THE TELKWA, RED ROSE, AND KLAPPAN COAL MEASURES IN NORTHWESTERN BRITISH COLUMBIA (93L, M; 104H)

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INTRODUCTION

Potentially economic coal measures underlie the areas surrounding Telkwa River, Red Rose Creek, and Mount Klappan in northwestern British Columbia. In this report these are referred to as Telkwa, Red Rose, and Klappan coal measures. Recently, they have been attracting keen exploration interest.

The present project began with geological field investigation of the Telkwa coal measures in August of 1982. Preliminary results of the 1982 field work were reported in *Geological Fieldwork, 1982* (Koo, 1983). Investigation of the Telkwa coal measures was continued, together with a geological reconnaissance survey of the Red Rose and Klappan coal measures, during the summer of 1983. The objectives of the investigations were to unravel the stratigraphy, structural development, depositional environments, ages, areal extent, and relationships to surrounding rocks of the coal measures; special attention was paid to their coal seams.

STRATIGRAPHY

TELKWA COAL MEASURES

During the intial stage of the present project, Koo (1983) applied the term Telkwa coal measures to the coal-bearing sedimentary sequences exposed at Telkwa River, Goathorn Creek, and Cabinet Creek near the town of Telkwa. The same measures, however, also occur in isolated areas at Denys Creek, Thautil River, Chisholm Lake, and Zymoetz River (Fig. 30). Therefore, coal measures in these other areas are also referred to as Telkwa coal measures in this report. Evidently, these are erosional remnants of the original Telkwa basin which was much more extensive than now.

The Telkwa coal measures can be divided into Lower, Middle, and Upper units (Fig. 31). The Lower unit ranges in thickness from 15 metres to 120 metres. It consists of conglomerate, coarse to fine-grained sandstones, siltstone, claystone, and coal seams. Up to seven fining-up cycles comprise its vertical sections. The individual cycles, each 4 to 40 metres thick, show a lithological variation from conglomerate or coarse-grained sandstone at the base through medium-grained sandstone to fine-grained sandstone and mudstone at the top. In some of the cycles the conglomerates occur near the base of the Lower unit. Most conglomerate layers are 50 centimetres to 15 metres thick; they consist of subrounded clasts that change in size upsection from cobbles through pebbles to granules. The clasts originate mostly from subaerial volcanic rocks of the Early to Middle Jurassic Hazelton Group which underlies the Telkwa coal measures. The coarse to fine-grained sandstones are 10 metres to 40 metres thick; they are similar to the conglomerates in composition. The mudstones have a thickness from 2 to 25 metres. The mudstone layers that are closely associated with coal seams near the top of the Lower unit are relatively thicker.

The Middle unit consists of 90 to 140 metres of medium to fine-grained sandstones and mudstones. Their layers are relatively thick, up to 100 metres, and extend for distances greater than 1 kilometre. Locally, several 2 to 20-metre-thick, fining-up cycles characterize the Middle unit. They begin with medium-grained

