Coal Studies

ELK VALLEY COALFIELD, NORTH HALF (82J/02, 07, 10, 11)

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KEYWORDS: Coal geology, Elk Valley coalfield, Mount Veits, Mount Tuxford, Henretta Ridge, Bourgeau thrust, coal rank, Elk River syncline, Alexander Creek syncline.

INTRODUCTION

Detailed geological mapping and sampling of the north half of the Elk Valley coalfield began in 1986 and were completed in 1987. The end poduct, a preliminary map at a scale of 1:10 000, will extend available map coverage in the coalfield north from the areas covered by Preliminary Maps 51 and 60 (Figure 4-1-1), which in turn expanded previous coverage in the adjacent Crowsnest coalfield (Preliminary Maps 24, 27, 31 and 42).

Work in 1986 (Grieve, 1987) was mainly concentrated in the Weary Ridge – Bleasdell Creek area. The more extensive 1987 field program was completed by R.J. Morris.

The study area, which includes some of the least well-explored parts of the southeast coalfields, extends 40 kilometres in a north-south direction. The southern boundary of the area is formed by Henretta and Britt creeks, and is immediately north of the Fording River operations of Fording Coal Ltd. (Figure 4-1-1). The northern boundary is the British Columbia – Alberta border. The map area includes the upper Elk Valley and a portion of the upper Fording Valley.

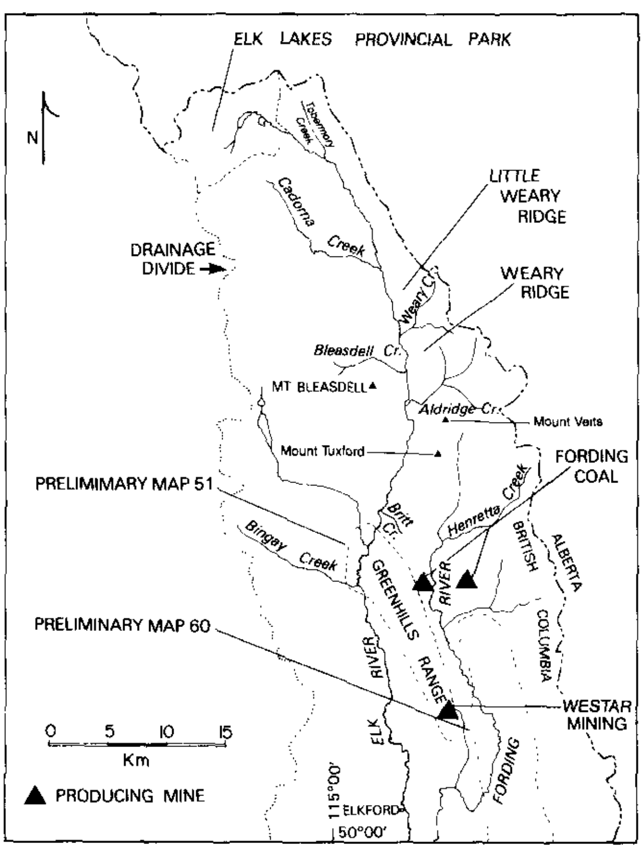

Figure 4-1-1. The Elk River valley north of Elkford.

Most of the area is Crown land and includes three coal properties. The most southerly comprises the north end of the Fording Coal Ltd. Fording River property. Adjacent to the north is the Elk River property, in which Fording Coal currently holds a 50-per-cent interest. Coal rights to the most northerly property, formerly known as the Vincent option, are reserved to the Crown.

Exploration history of the Weary Ridge – Bleasdell Creek area was summarized by Grieve (1987). Of the remaining parts of the study area, only Little Weary Ridge and vicinity has received a significant exploration effort. Little Weary Ridge was the focus of considerable attention in the 1970s as the proposed site of the planned Elco mine development. Other parts of the area have received some exploration, including drilling programs in the north end of the reserve area by Rio Tinto Canadian Exploration Ltd., and at Henretta Ridge and in the Aldridge Creek area by Fording. Mount Tuxford on the Fording River property has received essentially no exploration and as such is the largest unassessed block of coal-bearing land in the southeast coalfields.

The part of the map area north of Cadorna Creek has been the subject of two previous geological studies. Pearson and Duff (1977) carried out a mapping and core logging program. Graham *et al.* (1977) carried out a study which included mapping and drilling of four diamond-drill holes, for a total of 1641 metres, at the extreme north end of the Elk Valley.

