IDENTIFICATION OF LITHOTYPES IN LIGNITES OF SOUTHERN SASKATCHEVAN

R E P O R T N O . 1

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1.0 INTRODUCTION

To start with, I have tried to correlate the ASTM-RANK System with the German system, that is the so-called scientific rank classification system (see table 1, modified after ASTM and ICCP). Due to this correlation the lignites A of Southern Saskatchevan with a bed moisture content of about 40 % belong to the high rank soft brown coals.

An internationally accepted macropetrographic classification system of the lignites mentioned above is still missing today. The ICCP is very interested in this problem and has done a lot to solve it since 1976. As a matter of fact, we could not solve it until now. Consequently, we are depending on national classifications erected in the main brown coal producting countries.

In this connection I would like to mention the classification systems of the GDR (SONTAG & SUESS, 1976; SEIFERT and others, 1978; SEIFERT & RASCHER, 1979), of Australia (ALLARDICE and others, 1977), of Czechoslovakia (MALAN, 1971) and my own proposal (HAGEMANN, 1978; HAGEMANN & HOLLERBACH, 1981). Most of these systems are mainly dealing with soft brown coals (lignites B). You can apply them only modified to lignites A and subbituminous coals.

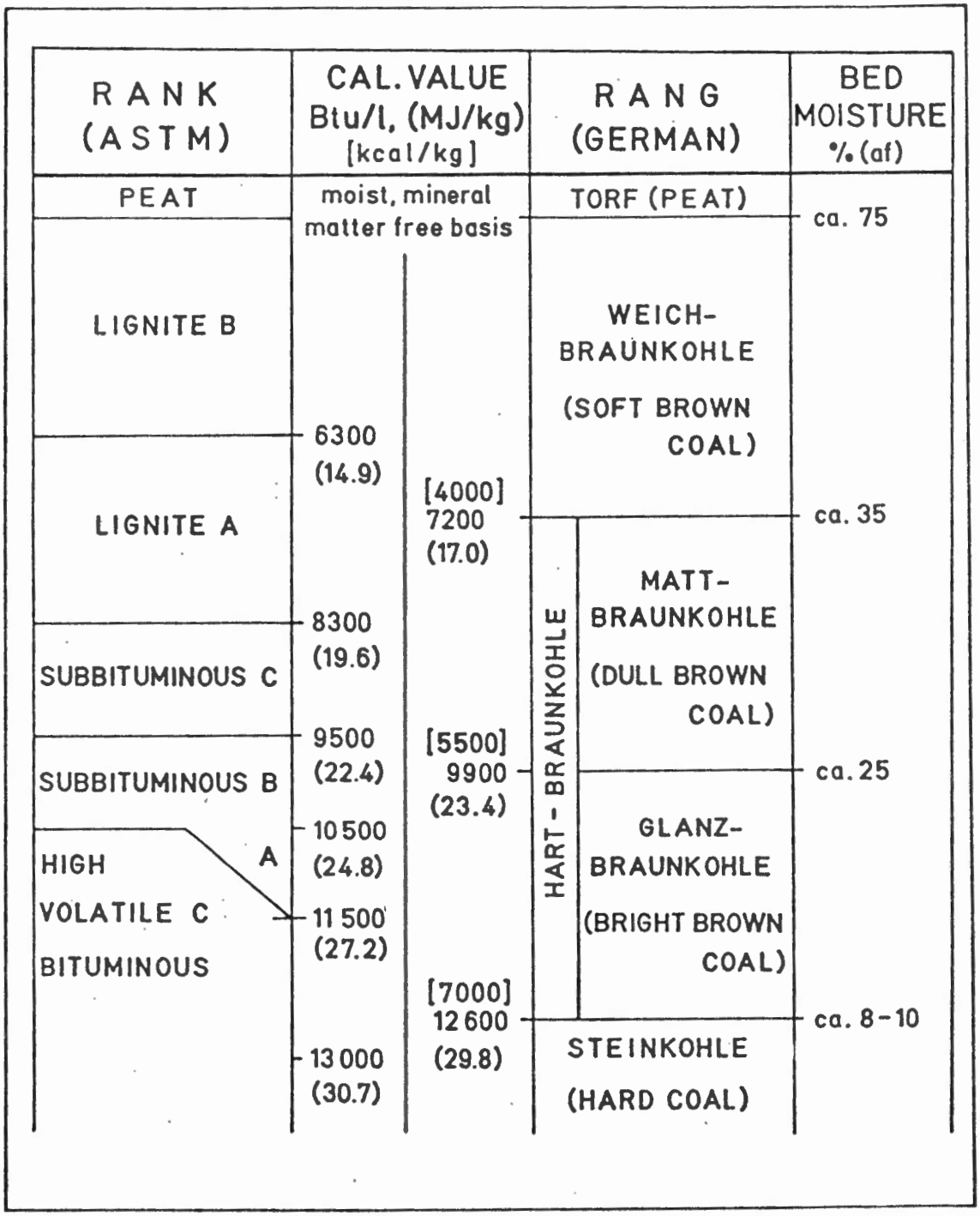

RANK (ASTM)
CAL. VALUE Btu/l, (MJ/kg) [kcal/kg]
RANG (GERMAN)
BED MOISTURE % (af)
PEAT
moist, mineral matter free basis
TORF (PEAT)
ca. 75
LIGNITE B
WEICH-BRAUNKOHLE
(SOFT BROWN COAL)
6300
(14.9)
[4000]
7200
(17.0)
LIGNITE A
ca. 35
8300
(19.6)
SUBBITUMINOUS C
MATT-BRAUNKOHLE
(DULL BROWN COAL)
9500
(22.4)
[5500]
9900
(23.4)
SUBBITUMINOUS B
ca. 25
HART-BRAUNKOHLE
10500
(24.8)
HIGH VOLATILE C BITUMINOUS
A
GLANZ-BRAUNKOHLE
(BRIGHT BROWN COAL)
11500
(27.2)
[7000]
12600
(29.8)
ca. 8-10
13000
(30.7)
STEINKOHLE
(HARD COAL)

TABLE 1

2.0 MACROPETROGRAPHIC DESCRIPTION AND CLASSIFICATION OF LIGNITES

The heterogeneous structure of a lignite seam can be recognised in the seam section by the successive bands of different structure, texture, intensity and hue of colour and by other organic or inorganic inclusions. It is well known that such differences in the characteristics of the layers of a coal seam are generally determined by (a) the type of coal, which is characterised by the parent plant material and its depositional conditions; and (b) by the rank, which is mainly affected (within the range of lignites) by the intensity of biochemical degradation of the parent plant material, which produces changes in its structure and material composition.

Considering the macropetrographic composition of the lignites as a unit, you can identify two main components, the groundmass and the inclusions. The groundmass of the coal of which single particles cannot be seen with the naked eye represents the coal substance as a whole and is used as a matrix for different inclusions. All macropetrographically identifiable plant remains can be defined as inclusions, independant of their size. In spite of their eyecatching indication in the average of the investigated samples, broad inclusions, for example xylites, such as stumps, trunks, branches etc., only have a minor part in the composition of the lignites although they can dominate in some layers.

The per definitionem separated smaller tissues, such as plant remains with cell structure, stems, leaves, barks and other tissues, often form the main substance of the coal. They build up the successive bands of different texture within the seam sections. Resin bodies, fusinitizised tissues (charcoal) and cuticles are to be regarded as special inclusions because usually they form a very small part of the coal. Their importance can be seen in their application as leading-horizon or as signs of facies patterns.

A different view of lignites is given on dried seam sections only. In that case, features such as intensity and hue of colour, evidence of gelification and the extensive cracking of the surface texture are very obvious.

If one analyses the coal, these characteristic differences may be expressed by the following macropetrographically ascertainable parameters which are compiled in the classification illustrated below (see table 2). This is the scheme (HAGEMANN, 1978) of a new macropetrographic classification of lignites in which xylite and/or impure coal (structural pattern) determine the lithotype classes. The term lithotype covers the proportions of plant (i.e. tissue) remains in the groundmass of the coal characteristic (characteristic of the texture). The lithotype varieties can be distinguished in dried lignites only, and are distinguished from one another by the hue and the intensity of colour, the kind of gelification as well as the proportion of other original vegetal debris. Additional descriptive features that may be taken into account are the surface texture, the fracture, and the crumbling of the coal when it dries.

MACROPETROGRAPHIC CLASSIFICATION OF LIGNITES (A AND B)						
categories	lithotype-classes	lithotypes	lithotype-varieties			
reading column matrix	10	20	30	40	50	
quality parameter	structure: presence of xylite and/or contamination by mineral matter	texture: ratio between groundmass and plant remains	intensity and hue of colour	evidence of gelification	inclusions	additional features
macropetrographic description	① pure coal, non-xylitic ② pure coal, xyl. fibrous xylite brittle xylite - - - - - - - - - tree stumps tree trunks etc. ③ impure coal, non-xylitic clayey coal sandy coal calcareous coal iron sulphides etc. ④ impure coal, xylitic	① unbanded coal ② moderately banded coal ③ banded coal ④ highly banded coal	① pale-yellow ② medium light-yellow ③ pale-brown ④ medium light-brown ⑤ dark-brown ⑥ dark-black	① gelified groundmass (+,++,+++) ② gelified tissues (+,++,+++) ③ microgranular humic gel particles (+,++,+++) ④ -	① resin bodies (+,++,+++) ② cuticles (+,++,+++) ③ charcoal (+,++,+++) ④ -	a) surface texture extensive cracking moderate cracking no cracking b) fracture even imbricated c) size degradation coarse fragmentation fine fragmentation crumbling

TABLE 2

Theoretically, a great number of possible combinations is given by the five main macropetrographic parameters shown in the matrix. A part of these combinations of different features, however, will seldom or never appear in nature because equal features occurring mainly on the lithotype-varieties exclude themselves.

A classification system which enables different combinations of macropetrographic parameters will fit much easier into an internationally accepted system. It also gives the opportunity to registrate an a-typical lignite.

3.0 METHODS AND SAMPLES

In the field identification of lithotypes in lignites was carried out in fresh, unweathered coal. As mentioned above, it is in moist coal only that the content of xylite and mineral matter, of tissues and groundmass, and of inclusions, like resin bodies and charcoal, can be clearly distinguished. Further important classification-parameters, such as intensity, hue of colour and evidence of gelification of the groundmass and the tissues can only be commented on dried coal sections.

In order to show clearly the original colour of the coals and to keep its structure after drying, the freeze-drying method is most advantageous. This method offers above all the following advantage: water is withdrawn by sublimation from the frozen sample (minus 60 - 80°C) after which oxidising processes and structural changes of coal remain negligable. As a result, the texture, hue and gelification of lignites can be seen more clearly than in a normal drying process in the open air.

The trouble is, that the capacity of the available apparature at the ISPG was not sufficient. Thus, we could only dry the coal very roughly under a ventilator, resulting in a extensive cracking of the surface texture in most cases. Most resistance against cracking could be observed in the xylite layers, basing on simular shrinking and, on the other hand, in the very compact unbanded and moderately banded coals.

In spite of that, we cut one or two typical pieces of bed moisture coal for each lithotype, put it under a binocular, and determined the macropetrographic parameters.

All together, I looked at 59 lithotype samples from 4 coal seam sections. I am talking about the lignites of the Willow Bunch and Estevan area of Southern Saskatchevan, which occur in the Ravenscrag formation, Paleocene (see table 3).

With the help of photographs taken from wet coal disks, the ratio between the groundmass and the plants remains was determined qualitatively. Furthermore, we looked for a possibility to divide the intensity of colour into two steps - dark brown and dark black.

Mine / area		coal zone	samples no:
Poplar River Mine	Coronach	Hartseam	CQ 269 / 1 - 20
Souris River Mine	Estevan	Estevan	CQ 270 / 1 - 20
Boundary Dam Mine	Estevan	Souris ?	CQ 283 / 1 - 9
Bienfait Coal Mine	Bienfait	Estevan	CQ 284 / 2 - 13

Table 3

4.0 RESULTS

4.1 Description of lithotypes occurring in the Saskatchevan Lignites

A total view shows that xylitic coals dominated within lithotype-classes; beside that, many samples are also contaminated by clay.

Within lithotypes unbanded coals are very rare, and only few moderately banded lithotypes occur. Altogether, banded and highly-banded coals dominate.

The striking thing about the lithotype-varieties is that there is a relatively high content of charcoal in most samples.

