains. The portion of the Wood Hills in the Elko quadrangle consists principally of Eureka Quartzite. The dominant structural feature of the Wood Hills is the Wood Hills thrust-fault of Cretaceous age.

Two Cenozoic domes formed in the area, one under the Wood Hills and the other just west of the Pequop Mountains. The Wood Hills uplift occurred without major faulting. The Pequop Mountains are an east-tilted fault-block (Thorman, 1970). References

on the area include Harlow (1956), Oesterling (1962), Robinson (1961), Snelson (1955), and Thorman (1962).

Toano Range and Goshute Mountains

The Toano (Toana) Range and Goshute Mountains in the eastern part of the Elko quadrangle are geologically continuous as an east-tilted fault block. Virtually all Paleozoic units of the quadrangle are represented in these ranges. A gentle doming of the rocks is represented by the variation in age of the exposed units. Older rocks are exposed near the northern border of the Elko quadrangle in the Toano Range, representing a dome or antiformal feature. A synformal area is represented in the central Toano Range where Permian rocks are exposed, rising to a domal feature in the northern Goshute Mountains where Ordovician rocks are widely exposed. The synformal area is also represented in the southern Goshute Mountains on the limb of the domal or antiformal feature that has Pennsylvanian Ely Limestone in wide areas of outcrop. High-angle faulting is abundant and complex in the Toano Range and Goshute Mountains. Tertiary volcanism is generally of the 17 to 6 Myr BP age group, but a large area of volcanic deposits of 41 to 34 Myr BP age is present in the southern Goshute Mountains.

References on the area include Pilger (1972), Desai (1969), Berge (1960), Messin (1973), Buckley (1967), Sayyah (1965), Steininger (1966), Slade (1961), and Berge (1960). The geology of the nearby Pilot Range is outlined by O'Neill (1968).

Cherry Creek Range

The Cherry Creek Range consists principally of Pennsylvanian and Permian rocks. An antiformal feature in the southwestern area exposed rocks of Cambrian age. The range appears to be an east-tilted fault block and is located in the south-central portion of the Elko Quadrangle. References on the area include Adair (1961), Holmes (1950), Fritz (1968), and Nelson (1956).

Antelope Range and Dolly Varden Mountains

The Antelope Range and Dolly Varden Mountains in the south-central portion of the Elko quadrangle consist mostly of volcanic deposits of 41 to 34 Myr BP age with a limited amount of bedrock of Permian to Triassic age outcropping. References on the area include Avents (1961), Blake and Hose (1968), Snow (1964), and Sanderson (1972).

Schell Creek Range

References on this area include Dechert (1963), Young (1960), Dechert (1967), and Drewes (1967).

Medicine Range

References on this area include Collinson (1966 and 1968), Sides (1966), and Freyne (1973).

Mineral Resources

The mineral resources of the Elko 1° x 2° NTMS quadrangle include a wide range of metallic and nonmetallic resources. Metallic resources include copper, lead, silver, tungsten, gold, zinc, and antimony.

Metallic Resources

The Delker district (Hill, 1916; Lincoln, 1923; Granger and others, 1957) is located in the area of T.28N., R.62E. This district was discovered in 1894 and produced copper ore during the years 1916 and 1917.

The Dolly Varden district (Hill, 1916; Lincoln, 1923; Granger and others, 1957) is located in an area about 25 km (16 mi) north-east of Currie. The district was discovered in 1860 and produced intermittently to about 1978. The deposits of the district are contact-metamorphic and replacement deposits containing copper, lead, silver, and some gold-bearing veins. Recent production has been from the Victoria Copper mine.

The Ferber district (Hill, 1916; Lincoln, 1923; Granger and others, 1957) is located in the area of T.17N., R.70E. The contact-metamorphic and replacement deposits contain copper, lead, and silver. The district was discovered about 1880 and produced intermittently until about 1943.

The Ferguson Spring district (Hill, 1916; Lincoln, 1923; Granger and others, 1957) is located in the area of T.30N., R.69E. The deposits were discovered in the late 1880's and little production has been seen from the district. The deposits consist of oxidized, irregular, replacement bodies.

The Harrison Pass district (Hess and Larsen, 1922; Klepper, 1944) is located in the vicinity of T.28N., R.58E. The deposits are of tungsten from tectite in a contact zone between granite and limestone.

The Kinsley district (White, 1871; Whitehill, 1875; Hill, 1916; Lincoln, 1923) is located in the area of T.26N, and R.67E. to R.68E. The district was discovered in 1862. The ore is found in Paleozoic sedimentary rocks of dolomitic limestone, shale, and shaly-limestone intruded by quartz monzonite. There has been little production from the area. Gold and copper, and minor silver and lead are the principal minerals of the district.