Access to most parts of the area is good, ultilizing the Elk Valley road, Fording mine access roads (permission required), the powerline access road and subsidiary exploration roads. The upper Fording Valley, however, has no vehicle access, and consequently most of Mount Tuxford can only be reached by helicopter. The west side of the Elk River north of Cadorna Creek, and Henretta Ridge, also have no road access.

Relief varies throughout the area from very low in the north, where the coalfield essentially occupies the bottom of the Elk Valley, to relatively extreme on Mount Tuxford and Mount Veits. Elevations range from 1500 to over 2400 metres.

FIELDWORK AND METHODS OF STUDY

Field data were plotted directly on British Columbia government air photographs, enlarged to a scale of approx-

British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1987, Paper 1988-1.

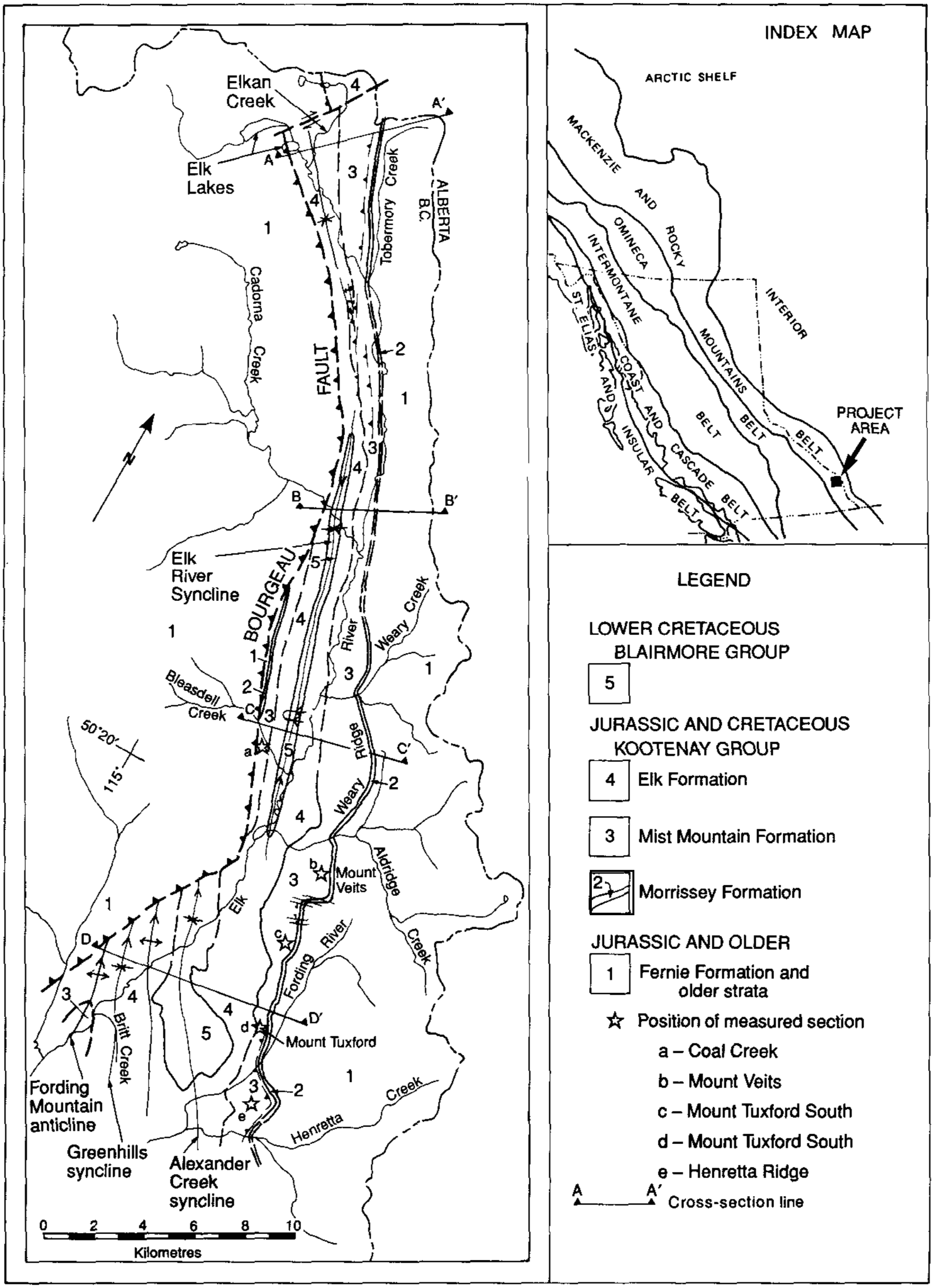

Figure 4-1-2. General geology of the north half of the Elk Valley coalfield.

imately 1:7500. Data and interpretations will be transferred to specially prepared 1:10 000-scale orthophoto base maps.