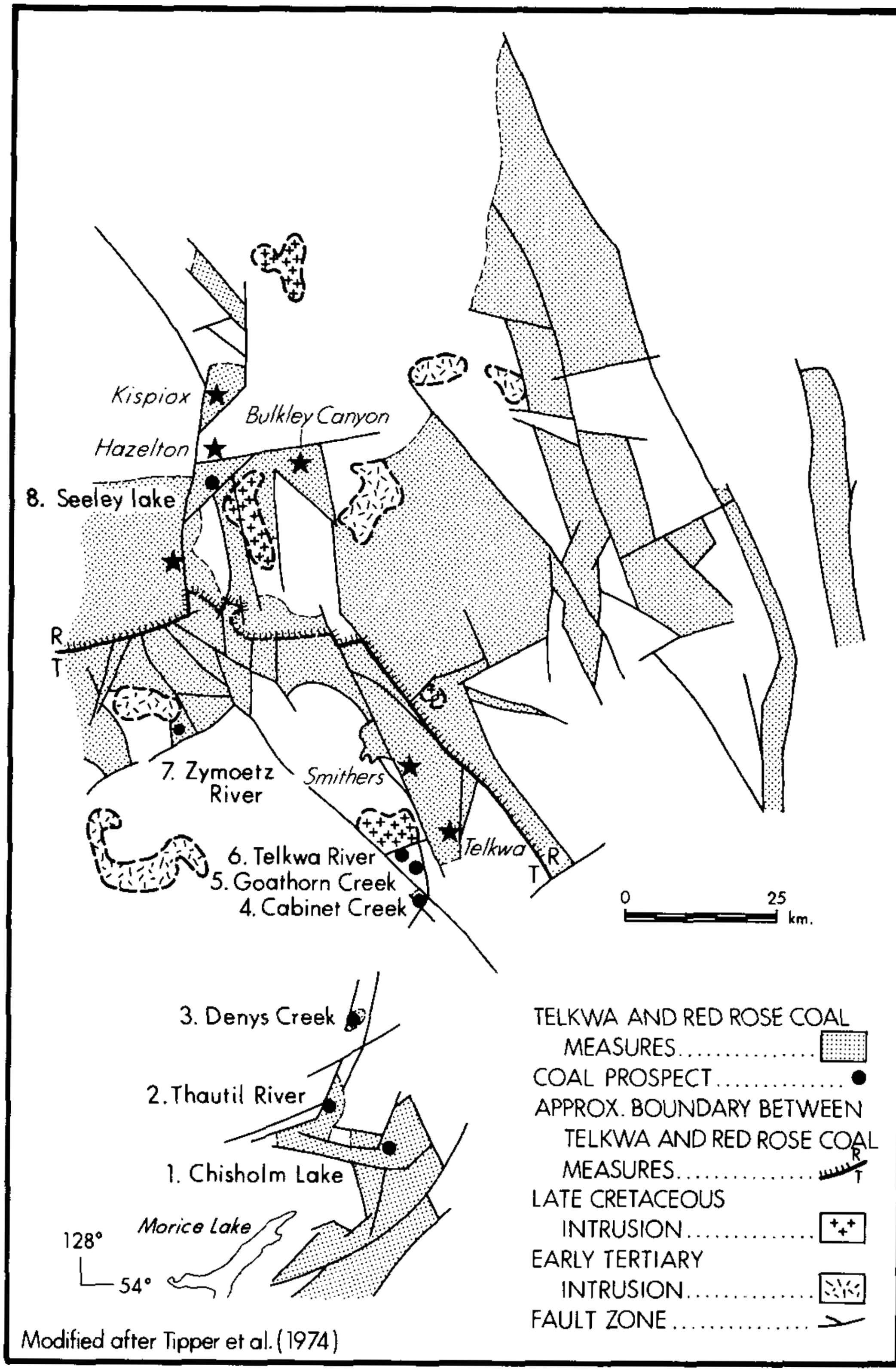

Figure 30. Distribution of the Telkwa and Red Rose coal measures.

sandstone and end with fine-grained sandstone to mudstone. Coal fragments and thin coal seams up to a few centimetres thick occur in this unit. However, intensely bioturbated sandstone and mudstone layers with marine molluscan faunas are dominant in the Middle unit.

The Upper unit consists of more than 330 metres of sandstones, mudstones, and coal seams. The lower part of this unit consists of up to 180 metres of medium to fine-grained sandstones, mudstones, and coal seams. Up to eight cycles make up the lower succession of this unit; each cycle shows a lithological variation from medium-grained sandstone at the base through fine-grained sandstone to mudstone and coal seams. Individual cycles are 10 to 30 metres thick. The upper part of this unit is th cker than 150 metres and consists of mudstone layers with minor amounts of fine to medium-grained sandstones and marl. Several fining-up cycles and varves occur in this unit.

RED ROSE COAL MEASURES

These coal measures are named after the coal-bearing Red Rose Formation. The Red Rose Formation consists of Late Jurassic and Early Cretaceous marine and nonmarine sedimentary sequences exposed south of Red Rose Creek in the Rocher Deboule Range near the town of Hazelton (Sutherland Brown, 1960). The lowermost member of the Red Rose Formation is a coal-bearing, nonmarine sequence that is greater than 750 metres thick. It is overlain by a shale and siltstone sequence 1 210 metres thick of probable marine origin.

