GEOLOGICAL INVESTIGATIONS IN THE COAL MEASURES OF THE OYSTER RIVER, MOUNT WASHINGTON AND CUMBERLAND AREAS, VANCOUVER ISLAND (92F/10, 11, 14)

By Corilane G.C. Bickford and Georgia Hoffman
Bickford Consulting Ltd.
and
Candace Kenyon

KEYWORDS: Coal geology, stratigraphy, Vancouver Island, Comox sub-basin, Nanaimo Group, Comox Formation, stratigraphic nomenclature, coalbed mineability.

INTRODUCTION

This report is part of an ongoing project begun in 1987 to update knowledge of critical geological relationships in the Vancouver Island coal deposits. Objectives of the year's study are to deliniate the extent and continuity of coal-bearing strata in the Comox Formation between Oyster River and Tsable River, and to document the structural geology and stratigraphy of the area. Also, the potential underground mineability of the coalbeds of the area will be assessed.

The study area occupies part of the eastern coastal plain of Vancouver Island, from Campbell River in the north to Cowie Creek in the south (Figure 4-2-1).The Comox sub-basin is approximately 1230 square kilometres in area and is accessible by coastal waterways, paved highways and secondary roads. Elevations range from sea level to 457 metres with fairly gentle topography. Most of the area is covered by thick underbrush, limiting coal exposures to roadcuts, and

