STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
DONALD A. HULL, STATE GEOLOGIST
WALLOWA, OREGON–WASHINGTON

Post–Umatilla Member flows and sedimentary rocks in the Troy basin

plate I

30X60 MINUTE SERIES (TOPOGRAPHIC)

Open-File Report O-85-2

Preliminary report on northeastern Oregon lignite and coal resources, Union, Wallowa, and Wheeler Counties

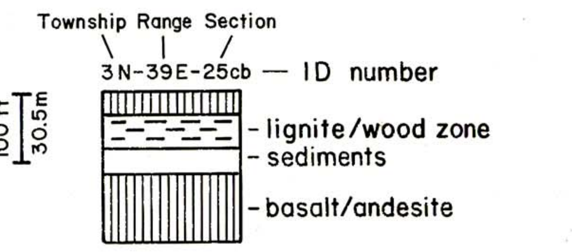
By Mark L. Ferns, 1985

Geology compiled from:
Swanson and others (1981)
Walker (1973)
Stoffel (1984)

EXPLANATION

x lignite in outcrop

● 160 (49m) well or drill hole with depth in feet(meters) to lignite or wood



	Columbia River Basalt Group		Sedimentary interbeds	Other units
	formation	member		
Composite unit outlined on map	Saddle Mountain	Buford Mbr.		unnamed andesite
		Elephant Mtn. Mbr.		
			Menatchee Ck. interbed	
		basalt of Eden	Grouse Ck. interbed	
	Basalt	Umatilla Mbr.	Squaw Ck. interbed	
Underlying units not shown on map	Wanapum Basalt			
	Grande Ronde Basalt			
	base not exposed			

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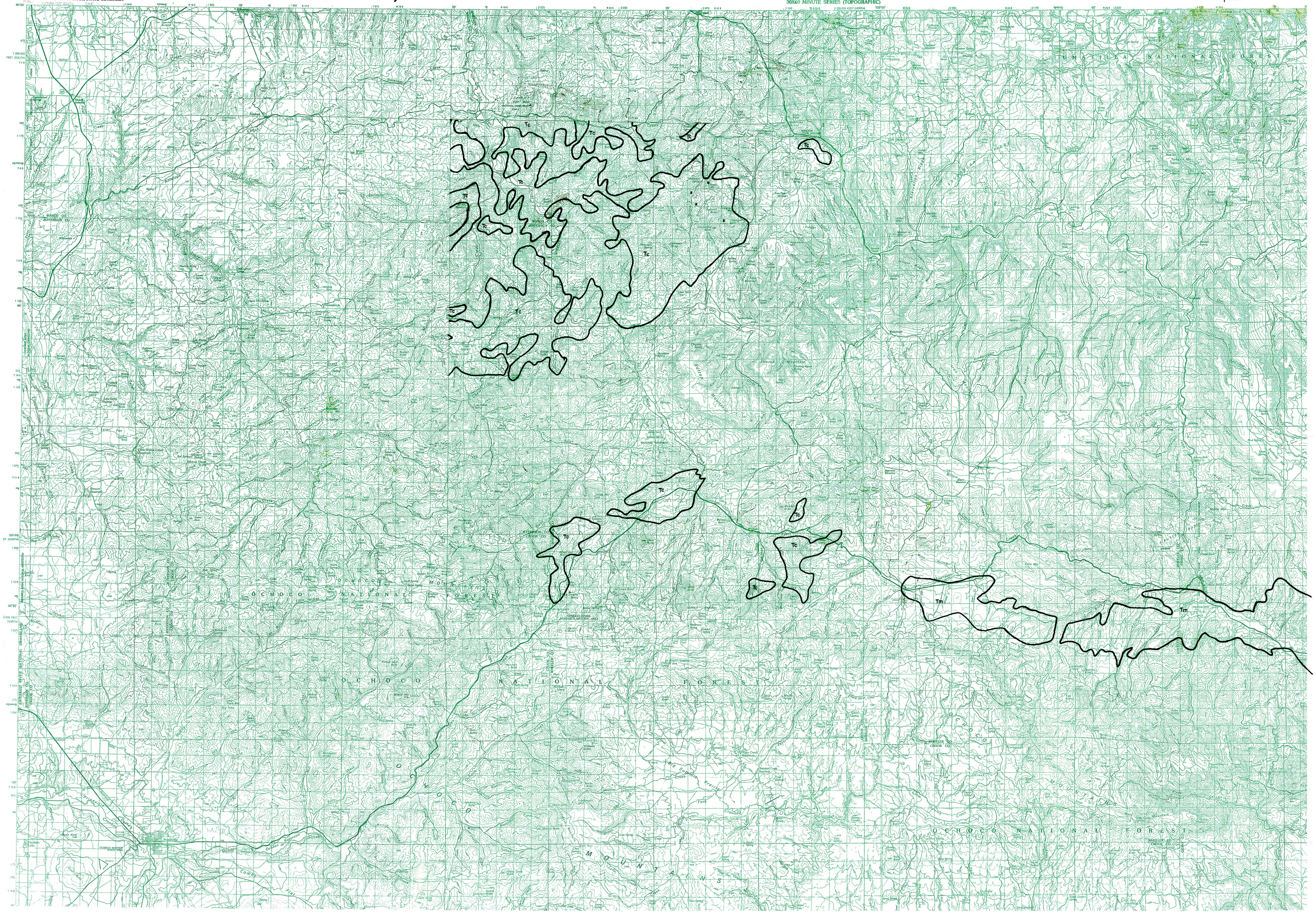
Eocene and Miocene tuffaceous sedimentary rocks of the Mitchell area

plate 2



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Geology compiled from:
Brown and Thayer (1966)
Swanson (1969)

EXPLANATION

x	Reported coal prospects and occurrences
Tm	Rattlesnake Ash-flow Tuff and underlying Mascal Formation tuffaceous sediments
Tc	Sedimentary facies of the Clarno Formation

0 1 2 3 4
miles

STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

910 State Office Building

Portland, Oregon 97201

OPEN-FILE REPORT 0-85-2

PRELIMINARY REPORT ON NORTHEASTERN OREGON LIGNITE AND COAL RESOURCES, UNION, WALLOWA, AND WHEELER COUNTIES

By Mark L. Ferns

Oregon Department of Geology and Mineral Industries

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NOTICE

The Oregon Department of Geology and Mineral Industries is publishing this paper because the subject matter is consistent with the mission of the Department. To facilitate timely distribution of information, this paper has not been edited to our usual standards.