The Red Rose coal measures have been most intensively explored at the Seeley Lake coal prospect; the stratigraphy can be best documented there (Figs. 30 and 31). They also occur in Kispiox Valley, Bulkley Canyon, and Skeena Crossing. A minimum 200-metre-thick sequence of coal measures occurs at the Seeley Lake prospect. The sequence consists of conglomerates, coarse to fine-grained sandstones, mudstones, and coal seams. Up to 25 fining upward cycles characterize vertical sections of the sequence. Individual cycles are 0.3 to 22 metres thick; they vary from conglomerate or coarse-grained sandstone at the base through medium-grained sandstone to fine-grained sandstone and mudstone at the top. Congomerates consist of subrounded, black to grey chert or volcanic clasts which are well sorted in size and grade from 1 centimetre to 2 millimetres upward in the section. Conglomeratic layers vary from 0.2 to 3 metres in thickness; they occur most commonly in the lower parts of the sequence. The coarse-grained sandstones are 0.2 to 1 metre thick and light grey in colour. The medium to fine-grained sandstones are grey or nearly black, and their layers range in thickness from 0.3 to 16 metres. The mudstones are dark grey or black and 0.3 to 15 metres thick. The black mudstones or fine-grained sandstones are closely associated with coal seams.

KLAPPAN COAL MEASURES

The Klappan coal measures are well exposed at Mount Klappan and in its neighbouring area (Fig. 32). They are greater than 350 metres thick and can be divided into Lower, Middle, and Upper units (Fig. 33).

The Lower unit consists of coarse to fine-grained sandstones, mudstones, and coal seams. Its thickness ranges from 150 metres to 200 metres; its base has not yet been clearly determined. It differs from Telkwa and Red Rose because cycles coarsen upward; up to seven coarsening-up cycles characterize most of its vertical sections, and individual cycles vary in thickness from 1 metre to 30 metres. Each cycle changes from fine-grained sandstone to mudstone and coal seams at the base through to coarse-grained sandstone at the top. Thinly laminated successions of fine-grained sandstone and mudstone occur in some parts of the Lower unit. They are up to 15 metres thick and contain marine molluscan faunas. The laminae are commonly 1 millimetre to 15 centimetres thick; intense bioturbation is common. Angular rip-up clasts of black fine-grained sandstone or mudstone, up to 5 centimetres across, are common within coarse to fine-grained sandstones in upper parts of the cycles. The latter sandstones are generally oxidized and brown in colour.