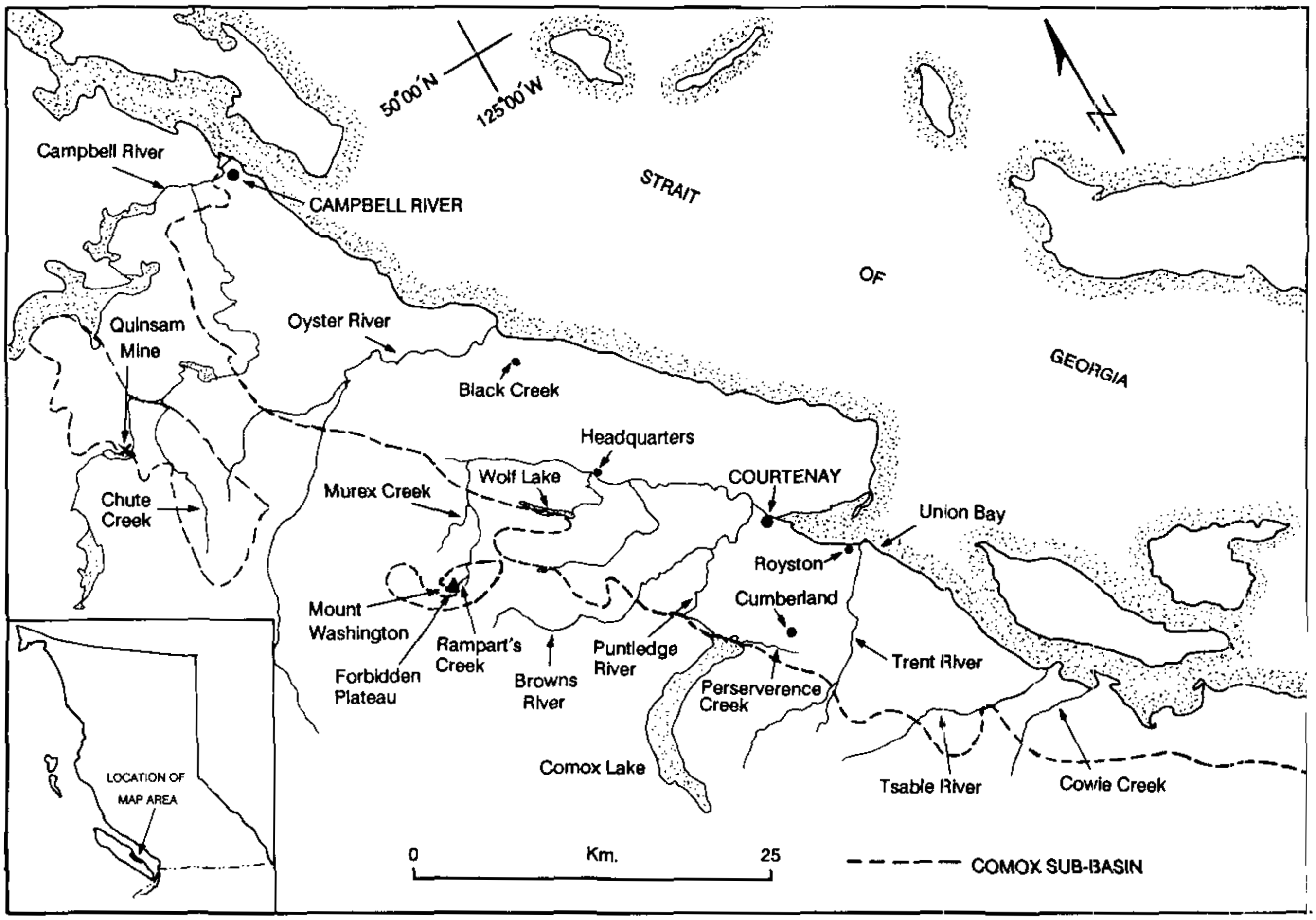

Figure 4-2-1. Location map, northern Comox sub-basin, Vancouver Island.

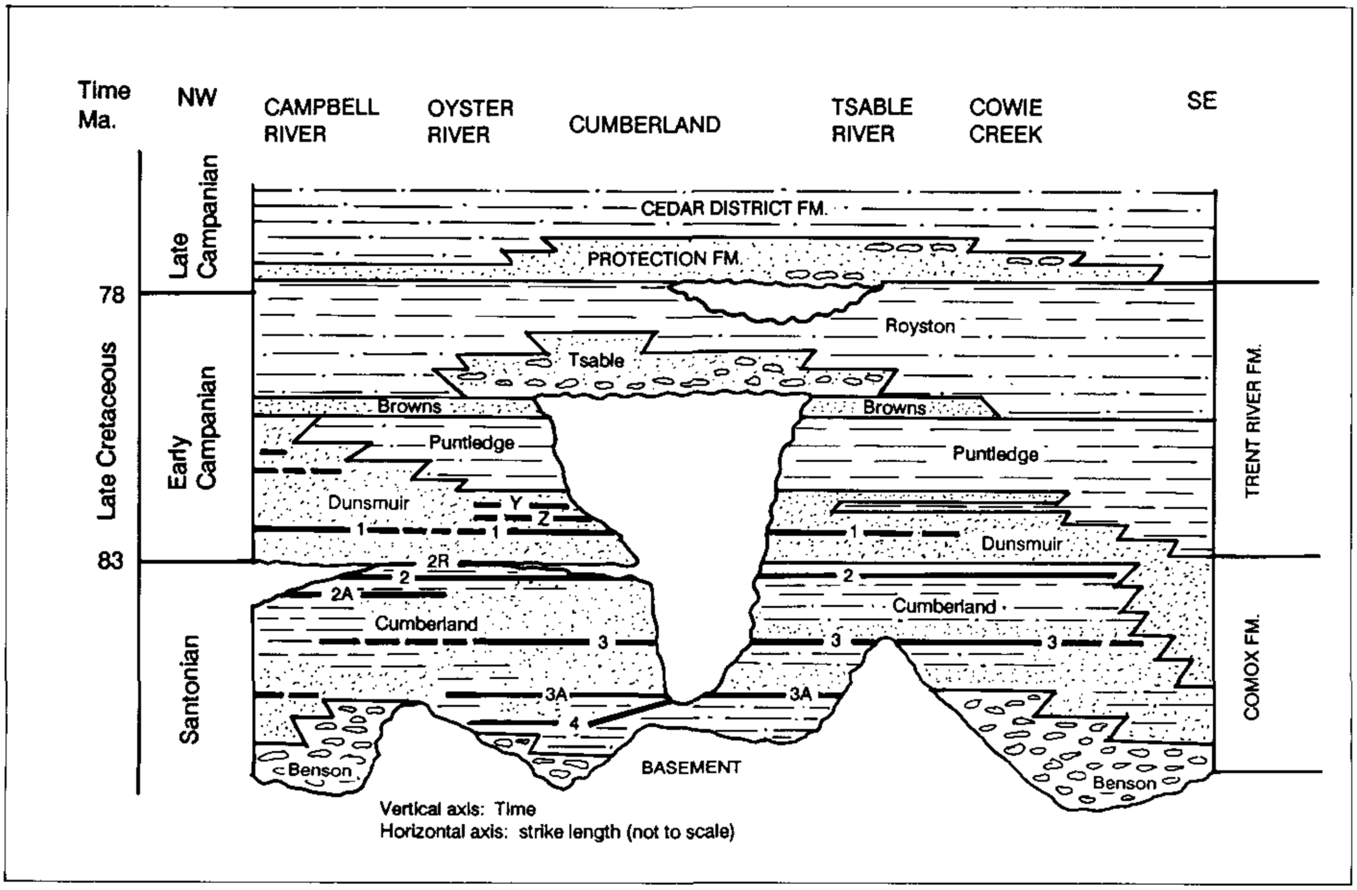

Figure 4-2-2. Chronostratigraphic diagram of the Lower Nanaimo Group.