Stratigraphic sections were measured on Mount Veits, Mount Tuxford and Henretta Ridge and at Coal Creek, using pogo stick, compass and chain. They have been generalized for inclusion here. Coal units thinner than 1.0 metre are not included in the generalized sections.

Grab samples of coal were taken frequently to provide material for petrographic rank determinations. In all cases, bloom and other highly degraded coal was avoided, usually by sampling from fresh-looking cuts or by digging through softer material. Average sample size was 250 grams and no attempt was made to make the samples representative.

Petrographic rank of coal was determined by the $\bar{R}_o$max method (mean maximum vitrinite reflectance in oil) on pelletized particulate samples. Samples were lightly crushed using mortar and pestle; only the -20-mesh fraction was utilized. Maximum readings on 50 grains per sample were measured and averaged. Coals are classified into ASTM categories as follows: high volatile bituminous, $\bar{R}_o$max <1.12 per cent; medium volatile bituminous, 1.12 per cent $<\bar{R}_o$max <1.51 per cent; and low volatile bituminous, $\bar{R}_o$max >1.51 per cent.

STRATIGRAPHY

The stratigraphic column in the study area is shown as the legend in Figure 4-1-2. Economic coals in southeastern British Columbia are contained within the Jurassic-Cretaceous Kootenay Group. The Kootenay Group conformably overlies the Jurassic Fernie Formation, a marine unit predominantly composed of shale. The Kootenay is conformably (?) overlain by the Lower Cretaceous Blairmore Group. The basal unit of the Blairmore Group is the Cadomin Formation, a distinctive marker conglomerate, which is preserved in two areas and represents the only exposed Blairmore strata in the study area.

MORRISSEY FORMATION

The basal unit of the Kootenay Group is the Morrissey Formation, a resistant sandstone unit ranging in thickness from 20 to 80 metres (Gibson, 1979). It consists of two members, the lower Weary Ridge member and the upper Moose Mountain member. The Moose Mountain is a distinctive marker which is utilized in all surface and subsurface studies of the Kootenay Group to define the base of coal occurrences. It is a well-indurated, medium to coarse-grained, medium grey-weathering, quartz-chert sandstone (Gibson, 1979). Within the study area it was observed to be more variable than normal. For example, it includes one or more carbonaceous partings in the area between Weary Ridge and Mount Tuxford, and at two localities it was observed to include an unusual light grey-weathering, quartzose facies.

MIST MOUNTAIN FORMATION

The overlying Mist Mountain Formation contains essentially all the coals of economic interest in southeastern British Columbia. Its average thickness south of the study area is between 500 and 600 metres, of which coal forms roughly 10 per cent of the total thickness. An almost complete section of Mist Mountain Formation measured on Weary Ridge in 1986 (Grieve, 1987, Figure 5-1-4) is 507 metres thick, and contains 63.8 metres of coal. Good exposures of the formation occur throughout much of the southern part of the area; some of these were measured and are generalized here in Figure 4-1-3 and are discussed below. North of Little Weary Ridge, however, exposures of Mist Mountain Formation are extremely poor and little can be said about its general features. Logs of drill cores from the extreme north end of the area are shown in Graham *et al.* (1977).

Coal Creek

At Coal Creek, a tributary of Bleasdell Creek, a partial section of Mist Mountain Formation in the immediate footwall of the Bourgeau thrust fault was measured (Figure 4-1-3). At this location the Morrissey Formation and the base of the Mist Mountain are not present due to movement on the Bourgeau thrust (*see* Figure 4-1-2). The base of the section chosen was an arbitrary point beneath a prominent coal seam in the lower Mist Mountain Formation. A structurally complex area within the lowest part of the exposed section was not included. The starting point was on the north side of the creek. On the opposite side, the lowest seam in the measured section has been locally tectonically thickened to considerably more than its true thickness (*see* Structure).

The top of the section corresponds with the last of the exposures in the creek. It is estimated to be within 100 metres of the top of the Mist Mountain Formation.

Of the 304.2 metres of section represented in Figure 4-1-3, 29.4 metres consists of coal seams greater than 1 metre in thickness. These range from 1.0 to 5.9 metres; only three are greater than 3 metres. Prominent channel sandstones occur near the base of the section, notably in the roof of the lowest major seam, and at the top of the section.

