NUMERICAL DEPOSITIONAL MODELLING - GETHING FORMATION ALONG THE PEACE RIVER (93O, 94A, 94B)

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INTRODUCTION

This study was initiated during the 1984 field season to examine the lower Moosebar and upper Gething Formations along the Peace River. Volcanic ash bands, tonsteins and bentonites, occur in the lower Moosebar Formation (Kilby, 1984b) and were recognized in the upper Gething Formation of this area during the 1984 field season; they provided excellent marker horizons on which to base regional correlations. A total of 1 280 metres of drill core was examined from 16 boreholes spanning an east-west distance of 100 kilometres (Fig. 79). This paper presents a preliminary correlation of these strata along the Peace River (Fig. 80) and a numerical analysis of the sedimentary sequences undertaken in an effort to generalize the sedimentary pattern of the area.

Many workers have contributed to the understanding of the stratigraphic position, lithologic character, and paleo-environments of deposition of formations along the Peace River. The number of authors is too great to list here but a few of the major contributors are D. F. Stott, J. E. Hughes, R. D. Gilchrist, and P.McL.D. Duff.

STRATIGRAPHY

The strata under study represents a regressive/transgressive cycle of the Albian Clearwater Sea. During the regressive phase non-marine fluviodeltaic sediments, including coal, were deposited. Flooding by the Clearwater Sea during the transgressive phase resulted in deposition of the marine Moosebar Formation. Sediments were predominately derived from the west, both from the Omineca Geanticline and the uplifting Rocky Mountain Fold and Thrust Belt. The development of the basin and its consequent infilling of clastic sediments seem to be related to a northeast-trending hingeline parallel to the ancient Peace River Arch (Stott, 1975).

The Gething Formation, in the interval examined in this study, contains a series of thin-bedded rocks, derived from overbank sediment, and coal. The sequence is occasionally broken by a thick fluvial sequence of sandstone and uncommon lag conglomerates. Three notable coal horizons are present in the interval examined:

(1) Superior seam, situated at the top of the formation directly in contact with the Bluesky unit or up to several metres below this contact;

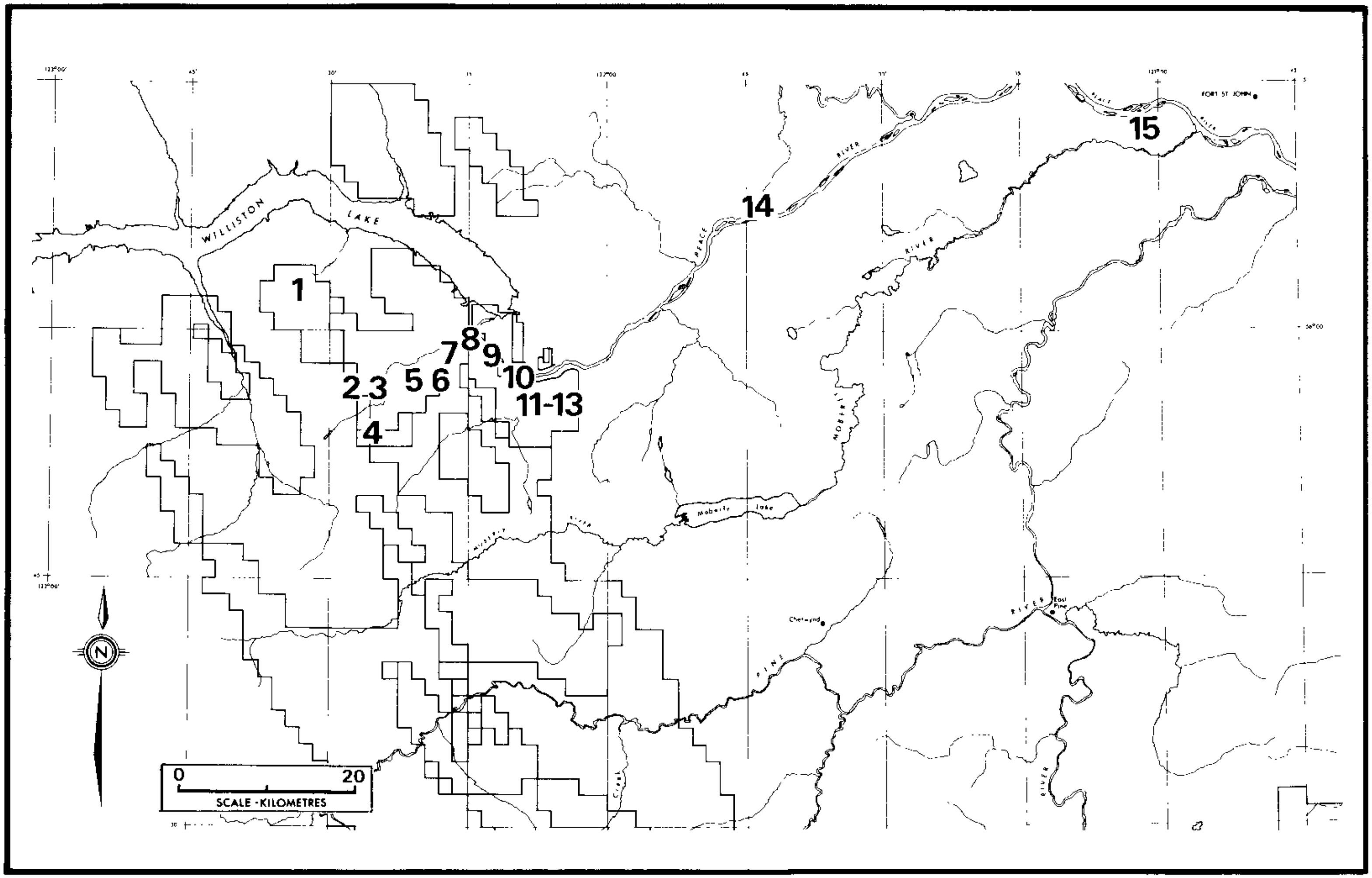

Figure 79. Location map of diamond-drill holes examined along the Peace River.

(2) Trojan seam, located about 30 metres below the top of the formation. The Fisher Creek Tonstein zone has been located in this seam;

(3) Titan seam, located about 60 metres below the top of the formation. The No. 2 Tonstein is present in this seam along Moosebar Creek. Many minor seams occur between these three horizons and there is great difficulty in correlating the zones any great distance (Fig. 80). The seams, which are generally 1 to 2 metres thick, are of medium to high volatile bituminous rank.

