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An Assessment of the Uranium Potential in the Ellensburg Formation, South-Central Washington.

By

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INTRODUCTION

The purpose of this report is to assess possible uranium resources in the Miocene-Pliocene inter-basalt volcanic and volcaniclastic sedimentary rocks of the Ellensburg Formation.

The study area (see Map 1) encompasses approximately 1,000 square miles and parts of thirteen 15-minute quadrangles in south-central Washington in the western part of the Columbia Basin and the eastern flank of the Cascade Mountains.

The field work for this survey occupied almost five months of the 1978 field season.

GEOLOGIC BACKGROUND

The name "Ellensburg Formation," as used in this report, includes not only the Ellensburg (Pliocene), referring to fanglomeritic volcanic rocks of post-Yakima Basalt age, but also the older (Miocene intra-Yakima Basalt) Vantage Sandstone Member (see figure 1). "Yakima Basalt," as well as younger basalts, is referred to here as the Columbia River Basalt Group. This combination has been made for the sake of simplicity and also because of similarities in lithologies and probable source areas, especially the volcanic (tuffaceous) units in both the Ellensburg Formation and Vantage Sandstone.

The type section of the Ellensburg Formation has been accepted as that exposed in the cliffs north and southeast of Naches. Calkins (in Smith, 1901, 1903a) measured over 1500 feet of section (sec. 24, T. 14 N., R. 17 E.) but I found nowhere a true thickness this great. I measured a section that was about 870 feet thick (SE¼SW¼ sec. 12, T. 14 N., R. 17 E; see Map 4). A recent DNR water well in the Wenas Valley (Map 2) was drilled into over 1600 feet of Ellensburg sediments, but I estimate only 800 to 1000 feet of true section.

The Ellensburg Formation is predominantly a heterogeneous fanglomeratic sequence consisting of fluvial sediments and volcaniclastic rocks. The fluvial sediments are largely reworked volcanic rocks although some units are derived from igneous and metamorphic detritus (i.e. Vantage Sandstone Member). The units include crossbedded pumice lapilli sandstones, arkoses, siltstones, conglomerates, and claystones. Volcaniclastic rocks of the Ellensburg including lahars are andesitic, rhyolitic, and dacitic in composition, and are largely of

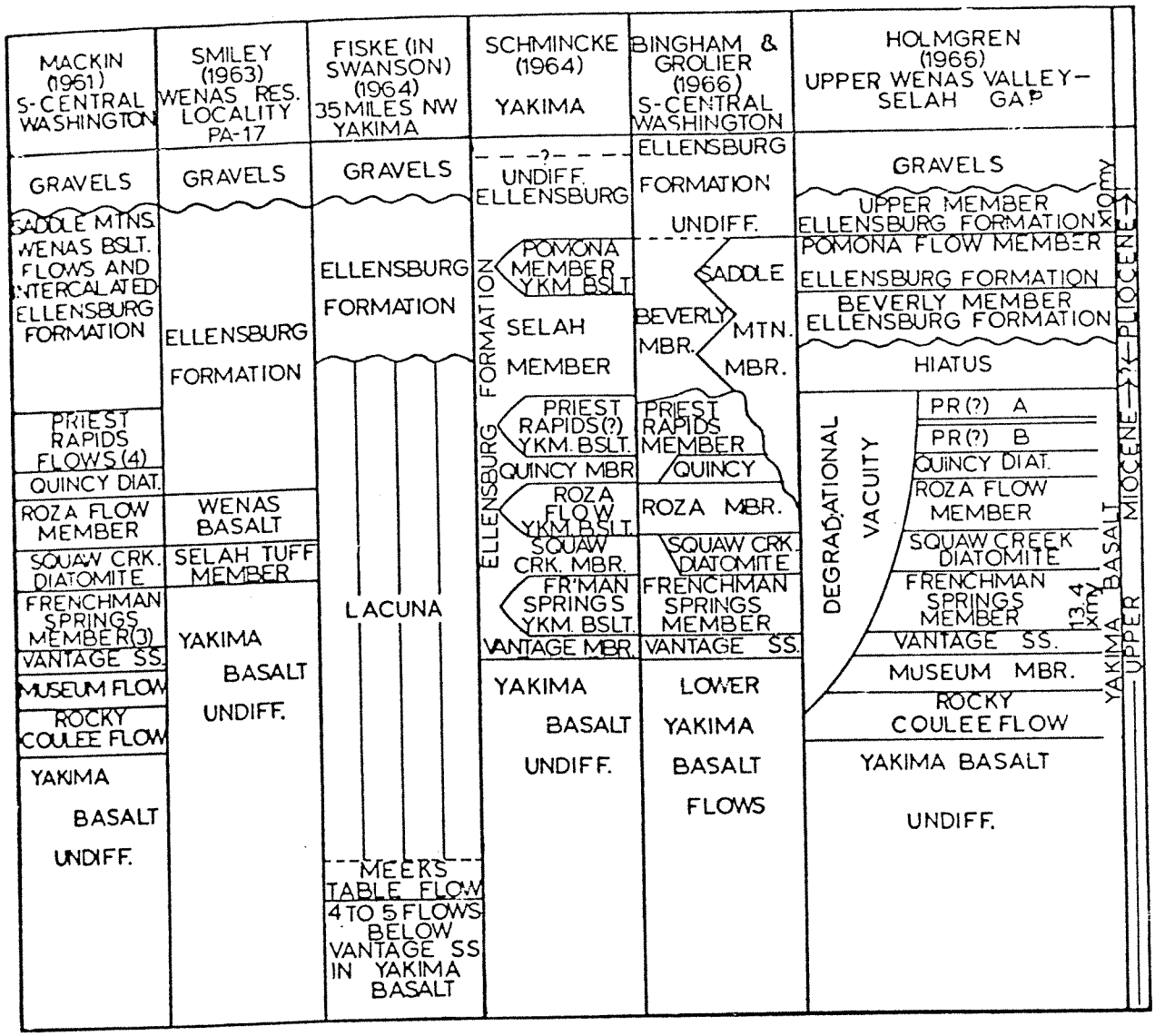

Figure 1. Proposed stratigraphies of the Ellensburg Formation and Columbia River Basalt Group (after Holmgren, 1967).

a pyroclastic nature. Fragments of crystal tuff, subporphyritic flows, and pumice predominate, and are light gray to red in color. Rhyodacitic ash fall tuffs and minor welded tuff appear to be the only true volcanics (or pyroclastics) included in the Ellensburg Formation.

PREVIOUS WORK

Geologic investigations of the Ellensburg have stemmed back to the turn of the century (see Holmgren, 1967, for a comprehensive bibliography). Figure 1 denotes most of the significant recent studies, except for those by Campbell (1975-1977) and Bentley (1977).

An understanding of the geology of some of the eastern Cascades and the probable source region (see Map 4) for the Ellensburg Formation can be obtained from workers such as Fiske and others (1963), Foster (1960), Simmons (1950), Simmons and others, (1974), Stout (1959, 1964), and Swanson (1964, 1966).

METHODS OF INVESTIGATION

Work on this project commenced with a review of published and unpublished reports, including miscellaneous water well reports, on the south-central Washington region, as well as published studies of uranium occurrences in volcanic terrains elsewhere in the world.

Field studies were initiated by geologic and radiometric traverses that were conducted (see Map 2) normal and parallel to strike on exposed stratigraphic sections, in most cases for considerable distances; isolated and semiconcealed outcrops were also traversed. One hundred and twenty-five geologic radiometric traverses were made. Cross sections were measured where possible (see Map 4). A GIS-4 Scintrex hand-held spectrometer was used in the field. Areas with higher than background radiation were traversed in detail and usually sampled for geochemical analysis. Previous mapping was examined and occasionally remapped.

Field work was concentrated predominantly on the Ellensburg Formation but older volcanics to the west (Cascades) were examined in a reconnaissance fashion and will be investigated in more detail in future studies.