On the following figures 1-8 some samples of lithotypes from lignites of Southern Saskatchevan are shown in order to illustrate the classification system. The pictures were made on only roughly dried coal:

(a)

Fig. 1

photograph no. 1509-4
sample no. CQ 270/13, Souris River Mine, Estevan coal zone.

The coal shown here comes from a xylitic lithotype which is slightly mixed with clay. It has a very compact groundmass with only rather few, tiny gelified and fusinitizised tissues. This groundmass which is contaminated with clay has been classificated as impured unbanded coal.

Fig. 2:

(b)

photograph no. 1509-2

sample no. CQ 269/1, Poplar River Mine, Hartseam.

This lithotype is contaminated by clay and probably speckled with sand-grains. The groundmass contains very tiny gelified and some fusinized plant remains associated with some brownish and therefore moderately gelified tissues which can really be seen only under low magnification microscopy.

This impure non-xylitic lithotype has been classified as moderately banded coal.

Fig. 3:

(c)

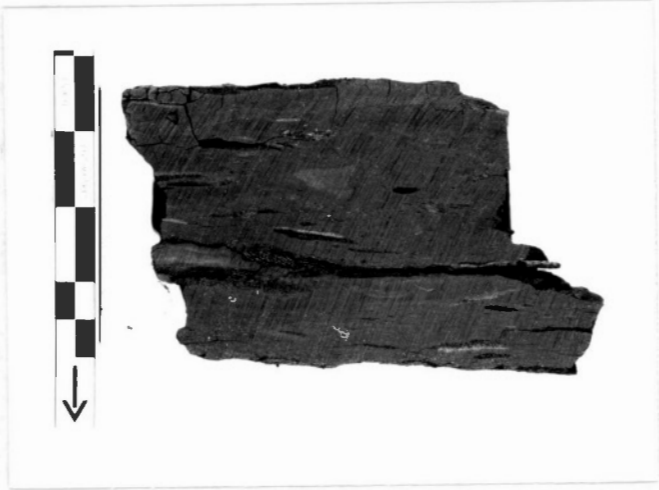
photograph no. 1509-9

sample no. CQ 269/18, Poplar River Mine, Hartseam.

This sample comes from a xylitic lithotyp. It is a very compact coal. In the dark groundmass there are some spots of brighter tissues and some charcoals. In the lower third of the figure there are plenty of resin bodies.
It can be described as a moderately banded coal.

Fig. 4: Sample no. CQ 269/19, Poplar River Mine, Hartseam:

(d)

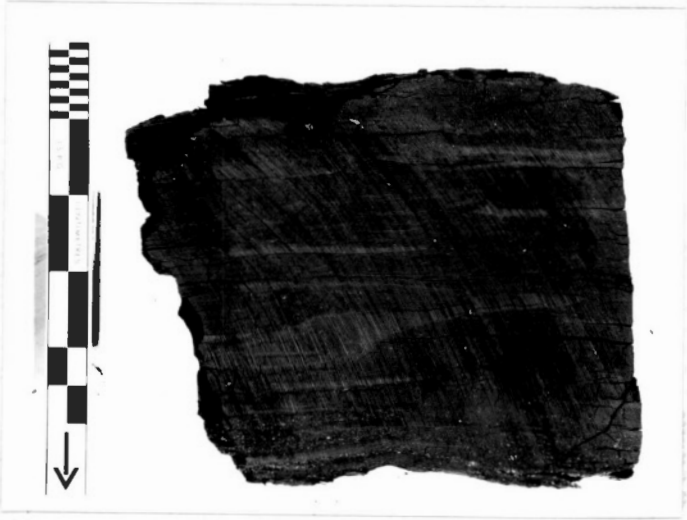


photograph no. 1509-7.

This is an example for a non-xylitic, moderately banded lithotype, contaminated by some clay-lenses. In the gelified groundmass there are some dull black charcoals and a few tissues, which are somewhat brighter than the groundmass.

Fig. 5:

(e)



photograph no. 1509-12

sample no. CQ 269/2, Poplar River Mine, Hartseam.

Especially in the upper quarter of the figure the contamination of the coal by clay can be perceived clearly. This sample has been taken from some xylitic, impured coal which is composed of 1-3 cm broad xylite layers in which quite a lot of tiny charcoals and brighter (i.e. only moderately gelified) tissues occur.

This figure should be classificated as an impure, banded lithotype.

Fig. 6:

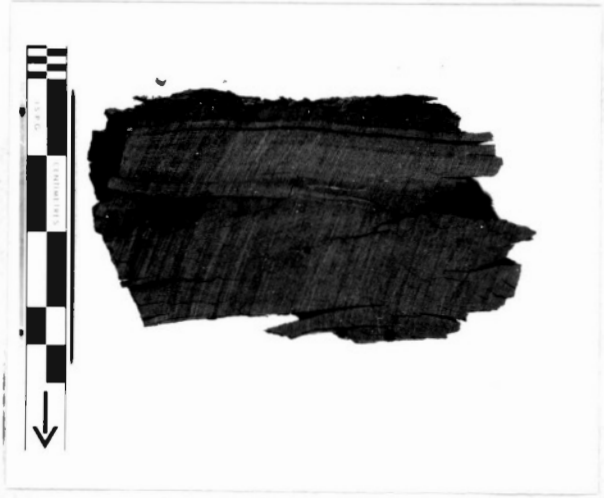
(f)

photograph no. 1509-14

sample no. CQ 269/7, Poplar River Mine, Hartseam. This sample comes from a non-xylitic, impured moderately banded lithotype. The figure shows only a very small part of this lithotype. In the lower third of the figure some unbanded coal can be seen, which is contaminated by clay, and above that you can see a lithotype which is highly banded by many, only weakly gelified tissues.

Fig. 7: Sample no. CQ 270/2, Souris River Mine, Estevan coal zone:

(g)

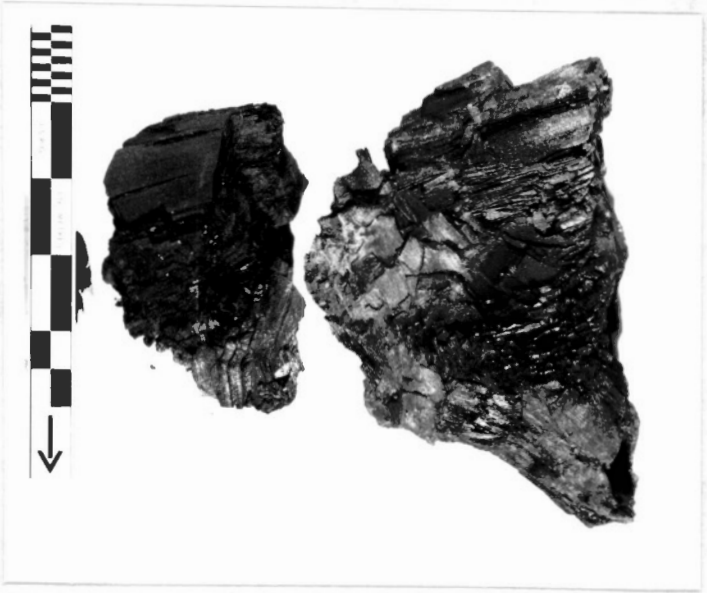


photograph no. 1509-6

The figure shows two relative bright xylites which are only moderately gelified, and below them a thin layer of charcoal. Macropetrographically, this coal should also be classificated as a highly banded lithotype.

Fig. 8:

(h)



photograph no. 1509-13

sample no. CQ 270/4, Souris River Mine, Estevan coal zone.

This sample represents a 4 cm broad fusain layer which mostly consists of fusinitizised xylites and tissues.

This coal should also be classificated as a highly banded coal.

4.2 Description of the four seam sections in detail

Looking at the seam sections in detail, we can make the following statements:

(a) POPLAR RIVER MINE, HARTSEAM, CORONACH

67% xylitic coals, from which about 50% are contaminated; no unbanded lithotype occurs;

29% of the coal are moderately-banded, the rest of the coal are banded and highly banded lithotypes, whereas in the lower part of the seam the highly banded lithotypes predominate (see table 4, 5 and Fig. 9).

POPLAR RIVER MINE, CORONACH, WILLOW BUNCH AREA, HARTSEAM, RAVENSCRAG FORMATION, PALEOCENE

TABLE 4

SAMPLE NO.	FROM TOP (cm)	THICK-NESS (cm)	LITHOTYPE CLASSES	LITHO-TYPES	LITHOTYPE - VARIETIES		
					INTENSITY + HUE OF COLOUR	EVIDENCE OF GELIFICATION	INCLUSIONS
CQ 269/ 5	0 - 14	14	13 (clayey)	23	36	41 (++), 42 (+), -	51 (++), -, 53 (+++)
CQ 269/ 6	14 - 18	4	14 (clayey, fibrous)	24	35	41 (+), 42 (+), -	-, -, 53 (+)
CQ 269/ 7	18 - 33	15	13(clay lenses)	22	36	41 (++), 42 (+), -	51 (+), -, 53 (+++)
" 8	33 - 52	19					
CQ 269/ 9	52 - 68	16	14 (clayey, fibrous)	23	35	41 (++), 42 (+), -	-, -, 53 (++)
CQ 269/10	68 - 86	18	12 (fibrous)	23	35	41 (++), 42 (+), -	-, -, 53 (++)
" 4	86 - 102	16					
" 3	102 - 118	16					
CQ 269/ 2	118 - 126	8	14 (clayey, fibrous)	24	35	41 (+), 42 (+++), -	-, -, 53 (+++)
CQ 269/ 1	126 - 142	16	13 (clayey)	22	35	41 (+), 42 (++), -	-, -, 53 (+)
CQ 269/11	142 - 164	22	— C L A Y —				
CQ 269/12	164 - 181	17	14 (clayey, pyrit. fibrous)	23-24	36	41 (+), 42 (++), -	-, -, 53 (++)
CQ 269/13	181 - 205	24	14 (clay. pyrit. fibrous)	23-24	35	41 (+), 42 (++), -	51 (++), -, 53 (+)

continuation POPLAR RIVER MINE, TABLE 4.

SAMPLE NO.	FROM TOP (cm)	THICK-NESS (cm)	LITHOTYPE CLASSES	LITHO-TYPES	LITHOTYPE - VARIETIES		
					INTENSITY + HUE OF COLOUR	EVIDENCE OF GELIFICATION	INCLUSIONS
CQ 269/14	205 - 243	38	12 (fibrous)	24	35	41 (+), 42 (++), -	-, 53 (+++)
CQ 269/15	243 - 262	19	12 (fibrous)	23	36	41 (+), 42 (++), -	-, -, 53 (+++)
CQ 269/16	262 - 275	13	11	22	36	41 (+), 42 (++), -	-, -, 53 (+++)
CQ 269/17	275 - 302	27	14 (clayey, fibrous)	24	35	41 (+), 42 (++)	51 (+), -, 53 (++)
CQ 269/18	302 - 330	28	11	22	35	41 (+++), 42 (+), -	51 (+), -, 53 (+)
CQ 269/19	330 - 350	20	13 (clay lenses)	22	36	41 (+++), 42 (+), -	-, -, 53 (++)
CQ 269/20	350 - 400	50	14(clay lenses, fibrous)	24	35	41 (+), 42 (++), -	51 (+), -, 53 (++)