The Lee district (Granger and others, 1957) is located on the west side of the Ruby Mountains opposite the Ruby Valley district. Copper, silver, lead, zinc, antimony, and trace gold were noted in quartz veins in limestone. The district has had little production.

The Mud Springs district (Hill, 1916; Lincoln, 1923) is located in T.28N., R.60E. The district was discovered in 1910. The principal mine of the district, the Silver Butte mine, was established in 1911. There is no current production from the district. The ore deposits consist of galena in a barite gangue.

The Proctor district (Lincoln, 1923) is located in T.35N., R.68E. The district has produced small amounts of silver ore.

The Railroad district (Emmons, 1910; Van Barneveld, 1916; Lincoln, 1923; Ketner and Smith, 1963) is located in T.30N., R.53E. The district was discovered in 1869 in an area of limestone intruded by granodiorite. The ore is principally replacement deposits of lead, silver, and copper ore in marbleized limestone. There is no current production from the district.

The Ruby Valley district (Hill, 1916; Lincoln, 1923; Granger and others, 1957) is located on the east side of the Ruby Mountains about 17 km (11 mi) north of the old Ruby Valley Post Office. The district was discovered about 1903 and has produced gold, silver, copper, lead, and zinc. The ore bodies appear to be small, in limestone, and associated with a granitic intrusive.

The Spruce Mountain district (Raymond, 1873; Schrader, 1931) is located in T.31N, and R.63E. to R.6E. along the crest of the Spruce Mountains. The district produced lead, copper, and silver until the 1950's.

The Valley View district is located in T.29N., R.57E., where native bismuth was discovered in 1913. The ore consists of scheelite in limestone associated with a quartz monzonite.

Nonmetallic Resources

Nonmetallic mineral resources are varied and abundant in the Elko quadrangle (Granger and others, 1957). Sand and gravel are abundant in the valley areas of the quadrangle, and several local deposits are currently being worked. Limestone and dolomite are plentiful in the Elko quadrangle, and Granger and others (1957) report potential for limestone suitable for use in quicklime and cement. Marble of commercial-grade dimension-stone quality is reported in the Elko quadrangle by Reid (1904). Granite for dimension-stone was quarried north of Elko prior to 1907, and sandstone for dimension-stone was quarried near Elko (Winchester, 1923). Diatomaceous earth has been produced from the Humboldt Formation (Fulton and Smith, 1932). Small amounts of impure coal have been noted in an area just west of the Elko quadrangle in Paleozoic limestone, and lignite has been noted in the Humboldt Formation (Schrader and others, 1917; Winchester, 1923).

Oil shale was discovered in the vicinity of the town of Elko in the 1870's (Winchester, 1923; Winfrey, 1958). Some production of oil-shale products were recorded in 1917 and 1918 (Couch and Carpenter, 1943). Several oil exploration wells have been drilled in the Elko quadrangle. An oil show was reported near Elko, and oil and gas were reported from a well near Jiggs, Nevada (still under active exploration), and south of Wendover, Nevada (Garside and Schilling, 1977).

HYDROLOGY

Climate

The climate in the Elko 1° x 2° NTMS quadrangle is controlled by elevation and is cold during the winter months and mild during the summer months. The average July temperature is about 24°C and the average January temperature is about -5°C. The eastern portion is warmer than these averages by a few degrees. The small amount of precipitation ranges from about 127 mm in the east to 317 mm in the west (NOAA, 1977). Most of the precipitation occurs during the cooler months and occurs as snowfall in the higher elevations. Precipitation data for the months in which sampling took place are presented in Table 3.

Geography

The entire Elko 1° x 2° NTMS quadrangle lies in the Great Basin section of the Basin and Range Province (Figure 2 and Fenneman, 1931, p. 328). Block-faulted mountains and intervening

TABLE 3

Precipitation Totals for 1979 at Selected Weather Stations in the Elko Quadrangle

Weather Station and Elevation	Average Monthly Precipitation, mm											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Elko FAA AP (1550 m)	29.5	19.6	21.1	20.8	21.2	25.7	10.4	15.5	8.64	16.8	25.7	28.7
Ruby Lake (1830 m)	31.0	30.5	32.0	29.7	30.5	26.9	14.5	14.2	13.7	21.3	32.8	40.4
Wendover Auto B (1290 m)	7.37	7.87	10.4	11.2	17.3	18.5	5.59	9.14	6.86	11.4	10.2	8.13

valleys filled with detritus from the mountain slopes are characteristic. The mountains and valleys, trending roughly northward, are about equal in area.