A geochemical survey was carried out and included rock chip, well and spring water, and stream sediment (silt) sampling (see Map 3 and tables 1-3). Rock chip samples were taken in areas where there was greater than background gamma

radiation. Water and stream sediment samples were also taken where there was greater than background radiation in the general area, and also in regions where there is much cover and inferred geology appeared to warrant an investigation of the subsurface. Silt samples were taken in selected areas where there is structural complexity and(or) much colluvial cover.

All samples were analyzed fluorimetrically for uranium. Rock chip samples were analyzed for total and(or) leachable uranium. Radioactive ash fall tuffs were further analyzed for whole rock and trace element geochemistry. One disequilibrium analysis and one permeability test were also completed on one of the tuffs. Some fluorine analyses were undertaken on water samples.

GEOLOGIC SETTING

Basement rocks bordering the Ellensburg Formation on the west and north and underlying the Columbia River Basalt Group are the upland sources of the Ellensburg Formation. The basement rocks are predominantly volcanics of the Fifes Peak, Stevens Ridge, and Ohanapecosh Formations and related granodiorite to quartz monzonite intrusives of the Tatoosh pluton complex (Fisk, and others, 1963). The ages of these rocks range from Eocene to middle Miocene (see Engels and others, 1976, for absolute dates). The basement rocks probably represent deroofed cores of ancestral Cascade stratovolcanoes (see Map 4). The more acidic nature of clasts in the Ellensburg relative to the in-place andesitic rocks to the west may testify to this.

Stratigraphic sections of the Ellensburg Formation are generally less than 200 feet thick, with the exception of the Nile (300 feet plus) and Naches (800 feet plus) sections. The Vantage Sandstone is only 15 to 30 feet in thickness.

Wedges of Ellensburg fanglomerates interstratified with Columbia River basalt are buckled in a long, linear, northwest- to westward-trending fold belt. Folds are symmetrical to asymmetrical, and most are reverse or thrust-faulted along their crests and particularly in fold crests that incorporate both Ellensburg units and basalt. Sediment ponding due to basalt flow damming does not appear to have been a common mechanism for Ellensburg deposition as it was with the Latah Formation (probable Vantage equivalent). Carbonaceous beds and lenses and finely laminated silts and clays are essentially lacking in the Ellensburg but are fairly abundant in the Latah.

The Ellensburg Formation (minus the Vantage Sandstone) apparently has two subdivisions which are separated by the Pomona Basalt. The lower subdivision is the Beverly (Pomona) section comprising fanglomeratic units and volcanics (ash fall tuffs). This lower subdivision is exemplified by the Beverly, Pomona (Burbank Valley), Manastash(?), Union Gap-Elephant Mountain, Toppenish, Snipes Mountain and Prosser sections (see Map 4). The upper Ellensburg subdivision includes lithologically diverse stratigraphic sections from the Wenas-Selah (Naches Cliffs), and Thorp (northwest of Ellensburg) areas. The Nile section includes the coarsest of the Ellensburg volcaniclastic sediments (lahars) and, although similar to the upper Ellensburg, it may be older because it rests on Yakima (Holmgren, 1967) and not Pomona Basalt. No true volcanics (i.e., ash fall tuffs) were observed in the upper Ellensburg subdivision.

SIGNIFICANT FINDINGS

RADIOMETRIC SURVEY

Radiometric reconnaissance of the Ellensburg Formation and some outlying regions revealed a number of areas with anomalous surface radiation (see Map 2); however, no radioactive minerals were observed. Background radiation was found to be approximately 2600 counts per minute (cpm) from the 125 traverses. For reference this is approximately one-third to one-fourth the background radiation encountered in the porphyritic quartz monzonite surrounding the Midnite and Sherwood uranium mines using the same spectrometer. The highest levels of radiation are approximately 8 to 9 times background (Map 2), and occur in areas that contain volcanic ash units, referred to here as ash fall (or air-fall) tuffs because they were apparently deposited from eruption clouds as opposed to ash flows which are deposited by inter-caldera avalanches. These most highly anomalous areas of radioactivity (ash fall tuff exposures) include particularly the Beverly exposure (18,000-24,000 cpm), and also the Burbank Valley (Pomona) area (15,000-21,000 cpm), the Manastash area (12,000-16,000 cpm), the Elephant Mountain--Union Gap area (15,000-18,000 cpm), the Snipes Mountain area (13,000-18,000 cpm), and the Toppenish area (10,000-12,000 cpm).

Areas surrounding ash fall tuff exposures (see Maps 2 and 4) are represented in Map 2 as showing some slight radioactivity (2 to 4 times background). These areas represent localities where physical weathering of the tuff has

created some radioactive colluvium where the tuff is probably present in the subsurface, and where some arkosic units associated with the tuff show some slightly anomalous radioactivity.

The Vantage Sandstone is sporadically exposed in the Vantage area in and around the Ginkgo State Park, and has slightly anomalous (2 to 4 times background) surface radioactivity, particularly in a tuffaceous unit which may overlie the sandstone. Because of poor outcrop and limited reconnaissance work in the Vantage area, the exact stratigraphic position of the tuff is not known.

Areas beyond the western and northern extent of the Ellensburg Formation revealed a few slightly anomalous rock types during reconnaissance work (see Map 2).

GEOCHEMICAL SURVEY

Rock chip samples

Fluorimetric analyses of rock samples (see table 1 and Map 3) revealed that within the Ellensburg Formation ash fall tuff samples have the highest values of uranium (5-13 ppm total and 1-3 ppm leachable U_3O_8) which correlates with the highest radiometric grade. Among the ash fall tuff samples, areas with values of 9-13 ppm (see Map 3) include Beverly, Manastash, Burbank Valley, Snipes Mountain, and possibly the Wenas-Selah area where tuffaceous units in the subsurface (800 to 1400 foot depths of drilling) of the Wenas Valley are inferred by leachable uranium values (2-3 ppm) and anomalous deep well water values (5 and 8 ppb U_3O_8).

The Vantage area, which is radiometrically 2 to 4 times background, provided uranium values of 4 to 7 ppm total uranium (approximately 1 ppm leachable) in rock chip samples of sandstone, tuffaceous sandstones, and tuff. Tuffaceous material contained the highest uranium values.

Outside the Ellensburg Formation, a sample of the Teanaway rhyolite (sample prr-1), while only about 3 times background radiation in the outcrop area, contains 26 ppm U_3O_8 (only 1 ppm leachable). This rock is of rhyodacitic composition is altered (much limonitic banding showing onion structures), and is perhaps partly devitrified tuff. Two to three times background radiation in a rhyolite

lapilli tuff (Bumping area sample 154158) and an andesite feeder dike (Meeks Table area sample 154152) revealed only 1 ppm leachable U_3O_8.

Water samples

Samples from springs, domestic wells, deep irrigation wells, and city wells contained uniformly 1 ppb U_3O_8, except for several in the Wenas-Selah area (see table 2). Two 400-foot wells in the Wenas Valley contained 5 and 8 ppb U_3O_8 and one spring contained 2 ppb U_3O_8. These values may suggest some uranium mineralization at depth.

Stream sediment samples

All silt samples were taken in drainages where tuffaceous rocks are exposed or suspected to occur in the subsurface of synclinal valleys, including the Squaw Creek, Burbank Valley, and Wenas-Selah areas and also the relatively undeformed Vantage area. The minus 80 mesh portion was collected and sent for analysis. All analyses yielded 1 ppm U_3O_8, except one sample in the Vantage area which yielded 800 ppm U_3O_8 (see table 3).

The Vantage sample with 800 ppm U_3O_8 (#154114) is located on the western edge of the Ginkgo State Park in the Rocky Coulee area (see table 3 for precise location). There is much colluvial cover on the low sloping ridges of the Vantage area, but it is suspected from inferred geologic relations that upstream from the sampling site the Vantage Sandstone probably occurs below a ridge top of basalt. There was no anomalous radioactivity found in the immediate area of the sampling site, but the sample itself was later found to be radioactive by examining a paired sample. Subsequently, the paired sample was split five times, again assayed, and obtained the same results of 800 ppm U_3O_8. X-ray diffraction showed no identifiable uranium mineral in the sample. A complete stream sediment survey was not made in the Vantage area and the few well and spring waters were not sampled.

