British Columbia Geological Survey
Geological Fieldwork 1989

STRATIGRAPHY AND SEDIMENTOLOGY OF THE LOWER SKEENA GROUP, TELKWA COALFIELD, CENTRAL BRITISH COLUMBIA (93L/11)

By R.J. Palsgrove and R.M. Bustin
The University of British Columbia

KEYWORDS: Coal geology, sedimentology, Telkwa coalfield, Skeena Group, Red Rose Formation.

INTRODUCTION

Significant coal resources occur in the Lower Cretaceous Skeena Group near the town of Telkwa in central British Columbia. The coal deposits have been mined on a small scale since the early 1900s and a major exploration project designed to delineate further exploitable coal reserves is currently in progress (Handy and Cameron, 1983). Early attempts to resolve the lithostratigraphy and subsequently interpret the depositional history of the coal measures have been hampered by the lack of outcrops and subsurface information. As a result of recent exploration a large quantity of drill cores, geophysical logs and data are now available, facilitating a detailed sedimentological and coal-quality study of the coal measures in the Telkwa area.

The objectives of this study are: to describe and define the stratigraphy and lateral facies changes of the Skeena Group; to interpret the depositional history of coal measures in the Telkwa area; and to relate the quality and mineability of the coals to their depositional environments. The results of this study will contribute to understanding of the regional geology of Cretaceous basins and evolution of the Skeena arch in the Intermontane Belt in central British Columbia. In addition, the results will aid in the development of depositional models to predict variations in coal quality in other basins.

This report summarizes the preliminary results of fieldwork completed during the summer of 1989. It describes the stratigraphy and major facies changes, and interprets the depositional history of the eastern half of the Telkwa coalfield.

LOCATION AND REGIONAL GEOLOGY

The Telkwa coalfield is in the Intermontane Belt of west-central British Columbia, approximately 18 kilometres south of Smithers, near the town of Telkwa (Figure 4-5-1). The Telkwa River and Goathorn Creek run through the basin, dissecting it into three segments, locally known as the North Telkwa, West Goathorn and East Goathorn areas. The East Goathorn area is the subject of this paper.

The coalfield is located on the northern flank of the Skeena arch, near the southern limit of Jurassic sediments in the Bowser Basin. The coal measures, which are included in the Lower Cretaceous Skeena Group, are an erosional remnant of a larger Cretaceous basin which Hunt and Bustin (in press) refer to as the "Nazko basin". Local tectonism was a significant factor during the deposition of the coal measures.

The Skeena Group comprises a Lower Cretaceous sedimentary unit and an Upper Cretaceous volcanic unit. Sutherland Brown (1960) applied the names Red Rose Formation and Brian Boru Formation to the lower sedimentary and upper volcanic units respectively. Tipper and Richards (1976) follow Sutherland Brown's nomenclature, but include the Lower Cretaceous Kitsun Creek Formation, the Rocky Ridge volcanics and other unnamed sediments at the base of the Skeena Group. Tipper and Richards assigned the coal measures in the Telkwa area to undifferentiated Lower Cretaceous Skeena Group. MacIntyre *et al.* (1989) include them in the Red Rose Formation. In this discussion, the sediments of the Telkwa coalfield are referred to as Lower Skeena Group. The name Red Rose Formation will not be applied to the Telkwa coal measures; Tipper and Richards describe the Red Rose Formation as containing chert-pebble conglomerates, whereas in the Telkwa area, conglomerates consist entirely of volcanic clasts.

Deposition of the Skeena Group sediments began during the Early Cretaceous, following regional uplift and erosion of