Both Ruby Valley and Steptoe Valley have broad flat valleys at altitudes of about 1900 m. The west side of Ruby Valley is bordered by an escarpment leading upward to Ruby Mountain (3000-m altitude). The east side of Steptoe Valley is bordered by steep slopes of the Toano Range (2600-m high). Most other valley walls are less steep, and gentle pediment slopes are common. In some places, the sloping margins of the basins are an assemblage of alluvial fans; and, in other places, bare-rock pavements are prominent. Arroyos and washes add to local irregularities in the lower mountain slopes, whereas playas and alkali flats occupy low places in several valleys. Natural vegetation is sparse; the more arid areas have scattered creosote bush, cactus, and sage brush.

There are many ranches in the area that raise cattle and sheep. Most farms use irrigation and raise forage and grain crops to support the cattle. Some dry farming is practiced in the area.

The area has a population of about 8000 (U.S. Bureau of Census, 1970). The town of Elko, Nevada, accounts for most of the population.

Drainage and Hydrology

The only perennial surface drainage into and out of the Elko quadrangle is the Humboldt River, which flows southwestward through the northwest part of the area. Ephemeral streams of the mountains, carrying occasional rainwash and snowmelt, lose their water as downward percolation in the alluvium. Most lakes in the area are dry during summer months. The average discharge for 40 years for Humboldt River near Elko is $6.68 \text{ m}^3/\text{sec}$ ($236 \text{ ft}^3/\text{sec}$), and the average discharge for 29 years for South Fork Humboldt River (near Elko) is $3.285 \text{ m}^3/\text{sec}$ ($116 \text{ ft}^3/\text{sec}$).

All of the consolidated rocks are fractured to varying degrees and are capable in most places of yielding some water to wells. The carboniferous carbonate rocks are much more permeable than are the Tertiary intrusive rocks.

All of the alluvial valleys have permeable sands and gravels and have large amounts of ground water in storage. Ruby Valley is the largest, having no groundwater outflow but very significant evapotranspiration within it. Ground water recharge is reported to be about 84 million cubic meters (68,000 acre-feet) per year. Goshute and Antelope Valleys also have significant alluvial aquifers (Eakin and others, 1976). However, the average permeability

of the sediments of the valley-fill of Goshute-Antelope Valley, as well as that of sediments in the other valleys, is thought to be relatively low because fine-grained lake sediments compose much of the valley fill. Some of the irrigation wells that penetrate the more permeable zones yield as much as 1300 liters per minute.

The runoff originating in the mountains sinks into the ground as it passes over the alluvium at the edges of the alluvial basins (McGuinness, 1963, p. 507). Only after heavy storms does the water travel far over the surface of the valleys. Springs are not uncommon along the lower slopes of the mountains, such springs represent concentrated discharge points of water from the fractured rocks in the mountains.

The depth of the water table is as close as 4 or 5 meters below land surface in the low valley areas, and these areas are also the lowest elevations of the water table. From these low places in the valleys, the water table rises toward the valley edges and further toward the center of the mountains; yet, the land surface rises even more rapidly so that the depth of the water table increases outward from the centers of the valleys.

The quality of surface waters varies according to the extent of evapotranspiration and inflow of mineralized thermal water in the respective drainage basins. Thus, water from the small creeks of the mountains is relatively low in mineral matter, whereas total solids in the water in the Humboldt River increases progressively down stream.

Most of the springs discharge water having less than 500 mg/L of solids, although the few thermal springs are highly mineralized. Acceptable water for domestic use and irrigation is widespread, and water containing more than 1000 mg/L is not common. In addition to the total salt content being objectionable in some cases, excessive amounts of iron, manganese, fluoride, and boron are troublesome locally.

Most surface waters are of good quality until they reach the closed lakes and flats where evaporation occurs. The larger rivers that are used extensively for irrigation rarely have dissolved solid content greater than 500 mg/L, which is the result of leaching and fertilizer.

FACTORS AFFECTING THE DATA

Sediment and ground water samples and associated site data were collected during July and August of 1979. Sediment samples were collected from dry strams, a few wet streams, and soils. Most of the ground water samples were collected from springs in the more mountainous areas. The well-water samples were collected near the few dwellings in the quadrangle.

QUALITY ASSURANCE

Sample Collection

Sampling teams marked each sampling site on an SRL-approved map and completed a Field Data Form (Figure 3) for every sample. At least five percent of sampled sites were routinely checked by SRL personnel to ensure that the reported field locations were accurate. No evidence has been discovered of deliberate malfeasance by the sampling teams. In addition, 105 sediment and 15 ground-water sampling sites were field-checked by an SRL subcontractor during December 1979. All but three (97%) of the sites checked were found to be located within 800 m (0.5 mi) of the locations plotted on sample maps. Thus, the goals of a regional reconnaissance have not been compromised by map errors. Details of the quality assurance program are given elsewhere (SRL-138).