Between the Gething and Moosebar Formations is an excellent marker horizon known as the Bluesky unit; it defines the top of the Gething Formation. This unit is considered to be equivalent to the Bluesky Formation in the Alberta subsurface. In the Peace River Canyon area, the Bluesky contains three principal units ranging from 1 to 25 metres in thickness; local accumulations are to 50 metres. The basal zone is a chaotic, sometimes glauconitic, chert pebble conglomerate with a mud or sand matrix and a scoured base. The scoured base may represent a hiatus in sedimentation. The conglomerate beds are massive with little sorting. Pebbles, which range from less than 1 to 5 centimetres in diameter, are generally subrounded to rounded. In places pebbles are absent and the basal zone is a coarse sand. The middle unit is a bioturbated and turbiditic silty, pyritic mudstone. Individual trubidites are usually less than 10 centimetres in thickness and the unit commonly exhibits a coarsening upward response on geophysical logs (Kilby, 1984a). The upper unit is a moderately bioturbated, glauconitic mudstone with thicknesses to several metres. Generally, glauconite occurs as scattered grains but sometimes dominates the zones as a coarse gritty sand. All three Bluesky units are believed to be marine; however their depositional history is still in question.

The Moosebar Formation overlies the Bluesky. It is a monotonous sequence of dark grey marine shales with occasional siderite bands or septarian concretions. The origin of the siderite bands is also uncertain but they are probably diagenetic. Numerous 1 to 15-centimetre-thick bentonite bands have recently been documented in the lower Moosebar Formation (Kilby, 1984b). Commonly, these bentonite bands are bioturbated; rare shell casts occur.

METHODOLOGY

The diamond-drill core was examined during a 15-day period in July, 1984 at the British Columbia Ministry of Energy, Mines and Petroleum Resources core storage facility in Charlie Lake, British Columbia. A total of 1 280 metres of core from 16 drill holes were described. Lithologies were grouped into one of 12 possible lithologic categories (Fig. 81). A total of 1 022 discrete rock units were measured. The lithologic categories are described in detail in a following section. Information was entered into a computer data base system using the CAL DATA LTD. Geological Analysis Package and a Kaypro II 64K micro-computer. Computer

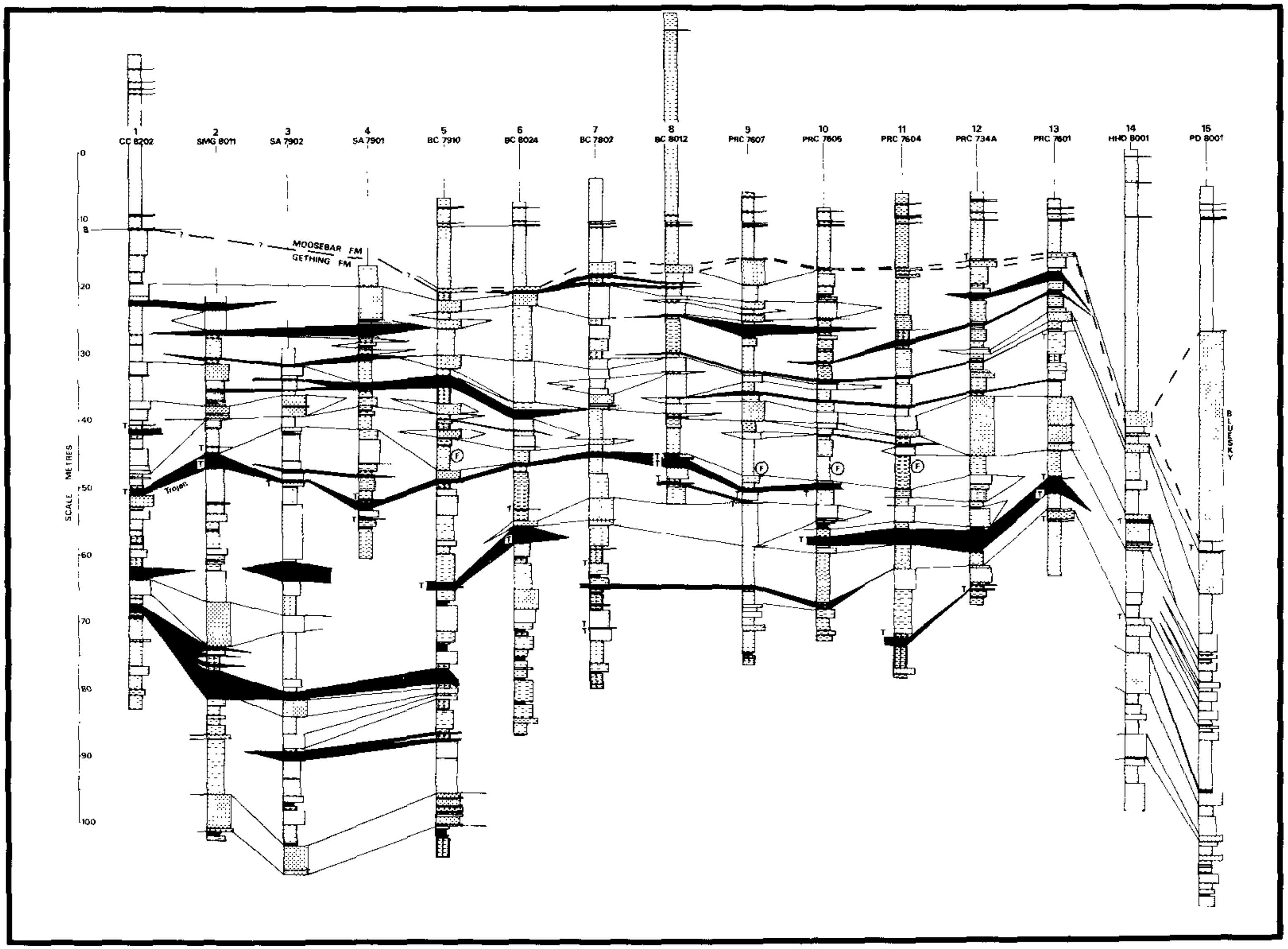

Figure 80. Schematic diagram of lithologies measured from the lower Moosebar and upper Gething Formations along the Peace River.