PHYSICAL EXAMINATION OF THE ASH FALL TUFF

Ash samples are composed predominantly of triangular glass shards and approximately 10 $\pm$ 3 percent of quartz, sericite, and dark (Fe-Ti-Mn oxide?) fragments. X-ray diffraction of the ash demonstrates a typical "hump" pattern

over the most intense quartz peak (26.6^{o}), with no perceptible crystal peaks due to low mineral concentrations (minerals commonly are not recorded below approximately 5 to 10 percent concentrations).

Field examination, in particular the Beverly outcrop which is the best exposure of ash (see Map 4), reveals that the ash is very uniform in texture and has not been reworked. Some opaline layers (≤1 cm thick) are present, probably due to local devitrification and diagenetic processes. The ash in most places is essentially unaltered. One foot above the base of the ash-arkose contact and in the ash, spherulites (≤1 cm in diameter) occur in a 1- to 2-inch thick layer. This layer also occurs in the Pomona outcrop (Burbank Valley area) along the east roadcut face of Interstate route 82 (opposite face of section H-H', Map 4). This thin spherulitic layer may be physical indication of a correlation of the Pomona and Beverly tuffs.

Rock permeability is important for the migration of the very mobile hexavalent uranium ions. The Washington State Transportation Department Materials Laboratory calculated the permeability of Beverly ash from a rock sample 3 inches in diameter by 3 inches in length. The results indicated an average horizontal coefficient of permeability of 4.1×10^{-4} cm/sec and an average vertical coefficient of permeability of 1.4×10^{-4} cm/sec. This is about what would be expected to exist in a silty sand (Le Clerc, written communication, 1979). In the field, a quarry face in the Beverly area (ash unit) is partially water saturated indicating ground water migration in a permeable rock. The ash was also observed in the Prosser section (see Map 4) where ground water was flowing from the (super-) saturated rock.

WHOLE ROCK AND TRACE ELEMENT ANALYSIS ON THE ASH FALL TUFF

After uranium analyses were completed on ash fall tuff samples, a closer geochemical examination was undertaken for several reasons: (1) to try to define the rock chemistry as being of a favorable nature for a uranium source; (2) to try to correlate the Beverly and Pomona ashes so as to indicate how extensive the ash unit is with respect to uranium favorability (i.e. the more extensive, the more relative potential for uranium mineralization); (3) to try to determine a parental source of volcanism for the ash. Table 5 shows an average alkali index ($K_2O + Na_2O/CaO>3$) greater than 3 for the Beverly and

Pomona ashes, indicating relatively alkaline rock ("ultra-potassic"), although not peralkaline ($K_2O + Na_2O/Al_2O_3 < 1$; in this case the ratio is 0.65). A computer calculated normative analysis on these whole rock data (Dr. Felix Mutschler, Eastern Washington University, written and oral communicaiton, 1979) indicates that the ash is a "calc-alkaline dacite," referred to in this report as rhyodacite. High differentiation indexes of 87 and 85 percent indicate that this rock material is of the type that is concentrated in the residual portions of a magma chamber, a conducive mechanism for uranium accumulation.

A trace element comparison is demonstrated in figure 2. Figure 2 shows not only the quantitative abundances of trace elements in the Ellensburg volcanics (compare similar values in Pomona and Beverly ash fall tuffs), but also a schematic relating what appear to be less favorable source rocks for uranium and highly favorable source rocks (ore grade), represented by USGS glassy volcanic samples from Washington State and the Rexspar uranium deposit trachytic volcanics, from British Columbia, respectively. In general, the Ellensburg volcanics show more favorable source relationships to uranium than the USGS samples because of higher uranium content and a slightly closer trace element affinity to the Rexspar volcanics. Unfortunately, whole rock analyses were not available on the Rexspar volcanics at the present time but will be included in a future publication.

Figure 3 demonstrates the relationship between selected trace elements in the Beverly ash* and trace elements in the average crustal granite (Krauskopf, 1967) represented in ratio proportions of ash element abundances to granite element abundances. In the figure where the ratio is one or greater than 1 (higher elemental abundances in ash than granite for the same element), subdivisions of anomalous and highly anomalous have been drawn. Sixty-eight percent of the ratio comparisons fall between a 1:1 ratio and a 5:1 ratio, while 2 percent

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* The Beverly sample (154171), it should be noted, is perhaps the most representative sample taken of the ash fall tuffs exposed in the study area. This sample is a split from a complete vertical channel sample of the bottom 35 feet of the unit (the unit may be 90-100 feet thick, although the middle portion, perhaps 30-40 feet, is not well exposed). The Pomona sample (154102) was channel sampled from the 5 to 6 foot section exposed along Interstate 82 (see Map 4).

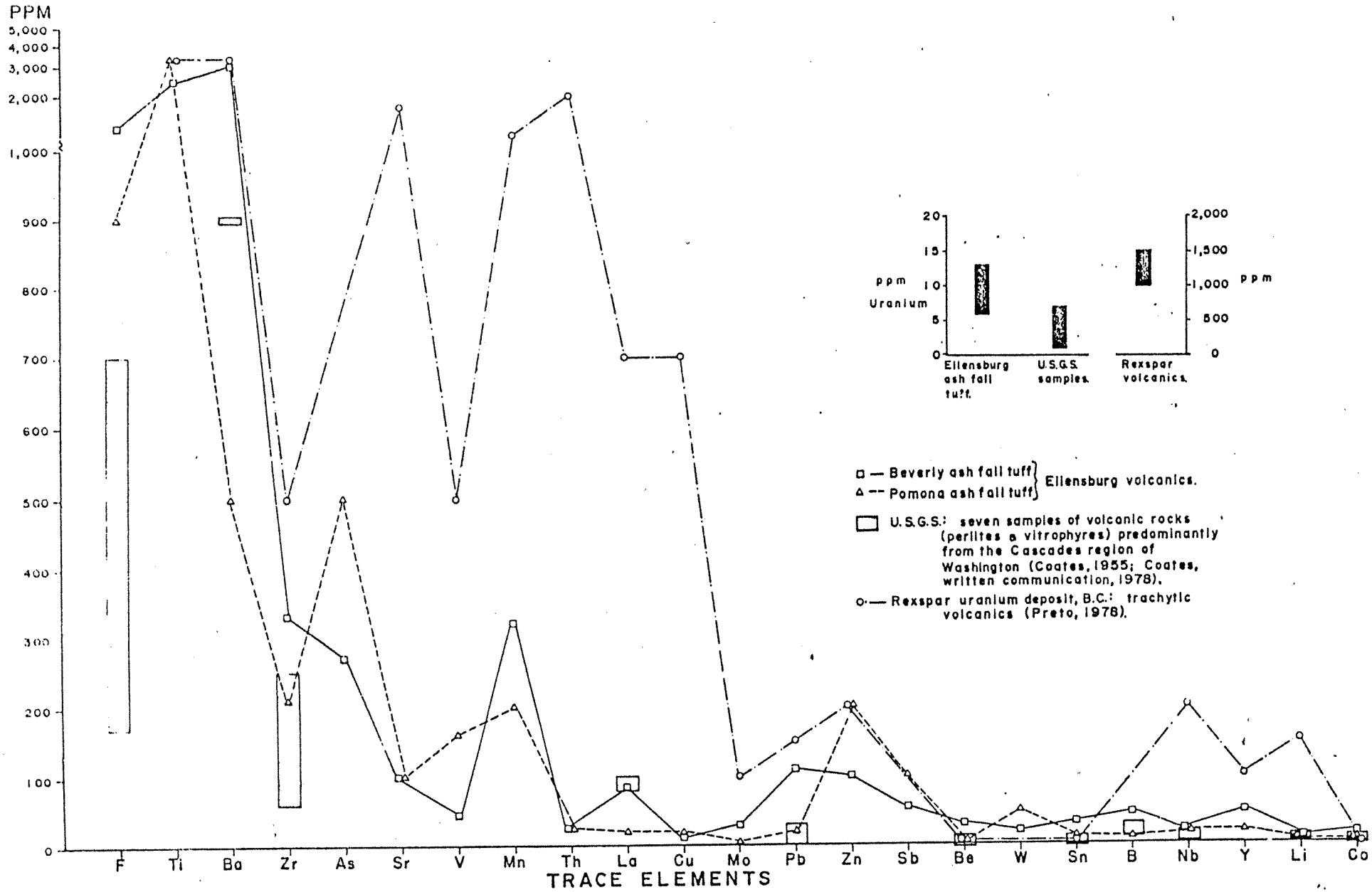

FIGURE 2. Trace element comparison of Ellensburg ash fall tuffs, U.S.G.S. tuff samples in Washington, and the Rexspar uranium deposit trachytic volcanics.

