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LOCATION MAP

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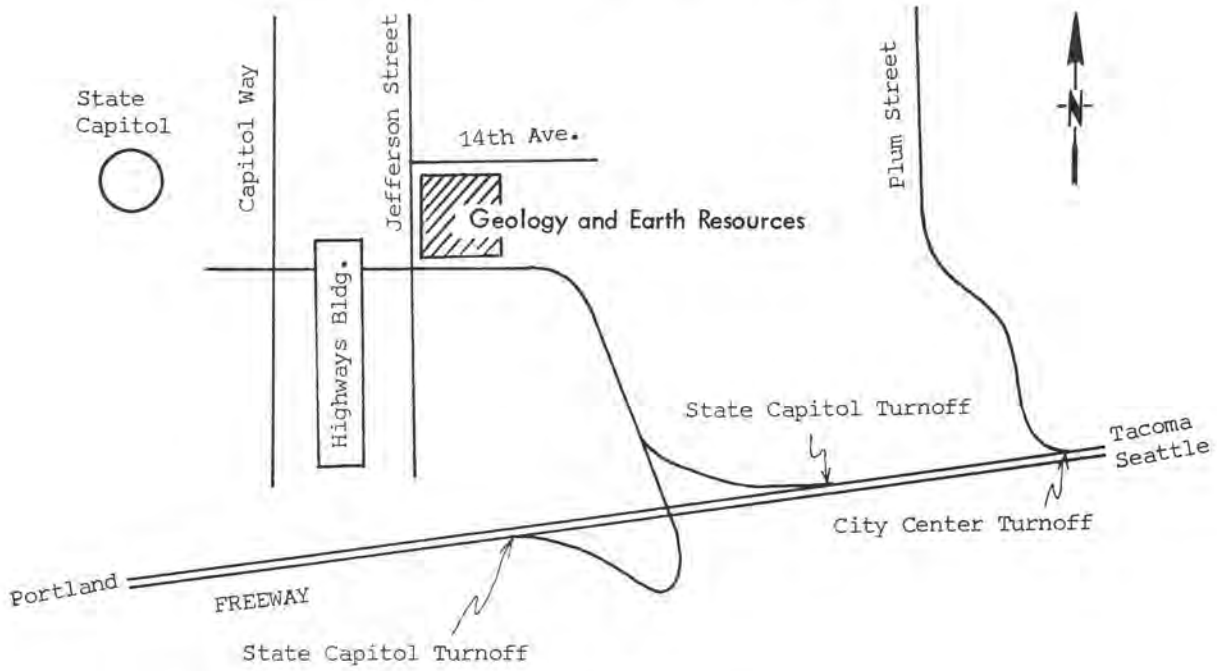

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COVER PHOTO

Uranium exploration.

WASHINGTON STATE
EXPLORATION ROUNDUP, 1976

by

John M. Lucas

During 1976, uncertainties generated by pre-election politics and worldwide economic and political problems, plus fluctuations of the various metal markets, have apparently contributed to the significant decline in both base and precious metal exploration in the state and elsewhere over the past year. This negative development has been more than offset by a dramatic increase in uranium exploration. Metals companies that have remained active here, however, have been engaged in all facets of exploration from general reconnaissance to drilling and test tunneling. In spite of rapidly changing corporate and national priorities, over 60 companies are known to have been active in the state during 1976. This figure, which represents a moderate increase over last year's figure of 50 or so companies, is due primarily to the increased interest in uranium. It was estimated in 1975 that over $1.5 million was expended on exploration during this year, so the figure for 1976 should be well in excess of the previous year's estimate. When one considers the effects of inflation and the apparent increase in the number of exploration teams supported, miles of airborne geophysical coverage flown, acres of land acquired this year, etc., expenditures on exploration may well exceed $2 million.

The noted increase in local uranium exploration activities, together with those related to exploration for coal in western Washington, seems to have captured the lion's share of this year's mineral news. The bulk of this energy-related news, however, appears to have originated from developments that are taking place daily in northeastern Washington.

The Cascade Mountains and Okanogan Highlands are the two physiographic provinces within which most of the state's exploration activity has been concentrated.

The Cascade Mountains province occupies the eastern one-half of the western one-half of the state and extends southward from the Canadian border to the Columbia River. The Okanogan Highlands province extends into the eastern foothills of the Cascades on the west, eastward to the Idaho border, and south from the Canadian border to an irregular line more or less following the 48th parallel.

These provinces, with the areas of primary and secondary mineral exploration shown in figure 1, are outlined below:

Cascade Mountains Province

1. St. Helens and Washougal mining districts of Skamania County.
2. Glacier Peak, Monte Cristo, Index, and Silver Creek districts of Snohomish County; and the Chiwawa district, Chelan County.
3. Wenatchee and Blewett districts, Chelan County; and the Swauk and Cle Elum districts of Kittitas County.
4. Conconully, Twisp, Tonasket, and Mazama districts of Okanogan County.
5. Loomis and Nighthawk districts, Okanogan County.

Okanogan Highlands Province

6. Myers Creek and Sheridan districts of Okanogan County; and the Danville district of Ferry County.
7. Northport and Orient districts, Stevens County.
8. Newport district, Pend Oreille County; Mount Spokane district, Spokane County;