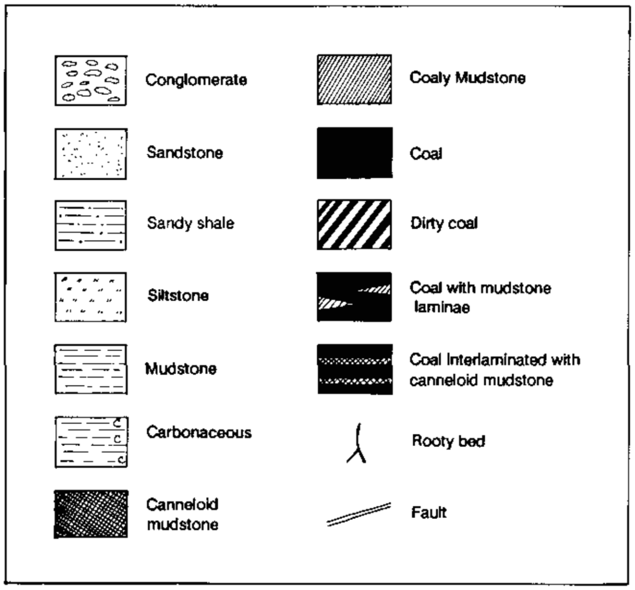

Figure 4-2-2a. Standard symbols for coal-measures sections.

creeks and rivers which drain into the Strait of Georgia. The climate is mild and humid with snow occuring only at higher elevations.

Campbell River and Courtenay are the major population centres. Small towns and resort areas are scattered along the coast. The logging and fishing industries are the economic base of the area.

FIELDWORK

Geological mapping was done using 1:20 000-scale aerial photographs to plot data which were later transferred to 1:20 000 base maps. Detailed sections of coal beds were measured on Oyster River, Ramparts Creek, Murex Creek, Perseverence Creek, Tsable River, the eastern shore of Comox Lake, in the Mount Washington area, and in several old mine tunnels near Cumberland village. Samples of coal and associated rocks were taken for petrographic analysis. Data from 36 new coal outcrops will be used to update the regional vitrinite reflectance study (Kenyon and Bickford, 1989). Fossil plants and invertebrate shells were collected at 20 locations for later identification. Trace-fossil assemblages were described where well-exposed, but were not collected owing to the impracticability of transporting large samples.

GEOLOGICAL SETTING

The study area covers the northern half of the Comox sub-basin of the Late Cretaceous Georgia basin. The coal measures occur in the Cumberland and Dunsmuir members of the Comox Formation (Bickford and Kenyon, 1988). The Comox Formation outcrops along the western edge of the eastern coastal lowland of Vancouver Island, and dips gently eastward beneath younger Cretaceous rocks and unconsolidated Pleistocene sediments. It has been traced down dip by means of drilling to the shore of Georgia Strait; its eastward submarine extent remains unknown.

In addition to the main body of Comox Formation under the coastal lowland, several outliers of the formation occur farther to the west, in the foothills of the Vancouver Island Ranges. The largest outlier contains the Quinsam and Chute Creek coal deposits (Bickford *et al.* 1989), while the smaller outliers near Mount Washington (Carson, 1960), Forbidden Plateau, (Gunning, 1931,) and Comox Lake (Daniels, 1920) contain coal showings of more limited extent. Geology maps of this area can be found in Kenyon and Bickford, 1989.

STRATIGRAPHY

Lithostratigraphic units of the lower half of the Nanaimo Group are shown in Table 4-2-1 and illustrated in Figure 4-2-2. Some formation and member names have been changed since last year's report, in light of further fieldwork during the 1989 mapping season and because of suggestions made by England (1989). England states that units at higher stratigraphic levels in the Nanaimo Group, previously mapped by Muller and Jeletsky (1970) as formations, cannot be traced from the Nanaimo sub-basin to the Comox sub-basin and these formation names therefore "contravene the rules of stratigraphic nomenclature (American Commission on Stratigraphic Nomenclature, 1970)". We recognize the validity of the Trent River Formation as suggested by England. The lithostratigraphic nomenclature suggested here represents a compromise among proposals by Muller and Jeletsky (1970), Ward (1978), Bickford and Kenyon (1988) and England (1989).