Mount Veits

Mist Mountain Formation on Mount Veits dips westerly and underlies the west slope (dip slope) and upper east slope. A partial section was measured on the east slope. The base of the section is the contact between the Morrissey and Mist Mountain formations; the top corresponds with the peak of the mountain.

The Mount Veits section (Figure 4-1-3) includes 127.7 metres of strata, of which only 7.6 metres represents coal seams thicker than 1 metre. These range from 1.5 to 2.5 metres in thickness. A prominent channel sandstone unit marks the top of the section.

Mount Tuxford North

A complete section of Mist Mountain Formation was measured along the north-trending spur of Mount Tuxford, roughly 3 kilometres south of Mount Veits. At this point, the Mist Mountain Formation is 550.5 metres thick (Figure 4-1-3). It contains at least 39.5 metres of coal in seams greater than 1 metre in thickness. It is possible that more coal seams underlie the covered intervals within the section, particularly those in the lowest 50 metres. The observed

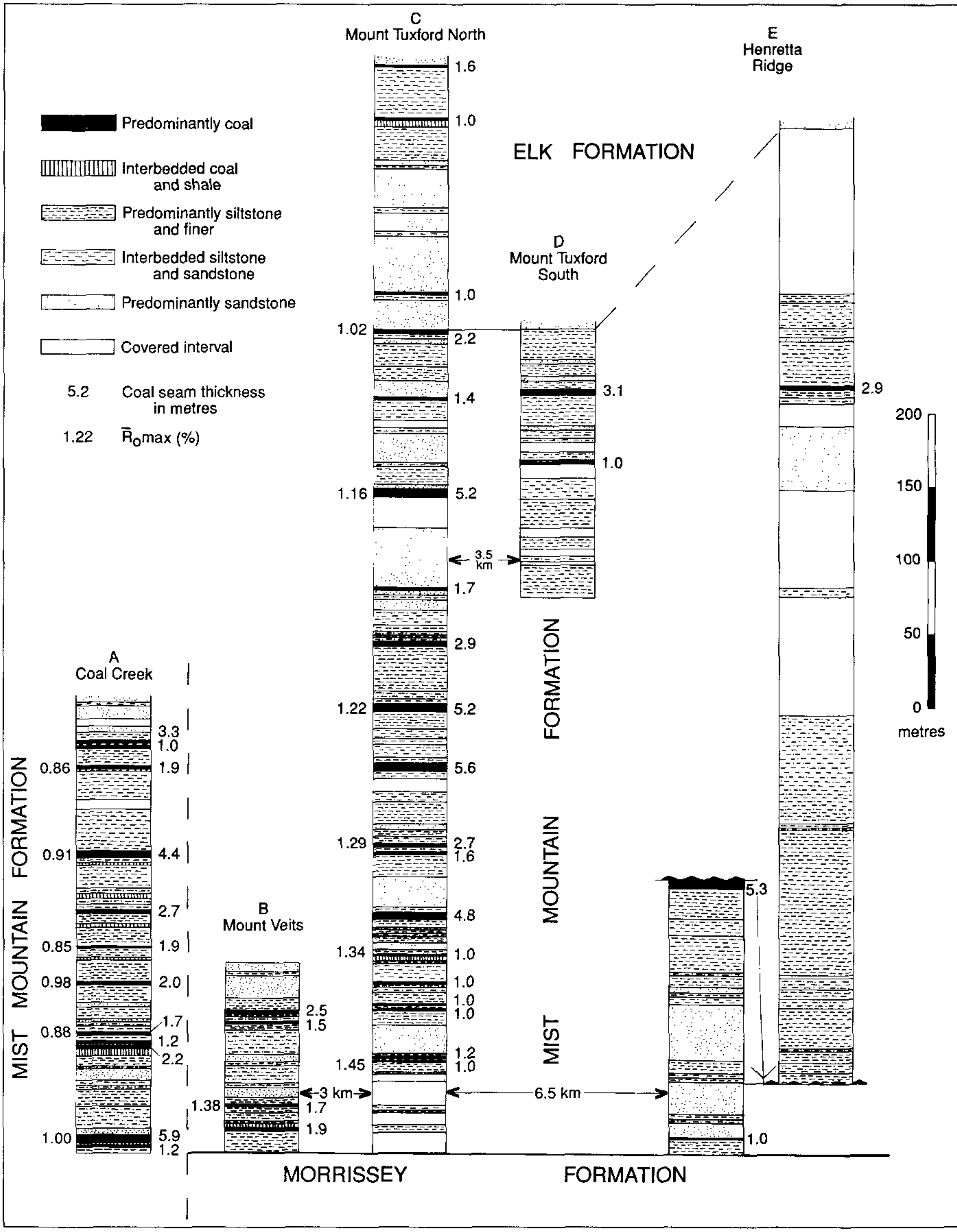

Figure 4-1-3. Generalized measured sections of parts of the Mist Mountain and Elk formations in the north half of the Elk Valley coalfield. *See* Figure 4-1-2 for locations; sections are described in the text.