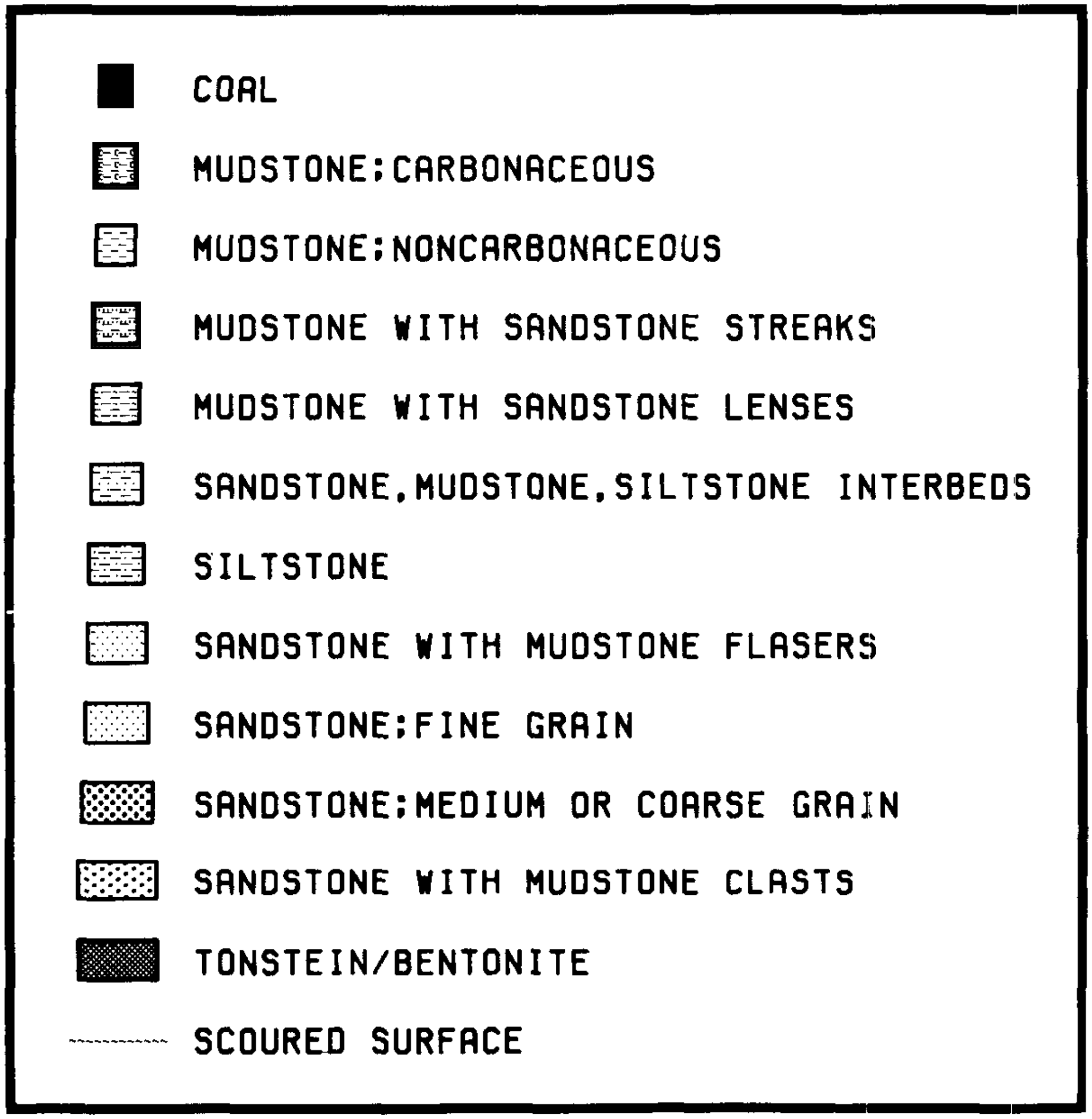

Figure 81. Legend of lithologies.

files consisted of one record for each described lithological unit. The hole identification, down hole depths to the top and bottom of each unit, lithology, grain size, and a visual estimate of the percentage of sand in the unit were entered in the appropriate computer fields. The data base package provided easy access to all data. Once all drill hole data was entered and edited, borehole columnar sections were plotted with the computer (Fig. 80). The Markov analysis and plotting programs were written by one of the authors (Kilby) to be compatible with the CAL DATA LTD. package.

Twelve lithologic units were used to describe Gething Formation core. These units are described following:

(1) SCG - coarse to medium-grained sandstone, relatively thick, high angle cross-stratified, frequently having a scoured basal contact. This unit shows a slight fining-up in grain size and a noticeable absence of burrowing. Laminae are commonly very faint and may often only be apparent due to concentration of carbonaceous debris along bedding planes. Reactivation surfaces are common.

(2) CGL - a mudstone pebble conglomerate. Clasts are of mudstone and often angular with a coarse or medium-grained sandstone matrix and occasional fossilized wood fragments. The clasts, which often show original primary bedding, usually have an imbricated structure and may occur in multiple bands each up to 3 centimetres thick.

(3) SFG - fine-grained sandstone has a sharp but not scoured basal contact and usually a fining-up gradational upper contact. Small-scale climbing ripples, and planar and ripple cross-lamination are the primary sedimentary structures. Soft sediment deformation appears as convoluted bedding, slumping, root growth, and burrowing. Evidence of water fluctuation in the form of reactivation surfaces and thin mud drapes are locally present. Fine-grained plant debris and coal spar is usually present along bedding planes.

(4) SMLF - sandstone with flaser bedding, is very fine to fine-grained, commonly silty, and ranges from simple to bifurcated wavy mud flasers. Up to 30 per cent of this unit is mudstone. Plant fossils are abundant on bedding planes. Moderate burrowing and rootlet growth cause colour mottling.

(5) SLT - siltstone showing faint to indistinct bedding that is commonly convoluted; slump structures and bioturbation are common. Fossilized plant remains are usually abundant. Uncommon small-scale planar cross-laminations and climbing ripples are present.

