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RITZVILLE 1° x 2° NTMS AREA WASHINGTON

DATA REPORT

MASTER

NATIONAL URANIUM RESOURCE EVALUATION PROGRAM

HYDROGEOCHEMICAL AND STREAM SEDIMENT RECONNAISSANCE

C. B. BENNETT

**E. I. du Pont de Nemours & Co.
Savannah River Laboratory
Aiken, SC 29808**

PREPARED FOR THE U. S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC09-76SR00001

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C. B. BENNETT

Approved by

M. L. Hyder
Analytical Chemistry Division

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ABSTRACT

This data report presents results of ground water and stream/surface sediment reconnaissance in the National Topographic Map Series (NTMS) Ritzville 1° x 2° quadrangle. Surface samples (sediment) were collected from 1063 sites. The target sampling density was one site per 20 square kilometers (eight square miles). Dry conditions contributed to the relatively small number (109) of surface water samples collected. Ground water samples were collected at 830 sites. 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 applicable (pH, conductivity, and alkalinity), and (2) elemental analyses for sediment samples (U, Th, Hf, Al, Ce, Dy, Eu, Fe, La, Lu, Mn, Sc, Sm, Na, Ti, V, and Yb). Sample site descriptors (stream characteristics, vegetation, etc.) are also tabulated. Areal distribution maps, histograms, and cumulative frequency plots for most elements; U/Th, U/Hf, and Th/La ratios; and scintillometer readings for sediment samples are included on the microfiche.

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(In Pocket)

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RITZVILLE TABLES

Tabulated reconnaissance data and elemental concentrations in surface sediment samples and ground water samples (Tables A-1, A-2, B-1, B-2, B-3, and C-1).

RITZVILLE SEDIMENT PLOTS

Areal distribution maps, histograms, and cumulative frequency plots for U, Th, Hf, La, Ce, Al, V, Ti, Mn, Fe, Sc, Na, Sm, Eu, Dy, Yb, Lu, scintillometer readings, conductivity, alkalinity, ph, log (U/Hf), and log (U/Th).

RITZVILLE SURFACE WATER PLOTS

Areal distribution maps, histograms, and cumulative frequency plots for U, Th, Na, Mg, Al, Mn, Br, Dy, V, Sc, conductivity, alkalinity, pH, and U x 1000/conductivity.

RITZVILLE 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 x 1000/conductivity, He, and scintillometer readings.

USER'S GUIDE**RITZVILLE SURFACE SITE CODE MAP****RITZVILLE GROUND WATER SITE MAP**

DATA REPORT: RITZVILLE 1° x 2° NTMS QUADRANGLE:
WASHINGTON

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. 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 Ritzville 1° x 2° NTMS Quadrangle

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

GEOLOGIC SUMMARY AND MINERAL OCCURRENCES

General Features

The Ritzville 1° x 2° NTMS quadrangle lies mostly within the Columbia Plateau and is largely covered by basalt of the Columbia River Basalt Group. Only the north and extreme northwestern areas of the quadrangle lie outside the Columbia Plateau (Figure 2). The transition from the Columbia Plateau to older crystalline terraine is marked by the Columbia River, except for the Pitney Butte area north of Davenport where older crystalline rocks are found in outcrop. Rocks of the northeastern part of the quadrangle lie in the Okanogan Highlands, while rocks of the northwestern corner lie in the Northern Cascades.

Geology

Crustal unrest in early Tertiary time concluded with mountainous terraine under active erosion in the area of the Ritzville quadrangle (Griggs, 1976). Eocene-age volcanic deposits are present in the quadrangle (Pearson and Obradovich, 1977) and the basalt flows were deposited on a thickly weathered sequence of Tertiary volcanics with considerable relief (Raymond and Tillson, 1968; Newman, 1970; Jackson, 1975; Swanson and others, 1979). The Columbia River Basalt Group (Griggs, 1976) is generally typical of flood-basalt provinces (Greeley, 1977). Flows advanced as sheet floods, forming thick cooling units composed of one or more thinner flows and covering as much as 40,000 km² with a maximum volume of 700 km³ (Swanson and others, 1979).

Basement rocks of the Columbia Plateau are principally Precambrian sedimentary rocks of the Belt Supergroup (Griggs, 1973). Paleozoic sedimentary rocks make up a small percentage of the basement rocks and are exposed in the northern part of the Ritzville 1° x 2° NTMS quadrangle. These Paleozoic rocks have been intruded by many granitic plutons of Mesozoic (Cretaceous) and Cenozoic (Tertiary-Eocene) age. Grouping of these plutons formed the Loon Lake batholith (Weaver, 1920), located in the northern part of the quadrangle. The Belt Supergroup has been folded, faulted, and metamorphosed (Griggs, 1976).

Columbia Plateau

Russel (1893) called the Columbia Plateau basalts "Columbia lavas" and later changed to "Columbia River lavas". Pardee and Bryan (1926) termed the plateau basalts "rim-rock" flows. The interlayered relations between the basalt and lacustrine deposits

in this general area were described by Kirkham (1926) and Kirkham and Johnson (1929). After long, informal usage, the term Columbia River basalt was raised to Group rank by Waters (1961), but later modification of the group (Thayer and Brown, 1966) seriously altered the usage. Griggs (1976) restricted the usage by renaming the group as the Columbia River Basalt Group which remains as the current terminology. Swanson and others (1979) worked out a formal stratigraphic division of the Columbia River Basalt Group. They relied on petrography, magnetic polarity, and chemical composition as criteria to identify stratigraphic units. They further indicate that chemical analysis was so helpful and (in places) necessary, that "no field study of the basalt should be undertaken without provision for chemistry".

The thickness of the basalt has been affected by prebasalt topography--a paleoslope to the west has been suggested by Griggs (1976)--and by subsidence during and after basalt extrusion. Subsidence of the Columbia Plateau began no sooner than late Grande Ronde time as indicated by the lack of interbeds within the Grande Ronde Basalt and by the presence of interbeds along the margin of the plateau, along with a similar thickness of Unit N₂ in the Grande Ronde Basalt in and west of the Pasco Basin (Beck and others, 1978). The continuing presence of a regional westward paleoslope prior to and during Grande Ronde time (Swanson and Wright, 1976) suggests subsidence likely began in post-Elephant Mountain time [10.5 million years before the present (Myr BP)] and was likely completed by Lower Monumental time (6 Myr BP). Most of the Columbia River Basalt Group was erupted before about 14 Myr BP and the later subsidence appears to be from tectonic causes (Swanson and others, 1979).

