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ANNOTATION, ERROR ANALYSIS AND ADDENDA TO SCHEFFERVILLE PERMAFROST DATA FILE, VOL I, SUMMARY & INDEX

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ABSTRACT

The series of 17 further reports outlined completes the collection and collation of permafrost ground temperature information from the Schefferville area. Thermocable data is presented for some 230 sites along with maps and stereophotos showing locations, geology, geological cross-sections. An extensive index to the entire series and a catalogue of reports and papers are provided. The entire collection is available through the Earth Physics Branch on microfiche.

RESUME

La série de 17 volumes supplémentaires décrits dans ce rapprot termine le rassemblement et la collation des données sur le pergélisol et les températures du sol dans la région de Schefferville. Des cartes et des stéréophotographes indiquant le lieu, la géologie et des coupes géologiques sont présentes pour quelques 230 emplacements, ainsi que des mesures de température du sol à ces endroits. Un index étendu de la série entière et une liste des rapports et des publications sont inclus. Tous les volumes de ce recueil sont disponibles sur microfiche à la Direction de la physique du globe.

ANNOTATION, ERROR ANALYSIS AND ADDENDA TO THE SCHEFFERVILLE PERMAFROST DATA FILE

VOLUME I

Summary and Index

compiled by

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We also wish to acknowledge the efforts of the many individuals who have over the years contributed to permafrost research at Schefferville and the efforts of many geologists and other professionals whose work is presented here. Only in a few cases has it been possible to acknowledge their contribution through direct reference to written reports and publications.

Funds for this project were made available through DSS Contract No. OST83-00302. Dr. Alan Judge of the Earth Physics Branch, Energy, Mines and Resources served as the Scientific Authority for the project but in addition provided much assistance and encouragement throughout the project.

We hope that the now relatively complete documentation of the permafrost research at Schefferville will amply recompense both the I.O.C.C. in particular and Canadians in general by preventing existing knowledge from being lost and by generating new knowledge through the research that the Schefferville Permafrost Data File will stimulate.

VOLUME I

SUMMARY AND INDEX

1.1 INTRODUCTION

1.1.1 BACKGROUND

The purpose of the work presented in this report is to provide background information that is essential for future users of thermocable data from some 25 years of permafrost research at Schefferville, Quebec. These data are contained in a previous report by Granberg et al (1983) and consist of a unique collection of ground temperature data from over 200 thermocable installations in a wide variety of terrain situations in the ridge areas west of Schefferville. The thermocable installations have been made and maintained by personnel of both the Iron Ore Company of Canada who have, until recently, carried out iron ore mining in the area, and by personnel of the McGill Subarctic Research Station in Schefferville who have been participating in the permafrost research.

There is a variable prevalence of permanently frozen ground in the Schefferville area with a relatively large percentage of the ridge terrain frozen. In lower, forested areas, permafrost is less common. The distribution of permafrost is controlled by a series of factors including snow cover, groundwater, microclimate and properties of the bedrock. The thermocable data were originally collected for the purpose of verifying whether permafrost was present in the ground or not; an essential information to the mining company. Permafrost greatly influences the physical properties of the ground and has a profound and multi-faceted influence on the different stages of the exploration and mining process. The thermocable records are therefore often of short duration, the data sets from individual cables do not coincide in time and the time interval between observations is uneven. Furthermore, the overall data set is biased towards ore deposits and towards areas within ore deposits where the presence of permafrost was suspected. These features of the data set do not reduce its usefulness, however, they do impose restrictions on the analytical procedures that can be applied.

In the extremely variable terrain conditions that prevail at Schefferville the nature of the permafrost conditions at any given cable site depends strongly on the local environment. It is therefore important that the conditions affecting any given thermocable site be considered in any analysis of the data set. In this report an attempt has been made to collate a package of background data which includes the essential terrain information. It has not been possible to include all the available information, however. The reader should be aware that there exists much additional information in the form of large-scale aerial photographs taken for the purpose of geological exploration and mapping. Another important source of information is several years of sequence aerial photographs taken at different stages of the snowmelt period. Most of the ridge areas west of Schefferville have been covered by such aerial surveys which constitute a wealth of snowcover information.

1.1.2 ORGANIZATION OF THE REPORT

The auxiliary information compiled in this volume of the report includes detailed location maps showing the location of each thermocable in the terrain. The cable locations have been plotted on photomaps for easy reference to the terrain and to both stereophotographs, topographic maps and geological maps on the IOCC grid system. To facilitate analysis of terrain factors influencing the thermocable data, geological information is provided in Volumes II to V in the form of 55 geological maps and 149 geological cross-sections. Topographic maps of scale 1:2 500 and 1:10 000 are found in Volume VI. Volume VII contains a set of stereograms showing all permafrost research sites prior to disturbance by mining operations. Overlays to the stereograms provide information about the location of each thermocable in the terrain. A set of photographs showing the terrain from a more familiar perspective are also included in Volume VII in order to further inform about the character of the terrain and about other factors influencing the thermocable data. The drill logs of individual thermocable sites have been collated in order to provide detailed geological information for each drill hole. The drill logs are found in Volumes VIII to XI.

The work towards this report also includes a detailed scrutiny of the thermocable data set and correction of typographical and other easily corrected errors. Plots of the thermocable data are found in Volumes XII, XIII and XIV and annotation of the individual data sets are presented in Volume XV. That volume also lists the corrections that were made to the data set and includes annotations to the permafrost prediction maps that were included in Volume XXV of Granberg et al (1983). Volume XVI contains additional literature on permafrost research at Schefferville that was assembled during the course of the work and that had not been found and included in the previous report. Other addenda include data from 33 thermocables for which calibrations were found. An upgraded and corrected thermocable data file is available on flexible discs as Volume XVII of this report.

The tables of content of Volumes II to XVII of this report are included in Appendix I of this Volume. In order to provide an overview of available materials, the tables of content of Granberg et al (1983) are given in Appendix II.

1.2 THERMOCABLE INSTALLATIONS NEAR SCHEFFERVILLE

1.2.1 INTRODUCTION

Thermocables were usually installed to assess the absence or presence of permafrost in ore deposits. This gives a locational bias to the thermocable data set in that most of the data is from ore deposit areas where the thermal properties of the ground may differ substantially from the average. In addition, thermocables were usually only installed where there was a high probability that permafrost would be encountered. The data set therefore is not representative of all terrain conditions in the Schefferville area but is biased towards the alpine tundra environments which are well represented. There are not many data sets available for lowland, forested locations.

1.2.2 THERMOCABLE INSTALLATIONS

Three main types of thermocable installations have been used at Schefferville. Thermocouple cables were used from the start of permafrost research until about 1970 when they were discontinued in favor of thermistors. A large number of thermistor cables have been installed since then. The third type of thermocable is an antifreeze-filled plastic pipe installed in drill holes. The temperatures in the pipe are measured using a portable thermistor probe.

Thermocouple cables and their installation is described by Bonnlander and Major-Marothy (1957;1964). Temperature measurements were taken in the field using a portable Honeywell potentiometer. The accuracy of this instrument is 0.1 C under ideal conditions, however it is less accurate under actual field conditions (Franks, 1970; Granberg, 1972).

Annersten installed a thermistor cable at Ferriman 1 but the cable was destroyed shortly afterwards. After another unsuccessful attempt in 1969, the first installation of thermistor cables at Schefferville was made at the Timmins 4 site in 1971 (Granberg, 1971). Since then, thermistors have been used almost exclusively. Initially, Yellow Springs Instruments (YSI) epoxy bead thermistors, factory calibrated to an accuracy of 0.1 C were used. Subsequently, Fenwal glass probe thermistors (GB32P2) were employed. Both types were calibrated to an accuracy of better than 0.01 C. Calibration facilities were made available by the Heat Flow Group of the Earth Physics Branch, E.M.R., Ottawa. In later years, Fenwal Uni-Curve were used by the IOCC in their thermocable installations. These factory calibrated thermistors had an accuracy better than 0.1 C. In 1976 and 1977 UUD31J1 thermistors were used. From 1978 onwards a switch was made to the UUB31J1 type (G. Mihalovic, pers. comm.).

The cable installations in 1971 and early 1972 were made using a 12-conductor vinyl jacketed cable which, unfortunately became brittle at low temperatures. Two cables at Timmins 4, some six cables at Fleming 3 and the four Timmins Dyke installations all employed this type of cable. In the period 1972 to 1976 the thermistor cable installations were prepared using standard 50-conductor (AWG 22) telephone cable manufactured by Northern Telecom. This cable is sheathed in polyolefin tubing which withstands low temperatures without cracking. From about 1976 onwards a 12-conductor version of this type of cable was used.

A manual used by IOCC personnel in thermistor cable preparation has been included in Volume XVI of this report (Mihalovic, 1980). One particularly important aspect of cable preparation is that of producing a completely waterproof seal where thermistors are installed in the cable. To install a thermistor, the cable is slit at the desired level and a thermistor is soldered onto two free conductors. The slit is filled with silicone caulking compound, with the thermistor embedded in the silicone. The silicone is then left to dry completely to avoid conducting bubbles of acetic acid forming between the thermistor electrodes. After the silicone is completely dry vulcanising rubber tape is tightly wound over the slit and its immediate surroundings. This is followed by several layers of tightly wound vinyl tape.

Initially, a simple Wheatstone bridge was used for the thermistor resistance measurements. A precision Wheatstone bridge (Jessop, 1968) was used from 1972 to 1975. Since then, a less accurate but more convenient Data Precision Digital VOM has been used for most readings, giving an accuracy of about 0.1 degrees C.