TABLE 4-2-1
LITHOSTRATIGRAPHIC UNITS OF THE LOWER NANAIMO GROUP, NORTHERN COMOX SUB-BASIN

Formation:	Member:	Lithology:
Cedar District		Mudstone and siltstone.
		—Intertonguing contact—
Protection		Sandstone and conglomerate.
		—Erosional contact—
Trent River	Royston	Mudstone and siltstone.
		—Intertonguing contact—
	Tsable	Conglomerate; minor sandstone and siltstone.
		—Erosional contact—
	Browns	Sandstone; minor siltstone.
		—Intertonguing contact—
Comox	Dunsmuir	Sandstone; minor siltstone, shale, coal and conglomerate.
		—Abrupt, locally erosional contact—
	Cumberland	Siltstone and sandstone; minor shale and coal.
		—Intertonguing contact—
	Benson	Conglomerate and red siltstone.
		—Erosional contact—
pre-Cretaceous volcanic, plutonic and metasedimentary basement.		

SUBDIVISION OF THE TRENT RIVER FORMATION

Sedimentary rocks previously mapped as the Haslam, Extension, and Pender formations are now considered to be part of the Trent River Formation in the Comox sub-basin, although Haslam, Extension and Pender are still valid names in the Nanaimo sub-basin. McGugan (1979) and England (1989) expressed concerns with the transfer of formation and member names from one sub-basin to another; we must therefore propose some new member names within the Trent River Formation in order to correctly describe these mappable units.

PUNTLEDGE MEMBER

The Puntledge member consists of dark grey to black mudstones and siltstones, 100 to 150 metres thick, which overlie the sandstones of the Dunsmuir member of the Comox Formation. This unit was previously mapped by Muller and Jelesky (1970) as the Haslam Formation. The name Puntledge is taken from the Puntledge River, along which these mudstones and siltstones are well exposed. The Puntledge member contains numerous ammonites and bivalves. Recently, a vertebrate fossil, a plesiosaur, was found in this member (Michael Trask, surveyor, B.C. Ministry of Highways, personal communication, 1989). An isolated sandstone bed, 3 to 5 metres thick, commonly occurs near the base of the member.

BROWNS MEMBER

We propose the name Browns member for a sandy unit which forms ledges in Browns, Puntledge and Tsable River, and underlies a low swamp-bounded ridge between Headquarters Village and Black Creek. It consists mainly of mixed granitic-basaltic sandstone and siltstone which is moderately to intensely bioturbated and contains abundant shell fossils, chiefly *Inoceramus*. The base of the member is abrupt, while the top is gradational and interfingering with the Royston member. Contacts between the Browns member and the laterally adjacent Tsable member are not exposed in outcrop, but borehole and mine records on file with the Ministry of Energy, Mines and Petroleum Resources suggest that the Browns member is erosionally truncated by the Tsable member.

The Browns member is 9 metres thick on Browns River and 15 to 20 metres thick at Black Creek. Locally, sedimentary structures have been almost obliterated by bioturbation, but less intensely burrowed parts of the member are usually either planar laminated or trough crossbedded. Original sorting of the sandstones is fair to good, and the less bioturbated sandstones display fair intergranular porosity. The Browns member was probably deposited as a complex of offshore bars, generally below storm wave base.

TSABLE MEMBER

The Tsable member was introduced by England (1989) for a ridge-forming conglomerate unit which outcrops between Courtenay and Tsable River. It consists of mixed basaltic-granitic conglomerate, which contains numerous blocks and cobbles of sandstone and siltstone identical to those of the underlying Dunsmuir and Puntledge members. Sandstone and siltstone interbeds are abundant in the upper half of the member, which intertongues with the overlying Royston member.

Tsable conglomerates are distinguished from the Comox Formation by their greater (although not predominant) content of granitic clasts and the ubiquitous presence of sedimentary rock clasts, which are extremely rare in the Comox conglomerates. The base of the Tsable member is erosional, truncating the underlying Browns and Haslam members of the Trent River Formation, and locally cutting down deeply into the Comox Formation. The member is 40 to 65 metres thick in the subsurface between Courtenay and Royston, but along its outcrop, east of Cumberland, it is at least 140 metres thick, while in the canyon of the Trent River, it is less than 5 metres thick. It pinches out to the northwest and southeast and does not appear to extend beyond Puntledge River in the north and Tsable River in the south.

Disorganized and chaotic sedimentary fabrics typify the basal part of the Tsable member while the upper part often displays planar graded bedding with fair to good sorting of framework grains. It was probably deposited as a submarine canyon fill; the uppermost beds were probably spilled out over a submarine fan, following filling of the main channel.