Analytical Standards

Sediment Standards SRL 2.2, 3.1, and 4.1 were analyzed along with NURE sediment samples to provide precision data and routine checks for the analytical equipment and software. Tables 4a, 4b, and 4c contain the results from the standards run during the same time period as the Elko sediment samples. These results give a good estimate of the precision of the data and can be used in estimating bias between this and other SRL reports.

Periodically, DOE intersite comparison standards are analyzed. An independent quality assurance program based on these standards is conducted for DOE by Ames (Iowa) Laboratory (D'Silva, et al.).

DESCRIPTION OF DATA TABLES

This section of the report summarizes the types of data tabulated on microfiche. Detailed descriptions of the tables and definitions of abbreviations can be found on the microfiche

SRL FIELD DATA FORM

SITE CODE				DATE				TEAM NO.		SURFACE SITE DATA														FORMATION		ODOR													
Sheet	Map Code	Site Number		Mo.	Day	Yr.	Mr.	Sample Type	Rock Type	Sed Size	Width	Depth	Flow	Level	Veg Type	Veg Density	Relief	No. of Sample Composites	Activities Contaminants (List up to four)																				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
HAVE A GOOD DAY																																							
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
pH		SPECIFIC CONDUCTANCE $\mu\text{mhos/cm}$		WATER TEMP. °C		ALKALINITY		Drops H_2SO_4 / ml Water		ml OF WATER ION-EXCHANGED		WELL DEPTH		CONDENS. WELL CLIM.		WHERE SAMPLE TAKEN		STATE		SCINTILLOMETER READING																			
ADDRESS (use / to separate lines)																																							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
IN THE CASE OF EACH CIRCLED ENTRY SPACE, ENTER MOST APPROPRIATE DESIGNATORS LISTED BELOW																																							
<p>20</p> <p>A Other sediment (8) B Other resin (9) C Well water (9) D Spring water (9) E Stream sediment + water (8) F Stream sediment only (8) G Soil (8) H Talus (8)</p>										<p>21</p> <p>1 Other (explain) 2 Volcanic - felsic 3 Volcanic - mafic 4 Plutonic - felsic 5 Metamorphic 6 Clastics - coarse 7 Sandstone 8 Shale 9 Carbonate</p>										<p>22</p> <p>1 Other (explain) 2 Pebbles & coarser 3 Sand 4 Silt & clay 5 Organic muck</p>										<p>23 and 24</p> <p>1 Dry 2 < 1/4" 3 1/4 - 1" 4 1 - 2" 5 2 - 4" 6 4 - 8" 7 8 - 16"</p>									
<p>25</p> <p>1 Dry 2 Slow 3 Moderate 4 Fast 5 Torrent</p>										<p>26</p> <p>1 Dry 2 Low 3 Normal 4 High</p>										<p>27</p> <p>1 Other 2 Forest 3 Desert scrub 4 Grassland 5 Saltbush 6 Marsh</p>										<p>28</p> <p>1 Sparse 2 Moderate 3 Dense</p>									
<p>29</p> <p>1 0 - 10' 2 10 - 50' 3 50 - 200' 4 > 200'</p>										<p>32 thru 35</p> <p>1 Other 2 None 3 Chemical 4 Smelting 5 Mining 6 Garbage 7 Farming 8 Grazing 9 Oil field</p>										<p>40</p> <p>1 Other 2 None 3 H_2S 4 Oil</p>										<p>62</p> <p>1 Certain 2 Probable 3 Possible 4 Educated guess 5 Unknown</p>									
<p>53</p> <p>1 Other 2 Domestic 3 Municipal 4 Livestock 5 Irrigation 6 Industrial - commercial</p>										<p>64</p> <p>1 Others 2 Immediately after storage tank 3 Before storage tank 4 Direct from pump 5 Direct from well or spring 6 From municipal system</p>										<p>77</p> <p>Enter "X" when analysis information is requested</p>										<p>80</p> <p>Enter number in parentheses () for column 20 options</p>									
<p>Sampler(s) Signature(s)</p>																																							
<p>Field Supervisor (initials)</p>																																							
<p>Standard Letters and Numbers A B C D E F G H I J K L M N O P Q R S T U V W X Y Z 0 1 2 3 4 5 6 7 8 9</p>																																							

FIGURE 3. SRL Field Data Form for Western Quadrangles

TABLE 4a

Accuracy and Precision of Analyses of SRL Standards

a. Sediment Standard SRL 2.2

<u>Element</u>	<u>Number</u>	<u>Mean, ppm</u>	<u>Coefficient of Variation, %</u>	<u>Accepted Value, ppm</u>
U	30	21.0	17.4	22.2
Th	25	109	13.4	125
Hf	26	123	20.6	173
Al	30	6850	23.7	6500
Ce	22	497	15.2	614
Fe	25	8570	22.6	6700
Mn	30	246	13.8	300
Sc	28	2.7	31.5	3.9
Na	29	130	39.6	145
Ti	30	11,100	16.3	13,200
V	30	31	16.5	34.7
Dy	30	18	39.3	<22
Eu	18	2.5	50.6	2.5
La	25	289	28.4	301
Lu	22	2.3	15.3	2.9
Sm	25	45	39.5	51.3
Yb	22	14.6	23.4	18.2