Much of the basalt of the Columbia Plateau area is mantled by Pleistocene loess deposits of the Palouse Formation which reaches a thickness of as much as 75m (250 ft) near the southeast corner of the quadrangle (Ringe, 1970). Channeled scab-land of the plateau was formed when parts of the loess mantle were stripped by the Spokane Flood (Bretz, 1959).

The Grande Ronde Basalt is the oldest, most voluminous, and areally extensive formation of the Yakima Basalt Subgroup of the Columbia River Basalt Group. The Grande Ronde Basalt has an estimated volume of more than 150,000 km³ (Swanson and others, 1979) with thicknesses up to 1,000 m. The Grande Ronde Basalt is normally capped by thick soil and autochthonous sediment deposits.

The Wanapum Basalt is the most extensive formation exposed in the Ritzville 1° x 2° NTMS quadrangle, but probably has a volume of less than 10,000 km³. The Wanapum Basalt overlies the Grande Ronde Basalt, locally conformably.

The Saddle Mountains Basalt is the youngest formation in the Columbia River Basalt Group and has a volume of about 2,000 km³ (Swanson and others, 1979). The Saddle Mountains Basalt tends to fill valleys, canyons, gorges, and basins of the Columbia Plateau.

The Columbia River Basalt Group typically contains gray to almost black fine-grained to aphanitic basalt. Tops and bottoms of flows are typically vesicular. The rest of the flow exhibits dense or occasionally patchy diktytaxitic textures. Where the top of a flow is not severely weathered, it is commonly scoriaceous. Vesicles extend through many feet at the top of flows but are found in only a narrow band at the base. The base of flows normally display well-developed columnar jointing, termed colonnade jointing (Mackin, 1961). Colonnade jointing penetrates less than a third of an individual cooling unit. The rest of the unit is jointed in an irregular, poorly developed style called entablature (Mackin, 1961). Single flows and groups of flows have been traced by a number of investigators (Mackin, 1961; Bingham and Walters, 1965; Bingham and Grolier, 1966; Schmincke, 1967a; Grolier and Bingham, 1971).

Near the margin of the Columbia Plateau, pillow-palagonite complexes formed from fluid lava invading water or marshland (Fuller, 1931). The pillow-palagonite complexes commonly form the basal part of a flow and may be as much as 25 m (~80 ft) thick. The pillow-palagonite complexes normally lie directly on a sedimentary interlayer (Griggs, 1973). Where fluid lava invaded a wet unconsolidated sedimentary deposit, a strong, explosive disruption occurred. This resulted in a mixture of fragmented lava, much of it palagonitized sideromelane, and broken and shattered sedimentary rock called peperite (Schmincke, 1967b).

The thickness of the basalt layer in the Ritzville 1° x 2° NTMS quadrangle varies from less than 30 cm (1 ft) along the margin to at least 1421 m (4,665 ft) near Odessa, Washington (Griggs, 1973). Brown (1970) believes part of the depth of Odessa is from older Tertiary flows but the evidence is inconclusive (Griggs, 1973).

The source of the Columbia River Basalt Group appears to be from dike invasion of fissures (Lindgren, 1901; Waters, 1961). Reck (1910) considered the possibility that lava issued simultaneously from many vents throughout the area, while Swanson and others (1975) consider at length the probability that the lava was erupted from vents that were restricted geographically but were possibly located at various points in the Columbia Plateau. Swanson and others (1975) found no evidence of areal eruptions for any of the flow sequences of the plateau and some of the widespread Yakima flows apparently traveled as much as hundreds of kilometers from their source (Mackin, 1961; Schmincke, 1967a,b; Swanson, 1967).

The principal dike system of the Columbia Plateau is the Chief Joseph dike swarm of extreme northeast Oregon and nearby parts of Washington and Idaho (Waters, 1961; Taubeneck, 1970). Taubeneck estimates at least 21,000 dikes may be present in the Chief Joseph dike swarm. Irwin (1938) reported a set of possible Yakima feeder dikes in the area of Grand Coulee Dam, but Swanson and others (1975) believe these dikes are older than the Columbia River Basalt Group. However, Swanson and others (1975) found a possible feeder dike along the west shore of Banks Lake in the Ritzville 1° x 2° NTMS quadrangle. The existence of multiple-vent areas follows the suggestion of Shaw and Swanson (1970) that multiple vents would be necessary for the eruption of large volumes of lava in short periods of time.

The Roza Member of the Wanapum Basalt is one of the most widespread of the units in the Yakima Basalt Subgroup. Watkins and Baski (1974) date the Roza Member at about 15 Myr BP (Miocene Epoch). Lofgren (1974) sites evidence of rapid cooling in widespread areas of the Columbia Plateau for the Roza Member that suggest emplacement rates so rapid that cooling during transport was minimal. Shaw and Swanson (1970) further suggest a period involving only several days to a week for emplacement of the Roza Member, requiring a large vent system for the eruption of hundreds of cubic kilometers of lava in such a short time. Swanson and others (1975) suggest the possibility of a large number of feeder dikes in areas outside the Chief Joseph dike swarm to account for the flow rates required.

Okanogan Highlands and Northern Cascades

Rocks of the Okanogan Highlands within the Ritzville 1° x 2° NTMS quadrangle consists of two general groupings, the Loon Lake batholith (Weaver, 1920), and the Sanpoil volcanics (Pearson and Obradovich, 1977). Rocks of the Loon Lake batholith vary widely in composition but are generally granitic (Miller and Engles, 1975). The age of the Loon Lake batholith ranges principally within 90 to 110 Myr BP. The Loon Lake batholith includes granitic intrusives which appear to have contained uranium and were intruded in a situation favorable for the formation of ore-grade deposits.

The Sanpoil volcanics (Muessig, 1962) consist of a thick unit of rhyodacitic lava flows, volcanic breccias, tuffs, and associated sedimentary rocks. The age of the Sanpoil volcanics is Eocene (Pearson and Obradovich, 1977).

Rocks of the northwestern corner of the Ritzville 1° x 2° NTMS quadrangle lie in the Northern Cascades and are of the Chelan Complex (Mattinson, 1972). The Chelan Complex consists of gneisses and intrusives (principally quartz diorite) in this quadrangle.