Antifreeze-filled pipes were easier and cheaper to install than other types of thermocables. Nicholson (1978) gives a full description of the well-logging method. A large number of thermal wells were installed at Schefferville. They consist of ABS or PVC plastic pipes of approximately 30 mm inner diameter that were installed in exploration and tonnage drill holes. They provide a relatively accurate assessment of whether or not permafrost is present. They are, however, affected by convective heat transfers whenever an unstable density stratification of the liquid occurs. This limits their usefulness for long-term monitoring of ground temperatures in areas where there is a strong increase in temperature with depth.

1.2.3 LOCATION OF THERMOCABLES

Thermocables were usually installed in exploration and tonnage drill holes which were drilled for geological purposes. Only rarely were holes drilled specifically for thermocable installations. Examples of holes drilled specifically for thermal monitoring are the Timmins Dyke cables and the drill holes for Nicholson's Permafrost Amelioration experiment at Timmins 4. The spatial distribution of thermocables in the terrain is thus almost entirely controlled by the need for geological information. The thermocables are therefore located at known iron ore deposits and their local distribution follows the geological drill sampling pattern.

Figure 1.2.1 shows the locations of major permafrost research sites near Schefferville. A set of detailed photo maps were prepared to show terrain features and the road network surrounding the different thermocable sites (Figures 1.2.2 to 1.2.9). Overlays to the photo maps show the locations of individual thermocables identified by their IOCC drill hole number. The overlays also show the IOCC map grid which can be used for exact registering against the grid shown on the photo map. The grid also gives immediate reference to the appropriate map sheet of the topographic and geologic maps in Volumes II and VI.

Great care has been taken to locate the thermocables exactly. However, because of unavoidable distortions in the photo map, the locations are only plotted to within approximately 20 metres of their actual location. The most accurate location of the thermocables is given by the geologic and topographic maps in Volumes II and VI where the locations have been plotted from survey data.

1.2.4 STEREO MODELS OF THERMOCABLE LOCATIONS

Volume VII of this report contains a set of stereo models of the thermocable locations. The stereo models are accompanied by a set of surface oblique photographs to facilitate the interpretation of the stereo models by those who are unfamiliar with the Schefferville area.

The stereo models have been assembled for convenient use with a pocket stereoscope. Each stereo model is accompanied by an overlay showing the ore deposits, the locations of thermocable sites, the flight line numbers and the scale. The air photographs were flown in the summer of 1948 at an elevation of 17,340 ft ASL (5285 m) with a 6 inch (15 cm) lens giving a nominal scale of 1:30,000. The stereo models show the undisturbed terrain as it appeared prior to disturbance by mining activities.

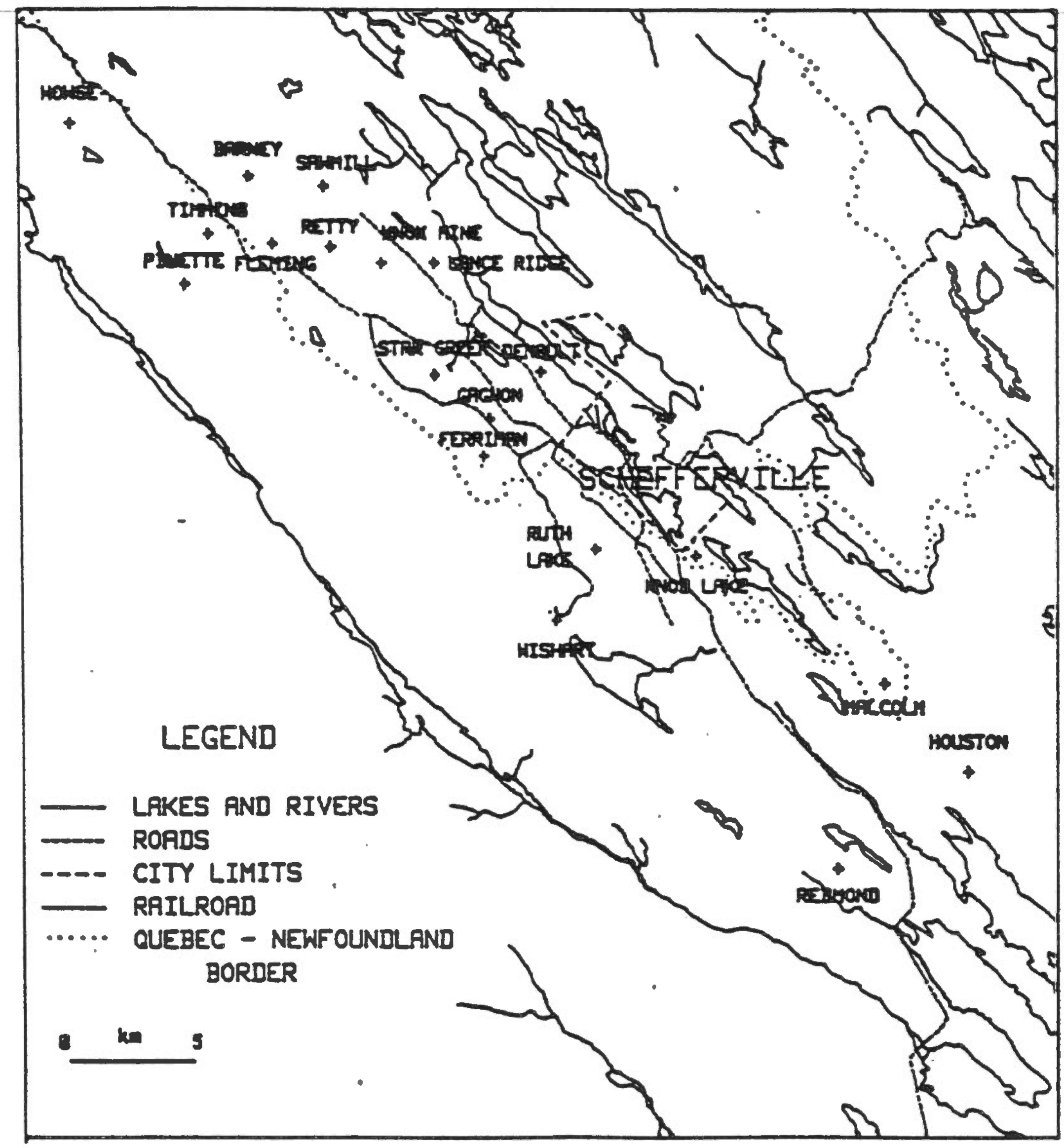
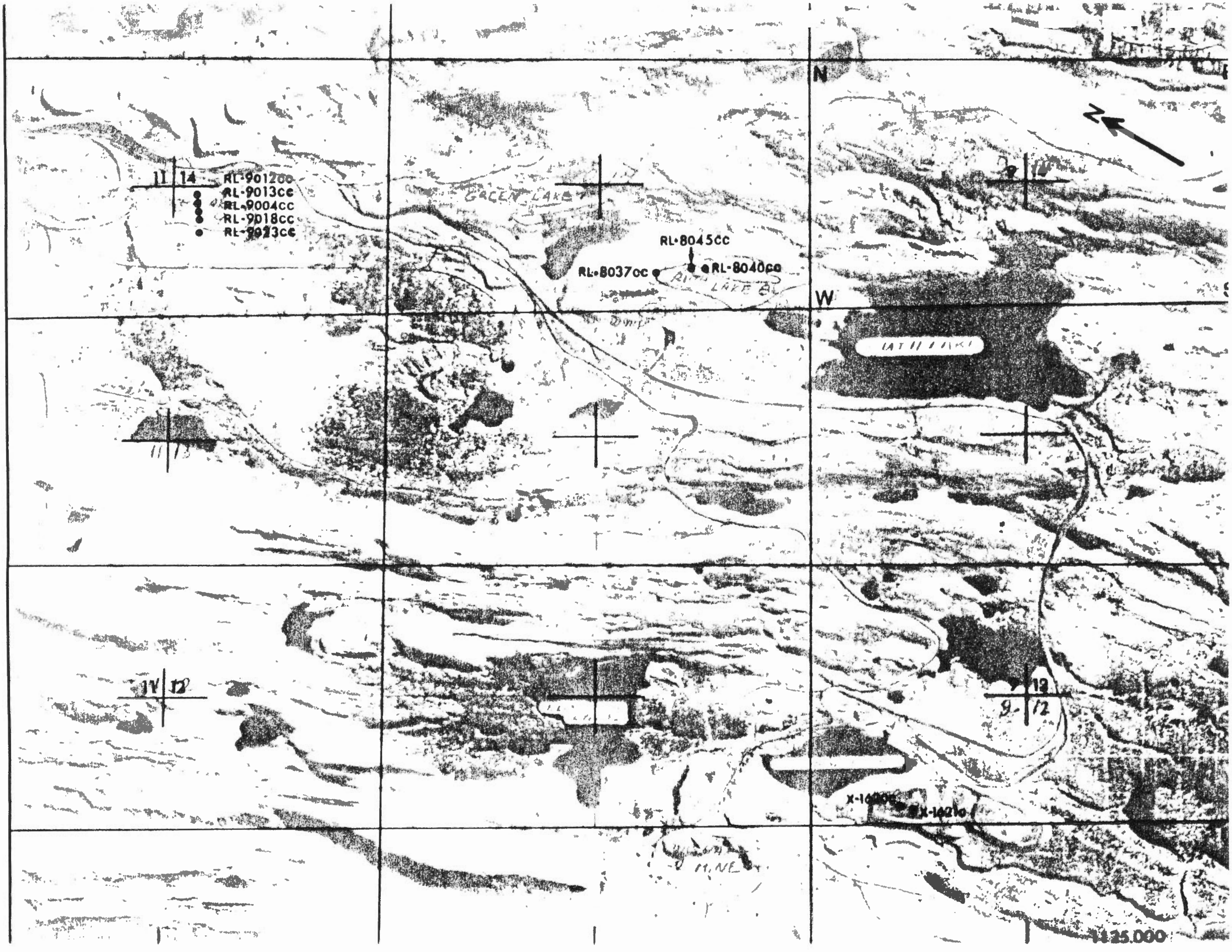