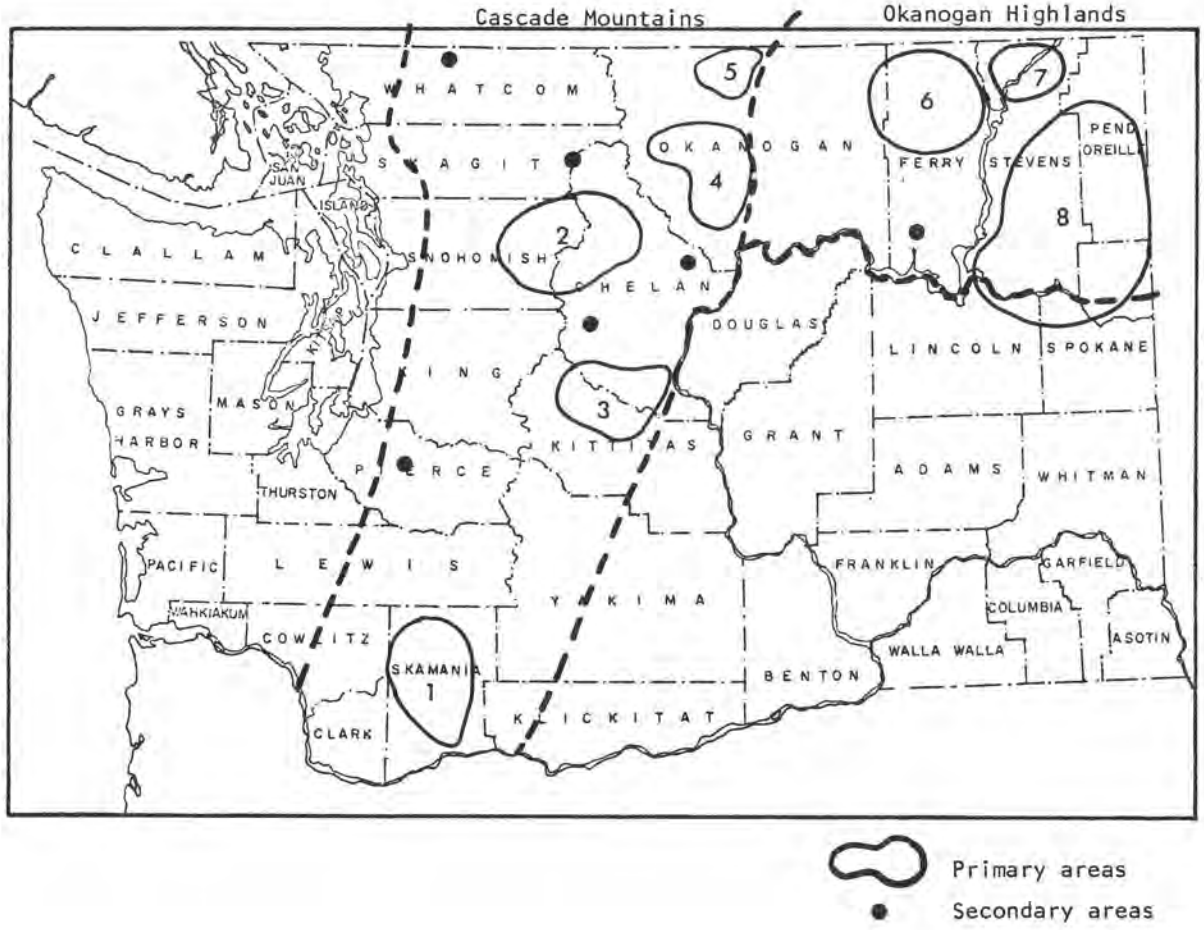

FIGURE 1.—Areas of metallic mineral exploration in Washington, 1976.

and Loon Lake, Chewelah, Colville, Summit, Deer Trail, and Springdale mining districts of Stevens County.

The other two figures accompanying this brief discussion illustrate the approximate locations of various exploration projects throughout the state, arranged according to the specific metals sought.

Uranium Exploration

As noted earlier, the most intense exploration activity in the state has been directed toward the discovery of new deposits of uranium. Rapidly rising prices for this vital energy source, combined with diminishing supplies, sparked the interest of many of the major foreign and domestic energy and mining companies (see fig. 3).

Needless to say, the greatest volume of uranium news can be attributed to the activities of the state's only producing uranium mine owned by Midnite Mines, Inc. This mine is located a few miles north of Wellpinit on the Spokane Indian Reservation, in Stevens County. A few miles south of Wellpinit, Western Nuclear's sizable Sherwood mine is approaching the final stages of development.

Companies that have been scouring the northeastern part of the state for various types of uranium deposits include Exxon, Reserve Oil and Minerals Corp., Burlington Northern and Westinghouse (BurWest), Kerr-McGee, Westinghouse (Wyoming Minerals), Pechiney, General Electric (Utah International), U.S. Steel, Continental Oil Co., and many others. Several of these companies are known to have planned or commenced core drilling operations to test anomalies established by recent field investigations. To date, however, there has been no official announcement of any significant new discoveries to rival those of the Midnite and Sherwood deposits.

Three reports released last May by the federal Energy Research and Development Administration (ERDA) assessing the potential for Tertiary sediments to contain economic deposits of uranium minerals pointed out in particular that the sediments of the Tertiary Tiger Formation possess a number of textural, compositional, and structural features that would seem to favor the development of these deposits. Foremost among the compositional features are the scattered occurrences of uranium that have been discovered during the past 20 or so years of uranium exploration.

The Tiger Formation, with varying degrees of exposure and potential, crops out on both sides of the Pend Oreille River, from around Box Canyon Dam in the north to below the Cusick area in the south. There is a strong possibility that the entire valley area is underlain by this formation.

Other localities under investigation in the northeast tri-county area tend to be concentrated along or adjacent to the contacts between sedimentary, metamorphic, and(or) volcanic units of diverse ages and the various plutonic phases of the extensive Kaniksu, Colville, and Loon Lake batholith of Cretaceous age. Moving in a clockwise direction, these areas of interest are first, of course, the Midnite-Sherwood mine areas, then the Deertrail-Springdale area, followed by the Old Dominion Mountain, Box Canyon Dam, Newport, Mount Spokane area, thence west to the Midnite-Sherwood area.

Most of the interest in Ferry County has been directed toward detailed examination of the many uraniferous pegmatites concentrated in the Mount Leona, Sherman Pass, and Nancy Creek areas of north-central Ferry County. Considering the current stagnant state of the world's economy, these deposits may well become economic sooner than anticipated.

Copper Exploration

The largest single concentration of companies engaged in copper exploration during this year appears to be in the Southern Cascades, in Skamania County.

Amoco Minerals has continued core-drilling operations on their Silver Star or Miners Creek property, which is about 20 miles due east of the town of