seams range from 1.0 to 5.6 metres thick, and four seams are in the range of 4.8 to 5.6 metres. Channel sandstone units are mainly confined to the lowermost and uppermost 200 metres of the section. The intervening 150 metres of predominantly recessive strata contains two closely spaced coal seams each greater than 5 metres in thickness.

Mount Tuxford South

A partial section of upper Mist Mountain Formation was measured on the east-facing slope of Mount Tuxford, roughly 3.5 kilometres south of the previous section. The base of the section was chosen arbitrarily and represents the lowest point of consistently good exposure. The top of the section corresponds with the base of a prominent channel sandstone believed to mark the base of the Elk Formation.

The Mount Tuxford south section is 181.6 metres thick and contains only two coal seams (1.0 and 3.1 metres thick) which exceed 1 metre in thickness. Covered zones within the section may hide more coal seams. In contrast with the upper 200 metres of the Mount Tuxford north section, this section is relatively recessive and devoid of major channel sandstone units.

Henretta Ridge

A section, representing all Mist Mountain strata underlying Henretta Ridge, was measured 3 kilometres south of the Mount Tuxford south section. The base of the section corresponds with the Morrissey – Mist Mountain contact and the top corresponds with the Mist Mountain – Elk contact. Unfortunately, the section location is characterized by structural complications and poor exposure. A thrust repeat of roughly 135 metres of strata in the lower Mist Mountain Formation was noted and split out (Figure 4-1-3). At just under 700 metres, however, the total Mist Mountain section is still anomalously thick, which suggests that other structural repetitions probably occur within thick recessive or covered intervals.

The part of the section occupying the footwall of the thrust (plotted on the left in Figure 4-1-3) is well enough exposed to permit the observation that it is remarkably lacking in coal (it contains only two coal seams, one 1.0 metre thick and the other 5.3 metres thick), and contains a relatively large thickness of channel sandstone units. The presence of channel sands may have a bearing on the lack of coal; channel sandstones often fill washouts of coal seams.

The hangingwall portion of the section (plotted on the right in Figure 4-1-3) defies generalization. It contains almost no coal, although the thick covered intervals are almost certainly hiding some coal seams. However, the lowest 250 metres is well exposed, and contains no coal. The continuous thick intervals of fine-grained rocks are extremely anomalous.

It is noteworthy that the overlapping portion of the Mist Mountain Formation on Henretta Ridge is very different in each of the two thrust sheets (Figure 4-1-3). The hangingwall portion contains a predominantly recessive sequence, lacking the major sandstone unit present in the footwall. Further-