TABLE 4b

Accuracy and Precision of Analyses of SRL Standards

b. Sediment Standard SRL 3.1

<u>Element</u>	<u>Number</u>	<u>Mean, ppm</u>	<u>Coefficient of Variation, %</u>	<u>Accepted Value, ppm</u>
U	23	42.5	18.7	41.3
Th	26	135	22.1	162
Hf	15	6.5	40.4	7.4
Al	28	32,300	16.6	30,600
Ce	21	773	14.0	903
Fe	26	16,700	29.4	15,200
Mn	28	229	15.2	289
Sc	26	3.9	27.2	4.19
Na	28	840	14.7	901
Ti	24	5100	23.0	6100
V	27	42	14.4	54.4
Dy	27	42	39.2	50
Eu	21	4.2	50.3	3.86
La	26	391	16.1	443
Lu	21	4.0	12.4	4.4
Sm	23	62	43.7	69.2
Yb	22	28	16.9	29.9

TABLE 4c

Accuracy and Precision of Analyses of SRL Standards

c. Sediment Standard SRL 4.1

Element	Number	Mean, ppm	Coefficient of Variation, %	Accepted Value, ppm
U	28	0.5	15.6	0.58
Th	13	3.2	28.9	2.1
Hf	25	3.0	36.5	4.4
Al	28	57,800	16.5	66,700
Ce	15	54.6	32.4	44
Fe	28	78,000	9.4	87,300
Mn	24	1650	20.4	1970
Sc	28	13.8	28.3	21
Na	27	16,300	15.5	16,100
Ti	23	21,700	26.5	25,200
V	27	225	17.5	273
Dy	3	2.2	37.0	<22
Eu	20	1.3	37.4	1.16
La	23	15.3	19.7	18.6
Lu	16	0.2	30.3	0.28
Sm	22	2.8	24.9	4.2
Yb	7	2.4	33.0	1.6

labeled **USER'S GUIDE**. Ground-water analyses and site descriptions are tabulated in Tables A-1 and A-2, both of which can be found on the microfiche titled **ELKO TABLES**. Sediment analyses and site descriptions are tabulated in Tables B-1, B-2, and B-3, which are also on the microfiche titled **ELKO TABLES**.

Table A-1 begins with the sample's SRL identification number, which is composed of four letters and a three-digit number. The first two letters identify the quadrangle from which the sample was collected. EK is the two-letter designator for the Elko 1° x 2° NTMS quadrangle. The third and fourth letters define which 15-minute quadrangle contains the sampling site (see chart below).

	A	B	C	D	E	F	G	H
A	AA	AB	AC	AD	AE	AF	AG	AH
B	BA	BB	BC	BD	BE	BF	BG	BH
C	CA	CB	CC	CD	CE	CF	CG	CH
D	DA	DB	DC	DD	DE	DF	DG	DH

Numbers from 001 to 499 designate surface sites. Numbers from 501 to 999 designate ground-water sites. The first sediment sample, therefore, taken from the extreme northeastern portion of the Elko 1° x 2° NTMS quadrangle would be EKAH001.

Other entries on Table A-1 include a DOE identification number; pH, conductivity, alkalinity, and scintillometer readings; analyses for U, Br, Cl, F, He, Mn, Na, and V; and the ratio of uranium-to-conductivity (multiplied by 1000 for convenience; U x 1000/cond.). All entries are self-explanatory except those noted below (see **USER'S GUIDE** also).

DOE ID is a 28-digit number that includes the following parts:

Digit Number

1-2	State (See Table 1 in the USER'S GUIDE)
4-10	Latitude of site
12-19	Longitude of site
21	Laboratory code (4 = SRL)
23-24	Sample type (See Table 2 in the USER'S GUIDE)
26-28	Replication code. Generally only original samples (-000) are reported in the Data Reports.

Table A-2 shows SRL identification number; concentrations of Al, Dy, and Mg; sampling date; sample collection team number; and the following characteristics of the well or spring that was sampled:

WATRTEMP	Water Temperature, in °C.
WELDEPTH	Depth of well in feet.
DPTHCONF	Confidence in depth measurement.*
WELCLASS	Classification of well use.*
SMPPPOINT	Point in plumbing system where water was taken.*
WELLOPOR	Presence of hydrogen sulfide or other odor.

Sediment analyses and site descriptions are tabulated in Tables B-1, B-2, and B-3, which are on the microfiche labeled **ELKO TABLES**.