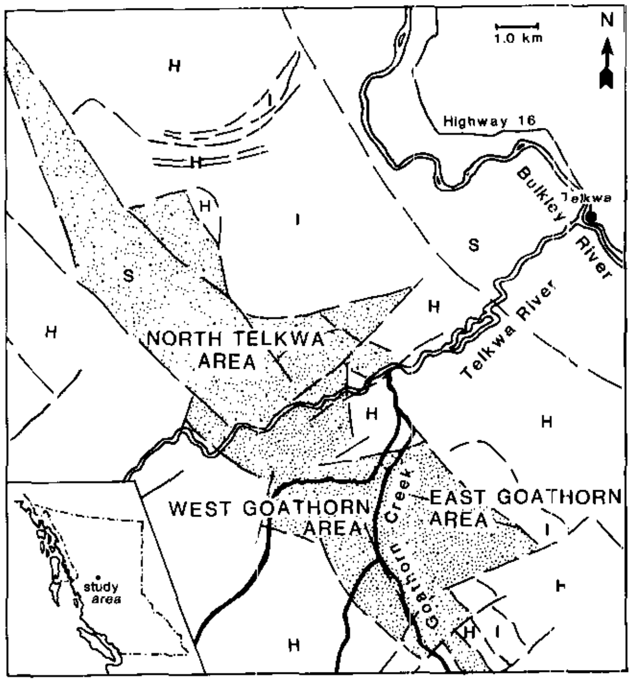

Figure 4-5-1. Location map of study area. S = Skeena Group, H = Hazelton Group, I = Tertiary intrusions. Telkwa coalfield is shown stippled. (Modified after MacIntyre *et al.*, 1989).