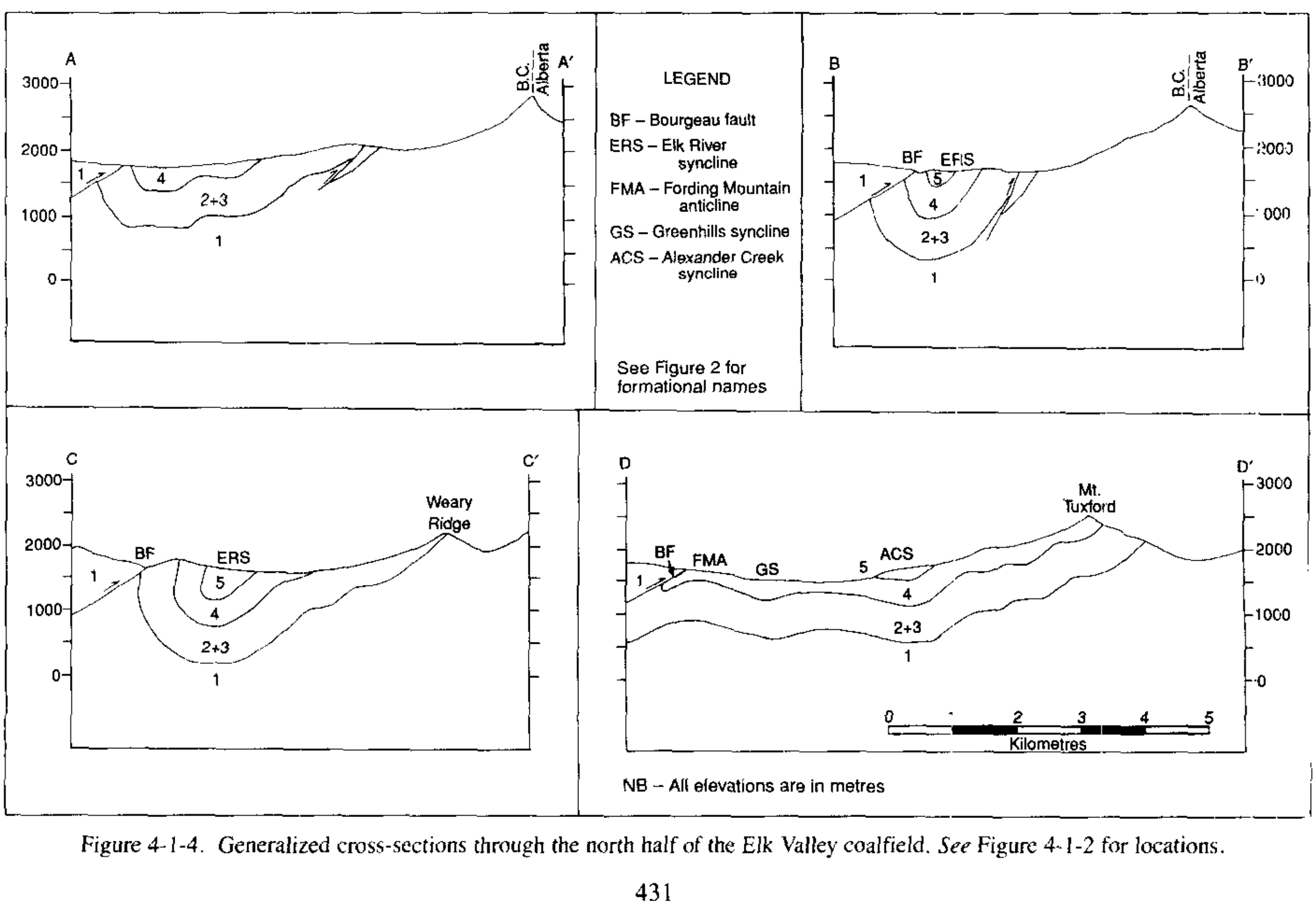

Figure 4-1-4. Generalized cross-sections through the north half of the Elk Valley coalfield. *See* Figure 4-1-2 for locations.

more, the 5.3-metre seam just beneath the thrust is apparently absent in the hangingwall.

ELK FORMATION

The overlying Elk Formation is a coarser grained facies than the Mist Mountain and distinguished from it in several ways. In particular it generally lacks thick coal seams and contains unusual sapropelic coals known as "needle coals" (*see* Kalkreuth, 1982). In the Mount Tuxford and Henretta Ridge areas the Elk Formation is distinguished by a yellow or orange-brown weathering colour to the resistant sandstone units.

Based on cross-sections, the thickness of the Elk is approximately 350 to 400 metres throughout the study area (Figure 4-1-4).

A partial section containing 177.9 metres of the lower Elk Formation was measured on the north end of Mount Tuxford, and is included in Figure 4-1-3 (Section c). The base of the section is the Mist Mountain – Elk contact and the top is at an arbitrary point. The relatively coarse-grained nature of the Elk, in comparison with the Mist Mountain Formation at this point, is noticeable in Figure 4-1-3. The lower two-thirds of the section consists of several stacked channel-sandstone units separated by thin, recessive, finer grained intervals, including a 1.0-metre coal seam. The upper third is a recessive interval including coal seams 1.0 and 1.6 metres thick. The section is overlain by a prominent cliff-forming sandstone which marks the base of another sequence of stacked sandstone units.

At Elkan Creek, at the extreme north end of the study area, a series of several thick, cliff-forming conglomerates and conglomeratic sandstones occurs within the Elk Formation. The coarseness of this occurrence is unusual for the Elk Formation in the Elk Valley coalfield, but we see no reason to place these strata in the Blairmore Group as was done by Graham *et al.* (1977). We feel this occurrence is analagous to the Elk Formation occurrences on the west side of the Crowsnest coalfield, including the type area near Fernie. The type area is believed to represent an alluvial fan facies of Elk Formation (Gibson, 1985; Grieve and Ollerenshaw, in preparation) and perhaps the north end of the Elk Valley coalfield is on the fringes of another fan system.