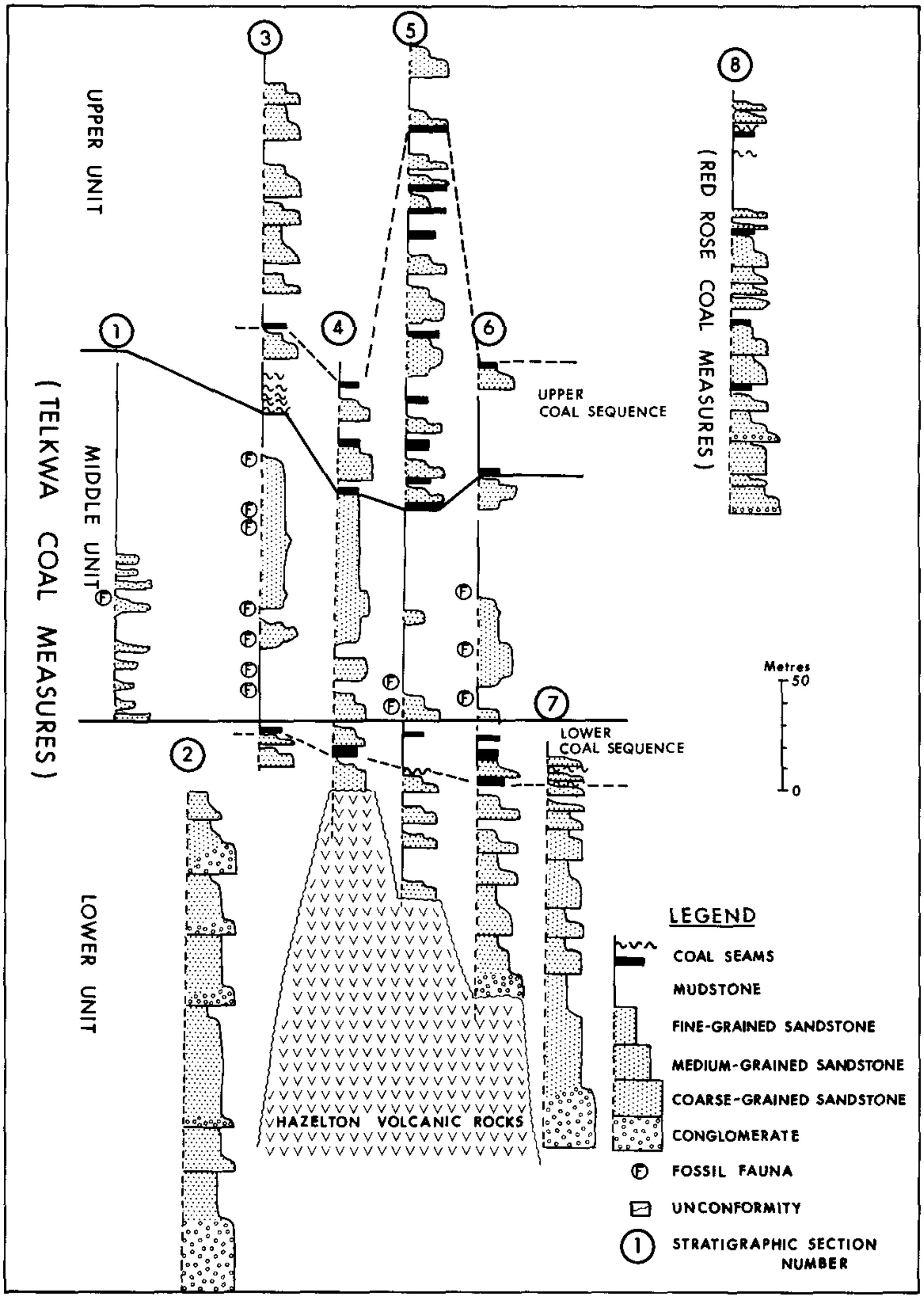

Figure 31. Stratigraphic sections of the Telkwa and Red Rose coal measures.