(6) MSF - mudstone with up to 50 per cent lenticular or wavy-bedded, silty to sandy intercalations. In wavy-bedded units, mud and sand layers alternate and form continuous layers. In lenticular-bedded units, sand lenses or ripples are discontinuous and isolated throughout the mudstone host. Some sandstone lenses show micro-crossbedding. Sedimentary structures present include horizontal and vertical burrows, load structures, and syneresis cracks. Syneresis cracks are postulated to result from changes in water salinity (Burst, 1965). Macerated plant debris is commonly present. Contacts are gradational.

(7) MNC - non-carbonaceous mudstone, massive to faintly laminated in more silty units. Plant debris and ironstone bands are rare. One interesting feature noted in one of these mudstone units is a thin pelecypod shell band that can be traced through several cores (Fig. 80). Bioturbation is normally very slight. Contacts are gradational to sharp.

(8) MC - carbonaceous mudstone found in association with coal seams in the stratigraphic sequence. Locally the mudstones contain coaly laminations or abundant macerated plant debris along bedding planes. Soft sediment deformation occurs mostly as rootlet penetration. Bioturbation is slight. Contacts with coal seams are abrupt; elsewhere contacts are generally gradational.

(9) MSL - mudstone with thin, flat sandstone streaks floating in a mudstone host. Less than 10 per cent sand is normally present. The unit is typically barren of plant debris and rootlets.

(10) COAL - coal displays dull to moderately bright lustre, reflecting the maceral content. Cleat development is good; and locally there is abundant pyrite on bedding planes or fractures surfaces.

(11) SMSI - interbedded sandstone, siltstone, and mudstone usually in less than 10-centimetre layers. The sandstones are fine grained with small-scale crossbedding, ripples, and flaser bedding; laminations are faint and often convoluted. Mudstones are generally silty. All three lithologies commonly contain abundant comminuted plant debris and low to moderate levels of bioturbation.

(12) ASH - tonsteins and bentonites are altered volcanic ash bands deposited in non-marine and marine facies, respectively. Tonsteins are kaolin rich; often they have a speckled appearance from the development of vermicular kaolinite (Kilby, 1984b). In core they are medium grey, have sharp contacts, can be scratched with a fingernail, and often contain coal spar and plant debris. Bentonites consist of clay-sized material, are light grey to greenish grey, break in poker-chip fashion, and often display low levels of bioturbation.

MARKOV PROCEDURES AND STANDARD SECTION DEVELOPMENT

The Markov procedures used in this study have borrowed heavily from techniques described by Siemers (1978) and Davis (1973). In this study units in individual holes were not numerous enough to provide meaningful results, so all holes were combined. The first step in this study was to count the number of transitions from one lithological unit to another in an upward direction. The count transition matrix (Fig. 82) displays the results of this procedure; 802 transitions were recorded from the 16 boreholes.

From the count transition matrix it was apparent that some transitions were more common than others, such as MC to COAL with 80 occurrences of this transition recorded. Note that these values do not take into account the relative amounts of each unit present. To examine this problem, following Siemer (1978), the expected matrix was calculated.

COUNT TRANSITION MATRIX

	COAL	MNC	MC	MSF	SLT	MSL	SFG	SCG	SMLF	CGL	SMSI	SCOR	TOTAL
COAL	0	39	57	11	13	4	2	3	9	0	4	2	144
MNC	14	0	21	14	16	5	16	12	18	2	2	10	130
MC	80	19	0	5	7	1	6	1	4	0	7	3	133
MSF	7	7	9	0	3	2	4	2	4	0	2	2	42
SLT	14	21	10	1	0	0	8	3	1	0	2	6	66
MSL	3	4	1	1	1	0	1	5	3	1	0	3	23
SFG	10	10	8	6	4	2	0	2	5	10	2	0	59
SCG	3	13	6	1	12	2	3	0	2	12	5	2	61
SMLF	7	12	14	1	6	5	1	0	0	1	2	4	53
CGL	0	2	0	0	0	0	10	15	2	0	1	1	31
SMSI	8	2	5	0	2	1	3	1	0	0	0	3	25
SCOR	0	0	1	1	2	1	6	15	4	5	0	0	35
TOTAL	146	129	132	41	66	23	60	59	52	31	27	36	802

EXPECTED MATRIX

	COAL	MNC	MC	MSF	SLT	MSL	SFG	SCG	SMLF	CGL	SMSI	SCOR
COAL	26	23	23	7	11	4	10	10	9	5	4	6
MNC	23	20	21	6	10	3	9	9	8	5	4	5
MC	24	21	21	6	10	3	9	9	8	5	4	5
MSF	7	6	6	2	3	1	3	3	2	1	1	1
SLT	12	10	10	3	5	1	4	4	4	2	2	2
MSL	4	3	3	1	1	0	1	1	1	0	0	1
SFG	10	9	9	3	4	1	4	4	3	2	1	2
SCG	11	9	10	3	5	1	4	4	3	2	2	2
SMLF	9	8	8	2	4	1	3	3	3	2	1	2
CGL	5	4	5	1	2	0	2	2	2	1	1	1
SMSI	4	4	4	1	2	0	1	1	1	0	0	1
SCOR	6	5	5	1	2	1	2	2	2	1	1	1

DIFFERENCE MATRIX

	COAL	MNC	MC	MSF	SLT	MSL	SFG	SCG	SMLF	CGL	SMSI	SCOR
COAL	-26	16	34	4	2	0	-8	-7	0	-5	0	-4
MNC	-9	-20	0	8	6	2	7	3	10	-3	-2	5
MC	56	-2	-21	-1	-3	-2	-3	-8	-4	-5	3	-2
MSF	0	1	3	-2	0	1	1	-1	2	-1	1	1
SLT	2	11	0	-2	-5	-1	4	-1	-3	-2	0	4
MSL	-1	1	-2	0	0	0	0	4	2	1	0	2
SFG	0	1	-1	3	0	1	-4	-2	2	8	1	-2
SCG	-8	4	-4	-2	7	1	-1	-4	-1	10	3	0
SMLF	-2	4	6	-1	2	4	-2	-3	-3	-1	1	2
CGL	-5	-2	-5	-1	-2	0	8	13	0	-1	0	0
SMSI	4	-2	1	-1	0	1	2	0	-1	0	0	2
SCOR	-6	-5	-4	0	0	0	4	13	2	4	-1	-1

Lithology	Total Thickness (metres)	No. of Units	Average Thickness (metres)
COAL	83.67	147	0.57
MNC	243.22	133	1.82
MC	78.42	136	0.57
MSF	67.57	42	1.61
SLT	105.65	68	1.55
MSL	38.30	23	1.66
SFG	101.20	60	1.68
SCG	116.76	62	1.88
SMLF	77.46	54	1.43
CGL	6.16	31	0.20
SMSI	81.83	27	3.03
SCOR	0.38	36	0.01

Figure 82. Count, expected, and difference matrices for Gething Formation sediments. Table summarizes abundance and average thickness of lithological units.