ROYSTON MEMBER

We propose the name Royston member for a unit of fine-grained sedimentary rocks which overlies the Tsable and Browns members and underlies the Protection Formation of the Comox sub-basin. The name Royston comes from the village of the same name, where this unit outcrops extensively. The Royston member replaces the Pender Formation, which is now considered to be an invalid name in the Comox sub-basin.

The Royston member consists of dark grey to olive-drab silty mudstone, siltstone and fine-grained thin-bedded sandstone, distinguishable from the Puntledge member by its greater content of sand and silt, and slightly lighter colour. The Royston member contains numerous ammonites, some rudistid and inoceramid bivalves, and occasional fish scales. It is 150 to 220 metres thick in its type locality at Royston.

STRUCTURAL GEOLOGY

According to Muller (1989), much of the Cretaceous sedimentary rock mass in the Mount Washington area is in tectonic contact with underlying basement rocks. Mapping during the field season demonstrated the validity of Muller's structural model. Some of the other Cretaceous outliers in the Mount Washington area are klippen emplaced by east-directed low-angle extensional faults. Most of the faults which affect the Cretaceous rocks tend to follow bedding near the base of the Benson member (Bickford and Kenyon,

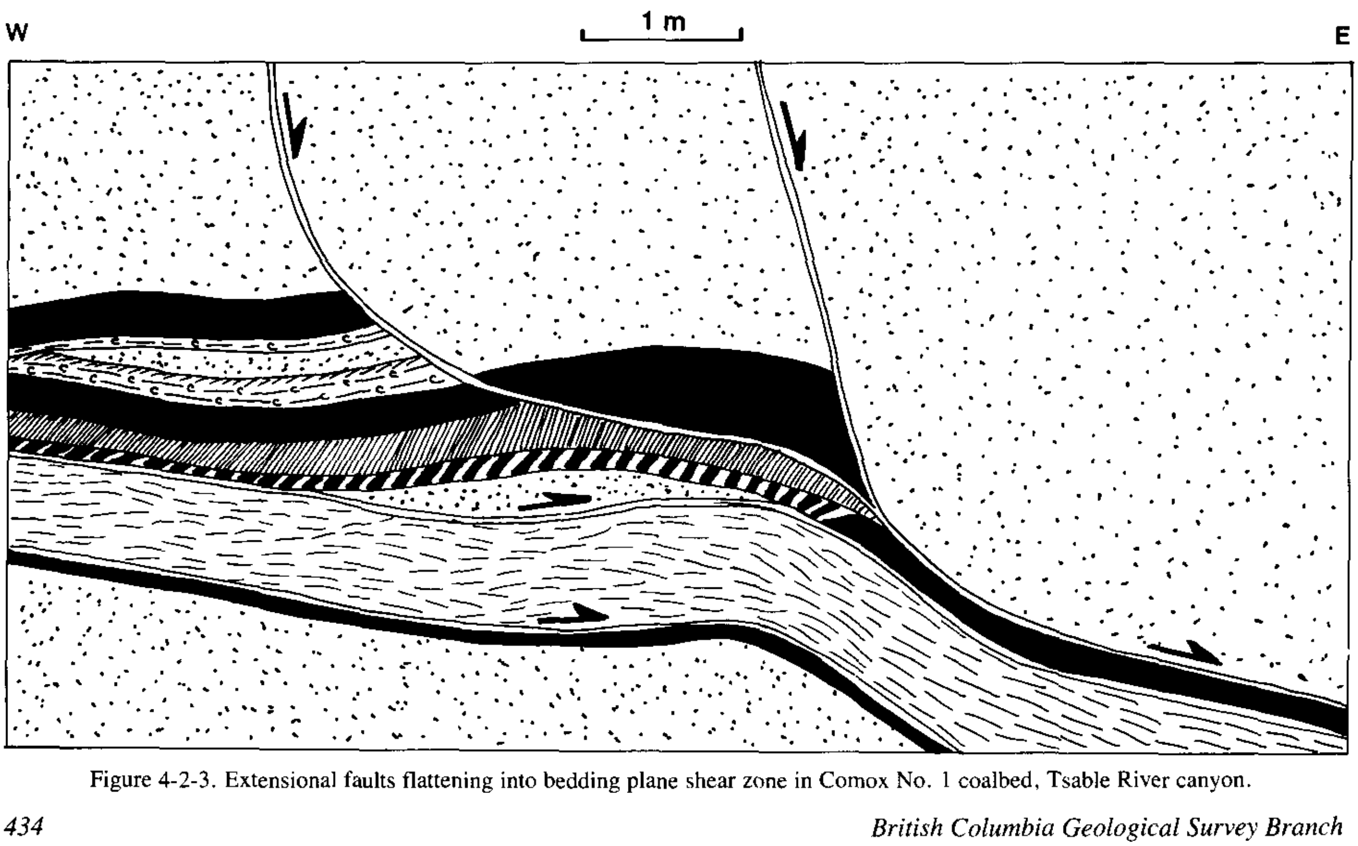

Figure 4-2-3. Extensional faults flattening into bedding plane shear zone in Comox No. 1 coalbed, Tsable River canyon.