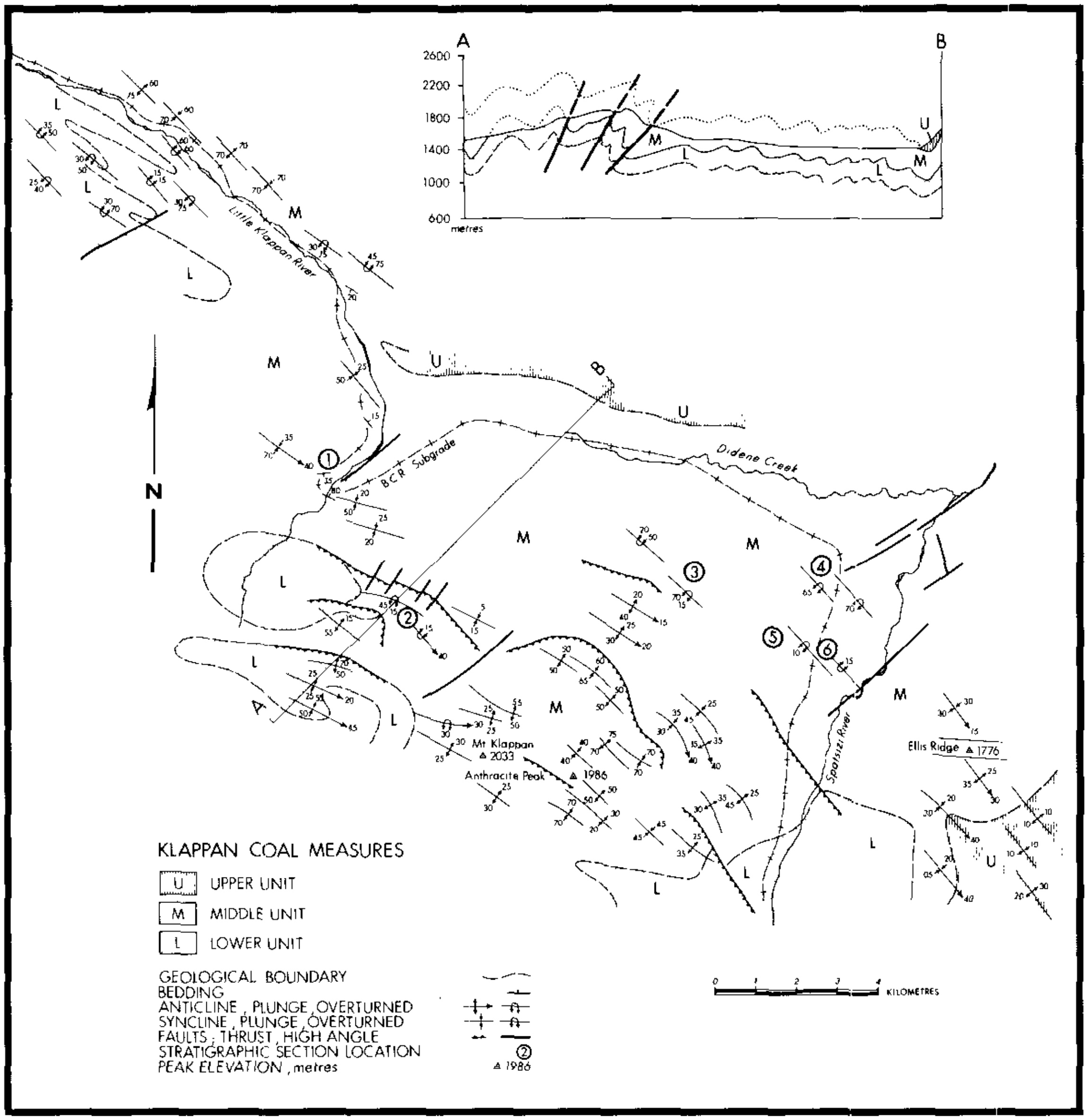

Figure 32. Simplified geology of the Mount Klappan area.