POPLAR RIVER MINE, CQ 269

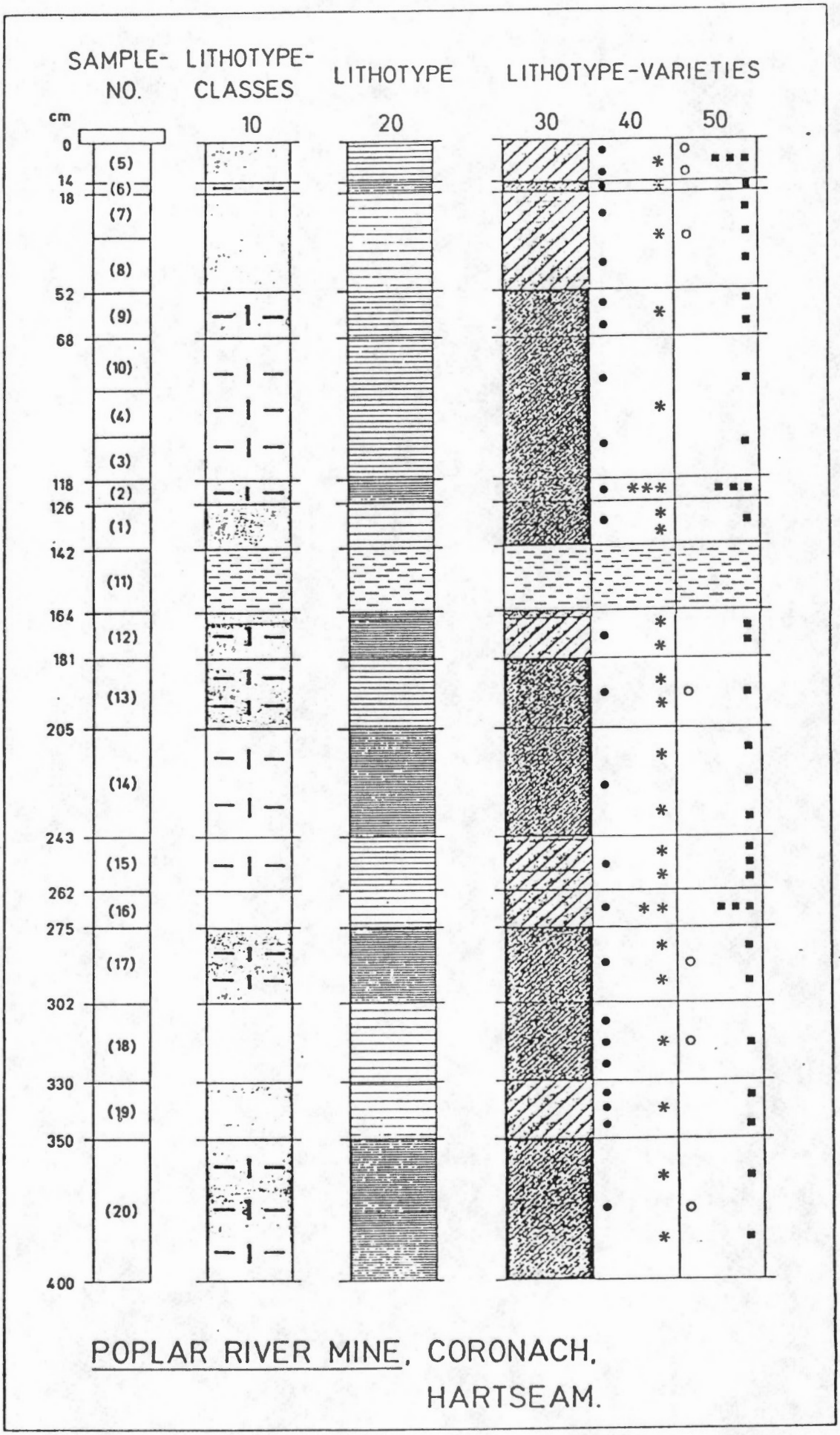
TABLE 5 :
Additional remarks

Sample no.	from Top (cm)	
(5)	0 - 14 :	Cell tissues up to 0.3 cm in diameter strongly gelified; groundmass with inclusions of small tissues which are mostly fusinitisized; both groundmass and cell-tissues contaminated by clay-minerals. A great number of Resinite bodies appears.
(6)	14 - 18 :	Lithotype xylites which are up to 2.5cm broad, showing differences of gelification. Degree of gelification is shown by imbricated fracture and changes in colour from dark-brown to dark-black of the different woody layers. Some of the xylites are partly fusinitisized. Besides the broad xylites there are layers (<1cm) of fusinitisized cell tissues (<3cm) and frequently there can be found fruits showing strong gelification in the inner central part.
(7) (8)	18 - 33 : 33 - 52 :	Lithotype, moderately banded; plant remains consist mainly of gelified and/or fusinitisized tissues. One xylite up to 1.5 in diameter; lenticular occurrance of clay-minerals.
(9)	52 - 68 :	Alternation between xylite-layers (max 1.5 cm), mostly slightly brownish, weakly gelified and layers of moderately banded lithotypes which are of the same composition as samples 7+8. Due to these features this lithotype has to be classified as banded coal.

Sample no.	from Top (cm)	
(10) (4) (3)	68 - 86 86 - 102: 102 - 118	The same lithotype as sample no. 9, except contamination by clay mineral. Alternation between xylite-layers of max. 2 cm thickness, mostly medium light brown and layers of unbanded and moderately banded lithotypes, which are of about the same composition as samples nos. 7, 8, 9 and 10. On the whole it is considered to be a banded lithotype.
(2a,b)	118 - 126:	Alternation between broad layers of xylite (1-3 cm) and highly banded lithotypes showing a very high content of charcoal (fusinitisized tissues and fruits) and moderately gelified tissues. Groundmass contaminated by clay. The macroscopically visible fusain-horizon is included within sample (2a, b).
(1)	126 - 142:	This impure, non-xylitic lithotype has been classified as moderately banded in the mine. A low magnification (6x) reveals many tiny gelified and some fusinized plant remains together with some brownish moderately gelified tissues. The groundmass is contaminated by clay and probably mixed with sand-grains.
(11)	142 - 164:	C L A Y
(12)	164 - 181:	Xylite-layers up to 1.5 cm in diameter; lenticular clay-inclusions and few pyrites; besides that plenty of fusinized tissues and few gelified cell tissues; therefore changes between banded and highly banded coal.

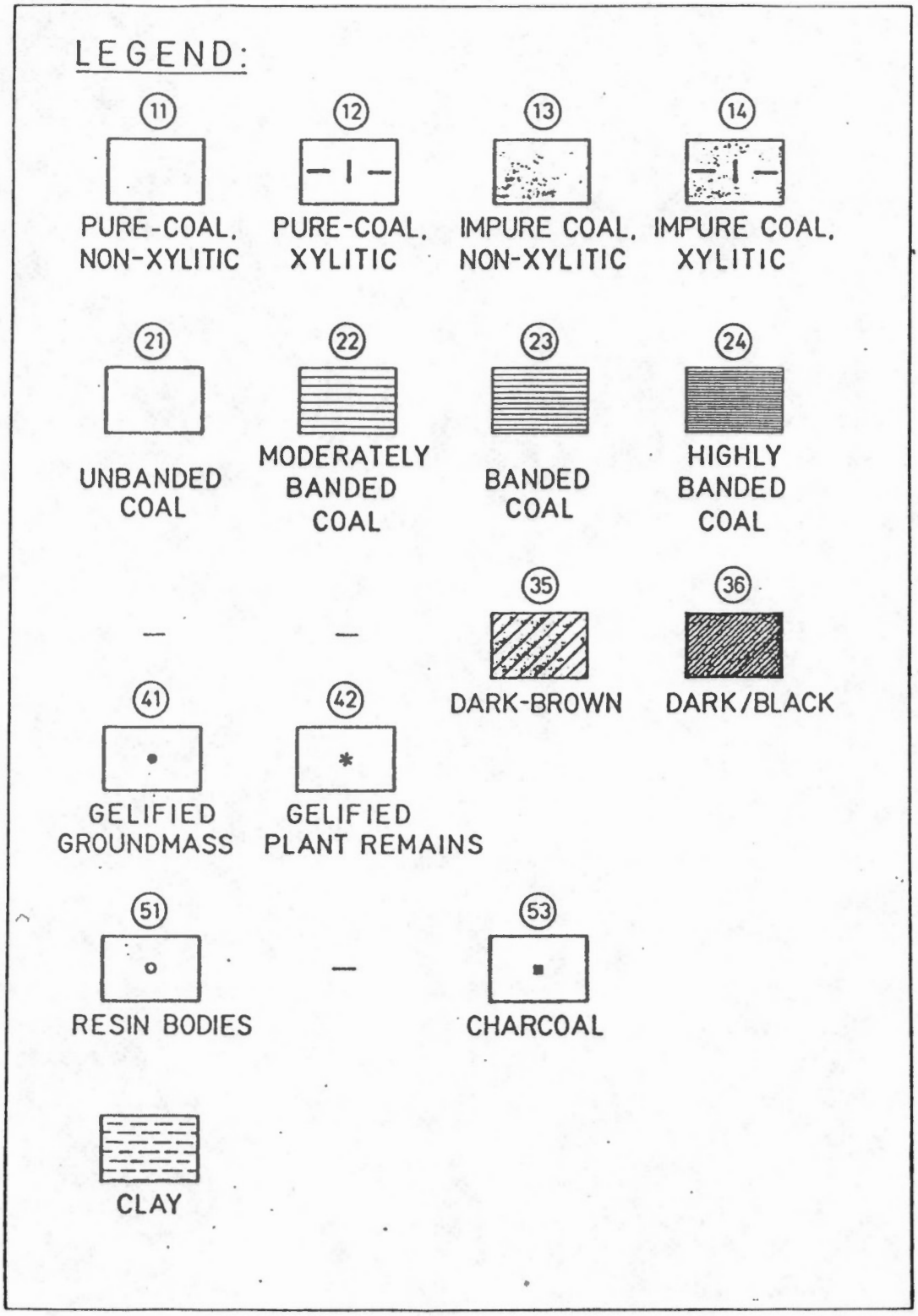
Sample no.	from Top (cm)	
(13)	181 - 205:	Within this lithotype a Tonstein (?)-layer with a thickness of about 1cm, an extra sample taken for examination; xylitic lithotype, impure coal: besides the Tonstein-layer there could be found lenses of clay and pyrite. Similar to sample no. 12, changes between banded and highly banded coal, but in contrast to sample no. 12, resinite and less charcoal.
(14)	205 - 243:	Xylitic and highly banded coal; tissues weakly gelified and to a lower degree strongly gelified; besides that a great amount of charcoal-tissues in layers.
(15)	243 - 262:	Xylitic, few pyrites (< 10%); banded lithotype, occurrence of many tiny particles of charcoal and strongly gelified of tissues to a lesser extent
(16)	262 - 275:	Pure coal, non-xylitic; moderately banded lithotype; fusain-layer with a thickness of 1.5cm at the bottom containing some medium light brown xylites.
(17)	275 - 302:	Relatively thick xylites (< 3.5 cm); colour changing from medium light brown to dark brown, indicating differences in intensity of gelification; groundmass itself is moderately banded containing tiny particles of charcoal and some gelified tissues; due to the big amount of xylites, this section has to be classified as highly banded coal.

Sample no.	from Top (cm)	
(18)	302 - 330:	Compact coal within some small (<0.5cm) gelified tissues; differences between the dull groundmass and the cell tissues with a faintly greasy lustre can be seen very clearly; some charcoals but less than there are usually in this seam could be found.
(19)	330 - 350:	Very compact coal; typical of the type of unbanded coal; in groundmass there are only few gelified tissues and fragments of charcoal.
(20)	350 - 400:	Xylite-rich lithotype; contaminated by clay; groundmass is similar to the one in sample (19), due to the abundant xylites it has to be classified as highly banded coal.



POPLAR RIVER MINE, CORONACH.
HARTSEAM.

Fig. 9


LEGEND:
11
PURE-COAL, NON-XYLITIC
12
PURE-COAL, XYLITIC
13
IMPURE COAL, NON-XYLITIC
14
IMPURE COAL, XYLITIC
21
UNBANDED COAL
22
MODERATELY BANDED COAL
23
BANDED COAL
24
HIGHLY BANDED COAL
35
DARK-BROWN
36
DARK/BLACK
41
GELIFIED GROUNDMASS
42
GELIFIED PLANT REMAINS
51
RESIN BODIES
53
CHARCOAL
CLAY

(b) SOURIS RIVER MINE, ESTEVAN COAL ZONE

40% xylitic coals, from which about 16% are contaminated;

53% of the coal layers are unbanded and mostly moderately banded lithotypes, and only one layer with a thickness of 20cm (= 6%) of unbanded coal has been found (see table 6, 7 and Fig. 10).