1988). Fault movement appears to have been facilitated by the intense lateritic weathering zone which is characteristic of the basement paleosurface. The shearing exhibited by the coals of the Comox Formation, (for example, the thick coal near the top of the Cumberland member along Ramparts Creek) may have been produced during this movement.

East-directed low-angle extensional faults are also exposed along the Trent and Tsable rivers, farther to the south. On Trent River, the basal Haslam shales are intensely sheared and are in fault contact with the underlying Dunsmuir sandstones. On Tsable River, the basal Haslam shales are intensely sheared and crumpled, and contain contorted ankerite veinlets. The underlying Comox No. 1 and No. 2 coals are also the loci of bedding plane shearing (Figure 4-2-3).

PALEOCURRENT STUDIES

Paleocurrent indicators are abundant in the Benson member of the Comox Formation and the Tsable member of the Trent River Formation. Indicated paleocurrents are generally to the southwest and west in the Benson member, with a grand vector mean paleocurrent direction (based on 19 outcrops) of 237°. Benson conglomerates usually display good framework imbrication. The long axes of Benson framework clasts are parallel to bedding and perpendicular to paleoflow, indicating clast transport by rolling along a bed, consistent with a fluvial environment (Walker, 1984).

In the Tsable member, indicated paleocurrents are generally to the south and southwest. The grand vector mean paleocurrent direction (based on 14 outcrops) is 224°, slightly more southerly than that of the Benson member. Tsable conglomerates often have chaotic fabrics and, where framework imbrication is present, the long axes of the clasts dip parallel to paleoflow, consistent with transport by either mass movement or in a fluidised bed, probably under conditions of turbulent flow consistent with the interpretation of the Tsable member as a submarine canyon fill.

Further work will be required to assess whether these palecurrent directions are consistent throughout the Comox sub-basin; at present a Coast Range sediment source is possible for both the Benson and Tsable conglomerates.

ECONOMIC CONSIDERATIONS

Several coalbeds thicker than 1.2 metres have been identified in the Comox Formation during this field season. Details of these are summarized in Table 4-2-2. The UTM coordinates are included as the locations are not indicated on Figure 4-2-1. Detailed sections along the Trent and Browns rivers can be found in Kenyon and Bickford, 1989. It is likely that potential remains for additional coal discoveries in the Comox sub-basin. There are two areas that have had little exploration work; one between Oyster River and Headquarters Village and the other south of Trent River, along the coastline toward Union Bay.

The best coal showing found during the 1989 field season is on the Oyster River, where the No. 2 bed has a gross thickness of 1.73 metres and a net coal content of 90 per cent by thickness. Two other noteworthy coal outcrops are on Ramparts Creek, on the southwest side of Mount Washington, and Murex Creek, north of Wolf Lake. In both cases the coal measures have undergone low-grade contact metamorphism in the vicinity of Tertiary plutons, and the coals are of a higher rank compared to elsewhere in the sub-basin.

It is probable that the Ramparts Creek coal correlates with the Comox No.2 bed. It is intensely weathered at outcrop and it will be necessary to trench in this area to obtain an accurate section. At outcrop, the coalbed is 1.94 metres thick, with a net coal content of about 78 per cent by thickness. The Murex Creek coal is probably correlative with the Comox No.3 bed. It is only 1.31 metres thick, with a net coal content of 66 per cent by thickness, but it is of interest because it has a mean maximum vitrinite reflectance of 2.52 per cent, indicative of semi-anthracite rank (Kenyon and Bickford, 1989, sample 61). Sections of these and other potentially workable coalbeds are given in Figure 4-2-4.