The values in this matrix were those expected if the succession of lithological states was perfectly random. Each element in this matrix was computed by cross-multiplying the count matrix row and column totals and dividing by the total number of transitions. This expected matrix was subtracted from the count transition matrix of observed transitions to produce a difference matrix (Fig. 82), that shows the differences between the observed and expected values. Positive elements in the difference matrix represent upward transitions that had a higher than random probability of occurring. Figure 82 also contains a tabulation of the number, total, and average thickness of the 12 units.

A refinement and expansion of the previously mentioned procedure was performed following Davis (1973). Five matrices were contructed; upward and downward transition probability matrices, upward and downward substitutability matrices, and a mutual substitutability matrix (Figs. 84 and 85). The upward transition probability matrix is a measure of how frequently a given unit is followed up section by another particular unit. It was calculated by dividing each element in each row of the count matrix by the total of the row; each row sums to one. The downward transition probability matrix is a measure of the frequency a given unit

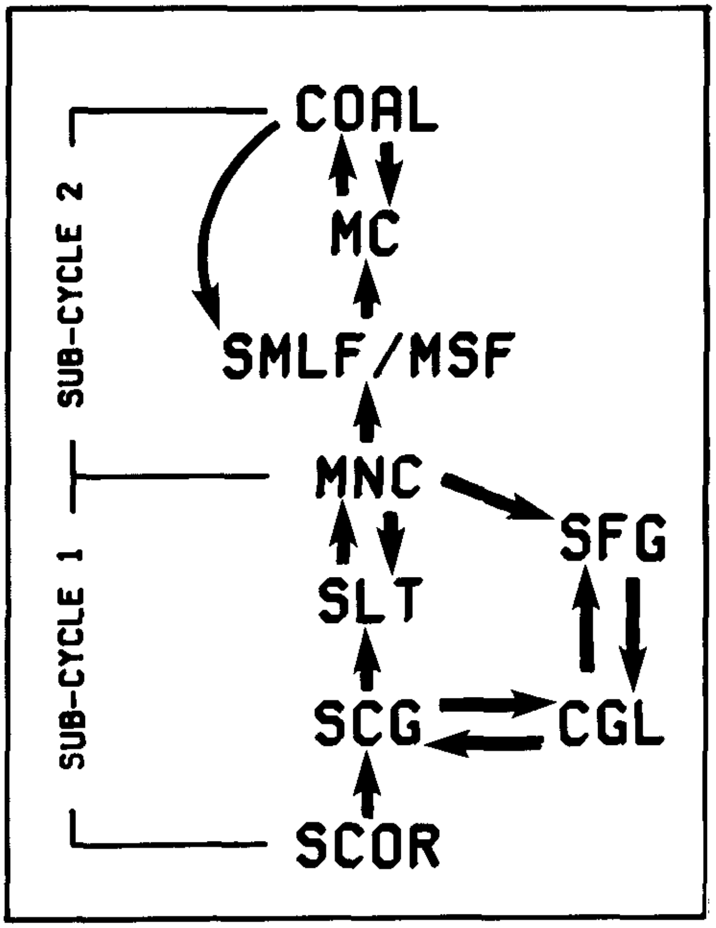

Figure 83. Transition flow diagram illustrating significant transitions on the basis of strongly positive values in the difference matrix.

UPWARD TRANSITION PROBABILITY MATRIX

	COAL	MNC	MC	MSF	SLT	MSL	SFG	SCG	SMLF	CGL	SMSI	SCOR
COAL	0	.27	.40	.08	.09	.03	.01	.02	.06	0	.03	.01
MNC	.11	0	.16	.11	.12	.04	.12	.09	.14	.02	.02	.08
MC	.60	.14	0	.04	.05	.01	.05	.01	.03	0	.05	.02
MSF	.17	.17	.21	0	.07	.05	.10	.05	.10	0	.05	.05
SLT	.21	.32	.15	.02	0	0	.12	.05	.02	0	.03	.09
MSL	.13	.17	.04	.04	.04		.04	.22	.13	.04	0	.13
SFG	.17	.17	.14	.10	.07	[illegible]	[illegible]	.03	.08	.17	.03	0
SCG	.05	.21	.10	.02	[illegible]	[illegible]	.05	0	.03	.20	.08	.03
SMLF	.13	.23	.26	.02	.11	.09	.02	0	0	.02	.04	.08
CGL	0	.06	0	0	0	0	.32	.48	.06	0	.03	.03
SMSI	.32	.08	.20	0	.08	.04	.12	.04	0	0	0	.12
SCOR	0	0	.03	.03	.06	.03	.17	.43	.11	.14	0	0

DOWNWARD TRANSITION PROBABILITY MATRIX

	COAL	MNC	MC	MSF	SLT	MSL	SFG	SCG	SMLF	CGL	SMSI	SCOR
COAL	0	.30	.43	.27	.20	.17	.03	.05	.17	0	.15	.06
MNC	.10	0	.16	.34	.24	.22	.27	.20	.35	.06	.07	.28
MC	.55	.15	0	.12	.11	.04	.10	.02	.08	0	.26	.08
MSF	.05	.05	.07	0	.05	.09	.07	.03	.08	0	.07	.06
SLT	.10	.16	.07	.02	0	0	.13	.05	.02	0	.07	.17
MSL	.02	.03	.01	.02	.02	0	.02	.08	.06	.03	0	.08
SFG	.07	.08	.06	.15	.06	.09	0	.03	.10	.32	.07	0
SCG	.02	.10	.05	.02	.18	.09	.05	0	.04	.39	.19	.06
SMLF	.05	.09	.11	.02	.09	.72	.02	0	0	.03	.07	.11
CGL	0	.02	0	0	0	0	.17	.25	.04	0	.04	.03
SMSI	.05	.02	.04	0	.03	.04	.05	.02	0	0	0	.08
SCOR	0	0	.01	.02	.03	.04	.10	.25	.08	.16	0	0