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INTRODUCTION

This is a preliminary report that briefly summarizes available information on coal resources in two areas of northeastern Oregon (Figure 1). The Grande Ronde lignite field in northern Wallowa and Union Counties and the Mitchell area in Wheeler County were selected for study on the basis of known or reported coal occurrences. The distribution of potential coal-bearing strata in these areas is shown on the 1:100,000-scale maps (Plates 1 and 2) accompanying this report.

The information in this report is summarized from previous work by government and industry geologists. Information on the Grande Ronde lignite field is summarized from published reports by Ross (1978), Swanson and others (1983), and Stoffel (1981, 1984); published maps by Walker (1979) and Swanson and Wright (1983); and proprietary information furnished by the Boise Cascade Corporation. Additional information was obtained from water-well logs on file with the Union and Wallowa County watermasters.

The information on coal deposits in the Mitchell area is mainly from a published report by Collier (1914). Additional information on the geology in the area comes from published maps by Brown and Thayer (1966), Swanson (1969),and Robinson (1975) and from unpublished theses by Taylor (1960) and Patterson (1965).

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We gratefully acknowledge the assistance provided by Boise Cascade Corporation geologists Ed Fields, Barney Guarnera, and Craig Simon. Additional valuable information was provided by Oregon Water Resources Department District Watermasters Robert DeBow, H. Boyde Hadden, and Jerry Rodgers. We would also like to thank Peter Hooper, Washington State University, and Michael Cummings, Portland State University, for their comments.

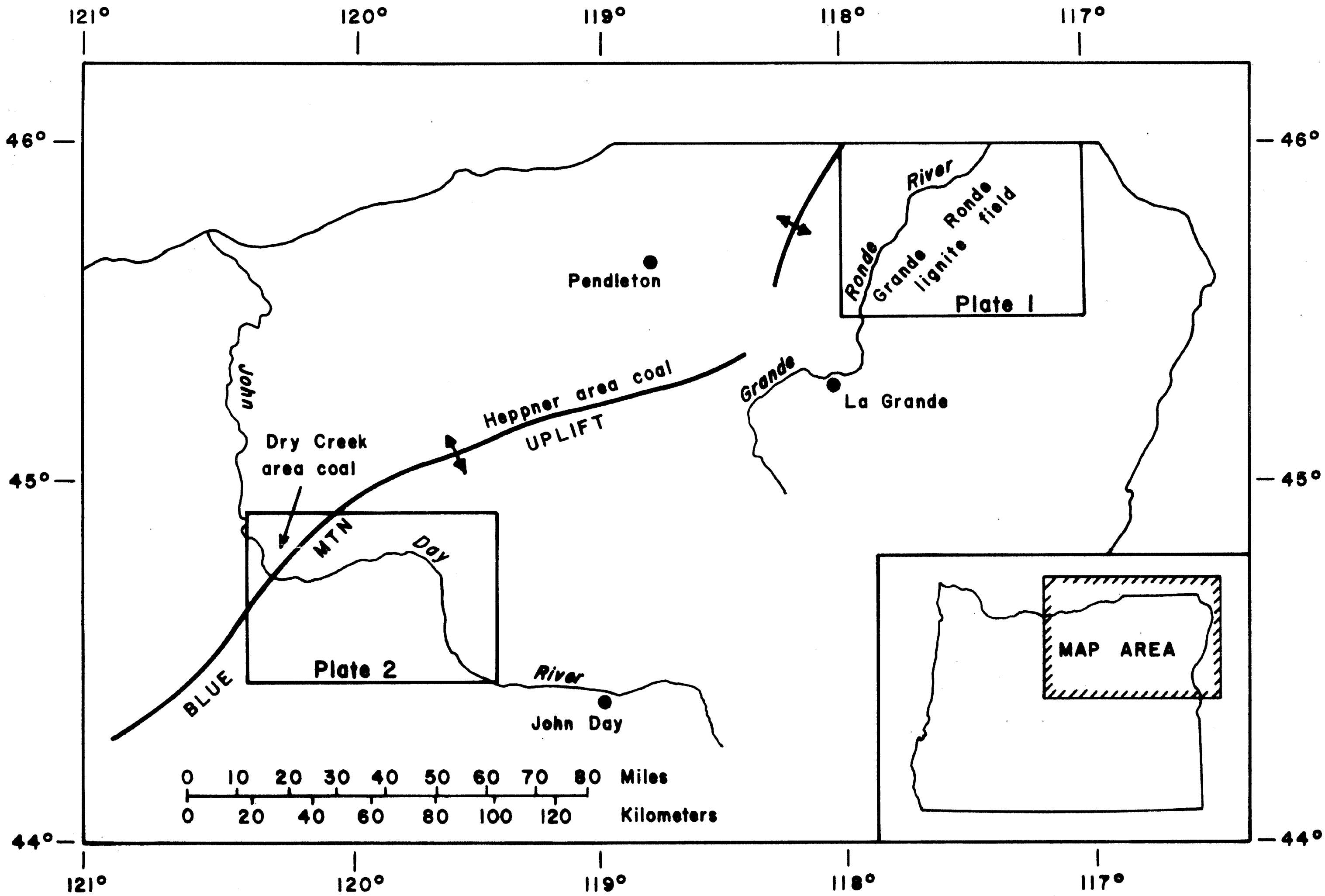

Figure 1. Map showing areas covered by this study, major structural features, and areas covered by Plates 1 and 2.

REGIONAL GEOLOGY

Several lignite/coal-bearing areas in northeast Oregon occur along the crest and flanks of the Blue Mountains uplift, a broad, northeast-striking anticlinal feature developed during late Cenozoic time. Rocks exposed along the Blue Mountains uplift area are mainly basalt flows of the Columbia River Basalt Group of Miocene age. Older rocks are exposed locally in the core of the uplift and include folded and faulted Paleozoic and Mesozoic metamorphic and intrusive rocks, Upper Cretaceous marine sedimentary rocks, and Eocene to Oligocene andesitic and silicic volcanic and nonmarine sedimentary rocks.

Thin seams and small lenses of bituminous and subbituminous coals are known to occur in two localities in the Eocene-Oligocene rocks where they are exposed along the core of the Blue Mountains uplift. One of the localities, the Dry Hollow area, will be further described in this report. Fragmentary information on the second locality, which is near Heppner, is found in Mason and Erwin (1955) and Mason (1969).