Table B-1 includes SRL and DOE identification numbers similar to those described above for ground-water sites. Table B-1 also includes scintillometer readings, pH, conductivity, and alkalinity of stream water, plus elemental concentrations of U, Th, Pf, Ce, Fe, Mn, Na, Sc, Ti, and V.

Table B-2 (Supplementary Data - Sediments) includes the SRL identification number and concentrations of Al, Dy, Eu, La, Sm, Yb, and Lu.

* Definitions of entries under these headings are detailed in the **USER'S GUIDE**.

Table B-3 (Supplementary Data - Sediments) includes the SRL identification number and the following entries:

SAMPTYPE	Type of soil, sediment, etc., sampled (see Table 2 in the USER'S GUIDE).
ROCKTYPE	Type of rock underlying sampling site.*
SEDSIZE	Dominant size of particles in sediment at site.*
STRWIDTH	Size and flow rate of stream at sampling site.*
STRDEPTH	
STRFLOW	
STRLEVEL	
VEGTYPE	Dominant type of vegetation at site.*
VEGDENS	Vegetation density at site.*
RELIEF	Local relief at site.*
COMPOSIT	Number of subsamples blended into sample.*
CONTAMN1	Activities or contaminants that may affect the material sampled.*
CONTAMN2	
CONTAMN3	
CONTAMN4	
FORMATION	The rock formation that underlies the site.*
ODOR	Odors detected in sampled material.*
WATERTEMP	Water temperature in °C.
SAMPDATE	Date sample was collected.
TEAM	Numerical designator of sample collection team.

Site descriptions and field measurements are recorded on the SRL Field Data Form (Figure 3). Data are recorded in the spaces numbered 1 through 80. The spaces have self-explanatory labels. Spaces whose numbers are circled are filled with one of the choices

* Definitions of entries under the headings are detailed in the **USER'S GUIDE**.

listed beneath the appropriate number on the Field Data Form. Some data are listed differently on the Field Data Form and in the data tables on microfiche. For example, well water samples are coded as Sample Type "C" on the Field Data Form and are reported as Sample Type "52" in Table A-1. Details of how the Field Data Form is used can be found in the **USER'S GUIDE** and in Price and Jones (1979).

Elemental Analyses

The elements after uranium are generally listed alphabetically. Concentrations of each element are reported in parts per million (ppm) by weight for sediment samples and parts per billion (ppb) for water samples. Values have been rounded to appropriate significant figures. Note that elemental (not oxide) concentrations are quoted in this table. Values below detection limits are indicated by a minus (-). For example, -3 means that the sample contains less than 3 ppm of that element. If background is high, a period (.) is used to indicate that the element was not detected, and that an estimate of the detection limit is not available for that element. Missing data are indicated by "M". All analytical results are missing when there was insufficient sample for analysis.

RESULTS AND DISCUSSION OF THE DATA

Surface Sediment Samples

Sediment samples were collected from 1713 surface sites in the Elko 1° x 2° NTMS quadrangle. Basic statistical data for uranium and 16 other elements in these sediments are given in Table 5. Log histograms, cumulative frequency plots, and areal distribution maps for these 17 elements as well as elemental ratios (U/Th and U/Hf) are shown on the microfiche sediment plots.

SRL experience suggests that most uranium in surface sediment samples is present in resistate minerals. Interpretation of the areal distribution of uranium (Plate 4) is best done by studying the areal distributions of the ratio of uranium to geochemically associated elements such as Th, Hf(Zr), Ce, etc. Elemental associations suggested here should be considered speculative pending detailed mineralogical investigations.

An areal distribution map of uranium concentrations in a given stream sediment sample may be more dependent on stream gradient or sampling conditions than on any proximity to a commercial uranium deposit. For example, if uranium were uniformly present in the mineral zircon at a concentration of 5000 ppm, then a uranium distribution map for stream sediment samples comprised of particles

TABLE 5

Statistical Summary of
Elemental Analyses - Sediments; Elko

Element	n*	Measured Values		Log Mean††	Log Std. Deviation
		Max.**	Min.†		
U	1694	67.5	0.7	0.47	0.16
Th	1689	124	2	1.06	0.13
Hf	1536	36	1	0.73	0.21
Al	1707	98,400	15,000	4.67	0.14
Ce	1629	415	10	1.76	0.17
Fe	1689	81,700	6200	4.36	0.14
Mn	1643	4270	80	2.70	0.14
Na	1690	96,800	1200	4.01	0.18
Sc	1699	14.1	0.8	0.69	0.15
Ti	1411	14,300	700	3.56	0.17
V	1700	280	9	1.70	0.16
Dy	620	44.4	0.1	0.50	0.36
Eu	741	7.5	0.3	0.09	0.22
La	1693	198	6	1.43	0.16
Lu	1359	1.4	0.1	-0.56	0.17
Sm	1678	53	1.0	0.52	0.18
Yb	765	11.3	0.7	0.35	0.17

* Number of observations.