Figure 84. Upward and downward transition probability matrices.

was preceded by deposition of another particular unit. This factor was calculated from the count matrix by dividing each element in each column by the column total; each column of this matrix sums to one. The third, fourth, and fifth matrices are the substitutability matrices, they measure the degree of similarity between two units with respect to surrounding units. The upward substitutability matrix contains measures of similarity of any two lithologic units to be overlain by a similar lithological unit. The downward substitutability matrix is the same except the similarity is based on the tendency for two states to be underlain or preceded by a similar lithology. The upward substitutability matrix was calculated for each pair of lithologies by calculating the cross-product ratio of the respective rows. The downward substitutability matrix was calculated in the same manner but using columns instead of rows. The mutual substitutability matrix measures the degree to which two units are over and underlain by similar units. This matrix was obtained by multiplying the corresponding values from the upward and downward substitutability matrices.

A chi-square test was used to test the count transition matrix for the Markov property (Davis, 1973, p. 288). The null hypothesis stated that the observed transitions were independent of each other and therefore random. The alternative hypothesis was that they had a significant degree of dependency and thus formed a Markov chain. The statistic obtained was 854 with 120 degrees of freedom, therefore the null hypothesis was rejected with a confidence of at least 99.5 per cent; the sequence has a first order Markov property. With such a strong rejection, the possibility exists that higher order chains may be present; this hypothesis was not tested.

Attempts to obtain a representative sequence of lithological units descriptive of the major sedimentary pattern for the Gething Formation was made by a combination of traditional and automated techniques. Traditionally the difference matrix is interpreted and a schematic flow diagram constructed to illustrate the determined pattern of unit transitions. Figure 83 is such a diagram; it is based on the strongly positive difference values (highlighted) in the difference matrix (Fig. 82). This interpretation suggested a general fining upward depositional cycle composed of two fining up sub-cycles. The overall cycle in the Gething goes from a scour surface through successively finer grained sediments to coal. At the position of non-carbonaceous mudstone (MNC) the progression has about an even statistical chance of continuing on to finer grained sediments or cycling back into coarser grained material. When the progression passes MNC into the finer sediments, fining generally continues until COAL is encountered. Coal will in turn be followed by either carbonaceous mudstone or non-carbonaceous mudstone. The two sub-cycles are the coarse-grained cycle SCOR to MNC and the fine-grained, coal-bearing, cycle MNC to COAL. These two sequences are believed to represent fluvial (lateral accretionary) and overbank (vertical accretionary) deposits, respectively. The units SMSI and MSL were not

UPWARD SUBSTITUTABILITY MATRIX

	MNC	MC	MSF	SLT	MSL	SFG	SCG	SMLF	CGL	SMSI	SCOR
COAL	.58	.16	.81	.69	.47	.67	.64	.89	.13	.52	.15
MNC		.42	.78	.52	.68	.64	.51	.61	.48	.72	.56
MC			.61	.66	.51	.61	.33	.48	.09	.80	.06
MSF				.87	.71	.78	.67	.91	.34	.86	.32
SLT					.73	.73	.62	.84	.33	.79	.21
MSL						.68	.53	.56	.65	.61	.68
SFG							.81	.77	.16	.66	.33
SCG								.74	.16	.48	.29
SMLF									.10	.77	.11
CGL										.26	.91
SMSI											.23

DOWNWARD SUBSTITUTABILITY MATRIX

	COAL	MNC	MC	MSF	SLT	MSL	SFG	SCG	SMLF	CGL	SMSI
MNC	.47										
MC	.14	.83									
MSF	.42	.61	.79								
SLT	.43	.67	.77	.87							
MSL	.31	.62	.78	.79	.89						
SFG	.46	.38	.42	.65	.66	.59					
SCG	.16	.21	.31	.48	.43	.42	.82				
SMLF	.36	.48	.69	.94	.86	.78	.79	.66			
CGL	.12	.31	.20	.33	.53	.43	.26	.29	.36		
SMSI	.77	.82	.56	.62	.79	.64	.55	.27	.56	.49	
SCOR	.47	.50	.54	.71	.74	.74	.84	.52	.77	.21	.58

MUTUAL SUBSTITUTABILITY MATRIX

	COAL	MNC	MC	MSF	SLT	MSL	SFG	SCG	SMLF	CGL	SMSI	SCOR
COAL	1											
MNC	.28	1										
MC	.02	.34	1									
MSF	.34	.48	.48	1								
SLT	.30	.35	.51	.76	1							
MSL	.14	.42	.39	.56	.65	1						
SFG	.31	.25	.25	.51	.48	.40	1					
SCG	.10	.11	.10	.32	.27	.23	.67	1				
SMLF	.32	.30	.33	.86	.71	.44	.61	.49	1			
CGL	.02	.15	.02	.11	.18	.28	.04	.05	.04	1		
SMSI	.40	.59	.45	.53	.62	.39	.36	.13	.44	.13	1	
SCOR	.07	.28	.03	.23	.16	.50	.28	.15	.09	.20	.13	1

Figure 85. Upward, downward, and mutual sutstitutability matrices for Gething sediments measured.

represented in this interpretation, due largely to the low number of transitions involving these units. The upward transition probability matrix (Fig. 84) is similar in some respects to the difference matrix (Fig. 82) but quite different in others. The probability matrix does not address the problem of the relative abundance of the units, however, it can be used to generate a representative stratigraphic pattern by a form of Monte Carlo simulation. In the simulation a starting unit was chosen, in this case SCOR, and on the basis of the probability values in the matrix the sequence of transitions determined. The first simulation was allowed to continue until all 12 sedimentary units were represented at least once. One thousand simulations were performed with the average length of section required to include all 12 units being 61 lithologic units. In most cases the last unit to be referenced was either SMSI or MSL due to the relatively low upward transition probabilities for both. In an effort to obtain a more compact sequence these two lithologic units were assumed to be a subset of larger unit and grouped with other similar units. Groupings were based on the mutual substitutability matrix (Fig. 85). As described earlier, two units which are strongly substitutable are overlain and underlain by similar units, and thus deposited in similar environments. Both SMSI and MSL were most closely matched with the siltstone (SLT) unit. The modified upward transition probability matrix was then utilized in another Monte Carlo simulation. The average section length in this case was 36 units. The simulation was then continued and 10 sequences of exactly 36 units were generated. The average number of each unit was then calculated from these 10 sequences to arrive at the number and type of units in the Monte Carlo standard section. Based on this simulation and the flow diagram (Fig. 83), a representative sequence was constructed (Fig. 86). The standard section is 36 units in length and contains four fining-up sub-cycles. For ease of unit identification the standard and simulated sequences displayed all units with the same thickness; Figure 82 contains a tabulation of the average unit thicknesses. The simulation confirmed the interpretation represented on Figure 83; the two sub-cycles are present and lithologies of the two do not mix. Sequence No. 2 of the standard section is an example of the complete, uninterrupted sequence from coarse-grained through finer grained sediments to coal.