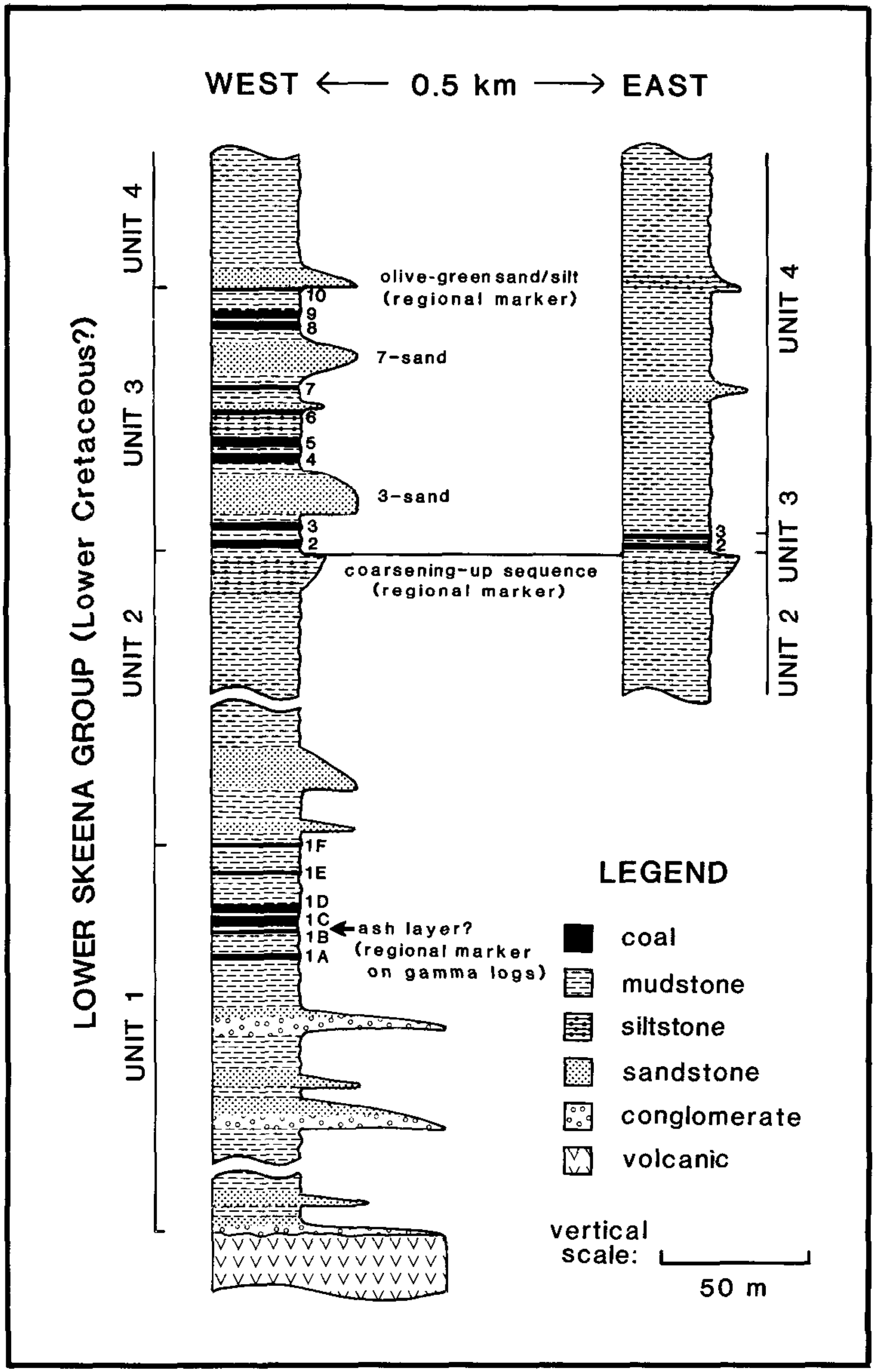

Figure 4-5-2. Representative stratigraphic columns of the Telkwa coalfield.

the Skeena arch. The sediments of the Skeena Group were transported southwest across the arch from the Pinchi belt and Columbian orogen (Tipper and Richards, 1976). The lower sedimentary unit is comprised of marine or continental and coal-bearing beds, which typically contain an abundance of fine-grained detrital muscovite (Leach, 1910; Sutherland Brown, 1960; Tipper and Richards, 1976).

LOCAL STRATIGRAPHY AND STRUCTURE

The Telkwa coalfield is fault bounded on all sides by the Lower Jurassic Telkwa Formation of the Hazelton Group (MacIntyre *et al.*, 1989) (Figure 4-5-1). The displacement on the faults is primarily vertical and estimated to be between 50 and 300 metres (Koo, 1983). Several high-angle faults strike north and west across the basin, with normal or reverse displacement of up to 30 metres (Koo, 1983). In addition, thrust faults strike northwest across the southeastern corner of the coalfield causing repetition of strata in some drill holes. Porphyritic Tertiary dikes and sills intrude the sediments throughout the coalfield, and a large granodiorite and quartz monzonite intrusion is present in North Telkwa (Koo, 1983).

More than 500 metres of Lower Skeena Group unconformably overly Hazelton Group volcanics. Plant fossils found in Skeena sediments in the Telkwa coalfield were dated as Early Cretaceous by Hacquebard *et al.* (1967). Palynological data from the base of the stratigraphic succession indicate that the oldest strata are Neocomian (Handy and Cameron, 1983).

Over most of the study area, the stratigraphic succession is divisible into four informal units based upon gross lithology (Figure 4-5-2). Coal occurs in ten "zones" (Handy and Cameron, 1983); each zone consists of one or more seams which are split by a thickness of organic-rich mudstone that is less than or equal to the thickness of the coal seams themselves. The one exception is Coal Zone 1, in which all the laterally correlatable seams are grouped together as one zone, despite the fact that the seams may be separated by as much as 8 metres of carbonaceous mudstone.

The four lithological units defined in this study correspond to those defined by Handy and Cameron (1983), and the three lowest units correspond roughly to those recognized by Koo (1983). The lowest unit (Unit I) unconformably overlies the volcanic basement and consists of fine to coarse-grained crossbedded lithic sandstone, volcanic-derived conglomerate, siltstone, mudstone and coal (Coal Zone 1). Coal Zone 1 contains a highly radioactive interval which is a regional marker on gamma ray logs. Unit II overlies Coal Zone 1 and consists primarily of monotonous silty mudstone, with occasional siltstone and sandstone beds. The top of Unit II is defined by a 10 to 15-metre coarsening-upward sequence that serves as a regional marker on geophysical logs. Unit III, which overlies the coarsening-upward sequence, comprises micaceous sandstone, siltstone and mudstone, and up to nine coal zones (Coal Zones 2 through 10). The uppermost unit, Unit IV, overlies Coal Zone 10 and is characterized by monotonous silty mudstone similar that in Unit II. A 2 to 4 metre thick bright green sandstone or siltstone marks the base of Unit IV and serves as a regional marker in the drill core.