Mineral Resources

General

The mineral resources of the Ritzville 1° x 2° NTMS quadrangle vary according to the province involved. Mineral resources of the Columbia Plateau include basalt (for crushed stone), peat, saline lake deposits, diatomite, caliche, sand and gravel, pumice, sodium carbonate, oil, and gas. Saline lakes of the quadrangle are found in Soap Lake and Mitchell Lake (Bennett, 1962). Caliche occurs in the south and southwest area of the quadrangle. Pumice occurs over a wide range in the northwestern part of the quadrangle and has had commercial production from several deposits. Sodium carbonate has been produced from an area near the center of the quadrangle. Sand and gravel has been produced principally from areas located within access to railroads. Oil and gas potential of the Columbia Plateau has been outlined by Glover (1936). References concerning metallic minerals of the quadrangle include Moen (1976), silver; Purdy (1954), molybdenum; Bennett (1941), magnesite; Mills (1977), zinc and lead; and Huntting (1955), gold. References on nonmetallic mineral resources include Valentine (1960), general; Glover (1936), oil and gas; Carithers (1946), pumice; Huntting (1949), perlite; Rigg (1958), peat; and Bennett (1962), saline lake deposits. Metallic deposits occur principally in the Okanogan Highlands.

Uranium

Only a few scattered occurrences of radioactive minerals were known in Washington until 1954, when the Midnite mine deposit was discovered in the Ritzville 1° x 2° NTMS quadrangle (Conrad, 1955). Detailed accounts of the geology and ore body worth reading include those by Barrington and Kerr (1961), Nash and Lehrman (1975), and Nash (1975, 1977, 1978, 1979). The Midnite mine is located in the Okanogan Highlands at location T.28N., R.37E., Sects. 1, 2, 11, and 12 in the northeastern corner of the Ritzville 1° x 2° NTMS quadrangle.

Uranium mineralization (Table 1) occurs along the contact between the Cretaceous Loon Lake granite and Precambrian meta-sediments, principally associated with fractures and shear zones. Above the water table, the ore zone consists of secondary, oxidized, uranium minerals, principally autunite and meta-autunite. Below the water table, the ore is made up of uraninite and sulfide mineralization. The primary ore zone was likely precipitated from hydrothermal solutions of moderate temperatures.

The Loon Lake granite (Weaver, 1920) occurs in tongues and ridges which have intruded the Toto Formation (Shelden, 1959) metasediments of the Deer Trail argillites. The specific member that was intruded at the mine is the Prichard schist. Quartz of the granite is smoky near ore bodies (Wright and Bieler, 1960).

Other mines and prospects of the Ritzville 1° x 2° NTMS quadrangle include anomalies similar to the Midnite mine. Most of the land in the area of similar terraine, with or without anomalies, is currently under lease. About ten kilometers south of the Midnite mine, the Lowley lease prospect is located in a zone of shattered rock at the contact of impure quartzite and granodiorite. At the nearby Big Smoke lease, mineralization has been noted along the fault contact between granodiorite and the Gerome andesite.

The Northwest Uranium mine, located about 7 kilometers southeast of the Midnite mine, contains uranium ore in a carbonaceous conglomerate of the Gerome andesite. The Gerome andesite locally consists of about 30 m (100 ft) of poorly sorted, locally carbonaceous, conglomerate overlain by interbedded tuffaceous sandstone, arkose, and carbonaceous shales. The unit is underlain by quartz monzonite of the Loon Lake granite and the ore zone is located near the base of the conglomerate.

The Spokane Molybdenum mine is located on the northeast side of Pitney Butte. This locality contains a wide range of sulfide minerals. Some pitchblende has been noted at depth in the mine. South of Electric City, a small amount of polycrase in pegmatite was noted as uranium-bearing (Huntting, 1956).

The Latah Formation consists of detrital sedimentary rocks associated with the Columbia River Basalt Group. The Latah Formation is made up of accumulations of sediments which occurred principally during periods of quiescence between flood basalt outpourings. The Latah Formation was examined for uranium potential (Wopat, 1978) and found to be unfavorable for ore-grade uranium deposition.

TABLE 1

Principal Uranium Occurrences in the Ritzville 1° x 2° NTMS Quadrangle

Site	Location	Name	Description
1	T.28N., R.37E., Sec. 1, 2, 11, and 12	Midnite mine	Uranium minerals in joints and fractures along contact with porphyritic quartz monzonite and metasediments.
2	T.27N., R.37E., SW1/4 Sec. 13	Lowley lease	Uranium minerals deposited on grain boundaries and fractures along contact between quartz monzonite and quartzitic schist.
3	T.28N., R.37E., SE1/4 Sec. 32	Spokane Molybdenum mine	Uranium minerals in quartz veins in altered granite.
4	T.27N., R.30E., Sec. 6	Grand Coulee	Polycrase in pegmatite.
5	T.27N., R.37E., E1/2 Sec. 14	Bair Mine	Veinlets of uranium minerals.
6	T.27N., R.37E., Sec. 11	Big Smoke Uranium mine	Uranium minerals in country rock associated with granitic intrusive.
7	T.28., R.37E., Sec. 13	Dahl Uranium mine	Uranium minerals in country rock associated with granitic intrusive.
8	T.28N., R.37E., Sec. 7	Lucky Charm Uranium mine	Uranium minerals in joints in altered basalt.
9	T.28N., R.37E., Sec. 25	Northwest Uranium mine	Uranium minerals in fault and carbonaceous zones of Gerome andesite sedimentary units overlying granite.

Ages of Area Rocks

Current age dates are sparse in the Ritzville 1° x 2° NTMS quadrangle (Table 2), but a general guide to ages of rocks in the quadrangle can be gained from the ages of rocks in nearby quadrangles.

Miller and Engles (1975) dated plutonic rocks of the Sandpoint and Spokane 1° x 2° NTMS quadrangles to the northeast and east of the Ritzville quadrangle. At least the western portion of the area dated is part of the Loon Lake batholith. They indicate four episodes of intrusion at about 200+, 170, 93 to 101, and 45 to 51 Myr BP. The events of 200+ and 170 Myr BP represent isolated plutons. The event during 93 to 101 Myr BP is represented by widespread plutonism, and the Loon Lake batholith likely formed at this time. The youngest event at 45 to 51 Myr BP is represented by plutons farther east of the quadrangle, in the area of the Washington-Idaho border and the Purcell Trench structure.