Figure 1.2.1 Location map of permafrost research sites

Figure 1.2.2 Photomap of the Redmond area

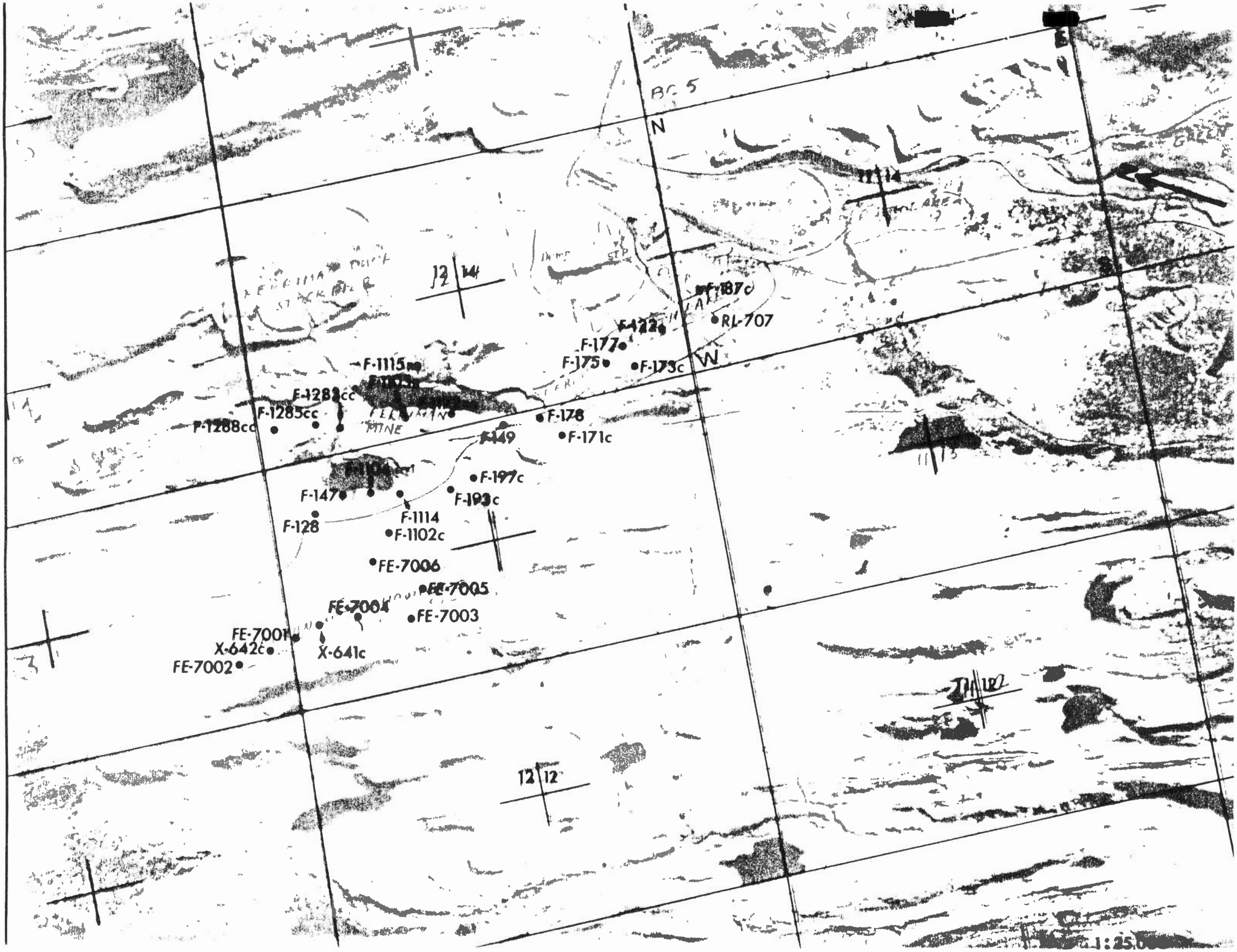

N
W
6 14
5 14
4 14
REDMOND ROAD
5 13
6 12
5 12
4 12
REDMOND 4
REDMOND 5
RE-5001cc
RE-5012cc
REDMOND 2B
1:25,000

Figure 1.2.3 Photomap of the Ruth Lake deposit area and Wishart Dump



N
W
11 | 14
RL-9012CC
RL-9013CC
RL-9004CC
RL-9018CC
RL-9023CC
RL-8045CC
RL-8037CC
RL-8040CC
GREEN LAKE
11 | 12
9 | 12
X-16210
1:25,000

Figure 1.2.4 Photomap of the Ferriman area



BC 5
N
W
F-187c
RL-707
F-122
F-177
F-175
F-173c
F-1115
F-1283cc
F-1285cc
F-1288cc
MINE
F-178
F-171c
F-149
F-197c
F-193c
F-147
F-1114
F-128
F-1102c
FE-7006
FE-7005
FE-7004
FE-7003
FE-7001
X-642c
X-641c
FE-7002
12 14
12 12
1:25,000