SOURIS RIVER MINE, ESTEVAN, ESTEVAN-COAL ZONE,
RAVENSCRAG FORMATION, PALEOCENE

TABLE 6

SAMPLE NO.	FROM TOP (cm)	THICK-NESS (cm)	LITHOTYPE CLASSES	LITHO-TYPES	LITHOTYPE - VARIETIES		
					INTENSITY + HUE OF COLOUR	EVIDENCE OF GELIFICATION	INCLUSIONS
CQ 270/13	0 - 27	27	11	22	36	41 (+++), 42 (+), -	51 (+), -, 53 (++)
CQ 270/12	27 - 42	15	11	23	36	41 (++), 42 (+++), -	51 (+), -, 53 (+++)
CQ 270/11	42 - 46	4	12 (fibrous)	24	35	41 (+), 42 (++), -	51 (+), -, 53 (++)
CQ 270/10	46 - 53	7	11	22	36	41 (+++), 42 (+), -	-, -, 53 (+++)
CQ 270/ 9	53 - 62	9	12 (fibrous)	24	35	41 (+), 42 (++), -	-, -, 53 (++)
CQ 270/ 8	62 - 70	8	11	22-23	36	41 (++), 42 (+++), -	-, -, 53 (+++)
CQ 270/ 7	70 - 84	14	11	22	36	41 (+), 42 (++), -	-, -, 53 (++)
CQ 270/ 6	84 - 104	20	11	21	36	41 (+++), 42 (+), -	51 (+), -, 53 (++)
CQ 270/ 5	104 - 125	21	14 (clayey, fibrous)	23	35	41 (+), 42 (++), -	51, -, 53 (++)
CQ 270/ 4	125 - 129	4	12 (FUSAIN)	24	36	-, 42 (++), -	-, -, 53 (+++)

continuation SOURIS RIVER MINE, TABLE 6

SAMPLE NO.	FROM TOP (cm)	THICK-NESS (cm)	LITHOTYPE CLASSES	LITHO-TYPES	LITHOTYPE - VARIETIES		
					INTENSITY + HUE OF COLOUR	EVIDENCE OF GELIFICATION	INCLUSIONS
CQ 270/ 3	129 - 138	9	11	22	36	41, (+++) 42, (++) -,	51, (+) -, 53 (+++)
CQ 270/ 2	138 - 157	19	12 (fibrous)	23	35	41, (+) 42, (++) -,	51, (+) -, 53 (++)
CQ 270/ 1	157 - 175	18	—— CLAY, SANDY ——				
CQ 270/14	175 - 180	5	13 (clayey)	22	36	41, (+++) 42, (+) -,	-, -, 53 (+)
CQ 270/15 " 16	180 - 220 220 - 254	40 34	11	21-22	36	41, (+++) 42, (+) -,	-, -, 53 (+++)
CQ 270/17	254 - 273	19	13(clayey)	22	36	41, (+++) 42, (+) -,	51, (+) -, 53 (+)
CQ 270/18	273 - 274	1	—— Siltstone	?			
CQ 270/19	274 - 292	18	14 (clay. pyrite fibrous)	23	36	41, (+++) 42, (+) -,	-, -, 53 (++)
CQ 270/20	292 - 347	55	12 (fibrous)	24	35	41, (+) 42, (+++) -,	51, (+) -, 53 (+)

SOURIS RIVER MINE, CQ 270

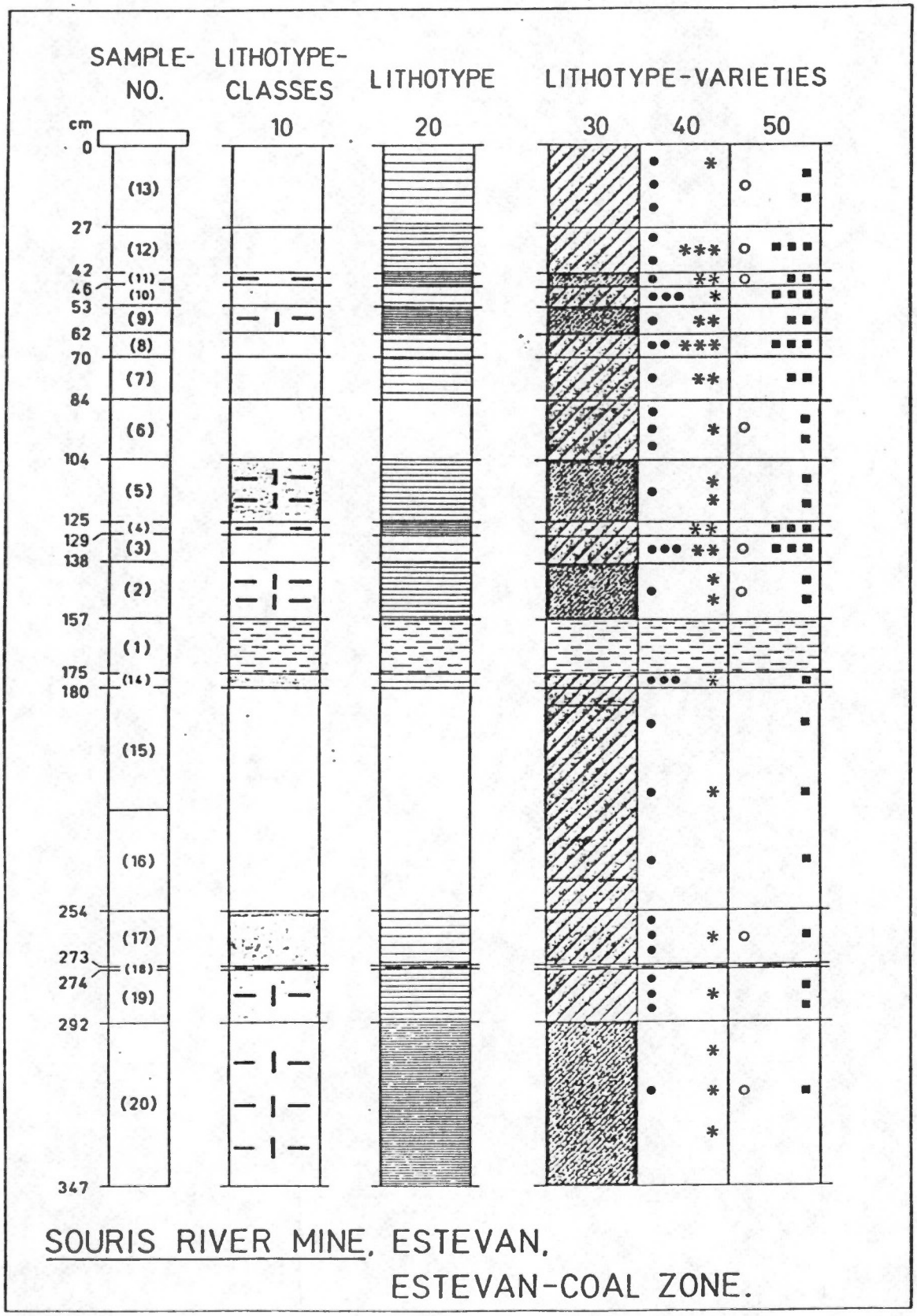
TABLE 7 :
Additional remarks

Sample no.	from Top (cm)	
(13)	0 - 27 :	Very compact coal with some relatively broad, gelified tissues and tiny fusinitizised tissues; the coal shows a conchoidal fracture.
(12)	27 - 42 :	This lithotype has a similar composition as sample no.13, it only possesses more gelified and fusinitized tissues.
(11)	42 - 46 :	This sample has xylites which are about 2cm wide, apart from that, there are no important changes.
(10)	46 - 53 :	There are no broad xylites, as there were in sample no.11; on the other hand partly very compact coal.
(9)	53 - 62 :	Similar to sample no. 11: about 3cm wide xylite-layers, also groundmass with some gelified tissues and charcoal-fragments.
(8)	62 - 70 :	The gelified tissue is up to <0.5cm in diameter; the content of moderately banded coal is higher.
(7)	70 - 84 :	There are some single gelified tissues (ca. 0.5cm), but a groundmass with smaller gelified tissues and charcoal-fragments predominates.
(6)	84 - 104:	Compact coal, formed by some single gelified tissues (up to 1mm in diameter) and numerous tiny fusain-fragments.within a dull groundmass. Macroscopically it should be classified as unbanded coal.

Sample no.	from Top (cm)	
(5)	104 - 125:	Little contamination by clay; xylites up to 1.5cm wide; otherwise an unbanded to moderately banded groundmass with a lot of tiny charcoal-fragments.
(4)	125 - 129:	Fusain-horizon, containing also charcoal-xylites.
(3)	129 - 138:	A groundmass with numerous mostly tiny charcoal-fragments and single gelified tissues.
(2)	138 - 157:	Up to 1.5cm broad xylites, partly with resin bodies; but also a groundmass with charcoal tissues and gelified tissues.
(1)	157 - 175:	C L A Y (sandy)
(14)	175 - 180:	Altogether very compact coal, which is contaminated by clay in lenses and layers.
(15) (16)	180 - 220 220 - 254	Apparently an absolutely unbanded coal does not exist; nevertheless it has to be classified as unbanded or moderately banded coal, in spite of numerous tiny charcoal-fragments.
(17)	254 - 273:	The groundmass is contaminated by clay. There are some wide, gelified tissues next to very tiny fusain-fragments. Resin bodies occur in form of nests.

ontinuation SOURIS RIVER MINE, CQ 270

ample no.	from Top (cm)	
(18)	273 - 274:	Siltstone, mixed with charcoal; no signs of a Kaolin-Coal Tonstein.
(19)	274 - 292:	Up to 2cm broad xylites; coal contaminated on cracks; otherwise very compact, with gelified tissues and charcoal.
(20)	292 - 347:	With broad and more numerous xylites than in sample no. 19; the groundmass consists of moderately banded as well as banded coal; together with the xylites it has certainly to be classified as highly banded coal.



SOURIS RIVER MINE, ESTEVAN,
ESTEVAN-COAL ZONE.

Fig. 10

(c) BOUNDARY DAM MINE, PROBABLY SOURIS COAL ZONE

68 % xylitic coals, from which about 70% are contaminated;

54 % of the coal seam are unbanded to moderately banded lithotypes;

The occurrence of petrified wood within this section is noteworthy (see table 8, 9 and Fig. 11).

JNDARY DAM MINE, ESTEVAN, PROBABLY SOURIS COAL ZONE,
RAVENSCRAG FORMATION, PALEOCENE

TABLE 8

AMPLE NO.	FROM TOP (cm)	THICK-NESS (cm)	LITHOTYPE CLASSES	LITHO-TYPES	LITHOTYPE - VARIETIES		
					INTENSITY + HUE OF COLOUR	EVIDENCE OF GELIFICATION	INCLUSIONS
) 283/1	-	-	CLAY WITH SHELLS				
) 283/2	0 - 13	13	14 (clayey, fibr. weathered!)	22-23	36	41, (+) 42, (++) -,	-, -, 53 (+++)
) 283/3	13 - 32	19	14 (petrif. wood, pyrit.)	24	35	-, 42, (++) -,	-, -, 53 (+)
) 283/4	32 - 62	30	14 (pyrit. fi-brous)	23	36	41, (+) 42, (++) -,	-, -, 53 (+++)
) 283/5	62 - 88	26	13(pyrit. Fusain-layers)	22	36	41, (++) 42, (+) -,	-, -, 53 (+++)
) 283/6	88 - 109	21	14 (pyrit. fi-brous)	23	35	41, (+) 42, (++) -,	-, -, 53 (++)
) 283/7	109 - 137	28	11	21-22	36	41, (++) 42, (+) -,	-, -, 53 (+)
) 283/8	137 - 146	9	12 (fibrous)	23	35	41, (+) 42, (++) -,	-, -, 53 (+)
) 283/9	146 - (? 24 cm)	24	12 (fibrous)	22-23	35	41, (++) 42, (+++) -,	-, -, 53 (++)

Boundary DAM MINE, CQ 283

TABLE 9 :
Additional remarks

Sample no.	from Top (cm)	
(2)	0 - 13 :	This lithotype is weathered, because within the seam section the coal has fallen into pieces already; the imbricated fracture of this coal signifies a high content of tissues.
(3)	13 - 32 :	A coal composed of almost pure xylite-layers; some xylites are petrified.
(4)	32 - 62 :	Compact xylitic coal; the groundmass is moderately banded as well as banded. This lithotype has much charcoal, and a broad fusain layer (ca. 3 cm) appears at the bottom.
(5)	62 - 88 :	This lithotype is similar to sample no.4, only the xylites are missing. Characteristic of this lithotype variety are several (1cm) wide fusain-layers.
(6)	88 - 109:	Compact xylitic coal, containing coppercoloured pyrites. Most of the groundmass is moderately banded, but because of the xylites which were found this lithotype has to be classified as banded coal.
(7)	109 - 137:	Very compact, non-xylitic coal in which only single broad gelified tissues occur.
(8)	137 - 146:	Xylite-layers with broad gelified tissues; in between some groundmass.

ample no.	from Top (cm)	
(9)	146 - 170	Next to xylites and broad gelified tissues in the groundmass there are tiny charcoal-fragments.