The Sanpoil volcanics as mapped by Pearson and Obradovich (1977) include all the volcanic and sedimentary rocks of the northeast corner of the quadrangle. They dated rocks of the Sanpoil structure as 50 to 52 Myr BP or Eocene in age.

The Columbia River Basalt Group in the Ritzville 1° x 2° NTMS quadrangle includes the Yakima Basalt Subgroup. The oldest of the, basalt flows in the quadrangle, the Grande Ronde Basalt ranges in age from 14 to 16.5 Myr BP (Swanson and others, 1979; Watkins and Baski, 1974). The youngest basalt flow of the quadrangle is the Wilbur Creek Member of the Saddle Mountains Basalt which is no younger than 12 Myr BP (McKee and others, 1977; Swanson and others 1979).

Map Units

The map units listed below have been adopted or quoted from Swanson and others (1979).

QUATERNARY

Qs **SEDIMENTARY DEPOSITS.** Alluvium, moraine, and glacial outwash material, and gravel, sand, and silt deposited by Missoula floods. Locally includes loess of Palouse Formation. More extensive than shown; generally mapped only where important bedrock relations are obscured.

TABLE 2

Radiometric Age Dates of Rocks in the Ritzville 1° x 2° NTMS Quadrangle

Site No.*	Age	Rock Type	Mineral	Method/ Reference	Formation
1a	113	Quartz diorite gneiss	Zircon	2/1	Chelan Complex
1b	82	As above	Sphene	2/1	Chelan Complex
1c	113	As above	Zircon	3/1	Chelan Complex
1d	107(25)	As above	Zircon	4/1	Chelan Complex
2a	101	Qtz. diorite	Zircon	2/1	Chelan Complex
2b	100	As above		2/1	Chelan Complex
2c	87	As above	Sphene	2/1	Chelan Complex
2d	111(15)	As above	Zircon	4/1	Chelan Complex
3	20.6(0.7)	Basalt	Whole rock	1/2	Yakima Basalt
4	15.7(0.4)	Basalt	Whole rock	1/2	Yakima Basalt
5	105(10)	Qtz. monz.	Zircon	5/3	Loon Lake Granite
6	105(10)	Granodiorite	Zircon	5/3	Loon Lake Granite
7	100(10)	Granodiorite	Zircon	5/3	Loon Lake Granite
8	95(10)	Qtz. monz.	Zircon	5/3	Loon Lake Granite
9	95(10)	Granodiorite	Zircon	5/3	Loon Lake Granite
10	75(10)	Qtz. monz.	Zircon	5/3	Loon Lake Granite
11	50.3(1.4)	Amphibolite	Biotite	1/4	Sanpoil Volcanics (?)

*Explanation of Columns: Site No. is keyed to Plate 1B; Age No. in parens is the numerical value of uncertainty; Method, 1 is K/Ar, 2 is Pb(206)/U(238), 3 is Pb(207)/U(235), 4 is Pb(207)/Pb(206), 5 is Pb-alpha; Reference 1 is Mattinson (1972), 2 is Gray and Kittleman (1967), 3 is Beacraft and Weis (1963), 4 is Engles and others (1976).

- Qls **LANDSLIDE DEPOSITS.** Poorly sorted chaotic deposits, generally with hummocky topography. Mostly along contact of poorly lithified or clay-rich sediments and overlying flows of Grande Ronde Basalt or Wanapum Basalt. Includes deposits of block slides.
- Qts **LOESS AND RINGOLD FORMATION.** Mostly loess of Palouse Formation; but locally includes fine sand and silt, possibly correlative to Ringold Formation. More extensive than shown; mapped only where important bedrock relations are obscured.

TERTIARY (Miocene)

COLUMBIA RIVER BASALT GROUP, YAKIMA BASALT SUBGROUP.

- Sb **BASALT OF SPRAGUE LAKE.** Sparsely phyrlic basalt flow (or flows) filling shallow ancient valley; eroded into Priest Rapids Member in the Lamont-Sprague area southwest of Spokane. Chemically distinct from most other flows of Columbia River Basalt Group (T. L. Wright and D. A. Swanson, unpubl. data, 1978). Normal magnetic polarity. Possibly equivalent to Weissenfels Ridge Member of Saddle Mountains Basalt (Swanson and others, 1979).
- Wb **WANAPUM BASALT.** Includes Priest Rapids Member, Roza Member, and Frenchman Springs Member, undivided.

The **Priest Rapids Member** consists of fine- to coarse-grained basalt flows with reversed magnetic polarity (Rietman, 1966). Flows are typically of Rosalia chemical type (Swanson and Wright, 1978); and as such, are nearly aphyric with visible olivine in fine-grained samples. Near the border of the Latah Formation (Swanson and others, 1979).

The **Rosa Member** consists of one or two flows over most of its occurrence in the Columbia Plateau, but likely contains three flows in the Wilson Creek-Lower Grand Coulee area (Lefebvre, 1970). Basalt flows of the Roza Member chemical type (Wright and others, 1973) consistently contain several percent of single or clotted plagioclase phenocrysts averaging 10-mm across and evenly distributed throughout most flows (Swanson and others, 1979). Northeast of Moses Lake, the upper vesicular zone of a flow is aphyric or very sparsely phyrlic. In the area of Soap Lake, the Roza Member may be difficult to distinguish from the Frenchman Springs Member. The Rosa Member may pinch out in several places near the Columbia River north of Wilbur (Swanson and others, 1979). The Rosa Member exhibits transitional magnetic polarity (Rietman, 1966).

The **Frenchman Springs Member** (Wright and others, (1973) consists of many flows with irregularly distributed plagioclase glomerocrysts (to 50-mm across), while some flows are virtually aphyric (Swanson and others, 1979). The unit is generally fine- to medium-grained and is of normal magnetic polarity (Rietman, 1966).

Grb GRANDE RONDE BASALT. The Grande Ronde Basalt flows are the thickest and most voluminous of the Columbia River Basalt Group. They are generally fine-grained. Individual flows range in thickness from 1 m to 50 m, averaging between 10 and 20 m (Swanson and others, 1979). The flows are aphyric to very sparsely plagioclase-phyric. Near the margin of the Columbia Plateau, the Grand Ronde Basalt may be invasive into interbedded subarkosic sediments, forming sill-like bodies to 120 m thick (Hoyt, 1961; Byerly and Swanson, 1978; Swanson and Wright, 1978). In the margins of the Columbia Plateau, flows may be pillowed. The unit shows both normal and reversed magnetic polarity.