Lignite deposits are found in several areas east of the crest of the Blue Mountains uplift. The newly recognized Grande Ronde lignite field (Stoffel, 1981) contains the most extensive lignite deposits in Oregon and occurs in sedimentary rocks interbedded with the upper part of the Columbia River Basalt Group in northern Wallowa and Union Counties. Other scattered small lignite deposits have been found in tuffaceous sedimentary rocks of similar age in Grant, Baker, and northern Malheur Counties.

GRANDE RONDE LIGNITE FIELD

Extensive lignite deposits are found in the Grande Ronde lignite field, which is located in northern Wallowa and Union Counties in Oregon and in southern Asotin County in Washington (Stoffel, 1981, 1984). The lignite field occurs in interbedded sedimentary rocks in the upper part of the Columbia River Basalt Group. The lignite-bearing sedimentary rocks are confined to the Troy basin, a structural depression that formed along the southeast flank of the Blue Mountains uplift during the later eruptive phases of the Columbia River Basalt Group (Swanson and others, 1977; Ross, 1978; Stoffel, 1981, 1984; Hooper and Camp, 1981).

The sedimentary interbeds that contain the lignites are preserved today as generally flat benches that lie along and above the Grande Ronde River. Remnants of the Troy basin cover over 240 mi^2 (620 km^2) in Oregon and can be traced from Elgin to Promise.

The northern part of the Troy basin along the Grande Ronde River is now topographically dominated by narrow, flat-topped ridges and benches that are separated by deep, precipitous canyons. The southern part of the basin forms the northern end of the Grande Ronde Valley and the plateau lands to the east.

GENERAL GEOLOGY

Rocks exposed in the Grande Ronde lignite field include basalt of the Columbia River Basalt Group and interbedded sedimentary rocks of Miocene age (Figure 2). Swanson and others (1979) have restricted the Columbia River Basalt Group to include only extrusive volcanic rocks.

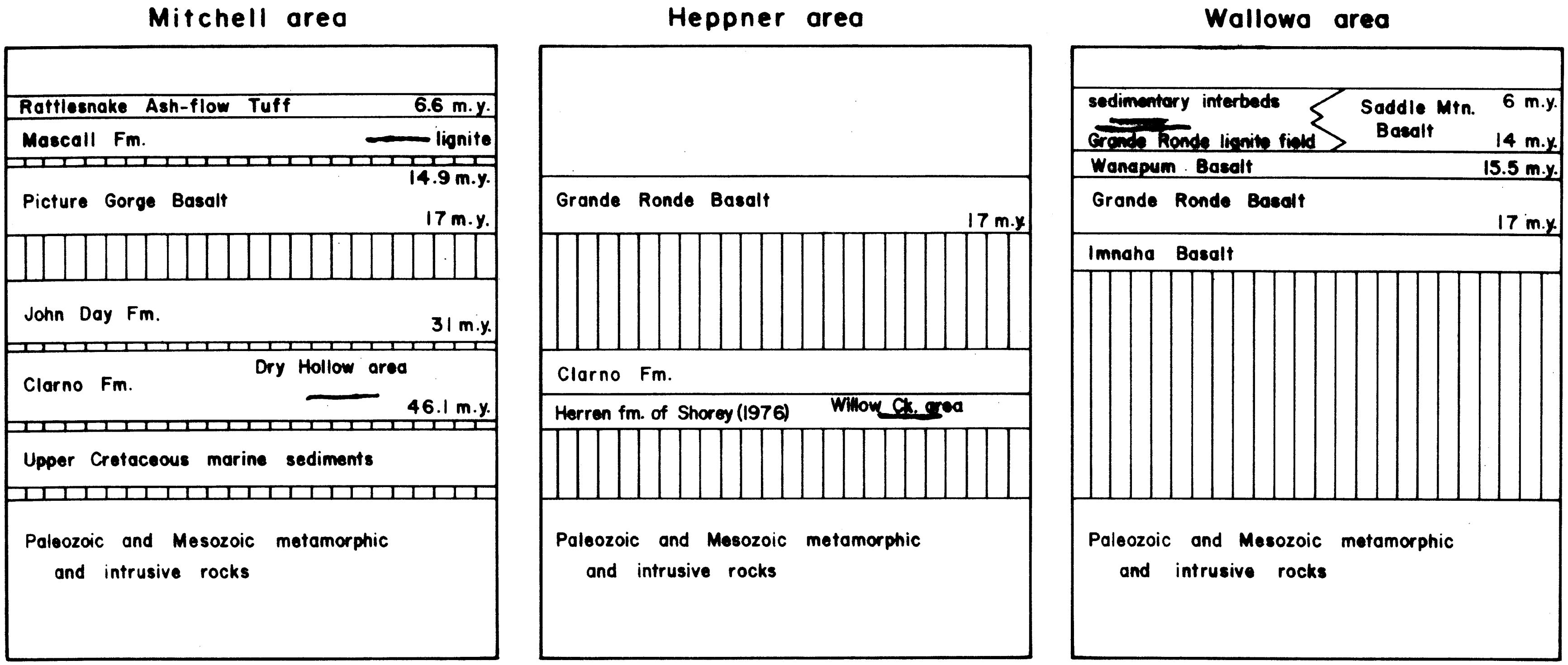

Figure 2. Stratigraphic correlation chart. Data after Barrash and others (1980) and Stoffel (1984). Horizontal lines indicate lignite and/or coal.

The interbedded sedimentary rocks have been considered as informal members of the Ellensburg Formation by Ross (1978), Stoffel (1981, 1984), and Swanson and others (1981).

This report follows the formalized stratigraphic nomenclature established for the Columbia River Basalt Group by Swanson and others (1979, 1981) and the informal nomenclature used for the sedimentary interbeds by Ross (1978) and Stoffel (1981, 1984).

Columbia River Basalt Group:

The oldest rocks exposed in the Troy basin are flows of Grande Ronde Basalt, which is the oldest member of the Yakima Basalt Subgroup of the Columbia River Basalt Group (Swanson and others, 1979). The Grande Ronde Basalt flows were erupted from fissures in southeastern Washington and northeastern Oregon approximately 17 to 15.5 million years (m.y.) ago (McKee and others, 1981; Long and Duncan, 1983). The aggregate thickness of the Grande Ronde Basalt is estimated to be more than 4,050 ft (1,234 m) in the Wenaha Tucannon Wilderness Area immediately to the north of the Troy basin (Swanson and Wright, 1983).