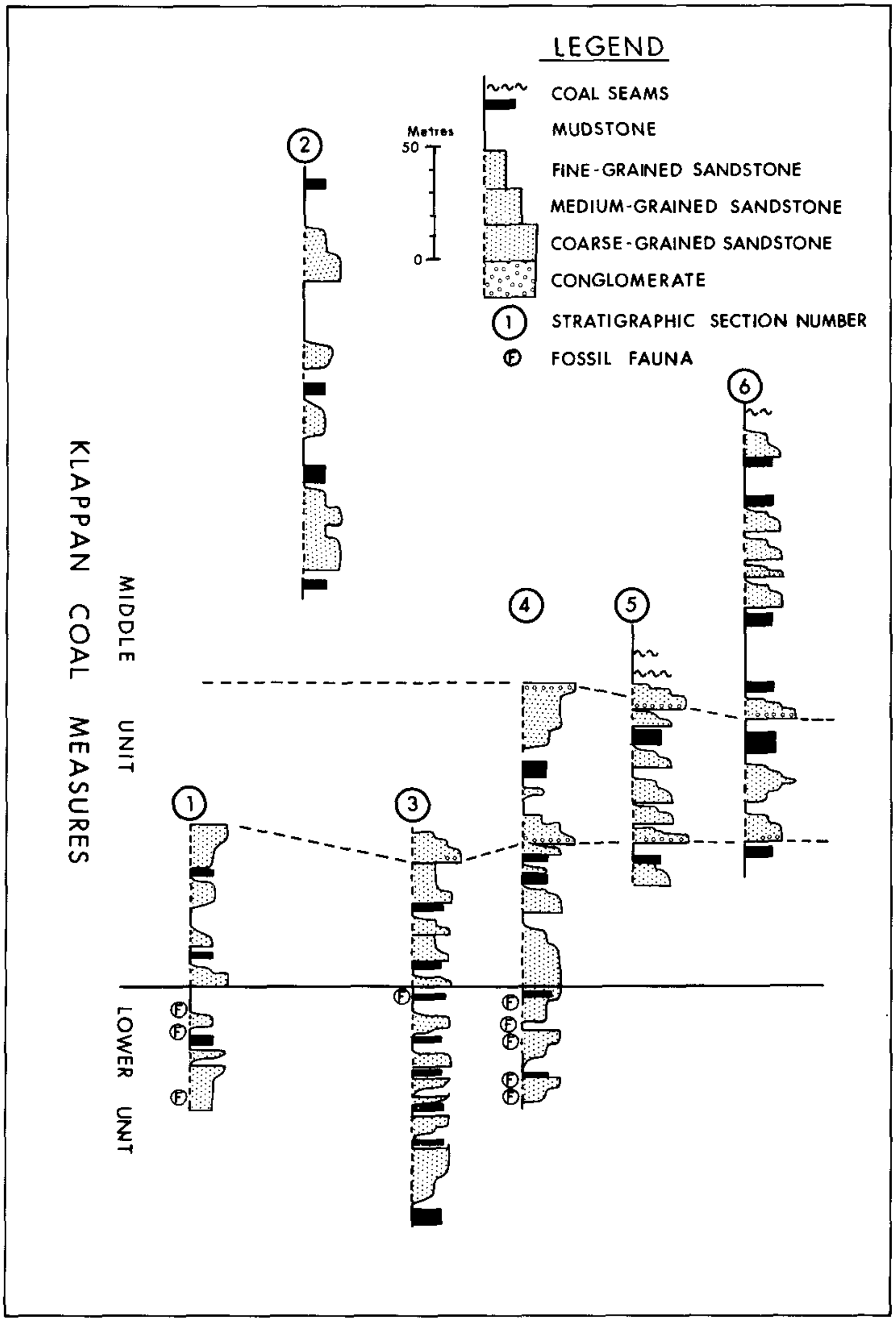

Figure 33. Stratigraphic sections of the Mount Klappan coal measures.

The Middle unit is 320 metres thick and can be subdivided into three zones. The lower zone, 35 to 75 metres thick, consists of coarse to fine-grained sandstones and mudstones; coal seams occur with the mudstone layers. This zone is transitional between the Middle and the underlying Lower units. It consists of up to 10 fining-up cycles that range in thickness from 1 metre to 20 metres.

The middle zone is 150 metres thick and consists of several fining-up cycles. The cycles are 2 to 45 metres thick and vary from chert pebble conglomerate or chert-pebbly sandstones at the base through medium-grained sandstone to mudstones at the top. Coal seams occur with the mudstones. The chert pebble conglomerates or sandstones are up to 15 metres thick.

The upper zone is 95 metres thick; it contains up to 20 fining-up cycles. The individual cycles range in thickness from 1 metre to 35 metres. They are made up of medium-grained sandstones at the base that grades through fine-grained sandstones to mudstones at the top. The mudstones are closely associated with coal seams. Scours, mud cracks, and brown oxidation bands are common in the Middle unit.

The Upper unit consists of medium to fine-grained sandstones, siltstones, claystones, coaly mudstones, and marl. The top has not been clearly defined; however, this unit appears to range in thickness from 150 metres to 200 metres. Varves are common and there are several fining-up cycles. Coal seams, up to 50 centimetres thick, occur with some coaly mudstone layers.

COAL SEAMS

Coal seams occur in the upper zone of the Lower unit and in the lower zone of the Upper unit within the Telkwa coal measures; these two zones are the lower and upper coal sequences (Fig. 31). Up to four coal seams, 1 to 15 metres apart, occur in the lower sequence. They range in individual thickness from 1 to 6 metres and have an aggregate thickness of 2 to 12 metres. The lower coal sequence varies from 2 to 40 metres in thickness. The upper sequence comprises up to 15 coal seams; they occur in the lower part of the Upper unit. Individual coal seams are 2 to 20 metres apart; these spacings almost correspond to the thickness of individual fining-up cycles. The coal seams range from 1 to 5 metres in thickness with aggregate thickness up to 26 metres. The upper coal sequence ranges from 20 to 170 metres in thickness.

The Red Rose coal measures at the Seeley Lake prospect (Fig. 31) comprise at least six coal seams, 0.3 to 27 metres apart. Individual seams range up to 1.5 metres and aggregate zones up to 5 metres in thickness. The coal sequence at Seeley Lake represents only a partial section of the Red Rose coal measures, therefore more coal seams may occur stratigraphically above and below it.