Tvs TERTIARY VOLCANIC AND SEDIMENTARY ROCKS, UNDIVIDED. Rocks of this unit are more widespread than mapping indicates, but are frequently thin or of limited extent. The unit is generally of fluvial or lacustrine origin and is formed of material eroded from the Columbia River Basalt Group. Members of this general grouping which may be found in the Ritzville 1° x 2° NTMS quadrangle include:

1. **Ellensburg Formation.** Weakly lithified sedimentary rocks interbedded with and overlying Columbia River Basalt Group.
2. **Subarkosic Deposits** of fluvial and lacustrine sandstone, siltstone, and lesser claystone and conglomerate, consisting chiefly of detritus eroded from rocks older than the Columbia River Basalt Group; mainly found along the present or inferred ancestral course of Columbia River. Commonly acts as host to invasive flows of Grande Ronde Basalt or Priest Rapids Member of Wanapum Basalt.
3. **Volcaniclastic Deposits** of well- to poorly-sorted and weakly lithified andesitic to rhyolitic detritus erupted from contemporaneous volcanoes in Cascade Range and transported into area by water, mudflows, air, and locally pyroclastic flows.
4. **Conglomerate of Snipes Mountain.** Weakly consolidated river gravel and sand containing abundant quartzite and meta-volcanic clasts. Interpreted as channel deposit of ancestral Columbia River (Schmincke, 1967a).

5. **Sandstone and Siltstone.** Moderately well-lithified arkosic to subarkosic deposits underlying (locally) the oldest flow of Grande Ronde Basalt along Columbia River north of Wilbur, Washington. Sandstone is commonly crossbedded; siltstone is leaf-bearing.
6. **Latah Formation.** Weakly lithified, fluvial and lacustrine arkosic sand-, silt-, and claystone. Interbedded through section of Columbia River Basalt Group (Griggs, 1976). Thickest deposits are found between Grande Ronde Basalt and Priest Rapids Member of Wanapum Basalt. Commonly contains invasive flows.
7. **Eocene Volcanic Rocks.** Includes Teanaway Basalt, Taneum Andesite, basalt of Frost Mountain (Tabor and others, 1980), rhyolite flows and tuff, and Sanpoil volcanics (Pearson and Obradovich, 1977).
8. **Eocene Sedimentary Rocks.** Includes the Roslyn and Chumstick Formations (Tabor and others, 1980; Gresens and others, 1977), the Swauk Formation, and Manastash Formation. Chiefly subarkosic sandstone.

PLUTONIC ROCKS (Tertiary and Mesozoic)

TMg Coarse-grained granitoids (chiefly granodiorite and quartz monzonite) associated with large batholithic complexes in the crystalline terrain along the northern margin of the Columbia Plateau. Probably mostly of Cretaceous and Eocene Age.

METAMORPHIC ROCKS (Mesozoic and Paleozoic)

MPm Metamorphic rocks of chiefly high-grade gneiss, schist, amphibolite, and foliated quartzite. Includes Swakane Biotite Gneiss, Methow Gneiss, relatively low-grade metamorphic rocks (particularly greenstone) of the Paleozoic Corvada Group (Campbell and Raup, 1964), and meta-sedimentary rocks of probable Paleozoic age (Griggs, 1973; Beacraft and Weis, 1963).

CAMBRIAN AND PRECAMBRIAN

CpCs Cambrian to Precambrian metamorphosed volcanic and sedimentary rocks, undivided. Principally rocks of the Belt Supergroup.

HYDROLOGY

Climate

The Ritzville 1° x 2° NTMS quadrangle area has long cold winters and short, fairly mild summers. The average July temperature is about 22°C. The average January temperature is about -4°C. These temperatures are fairly mild for this far north. Annual rainfall is fairly evenly distributed, ranging from about 200 mm in the dry southwest to more than 300 mm in the southeast (NOAA, 1977). Precipitation during the winter months occurs as snowfall. Precipitation data for the months in which field sampling took place are presented in Table 3.

Geography

Almost all of the quadrangle lies within the Columbia Plateau Province. A small area in the northeast corner, north of the Columbia River, is a remnant of the Rocky Mountain Province. This area has a rugged, subdued, mountainous topography characteristic of a variety of igneous and metamorphic rocks.

The Columbia Plateau Province is underlain by a series of lava flows of Tertiary age that are interlayered with lesser amounts of soils and clastic materials. The nearly sheet-like structure of the subsurface is also expressed in the land surface, where a moderately level plain is covered nearly everywhere by surficial sediments of varying thickness.

The flows, largely basalt, slope southwestward in much of the area, corresponding in general with the slope of the land surface. To a great extent, the geologic history during Pleistocene time has influenced the geography. During that time, glacial meltwater floods of enormous volumes swept across much of the pre-existing mantle of loess (wind-deposited silt), eroding the present drainageways, and exposing wide belts of basalt, today known as the "channeled scablands" (Bretz, 1959; Luzier and Burt, 1974). The region has a rolling surface of broad, rounded, wave-like swells in much of the upland areas covered by loess soils. In some scabland areas, the erosion by glacial meltwaters has exposed black basalts in channels and canyons, which are referred to as coulees.

The soils of the Columbia Plateau Province in the Ritzville quadrangle are relatively fertile. A large portion of the area is in the Columbia Basin Project and receives water from the many lakes, canals, and aqueducts. Wheat and vegetables are grown on the irrigated lands. The remaining area has grain crops for shipment and for support of livestock grazing.

TABLE 3

Precipitation for 1979 at Selected Weather Stations in the Ritsville Quadrangle

Weather Station and Elevation	Average Monthly Precipitation, mm											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Harrington 55 (641.4 m)	38.6	27.4	24.4	22.1	29.2	28.2	9.65	10.7	17.8	31.2	41.7	37.6
Mansfield (690.4 m)	35.1	25.7	18.5	20.6	27.2	30.7	7.11	13.5	12.7	20.6	36.3	39.6
Quincy 15 (388.3 m)	24.4	19.8	15.5	17.5	18.0	18.8	6.10	6.86	9.65	16.5	27.4	26.4

The area has many small towns but is still sparsely populated. The population is greater than 33,000, with Moses Lake accounting for about half of the population (U.S. Bureau of Census, 1970).