The next oldest rocks in the Troy basin are flows of Wanapum Basalt, which were erupted from fissures in southeastern Washington between 15.5 and 13.7 m.y. ago (Watkins and Baksi, 1974; Hooper and others, 1979; Long and Duncan, 1983). The Wanapum Basalt flows are usually exposed above the Grande Ronde Basalt flows near the tops of canyons. Wanapum Basalt flows reach an aggregate thickness of between 400 to 500 ft (122 and 152 m) (Ross, 1978; Swanson and Wright, 1983). A thick saprolite that separates the Grande Ronde and overlying Wanapum Basalts provides a distinctive marker horizon over much of the area (Ross, 1978).

The sedimentary rocks that contain the lignite seams in the Grande Ronde lignite field are interbedded with flows of the Saddle Mountains Basalt. The Saddle Mountains Basalt flows are the youngest of the Columbia River Basalt Group and were erupted from fissures along the east flanks of the Blue Mountains uplift during a period of relative volcanic quiescence between 13.7 and 6 m.y. ago. Flows in the upper part of the Saddle Mountains Basalt are restricted to the Troy basin in the Grande Ronde region and were emplaced as the Blue Mountain uplift was being formed (Stoffel, 1981, 1984; Swanson and Wright, 1983).

Five chemically distinct units make up the Saddle Mountains Basalt in the Grande Ronde lignite field. These include the Umatilla, Elephant Mountain, and Buford Members; basalt of Eden (Swanson and others, 1981; Stoffel, 1981, 1984); and an unnamed andesite member that crops out in the western part of the Troy basin near Elgin (Walker, 1973; Swanson and others, 1981).

Two separate flows belonging to the Umatilla Member crop out near the base of the Saddle Mountains Basalt in the Troy basin. The flows apparently were erupted from fissures at Puffer Butte in Washington (Price, 1977; Swanson and others, 1979, 1980) and just west of Troy (Stoffel, 1984). The aggregate thickness of the Umatilla Member in the Troy basin is estimated at about 400 ft (122 m) (Stoffel, 1984). Sedimentary interbeds both underlie and overlie the Umatilla Member flows throughout most of the Troy basin.

Basalt of Eden flows are complexly interbedded with sedimentary rocks near the middle of the Saddle Mountains Basalt (Swanson and others, 1981). At least one Eden flow is widespread through the central part of the Troy basin between Maxwell and Brock Meadows. A single flow near the Eden townsite reaches a maximum thickness of 180 ft (46 m), pinching out to the east.

The upper part of the Saddle Mountains Basalt in the Troy basin is comprised of flows belonging to the Elephant Mountain and Buford Members (Ross, 1978; Stoffel, 1981, 1984). Only the Elephant Mountain Member is exposed west of Grouse Flat (Walker, 1973; Ross, 1978; Swanson and Wright, 1983). A single flow reaches a thickness of 300 ft (91 m). The aggregate thickness of the Elephant Mountain Member in the eastern part of the Troy basin is about 550 ft (168 m) (Stoffel, 1984). Flows of the Buford Member have been found only in the eastern part of the Troy basin (Walker, 1973; Ross, 1978). Two separate flows of the Buford Member attain an aggregate thickness of 410 ft (125 m) in the Menatchee Creek area (Stoffel, 1984).

Andesite flows were erupted from vents along the western edge of the Troy basin north of Elgin at apparently the same stratigraphic horizon as the Elephant Mountain Member (Walker, 1973). Similar andesites occur in the La Grande area to the southeast, where they overlie the basalts of Glass Hill (Barrash and others, 1980). The basalts of Glass Hill are comprised of interbedded basalt and andesite flows and thin sedimentary units that apparently lap onto a slightly easterly tilted surface of Grande Ronde Basalt (Barrash and others, 1980). This unit reaches a maximum thickness of 500 ft (125 m) and contains interbedded sediments up to 50 ft (15 m) thick. The interbedded sediments appear to thin abruptly to the west (Barrash and others, 1980) and are apparently equivalent to the lignite-bearing sediments in the Grande Ronde lignite field.

Plate 1 shows the distribution of Saddle Mountains Basalt and Ellensburg Formation rocks younger than the Umatilla Member. These host the known lignite resources in the Grande Ronde lignite field.

Sedimentary interbeds:

Three sedimentary units are known to interfinger with the Saddle Mountains Basalt in the Troy basin (Figure 3). The sedimentary units have been informally considered to be part of the Ellensburg Formation (Stoffel, 1984) and include the Squaw Creek and Grouse Creek interbeds of Ross (1978) and the Menatchee Creek interbed of Stoffel (1981, 1984).

The Squaw Creek interbed underlies the Umatilla Member, marking the base of the Saddle Mountains Basalt in the Troy basin. The Squaw Creek interbed consists of tuffaceous siltstones, sandstones, and bentonitic clays that reach a maximum thickness of 160 ft (49 m) on the benches above the Wenaha River (Swanson and Wright, 1983). The Squaw Creek apparently thins to the east, where Ross (1978) notes a maximum thickness of 50 ft (15 m) north of Promise. The Squaw Creek is not known to contain lignite beds.

The bulk of the lignite resources in the Grande Ronde lignite field occur in the Grouse Creek interbed. This unit consists of a thick sequence of siltstones, subarkosic sandstones, and bentonitic clays that overlies the Umatilla flows. Stoffel (1984) reports diatomite, quartz mica sandstones, kaolinite clays, and hyaloclastite as constituents of the sedimentary interbeds. The Grouse Creek attains a maximum thickness of 160 ft (49 m) on the benches above the