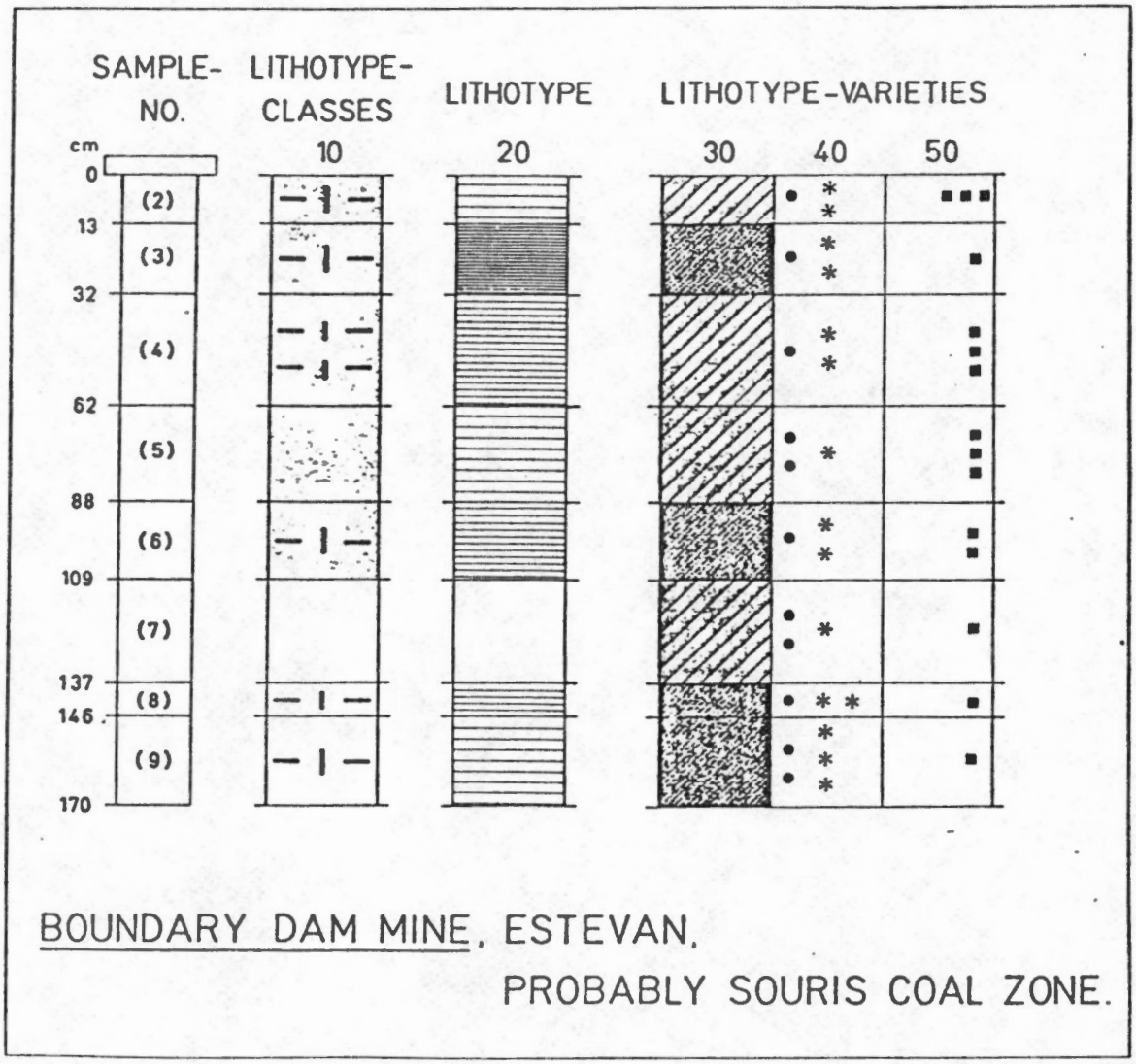

SAMPLE-NO.
LITHOTYPE-CLASSES
LITHOTYPE
LITHOTYPE-VARIETIES
cm
0
13
32
62
88
109
137
146
170
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
10
20
30
40
50
BOUNDARY DAM MINE, ESTEVAN,
PROBABLY SOURIS COAL ZONE.

Fig. 11

(d) BIENFAIT COAL MINE, ESTEVAN COAL ZONE

Only two small layers of non-xylitic, contaminated coal occur (= 11%);

Consequently, 89% of this seam are xylitic coals, from which 59% are contaminated, in the upper part of the seam mainly by pyrite;

There is one small layer of moderately banded coal (= 7%);

38% banded coals and 55% highly banded coals - that is together 93% - was found (see table 10, 11 and Fig. 12).

Furthermore, we can point out that there is a correlation between the occurrence of xylites and plant tissues: xylitic coals are mostly composed of banded or highly banded lithotypes.

IENFAIT COAL MINE, BIENFAIT, ESTEVAN COAL ZONE,
RAVENSCRAG FORMATION, PALEOCENE

TABLE 10

SAMPLE NO.	FROM TOP (cm)	THICK-NESS (cm)	LITHOTYPE CLASSES	LITHO-TYPES	LITHOTYPE - VARIETIES		
					INTENSITY + HUE OF COLOUR	EVIDENCE OF GELIFICATION	INCLUSIONS
CQ 284/ 2	0 - 10	10	14 (pyrit. fi-brous)	23	36	41, (++) 42, (+) -,	-, -, 53 (+)
CQ 284/ 3	10 - 20	10	13 (clayey, pyritic)	22	36	41, (++) 42, (++) -,	-, -, 53 (++)
CQ 284/ 4	20 - 41	21	14 (clay. pyrit. fibrous)	23	35	41, (+) 42, (++) -,	-, -, 53 (+)
CQ 284/ 5	41 - 70	29	12 (fibrous)	23	35	41, (++) 42, (+++) -,	-, -, 53 (+++)
CQ 284/ 6	70 - 76	6	14 (pyritic, fibrous)	24	35	41, (+) 42, (+++) -,	51, (++) -, 53 (+)
CQ 284/ 7	76 - 94	18	13 (clayey)	22	36	41, (++) 42, (+) -,	-, -, 53 (++)
CQ 284/ 8	94 - 103	9	14 (clay. pyrit. fibrous)	24	35	41, 42, (++) -,	-, -, 53 (+)
CQ 284/ 9	103 - 126	23	14 (clay. pyrit. fibrous)	24	35	41, (+) 42, (+++) -,	-, -, 53 (+)
CQ 284/10	126 - 155	29	14 (clay. pyrit. fibrous)	23	36	41, (++) 42, (+++) -,	-, -, 53 (+++
CQ 284/11	155 - 176	21	12 (fibrous)	24	35	41, (+) 42, (+) -,	-, -, 53 (+)

continuation BIENFAIT COAL MINE, TABLE 10.

SAMPLE NO.	FROM TOP (cm)	THICK-NESS (cm)	LITHOTYPE CLASSES	LITHO-TYPES	LITHOTYPE - VARIETIES		
					INTENSITY + HUE OF COLOUR	EVIDENCE OF GELIFICATION	INCLUSIONS
CQ 284/12	176 - 219	43	12 (fibrous)	24	35	41 (+), 42 (+), -	51 (+), -, 53 (+++)
CQ 284/13	219 - 260 ?	39	14 (clayey, fibrous)	24	35	41 (++), 42 (++), -	-, -, 53 (+++)

BIENFAIT COAL MINE, CQ 284

TABLE 11:
Additional remarks

Sample no.	from Top (cm)	
(2)	0 - 10 :	Compact coal; the groundmass is to be classified as banded coal, partly because of broad, closely packed bright tissues. An only moderately banded groundmass predominates. Together with the numerous xylites this lithotype can be defined as a banded coal.
(3)	10 - 20 :	This lithotype is darker than sample no. 2 because of more charcoal-fragments (and probably more pyrite).
(4)	20 - 41 :	Apart from the contamination by clay, there is also a contamination by pyrite, only single charcoals occur.
(5)	41 - 71 :	This lithotype contains more xylites and gelified tissues than sample no. 4, and also more charcoals.
(6)	70 - 76 :	Xylite-layers and only little moderately banded groundmass; single xylites with resin bodies.
(7)	76 - 94 :	Without xylite; but contaminated by clay. Groundmass partly unlayered, but because of many tiny charcoal-fragments and few gelified tissues; this coal has to be classified as moderately banded.
(8)	94 - 103:	Contamined xylite-layers with only little groundmass.

ample no.	from Top (cm)	
(9)	103 - 126:	This lithotype is similar to sample (8); there only are even more xylites.
(10)	126 - 155:	Apart from xylite-layers, a groundmass with high content of charcoal occurs.
(11)	155 - 176:	Here even broader xylite-layers than in sample no. 10, for that reason less content of charcoal, and also less pyrite.
(12)	176 - 219:	Next to xylites and gelified tissues a very particular groundmass with very many charcoal-fragments could be seen.
(13)	219 - 260 ?	This lithotype is very similar to sample no. 12, but is in contrast to sample no. 12 contaminated by clay.

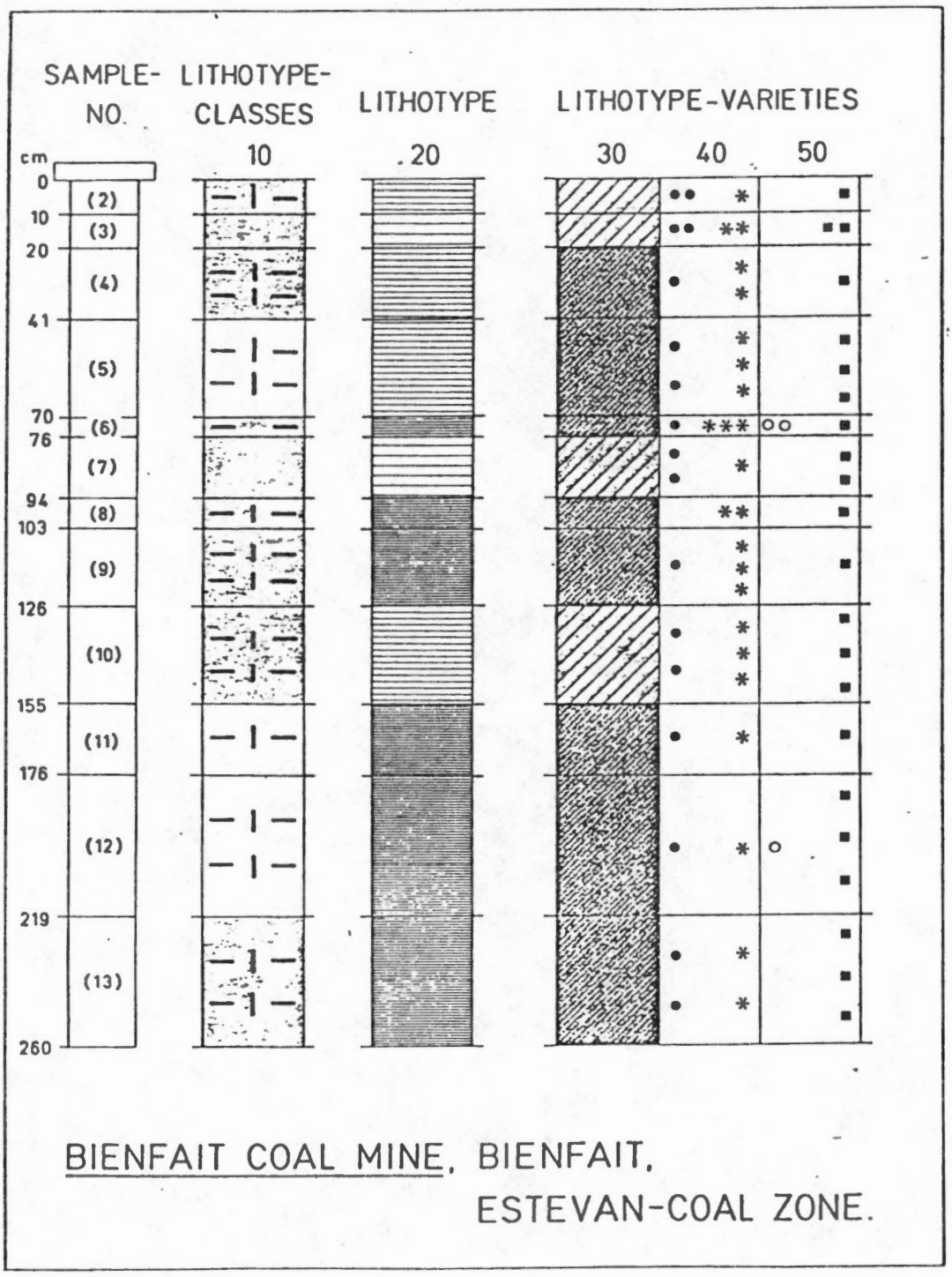

SAMPLE-NO.
LITHOTYPE-CLASSES
LITHOTYPE
LITHOTYPE-VARIETIES
10
20
30
40
50
cm
0
10
20
41
70
76
94
103
126
155
176
219
260
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
(10)
(11)
(12)
(13)
BIENFAIT COAL MINE, BIENFAIT,
ESTEVAN-COAL ZONE.