Drainage and Hydrology

The Columbia River is the dominant surface stream of the quadrangle, having an irregular westward course near the north border. The Grand Coulee Dam, on the Columbia River in the north-central area, stores much water in the deeply incised canyons of the river. A number of ephemeral and small perennial streams flow in a general southwestward direction toward Moses Lake. Much of the surface drainage is disarranged in the low flat plain in the southwestern part of the quadrangle, and considerable water is lost by evapotranspiration.

Groundwater is available in large quantities from the basalts that underlie the area south of Columbia River. Uncased well bores, 150 to 300 m deep, intersect a series of basalt aquifers that otherwise are poorly connected hydraulically (Luzier and Burt, 1974, p. 1). Many of the layered basalt beds contain permeable zones of broken basalt and sediments. Individual aquifers may be extensive over many square kilometers, but their permeability ranges markedly from place-to-place (Garrett, 1968, p. 6).

The gross movement of water in the basalt aquifers is in a southwest direction. The major recharge is almost entirely from hydraulically connected aquifers east and northeast of the quadrangle (Garrett, 1968, p. 8). The aquifers are generally 30 to 100 m below land surface; this range represents a composite confined, or artesian, water level. Heavy pumping for irrigation has lowered water levels in some areas. In other areas, there is a water table in the surficial deposits. In some coulee bottoms, especially in Crab Creek Valley, large yields are obtained from sand and gravel deposits only a few feet below the land surface.

The groundwater temperatures range from about 12° to 21°C (55° to 70°F), depending on the depth of the water table. The average temperature is about 16°C (60°F). The water is generally of good quality but has a high hardness content in most places.

Surface waters in the Columbia basin are of good quality and low in dissolved solids. Waters in the Crab Creek basin, which is part of the Columbia Basin Project, deteriorate in quality because of irrigation return flow from the area.

FACTORS AFFECTING THE DATA

Sediment and ground-water samples were collected during the summer of 1979. The lack of surface-water sites is due to the arid nature of most of the Ritzville 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, 107 sediment and 83 ground-water sampling sites were field-checked by an SRL subcontractor during November 1979. Ninety-seven percent of the sites checked were found to be located within 500 m (0.3 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. Analyses of the standards indicate the level of precision and provide routine checks of the analytical equipment and software. Tables 4a, 4b, 4c contain the results from the standards run during the same time period as the Ritzville 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.).

SRL FIELD DATA FORM

SITE CODE								DATE								TEAM NO.		SURFACE SITE DATA																FORMATION		ODOR																																											
Sheet		Map Code		Site Number				Mo.	Day			Yr.	Hr.					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 μ mhos/cm		WATER TEMP. °C		ALKALINITY		Drops H_2SO_4		ml Water		ml OF WATER ION-EXCHANGED		WELL DEPTH		Condepth		Well Class.		Where Sample Taken		STATE		SCINTILLOMETER READING				Inform. Request		DO NOT USE		CARD CODE																																															
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>(63)</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 4

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	19.7	16.2	22.2
Th	30	108	17.7	125
Hf	26	109	23.9	173
Al	30	6350	20.1	6500
Ce	24	531	21.5	614
Fe	29	7750	34.6	6700
Mn	26	314	85.6	300
Sc	30	2.58	37.4	3.9
Na	26	127	24.6	145
Ti	29	10,600	23.8	13,200
V	30	31.5	19.9	34.7
Dy	29	17	38.4	<22
Eu	24	2.9	109	2.5
La	30	325	25.3	301
Lu	25	2.4	22.0	2.9
Sm	27	47.1	37.8	51.3
Yb	24	15.9	22.3	18.2

TABLE 4 (Continued)

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	28	39.3	22.3	41.3
Th	28	145	22.4	162
Hf	16	4.8	57.4	7.4
Al	27	35,200	22.9	30,600
Ce	23	791	24.5	903
Fe	28	15,600	28.3	15,200
Mn	27	399	115	289
Sc	28	4.0	30.8	4.19
Na	25	1450	184	901
Ti	17	4820	18.9	6100
V	27	46.7	24.8	54.4
Dy	24	42.3	50.8	50*
Eu	27	3.5	41.2	3.86
La	28	406	23.7	443
Lu	23	4.1	25.4	4.4
Sm	23	71.7	73.0	69.2
Yb	25	28.7	26.0	29.9

* Only one laboratory reported values for dysprosium.

TABLE 4 (Continued)

c. Sediment Standard SRL 4.1

<u>Element</u>	<u>Number</u>	<u>Mean, ppm</u>	<u>Coefficient of Variation, %</u>	<u>Accepted Value, ppm</u>
U	28	0.5	14.7	0.58
Th	13	2.9	31.0	2.1
Hf	25	2.9	31.1	4.4
Al	28	59,700	25.9	66,700
Ce	15	51.1	27.1	44
Fe	28	77,200	13.6	87,300
Mn	24	1,520	21.9	1970
Sc	28	13.2	36.1	21
Na	27	15,500	21.6	16,100
Ti	23	19,700	24.1	25,200
V	27	217	20.6	273
Dy	3	4.4	97.4	<22
Eu	20	1.2	49.6	1.16
La	23	15.2	22.2	18.6
Li	16	0.2	36.6	0.28
Sm	22	2.9	30.6	4.2
Yb	7	1.6	24.3	1.6

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 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 **RITZVILLE TABLES**. Sediment analyses and site descriptions are tabulated in Tables B-1, B-2, and B-3, which are also on the microfiche titled **RITZVILLE TABLES**. Surface water analyses are tabulated in Table C-1, which is also on the microfiche titled **RITZVILLE 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. RZ is the two-letter designator for the Ritzville 1° x 2° NTMS quadrangle. The third and fourth letters define which 15-minute quadrangle contains the sampling site (see chart below).

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 Ritzville 1° x 2° NTMS quadrangle would be RZAH001.

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)
23-23	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.
DPHCONF	Confidence in depth measurement.
WELCLASS	Classification of well use.
SMPPOINT	Point in plumbing system where water was taken.
WELLODOR	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 RITZVILLE 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, Hf, 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.

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

SAMPTYPE	Type of soil, sediment, etc., sampled.
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
STRDEPTH	site.
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
CONTAMN2	the material sampled.
CONTAMN3	
CONTAMN4	
FRMATION	The rock formation that underlies the site.
ODOR	Odors detected in sampled material.
WATRTEMP	Water temperature in °C.
SAMPDATE	Date sample was collected.
TEAM	Numerical designator of sample collection team.