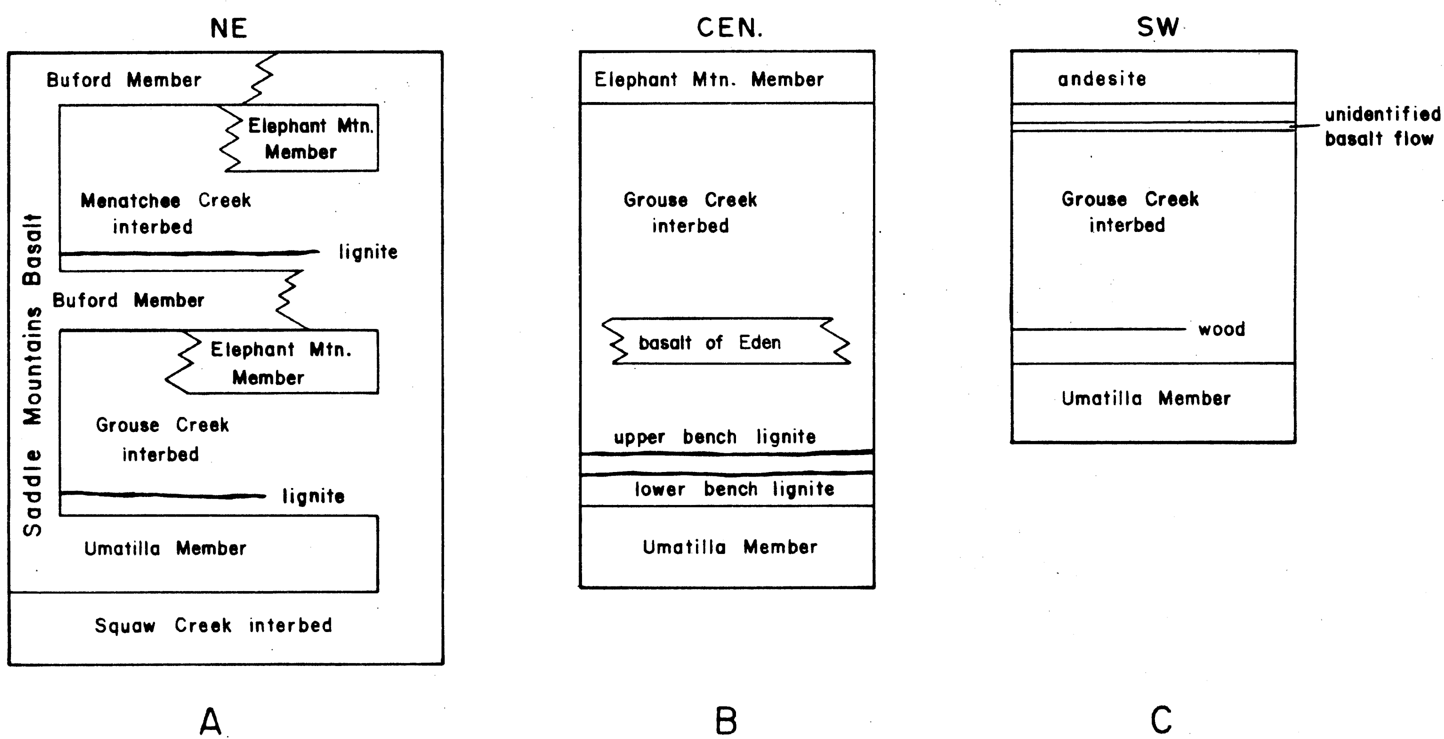

Figure 3. Stratigraphy of Saddle Mountains Basalt and associated interbeds in the northeast (NE), central (CEN), and southwestern (SW) parts of the Troy basin. A = composite column after Stoffel (1984); B = composite column for the Maxwell area; C = Elgin area water-well drill log 1N-25-39.

Wenaha River (Swanson and Wright, 1983) and ranges from 50 to 260 ft (15 to 79 m) in thickness in the Grouse Flat area (Stoffel, 1984). The Grouse Creek appears to thicken along the southern part of the Troy basin, where Ross (1978) indicates over 300 ft (91 m) of sediments west of Promise. Well logs from the Maxwell area show that the Grouse Creek is over 500 ft (152 m) thick. Water-well logs from the Elgin area on the southwestern edge of the basin indicate that the Grouse Creek is as much as 260 ft (79 m) thick in that area.

The Menatchee Creek interbed was recognized by Stoffel (1981, 1984) in Washington east of Menatchee Creek, where it is separated from the Grouse Creek by Elephant Mountain and Buford Member lava flows. The Menatchee Creek attains a maximum thickness of 200 ft (61 m) and consists of interbedded sandstones and siltstones that locally contain lignite seams (Stoffel, 1984).

Development of the Troy basin:

The Troy basin began to form about 14 m.y. ago in response to the initial development of the Blue Mountains uplift (Swanson and others, 1977; Ross, 1978; Swanson and Wright, 1983; Stoffel, 1984). Sediments of the Squaw Creek interbed were initially deposited onto a surface of Wanapum Basalt. Flows of the Umatilla Member were erupted from fissures on the eastern margins of the developing basin and flowed westward, overriding the Squaw Creek interbed (Swanson and Wright, 1983; Stoffel, 1984). The Umatilla flows crossed the Blue Mountains uplift southeast of Walla Walla and spread out over a large portion of south-central Washington (Swanson and others, 1979, 1981). Andesite and basalt flows apparently were erupted during this same period of time from local eruptive centers south of the Troy basin and flowed out onto a weakly eastward-dipping surface of Grande Ronde flows (Barrash and others, 1980).

The western outlet to the Troy basin was blocked after eruption of the Umatilla Member during the continued uplift of the Blue Mountains (Swanson and Wright, 1983). The major northeast-trending Big Hole fault apparently restricted the post-Umatilla flows and sediments to the eastern part of the Troy basin (Swanson and others, 1981). Shallow lakes and peat bogs developed on top of the Umatilla flows over a large portion of the basin (Stoffel, 1984). The peat bogs were later buried by epiclastic sandstones and siltstones of fluvial origin (Stoffel, 1984).

Eden Member flows were erupted from dikes exposed along the Grande Ronde River near the center of the basin and locally burrowed down through the newly deposited sediments (Swanson and others, 1981). The Eden flows apparently are restricted to the Troy basin and were erupted before the new northeast outlet to the basin was established.

Sporadic eruptions of Saddle Mountains Basalt continued from 10 to 6 m.y. ago. Flows of the Elephant Mountain and Buford Members flowed eastward down the newly established ancestral Grande Ronde drainage system before eventually turning northward into southeastern Washington (Swanson and Wright, 1983; Stoffel, 1984). Andesite flows were erupted during this time interval from centers on the southern and western edges of the Troy basin (Walker, 1973; Barrash and others, 1980; Swanson and others, 1981). Lava flows of the Elephant Mountain and Buford Members apparently interrupted drainage patterns locally and formed the base for ponded sediments and peat bogs within the Menatchee Creek interbed.

The thickest accumulation of sediments in the Grouse Creek and Menatchee Creek interbeds occurs near the center of the Troy basin, indicating that downwarping of the basin continued as the sediments were being deposited. Mild structural deformation continued within the basin after deposition of the Saddle Mountains Basalt and the interbedded sedimentary rocks (Ross, 1978; Stoffel, 1984), as evidenced by the folding of the interbeds in the Grouse Flat area. Further evidence for post-depositional downwarping is indicated by a broad, north-plunging syncline identified by exploration geologists in the Maxwell area.