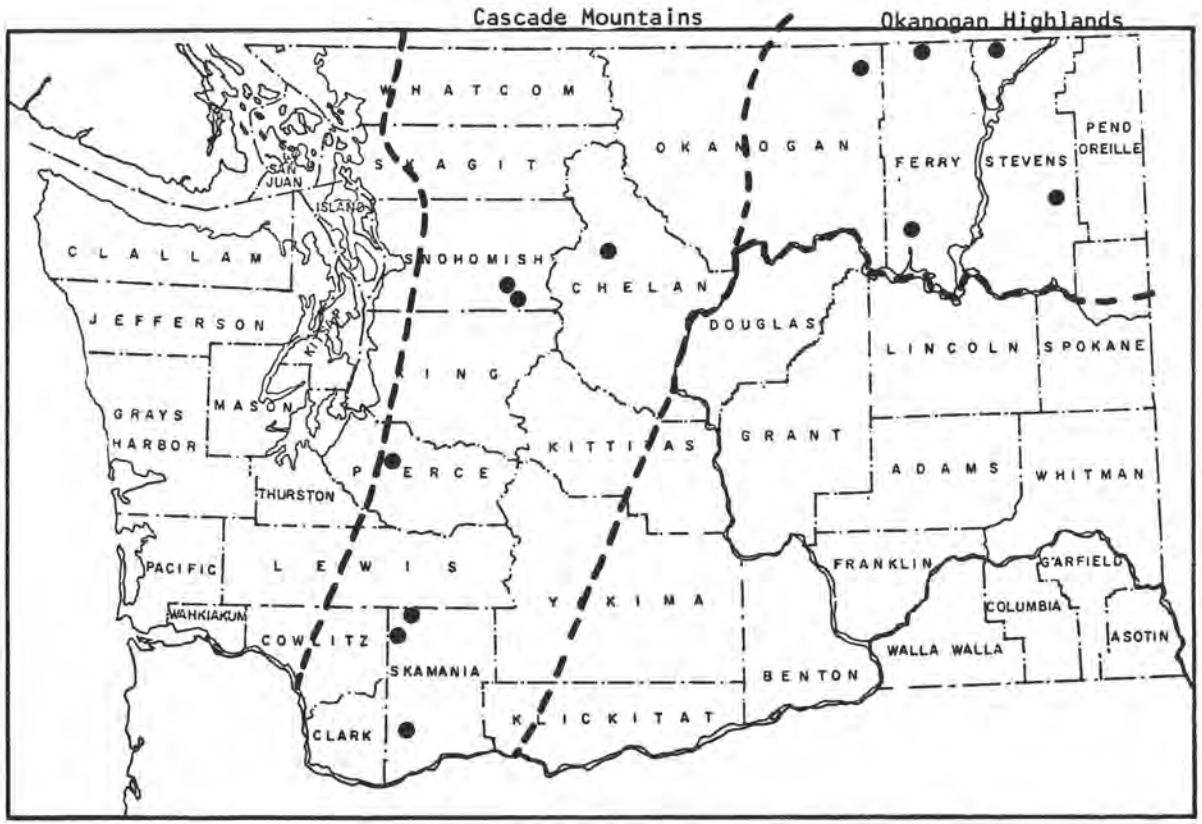

FIGURE 2.—Areas of copper exploration in Washington, 1976.

Battleground. North of Spirit Lake and within the Mount St. Helens mining district, Duval is still exploring and drilling at the Mount Margaret copper deposit; a short distance south of Duval and near the east end of Spirit Lake, New Cinch Uranium Ltd. of Toronto has been investigating the copper potential in and around the old Norway-Sweden mine.

Copper-tourmaline veins in granodiorite in the Coplay Lakes area of central Pierce County continue to hold the interest of several exploration companies.

To the north in Snohomish County, Cities Service Minerals Corp. commenced diamond drilling on their Silver Creek copper-moly prospect northeast of Index; BrenMac Mines is continuing full-scale underground exploration of their copper-moly-tungsten deposit. This property, which is near Monte Cristo and Vesper Peak, is still known as the Sunrise mine. Moving eastward into Chelan County, Texasgulf expanded their core-drilling project at the old Red Mountain mine, on Red Mountain just north of Lake Wenatchee. A number of individuals and a company or two have been actively examining other properties throughout Chelan County for copper, as well as lead, zinc, gold, and silver.

In Okanogan County, just south of the Canadian border, Dresser Industries of Houston have been busy drilling and prospecting their property on Buckhorn Mountain, east of Chesaw. Farther eastward into Ferry County, Granby Mining Co. of Vancouver, British Columbia, recently announced their plans to commence mining operations at their Lone Star copper mine just west of Danville. On Tolman Mountain near the town of Keller in southwestern Ferry County a prospect belonging to Bear Creek Mining is developing into a viable copper-moly deposit.

Continental Oil Co., which is also active in uranium exploration, is reported to have acquired land around the old United Copper-Copper King mine located east of Chewelah in Stevens County. Elsewhere in Stevens County, the Rossland Volcanics between Northport and Orient continue to be prospected for southern extensions of the copper deposits hosted by these rocks farther north in British Columbia.

Lead and Zinc Exploration

Economic uncertainties and the apparent inability of the various metal markets to comfortably absorb price increases have again this year been reflected by the lack of interest shown by companies in finding new sources of these two useful, if not strategic, metals.

The Pend Oreille mine of the Bunker Hill Company is still operating full time at their large underground mine at Metaline Falls. The mine is developed in the Middle Cambrian Metaline Limestone and it is presently the state's leading producer of zinc and lead. Bunker Hill is also carrying out exploration and feasibility studies nearby at the Yellowhead mine located west across the Pend Oreille River from Metaline Falls.

In the Onion Creek area of Stevens County between Colville and Northport, the Callahan Mining Corp. is continuing to explore and develop their Washington zinc unit. This property was formerly known as the Van Stone mine.

The Boggs Brothers Construction Co. of Spokane has been actively exploring their newly discovered Phillips Ranch lead-zinc-silver prospect, which is located several miles south of Northport near the west bank of the Columbia River.

Elsewhere within the state several months of investigatory work have been spent this year on the old Kaaba-Texas lead-zinc-silver deposit. This mine is developed in a fissure vein, located just outside of Nighthawk in Okanogan County.

Valumines Inc. of Mount Vernon, Washington, continued exploration efforts on their lead-zinc-silver property near Cascade Pass in eastern Skagit County.