Surface water analyses are tabulated in Table C-1 on the microfiche labeled RITZVILLE TABLES.

Table C-1 includes SRL and DOE identified similar to those described above for ground water sites. Table C-1 also includes pH, conductivity, and alkalinity, plus elemental concentrations of U, Al, Br, Cl, Dy, F, Mg, Mn, Na, V, and U x 1000/conductivity.

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 listed beneath the appropriate number on the Field Data Form. Some data are listed differently on the Field Data Form 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 in sediments and parts per billion (ppb) in 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. A period (.) is used to indicate that the element was not detected, and that the detection limit is not estimated 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 1063 surface sites in the Ritzville 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 (log U/Th and log U/Hf) and surface water quality measurements 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 is best done by studying the areal distributions of the ratio of uranium to geochemically associated elements such as Th, Hf, Ce, etc. Elemental associations suggested here should be considered speculative pending detailed mineralogical investigations.

TABLE 5

Statistical Summary of Elemental Analyses - Sediment;
Ritzville

Element	n*	Measured Values		Log Mean††	Log Std.‡ Deviation
		Maximum**	Minimum†		
U	1052	46.0	0.8	0.35	0.18
Th	1011	131	2.1	0.90	0.21
Hf	929	36.0	2.0	0.82	0.21
Al	1054	92,800	24,500	4.80	0.11
Ce	967	831	20	1.78	0.19
Fe	1027	98,700	8,800	4.58	0.13
Mn	1039	1600	2.70	2.82	0.10
Na	1049	37,400	8,300	4.23	0.09
Sc	1041	23.2	0.5	0.90	0.30
Ti	1009	21,300	2,200	3.84	0.14
V	1054	365	33	2.02	0.16
Dy	472	86.1	1.0	0.64	0.30
Eu	431	6.3	0.8	0.24	0.19
La	1039	417	6.0	1.44	0.16
Lu	835	1.7	0.2	-0.47	0.16
Sm	1028	36.8	1.2	0.63	0.15
Yb	463	11.4	0.7	0.45	0.19

* Number of observations

** Elemental concentrations in ppm.

† Minimum or detection limit.

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

‡ Log units.

An areal distribution map of uranium concentrations in stream sediment samples 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 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 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 are high imply either that uranium is present in minerals other than resistates (especially monazite) or that these resistates are particularly enriched in uranium. Areas with high uranium values sometimes persist on U/Th and U/Hf ratio figures. These areas may show 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.

Uranium concentrations in sediment samples from the Ritzville 1° x 2° NTMS quadrangle are comparatively high, with a maximum uranium content of 46.0 ppm. Most uranium anomalies (10 to 46 ppm) are associated with Quaternary and Triassic rocks.

Based on the distribution of uranium in sediments, 13 areas are of particular interpretive interest (Figure 4). All value judgments in the following discussion are confined within the context of the Ritzville 1° x 2° NTMS quadrangle. For example, a so-called fair prospect in the Ritzville quadrangle may be a better prospect than a so-called good prospect in another

quadrangle. The author intends only to make a first approximation of the relative merits of the uranium anomalies in the Ritzville quadrangle, and to caution the reader against attaching undue significance to certain features of the data. All areas are labeled and displayed on Figure 4.

Area A is near Farmer, Washington, in Quadrangle BA. This anomaly occurs in Quaternary eolian deposits, probably part of the Palouse Formation, a brown loess. Area A is very high in uranium and has relatively low thorium and hafnium, suggesting that little of the uranium present is in the resistates. This anomaly appears to be an excellent prospect for further exploratory work.

Area B is southeast of Grand Coulee, Washington, in Quadrangle AE. This anomaly also occurs in Quaternary eolian deposits, probably the Palouse Formation. The elongate trend of Area B is roughly parallel with the southeastern direction of local drainage off Jack Woods Butte. Area B is very high in uranium and has relatively low thorium and hafnium, suggesting that little of the uranium present is in the resistates. This anomaly appears to be an excellent prospect for further exploratory work.

Area C is near Spokane Mountain in Quadrangle AH. This anomaly occurs in Quaternary glacial deposits and the underlying Cretaceous granodiorites and quartz monzonites. There are several active mines in Area C, and a great deal of uranium is being extracted at the Midnite Mine. Area C is high in uranium and has relatively low thorium and hafnium, suggesting that little of the uranium present is in the resistates. This anomaly appears to be an excellent prospect for further exploratory work.

Area D is near Whitestone Ridge in Quadrangle AG. This anomaly occurs in Mesozoic granitic rocks above a valley fill of Quaternary glacial deposits. Area D lies at right angles to the direction at drainage off Johnny George Mountain. Although this anomaly is small and shows only moderately high uranium, it has very little thorium and hafnium, suggesting that little of the uranium present is in the resistates. This anomaly appears to be a good prospect for further exploratory work.

Area E is south of Steamboat Rock in Quadrangle AD. This anomaly occurs in the Columbia River Group volcanic basalts. Area E is very high in uranium and has relatively low thorium and hafnium, suggesting that little of the uranium present is in the resistates. Single point anomalies are inadequate for interpretive work, but any anticipated exploratory work should scrutinize this area very closely.

Figure 4. Uranium Anomalies in the Ritzville Quadrangle

Area F is in Bachelor Prairie in Quadrangles AG and BG. This anomaly occurs in the Columbia River Group basalts and the valley-filling Quaternary eolian deposits. Area F is moderately high in uranium and has relatively low thorium and hafnium, suggesting that little of the uranium present is in the resistates. This anomaly appears to be a good prospect for further exploratory work.

Area G is west of Mansfield, Washington, in Quadrangle AA. This anomaly occurs in a band oriented at right angles to the contacts between Quaternary glacial deposits, Columbia River Group basalts, and mesozoic granitic rocks. The trend of this anomaly parallels local drainage, which is westerly. Area G is moderately high in uranium and has relatively low hafnium and very low thorium, suggesting that little of the uranium present is in the resistates. This anomaly appears to be a moderately good prospect for further exploratory work.

Area H is south of Leahy, Washington, in Quadrangle AC. This anomaly occurs in Quaternary glacial deposits. Area H is moderately high in uranium and relatively low in thorium and hafnium, suggesting that little of the uranium present is in resistates. This anomaly appears to be a moderately good prospect for further exploratory work.