Precise identification of the Elk – Mist Mountain contact in southeastern British Columbia is generally difficult (Grieve and Ollerenshaw, in preparation). The study area is no exception. In the case of the good exposures near the summit of Mount Tuxford, it was possible to detect a significant colour change in the sandstone units at a stratigraphic horizon which also seemed to mark the base of a more resistant, coarser grained facies devoid of thick coal seams. The so-called needle coals were only observed near the top of the Kootenay at this location. This horizon was mappable for a short distance to the north and south, although confidence in its position decreases with distance. Using airphoto interpretation it was possible to extend it from Mount Tuxford to Weary Ridge, where the contact was mapped previously (Grieve, 1987). Definition of the contact lacks precision on the west side of the Elk River and throughout the area north of Weary Creek.

STRUCTURE

The study area lies in the Front Ranges of the Rocky Mountains and is part of the Lewis thrust sheet. The dominant structures are therefore thrust faulting and folding.

The area can be divided at Aldridge Creek into two distinct zones with contrasting structural elements. The zone south of Aldridge Creek contains north-plunging folds, northward extensions of those affecting the adjoining part of the coalfield. The major folds are, from east to west, the Alexander Creek syncline, the Greenhills syncline and the Fording Mountain anticline (Figure 4-1-2); minor folds are also observed. These folds are open and roughly symmetrical (Figure 4-1-4, Section D-D′).

Until now it was believed that the Alexander Creek syncline was continuous throughout the Elk Valley coalfield (for example, Pearson and Grieve, 1980; Grieve, 1987). It is evident now, however, that north of Aldridge Creek the coalfield is underlain by another newly defined major fold, the Elk River syncline (proposed name). The Elk River syncline is east and north of the Alexander Creek syncline, although its east limb becomes the east limb of the Alexander Creek syncline and is possibly related to it in an *en echelon* fashion (Figure 4-1-2).

The Elk River syncline is asymmetrical, with a steep to overturned west limb and a shallow to moderately west-dipping east limb (Figure 4-1-4). It is doubly plunging with a depression in the vicinity of Cadorna Creek (Cadorna Creek depression of Pearson and Grieve, 1980). It is cylindrical throughout except for the area of its origin where it is conical. In many areas its east limb is modified by zones of shallow dip which have been interpreted as minor step folds. Thrusting in the east limb is also common.

Concomitant with the change in structural style which takes place at Aldridge Creek is a pronounced change in the width of the coalfield (Figure 4-1-2). This is primarily due to the behaviour of the Bourgeau thrust fault. The Bourgeau fault is a regional feature which marks the western boundary of the surface exposures of the Lewis thrust sheet and, from Bingay Creek northward, the western boundary of the Elk Valley coalfield. Starting at a point roughly corresponding with the southern boundary of the study area, the trace of the Bourgeau fault begins to step to the northeast, possibly reflecting lateral ramping. In the process the fault cuts up-section relative to its footwall and cuts off the traces of all fold axes in the footwall, including the Greenhills and Alexander Creek synclines. At the point where the Elk River syncline begins to develop, the trace of the Bourgeau fault returns to a more normal northerly orientation.

From Aldridge Creek northwards, the Bourgeau thrust remains parallel to, and in contact with, the west limb of the Elk River syncline. The stratigraphic position of its footwall varies along its trace from the uppermost Fernie Formation to uppermost Kootenay (Figure 4-1-2). At the north end of the study area the Bourgeau fault is offset 2 kilometres to the northeast by a transverse fault (Leech, 1979).

Minor structures associated with the Bourgeau thrust are not generally observable because of poor exposure. At Coal Creek, the location of measured section A in Figure 4-1-3, a highly disturbed zone of Mist Mountain Formation occurs in the footwall of the thrust. This zone contains structures similar in style and orientation to the Bourgeau fault itself, as well as a transverse fault, parallel to the creek (roughly east-west). The former structures have caused local thickening of the strata, including one coal seam, while the latter has resulted in a dramatic contrast in the degree of structural deformation of the strata on opposite sides of the creek. In particular, the thickened coal seam referred to above, which outcrops on the south side of the creek, is undisturbed on the north side of the creek, where exposed at the base of our measured section. For this reason, the probability that the economic potential of this seam may be enhanced by structural thickening is believed to be low.