DISCUSSION

Correlation of gross features is relatively straightforward on the correlation diagram (Fig. 80) and the Moosebar-Bluesky-Gething contacts are easily followed across the section. The bentonites in the lower Moosebar Formation are everywhere present and provide a time constraint to the diagram. The thickness between these bentonites and the top of the Gething Formation increases to the east, suggesting marine deposition in the east and active coal swamps in the west. The Bluesky marker interval increases in thickness from the west to the east. Column 15 (Fig. 80) contains a very large thickness of sandstone believed to be Bluesky. The Bluesky Formation in the subsurface of Alberta and

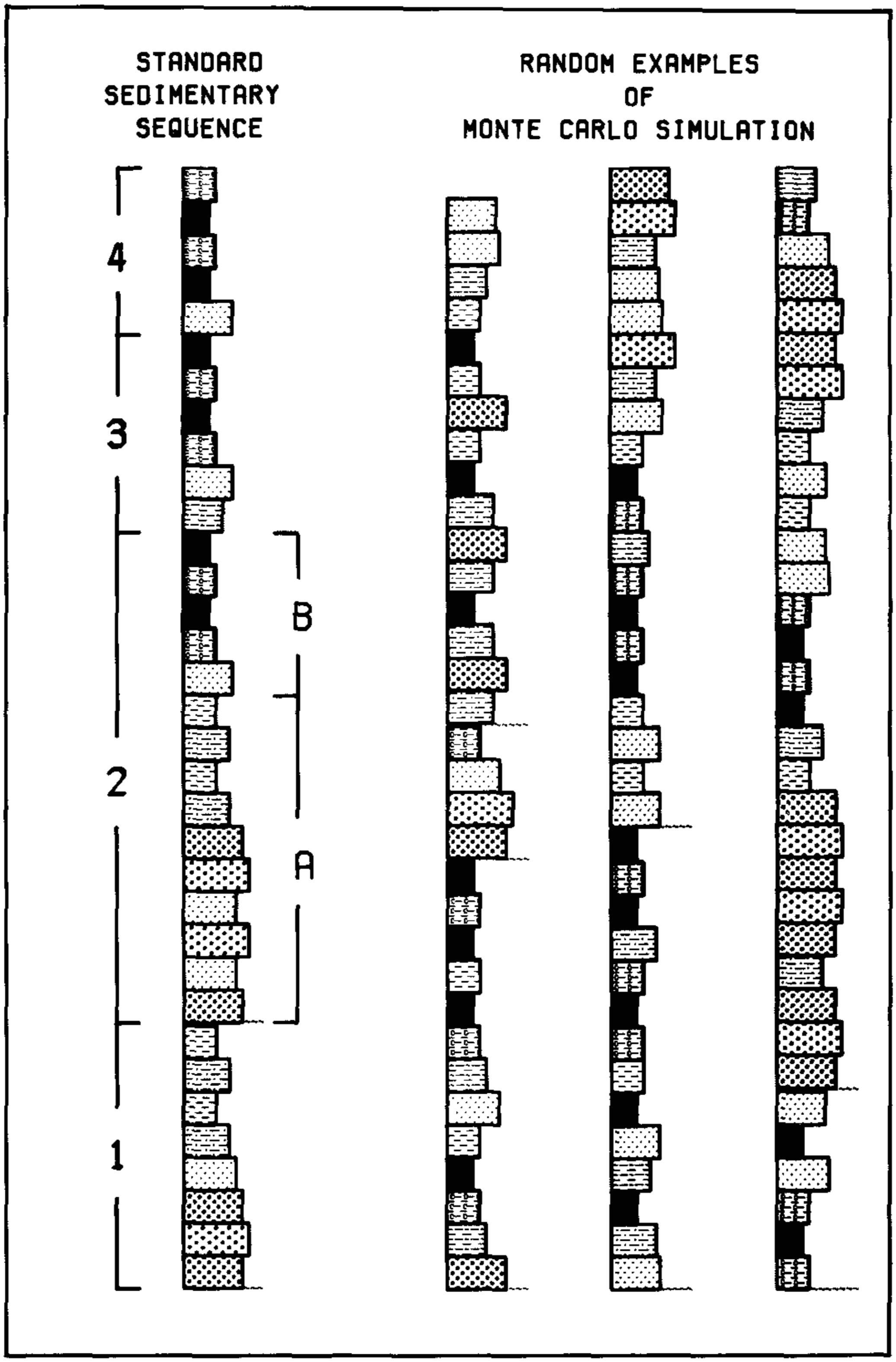

Figure 86. Derived standard sedimentary sequence for the upper Gething formation based on *a Monte Carlo simulation of the upward transition probability matrix.*

northeastern British Columbia is of a similar thickness; conceivably the section contains the transition zone from what is referred to as Bluesky on the coal properties of the Foothills to the formal Bluesky Formation in the subsurface.

Correlation of Gething strata is difficult. Coal seams can be correlated across several holes but, with the exception of the Trojan seam, individual seams are not laterally continuous on this section. The Trojan seam has been tentatively correlated across much of the western portion of the section. Tonsteins seem to be erratic, but this is not the case in reality. Two of the major zones have been correlated as far as 120 kilometres southward to the Sukunka region. Apparently significant numbers of these bands were removed from the core with the coal intervals during sampling thus limiting their usefulness in this study. A major mudstone zone, approximately 10 metres thick, has been correlated across the section. In some cases this correlation is tenuous, but in others the presence of a coquina band in several holes strengthened the correlation. Structure has also complicated borehole correlations. Fault duplicated sections were noted in outcrop sections, and geophysical logs show several duplicated intervals in the holes presented here. Resolution of the structure has not yet been attempted. Despite structural complications, several prominent zones were correlatable over significant distances.