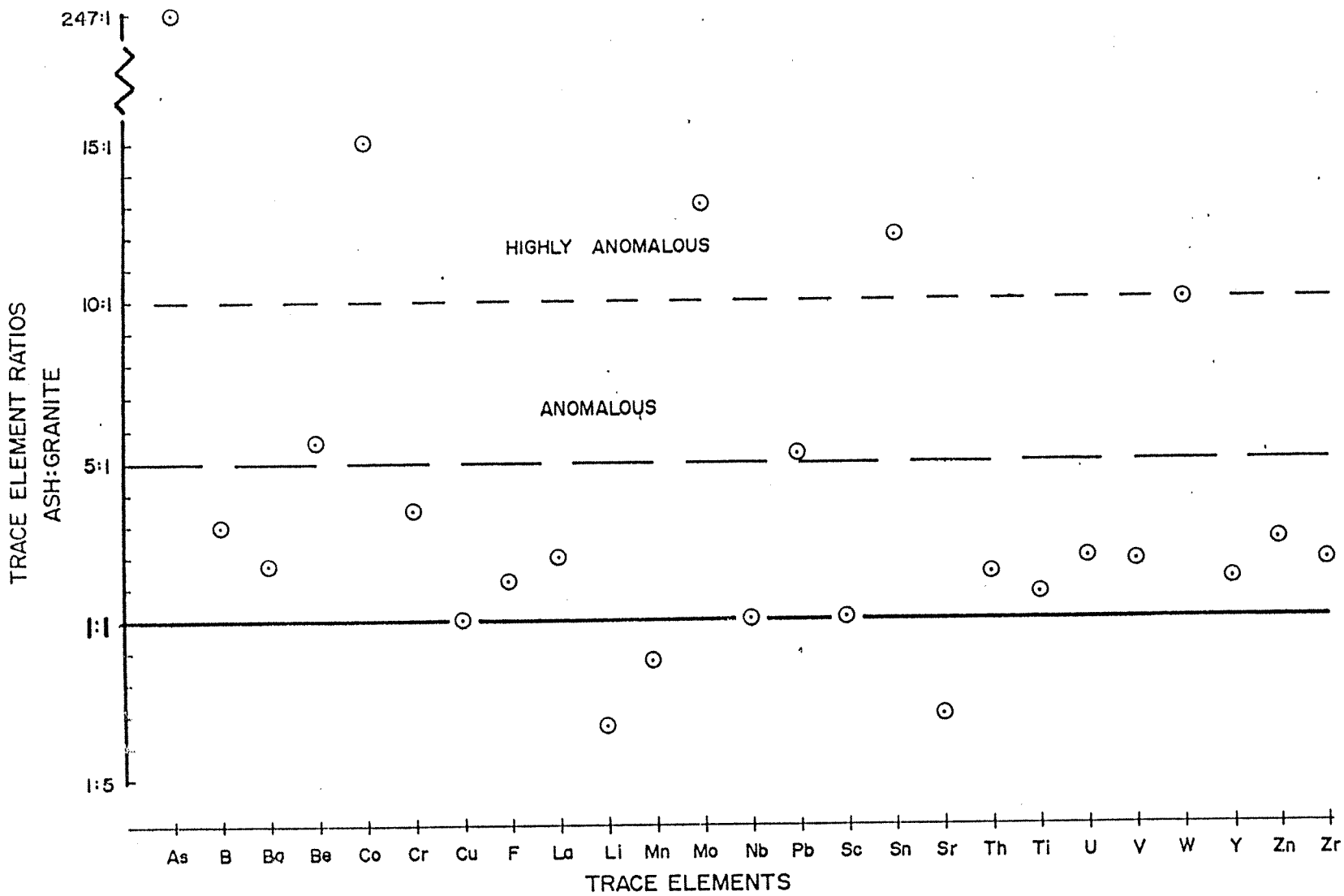

Figure 3. Trace element comparison of the Beverly ash fall tuff and the average crustal abundance for granite represented by ratio proportions. Zones of "anomalous" and "highly anomalous" ratios have been arbitrarily fixed at levels of 5:1 to 10:1 and 10:1 and greater, respectively. Sixty-eight percent of the ratios plots fall in the 1:1 to 5:1 area ("not anomalous"). Anomalous and highly anomalous elements As, Be, Co, Mo, Pb, Sn, and W correspond well to most areas of uranium mineralization and may be considered as "pathfinder elements" in the Ellensburg Formation (granite values from Kroupkopf, 1967).

have a 5:1 to a 10:1 ratio, and 23 percent have a 10:1 ratio or above. Considering this, and the probability that a 5:1 ratio could generally be considered as being anomalous, elements included as anomalous are As, Be, Co, Mo, Pb, Sn, and W. If a 10:1 ratio is considered "highly" anomalous, then this will only include the elements As, Co, Mo, Sn, and W. Supersaturated granitic meets within batholitic complexes are commonly enriched with respect to the elements Mo, W, Be, Sn, Li, and others including U, Th, Nb, F, and Ta (Krauskopf, 1967). This association represents end phases of magmatic differentiation or partial melting processes. There is a basic similarity between this above elemental association and the anomalous elements (5:1 and 10:1 categories of figure 3) in the (Beverly) ash. The ash fall tuff in this respect, represents an end phase of granitic differentiation (or partial melting) processes.

In estimating a parental source for the ash, the occurrences of Mo, W, and minor uranium/radioactivity in the Tatoosh pluton complex of the Bumping Lake region (see Milne, 1979) and the above trace element discussion may suggest that the ash is a differentiated product of this pluton (generally granodioritic to quartz monzonitic in composition; see Fiske, and others, 1963; Abbott, 1953). The pluton may itself represent an intrusive parent of Fifes Peak-related volcanism.

Two other apparent observations can be made in the light of this trace element study: (1) if the Tatoosh pluton is the parental source for the (uranium bearing-) ash fall tuff, perhaps a phase (alkaline or peralkaline) of the pluton complex may contain anomalous uranium concentrations; and (2) the anomalous trace element distribution in the ash appears to fingerprint a porphyry base metal association.

In relating figure 2 to figure 3 several other observations are listed below:

1. Lithium, an element that might also be expected to be anomalous in the above magmatic differentiation scheme, has a negative correlation in figure 3.

2. The anomalous elements Sn, Co and Be, in figure 3 (Beverly ash) have lover values in the Rexspar volcanics than in the Ellensburg volcanics of figure 2.

3. Mo and Pb values are relatively similar in both the Rexspar and Ellensburg volcanics (no W analysis in the Rexspar).

DISEQUILIBRIUM ANALYSIS ON THE BEVERLY ASH

The following is an analysis of rock chip sample 154171 (Beverly ash; analysis by Scienterra, Inc.):

Thorium: 26 ppm

Uranium: 8.6 ppm = 2.8×10^{-12} curies per gram

U-234/U-238: 1.52

Radium-226 compared to equilibrium with U-238: 1.19 = 3.4×10^{-12} curies per gram.

Lead-210 compared to equilibrium with Ra-226: 0.89 = 3.0×10^{-12} curies per gram.

The uranium to thorium ratio is 0.33, which is slightly higher than the average crustal ratio (0.2 to 0.25), but doesn't appear to be significant enough to imply secondary enrichment of uranium. The uranium 238 series is in equilibrium. Although the U-234/U-238 activity ratio is slightly greater than one, it also does not imply significant uranium migration with possible secondary enrichment. Minor devitrification probably accounts for the variance from a ratio of 1:1. Radon loss (Skyline Labs, Inc.) is insignificant.