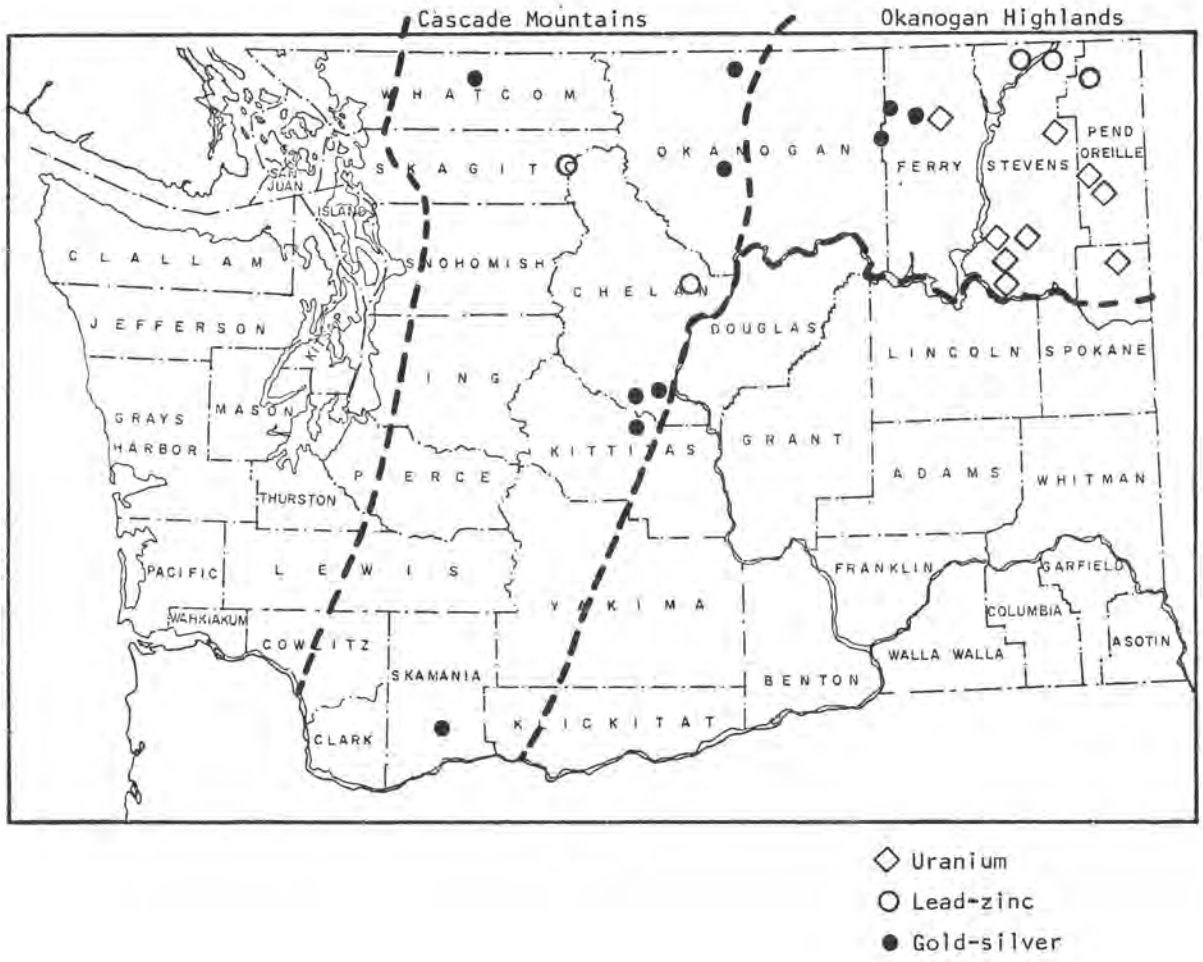

FIGURE 3.—Areas of uranium, lead-zinc, and gold-silver exploration in Washington, 1976

Gold and Silver Exploration

Repeating the same old theme, which was applied above to copper, lead, and zinc, subdued vitality in the market place this year has been reflected in a substantial reduction in the number of companies and individuals known to be actually prospecting for marketable gold and silver in Washington.

This negative picture does have a thin silver lining, however, which has been reflected in the popularity of our Information Circular 57, "Handbook for Gold Prospectors in Washington." This publication was released late last year by our Division of Geology and Earth Resources. It has been especially well received by weekend and hobby gold prospectors, with over 2,000 copies being sold within the year.

Despite a noticeable decline in prospecting activity over the previous year, interest in precious metal remains moderately strong. Following the sun across the state from east to west, Norex American reopened the old Melrose silver-lead mine in Stevens County between Northport and Boundary. The main adit here was enlarged enough to allow more efficient trackless mining methods to be employed.

In Ferry County, the Knob Hill mine at Republic continues as the state's only full-time operating gold mine. A few miles west of Republic, Houston Oil and Gas has been drilling and exploring for gold at the old Flag Hill mine. In the Sherman district, Canadian interests are reexamining the silver deposits around the Silver Belle mine; near Curlew Lake north of Republic, Ruby Mining Company of Omak, Washington, has undertaken development and exploration of the old Valley mine. Ore from this mine will be milled at the company's mill in Omak.

In the Conconully district of Okanogan County, Xerex Exploration Ltd. of Calgary, Alberta, recently completed the initial stages of their exploration and development program for the long-dormant 4th of July and First Thought silver mines on Ruby Hill. Here trackless mining, centered around a newly completed haulage decline, will be utilized to reduce mining costs. The Lone Star lead-silver mine, which is also in the Conconully area, is presently under development by an undisclosed private party.

South of Wenatchee, Cypress Mines have enlarged their mineral land holdings around the Gold King mine. Most of the exploration work to date has consisted of diamond drilling and rehabilitation and sampling of the old workings. This mine has been an intermittent producer of gold and silver since about 1894. It may in the near future have considerable potential as a large low-grade deposit amenable to modern high-volume mining methods.

West of Wenatchee in the Blewett Pass-Liberty area, a number of small placer mining operations continue to exist with some degree of success.

In south-central Skamania County, Foster Mining Co., of nearby Vancouver, has reopened the Old Wind River gold mine; at the other end of the state, Quintana Minerals Corp. completed six diamond-drill holes at the Great Excelsior gold-silver mine. This old mine, once a fairly large producer of gold-silver ores, is developed in a large zone of brecciated greenstone and is located within the old Mount Baker mining district of Whatcom County.

This concludes the summary of exploration activities of a number of companies known to have been operating within Washington State during 1976. Though a large segment of the state's mineral activities have been included here, a large segment has also not been mentioned, either to avoid disclosure of privileged information or because we simply are not aware of exactly what is being done by all of the companies operating here.

Mining Companies Active in Washington During 1976

AGIP
Amax Exploration Inc.
American Copper & Nickel Co.
Amoco Minerals Co.

Bear Creek Mining Co.
Bethlehem Copper Corp.
Boggs Brothers
BrenMac Mines Ltd.
Bunker Hill Co.
BurWest

Callahan Mining Corp.
Cities Service Minerals Corp.
Continental Oil Co.
Cypress Mines

Dawn Mining Co.
Dennison Mines, Ltd.
Dresser Industries
Dusty Mack Mines Ltd.
Duval Corp.

Empire Explorations Inc.
Exxon

Foster Mining Co.

Granby Mining Co.

Helena Silver
Houston Oil and Gas

Inspiration Development Corp.
International Nickel Co. of Canada Ltd.

Kerr-McGee

Metaline Mining & Leasing
Midnite Mines, Inc.
Mineral Associates Inc.
Minerals Exploration Inc.
Mitsubishi
Monetary Metals Inc.
Morse Brothers

Natural Resources Dev. Corp.
New Cinch Uranium Ltd.
Norex American
Nuclear Dynamics

P & H Mining Co.
Pechiney Ugine Kuhlmann Dev. Inc.
Pioneer Nuclear Inc.

Quintana Minerals Corp.

Reserve Oil & Minerals Corp.
RexCon Inc.
Rio Algom Mines, Ltd.
Rio Amex
Rocky Mountain Energy
Ruby Mining Co.

St. Joe Minerals Corp.
Silver Standard Mines Ltd.
Sumimoto Metal Mining Co. Ltd.

Texasgulf Inc.

U.S. Borax & Chemical Corp.
U.S. Steel
Union Carbide
Uranertz
Urania
Urangazelshaft
Utah International Inc.