Figure 1.2.5 Photomap of Lance Ridge, Fleming 8 and Star Creek Deposits

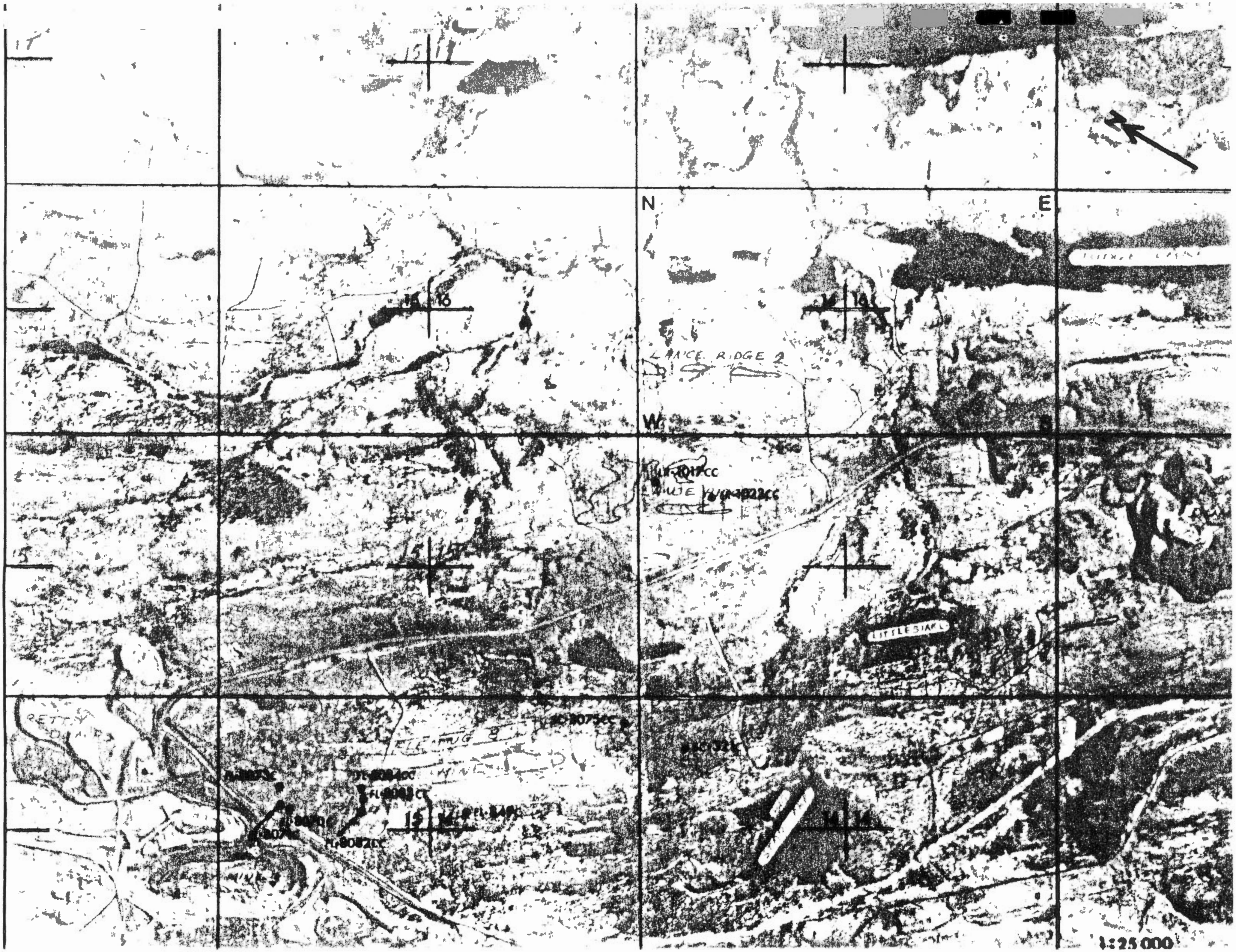

N
E
W
LANCE RIDGE 2
1:25 000

Figure 1.2.6 Photomap of Fleming 9, Retty Mine, Fleming 7 and Fleming 3

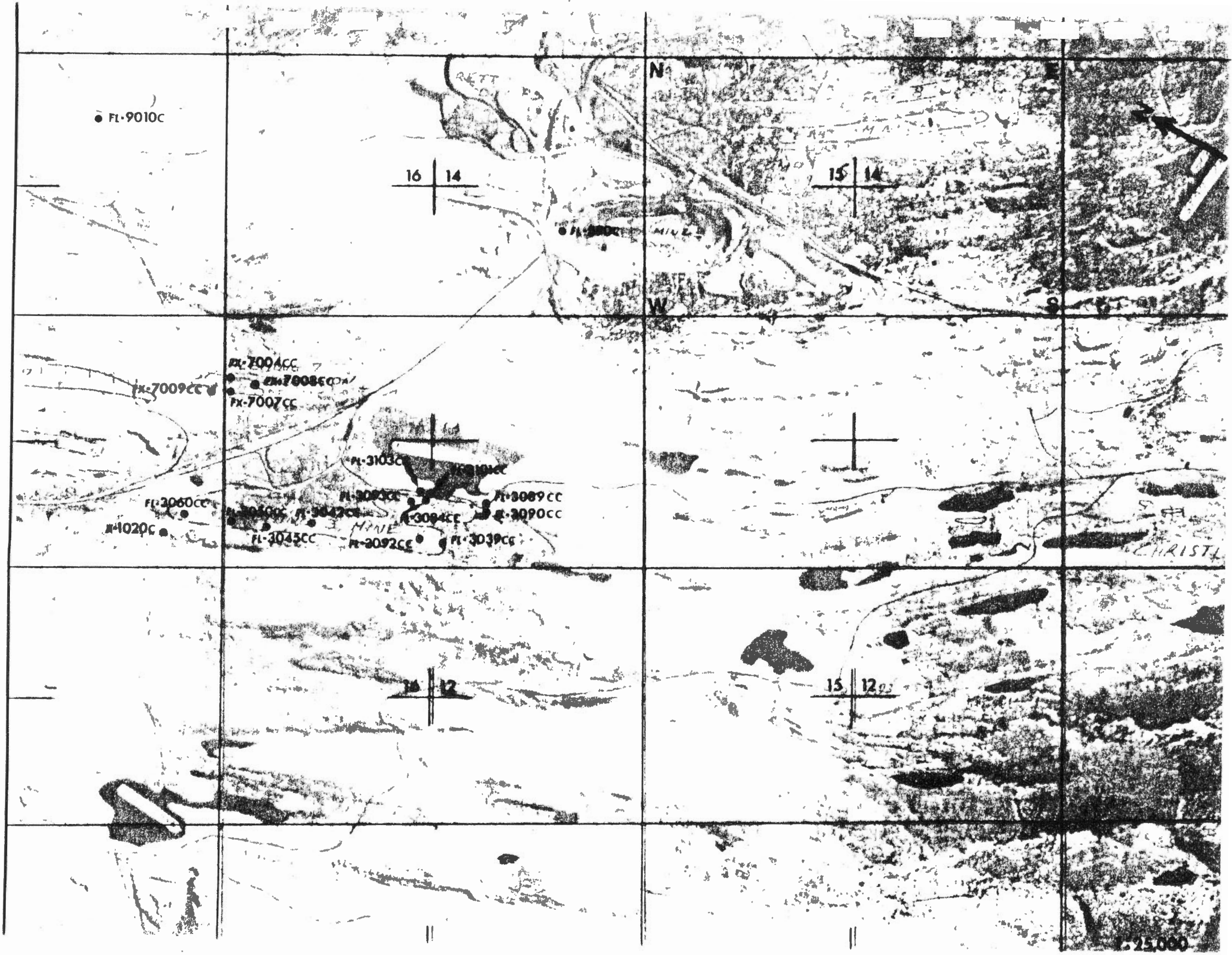
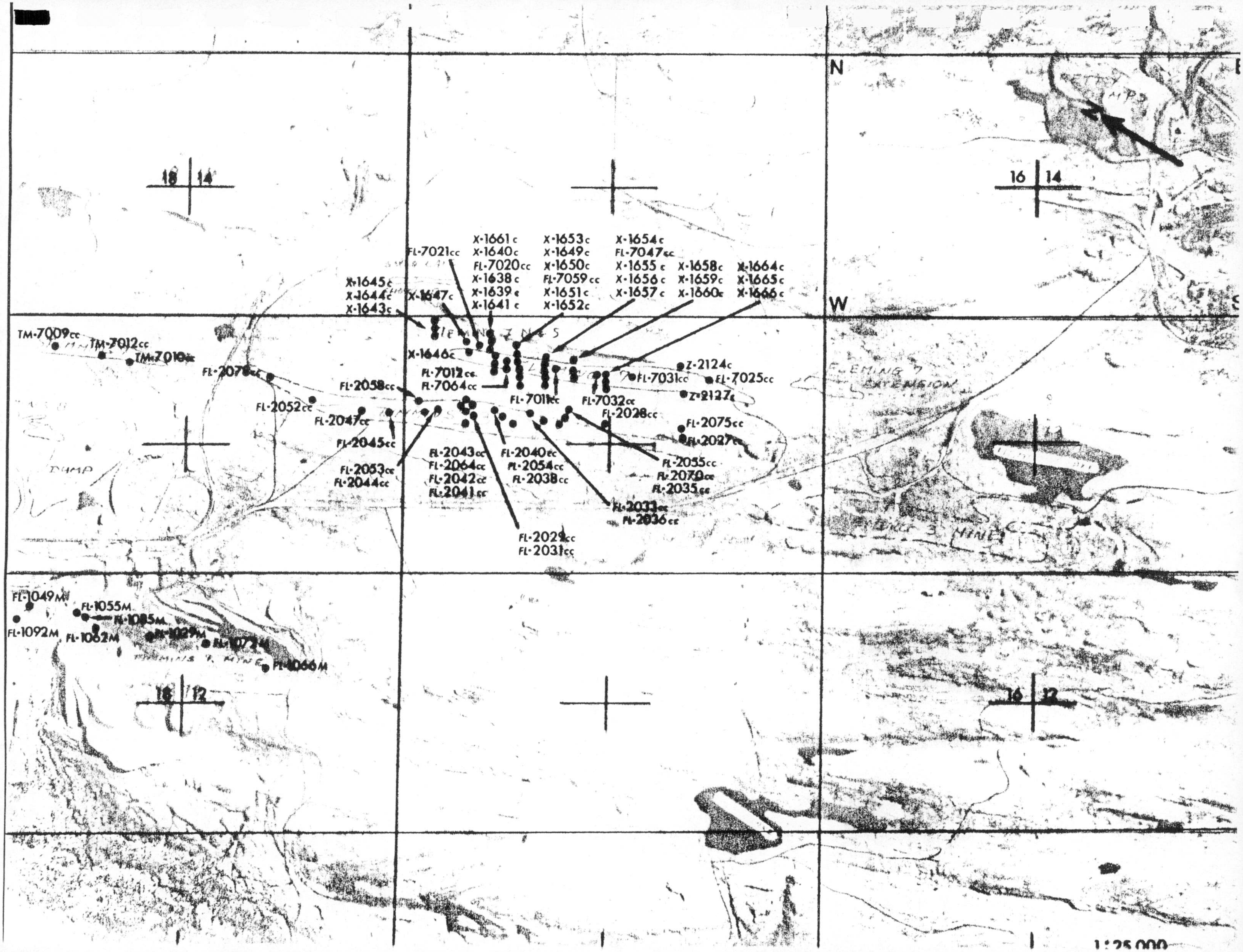

FL-9010C
16 14
15 14
N
E
W
S
MINE
FX-7004CC
FX-7008CC
FX-7009CC
FX-7007CC
FL-3103CC
FL-3089CC
FL-3090CC
FL-3094CC
FL-3060CC
FL-3042CC
FL-3045CC
FL-3092CC
FL-3039CC
MINE
CHRIST
16 12
15 12
1:25,000

Figure 1.2.7 Photomap of Fleming 7 and Timmins 1,3 and 7



N
W
16 14
16 12
X-1645c
X-1644c
X-1643c
X-1647c
X-1646c
FL-7021cc
X-1661c
X-1640c
FL-7020cc
X-1638c
X-1639c
X-1641c
X-1653c
X-1649c
X-1650c
FL-7059cc
X-1651c
X-1652c
X-1654c
FL-7047cc
X-1655c
X-1656c
X-1657c
X-1658c
X-1659c
X-1660c
X-1664c
X-1665c
X-1666c
Z-2124c
Z-2127c
FL-7031cc
FL-7025cc
FL-7032cc
FL-2028cc
FL-2075cc
FL-2027cc
FL-2055cc
FL-2070cc
FL-2035cc
FL-2033cc
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FL-2043cc
FL-2064cc
FL-2042cc
FL-2041cc
FL-7011cc
FL-7012cc
FL-7064cc
FL-2058cc
FL-2052cc
FL-2047cc
FL-2045cc
FL-2053cc
FL-2044cc
FL-2078cc
TM-7009cc
TM-7012cc
TM-7010cc
DUMP
FL-1049M
FL-1055M
FL-1085M
FL-1092M
FL-1082M
FL-1029M
FL-1072M
FL-1066M
FLEMING 7 EXTENSION
1:25 000