The stratigraphic succession changes markedly from west to east. In the eastern margin of the study area, although the same stratigraphy is recognized, Unit III is considerably thinner, lacks sandstone, and contains only the two lowest coal zones (Coal Zones 2 and 3).

UNIT I:

Unit I comprises conglomerate, sandstone, siltstone, mudstone and coal between the unconformable contact with volcanic basement and the top of Coal Zone 1 (Figure 4-5-2). It ranges in thickness from 50 metres to more than 100 metres, reflecting paleotopographic relief on the underlying basement.

The contact of the Skeena Group with volcanic basement was not observed in drill holes from the East Telkwa area. In the North Telkwa area, volcanics are bleached from green to brown or maroon near the contact. The basal strata of the Skeena Group consist of horizontally bedded or crossbedded, poorly sorted granule or pebble conglomerate, or coarse sandstone. The clasts are subangular and derived from Hazelton Group volcanic rocks. Pyritized coal spar and mudstone clasts are common.

In general, the sediments of Unit I consist of fining-upward sequences, 2 to 10 metres thick, comprising green and maroon carbonaceous conglomerate and sandstone, separated by organic-rich mudstone and thin coal seams. The fining-upward sequences have sharp, erosional bases. Sorting is poor at the base and moderate at the top. The top of Unit I contains Coal Zone 1, which consists, on average, of six seams (locally termed seams 1A, 1B, 1C, 1D, 1E and 1F) interbedded with carbonaceous mudstone in a 30-metre interval. Coal seams 1A, 1D, 1E and 1F are usually less than 1 metre thick, whereas coal seams 1B and 1C are 1 to 3 metres thick. All six seams are not found throughout the area: often they are thin, laterally discontinuous and impossible to correlate.

UNIT II:

Unit II is between Coal Zones 1 and 2 and is comprised primarily of monotonous grey mudstone or silty mudstone, with occasional light grey beds of bioturbated sandstone (Figure 4-5-2). Unit II has a minimum thickness of approximately 100 metres and is thought to exceed 140 metres (Koo, 1983). No complete section of Unit II was penetrated in a single drill hole.

There is an overall decrease in sandstone relative to mudstone from the base to the top of the unit. The top 50 metres consists almost entirely of silty mudstone. Silty mudstone throughout the unit has occasional centimetre-scale, very bioturbated (mottled) siltstone laminae, rare gastropods and inoceramid-like fragments (P. Smith, personal communication, 1989), and little organic matter other than rare pyritized carbonaceous fragments. The sandstone beds have gradational lower and upper contacts and range in thickness from less than 1 metre to 30 metres. Often the sandstone is thoroughly bioturbated, resulting in a mottled texture. A variety of trace fossils occur, including *Teichichnus–Skolithos–Paleophycus* assemblages and monospecific *Macaronichnus* and *Helminthopsis* assemblages. In rare undisturbed intervals, pelecypod shell hashes, crossbedding, and isolated granules and pebbles occur.

The top of Unit II is marked by a 10 to 15-metre coarsening-upward sequence, abruptly overlain by organic-rich mudstone followed by Coal Zone 2. The coarsening-upward sequence can be correlated throughout the study area. It is characterized by an upward-increasing abundance of irregular, planar, lenticular and wavy bedded siltstone or fine-grained sandstone laminae and beds.

UNIT III:

Unit III averages about 90 metres thick and includes the sediments between the base of Coal Zone 2 and the top of Coal Zone 10 (Figure 4-5-2). It comprises a diverse sequence of mudstone, siltstone, sandstone and nine distinct coal zones.

Coal Zone 2 averages 2 to 4 metres in thickness and consists of one or two 0.5 to 3-metre seams. Coal Zone 3 is 2 to 4 metres thick and comprises three seams 0.5 to 2 metres thick. Where split, Coal Zones 2 and 3 are separated by up to 4 metres of organic-rich mudstone and irregular millimetre-scale siltstone or fine sandstone beds. Coal Zone 3 is gradationally or sharply overlain by light grey, fine-grained bioturbated sandstone (herein referred to as "three-sand") up to 18 metres thick (Figure 4-5-2). Three-sand has abundant thin mudstone laminae. Its upper contact with organic-rich mudstone and Coal Zone 4 is usually sharp. Occasionally, three-sand is rippled or crossbedded with scour surfaces and shell hashes, but bioturbation is the predominant structure and the trace fossils *Skolithos*, *Zoophycus* and *Planolites* are present. Three-sand also contains a diverse assemblage of marine pelecypods (P. Smith, personal communication, 1989).