Fig. 12

4.3 Differences in identification of lithotypes of low and high rank soft brown coals

The differences in identification of lithotypes of low rank soft brown coals (lignite B) and high rank soft brown coals (lignite A) can be summarized as follows:

While the presence of xylite and/or the contamination by minerals can easily be recognized, it is in some cases difficult though still possible to differentiate between the groundmass and the plant remains. As a matter of fact, this is due to the rank of the coal which makes it appear dense, ± homogenous and dark-black.

The main differences are shown within the column 'lithotype-varieties':

(a) differences in intensity and hue of colour can neither be recognized during the field nor the laboratory identification of wet coal; only the xylites seem to be somewhat more dark-brown in contrast to the dark-black groundmass and plant tissues. Within the latter the groundmass is dull and the gelified tissues are mostly bright.

Additional measurements of remission (diffuse reflectance) of really freeze-dried coal disks show that there is a difference in the intensity of colour between the two measured samples (see table 12). These differences can clearly be recognized in the gelified groundmass with a value of 29 and 26 respectively.

TABLE 12

Measurements of Remission (Diffuse Reflectance)

of Freeze-Dried Coal Disks at a Wavelength of 546 nm

(in arbitary values)

a) 269/13 Hartseam, Coronach

gelified groundmass: 28 / 29 / 28/ 29 / 28 / 29 /
30 / 30 / 30 / 31 / 27 /

Ø = 29

ungelified or only moderately gelified tissues:

37 / 40 / 38 / 41/ 44 / 42 / 42
35 / 36 / 37 / 36 / 39 / 42

Ø = 39

b) 284/4, Estevan Coal zone, Bienfait

gelified groundmass: 25 / 24 / 28 / 26 / 25 / 27 / 29 /
27 / 26 / 27 / 24 / 24 / 26 / 27 /
24 / 23 / 25 / 28 / 25 / 26 /

Ø = 26

ungelified or only moderately gelified tissues:

37 / 38 / 43 / 44 / 35 / 41 /
37 / 35 / 45 / 42 / 44 / 35 /
38 / 38 / 43 / 37 / 38 /

Ø = 39

charcoal: 18 / 20 / 14 / 15 / 20 / 23 / 22 / 24 / 20 / 21 / 20 /
23 / 22 / 24 / 25 / 14 / 15 / 20 / 22 /

Ø = 20

(b) Within the column 'evidence of gelification' no differentiation can be made between several degrees of intensity of gelification. The whole groundmass and all plant remains (i.e. tissues) are highly gelified; only the broad, dark-brown xylites show a lower degree of gelification.

Consequently, it is only possible to estimate the content of gelified plant remains and gelified groundmass; granular humic gel particles cannot be identified either.

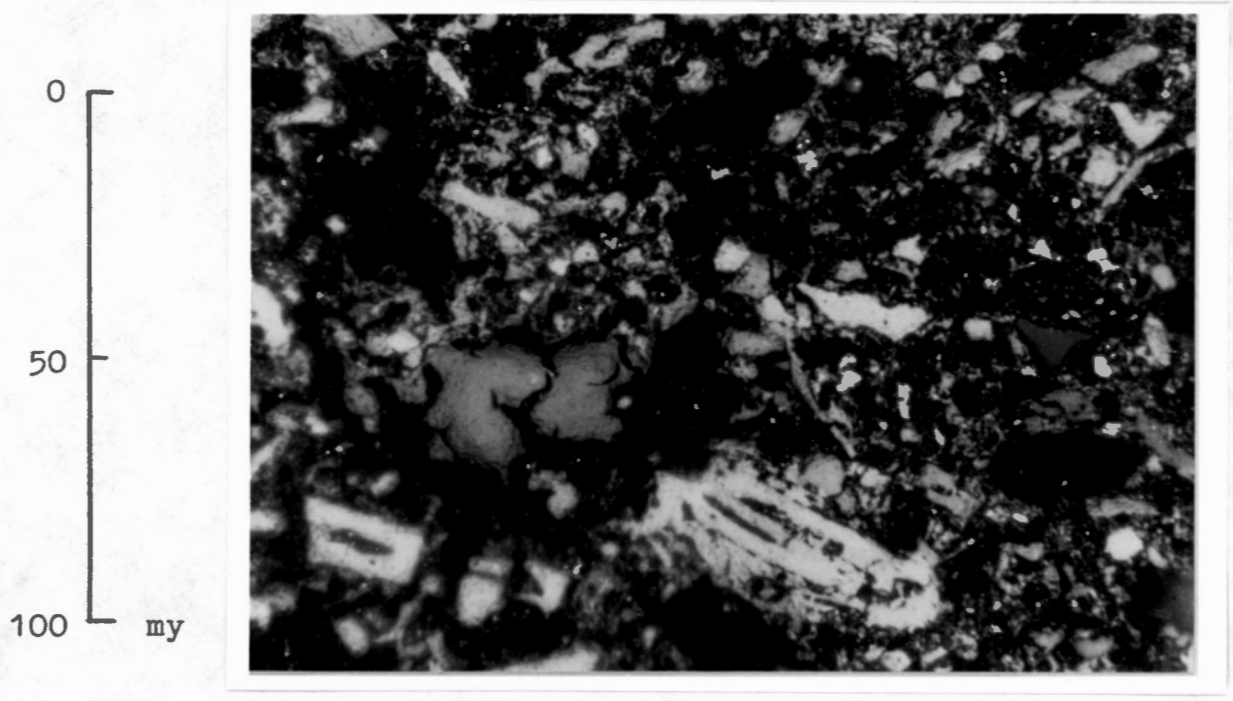
(c) Within the column 'inclusions' cuticles cannot be identified any longer, whereas resin bodies and charcoals in the wet lignites can still easily be recognized.

4.4 Microscopic Examination of the Lithotypes

In order to avoid misunderstandings which may arise, I would like to emphasize the fact that a strong correlation between lithotypes and microlithotypes (that means an association of macerals) cannot be expected. Past experience has shown that within the unbanded and moderately banded coals on one hand, and the banded and highly banded coals on the other, certain microlithotypes can dominate.

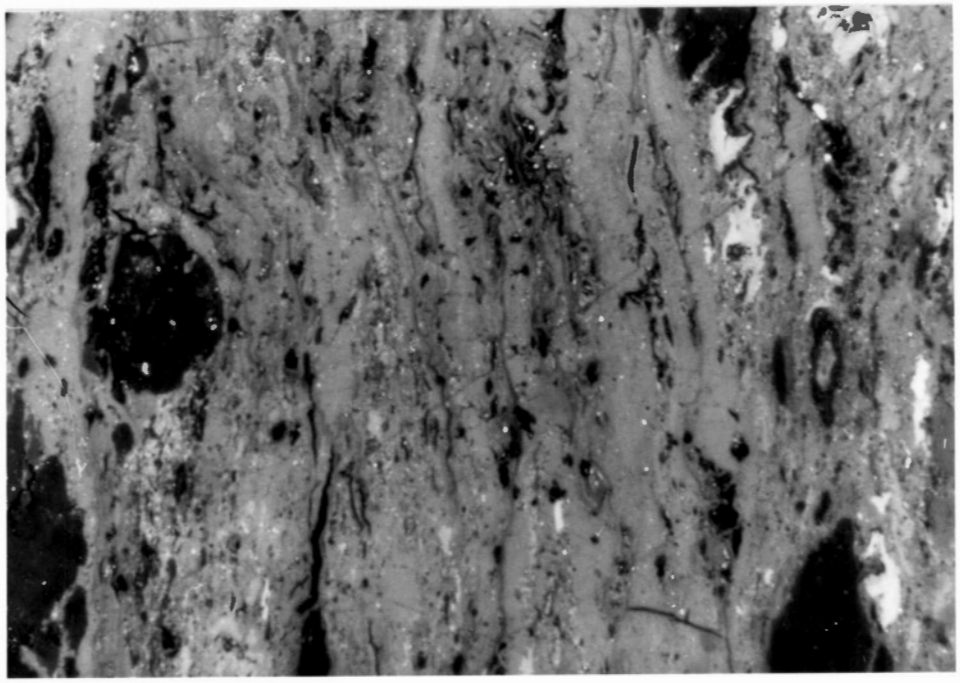
In the group mentioned first it can be seen that the groundmass can be composed of various elements:

(a) A close intergrowth of clay with the organic material. The striking thing about it is that the organic particles are composed of cornered fusinite- and semifusinite splitters (see Fig. 13):



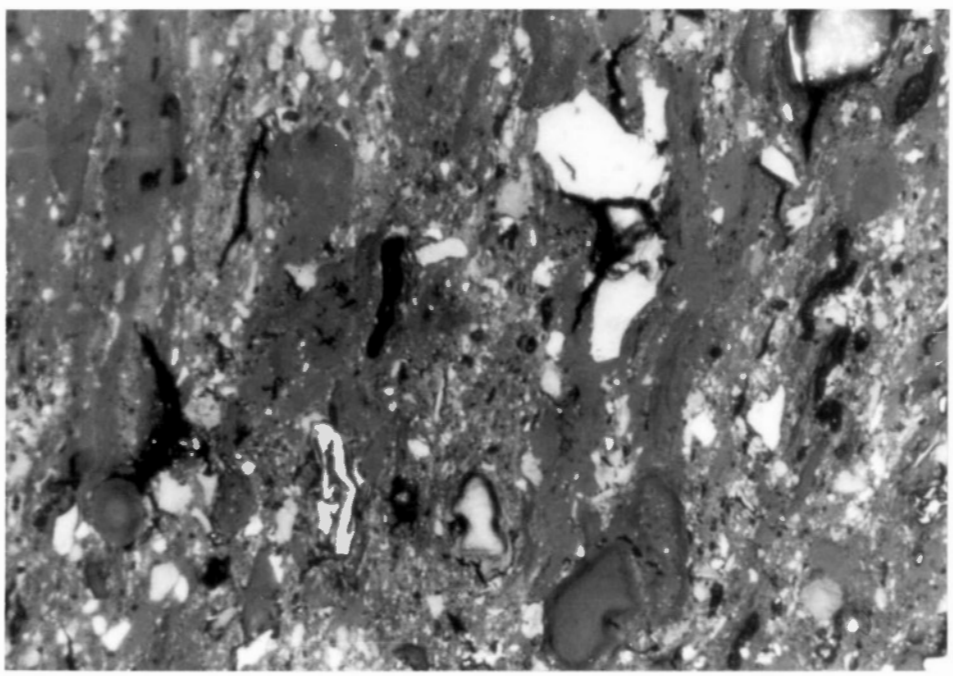
pellet no. 327/80, sample no. CQ 269/19

(b) a detritus enriched by liptinite with a different content of inertodetrinite (LIPTO-HUMODETRITE or INERTO-HUMODETRIT), see figs. 14 a and b:



pellet no. 330/80, sample no. CQ 270/7

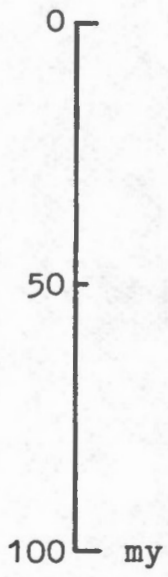
Fig. 14 a

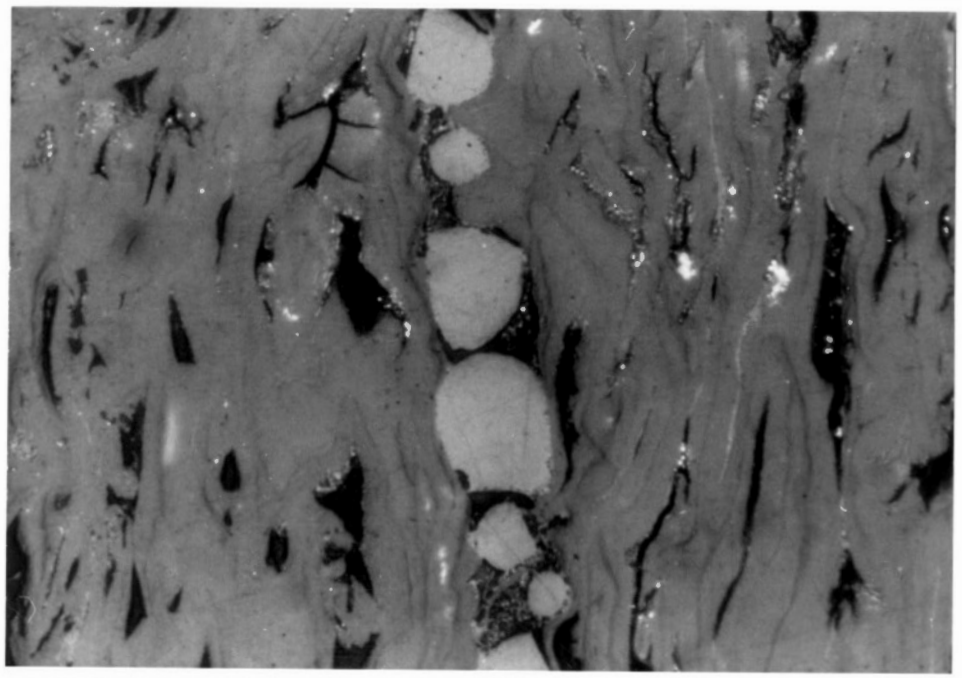


There is a big range of change between both types which are very abundant and differ very much from each other.

Likewise, various associations of macerals can be distinguished within the banded and highly-banded lithotypes.

(c) To begin with, I would like to mention those tissues with different cell structure which can be described almost always as eu-ulminite and only in very few cases as texto-ulminite. Textinite are missing absolutely (see Figs. 15-17):





pellet no. 326/80, sample no. CQ 269/17

Fig. 15

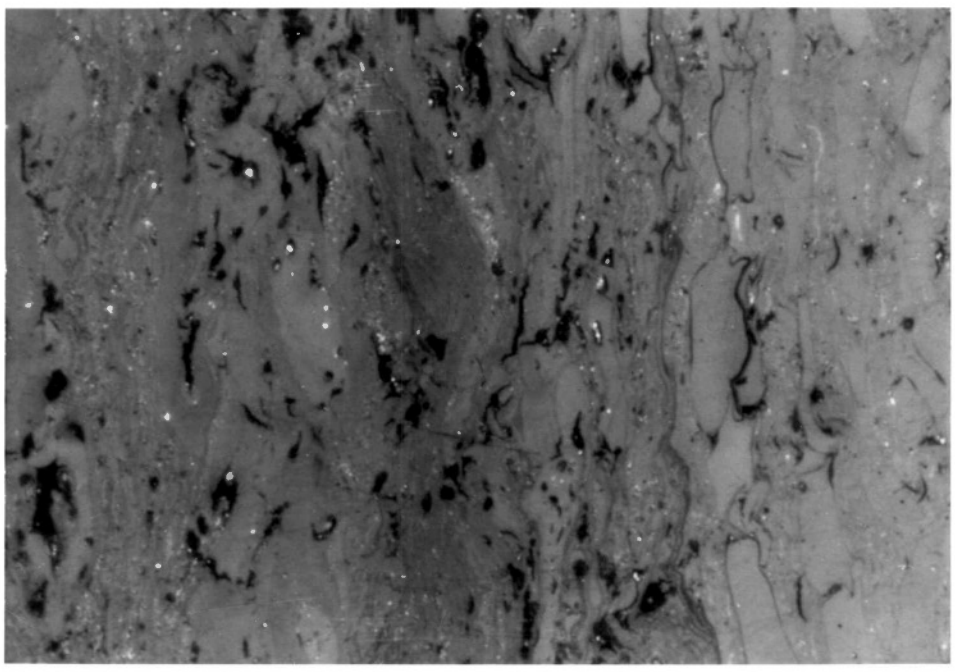
0

50

100 my

pellet no. 326/80, sample no. CQ 269/17

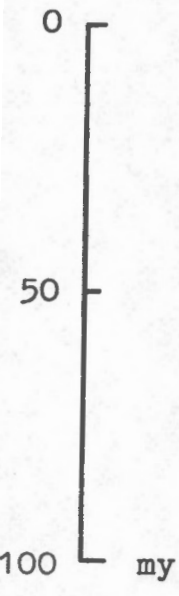
Fig. 16

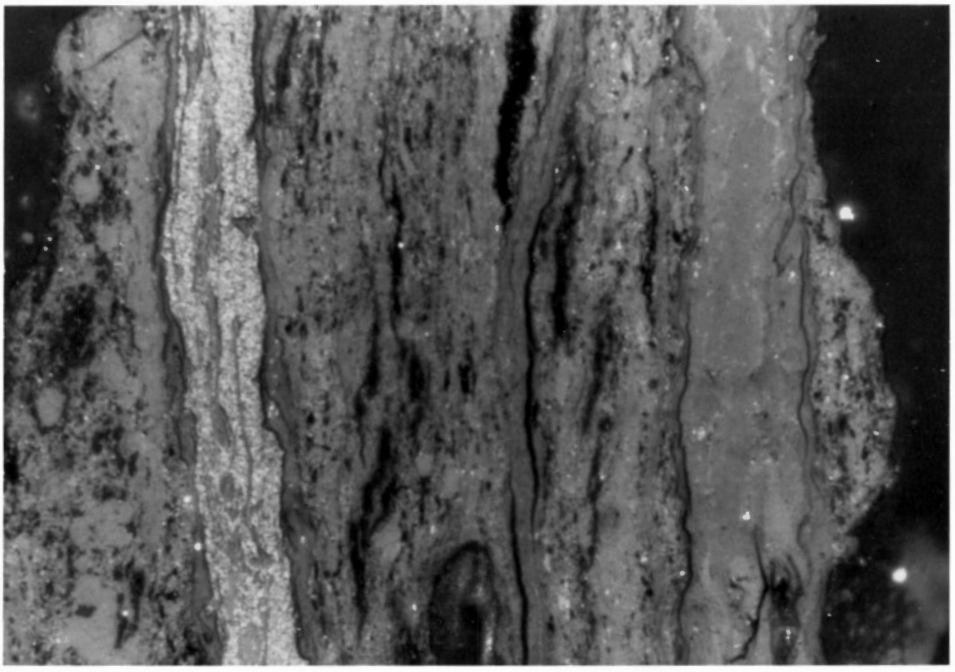


pellet no. 332/80, sample no. CQ 270/9

Fig. 17

In some lithotypes occur also eu-ulminites of which probably the cell-luminas contain micrinite (see fig. 18):

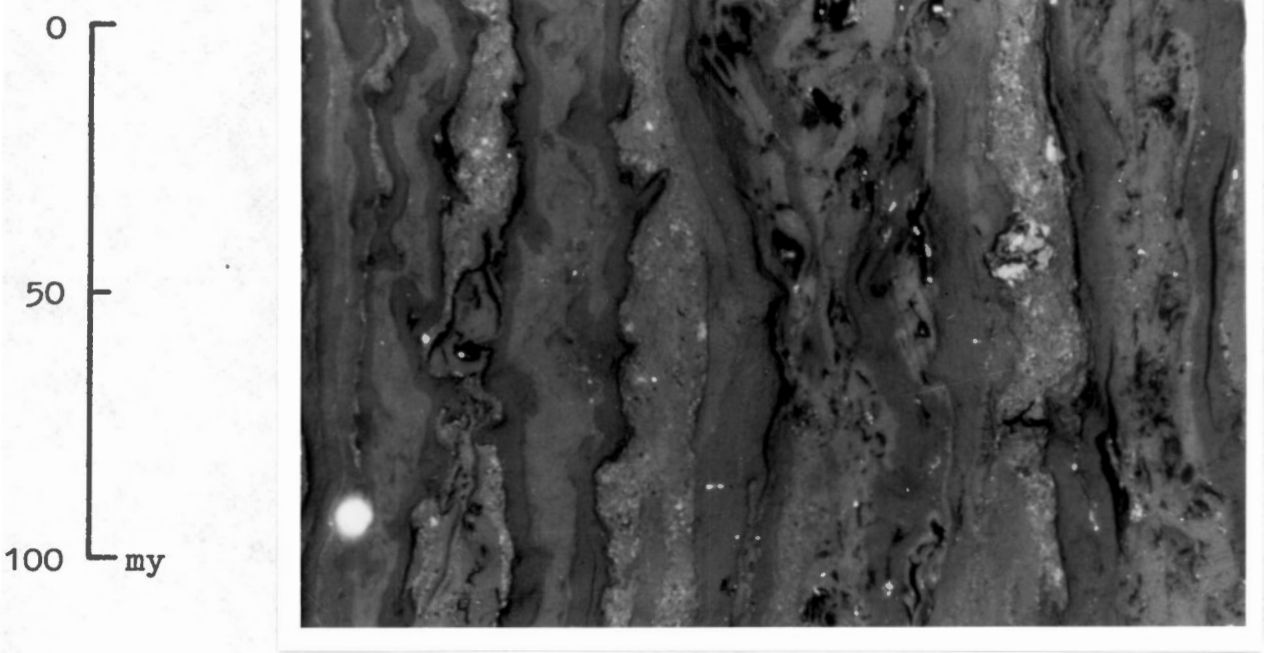




pellet no. 315/80, sample no. CQ 269/18$_2$

Fig. 18

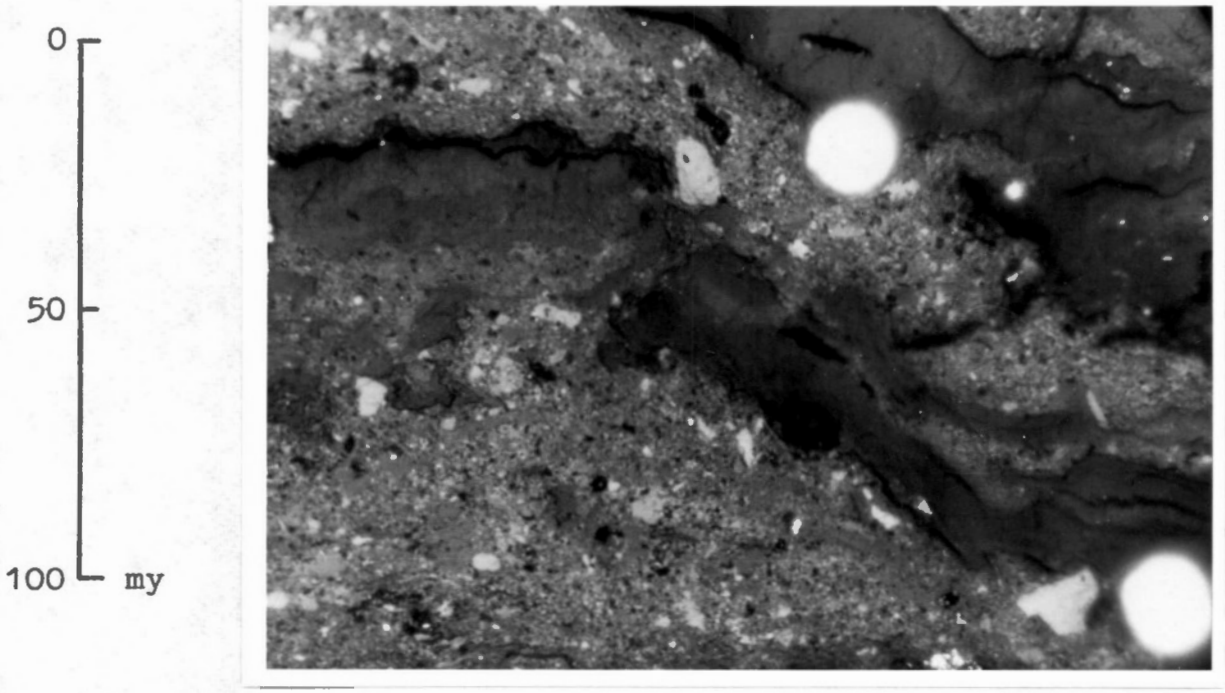
(d) A LIPTO-HUMOTELIT which is composed of eu-ulminite and cutinite occurs quite often too. It might probably be a leave-horizon (see Fig. 19).