Roof conditions play a major role in determining the success or failure of an underground colliery. Dark grey, variably carbonaceous mudstone forms the immediate roof of most of the Comox coals seen at outcrop. Where unsheared, this material can form a stable working roof, as has been evidenced by old workings, some more than 70 years in age. The critical roof span (Das, 1985) of these rocks is in the order of 4 to 6 metres. Where the mudstones are sheared their performance as a working roof is inadequate. Such sheared rocks formed the roof of the Comox No.2 bed in Tsable River colliery and were difficult to support for more than a few days to weeks (Stan Lawrence, retired colliery manager, personal communication, 1989). The critical roof span of the sheared mudstones is less than 4 metres. Above the immediate mudstone roofs, many of the Comox coals have a main roof of thick-bedded to massive, strong sandstone. Where this

TABLE 4-2-2
OCCURRENCES OF POTENTIALLY MINEABLE COAL AT OUTCROP IN THE COMOX SUB-BASIN

Locality	Coordinates	Coal bed	Gross Thickness	Per cent Coal by Thickness
Woodhus Cr.	331250 E 5530000 N	Comox 2	3.19 m	69
Oyster R.	334750 E 5527060 N	Comox 2	1.73 m	90
Ramparts Cr.	335240 E 5511250 N	Comox 2?	1.94 m	78
Murex Cr.	340570 E 5518755 N	Comox 3?	1.31 m	66
Browns R.	347770 E 5506220 N	Comox 2	1.41 m	76
Cumberland (No. 3 mine)	352300 E 5497605 N	Comox 1	1.31 m	78
Perseverence Cr.	352145 E 5496830 N	Comox 3A	1.65 m	85
Allen Lk.	353035 E 5495515 N	Comox 4	1.90 to 2.19 m	58 to 73
Hamilton Lk.	349450 E 5495865 N	Comox 3A	1.70 m	83
Trent R.	354505 E 5493610 N	Comox 3	1.55 m	75
Trent R.	354360 E 5493550 N	Comox 3A	2.10 m	82

Note: Coordinates given are UTM Zone 10.