Fluorine analysis

Because of the relatively high fluorine values (0.09 to 0.13%) in the ash, the fact that fluorine (and to a lesser degree, uranium) is easily released during alteration of glass, and the fact that uranium is uniformly distributed through glass in glass-rich volcanic rocks (Zielinski, oral communication, 1979; Zielinski, 1978; Zielinski and others, 1977), fluorine analyses of water samples were initiated by the author as being a possible prospecting tool for uranium.

Theoretically, areas where anomalous fluorine concentrations occur could also contain anomalous uranium values. Analysis of fluorine is simply and inexpensively done by selective ion electrode methods. Therefore, sampling waters and analysis for fluorine, followed by analysis of high-fluorine samples (>2 ppm) for uranium could save a great deal of assay expense over regional surveys in similar volcanic terrains where all waters are analyzed for uranium. However, none of the author's fluorine analyses (table 5) corresponded to anomalous uranium values in the Selah-Wenas area (samples 482507 and 482517). Also sample 154132, from an artesian well (oil well test hole over 800 feet deep) had 53 ppm F, but only 1 ppb U_3O_8. Other water samples that showed somewhat anomalous

fluorine values reported by the Department of Social and Health Services (DSHS) were not available for uranium analysis (table 5). The author suggests that the DSHS analyses probably do imply an ash unit at depth in the areas where they were collected.

CHARACTERISTICS OF THE ELLENSBURG FORMATION PERTINENT TO URANIUM MINERALIZATION

SOURCES OF URANIUM AND POSSIBLE HOST ROCKS

Possible sources for uranium in the Ellensburg Formation on the basis of all radiometric, geochemical, and geologic data are the ash fall tuff member(s). There is at least one distinct, extensive ash unit exemplified by the Beverly-Pomona tuff. There also appears to be one or two similar units but their stratigraphic relations are not so well defined. The lack of radiation greater than background and very low uranium content of other rock units, including fluvial sediments and volcaniclastic rocks, appear to eliminate them as possible source rocks. The Teanaway rhyolite, which has some low-level radioactivity, uranium content, similar composition to the Ellensburg volcanics, and is altered, may be a possible uranium source. The anomalous 800 ppm stream sediment sample in the Vantage area may suggest a possible source in sandstone or tuff in the Vantage Sandstone.

At least two possible host rocks for uranium may exist in the Ellensburg Formation. A pink to buff arkose, beneath the Beverly tuff, contains calcified lenses which, if uranium has been leached from the overlying tuff, could serve as possible carbonate traps for uranium in the arkose. Also, theoretically, if locally a (Miocene) caliche build-up occurred on basalt prior to ash deposition, this would create an excellent carbonate trap for uranium. Ash fall tuff rests on basalt in the Pomona, Elephant Mountain(?) , and Snipes Mountain areas although no basalt-caliche relations are observable.

REDUCTANTS

No carbonaceous lenses were observed in the Ellensburg Formation. If they were deposited locally, they were probably soon reworked by prograding alluvial fans. Limonitic staining and coatings along fractures are sporadic in sandstones and tuffaceous sediments and contain no anomalous radioactivity or uranium con-

centration. One geochemical (iron oxide) cell (pseudo roll-front-type structure) was examined at the Selah gravel pit about 0.25 miles west of the town of Selah (see figure 4). This iron-oxide cell occurs in a sandstone unit which is about 50 feet long by 3 to 5 feet thick. No anomalous radioactivity or uranium mineralization occurs, however.

Structure

Structures are relatively simple in most of the study area. Asymmetrical anticlines appear to be the most complex folds. Dips of 3 to 15 degrees on anticlinal or monoclinal limbs, however, may be favorable for possible migration of uranium in ground water. Low-angle thrusted Ellensburg units along crests of folds are common but no alteration or anomalous radioactivity were found to suggest uranium mineralization.

CONCLUSIONS

Potential uranium resources in the Ellensburg Formation generally fall into a volcanic apron-type of geological environment. Volcanic aprons can be possible sources of uranium because they may include tuffaceous units (ash fall or ash flow tuffs and sediments) that contain vast quantities of uranium-rich glass shards. Uranium may be released to the ground-water system and form deposits such as these in volcanic-volcaniclastic rocks in the Sierra Pena Blanca, Chihuahua, Mexico (see Henry and Walton, 1978, for a lengthy discussion of volcanic apron-type uranium deposits.)

Silicic volcanic glass (ash fall tuff) appears to be the only relatively significant source for uranium in the Ellensburg Formation (see figure 5). In order to create a secondary uranium deposit, uranium must be released from a source, transported in ground water, and concentrated in some trap. It appears from this study that at least a few of these requirements are fulfilled; namely, that there is a source rock and that this rock is permeable. The actual release of uranium to the ground-water system and subsequent entrapment by reductants and(or) structural controls can only be left to speculation.

Although there appears to be a low potential for uranium deposits in the Ellensburg Formation, several areas might be prospected: anomalously radioactive areas such as ash fall tuff exposures; the synclinal valleys (particularly the

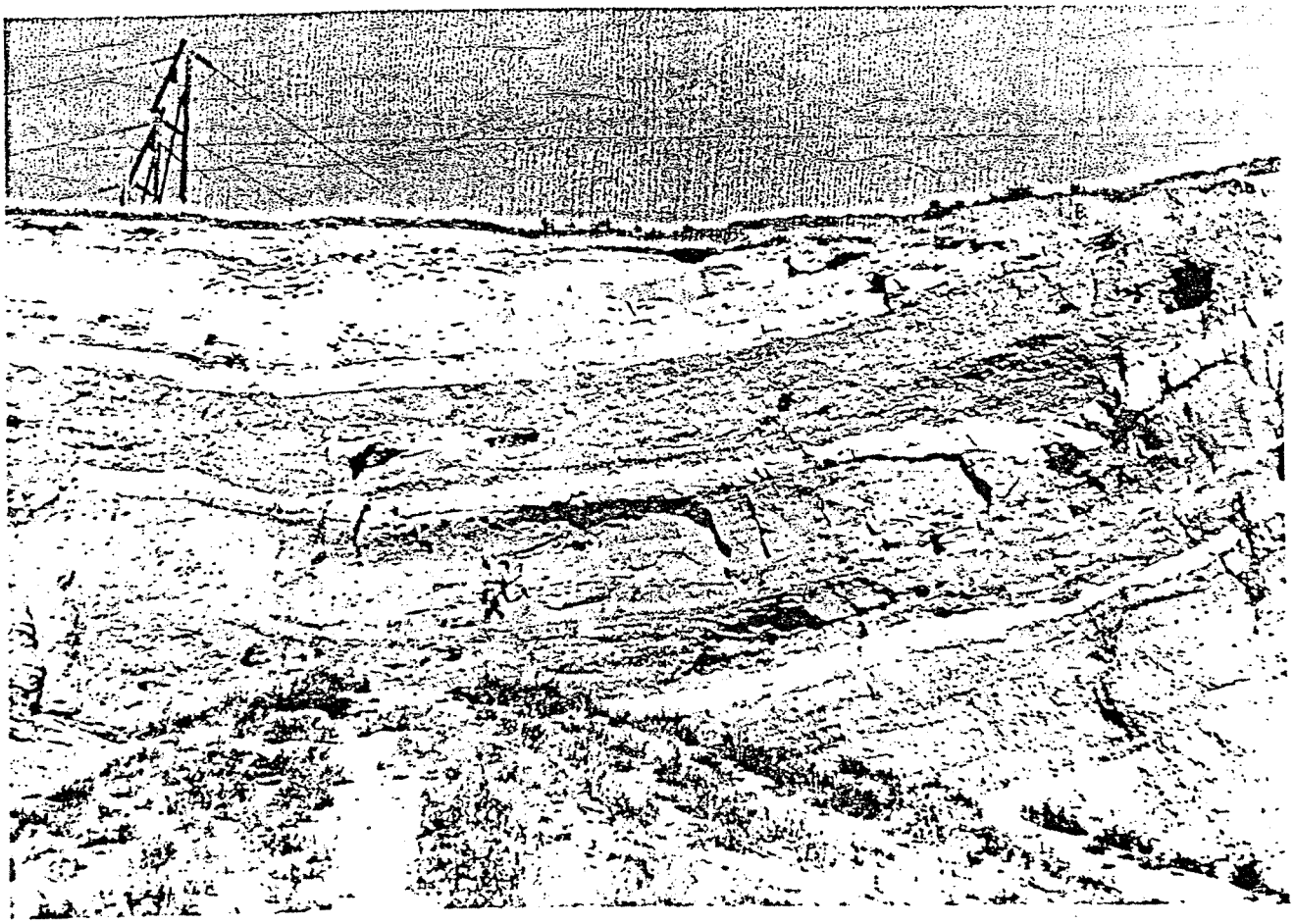

Figure 4. View of Ellensburg Formation fluvial sediments, largely sandstones and gravels, in the Selah gravel pit (T14N, R18E, Sec35P). Note altered zone (iron oxide) in sandstone above geologist and below white claystone unit.