The Monte Carlo standard section for the Gething Formation depicts two sub-cycles and one large cycle made up of the combination of two sub-cycles. The coarse-grained sediments represent active meandering stream deposits. The lower cycle (Fig. 86) consists of thick, fining-up, laterally accreted sandstone channel fill with a scoured base and lag deposits and ends with silts and non-carbonaceous mudstones. The finer, coal-bearing cycle represents vertically accreted floodplain deposits with well to poorly drained swamps and peat swamps and channel margin levee deposits. Episodic crevasse splay deposits comprise a third, minor cycle which can enter the floodplain cycle at any point (not represented on the standard section).

Typical meandering stream channels erode on the concave side and deposit on the convex portion of each meander, point bar. This combination produces a tabular sand unit overlying a near horizontal erosion surface, with or without lag deposits. Point bar deposits are commonly overlain by finer grained floodplain deposits. In this study lithological units associated with this environment would be SCOR, CGL, SCG, SFG, and SLT, with MNC representing the overlying fine-grained flood deposits.

With channel migration, substantial flood basin sedimentation, consisting of vertically accreted deposits in the interdistributary areas, is initiated. Flood plains act as settling basins in which long-continued accumulations of fine-grained suspended sediments are derived from overbank flows (Reineck and Singh, 1980). In well-drained swamps periodical subaerial exposure oxidizes sediments, destroying the organic matter. Non-carbonaceous mudstones (MNC) often seen in the section may represent this setting. In stagnant waters reducing conditions preserve organic matter, creating carbonaceous muds (MC). Continued accumulation of the organic matter results in thick vegetation growth that leads to peat development and the beginning of coal swamps. The association of mudstones and coals is demonstrated in the difference, upward and downward transition probability matrices where MC and COAL have high transition measures.

CONCLUSION

Examination of the upper portion of the Gething Formation along the Peace River has only begun. More work is needed to sort out the structural problems and to attempt detailed correlations to facilitate understanding of the depositional history of this area and document the areal distribution of the various facies. The study to date has:

(1) demonstrated the presence of potentially powerful marker horizons;

(2) shown the presence of a strong preferred ordering in the sedimentary sequence; and

(3) illustrated the time relationship of the Gething-Bluesky-Moosebar contacts in this area.

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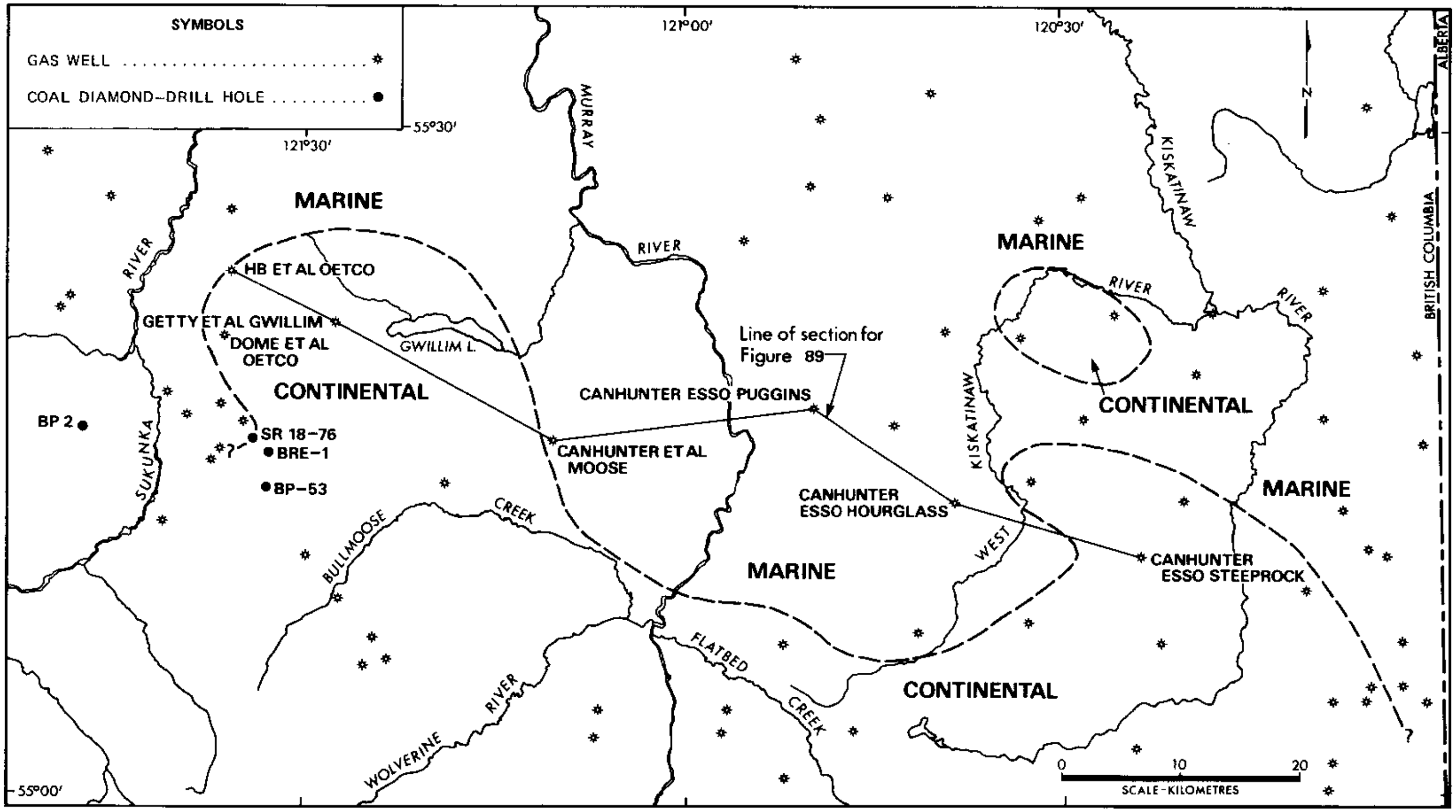

Figure 87. Eastern limit of upper coal measures of Gething Formation (Chamberlain member).