pellet no. 333/80, sample no. CQ 270/11

Fig. 19

(e) A typical association which mostly exists in the upper part of the Bienfait Coal seam is a minerite or carbominerite, which are composed of LIPTO-HUMODETRITE with high contents of pyrite (see fig. 20):



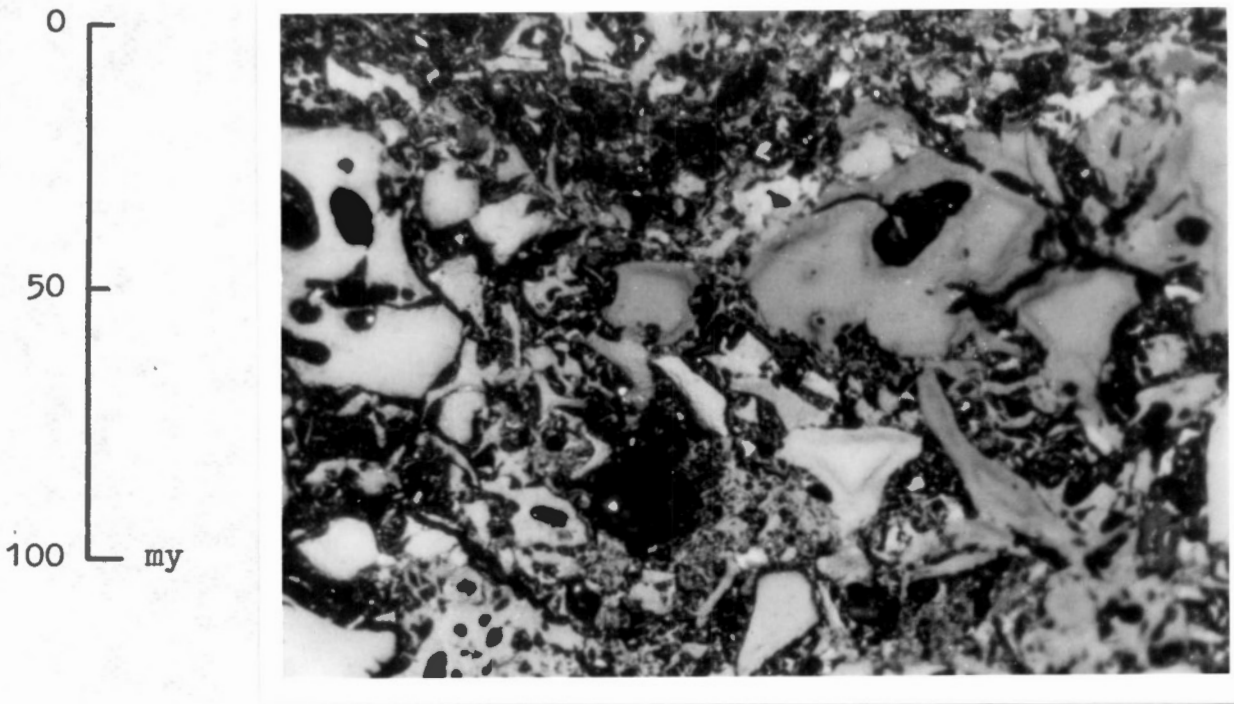
pellet no. 339/80, sample no. CQ 284/2

Fig. 20

(f) The numerous fusain layers which are very abundant in the lignites of Southern Saskatchevan give another extreme example of the highly banded lithotypes (see fig. 21).

When observed under the microscope an association of humotelinite, humodetrinite, semifusinite, fusinite, inertodetrinite and liptinite can be perceived. The content of semifusinite is highly dominating. The association of all these macerals underline the suggestion that these lithotypes are accu-

mulated under aquatic conditions, that means perhaps below a high groundwater level.



pellet no. 333/80, sample no. CQ 270/11

Fig. 21

At last, I would like to summarize some unusuals features:

(1) On the whole, a high content of inertinite which can be enriched very often in certain layers.

(2) The content of gelinite is relatively low. There is of course, a problem to identify clearly the gelinite, because we can regard it either as eu-ulminite or as densinite. There is no problem to make a good identification when there are crackings caused by the shrinking of the coal.

(3) In some detrite you find a high content of liptinite which are easy to be seen in fluorescence-light.

There are figured liptinites, such as sporinites, resinites and cutinites, as well as unfigured liptinites, such as exsudatinites, and probably some 'waxes' within the cell luminas.

4.5 Reflectance measurements of macerals of the huminite group

The result of the reflexion measurments of different macerals of the huminite-group have been summarized in table 13:

(a) as you can see, the Hartseam from Coronach has lower reflectance values than the Estevan coal: for the densinite we get values between 0.29-0.32% in contrast to 0.36-0.41% for the Estevan coal.

(b) From the few measurements we have got, we can hardly decide which maceral can be used for rank determination. The most convenient macerals will be eu-ulminite because it occurs in nearly every sample.

(c) A comparison of the results of the reflectance measurements done by A. Cameron and me showed corresponding results.

TABLE

	TEXTINITE B	TEXTO-ULMINITE A	TEXTO-ULMINITE B	EU-ULMINITE A	EU-ULMINITE B	DENSINITE	GELINITE	CORPO-HUMINITE	SEMIFUSINITE	FUSINITE
CQ 269/17, CORONACH	-	-	-	0.22	0.33	0.32	0.34	0.33	0.42	>0.60
CQ 270/16, ESTEVAN	-	0.31	-	0.31	0.39	0.38	-	0.43	>0.60	>1.0
CQ 270/9 , ESTEVAN	-	0.35	-	0.28	0.38	0.38	0.39	-	>0.50	>1.0
CQ 270/4 , ESTEVAN, Fusain	-	-	0.40	0.33	-	-	-	-	0.66	1.09
CQ 270/10, ESTEVAN,	-	0.35	-	0.35	-	0.39	0.39	~0.41	≳0.52	>1.00
CQ 270/11, ESTEVAN,	-	-	0.41	0.33	-	0.38	0.40	~0.40	>0.60	>1.00
CQ 269/18$_2$, Coronach	-	0.33	0.43	0.26	0.35	0.31	0.40	0.40	-	>1.00
CQ 269/1 , Coronach	-	0.25	-	-	0.32	0.30	0.41	0.40	-	-
CQ 269/2 , Coronach	-	-	0.31	0.24	-	0.29	-	0.35	-	-
CQ 269/19 , Coronach	-	-	-	0.28	-	0.30	-	-	-	-
CQ 270/7 , ESTEVAN	-	-	-	-	0.42	0.41	0.45	-	-	-
130/80 R- Glen D ?	-	-	0.35	0.21	0.33	0.28	-	0.37	-	-
138/80 unnamed	-	-	0.38	0.29	-	0.33	0.36	0.41	-	-
201/80, Estevan 60, Boundary F-G	-	0.34	0.40	-	0.43	0.36	0.47	0.46	-	-

5.0 Summary

The lignites of Willow Bunch and Estevan area, Southern Sakatchevan, show that within the lithotype-classes the xylitic coals are dominating; besides that, many samples are also contaminated by clay. Within the lithotypes the unbanded ones are very rare and only a few moderately banded lithotypes occur. Altogether, the banded and highly banded coals dominate. The striking thing about the lithotype-varieties is a relatively high content of charcoal in most samples.

The main difference in identification of lithotypes of lignite A in contrast to lignites B appears within the lithotype-varieties: difference in intensity of colour can neither be recognized during field nor laboratory identification on wet coal. Several additional measurements of the remission (diffuse reflectance) of freeze-dried coal disks show that there is a difference in intensity of colour between the single particles of the measured samples.

Microscopic examination of the lithotypes showed that certain microlithotypes can dominate within the unbanded and moderately banded coals on the one hand, and the banded and highly banded coals on the other hand. Furthermore, a high content of inertinite and a very low content of gelinite seems to be typical of these lignites.

The results of the reflectance measurements of various macerals of the huminite group indicate that the Hart-seam from Coronach has, all in all, lower values than the Estevan coal, which means that it is of a lower rank.

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MACROPETROGRAPHIC EXAMINATION AND COLLECTING SAMPLES FROM CORES STORED AT THE HAT CREEK MINE SITE, B.C.

R E P O R T N O . 2

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INTRODUCTION

Examination and collection of samples from cores stored at the Hat Creek mine site (lignitic to subbituminous coals) was done during a two days' field trip on October 1st and 2nd. Intensive drillings and geophysical surveys have taken place here during the last years sponsored by the British Columbia Hydro- and Power Authority.

Macropetrographic Description of Lithotypes

Macroscopically, the examined coal has a relatively uniform appearance from the top of the seam to the bottom (ca. 500m) apart from numerous contaminations and partings. Most common is a moderately banded coal which is composed of a dull groundmass with tiny inclusions of bright gelified plant remains (i.e. tissues). Besides that, there is found a dull unbanded coal and, on the other hand, a bright banded or highly banded coal consisting of xylite and/or broad gelified tissues. Furthermore, there can frequently be found a lithotype-variety with a high content of resin bodies.

To sum it up, it can be said that the classification of lignites (see report 1) can be applied for those Hat Creek coals even if there are some transitions to hard coals.

From the top to the bottom of the seam the reflectivity increases from 0.35 to 0.50% (D. MARCHIONI, 1979). This corresponds to an increase in rank from lignite A to subbituminous coal. Unfortunately, this change in rank could not be observed macroscopically.

SAMPLES (see table 1)

(a) TRENCH 1, No. 1 Deposit

3 samples were taken from the coal of zone B, about 3-4 m above the basis of the coal of zone C and also about 1 m below the burned zone.

(b) Core DDH 106

2 samples were taken from the upper part of the coal of zone A and from the lower part of the coal of zone D at about 1650' = 503 m depth.

(c) Core DDH 76 - 136

An intensive sampling has taken place in core section DDH 76-136 where 23 samples from different coal zones have been taken. Due to the lack of time, it was not possible to measure the following bands of lithotypes within the seam section exactly.

From the upper and lower part of zone A1, from zone A2, B, C and the upper and lower part of zone D three macropetrographically distinguishalbe lithotypes have been collected:

(a) dull moderately banded coal (called detritic);

(b) bright banded or highly banded coal (here called xylitic), and

(c) moderately banded coal with a high content of resin bodies (called resinitic).

TABLE 1

SAMPLES HAT CREEK, 1./2. Oct. 1980.

No. (8) } TRENCH 1, coal of zone B, 3-4 m above basis, ± xylitic

No. (9) } TRENCH 1, detritical

No. (10) TRENCH 1, 1 m below burned clay-zone.

No. (11) Core store DDH 106, upper part of zone A,

No. (12) Core store DDH 106, lower part of zone D, 1650' = 503 m.

No. (13) core store DDH 76-136, Cross section 'R'

zone A 1 upper part 275.5' - 516' (= 84-157 m)

(13) detritic (dull banded) (14) xylitic (bright or banded) (15) resinitic

- - - zone A 1 lower part 516'-792' (= 157-241 m)

(16) detritic (17) xylitic (18) resinitic

- - - zone A 2 792' - 875' (= 241 - 267 m)

(19) detritic (20) xylitic (21) resinitic

- - - zone B upper part, 875' - 995' (= 267 - 303 m)

(22) detritic (23) xylitic (24) resinitic

- - - zone B lower part, 995' - 1123' (= 303 - 342 m)

(25) detritic (26) xylitic (27) resinitic

- - - zone C 1123' - 1330' (= 342 - 405 m)
up to 1176' only clastic sediments

(28) detritic (29) xylitic (!) no resinite found

- - - zone D upper part, 1330' - 1477' (= 405 - 450 m)

(30) detritic (31) xylitic (32) resinitic

- - - zone D lower part, 1477' - 1636' (= 450 - 499 m)

(33) detritic (34) xylitic (35) resinitic

3	samples
2	"
23	"
28	samples