** Elemental concentrations in ppm

† Minimum or detection limit.

†† Mean of values above detection limit; $[(\sum \text{Log}_{10} x)/n]$.

of less than 149 micrometers would have highs and lows which were functions of many factors. These include: (1) the areal distribution of zircon, (2) the areal distribution of zircon grain size, (3) the effectiveness of sampled streams in sorting and concentrating zircon relative to diluent minerals such as quartz or micas, and (4) the effectiveness of the sampling method in obtaining "representative" samples.

On the other hand, comparison of a map showing the distribution of uranium with a map showing the distribution of the U/Hf (or U/Zr) ratio should show where zircon is an important contributor to the amount of uranium. The areal distribution of this ratio is presented on microfiche. The ratio of U/Hf should be low where zircon is the primary mineral host of uranium in sediment samples. High values of the ratio indicate areas where uranium is present in minerals other than zircon or where zircon is particularly enriched in uranium.

Using the same logic, areas where values of the U/Th ratio (on microfiche) are high show either that uranium is present in minerals other than resistates (such as monazite) or that these resistates are particularly enriched in uranium. Anomalous areas which persist on several ratio figures may be areas where uranium is present in some mineral other than common resistate minerals. If these anomalous areas are supported by other considerations (such as radioactivity highs, geologic conditions, or high values of dissolved uranium in natural waters), then they may warrant a detailed field examination or detailed geochemical sampling.

Several areas within the Elko quadrangle have relatively high uranium concentrations in the sediment samples. The largest such area, in the central portion of the Ruby Mountains (see areal distribution maps on microfiche), consists of lower Paleozoic sediments intruded by Mesozoic and Tertiary granitic plutons. Some of the sediment samples have high U/Th and U/Hf ratios. Several of the ground water samples from this area have relatively high uranium and helium concentrations. All of these factors suggest that within this area there is significant uranium mineralization which is not within resistate minerals.

A small uranium anomaly is located in the extreme southeastern corner of the 15' map unit CE. This anomaly persists on the U/Th and U/Hf ratio plots. This area has some of the only outcrops of the Aztec Sandstone and Chinle Shale in the Elko quadrangle. Uranium is mined from these formations in other areas.

Sediment samples from the Dolly Varden Mountains contain some anomalous uranium concentrations. These samples may be associated with a Cretaceous granitic intrusive unit in these mountains. The samples also have anomalous thorium concentrations, suggesting that most of the uranium may be held within monazite crystals.

Stream and Ground Water Samples

Water samples were collected from 154 ground water sites in the Elko quadrangle. A statistical summary of key field measurements and elemental analyses for ground water sites is given in Table 6. Log histograms, cumulative frequency plots, and areal distribution plots for uranium and ten other elements (Al, Br, Cl, Dy, F, He, Mg, Mn, Na, and V) in ground waters are shown on microfiche. Helium concentrations were determined by mass spectrographic analyses.

Uranium concentrations in stream and ground water samples are dependent on several factors: (1) the concentration of uranium in the rocks and soils through which the ground water passes, (2) the rate at which uranium-bearing minerals in the rocks (soils) release uranium, (3) the hydrologic character of the rocks (soils), and (4) the chemistry of the water (especially Eh, pH, and alkalinity).

The interpretation of uranium analyses in natural waters is not straightforward. In active roll-front deposits, solubility of uranium may be low. Concentrations of uranium in natural waters may be very low near areas of active uranium deposition or very high in oxidizing zones near dissolving ore bodies.

Uranium concentrations in water can be expected to vary with total dissolved solids in the water. Because conductivity of water increases with increasing total dissolved solids, the ratio of uranium concentration to conductivity gives an approximation of the proportion of uranium in natural waters. The areal distribution of uranium concentration/conductivity ratios for ground water and stream water are shown on the ground-water and stream-water plots on microfiche.

Interpretation of the ground-water analyses is tenuous due to the scarcity and spacing of the 154 samples collected. The sites with anomalous helium and uranium concentrations are in areas with anomalous sediment samples.