Figure 1.2.8 Photomap of Timmins 4 and 6

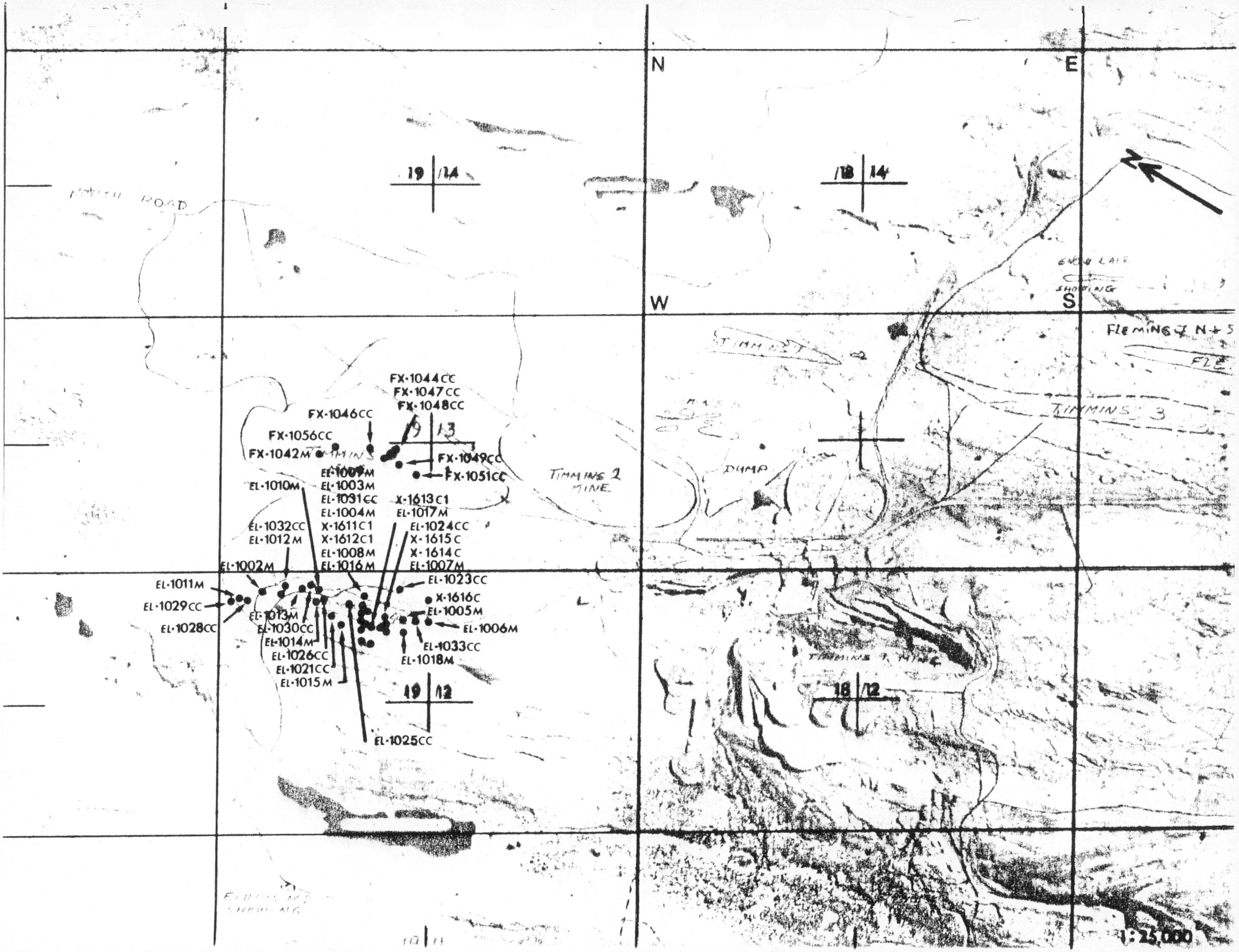
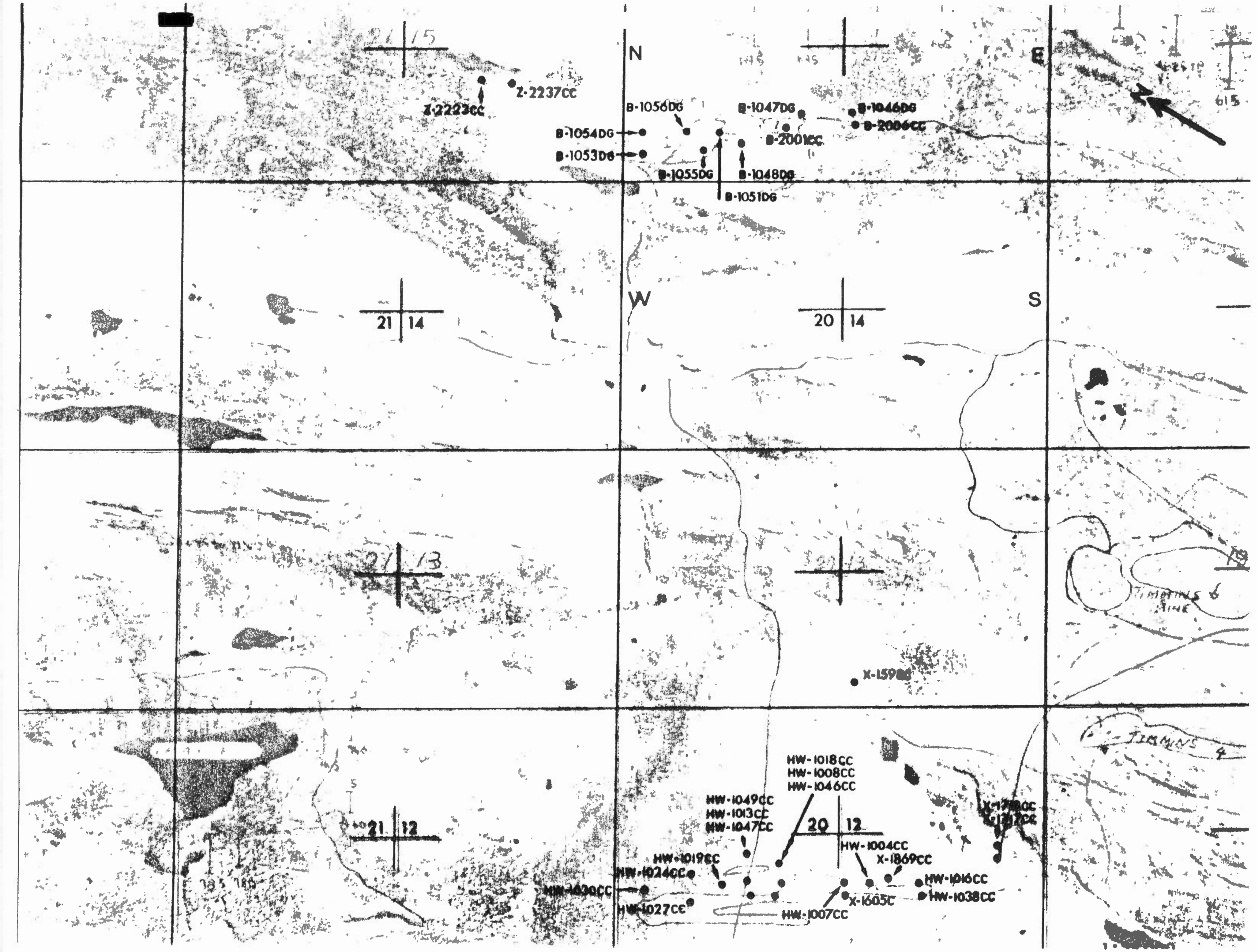

N
E
W
S
19 | 14
18 | 14
19 | 13
19 | 12
18 | 12
NORTH ROAD
TIMMINS 2 MINE
DUMP
TIMMINS 3
FLEMING 7 N+5
FX·1044CC
FX·1047CC
FX·1048CC
FX·1046CC
FX·1056CC
FX·1042M
FX·1049CC
FX·1051CC
EL·1009M
EL·1003M
EL·1031CC
EL·1004M
X·1611C1
X·1612C1
EL·1008M
EL·1016M
EL·1010M
X·1613C1
EL·1017M
EL·1024CC
X·1615C
X·1614C
EL·1007M
EL·1023CC
X·1616C
EL·1005M
EL·1006M
EL·1033CC
EL·1018M
EL·1032CC
EL·1012M
EL·1002M
EL·1011M
EL·1029CC
EL·1028CC
EL·1013M
EL·1030CC
EL·1014M
EL·1026CC
EL·1021CC
EL·1015M
EL·1025CC
1:25,000

Figure 1.2.9 Photomap of the Barney and Howse deposits


N
E
W
S
Z-2223CC
Z-2237CC
B-1056DG
B-1054DG
B-1053DG
B-1055DG
B-1051DG
B-1048DG
B-1047DG
B-2001CC
B-1046DG
B-2006CC
21 14
20 14
21 13
20 13
21 12
20 12
X-1598
TIMMINS 6
TIMMINS 4
HW-1018CC
HW-1008CC
HW-1046CC
HW-1049CC
HW-1013CC
HW-1047CC
HW-1019CC
HW-1024CC
HW-1027CC
HW-1007CC
HW-1004CC
X-1869CC
X-1605C
HW-1016CC
HW-1038CC
615

1.3 THE GEOLOGY OF THERMOCABLE SITES NEAR SCHEFFERVILLE

1.3.1 INTRODUCTION

Volumes II to V inclusive provide geological background information to the Schefferville Permafrost data set. They include a brief description of the bedrock characteristics in and adjacent to the iron ore deposits, a set of geological maps of a scale 1:2500 (100') and 1:5000 (200') and a set of cross-sections for each thermocable site in the study. Coverage of the maps with respect to the IOCC map grid is shown in Figures 1.3.1 and 1.3.2 Details of the different stratigraphical units, abbreviations and acronyms appearing in the cross-section and on the 1:5000 geological maps are given in Tables 1.3.1, 1.3.2 and 1.3.3.

1.3.2 GEOLOGY OF THE SCHEFFERVILLE AREA

The Schefferville ore deposits are located in the Labrador Trough, a geological province which extends from the southwest corner of Labrador to the northeast tip of Ungava. It is a structural depression of geosynclinal origin containing a sequence of varying Proterozoic rocks (Gross, 1968; Harrisson et al., 1972; Zajac, 1974).

The Trough is divisible into three parts on the basis of metamorphic rank of the rocks. The northern division of the geosyncline is made of high rank metamorphic rocks; the central division consists of low rank metamorphic rocks grading into high rank metasediments in an easterly direction; and the southern division consists of coarse grained metamorphic rocks.