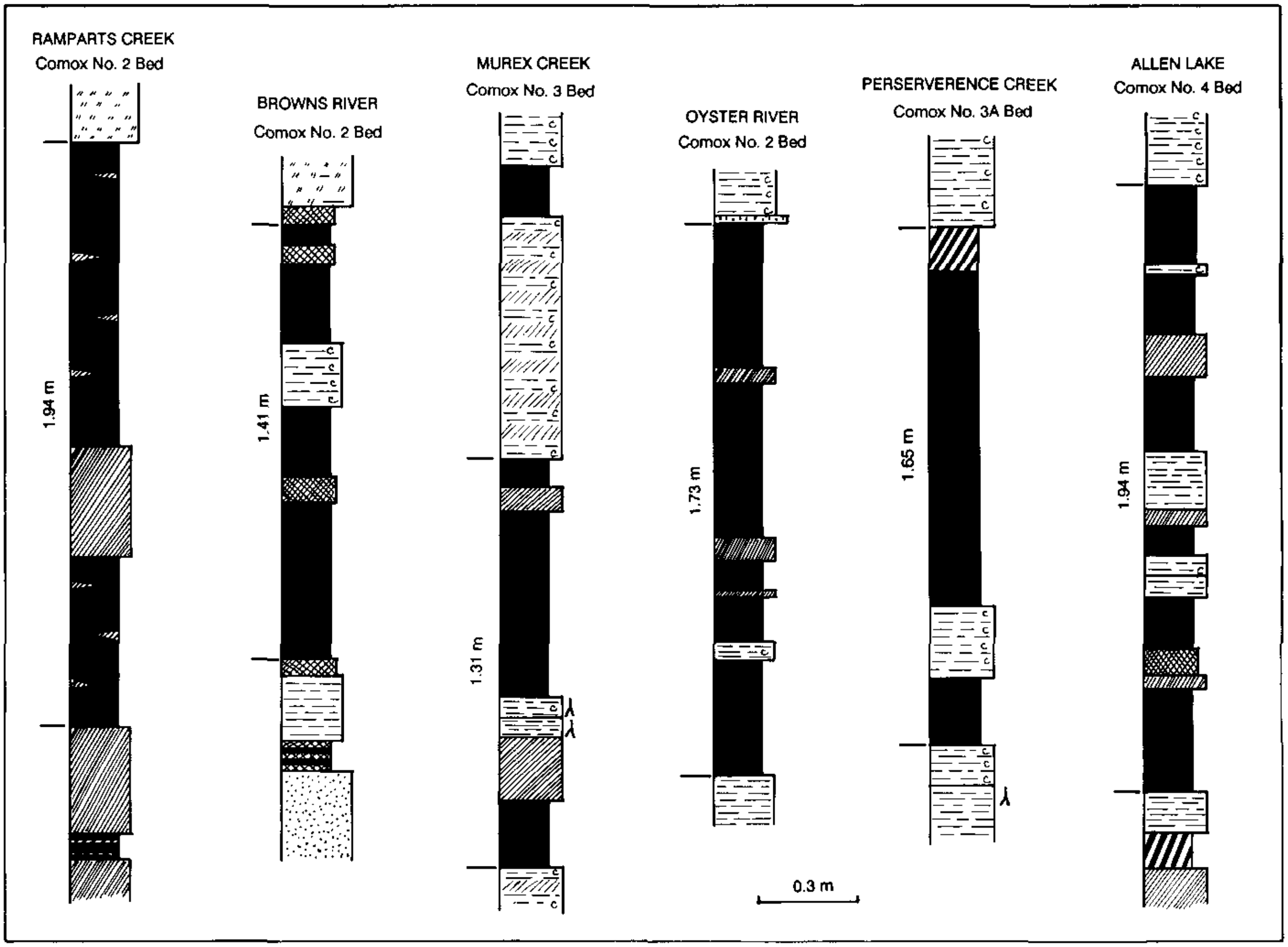

Figure 4-2-4. Measured sections of potentially mineable coalbeds in the Comox sub-basin.

sandstone is close to the underlying coalbed, it forms an excellent roof for room-and-pillar workings. For example, the hard sandstone roof of the Comox No.1 bed in the No. 3 mine at Cumberland has stood unsupported for more than 90 years.

ACKNOWLEDGMENTS

The authors would like to thank the forestry staff of Fletcher Challenge Canada Inc, and MacMillan Bloedel Ltd. for their assistance in many ways. The Campbell River Search and Rescue Society provided up-to-date logging-road maps. Michael Trask provided details of vertebrate fossil discoveries in the Trent River Formation. Stan Lawrence of Cumberland provided invaluable information regarding the Tsable River coalfield, and Cleo Pawson and Marie Norsed provided excellent field assistance.

REFERENCES

American Commission on Stratigraphic Nomenclature, (1970): Code of Stratigraphic Nomenclature; *American Association of Petroleum Geologists.*

Bickford, C.G.C. and Kenyon, C. (1988): Coalfield Geology of Eastern Vancouver Island (92F); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 441-450.

Bickford, C.G.C., Hoffman, G. and Kenyon, C. (1989): Coal Measures Geology of the Quinsam Area (92F); *B.C. Ministry of Energy, Mines, and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 559-563.

Carson, D.J.T. (1960): Geology of Mount Washington, Vancouver Island, British Columbia; unpublished M.Sc. thesis, *The University of British Columbia.*

Daniels, J. (1920): Memorandum regarding Hamilton Lake Coal Area; unpublished report, *Canadian Collieries (Dunsmuir) Limited*, Provincial Archives of British Columbia, Additional Manuscript 436, Box 3, File 5.

Das, B. (1985): Rock Classification for Coal Mining Applications; *Canada Centre for Mineral and Energy Technology, Coal Research Laboratories*, Report ERP/CRL 85-21.

England, T.D.J. (1989): Lithostratigraphy of the Nanaimo Group, Georgia Basin, Southwestern British Columbia; *Geological Survey of Canada*, Current Research, Part E, Paper 89-1E, pages 197-206.

Gunning, H.C. (1931): Buttle Lake Map Area, Vancouver Island; *Geological Survey of Canada*, Summary Report 1930, Part A, pages 56-78.

Kenyon, C. and Bickford, C.G.C. (1989): Vitrinite Reflectance Study of Nanaimo Group Coals of Vancouver Island (92F); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 543-552.

McGugan, A. (1979): Biostratigraphy and Paleoecology of Upper Cretaceous (Campanian and Maestrichtian) Foraminifera from the Upper Lambert, Northumberland and Spray Formations, Gulf Islands,British Columbia, Canada; *Canadian Journal of Earth Sciences*, Volume 16, pages 2263-2274.

Muller, J.E. and Jeletsky, J.A. (1970): Geology of the Upper Cretaceous Nanaimo Group, Vancouver Island and Gulf Islands, British Columbia; *Geological Survey of Canada*, Paper 69-25.

Muller, J.E. (1989): Tertiary Low-angle Faulting and Related Gold and Copper Mineralization on Mount Washington, Vancouver Island (92F/11, 14); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 81-91.

Walker, R.G. (1984): Turbidites and Associated Coarse Clastic Deposits; *in* Facies Models, Second Edition; *Geological Association of Canada*, Reprint Series 1, pages 171-188.

Ward, P.D. (1978): Revisions to the Stratigraphy and Biochronology of the Upper Cretaceous Nanaimo Group, British Columbia and Washington State; *Canadian Journal of Earth Sciences*, Volume 15, pages 405-423.

NOTES