Three-sand thins and disappears from west to east across the coalfield (Figure 4-5-3). Its disappearance coincides with the loss of Coal Zones 4 through 10 in the eastern half of the study area (Figure 4-5-2). Thus, in the eastern half of the study area, Coal Zone 3 is directly overlain by Unit IV; whereas elsewhere Unit IV overlies Coal Zone 10.

On average, Coal Zone 4 is 3.5 metres thick and consists of one or two seams 0.5 to 3 metres thick. Coal Zone 5 is 2 to 3 metres thick and comprises one or two seams 0.5 to 4 metres thick. Coal Zones 4 and 5 are separated by up to 3.5 metres of organic-rich mudstone. Above Coal Zone 5, strikingly regular, thinly laminated (1 millimetre) lenticular siltstone and carbonaceous mudstone are present. Well-preserved plant fossils and syneresis cracks are common. Coal Zone 6 is 2.5 to 4 metres thick and consists of one or two 0.5 to 3-metre seams. It is generally overlain by carbonaceous rooted mudstone, but occasionally by a thin, fine-grained, 1 to 2-metre sandstone resting on an erosional contact. The sandstone has limited lateral extent and fines upward into organic-rich mudstone followed by Coal Zone 7.

Coal Zone 7 comprises a single 1-metre seam. It is overlain by mudstone with moderately abundant carbonaceous fragments and occasional silt laminations and rooted intervals. The mudstone grades upward into a 3 to 11 metre thick, fine to medium-grained grey-green sandstone referred to as "seven-sand" (Figure 4-5-2). It is horizontally bedded or massive, with occasional crossbeds or scour surfaces. Thin mudstone beds with the trace fossil *Planolites* are common within seven-sand. Organic matter is abundant in roots and thin carbonaceous laminations or scattered throughout. Seven-sand coarsens and then fines upward, grading into mudstone and Coal Zones 8 and 9.

Coal Zones 8 and 9 each contain a single seam 1 to 2 metres thick. The seams are separated by less than 2 metres of carbonaceous mudstone, and in places Coal Zones 8 and 9 are considered one zone. Coal Zone 9 is overlain by organic-rich mudstone with siltstone interbeds. In some areas, a horizontally bedded fine-grained, green-grey sandstone, up to 5 metres thick with frequent mudstone laminations and moderately abundant organic matter, overlies Coal Zone 9. Coal Zone 10 is less than a metre thick, where present.

UNIT IV:

Unit IV overlies Coal Zone 10 in the western part of the study area and Coal Zone 3 in the eastern part, and is at least 40 metres thick. It is unconformably overlain by Quaternary sediments. Most of the unit resembles the upper part of Unit II, consisting primarily of silty mudstone with the trace fossil *Helminthopsis*, thin mottled siltstone laminations, bioturbated sandstone beds, and very rare carbonaceous matter.