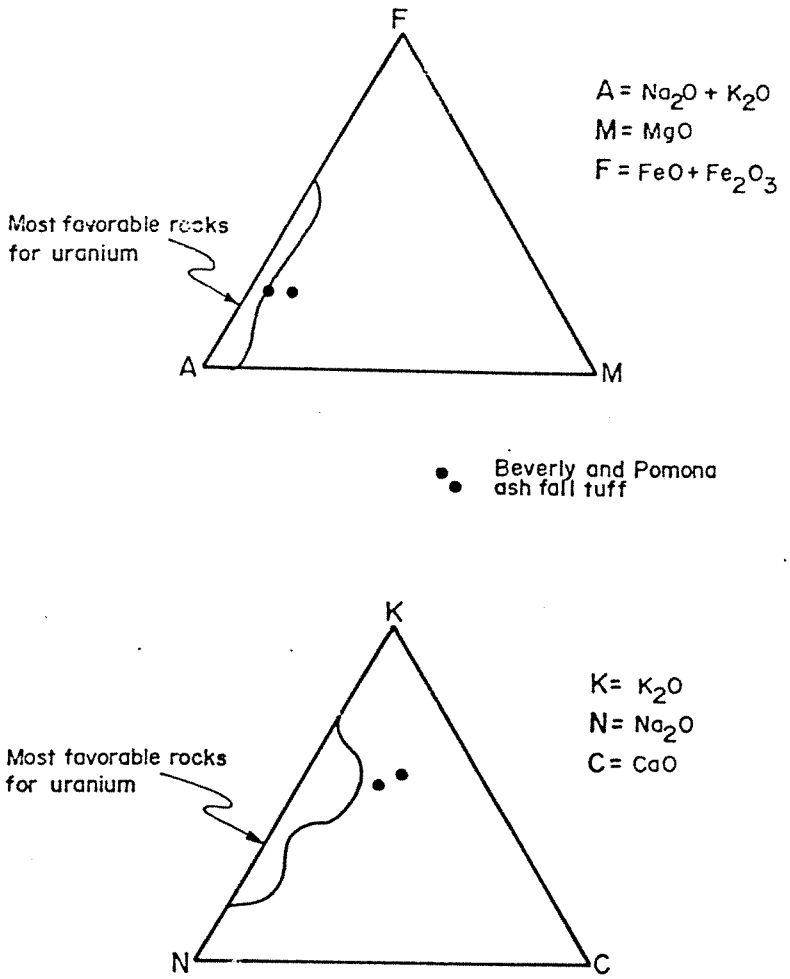

Figure 5. AMF-KNC diagrams of Ellensburg volcanic ash showing the relationship to the most favorable rock chemistry for uranium. The scheme is relative to differentiation in a magma chamber (computer analysis, Dr. Felix Mutschler, Eastern Washington University, written communication, 1979).

Wenas-Selah area) where ash fall tuff units are known or are inferred to occur: anticlinal ridges where structural controls may warrant investigation; the Vantage area because of the one anomalous stream sediment sample; and areas such as the Beverly area where calcified lenses in arkose may be found to contain uranium mineralization.

Table 1.—Rock chip analysis for uranium

Number	Rock Type	PPM U_3O_8 T=total, L=leachable	Location*
		Beverly Area	
154171	Ash fall tuff	9T; 2L; Th=26	15/23-23D; Beverly 15'
482601	" " "	11T; 1L	15/23-23C; Beverly 15'
482602	" " "	1L	15/23-23C; Beverly 15'
482603	" " "	1L	15/23-23C; Beverly 15'
482604	" " "	1L	15/23-23C; Beverly 15'
482605	" " "	1L	15/23-23C; Beverly 15'
482606	" " "	1L	15/23-23C; Beverly 15'
482607	" " "	1L	15/23-23C; Beverly 15'
482608	" " "	5T; 2L	15/23-23C; Beverly 15'
		Vantage Area	
154109	Tuff	7T	17/23-18R; Vantage 7.5
154110	Tuffaceous sandstone	6T	17/22-12C; Ginkgo 7.5
154111	Pebbly sandstone	5T	17/23-19F; Vantage 7.5
154112	Tuffaceous sandstone	4T	17/23-19C; Vantage 7.5
154115	Tuffaceous siltstone	5T	17/22-17L; Ginkgo 7.5
154184	Feldspathic sandstone	1L	17/21-9N; Boyleston 15'
		Kittitas Area	
154183	Limonitic, tuffaceous, sandstone	1L	17/20-12A; Badger Pocket
154185	Hematitic, tuffaceous, siltstone	3L	17/20-16C; Badger Pocket
		Manastash Area	
154103	Tuffaceous siltstone	13T; 3L	17/19-31Q; Ellensburg S.
154107	Vantage Sandstone	5T	16/19-10K; Kittitas 7.5
		Burbank Valley	
154102	Ash fall tuff	9T; 1L; eU=6, eTh=25	14/19-1P; Pomona 7.5
154105	" " "	4T	14/19-8J; Pomona 7.5
154147	" " "	12T	15/19-22D; Wymer 7.5
154149	" " "	7T	15/19-21A; Wymer 7.5
		Wenas-Selah Area	
154172	Limonitic sandstone	1L	13/18-2C; Selah 7.5
154176	Tuffaceous sandstone	1L	15/17-36A; Ellensburg 15 314-358 ft.
154177	" "	1L	15/17-36A; Ellensburg 15 600 ft.
154178	Tuff? (contaminated sample)	3L	15/17-36A; Ellensburg 15 865 ft.
154179	Tuffaceous sandstone	1L	15/17-36A; Ellensburg 15 955 ft.

Table 1. "Cont." Rock chip analysis for uranium

154180	Tuffaceous sandstone	1L	15/17-36A; Ellensburg 15 1,100 ft.
154181	" "	2L	15/17-36A; Ellensburg 15 1,355 ft.
	Teanaway Area		
PRR-1	Altered rhyodacite	26T; 1L	16/21-22F; Mount Stuart 15'
	Bumping Lake Area		
154158	Rhyolite lapilli tuff	1L	17/13-27A; Old Scab Mtn. 7.5
	Meeks Table		
154182	Andesite dike	1L	15/14-17J; Meeks Table 7.5
	Nile Area		
154157	Rhyolite crystal tuff (clast in Lahar)	1L	15/14-1B; Meeks Table 7.5
	Toppenish Area		
154159	Tuffaceous siltstone	1L	9/19-10M; Toppenish SW 7.5
154161	Tuff	1L	9/19-15F; Toppenish SW 7.5
482611	Welded tuff	5T; 2L	9/20-8B; Hembre Mtn. 7.5
	Snipes Mountain		
154187	Silver tuff	10T; 2L	10/22-34N; Granger 15'
482586	" "	1L	10/22-33M; Granger 15'

*Location includes: township, range, section, section portion; quadrangle:

"Section portion"; refers to a quadrangle lettering breakdown as used in USGS water supply papers