The Klappan coal measures contain potentially economic seams in their Lower and Middle units (Fig. 33). The Lower unit comprises up to six coal seams, 17 to 30 metres apart. Their individual thickness ranges from 1 to 5 metres with an aggregate thickness of up to 10 metres. The Middle unit contains 10 coal seams; its lower zone has two seams, 4 to 30 metres apart, and they are 1 to 5 metres thick with an aggregate thickness of up to 7 metres. Four coal seams, 8 to 35 metres apart, occur in the middle zone of the Middle unit. They are 2 to 10 metres thick with an aggregate thickness of up to 22 metres. There are four coal seams, 10 to 90 metres apart in the upper zone of the Middle unit. They are 3 to 8 metres thick with an aggregate thickness of up to 22 metres.

Bituminous coal characterizes Telkwa coal seams. Coal in the Red Rose coal measures, however, varies in rank from bituminous to anthracite. The higher rank Red Rose coal occurs in localities where there is tight folding and intrusion of Middle to Late Cretaceous granodiorite and quartz monzonite stocks. For example, Sutherland Brown (1960) documented a thermal aureole that is up to 1.5 kilometres wide around the Rocher Deboule stock. Higher ranked anthracite of the Seeley Lake prospect was produced by thermal metamorphism of Red Rose coal measures marginal to the Rocher Deboule stock. Anthracite also characterizes the Klappan coal seams.

DEPOSITIONAL ENVIRONMENTS AND AGES

The Telkwa coal measures represent a variety of sedimentary environments. The Lower unit consists of fluvial clastic sediments deposited on a terrane which was initially irregular but subsequently underwent multiple stages of pedimentation and peneplanation. The conglomerates and coarse-grained sandstones form lenticular layers with limited lateral extent; they represent high energy, channel-fill deposits. The medium to fine-grained sandstones and mudstones form relatively extensive layers; they represent low energy, floodplain or meandering drainage plain deposits. Coal swamps of the lower coal sequence formed during the periods of extensive floodplain development. The floodplain deposits are generally mud cracked and oxidized.

Sediments of the Middle unit represent shallow marine transgressions and regressions. The marine transgressions are indicated by sandstone and mudstone layers with marine molluscan faunas; the regressions are marked by thin, cyclic coal-bearing sequences that represent local fluvial deposits.

The lower contact of the Upper unit marks a widespread regression. It begins with a fluvial succession that gives way upward largely to a lacustrine sequence except for local minor marine transgressive facies. Fining-up cycles within the fluvial succession represent meandering channel-fill and floodplain deposits. Eutropic coal swamps developed locally on the floodplains at up to 15 sedimentary horizons.

The Red Rose coal measures are a fluvial sequence composed of channel-fill and floodplain deposits. Coal swamps also developed along with the floodplains.

Hacquebard, *et al.* (1967) determined plant fossils of the Telkwa coal measures to be of Early Cretaceous age. Sutherland Brown (1960) noted that the Red Rose Formation is probably of Late Jurassic and Early Cretaceous age. Tipper and Richards (1976) concluded that the coal-bearing sequences at Telkwa River and Red Rose Creek both belong to the Early Cretaceous sedimentary sequence of the Skeena Group. The sediments were derived from an easterly source, probably during uplift of the Omineca Crystalline Belt (Eisbacher, 1981).

Except for the lower Telkwa coal measures, both Telkwa and Red Rose coal measures contain significant amounts of detrital muscovite and quartz. These support the suggestion that the Omineca Crystalline Belt was a major source for detritus in most parts of the coal measures. However, sediments of the lower Telkwa coal measures are derived from underlying Hazelton volcanic rocks. Tipper and Richards (1976) showed that the Howson and Telkwa Ranges were centres of Hazelton subaerial volcanism and subsequently uplifted to form the southwest Skeena Arch during Jurassic time. During Early Cretaceous time, erosion of the Hazelton volcanic terrane in the ranges provided a local source of sediments for the lower Telkwa coal measures.

The Klappan coal measures consist of shallow marine, fluvial, and lacustrine deposits. The Lower unit was deposited in a transitional zone between marine and continental environments. The sedimentary succession represents progradation of alluvial fans and coal swamps over deltas during a marine regression. The Middle unit was deposited as a fluvial succession. The fining-up cycles containing the coal seams in the Middle unit represent meandering channel-fill, floodplain, and coal swamp deposits. The Upper unit is characterized by meandering channel, overbank, and ephemeral lake deposits.