LIGNITES

Although lignite is known to occur near the base of both the Grouse Creek and Menatchee Creek interbeds (Stoffel, 1984), the stratigraphy of the Grande Ronde lignite field has not yet been fully established. The lignites are rarely exposed at the surface. Information concerning their thickness, grade, and lateral continuity can be attained only by surface excavations, drilling programs, or examination of water-well logs.

Stoffel (1984) indicates that the accumulation of peat at the base of the Grouse Creek interbed in the Grouse Flat area was preceded only by the deposition of diatomite and/or carbonaceous shale. Well logs in the Maxwell area also suggest a low-energy depositional environment prior to formation of the peat bogs, as evidenced by a green clay seam that apparently separates the lignites from the underlying Umatilla flows over much of that area. Sandstones and siltstones suggestive of a higher energy depositional environment have been recognized by Stoffel (1984) as overlying the lignites. Stoffel (1984) suggests that this indicates that the peat bogs were inundated by fluvial sands and silts as the ancestral Grande Ronde River established a northeast outlet to the Troy basin.

The lignite seam at the base of the Grouse Creek interbed is reported to reach a maximum thickness of 40 ft (12 m) in the Grouse Flat area (Stoffel, 1984). Boise Cascade geologists report that there are two major lignite seams separated by a 3-ft (0.9-m)-thick clay seam near the base of the Grouse Creek interbed in the Maxwell area. The uppermost seam, referred to as the upper bench lignite, averages about 15½ ft (4.7 m) in thickness and is reportedly the cleaner of the two seams. The lower bench lignite reportedly averages 27 ft (8.2 m) in thickness but contains clay and silt interbeds that reduce its value.

The lignites at the base of the Grouse Creek (Table 1) are low in British thermal unit (Btu) content. Drill-core samples of the upper bench lignite in the Maxwell area are reported to average about 4,500 Btu. However, according to Boise Cascade Corporation geologists, the Btu values increase significantly when the inherent moisture in the samples is lost upon exposure to air. Higher Btu contents can be obtained from picked samples. A sample selected by Stoffel (1984) from a roadcut north of Flora yielded 7,944 Btu.

There is currently no information on the grade and thickness of lignite seams at the base of the Menatchee Creek interbed.

Exploration drilling programs in the Maxwell area do not indicate the presence of the Menatchee Creek lignite in that area.

Available evidence suggests that the lignite seams at the base of the Grouse Creek interbed underlie a large portion of the Troy basin. Drilling by Boise Cascade indicates that the upper and lower bench seams underlie most of the Grouse Creek interbed in the Maxwell area. Stoffel (1984) suggests that lignite underlies most of the northeastern part of the basin. Exploration activity in the Flora area also reportedly indicates the presence of an areally extensive lignite seam near the base of the Grouse Creek interbed in that area. Lignite resources apparently extend to the southwestern part of the Troy basin near Elgin, where water-well drill logs show the presence of wood/charcoal near the base of the Grouse Creek. At the present time, considering the lack of drill logs or other subsurface information and the tendency for the lignite not to crop out, all of the area in the Troy basin that is underlain by the Grouse Creek interbed should be considered as being also underlain by potential lignite resources.

RESERVES

Reserve and resource tonnages for the Grande Ronde lignite field cannot be adequately determined at this time. Stoffel (1984) describes a number of geologic processes, here illustrated in Figure 4, that may have substantially reduced the volume of lignite resources in the Grande Ronde lignite field: (1) The peat bogs that were later converted into lignite were initially formed on an irregular topographic surface that developed during the construction of the spatter cones and low shield volcanoes that were the source for the Umatilla flows. Stoffel (1984) suggests that this surface was likely to have had topographic highs on which the peat bogs were not formed. (2) Parts of the field have been destroyed by invasive burrowing of younger lava flows, a process in which the heavier basalt flows move out over poorly consolidated sediments and actually sink down into the sediments. Swanson and others (1981) report that the Eden flow in the central part of the Troy basin is commonly invasive into the underlying sediments. Stoffel (1984) cites a number of areas in the northeastern part of the Troy basin in which lava flows have burrowed down through the Grouse Creek interbed and disrupted the lignite seams. (3) Younger basalt flows have also been deposited as intracanyon fills into stream channels cut down into the Grouse Creek interbed. Presumably this process is more important in the eastern part of the basin, where both the Buford and Elephant Mountain flows are present. (4) The lignite beds have been folded and faulted during the continued development of the Blue Mountain uplift. (5) Erosional benches have developed in the Grouse Creek interbed as the Grande Ronde and Wenaha Rivers and their tributaries cut down through the Columbia River Basalt Group. This erosional cycle has removed a good portion of the original Grande Ronde lignite field.

The erosion of overlying flows and sediments is important in considering the future development of the lignite resource in the Troy basin. Industry geologists now working in the area consider only the upper bench lignite seam with less than 150 ft (46 m) of overburden when determining lignite reserves. Boise Cascade reserve estimates of