TABLE 6

Statistical Summary of Field Measurements and
Elemental Analyses - Ground Water; Elko

Variable	n*	Measured Values		Mean††	Log Mean	Log Std.¶ Deviation	Standard Deviation (±1σ)
		Max.**	Min.†				
pH	154	10.3	6.4	7.72			0.61
Conductivity	154	2550	65		2.49	0.24	
Alkalinity	154	18	0.4		0.48	0.23	
U	153	53.4	0.02		0.31	0.59	
Al	131	7600	81		2.39	0.39	
Br	101	2130	13.6		2.07	0.37	
Cl	154	1,150,000	11,600		4.49	0.29	
Dy	9	4.3	0.05		-0.55	0.63	
F	123	5100	18		2.20	0.45	
He¶¶	148	310	2.3		0.78	0.23	
Mg	143	61,000	1160		4.04	0.36	
Mn	14	357	19.6		2.13	0.32	
Na	154	640,000	5420		4.32	0.36	
V	90	100	0.8		0.68	0.40	

* Number of observations. Some values are missing for reasons other than being below detection limit.

** Elemental concentrations in ppb; conductivity in $\mu\text{mhos/cm}$; alkalinity in meq/L .

† Minimum or detection limit.

†† Mean of values above detection limit.

¶ Log units; $[(\sum \text{Log}_{10} x)/n]$.

¶¶ Helium in ppm by volume in 2 mL air gap over 200 mL of water.

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No.	Period	SRL Doc. No.	DOE-GJO Doc. No.*
1	January-March 1975	DPST-75-138-1	GJRX-5(76)
2	April-June 1975	DPST-75-138-2	GJBX-6(76)
3	July-September 1975	DPST-75-138-3	GJBX-7(76)
4	October-December 1975	DPST-75-138-4	GJBX-8(76)
5	January-March 1976	DPST-76-138-1	GJBX-17(76)
6	April-June 1976	DPST-76-138-2	GJBX-27(76)
7	July-September 1976	DPST-76-138-3	GJBX-63(76)
8	October-December 1976	DPST-76-138-4	GJBX-6(77)
9	January-March 1977	DPST-77-138-1	GJBX-35(77)
10	April-June 1977	DPST-77-138-2	GJBX-55(77)
11	July-September 1977	DPST-77-138-3	GJBX-90(77)
12	October-December 1977	DPST-77-138-4	GJBX-37(78)
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15	October 1978-March 1979	DPST-79-138-1	GJBX-86(79)
16	April-September 1979	DPST-79-138-2	GJBX-160(79)
17	October 1979-March 1980	DPST-80-138-1	(in process)

SRL-146, SRL-NURE Data Reports, E. I. du Pont de Nemours & Co.,
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No.	NTMS 1° x 2° Quadrangle	SRL Doc. No.	DOE-GJO Doc. No.*
1	Winston-Salem†	DPST-77-146-1	GJBX-66(77)
2	Spartanburg	DPST-77-146-2	GJBX-09(78)
3	Charlotte	DPST-78-146-1	GJBX-40(78)
4	Greenville	DPST-78-146-2	GJBX-47(78)
5	Winston-Salem††	DPST-78-146-3	GJBX-58(78)
6	Greensboro	DPST-78-146-4	GJBX-74(78)
7	Knoxville	DPST-78-146-5	GJBX-75(79)
8	Scranton	DPST-78-146-6	GJBX-02(79)
9	Athens	DPST-78-146-7	GJBX-20(79)
10	Harrisburg	DPST-79-146-1	GJBX-31(79)
11	Portland	DPST-79-146-2	GJBX-28(79)
12	Glens Falls	DPST-79-146-3	GJBX-44(79)
13	Augusta	DPST-79-146-4	GJBX-45(79)
14	Dyersburg	DPST-79-146-5	GJBX-58(79)
15	Poplar Bluff	DPST-79-146-6	GJBX-63(79)
16	Hartford	DPST-79-146-7	GJBX-94(79)
17	Williamsport	DPST-79-146-8	GJBX-152(79)
18	Newark	DPST-79-146-9	(in process)
19	Albany	DPST-79-146-10	GJBX-140(79)
20	Atlanta	DPST-79-146-11	GJBX-129(79)
21	Delta, Richfield†††	DPST-79-146-12	GJBX-161(79)
22	Walker Lake	DPST-79-146-13	GJBX-107(80)
23	McDermitt, Wells†††	DPST-79-146-14	GJBX-117(80)
24	Reno	DPST-79-146-15	GJBX-108(80)
25	Death Valley	DPST-79-146-16	(in process)
26	Flagstaff	DPST-79-146-17	(in process)
27	Marble Canyon	DPST-79-146-18	(in process)
28	Grand Canyon	DPST-79-146-19	(in process)
29	Pocatello	DPST-79-146-20	(in process)
30	Mesa	DPST-80-146-1S	GJBX-81(80)
31	Salton Sea	DPST-80-146-2S	GJBX-113(80)
32	Ritzville	DPST-80-146-3	(in process)
33	Elko	DPST-80-146-4	(this report)
34	Challis	DPST-80-146-5	GJBX-91(80)

† Sediment only.

†† Ground water only.

††† SRL analyses of samples collected by Lawrence Livermore
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