The rocks of the central division of the Trough (Kaniapiskau System) contain the ore bearing horizons. These are clastic and chemically precipitated sediments and volcanic deposits, and are metamorphosed to lower greenschist facies. The succession of rocks overlying the bsaement gneisses consists of slate, discontinuous dolomite and chert breccia, and a continuous member composed of orthoquartzite, conglomerate and grit. This is succeeded by a ferruginous red to gray-black slate, iron formation, and black slate.

The iron ore deposits are contained in the ferruginous slate and iron formation. Four types of iron ore are recognised in the Schefferville area: (i) Blue Ore containing primarily blue hematite; (ii) Red Ore containing primarily finely divided red hematite; (iii) Yellow Ore containing primarily limonite and goethite; and (iv) manganese ore. The deposits mined at Schefferville are soft hematite-goethite secondarily enriched ores and not the type originally found (i.e. magnetic primary iron formation).

The rocks of the area are intricately folded and highly faulted, forming a foothill regional structure. They strike in a northwest-southeast direction and generally maintain an intermediate easterly dip. The folds are generally closed, less than 8 km long and slightly overturned to the southwest. Most faults are strike thrusts which dip steeply to the east and indicate reverse dip slip movement of 30 to 60 metres. Short, steeply dipping cross faults are locally numerous and show little horizontal movement. The folding and faulting were produced by orogenic stresses from the northeast; the Labrador Orogeny in Precambrian time, and the late Cretaceous Orogeny.

The geology of the Schefferville area has been extensively studied and has been described in considerable detail by Stubbins et al.(1972), Zajac (1974), Krishnan (1976), Dimroth (1978) and by various reports produced by the Iron Ore Company of Canada. A generalised stratigraphic column of the area is shown in Table 2.1.

Seven major geological formations outcrop widely in the area. They are: (i) the Attikamagen Formation, (ii) the Denault Formation, (iii) the Fleming Formation, (iv) the Wishart Formation, (v) the Ruth Formation, (vi) the

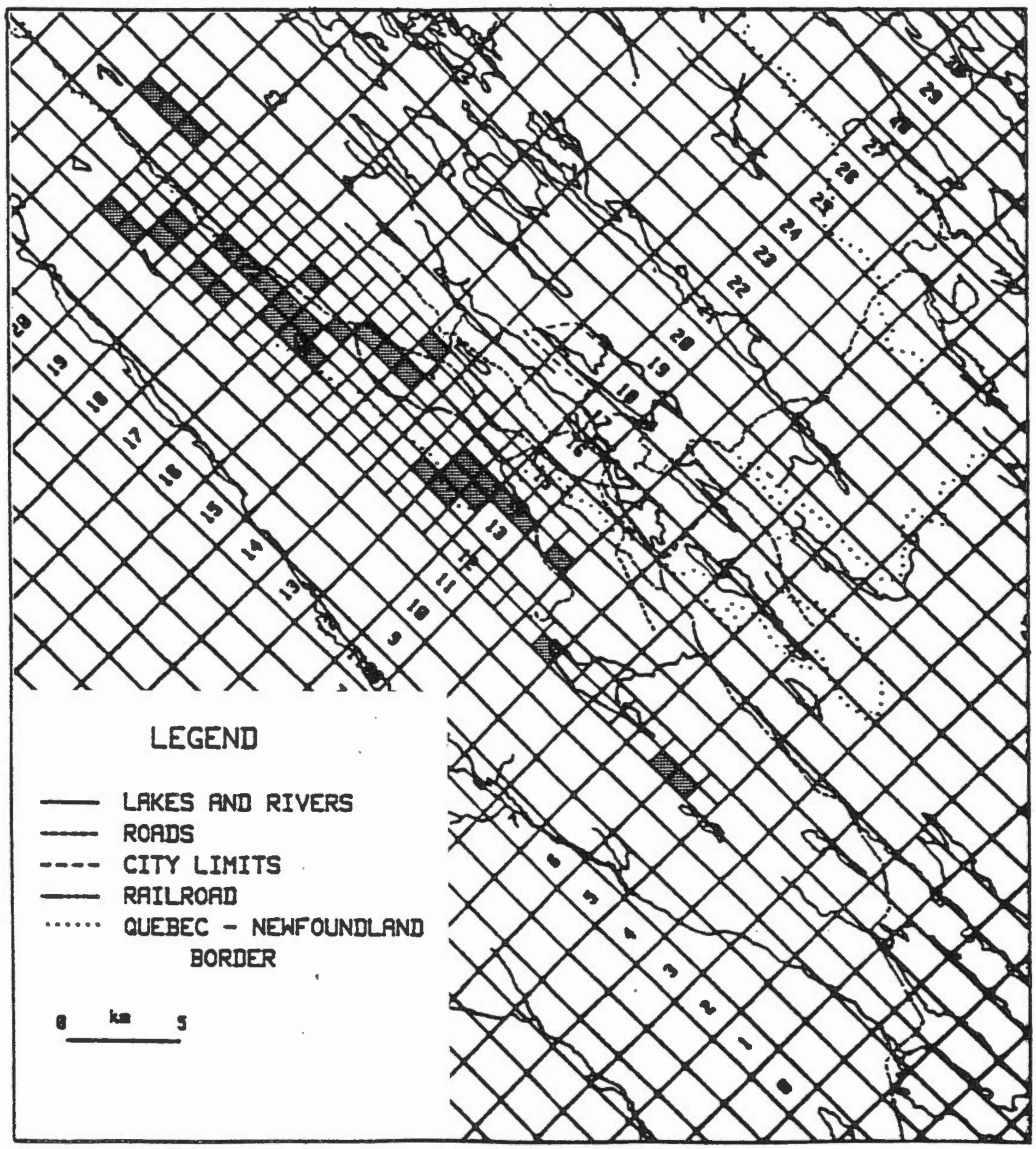


Figure 1.3.1 Coverage of 1:2 500 geological maps included in this report

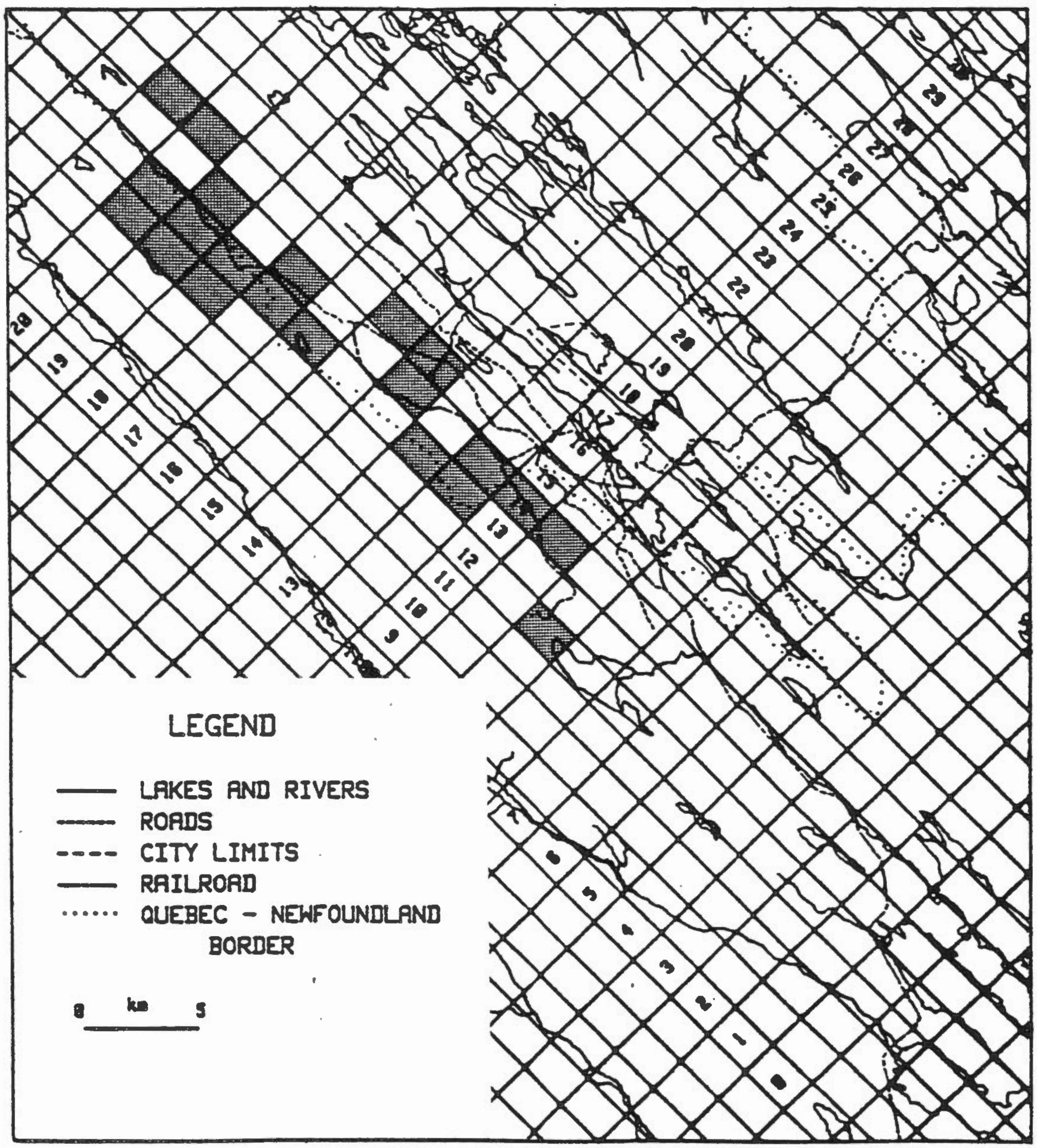


Figure 1.3.2 Coverage of 1:5 000 geological maps included in this report

ERA	SUPER-GROUP	GROUP	FORMATION	APPROXIMATE THICKNESS (in feet)	DOMINANT LITHOLOGY
Mesozoic			Redmond	0-300	Clay, Rubble
			UNCONFORMITY		
P					Diabase
R			INTRUSIVE CONTACT		
O	K	K	Menihek	1000+	Shale, Slate
T	A	N	Sokoman	300-700	Iron Formation
E	N	O			
R	I	B			
O	A		Ruth	75-120	Iron Formation
Z	P	L			
O	I	A	LOCAL(?) UNCONFORMITY		
I	S	K	Wishart	60-120	Quartzite
C	K	E	LOCAL UNCONFORMITY		
	A		Fleming	0-400	Chert Breccia
	U		Denault	0-600	Dolomite
			Attikamagen	0-1000+	Shale, Slate
			UNCONFORMITY		
Archean	Ashuanipi Complex				Gneisses

Table 1.3.1 Generalised stratigraphic column of the Schefferville area, northern Quebec (modified after Zajac, 1974 and Krishnan, 1976).