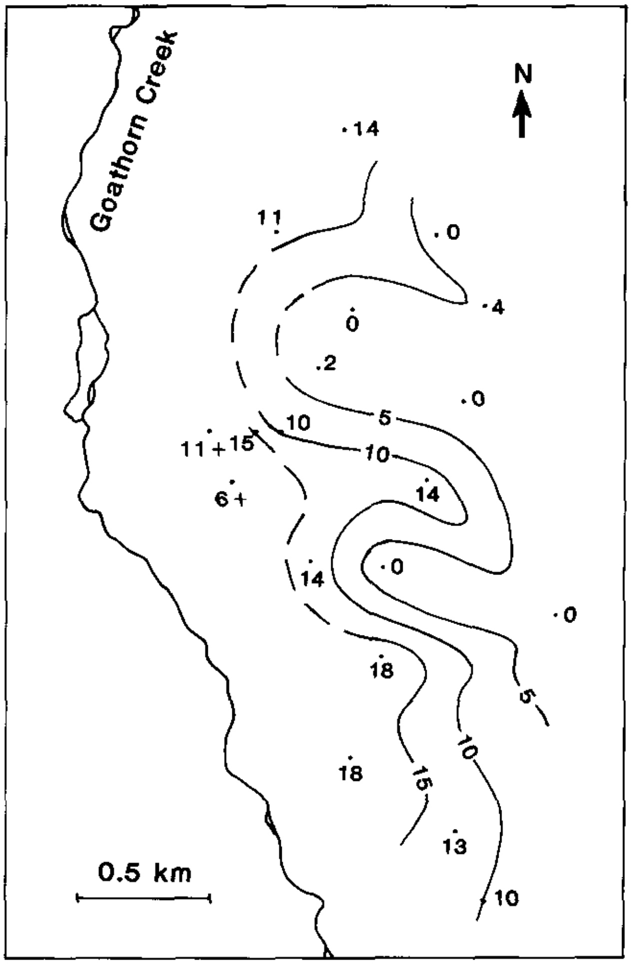

Figure 4-5-3. Isopach map (in metres) of three-sand, Telkwa coalfield.

In the western half of the study area, the base of Unit IV is marked by a thick, chloritic, bright green, massive, very fine grained sandstone or siltstone 2 to 4 metres thick. It sharply overlies Coal Zone 9 or 10. It fines upward very gradationally into the silty mudstone described above. In the eastern half of the study area, a similar green siltstone occurs at the same stratigraphic horizon (Figure 4-5-1), but it no longer marks the base of Unit IV.

DEPOSITIONAL ENVIRONMENTS

In previous studies, the Telkwa coal measures have been described as lacustrine (Hacquebard *et al.*, 1967), fluvial and shallow marine (Koo, 1983), and fluvial, deltaic and marine (Handy and Cameron, 1983). Detailed core logging during the 1989 field season, together with trace and macrofossil identification has led to further refinements in the interpretation of the depositional environments of the strata.

The Lower Skeena Group in the Telkwa area was deposited in alternating nonmarine, transitional, and open-marine environments. Unit I was deposited in a fluvial environment. Palaeotopographic lows were filled with coarse-grained sediments derived from the eroded Hazelton volcanic basement. Eventually a peat-forming floodplain was established, resulting in the formation of Coal Zone 1. Peat formation was periodically interrupted by migrating channels, resulting in laterally discontinuous, thin seams.

Unit II was deposited in a marine lower-shoreface environment. This is suggested by the presence of inoceramids, *Helminthopsis*, *Teichichnus*, *Skolithos* and *Paleophycus* in the mudstone and siltstone (Ekdale *et al.*, 1984). The paucity of organic matter (restricted to rare occurrences of coal spar and pyritized plant matter) is consistent with a lower-shoreface marine environment. The burrowed sandstone of Unit II, with relatively more organic matter and rare shells and granules, may indicate transitions to upper-shoreface conditions. The presence of *Macaronichnus* near the top of some of the sandstones is indicative of relatively higher energy conditions (Ekdale *et al.*, 1984), suggesting that some of the sandstone may have been deposited in a shoaling-upward environment.

The coarsening-upward sequence near the top of Unit II is a regressive sequence marking the transition between marine-shoreface sediments and nonmarine organic-rich rooted mudstone and Coal Zone 2. The absence of sediments characteristic of foreshore or beach environments suggests that the marine sediments were prograded over by a lower energy nearshore environment, such as an interdistributary bay.

Much of Unit III was deposited in a terrestrial environment as evident from the abundance of coal zones, but occasionally, marine conditions existed. Marine pelecypods are present in three-sand. Extensive bioturbation of three-sand and the presence of *Skolithos* and *Zoophycus* indicate that the sandstone was deposited in a shoreface environment (Ekdale *et al.*, 1984). Occasional ripples, crossbeds, shell hashes, and scours filled with coarse sand or granules suggest wave action, so it is probable that three-sand was deposited in an upper-shoreface (transitional with foreshore) environment.