Valumines

Western Nuclear Inc.
Wold Nuclear
Wyoming Minerals Corp.

Xerex Exploration Ltd.

TERMINATION OF PROPOSED WITHDRAWAL AND RESERVATION OF LANDS

In 1965, the U.S. Army, Corps. of Engineers, filed an application for withdrawal of 961.55 acres of land in Asotin County in connection with the construction of the Asotin Dam and Reservoir project. They applied for withdrawal of these lands from all forms of appropriation under the public land laws, including the mining laws and the mineral leasing laws.

The abandonment of the Asotin project by Public Law 94-199 on December 31, 1975 (89 Stat. 1117) brought about the cancellation of the withdrawal. Notice will soon appear in the Federal Register that the land in Asotin County will, on January 20, 1977, be relieved of the above-mentioned application.

FIRST FAR-WEST METRIC MAP ISSUED, KING COUNTY

The U.S. Geological Survey, in cooperation with the King County Planning Division, has published a new metric topographic map of King County. The

map is on a scale of 1:100,000 (1 centimeter represents 1 kilometer, or 1 inch represents about 1.6 miles); contour intervals and elevations are shown in meters instead of feet. Adoption of the metric scale and contour interval is part of a comprehensive plan for complete conversion to the metric system by the USGS under the Metric Conversion Act of 1975.

The new multicolor metric maps issued by the USGS were designed to fill a need by users for a scale between the present 1:24,000 series ($7\frac{1}{2}$-minute quads) and the 1:250,000 series.

Feature separation is used rather than color separation on the new maps. The major components of the maps (such as roads and water features) are subdivided into classes and separate master drawings are prepared for each class of map feature. This lets users who want to prepare maps to meet their particular needs to buy copies of the master reproducibles for only those map elements needed.

Copies of the metric King County map may be purchased for $2 each, prepaid, from the Branch of Distribution, U.S. Geological Survey, P.O. Box 25286, Federal Center, Denver, CO 80225. Copies of a map showing the status and progress of operations for the new 1:100,000 scale maps, and information on how to purchase copies of the feature separation drawings, can be obtained from the National Cartographic Information Center, Reston, VA 22092.

STAFF PROFILES

Pamela Palmer Ferguson

A new member of our geologic staff, Pam is investigating evidence of recent tectonic activity in the northern Puget Lowland. She is completing final requirements for her master's degree in geology from the University of Toledo, in Ohio.

Leslie Anne Clark

Leslie joined our office staff on October 5, 1976. She graduated from The Evergreen State College last June; her major field of study was creative writing.

FOLDED TOPO MAPS DESIGNED FOR PUBLIC USE

One of the most popular topographic maps, Mount Rainier National Park, has been made available in folded "pocket-sized" format by the U.S. Geological Survey. This is the first of 24 projected folded topo maps designed to allow better display by dealers and also as a more convenient carrying method

for recreationists.

The multicolor Mount Rainier map was prepared at a scale of 1:50,000 (1 inch equals about 4,200 feet). The park terrain is portrayed by bench marks and spot elevations; the 80-foot interval contour lines are printed in brown over the land surface and in blue over the glaciers.

The Mount Rainier topo map can be purchased for $2 each (prepaid) from the Branch of Distribution, U.S. Geological Survey, Box 25286. Federal Center, Denver, CO 80225. The maps will also be sold through many dealers.

DIVISION OPEN-FILE REPORTS

The Division of Geology and Earth Resources has placed the following reports on open file; they may be inspected in the division reference library:

Sketch map showing geology and mineral deposits in Stevens County, Washington, by Newell P. Campbell and Ronald K. Sorem. 1969. Four pages of text and 7 map transparencies. Open-file Report 69-1.

Report on geothermal ground noise measurements in Washington State by, Robert S. Crosson and Ian R. Mayers. 1972. 52 total pages. Open-file Report 72-1.

Preliminary report on the geology of southern Snohomish County, by Gerald Capps, John D. Simmons, and Frank D. Widegar. 1973. 11 p. Includes one geologic column and one geologic map. Open-file Report 73-1.

Slope stability of the Longview-Kelso urban area, Cowlitz County, Washington, by Allen J. Fiksdal. 1973. 4 p. Includes one geologic map. Open-file Report 73-2.

Tephra of Salmon Springs age from the southeastern Olympic Peninsula, Washington, by R. U. Birdseye and Robert J. Carson. 1974. 35 p. Open-file Report 74-1.

Sand and gravel deposits of Klickitat County, Washington, by Scott Milne and Randy Cross. 1974. Scale 1:125,000. Open-file Report 74-2.

Ground water in the Methow Valley, Mazama to Winthrop, by Ernest R. Artim. Four map prints. 1975. Nine pages of text plus the legend for the map sheets. Scale 1:2,400. Open-file Report 75-1.

Environmental geology of the Parkland-Spanaway area, Washington, by John Battie, Donella Johnston, and Craig Searls. 1975. Seven map sheets. Open-file Report 75-2.

Geologic map of the southern Hood Canal area, Mason County, Washington, by Robert J. Carson. 1975. Geology on the Potlatch and The Brothers 15-minute topographic quadrangle sheets. Open-file Report 75-4.

Geologic mapping of the Wenatchee area, by Randall Gresens. 1975. Four map prints. Scale 1:1,000. Open-file Report 75-6.

Geologic interpretive map showing areas of unstable slopes, Kitsap County, Washington, by Kurt Othberg. 1975. One page of text. Geology on 11 separate map sheets. Open-file Report 75-7.

Geomorphology of the Coluckum Pass area, Kittitas County, Washington, by Kurt Othberg. 1975. 3 p. Open-file Report 75-8.

Coal reserves of Whatcom County, Washington, by Ellis R. Vonheeder. 1975. 86 p. Open-file Report 75-9.

Petrogenesis of the Mount Stuart batholith plutonic equivalent of the high-alumina basalt association, by Erik H. Erikson, Jr. 1976. 38 p., 2 plates. Open-file Report 76-6.

Waste-disposal map of the Uncas-Port Ludlow area, Jefferson County, Washington, by

Kathryn L. Hanson. 1976. Scale 1:24,000. Open-file Report 76-7.

Monitoring of an active fault near Lilliwaup, Mason County, Washington, by Kurt Othberg and John B. Hall. 1976. 7 p. including 3 figures. Open-file Report 76-12

U.S. GEOLOGICAL SURVEY OPEN-FILE REPORTS

The following open-file reports from the USGS are now available for inspection in the Division of Geology and Earth Resources reference library:

Reconnaissance geochemical survey of gully sediments in part of the Okanogan Range, Okanogan County, Washington, by C. Dean Rinehart, 25 p. plus 3 plates. Our division library has reproducible copies for these three plates:

- Plate 1. Geologic map of the Okanogan Range, scale 1:96,000.
- Plate 2. Cold-acid extractable copper (xCu) in stream sediments (overlay to plate 1).
- Plate 3. Citrate-soluble heavy metals (cxHm) in stream sediments (overlay to plate 2). Open-file Report 76-680.