Section

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

8

Table 2.— Water sample analyses for uranium

Number	Type of sample (well depth if known)	ppb U_3O_8	pH	Location
		Squaw Creek Area		
154120	spring	1	5.5	16/19-22J; Wymer 7.5
154125	spring	1	5.5	16/19-34G; Wymer 7.5
154126	spring	1	6.0	16/19-36Q; Wymer 7.5
		Burbank Valley Area		
154135	spring	1	6.0	15/19-22B; Wymer 7.5
154140	spring	1	5.0	15/19-23N; Wymer 7.5
154142	spring	1	5.5	15/19-22H; Wymer 7.5
154145	spring	1	5.0	15/19-26C; Wymer 7.5
154146	spring	1	5.0	15/19-24Q; Wymer 7.5
154148	spring	1	5.5	15/19-21A; Wymer 7.5
154150	well	1	5.0	14/19-11P; Pomona 7.5
154151	spring	1	5.0	15/19-36H; Pomona 7.5
482533	spring	1	6.0	15/19-25P; Wymer 7.5
482536	spring	1	5.5	15/19-26R; Wymer 7.5
482539	spring	1	---	15/19-26G; Wymer 7.5
482541	spring	1	5.0	15/19-22N; Wymer 7.5
482551	USGS well (1390')	1	5.0	15/19-22L; Wymer 7.5
		Wenas-Selah Area		
482504	well (200')	1	5.0	14/18-5D; Selah 7.5
482506	well (200')	1	5.5	15/18-32G; Selah 7.5
482507	irrigation well (430')	8	---	14/18-5B; Selah 7.5
482508	well (503')	1	---	14/18-9A; Selah 7.5
482510	well	1	---	15/18-31G; Selah 7.5
482511	irrigation well (450')	1	---	15/18-31D; Ellensburg 1
482512	well (18')	1	---	15/18-19M; Ellensburg 1
482513	well (400')	1	---	15/17-25H; Ellensburg 1
482514	well	1	6.0	15/17-13G; Ellensburg 1
482515	well (550')	1	---	15/17-12N; Ellensburg 1
482517	well (400')	5	---	14/18-11C; Selah 7.5
482518	well (400')	1	---	14/18-3F; Selah 7.5
482520	spring	1	6.0	15/18-10D; Ellensburg 1
482521	irrigation well	1	6.0	15/18-29L; Ellensburg 1
482522	irrigation well (405)	1	6.0	15/18-29C; Ellensburg 1
482523	irrigation well	1	---	15/18-29H; Ellensburg 1
482525	spring	1	---	15/17-2K; Ellensburg 15
482526	irrigation well (158')	1	---	15/17-2Q; Ellensburg 15
482527	spring	2	---	15/17-11F; Ellensburg 1
482528	spring	1	---	15/17-2N; Ellensburg 15
482529	spring	1	---	15/17-2F; Ellensburg 15
482530	irrigation well (300')	1	---	16/17-33R; Ellensburg 1

Table 2 "Cont." Water sample analyses for uranium

482545	spring	1	5.0	16/16-22B; Milk Canyon 7
482547	spring	1	4.5	16/16-25R; Milk Canyon 7
482550	irrigation well	1	---	16/16-24F; Milk Canyon 7
482573	spring	1	7.0	15/19-7M; Ellensburg 15
482577	spring	1	7.5	16/18-26B; Ellensburg 15
482579	spring	1	6.5	16/18-27D; Ellensburg 15
482582	spring	1	6.0	16/17-1N; Ellensburg 15
	Union Gap - Elephant Mtn. Area			
154132	oil well (1326')	1	6.5	12/19-17C; Yakima East 7
154133	irrigation well (7500')	1	5.0	12/19-16N; Yakima East 7
482553	irrigation well (1290')	1	6.5	12/20-27N; Toppenish 7.5
	Granger Area			
482560	irrigation well (1140')	1	8.0	11/22-28H; Granger 15'
482562	irrigation well	1	7.5	11/21-5H; Granger 15'
482565	irrigation well (1200')	1	7.5	11/21-22G; Granger 15'
	Sunnyside Area			
482559	city well (1567')	1	6.5	10/22-25F; Granger 15'
	Grandview Area			
482557	city well (1200')	1	6.5	9/23-32J; Prosser 15'
482558	city well (1150')	1	6.5	9/23-23G; Grandview 15'
	Prosser Area			
482556	city well (1264')	1	7.0	8/24-1H; Prosser 15'

Table 3.—Stream sediment analyses for uranium

Number	PPM U_3O_8	Location
	Vantage Area	
154113	1	17/22-24B; Ginkgo 7.5
154114	800	17/22-13N; Ginkgo 7.5
	Squaw Creek Area	
154119	1	16/19-34N; Wymer 7.5
154121	1	16/19-22J; Wymer 7.5
154122	1	16/19-26E; Wymer 7.5
154123	1	16/19-26A; Wymer 7.5
154124	1	16/19-24N; Wymer 7.5
154127	1	16/19-1F; Wymer 7.5
154128	1	16/19-1F; Wymer 7.5
154129	1	16/19-2J; Wymer 7.5
154130	1	16/19-35P; Wymer 7.5
	Burbank Valley Area	
154134	1	15/19-21A; Wymer 7.5
154137	1	15/19-22F; Wymer 7.5
154138	1	15/19-23N; Wymer 7.5
154139	1	15/19-27A; Wymer 7.5
154141	1	15/19-21R; Wymer 7.5
154143	1	15/19-22J; Wymer 7.5
154144	1	15/19-26B; Wymer 7.5
154152	1	15/19-36H; Pomona 7.5
154153	1	15/19-36Q; Pomona 7.5
482532	1	15/19-36F; Pomona 7.5
482534	1	15/19-25P; Wymer 7.5
482535	1	15/19-25P; Wymer 7.5
482537	1	15/19-26R; Wymer 7.5
482538	1	15/19-26G; Wymer 7.5
482540	1	15/19-26L; Wymer 7.5
482542	1	15/19-22P; Wymer 7.5
482566	1	15/19-16E; Wymer 7.5
482567	1	15/19-21D; Wymer 7.5
482569	1	15/19-17K; Wymer 7.5
482570	1	15/19-18H; Wymer 7.5
482572	1	15/19-7R; Wymer 7.5
	Wenas-Selah Area	
15171-1	1	15/17-1R; Ellensburg 15'
151712-1	1	15/17-12B; Ellensburg 15'
154154	1	16/17-28G; Ellensburg 15'
154155	1	16/17-20F; Ellensburg 15'
154156	1	16/17-18G; Ellensburg 15'
482503	1	14/18-11N; Selah 7.5

Table 3 "Cont." Stream sediment analyses for uranium

482505	1	14/18-5E; Selah 7.5
482516	1	16/17-35G; Ellensburg 15
482519	1	15/18-3N; Ellensburg
482524	1	15/18-7E; Ellensburg 15
482531	1	16/17-33N; Ellensburg 15
482543	1	16/17-31H; Ellensburg 15
482544	1	16/16-23F; Milk Canyon 7.5
482549	1	16/17-25R; Milk Canyon 7.5
482576	1	16/18-25D; Ellensburg 15
482578	1	16/18-23C; Ellensburg 15

Table 4.—Fluorine analyses of water samples

Water sample number*	PPM Fluorine
154120	0.63
154125	0.96
154126	0.61
154132	53.00*
154133	0.295
154135	1.00
154139	1.38
154142	0.96
154145	0.75
154146	0.525
154148	0.83
154150	1.00
154151	0.96
482504	0.595
482506	0.31
482507	0.335
482508	0.367
482510	0.35
482511	0.51
482512	0.36
482513	0.525
482514	0.40
482515	0.96
482517	0.35
482518	0.35
482520	0.277
482521	0.265
482522	0.485
482523	0.66
482525	0.372
482526	0.80
482527	0.53
482528	0.32
482529	0.31
482530	0.87
482533	0.87
482536	0.96
482539	0.80
482541	1.08
482545	0.225
482547	0.235
48550	

*See Table 2 for locations.