The sandstones commonly present above Coal Zones 6 and 9 were deposited in a fluvial environment. This is suggested by their fining-upward character, their limited lateral extent, and their lateral facies association with carbonaceous mudstone and coal. They may represent thin channel deposits. Seven-sand was also deposited in a subaerial environment, evident from the abundance of rooted beds.

Unit IV marks a return to marine or transitional depositional environments. The presence of *Helminthopsis* is indicative of a lower-shoreface or offshore environment (Ekdale *et al.*, 1984).

DISCUSSION

The sediments of the Lower Skeena Group in the East Goathorn area of the Telkwa coalfield record a complex depositional history. Unit I was deposited in a fluvial environment on eroded volcanic basement. Peat growth took place in fluvial floodplains frequently interrupted by flooding and sediment influx. Deposition of Unit I was terminated by a marine transgression. Unit II was deposited in a marine shoreface environment. A subsequent regression occurred, resulting in deposition of the continental coal-bearing sediments of Unit III. Coal formed in peat marshes close to a shoreline, and later in fluvial floodplains. Unit IV was deposited in a shoreface environment during a second marine transgression.

The major facies change in the upper part of Unit III, from nonmarine coal-bearing strata in the west to transitional marine or marine strata of Unit IV in the east (Figure 4-5-2) indicates that the sea transgressed east to west across the area. Marine water inundated the eastern margin of the coalfield after the deposition of Coal Zone 3, and reached the western part of the coalfield after the deposition of Coal Zone 10. If this interpretation is valid, the source of the Lower Skeena Group in the study area must have been to the west. Elsewhere, it is generally thought that the Skeena Group has an eastern provenance (Tipper and Richards, 1976).

FUTURE WORK

In the future, the West Goathorn and North Telkwa areas will be examined in greater detail, to supplement the data from the East Goathorn area. Laboratory studies in progress, which include palynology, paleontology and petrology, will further refine the litho and biostratigraphy of the Lower Skeena Group in the study area. Coal-quality parameters, including sulphur content, ash content, and seam thickness and lateral distribution, will be interpreted in the context of the sedimentology of the coal measures.

ACKNOWLEDGMENTS

The authors wish to thank the staff of Crows Nest Resources Limited, particularly Brian McKinstry, for its interest in the project and access to its data. Financial support for the project was provided by the British Columbia Ministry of Energy, Mines and Petroleum Resources and is gratefully acknowledged. Special thanks are due to Bruce Kerr, his family, and his logging crew for helping us during the field season in every possible manner.

REFERENCES

Ekdale, A.A., Bromley, R.G. and Pemberton, S.G. (1984): Ichnology, the Use of Trace Fossils in Sedimentology and Stratigraphy; *Society of Economic Paleontologists and Mineralogists*, Short Course No. 15, 317 pages.

Hacquebard, P.A., Birmingham, T.H. and Donaldson, J.R. (1967): Petrography of Canadian Coals in Relation to Environment of Deposition; *Canada Energy, Mines and Resources*, Proceedings on the Symposium on the Science and Technology of Coal, Mines Branch, Ottawa, pages 84-97.

Handy, D.L. and Cameron, S.J. (1983): Geological Report–Telkwa Project; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 239.

Hunt, J.A. and Bustin, R.M. (in press): Stratigraphy, Organic Maturation and Source Rock Potential of Cretaceous Strata in the Chilcotin-Nechako Region (Nazko Basin); *in* Current Research, *Geological Survey of Canada*.

Koo, J. (1983): Telkwa Coalfield, West-central British Columbia; *B.C Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1982, Paper 1983-1, pages 113-121.

Leach, W.W. (1910): The Skeena River District; *Geological Survey of Canada*, Summary Report, 1909.

MacIntyre, D.G., Desjardins, P. and Koo, J. (1989): Geology of the Telkwa River Area (NTS 93L/11); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-16.

Sutherland Brown, A. (1960): Geology of the Rocher Déboulé Range, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 43, 78 pages.

Tipper, H.W. and Richards, T.A. (1976): Jurassic Stratigraphy and History of North-central British Columbia; *Geological Survey of Canada*, Bulletin 270, 73 pages.