Resume of the regional geology of the Grand Coulee area, Washington, by M. H. Staatz and R. H. Morris, 34 p. Open-file Report 76-782.

USGS REPORTS NOW AVAILABLE

The following reports are now available for inspection in our division reference library:

Griggs, A. B., 1976, The Columbia River Basalt Group in the Spokane quadrangle, Washington, Idaho, and Montana: U.S. Geological Survey Bulletin 1413, 39 p. Price - $1.95.

Rinehart, C. D.; Fox, K. F., 1976, Bedrock geology of the Conconully quadrangle, Okanogan County, Washington: U.S. Geological Survey Bulletin 1402, 58 p. Plate 1 - geologic map, scale 1:62,500. Price - $2.30.

Easterbrook, D. J., 1976, Geologic map of western Whatcom County, Washington: U.S. Geological Survey Miscellaneous Investigations Map I-854-B. Scale 1:62,500. Price - $1.50.

The bulletins may be purchased from: Branch of Distribution, USGS, 1200 S. Eads St., Arlington, VA 22202; the map is available at: Branch of Distribution, USGS, Box 25286, Federal Center, Denver, CO, 80225.

COAL EXPLORATION ON STATE-ADMINISTERED LANDS IN WHATCOM AND SKAGIT COUNTIES DURING 1976

by

Ellis R. Vonheeder

The first phase of a coal exploration drilling project in the Whatcom Basin of northwestern Washington State is close to completion. Three months' field work was accomplished concurrently with the exploration drilling phase of some 1,270 feet of plug drilling and 115 feet of core drilling. The project,

jointly funded in a ratio of 65:25:10 by the U.S. Geological Survey Conservation Division, Washington Department of Natural Resources, and the U.S. Bureau of Mines, respectively, was initiated to test the possibilities of increasing the overall coal reserves in Whatcom County, with emphasis on the DNR-administered state lands. Until a few years ago, little exploration effort had been expended on increasing the coal reserve base of Whatcom County. A notable exception was the project undertaken by USSRAM for Puget Sound Power & Light in the late 1950's and early 1960's. This project delineated 6 million tons of coal lying in a shallow syncline 5 miles north of Bellingham; this is in addition to reserves previously known.

Historically, Whatcom County contributed significant volumes to the overall coal production of Washington State. The Bellingham No. 1 mine, located in northwest Bellingham, produced over 1,100 tons of steam coal per day, with the bulk of the production occurring in the late 1920's. Coal production declined from that year until 1947, when a slight increase in production occurred. The last production of any significance was in 1954. Shortly thereafter, the buildings were demolished, adits filled, and the Bellingham No. 1 mine was closed permanently.

Another mine of commercial significance in the Whatcom Basin was the Blue Canyon mine near the extreme southeast shore of Lake Whatcom. Before the turn of the century, production approached 25,000 tons per year. After 1900, less than 10,000 tons of high-quality steam coal was produced annually. A disastrous fire and explosion occurred in 1894, killing a total of 23 people, including most of the supervisory staff. Sporadic attempts at renewed production occurred until 1918, at which time the mine was permanently closed. Other mines of lesser commercial significance were active in and around the Bellingham area. For a more in-depth discussion of production and geologic settings of these mines, the reader is referred to the Division of Geology and Earth Resources Open-file Report 75-9, "Coal reserves of Whatcom County, Washington" (Vonheeder, 1975) available for reference in division library.

The present exploration project was initiated to define as closely as possible those coal resources lying upon (or close to) state-owned lands. The main areas under consideration are contained in T. 39 N. R. 5 and 6 E., and T. 38 N., R. 6 E., an area of over 17,000 acres. Another 720 acres of state-owned land in T. 37 N., R. 4 E. (north and east of the town of Alger) is also considered to be potentially coal bearing. Aside from the most general reconnaissance work in these areas, little or no detailed work addressing coal exploration had been accomplished prior to the commencement of this project. Beikman (1961) does not show reserve figures for the first two areas due to insufficient data. Reserve estimates for the area northeast of Alger are presented in table 1.

Access

Access to the subject area is accomplished via Interstate 5 to Exit 255 in Bellingham. Thence east on highway 542 for 17 miles to the town of Welcome. At Welcome, turn right on the Mosquito Lake Road, after 1 mile turn left again on the North Fork Road, which parallels the North Fork of the Nooksack River. After gaining some elevation, the road forks at a gravel stockpile; the right fork (DE-S-1000) is followed up the hill about one-half of a mile where it again forks. The right fork (DE-R-1000) is again followed some 8 miles farther up into the Racehorse Creek drainage.

Geologic Setting

The study area (also referred to in this report as the Whatcom Basin) is located wholly within the Chuckanut Formation and is described by Weaver (1937) as:

TABLE 1.—Coal reserves on, or in close proximity to, state-administered lands, Whatcom County, Washington.

Coal bed or zone	Overburden (in feet)	Reserves, in millions of short tons, in beds of thickness shown Measured and indicated			
		14 to 28 inches	28–42 inches	42 inches or more	Total
			T. 39 N., R. 5 E.		
Unnamed	0–1,000	.62	...	.53	1.15
	1,000–2,000	1.90	...	1.61	3.51
	2,000–3,000	3.08	...	2.62	5.70
Township total ..		5.60		4.76	10.36
			T. 39 N., R. 6 E.		
Unnamed	0–1,000	.18	...	1.63	1.81
	1,000–2,000	.55	...	4.90	5.45
	2,000–3,000	1.10	...	8.70	9.80
Township total ..		1.83		15.23	17.06

> . . . essentially a massive cross-bedded to stratified, medium- to coarse-grained, grayish-brown to brownish-gray sandstone. There are subordinate amounts of sandy shales, varying in color from gray to light and dark-brown. Conglomeratic lenses reach thicknesses that locally exceed 100 feet.

Deposition of the Chuckanut Formation was within a rapidly forming geosynclinal trough where the rate of subsidence kept pace with, or was slightly ahead of, deposition. An extended structural continuity in a general northwest-trending belt across the present Cascade Mountains has been demonstrated by various writers (Vance, 1957; Foster, 1955, among others). This continuity delineates Chuckanut and Chuckanut-correlative rocks as being one of the largest regional type areas in the state.