Malloch (1914) concluded that coal measures in the Groundhog coalfield should be grouped as the Skeena series of Early Cretaceous age. Eisbacher (1974) argued that all major coal seams in the northeastern Bowser Basin occur in the 500-metre-thick Groundhog-Gunanoot facies of Latest Jurassic to Early Cretaceous age and that the coal-bearing facies is overlain by Early Cretaceous Jenkin's Creek facies that consists of continental fine-grained clastics and thin carbonate lenses. Richards and Gilchrist (1979) described strong similarities between the Gunanoot assemblage and the Early to Middle Cretaceous Skeena Group. The lower and middle Klappan coal measures correlate with the Groundhog-Gunanoot facies of the Gunanoot assemblage; the upper Klappan coal measures correlate with the Jenkin's Creek facies.

Widespread conglomerates in the Telkwa, Red Rose, and Klappan coal measures suggest active pedimentation across the Skeena Arch and west of the Omineca Crystalline Belt. The multiple cycles in the coal measures suggest periodic uplift followed by erosion of the Omineca Crystalline Belt. The occurrence of coal seams in mudstone zones near the tops of the cycles suggests that coal swamps formed largely during tectonically quiescent periods in the Omineca Crystalline Belt.

The Telkwa, Red Rose, and Klappan coal measures comprise mainly limnic and telmatic coal deposits. However, they may also contain some paralic coal due to local marine incursions near the top and bottom of the middle Telkwa coal measures, at the top of the Red Rose coal measures, and in the lower Klappan coal measures.

DEFORMATION

Faults disrupt the Telkwa and Red Rose coal measures (Fig. 30). They trend predominently northwesterly; however, some trend northeasterly to easterly. They dip mostly at high angles ranging from 70 to 90 degrees and show normal or reverse displacements of up to several kilometres. The coal measures commonly occur in the grabens which occupy low-lying poorly exposed areas. This type of structural setting is best exemplified by the Telkwa coalfield (Koo, 1983). The northwesterly trending faults are of Late Cretaceous and Early Tertiary age; the northeasterly to easterly trending faults are of Late Tertiary age (Carter, 1981).

Gentle bedding dips are common and broad open folds are developed in the Telkwa and Red Rose coal measures where dips range from 5 to 25 degrees northeast or southwest. However, tight folds also occur in localities where the coal measures are intruded by Cretaceous and Tertiary stocks. The tight folds are cut by the intrusions and by northwesterly trending thrust faults. Younger northwesterly trending high angle faults cut the folds, the thrust faults, and the intrusions. The folds and thrust faults are apparently of Middle Cretaceous age.

The Klappan coal measures show open to tight folds (Fig. 32) that are almost vertical or overturned to the northeast. The fold axes strike north 30 to 60 degrees west; their axial planes dip 25 to 85 degrees southwest. Most of the folds are asymmetrical; many are cut by thrust faults with maximum displacements of 150 metres. The thrust faults strike north 20 to 40 degrees west and dip 10 to 25 degrees southwest. These faults commonly have associated chevron, kink, or concentric style dragfolds. All folds and the thrust faults are cut by high angle faults that trend northerly or northwesterly. These high angle faults are themselves cut by easterly to northeasterly trending high angle faults. Richards and Gilchrist (1979) report that major faults in the Groundhog coal area immediately south of Mount Klappan also trend northwesterly or easterly.

CONCLUSIONS

The Telkwa, Red Rose, and Klappan coal measures consist mainly of fluvial clastic sequences with minor shallow marine and lacustrine sedimentary successions. Economic coal seams developed mainly in the fluvial sequences. The shallow marine successions comprise coastal beach, tidal flat, and lagoonal deposits. They appear to represent mainly regressive facies with local irregular transgressive facies.

All three coal measures are nearly isochronous and may be referred to collectively as the Early Cretaceous Skeena coal measures. Tectonic uplift of the Omineca Crystalline Belt largely controlled sedimentation of the coal measures, although locally the southwestern Skeena Arch also influenced deposition of the lower Telkwa coal measures.

The three coal measures were subjected to a minimum of four phases of deformation: open to tight folds; thrust faults; northwesterly high angle faults; and northeasterly high angle faults.

The coal measures contain economic coal seams of limnic, telmatic, and paralic origin. Their ranks range from bituminous to anthracite coal. The higher rank coal occurs in areas of tight folding and adjacent to Middle to Late Cretaceous intrusions.

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