STRATIGRAPHY			LITHOLOGY: UNALTERED	LITHOLOGY: ALTERED
SOKOMAN FORMATION	upper	LC	Thick, massive bedding Dense, fine grained Chert with carbonates.	Leaching of carbonates result in deep pits and vugs filled with secondary limonite and goethite.
	member	RUIF	Ferruginous slate, fine grained chert.	Alters to siliceous clay interbedded with disse-minated hematite.
		GUIF	Thickly bedded, ferrugi-nous chert. Blocky join-ting.	Same as LC; occasionally alters to friable granular ore.
	middle member	URC + PGC	Well defined, thickly bedded with widely spaced joint. Good segregaton of jasper & hem. rich layers. Well defined, thinly bedded with pink and grey chert and hematite rich layers.	Alters to porous sandy friable bedded ore with hard bands of chert interbedded. Alters to porous, friable bedded ore with distinct pink and grey chert layers with oxide stringers.
		LRC	Thinly to thickly bedded. Oolitic with cherty matrix.	Alters to dessiminated granules and nodules of hematite.
	lower mem.	LIF/ or SCIF	Thickly to thinly bedded with fine laminae. Fine grained silicates. Well developed cleavage.	Alters to soft limonite ore to very fine grained hematitic ores. Soft with clay-like bands.
RUTH FORMATION	JSP		Thinly banded material containing alternating bands of iron oxides	Alters to granular blue hematite with a sandy texture.
	RUTH SLATE & RUTH CHERT		Thinly banded fissile material contains lenses of chert and various amounts of iron oxide.	Alters to fine grained hematite with bands of soft clay.

Table 1.3.2 Detailed stratigraphy of Ruth and Sokoman Formations illustrating the dominant textures and bedding characteristics (modified from Raju, 1977).

LEGEND	
B	Breccia member
BC	Basal Chert
CB	Chert Breccia member
GUIF	Grey Cherty Upper Iron Formation
IF	Hard Iron Formation
JSP	Jaspillite member
LC	Lean Chert member
LIF	Lower Iron Formation
LRC	Lower Red Cherty member
LS	Lower Slate member
MIF	Middle Iron Formation
OBD	Overburden
PGC	Pink Grey Cherty member
PPF	Potential Plant Feed
QTE	Quartzite member
RC	Red Chert
RF	Ruth Formation
RUIF	Red Cherty Upper Iron Formation
UIF	Upper Iron Formation
URC	Upper Red Cherty member
W	Waste

ORE TYPE LEGEND	
LNB	Lean Non-Bessemer Ore
NB	Non-Bessemer Ore
PRX	Paint rock (Yellow Ore just below ore grade)
TRX	Treat Rock

SYMBOLS	
---	Geological Contact
	Ore Contact
	Fault Contact

Table 1.3.3 Stratigraphic units and their abbreviations for the geological maps and cross-sections of the Schefferville area.

Sokoman Formation, and (vii) the Menihek Formation (Zajac, 1974; Krishnan, 1976). Other formations, ranging from early Proterozoic to Mesozoic in age, also occur in and adjacent to the Labrador Trough. The most important iron ore deposits are found within the Ruth and Sokoman formations.

The ATTIKAMAGEN FORMATION is a gray-green fissile shale. It is not ubiquitous in the area; however, it is widespread and commonly forms the basal sediment.

The DENAULT FORMATION is a massive dolomite containing a stockwork of secondary chert along fractures and bedding planes.

The FLEMING FORMATION is a chert breccia composed of rounded quartz pebbles and angular fragments of chert, which are commonly colloform. The formation is bimodal, the sand size quartz is an offshore sediment and the larger chert fragments are probably caused by slumping of gel-like silica deposit. The cement in the breccia is chert. The Fleming and Denault formations are sporadic and occur as basin infillings below the quartzite.

The WISHART FORMATION consists of an orthoquartzite with rounded quartz sand cemented by chert and is commonly arkosic. The formations from Attikamagen to Wishart are not iron-rich. Some secondary goethite enrichment may occur but this never makes ore grade material.

The RUTH FORMATION is a finely laminated fissile ferruginous shale which is commonly interbedded with thin layers of chert and rarely with minnesotaite rich horizons. The Ruth Formation contains the majority of the finely divided red hematite ore mined in the Schefferville area. The fresh shale consists of finely divided quartz, limonite, goethite, minnesotaite, stilpnomelane, feldspar and graphite with minor lepidocrocite and nontronite. A transition from predominantly clastic deposition to predominantly chemical precipitation of iron and silica occurs in the Ruth Formation, the upper part displaying interbanded clastic and chemically precipitated iron rich chert beds.

In the northwest part of the Schefferville area, a lateral variation introduces a jaspillite unit at the top of the Ruth Formation. This unit is a blue hematite and magnetite bearing rock and makes blue iron ore.

The SOKOMAN FORMATION is economically the most important in the area, as it contains approximately 80% of all ore found. Included in this formation is a varied assemblage of iron rich cherty sedimentary rocks. The Sokoman Formation is divided into three main members on the basis of lithologic characteristics:

(i) The LOWER IRON FORMATION (LIF) forms the base of the Sokoman Formation. It occurs as a silicate-carbonate iron formation in the main Schefferville ore zone, but a lateral variation in a north-westerly direction produces a metallic oxide facies about 16 km northwest of Schefferville. The silicate-carbonate facies is a thin bedded, fine grained rock composed essentially of chert and minnesotaite with minor iron oxides and siderite. It is mainly a chemical sediment precipitated in a reducing environment in neutral to alkaline water. The oxide facies is a thicker bedded cherty iron formation with predominantly blue hematite and magnetite. This sediment was chemically precipitated in an oxidizing environment.

(ii) The MIDDLE IRON FORMATION (MIF) is predominantly a cherty metallic iron oxide facies. This member is the thickest of the Sokoman and approximately 60% of the ore is found in it. The Middle Iron Formation is medium to thick bedded and contains iron oxides finely disseminated throughout the chert or concentrated into thin layers, irregular laminae, lenses, oolites and granules. Minnesotaite, stilpnomelane, and ferrous carbonate occur in small amounts. The Middle Iron Formation was deposited in a predominantly oxidizing environment in shallow agitated water.

(iii) The UPPER IRON FORMATION (UIF) consists of three horizons. The basal member is very similar to parts of the Middle Iron Formation, the middle member is a ferruginous shale somewhat similar to the Ruth Formation, and the top member consists of a massive very lean chert containing minor carbonate. The Upper Iron Formation is predominantly an oxide facies with red and blue hematite and magnetite forming the majority of the ore.

The MENIHEK FORMATION is a black to green-gray fissile argillaceous rock containing abundant disseminated carbon but few chert beds. It is composed of very fine felt of sericite, chlorite and platy minerals, with very little iron oxides. This formation never makes iron ore.

CRETACEOUS sediments locally overlie the bedded ores unconformably. They are composed of water clastic sediments. The bedded iron ores have been reworked in Cretaceous times and the sediment produced, in some cases, now makes ore grade sands, gravels, talus and breccias.

1.4. TOPOGRAPHY OF THE PERMAFROST RESEARCH AREAS NEAR SCHEFFERVILLE

1.4.1 INTRODUCTION

Topography has a multi-faceted influence on the distribution of permafrost in the Schefferville area. First, it influences the geometry of the temperature field near the ground surface, necessitating the application of topographic correction factors to near-surface heat flow estimates in undulating terrain.

Secondly, topography influences the microclimate at the surface through its effects on solar radiation, wind, surface runoff and near-surface groundwater flow. The spatial variations in wind speed that are induced by topography influence the patterns of snow accumulation and thereby cause spatial variations in the insulating effects of the seasonal snow cover (Granberg, 1972; 1973; Nicholson and Granberg, 1973).

The hydrologic effects of topography include spatial variations in the latent energy flux at the surface, spatial variations in vertical and lateral heat transfers by near-surface groundwater flow and horizontal heat transfers towards groundwater recharge areas where large quantities of heat may be locally transferred to the groundwater table by interflow.

Volume VI provides a summary of the available topographic information for the permafrost research areas near Schefferville. It includes a brief description of the geomorphology of the area and a set of detailed topographic maps of scales of approximately 1:2500 and 1:10,000 respectively with a contour interval of 1.5 m (5 ft). The maps are reductions from originals of scale 1 in = 100 ft and 400 ft respectively. Full scale copies of these maps may be obtained from the Iron Ore Company of Canada or from the McGill Permafrost Research Group. Coverage of the maps with respect to the IOCC map grid is shown in Figures 1.4.1 and 1.4.2. Thermocable locations with corresponding IOCC drill hole designations (e.g. *RE-5001CC) are indicated on the 1:2500 scale maps.