Area I is southeast of Wilson Creek, Washington, in Quadrangles CD and CE. This anomaly occurs in the Columbia River Group volcanic basalts and the overlying Quaternary eolian deposits. Area I is moderately high in uranium, moderately low in hafnium, and low in thorium, suggesting that a significant amount of the uranium present is in resistates. The diffuse geographical distribution of this anomaly make it appear to be a fair prospect for further exploratory work.

Area J is west of Hanes, Washington, in Quadrangles BG and CG. This anomaly occurs in Quaternary glacial deposits. Area J is moderately high in uranium and moderately low in thorium and hafnium, suggesting that a significant amount of the uranium present is in resistates. This anomaly appears to be a fair prospect for further exploratory work.

Area K is around Banks and FDR Lakes in Quadrangles AD, AE, and AF. This anomaly occurs in the Columbia River Group basalts and the underlying Mesozoic granitic rocks, with a small area of Quaternary glacial deposits. Area K is generally high in uranium and generally high in thorium and hafnium (except Area E, above). Probably much of the uranium is in resistates. This anomaly appears to be a fair prospect for further exploratory work.

Area L is around the Columbia and Spokane Rivers in Quadrangles AG and AH. This anomaly occurs in the Columbia River Group basalts and the underlying Mesozoic granitic rocks, with a large area of Quaternary glacial deposits. Area L is generally high in uranium, thorium, and hafnium (except Areas C and D, above). Much of the uranium is probably in resistates. This anomaly appears to be a fair prospect for further exploratory work.

Area M is west of Ritzville, Washington, in Quadrangle DF. This anomaly occurs in Quaternary eolian deposits, probably the Palouse Formation. Area M is moderately high in uranium and relatively high in thorium and hafnium, suggesting that most of the uranium present is in resistates. This anomaly appears to be a poor prospect for further exploratory work.

Stream and Ground Water Samples

Water samples were collected from 838 ground water sites and 109 surface water (stream) sites in the quadrangle. Statistical summaries of key field measurements and elemental analyses for ground water and surface water sites are given in Tables 6 and 7, respectively. 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 and surface waters are shown on microfiche. Helium concentrations were determined by mass spectrographic analyses.

Uranium concentrations in ground and stream 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).

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.

The only area of particular interest in ground water uranium distribution occurs in Quaternary glacial alluvium within Quadrangle AC. This uranium anomaly is roughly parallel to the orientation of Banks Lake. Anomaly H in the Ritzville sediments overlaps the northern portion of this anomaly.

The small size and sparse distribution of the surface water data set make reliable interpretation difficult.

TABLE 6

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

Variable	n*	Measured Values		Mean††	Log Mean‡	Log Std. Deviation	Standard Deviation, ±1 σ
		Maximum**	Minimum†				
pH	838	11.2	6.3	7.9			1.4
Conductivity	838	3450	58		2.5	0.2	
Alkalinity	838	19.8	0.01		0.35	0.2	
U	754	53.6	0.10		-0.03	0.5	
Al	23	326	83		2.1	0.2	
Br	568	6970	6.5		1.7	0.5	
Cl	831	387,000	1200		4.0	0.4	
Dy	11	5.1	0.1		-0.7	0.5	
F	771	2050	15.0		2.2	0.3	
He¶¶	825	280	2.2		0.8	0.2	
Mg	787	108,000	860		3.9	0.3	
Mn	171	1390	3.0		1.9	0.3	
Na	833	>100,000	3200		4.3	0.2	
V	770	120	1.0		1.0	0.4	

* 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 300 mL of water.

TABLE 7

Statistical Summary of Field Measurements and Elemental Analyses - Surface Water;
Ritzville

Variable	n*	Measured Values		Mean††	Log Mean‡	Log Std. Deviation	Standard Deviation, ±1 σ
		Maximum**	Minimum†				
pH	106	9.5	6.6	8.1			0.5
Conductivity	106	1110	11		2.3	0.3	
Alkalinity	106	9.8	0.28		0.22	0.3	
U	97	423	0.2		0.18	0.5	
Na	109	95,200	400		4.3	0.3	
Cl	107	130,000	3000		4.0	0.4	
Mg	102	56,500	560		4.0	0.4	
Al	76	1550	82		2.3	0.3	
Mn	15	734	10		2.2	0.5	
Br	58	710	2.6		1.8	0.5	
V	85	112	2		1.0	0.4	
F	109	1510	4.0		2.4	0.4	
Dy	2	0.2	0.2		-0.7	0.001	

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

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No.	Period	DOE-GJO	
		SRL Doc. No.	Doc. No.*
1	January-March 1975	DPST-75-138-1	GJBX-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)
13	January-March 1978	DPST-78-138-1	GJBX-66(78)
14	April-September 1978	DPST-78-138-2	GJBX-13(79)
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.,
Savannah River Laboratory, Aiken, South Carolina.

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	(this report)

† Sediment only.

†† Ground water only.

††† SRL analyses of samples collected by Lawrence Livermore Laboratory.

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- EXPLANATION
- QUATERNARY
- Qs
Sedimentary deposits
- Qls
Landslide deposits
- Qs
Loess and Ringold Formation
- TERTIARY
- MIOCENE
- COLUMBIA RIVER BASALT GROUP, YAKIMA BASALT SUBGROUP.
- Sb
Basalt of Sprague Lake
- Wb
Wanapum Basalt
- Grb
Grande Ronde Basalt
- VOLCANIC, SEDIMENTARY, and METAMORPHIC ROCKS.
- OLIGOCENE to EOCENE
- Tvs
Volcanic and sedimentary rocks, Undivided.
- MESOZOIC to PALEOZOIC
- PLUTONIC ROCKS
- Tmg
Granodiorite and Quartz Monzonite Eocene and Cretaceous age
- METAMORPHIC ROCKS
- MPm
Metamorphic rocks, Mesozoic to Paleozoic, undivided
- CAMBRIAN to PRECAMBRIAN
- CpCs
Metamorphosed volcanic and sedimentary rocks, undivided
- Large body of water
- Geologic Contact

RITZVILLE, WASHINGTON
PLATE I-A GEOLOGY

Ritzville, Washington Geology
Compiled by D.E. Howell, 1980

Sources:
1. Swanson and others, 1979
2. Wild, Inc. 1978