Differential warping of the crust within the depositional area produced changes in the gradients of all the local streams, with a resultant overlapping and coalescing of adjacent alluvial fans. Ponding was widespread and irregular-shaped lakes formed within the accummulated stratified sandy clays which included remains of semitropical vegetation. The formation as measured along the type locality of Chuckanut Drive by Weaver, approaches 12,000 feet in thickness (Weaver, 1937). The basal contact of Chuckanut sandstone with underlying metamorphic rock is located approximately 1 mile to the east of the Racehorse Creek area and suggests the thickness of the local sedimentary section approaches 2,500 feet.

Within the study area, most major fold axes plunge moderately to the northwest, although a second generation of minor folding has been superimposed upon the broad and regionally open folds of the first generation. Observed dip angles are moderate to steep, averaging from 35° to 75°. The writer noted some examples of overturning near the basal portion of the formation. In the vicinity of Mount Baker, the presence of near-surface intrusives are thought to be responsible for more severe local deformation and elevation of Chuckanut coal ranging in grade from bituminous to semianthracite.

Local Geology

As is typical with most geologic exploration projects in the Puget Sound Lowland and adjacent

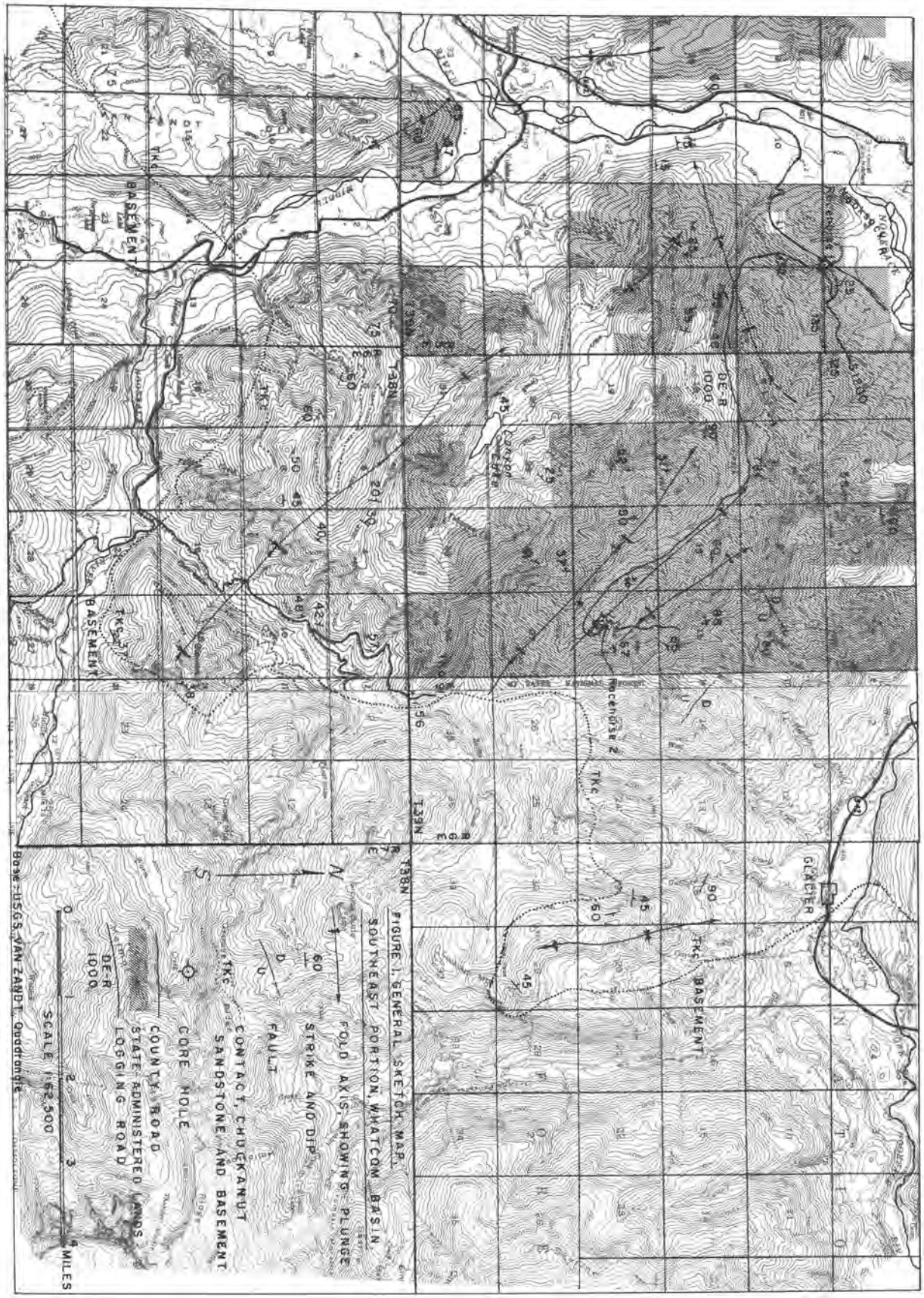
FIGURE 1. GENERAL SKETCH MAP,
SOUTHEAST PORTION, WHATCOM BASIN
FOLD AXIS, SHOWING PLUNGE
STRIKE AND DIP
FAULT
CONTACT, CHUCKANUT
SANDSTONE AND BASEMENT
CORE HOLE
COUNTY ROAD
STATE ADMINISTERED LANDS
LOGGING ROAD
SCALE 1:62,500
MILES
Base: USGS, VAN ZANDT Quadrangle
GLACIER
BASEMENT
Racehorse 2
T38N
T39N
DE-R 1000

foothills, outcrops are quite scarce. The combination of dense undergrowth and glacial overburden tends to complicate the local geology. Fortunately, because of extensive logging operations and the attendant network of roads developed upon DNR lands a greater-than-average frequency of outcrops were available in the study area.

Figure 1 is a sketch-map of the general area under consideration. Drill-hole location No. 1 (hereafter referred to as Racehorse No. 1) is located one-half mile north of the axis of a broad, west-plunging syncline. A 130-foot measured section in close proximity to the drill hole includes 10 feet of coal in seams of 27 to 67 inches in thickness; this section is considered to contain coal with excellent coking characteristics. A coal sample from this section was sent to the USGS in Denver for proximate, ultimate, and free-swelling analyses; the analytical results are unavailable at the time of this writing (results will be released in a future newsletter).