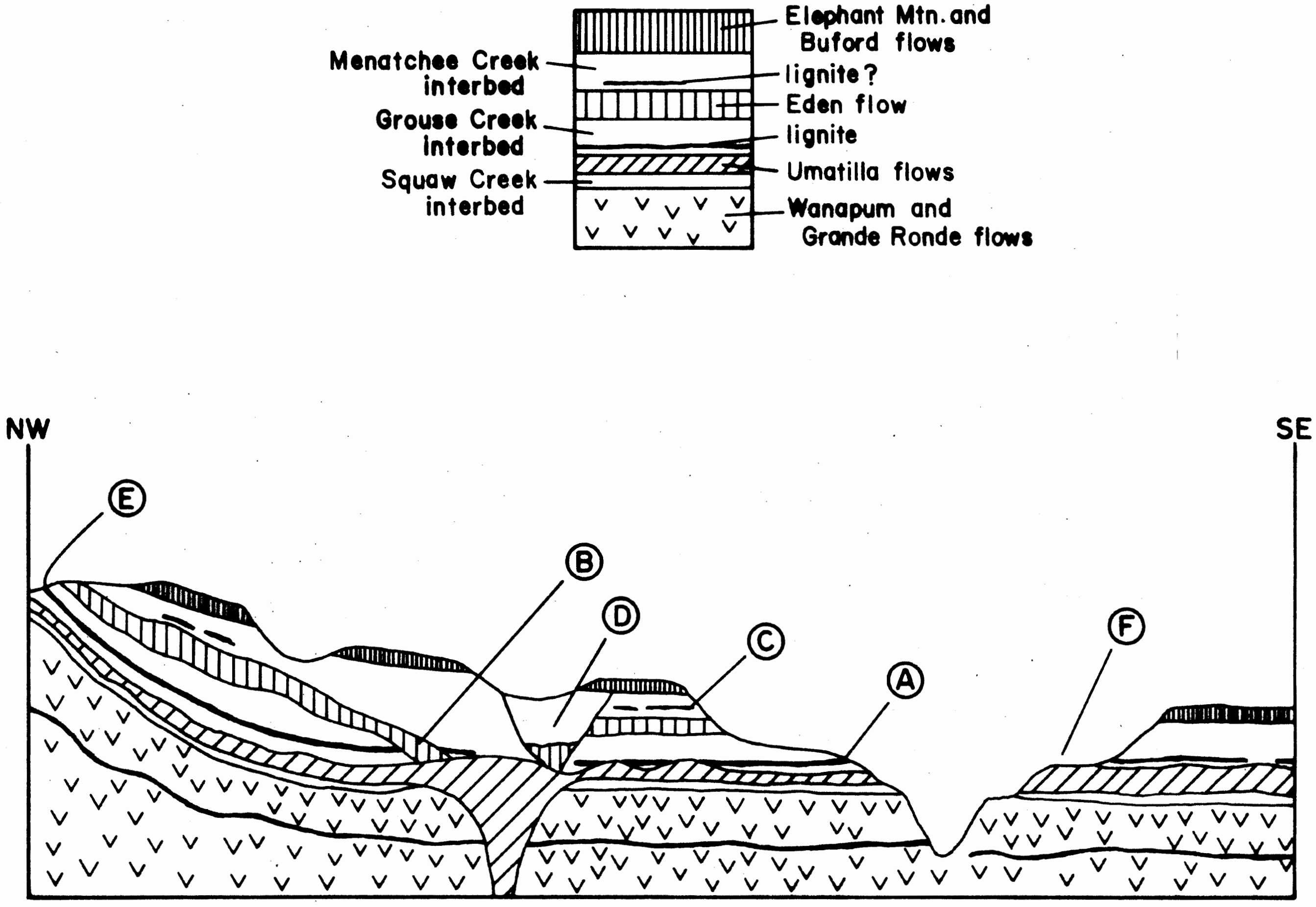

Figure 4. Schematic diagram illustrating stratigraphic and structural controls on lignite resources in the Grande Ronde lignite field:

A. Lignite coals form in peat bogs developed on irregular Umatilla Basalt flow surface.

B. Lignite is destroyed by invasive Eden flows.

C. Lignite coals form on irregular invasive and intracanyon flow surfaces.

D. Lignite is removed by erosion during period of erosion and filling by intracanyon lavas.

E. Lignite seams are folded.

F. Benches are formed and eroded as the Grande Ronde River and tributaries cut down through the lignite field.

the upper bench lignite seam indicate 140 million tons of recoverable lignite with 150 ft (46 m) or less of overburden in the Maxwell area.

Further study will be required to adequately evaluate the resource potential of the Grande Ronde lignite field. Preliminary work indicates that over 240 mi^2 (620 km^2) in Union and Wallowa Counties are underlain by the Grouse Creek interbed. Scattered shallow drill holes indicate that the lignite seam near the base of the Grouse Creek persists over much of the area between Elgin and Flora. If a 15-ft (4.6-m)-thick lignite seam of mineable quality is assumed to be present over half of that area, then the potential lignite resource in the Grande Ronde lignite field exceeds 1.9 billion tons (Table 2).

FUTURE STUDIES

Future work should first focus on the potential for the lignite seam at the base of the Grouse Creek interbed to extend north and west of the Grande Ronde River in the western part of the Troy basin. This will require detailed geologic mapping and correlation of stratigraphic units with the units established by Ross (1978), Swanson and others (1981), and Stoffel (1984). The primary emphasis should be placed on establishing the lateral extent of the Elephant Mountain Member, the basalt of Eden, and the andesite flows described by Walker (1973) and Barrash and others (1980).

Priority should also be given to establishing the stratigraphic relationships within the Grouse Creek and Menatchee Creek interbeds and the extent of lignite destruction by invasive Eden flows. Since the lignites generally do not crop out, it will be necessary to drill shallow holes to establish stratigraphic relationships and to test the lateral continuity of the lignite seams.

Table 1. Analyses of Grande Ronde lignites

Sample	A	B
Moisture	45.60	12.5
Volatile matter	26.7	43.9
Fixed carbon	15.78	28.2
Ash	11.57	15.4
Btu	4,548	7,944
Sulfur	0.25	0.4

All analyses on an "as-received" basis. Sample A is the weighted average of core samples recovered from a drilling program in the Maxwell area and provided by the Boise Cascade Corporation. Sample B is sample no. 4 from Stoffel (1984).

Table 2. Potential lignite resources[1]

Area	Areal extent (mi^2)	Estimated reserves[2] (tons)	Hypothetical resources[3] (tons)
Flora[4]	47	100,000,000	383,500,000
Maxwell[4]	90	140,000,000	739,400,000
Promise[4]	2	------	16,300,000
Grouse Flat[4]	10	------	81,600,000
Wenaha	48	------	391,700,000
Brock Meadows	14	------	114,200,000
Elgin[4]	23	------	187,700,000
Other	8	------	65,300,000
TOTAL	242	240,000,000	1,980,000,000

[1]Tonnage estimates based on 1,700 tons of lignite for a seam 1 ft (0.3 m) thick covering 1 acre.
[2]Based on industry estimates for the upper bench lignite seam within 150 ft (46 m) of the surface.
[3]Based on a seam assumed to average 15 ft (3 m) in thickness and to be present over 50 percent of the area.
[4]Areas known to contain lignite or "wood."

MITCHELL AREA

Coal has been reported from two widely separated areas near Mitchell in north-central Oregon (Collier, 1914). Subbituminous coals occur in the Dry Hollow area north of Mitchell along the crest of the Blue Mountains uplift, and lignite seams have been reported from along the banks of the John Day River near Dayville. The coal in the Dry Hollow area occurs within volcaniclastic sedimentary units of the Clarno Formation of late Eocene-early Oligocene age. The Dayville area lignites occur as thin isolated seams in late Miocene tuffaceous lake sediments of the Mascall Formation.