Late-stage, crosscutting normal faults occur in the Mount Tuxford and Mount Veits area parallel to prominent joint orientations. They have resulted in mass wasting of the Morrissey Formation, forming both topographic steps and landslide blocks. A large slide-block of Morrissey Formation on the north end of Weary Ridge is probably a related feature.

RANK DISTRIBUTION

Preliminary data on the coal rank distribution in the Weary Ridge – Bleasdell Creek area were given by Grieve (1987). They indicated an extreme rank contrast between opposite limbs of the syncline in this area. Coals from Weary Ridge, on the east limb, have reflectance values anomalously high for southeastern British Columbia, while reflectance values in the Bleasdell Creek area are anomalously low. For example, the Mist Mountain Formation on Weary Ridge contains coals which range in reflectance from 1.59 per cent down to 0.99 per cent, with a general decrease up-section. In contrast, Mist Mountain Formation coals from the Bleasdell Creek area range in rank from 1.00 per cent down to 0.65 per cent, with a less well-defined stratigraphic variation. Values plotted alongside the Coal Creek Section A in Figure 4-1-3 range from 1.00 per cent to 0.85 per cent, providing a further example of the low relative ranks in this area. A possible explanation for this contrast was briefly reviewed by Grieve (1987) based on work by Hughes and Cameron (1986).

To date only 25 of the 1987 samples have been analysed. These are from three general areas, which are discussed separately below.

LITTLE WEARY RIDGE TO MOUNT TUXFORD (EAST LIMB)

Samples from Little Weary Ridge, Mount Veits and Mount Tuxford have been analysed. One value from Mount Veits and six values from Mount Tuxford are plotted in Figure 4-1-3 by their appropriate stratigraphic positions.

The four samples from Little Weary Ridge have reflectances of 1.51, 1.48, 1.40 and 1.31 per cent. The two highest values represent seams very near the base of the Mist Mountain Formation, while the other two are both within the lower one-third of the formation.

Three samples from the lower half of the Mist Mountain Formation on Mount Veits have also been analysed. One corresponds with the Mount Veits measured section, and is plotted in Figure 4-1-3. The other two are from positions higher than the top of the measured section. The plotted value of 1.38 per cent represents a coal seam within 20 metres of the base of the formation. The other two values, in ascending stratigraphic order, are 1.36 and 1.31 per cent.

Six samples from Mount Tuxford have been analysed, representing stratigraphic positions ranging from 56 metres above the base of the Mist Mountain Formation to immediately beneath the Elk contact. All correspond with the measured section of Mount Tuxford north, and are plotted alongside it in Figure 4-1-3. The reflectance values range from 1.45 to 1.02 per cent, decreasing with ascending stratigraphic position.

The number of analyses is not sufficient to define rank trends. However, it appears that ranks along the east limb of the Elk River syncline are at a maximum in the vicinity of Weary Ridge and Little Weary Ridge, and decrease to the south.

BLEASDELL CREEK TO CADORNA CREEK (WEST LIMB)

Reflectances of six samples of Mist Mountain Formation from north of Bleasdell Creek, on the west limb, range from 0.63 to 0.84 per cent. Although stratigraphic control is poor in this area, this range appears to represent the entire Mist Mountain Formation. These results are compatible with those obtained last year from the Bleasdell Creek area.

ELK LAKES AREA

Five samples from the Mist Mountain Formation and one from the Elk Formation collected at the north end of the study area have been analysed. Reflectances of the Mist Mountain samples decrease from 1.06 to 0.70 per cent with ascendng stratigraphic position. The highest value corresponds with a seam in the lower part of the formation, but its exact stratigraphic position is unknown. The sample from the Elk Formation has a reflectance of 0.57 per cent.

These values are anomalously low, and are in general agreement with results of Pearson and Grieve (1980) who found the entire section in this area to be high volatile ($\bar{R}_o$max <1.12 per cent), and Graham *et al.* (1977) who determined that the highest reflectance value reached in subsurface (core) samples from this area is 1.16 per cent. Pearson and Grieve invoked the presence of a normal fault separating the north part of the study area from the area to the south, to account for the anomalously low ranks. However, we see no geological evidence for the existence of the fault, and, moreover, a major fault is not a necessary factor in producing large rank variations, given the extreme rank variation across the Elk River syncline within the south part of the study area.

Further analyses of samples collected in 1987 should allow refinement of rank trend definition. However, the lack of good exposure in key areas may limit our ability to interpret rank variations.

ACKNOWLEDGMENTS

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