Table 4 "Cont." Fluorine analyses of water samples

Recent miscellaneous Department of Social and Health Services Analyses

Nob Hill Water Co., Yakima	1.4
Yakima City Hall	1.6
Yakima, Suntides Mobile Court	1.4
Mabton City Hall	2.4
Mabton City Hall (north well)	2.2
Moxee well house #1	1.4
Moxee, Kohl's Tavern	1.63
Selah City Hall	3.5
Selah well # 3 and 4	2.2
Selah well #5	3.95
Selah well #6	4.0

Table 5.—Whole rock analyses of the Beverly and Pomona ash fall tuffs

Oxides	Beverly ash fall tuff RC 154171	Pomona ash fall tuff RC 154102
SiO_3	70.1	70.6
Al_2O_3	12.0	12.0
Fe_2O_3	1.1	0.94
FeO	1.0	1.4
Na_2O	1.3	1.9
K_2O	4.8	4.6
CaO	1.5	1.1
MgO	0.63	0.43
TiO_2	0.38	0.39
MnO	0.039	0.037
P_2O_5	<0.02	0.07
F	0.088; 0.13*	0.098
CO_2	0.2	0.1
SrO	0.011	0.013
Rb_2O	0.038	0.034
Li_2O	0.002	0.002
Subtotal	93.20	93.7
L.O.I.	6.9	5.9
Moisture	0.3	0.2
Total weight percent	100.4	99.8

*Second analysis

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OFR
79-2
Plate 1

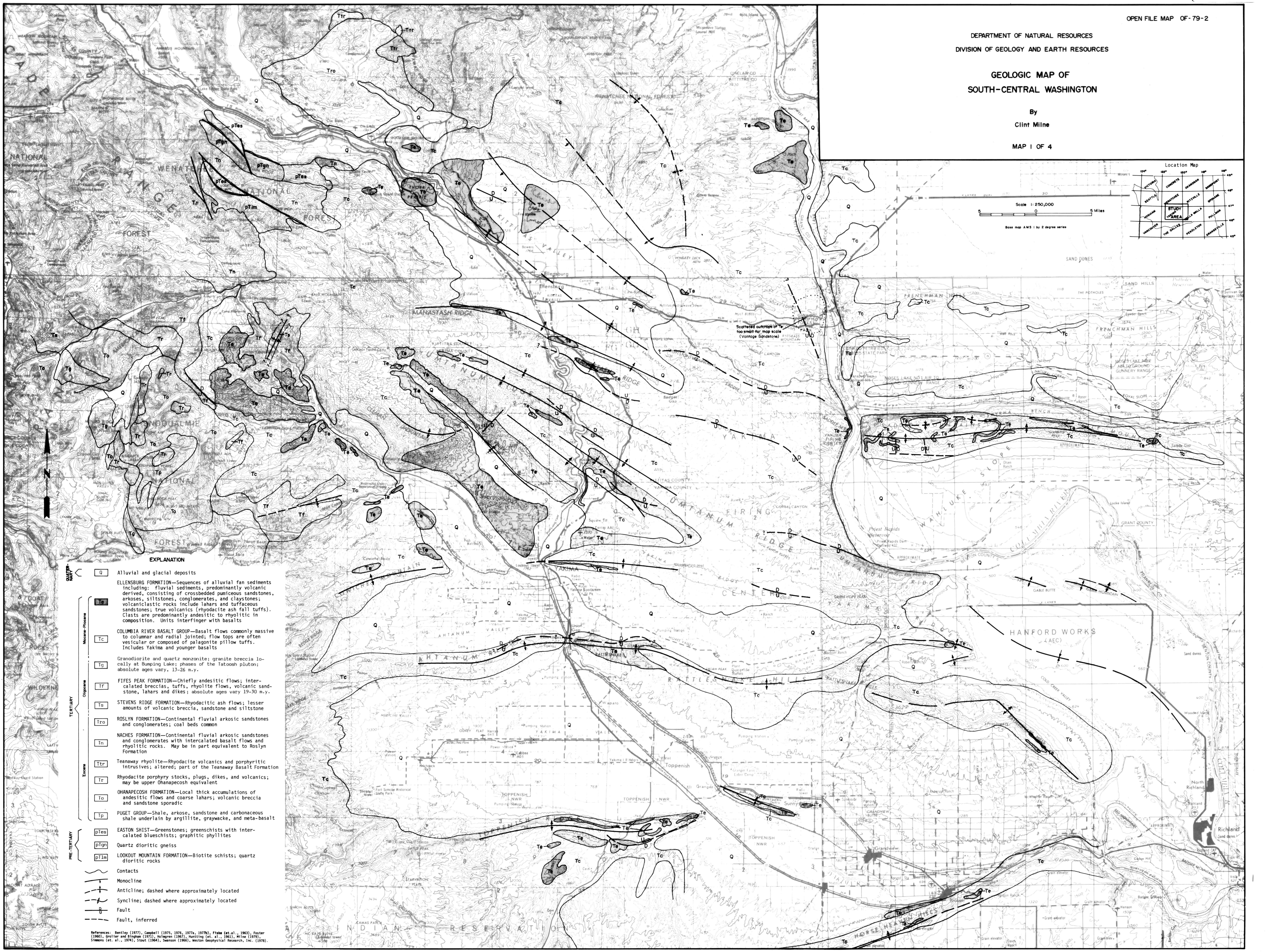
OPEN FILE MAP OF-79-2

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND EARTH RESOURCES

GEOLOGIC MAP OF SOUTH-CENTRAL WASHINGTON

By
Clint Milne

MAP 1 OF 4



EXPLANATION

QUATERNARY

- Q — Alluvial and glacial deposits

TERTIARY — Miocene-Pliocene

- Te — ELLENSBURG FORMATION—Sequences of alluvial fan sediments including: fluvial sediments, predominantly volcanic derived, consisting of crossbedded pumiceous sandstones, arkoses, siltstones, conglomerates, and claystones; volcaniclastic rocks include lahars and tuffaceous sandstones; true volcanics (rhyodacite ash fall tuffs). Clasts are predominantly andesitic to rhyolitic in composition. Units interfinger with basalts
- Tc — COLUMBIA RIVER BASALT GROUP—Basalt flows commonly massive to columnar and radial jointed; flow tops are often vesicular or composed of palagonite pillow tuffs. Includes Yakima and younger basalts
- Tg — Granodiorite and quartz monzonite; granite breccia locally at Bumping Lake; phases of the Tatoosh pluton; absolute ages vary, 13-26 m.y.

TERTIARY — Oligocene

- Tf — FIFES PEAK FORMATION—Chiefly andesitic flows; intercalated breccias, tuffs, rhyolite flows, volcanic sandstone, lahars and dikes; absolute ages vary 19-30 m.y.
- Ts — STEVENS RIDGE FORMATION—Rhyodacitic ash flows; lesser amounts of volcanic breccia, sandstone and siltstone

TERTIARY — Eocene

- Tro — ROSLYN FORMATION—Continental fluvial arkosic sandstones and conglomerates; coal beds common
- Tn — NACHES FORMATION—Continental fluvial arkosic sandstones and conglomerates with intercalated basalt flows and rhyolitic rocks. May be in part equivalent to Roslyn Formation
- Ttr — Teanaway rhyolite—Rhyodacite volcanics and porphyritic intrusives; altered; part of the Teanaway Basalt Formation
- Tr — Rhyodacite porphyry stocks, plugs, dikes, and volcanics; may be upper Ohanapecosh equivalent
- To — OHANAPECOSH FORMATION—Local thick accumulations of andesitic flows and coarse lahars; volcanic breccia and sandstone sporadic
- Tp — PUGET GROUP—Shale, arkose, sandstone and carbonaceous shale underlain by argillite, graywacke, and meta-basalt

PRE-TERTIARY

- pTes — EASTON SHIST—Greenstones; greenschists with intercalated blueschists; graphitic phyllites
- pTgn — Quartz dioritic gneiss
- pTlm — LOOKOUT MOUNTAIN FORMATION—Biotite schists; quartz dioritic rocks

Contacts

Monocline

Anticline; dashed where approximately located

Syncline; dashed where approximately located

Fault

Fault, inferred

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