GENERAL GEOLOGY

The oldest rocks exposed in the Mitchell area are Permian metasedimentary rocks (Oles and Enlows, 1971) that are unconformably overlain by marine sedimentary rocks of the Hudspeth and Gable Creek Formations of Late Cretaceous age (Wilkinson and Oles, 1968). Terrestrial volcanic and volcaniclastic sedimentary rocks of the Clarno Formation (Merriam, 1901) lie with slight angular discordance upon the Cretaceous marine sedimentary rocks (Oles and Enlows, 1971). Volcaniclastic sedimentary interbeds within the Clarno Formation locally contain abundant plant debris and occasional subbituminous coal seams.

The Clarno Formation is overlain by tuffaceous sedimentary rocks, siliceous ash-flow tuffs, and olivine basalt flows that belong to the John Day Formation of Oligocene age (Merriam, 1901; Oles and Enlows, 1971; Robinson, 1975). The John Day Formation is in turn overlain by flows of the Columbia River Basalt Group. The area east of the crest of the Blue Mountains uplift is comprised of Picture Gorge Basalt (Swanson, 1969). Younger basalts belonging to the Yakima Basalt Subgroup are missing in this area, suggesting that the rising Blue Mountain uplift acted as a barrier to the flows that poured into the northern part of the Columbia Plateau during eruption of the later members of the Columbia River Basalt Group.

Scattered small seams of lignite occur in small lacustrine basins that are found east of the crest of the Blue Mountains uplift. The lake beds have been mapped as part of the Mascall Formation (Brown and Thayer, 1966) and are equivalent in age to the interbedded sediments in the Grande Ronde lignite field. The lake beds in the Dayville area are overlain by the Rattlesnake Ash-flow Tuff, which has been radiometrically dated at 6.6 m.y. (Fiebelkorn and others, 1982).

DRY HOLLOW AREA

Subbituminous coals occur in sedimentary interbeds within the Clarno Formation in the Dry Hollow area. Two distinct lithologic units have been recognized in the Clarno Formation in this area (Taylor, 1960; Patterson, 1965; Swanson, 1969; Robinson, 1975). The basal unit in the Dry Hollow area is described by Patterson (1965) as a sequence of interbedded volcanic conglomerates and sandstones. This unit crops out over an area of about 36 mi^2 (93 km^2). Andesite flows and breccias overlie the sedimentary rocks (Patterson, 1965).

Robinson (1975) shows the volcanic sediments in the Dry Hollow area to overlie a similar sequence of andesite lavas and breccias, indicating that the volcaniclastic sediments are a sedimentary interbed within the Clarno Formation. Similar tuffaceous sedimentary interbeds have been mapped by Oles and Enlows (1971) in the Keyes Mountain area. These sedimentary rocks contain abundant plant debris (Oles and Enlows, 1971) and represent either channel-fill or lacustrine deposits that have been deposited in the upper part of the Clarno Formation.

Coal:

Coal was first discovered in the Dry Hollow area by Charles Miller in the 1880's. In 1887, the Eastern Oregon Coal and Railway Company filed articles of incorporation with Multnomah County. The Dry Hollow area was extensively prospected during this period of time, and a number of small mines and prospects were opened. The exploration efforts apparently failed to disclose significant amounts of coal. Collier (1914) notes, "The fact that all of the fields have been opened up more than ten years and that they have since lain with no attempt to develop them further makes it appear that the exploiters must have concluded that they are of little value."

The Dry Hollow area workings are now extensively caved. The only information on the underground seams comes from Collier (1914), who reports that the coal bed exposed in the tunnel in SW¼ SE¼ sec. 28, T. 8 S., R. 21 E., has a thickness of at least 11 ft (3.4 m) and consists of alternating layers of coal, bone, sandstone, and shale. None of the seams of pure coal were reported to have a thickness of more than 4 in. (10 cm). Collier (1914) reports a small fault that offset the coal seam within the tunnel and notes that the coal occurrences in the Dry Hollow area had been disrupted by folding and faulting.

Patterson (1965) indicates that a sequence of overlying massive volcanic conglomerates were deposited onto the coal swamp from the north and northeast. Collier (1914) reports an old channel fill of sand and gravel deposited in a scoured channel cut into the coal seam. The difficulty experienced by Collier (1914) in tracing the seam for any distance and the discordance in dips between the sands and shales and the overlying massive conglomerates (Patterson, 1965) indicate that part of the coal seam may have been removed by erosional processes prior to deposition of the conglomerates.

Resources:

Insufficient data are available to fully determine the coal resource potential of the Dry Hollow area. The potential is probably low due to the following factors: (1) The sedimentary interbeds are generally small in size and not areally extensive. Although over 36 mi^2 (93 km^2) have been mapped by Swanson (1969) as being part of the sedimentary sequence of the Clarno Formation, much of this includes the massive conglomerates described by Patterson (1965) as overlying the coal-bearing shales. (2) Where exposed, the coal seams are apparently discontinuous. This may be due either to removal of the coals prior to deposition of the volcanic conglomerates or to folding and faulting of the sediments during development of the Blue Mountains uplift. In either case, the coals do not appear to be areally extensive.

DAYVILLE AREA

Lignite:

A small number of lignite occurrences are reported from the tuffaceous lake sediments of the Mascall Formation of late Miocene age (Collier, 1914; Brown and Thayer, 1964). The Mascall Formation in the Dayville area lies within an east-west-trending structural low that lies along the John Day River. Here the Mascall Formation fills a basin not more than 5 mi (8 km) wide but with a maximum thickness of 1,000 ft (300 m) (Collier, 1914). The Mascall Formation in the Dayville area is locally overlain by tuffaceous sediments and ash-flow tuff of the Rattlesnake Formation.

The occurrences and reported occurrences of lignite described by Collier (1914) are shown on Plate 2 as reported lignite localities. Collier (1914) suggests that most of these lignite localities may be isolated tree trunks that have been converted into coal and, as such, do not represent continuous lignite seams. The largest seam reported was in sec. 11, T. 13 S., R. 27 E., and measured 26 in. in thickness.

Resources:

Although the Dayville area lignites are approximately the same age as the Grande Ronde lignites, they appear to have much less potential as a lignite resource. The late Miocene basin is much smaller in size and apparently contains a great deal of tuffaceous material. None of the known lignite deposits are thicker than 26 in. (66 cm), nor do they appear to be areally extensive.

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