Delineation of a commercial thickness of coking coal in the syncline would establish reserves in the "measured" category under some 950 acres of state land. Tentative reserves of about 3 million tons have been calculated; the figure is subject to change according to interpretive results of USBM geophysical logging efforts. No reserve estimates of T. 39 N., R. 5 E. have been noted or made by Beikman (1961). Farther up Racehorse Creek, a second drill-hole, Racehorse No. 2, was located to test coal possibilities in section 22, T. 39 N., R. 6 E. A measured section close to the drill hole shows 6 seams present, ranging from 6 inches to 34 inches in thickness. This particular location is less than 1 mile from the previously mapped basal contact of Chuckanut sandstone and subjacent Darrington graphitic phyllite. The general stratigraphic position occupied in this location is the same as that occupied by the Glacier coalfield located some 5 miles east of the headwaters of Racehorse Creek. As at Glacier, dips are steep and the general outcrop pattern shows moderate deformation, a feature noted in all areas that display roughly the same stratigraphic position in the Chuckanut Formation. A possible fault-sliver(?) of Darrington Phyllite crops out just south of the vicinity of Racehorse No. 2 corroborating the theory that an undulatory contact surface is present at the phyllite-Chuckanut interface. In the general area of Racehorse Creek headwaters, the structural fabric runs essentially north-northwest. This structural trend appears to differ somewhat from that at the previously mentioned site; more work needs to be accomplished to ascertain whether or not major structural differences exist near the southern corner of sections 7 and 8, T. 39 N., R. 6 E.

Recent logging-road construction in the extreme southeast corner of section 22, T. 39 N., R. 6 E. has uncovered a $2\frac{1}{2}$-foot seam of coal sandwiched between a massive arkose hanging wall and carbonaceous shale(?) footwall. The seam parallels a new roadcut and is exposed for a distance of some 400 feet along strike. The attitude of this particular bed (N. 10° W.; 36° W. which is omitted on the sketch map for clarity) suggests the presence of a small synclinal flexure between the southwest corner of section 22 and the new road. Time and weather constraints dictated that a more thorough assessment of the immediate area (including detailed sampling and seam description) be delayed until May or June of 1977.

Another area of interest is located in the $S\frac{1}{2}SW\frac{1}{4}SW\frac{1}{4}$ of section 35, T. 39 N., R. 6 E. Here, a 5-foot-thick seam of somewhat sheared and distorted coal strikes N. 2° E. and dips about 56° W. into state land (about 1,000 feet west of this outcrop). This outcrop again is very close to the basal contact of the Chuckanut Formation and underlying metamorphic rocks. The coal seam is overlain by a very resistant conglomerate unit estimated to be at least 20 feet in thickness. This rock unit seems to prevail throughout the basal portion of the Chuckanut Formation, although its appearance in the section does not guarantee the presence of coal. South of this area, in section 14, T. 38 N., R. 6 E., the conglomerate

is present but discloses no coal outcrops.

The section was sampled and displays the following characteristics:

Hanging wall—coarse quartz-phyllite pebble conglomerate

	Ft	In
Weathered coal, sheared along strike, top 2 in. ferruginous	1	0
Carbonaceous shale parting	0	4
Powdered to sheared coal	0	8
Sheared coal, fairly dirty	0	5
Sheared coal, bright and very graphitic tending to flakiness	0	10
Weathered zone; highly iron stained, fairly amorphous	0	7
Bony parting	0	2
Sheared coal, bright and flaky to lenticular in form	1	0
Carbonaceous shale parting	0	3
Total thickness	5	3

Footwall—deeply iron stained and amorphous, fault contact(?)

Further work needs to be done in this locality, as there appears to be a sufficient thickness of coal to warrant a possible commercial mining venture. Using 1,700 tons of coal per acre-foot and invoking a conservative recovery factor of 40 percent, approximately 2.25 million tons of coal underlie every square mile of land in this area. A reserve of this magnitude could sustain a 100,000-ton-per-year mine for over 20 years.

Another area of possible interest is on the north side of the Van Zandt Dike in SE¼NW½ section 34, T. 39 N., R. 5 E. A vein of coal trending N. 82° E. and dipping 57° N. was measured and sampled.

Hanging wall—massive sandstone

	Ft	In
Limonite and iron-stained coal	0	4
Clayey gouge and coal	0	3

Continued

	Ft	In
Hard and ashy(?) coal, limonitic stains	0	8
Alternate shaley partings and coal	0	8
Sheared coal, slickensided and limonitic stained	0	5
Hard coal, blocky, bright and shiny	0	5
Dirty coal and shale	0	4
Total thickness	3	1

Footwall—bluish-gray, carbonaceous shale

RESERVE ESTIMATES

Most of the reserve figures calculated for Whatcom County coals were done by Beikman and others (1961). Certain assumptions regarding Washington coals were incorporated by them in the calculations. Those assumptions are discussed briefly, as follows:

Weight of coal.—Bituminous coal is considered to weigh 1,800 tons per acre-foot (a thickness of one foot of coal covering a square 209 feet on a side) while subbituminous coal is considered to weigh 1,770 tons per acre foot. For purposes of calculation, it was considered best to be conservative where possible. Thus, an acre-foot value of only 1,700 tons was used. For calculation purposes, an overall recovery factor of 40 percent was used. This factor considers both mining and preparation plant efficiency.

Bed thickness.—For anthracite and bituminous coals the following bed thicknesses are generally applied.

1) Thin—14 to 28 inches in thickness.
2) Intermediate—28 to 42 inches in thickness.
3) Thick—42 inches (or over) in thickness.

The U.S. Geological Survey notes that anthracite and bituminous beds less than fourteen inches thick and subbituminous beds less than 30 inches thick are generally considered to be too thin to mine on a profitable basis and are usually neglected in final tonnage estimates. The coal present in the seams in the area under consideration in this report is considered to be of a bituminous rank.

Overburden thickness.—It is possible that some limited stripping can be accomplished in the area, although generally, it will be assumed that the majority of mining will be underground. For coal mined underground, the reserves presented are divided into the following categories: 1-1,000, 1,001-2,000, and 2,001-3,000 feet of overburden. Coal below 3,000 feet in depth is considered to be uneconomical to mine and final estimates presented here do not reflect coal below that depth.

Abundance of reliable data.—Normally, three categories have been calculated, based on different degrees of reliability.

Inferred reserves:

Tonnages based on a broad knowledge of geologic nature of individual coalbeds.

Good geologic evidence for assumed continuity of coalbed.

Indicated reserves:

Tonnage computed partly from specific measurements and partly from projection of reliable data for a reasonable distance. Points of observation generally 1 mile apart but may increase to $1\frac{1}{4}$ miles for a bed of known continuity.

Measured reserves:

Tonnage computed from outcrops revealed in trenches, wells, mine workings, and drill holes.

Points of observation no more than $\frac{1}{2}$ mile apart.

Thickness and extent of bed defined to point where tonnage is shown to be within ±20 percent of actual tonnage.

The writer considers the information available for reserve computation to be of a minimal nature. In addition, detailed geology of the area to establish any semblance of seam continuity is lacking. Tonnages, therefore, have been calculated for Measured Reserves only.

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