1.4.2 GEOMORPHOLOGY OF THE SCHEFFERVILLE AREA

Two main physiographic regions can be distinguished in the Schefferville area. They correspond to the outcrop of the two major geological formations. The trended ridge and valley landscape is associated with the interstratified rocks of the Labrador Trough and the rounded hills and minor ranges built of crystalline rocks are part of the Canadian Shield.

The geomorphology of the area reflects strong geological control and part glacial activity. Many landscapes have formed in the Labrador Trough most of which consist of discontinuous cuestas or hogbacks, valleys or depressions, anticlines and synclines (Twidale, 1957). The numerous lakes found in the low lying areas correspond to the shales, slates and weathered rocks, while the resistant quartzites, dolomites and ferruginous slates give rise to the higher elevated areas.

The morphology of the Schefferville area is characterised by a wide valley with numerous lakes to the east, a series of undulated ridges and small valleys to the west, and a series of broader ridges to the north. The ridges display a strong NNW-SSE trend and an average elevation of 690 metres. A number of glacial debris (i.e. till, englacial and subglacial, stratified and non-stratified) and glacial features (e.g. drumlins, eskers, esker-like till ridges, drainage channels, striae, roche-moutonnees) provide evidence of glaciation over the area (Twidale, 1957, 1958; Derbyshire, 1958, 1960, 1962; Henderson, 1959; Kirby, 1960; Andrews, 1961; Barr, 1964).

Till fabric analysis and drift morphology indicates extensive ice

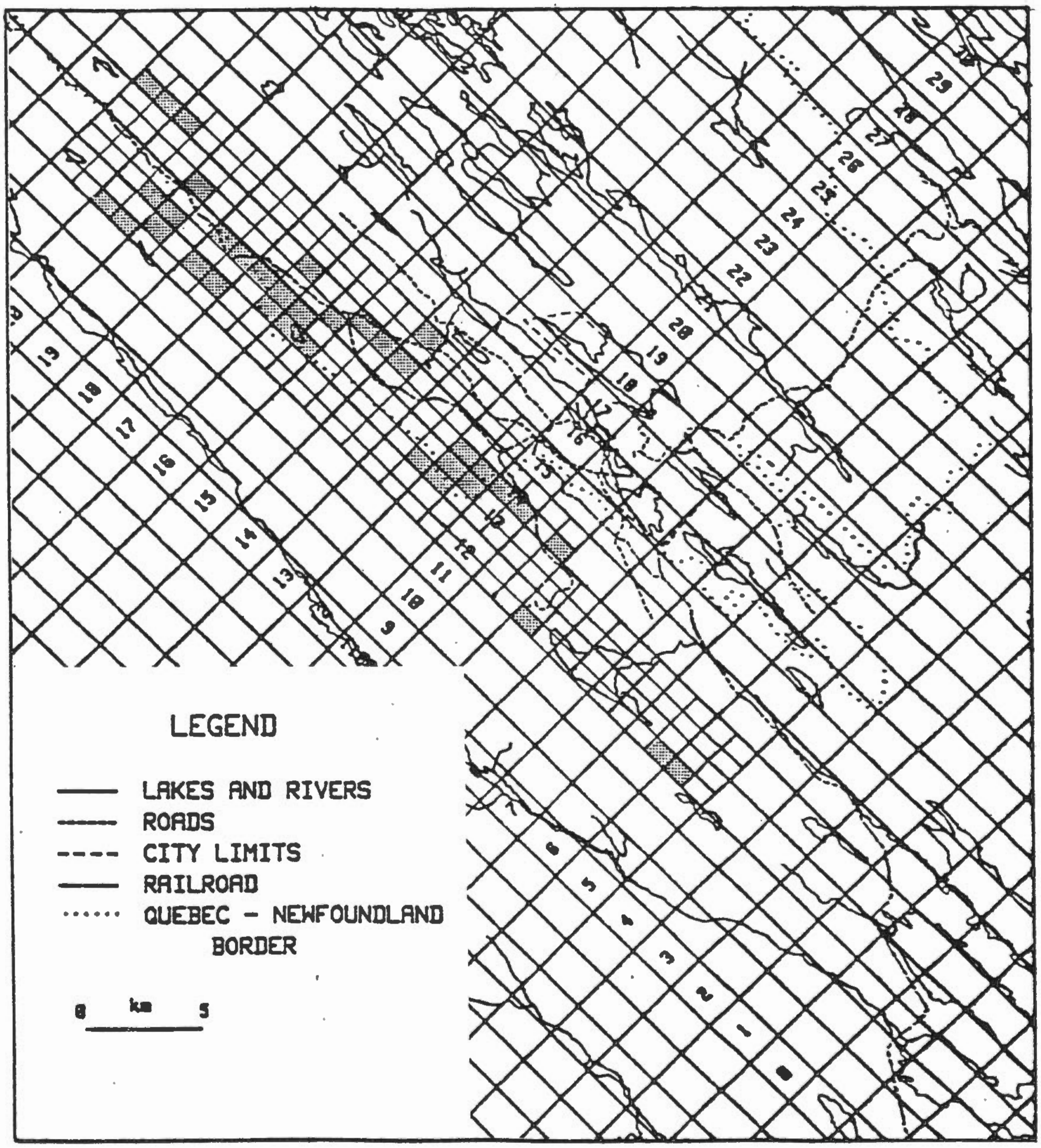


Figure 1.4.1 Coverage of 1:2 500 topographic maps included in this report

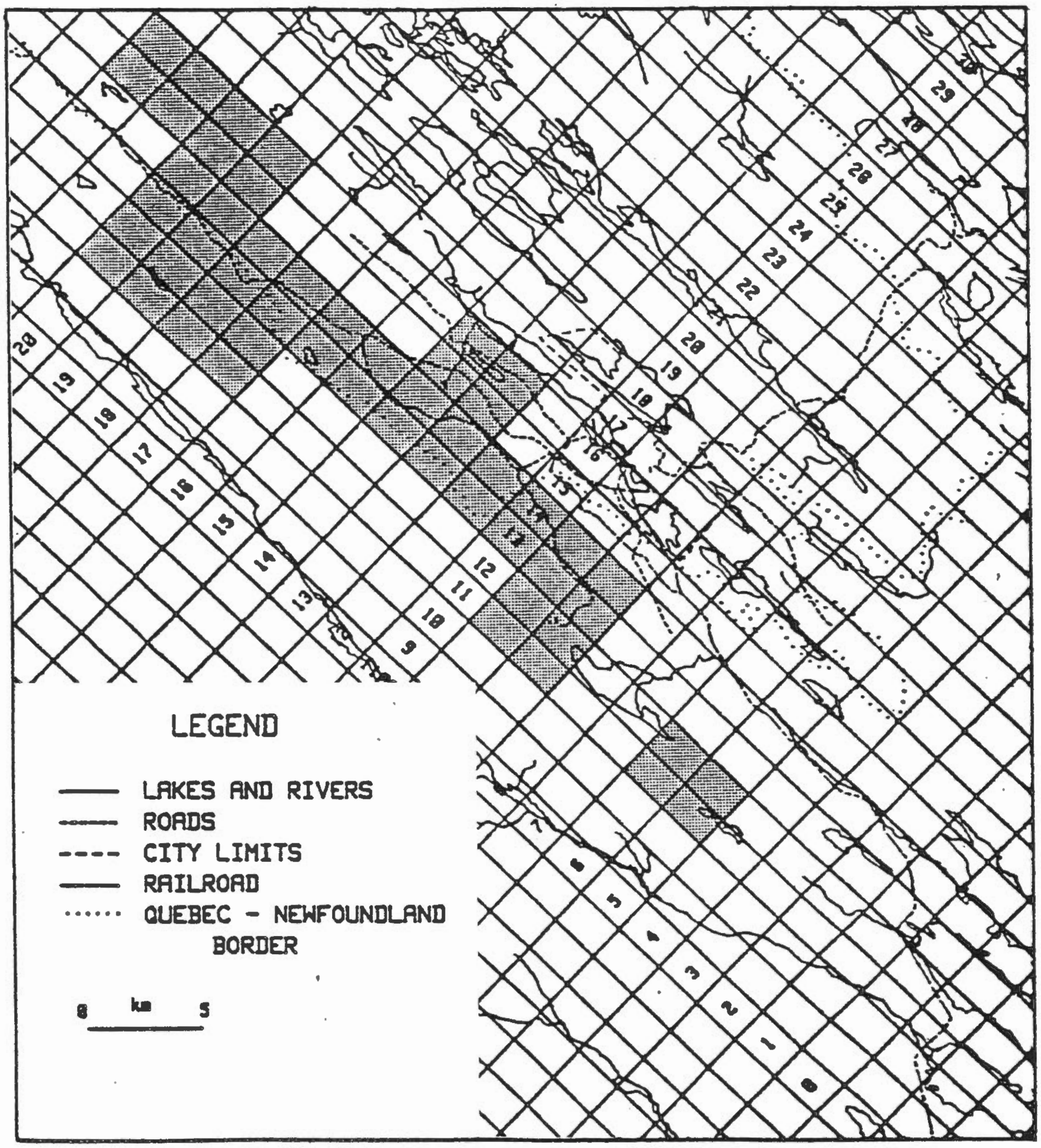


Figure 1.4.2 Coverage of 1:10 000 topographic maps included in this report

stagnation, substantiating the idea of an ice divide through this area (Cowan, 1966). The existence of an ice sheet over northern Quebec has been proposed at different times by Flint (1943, 1971), Wheeler (1958), Ives (1960), Prest et al.(1968), Hillaire-Marcel et al.(1980), Shilts (1980), Denton and Hughes (1981) and Dyke et al.(1982). The details regarding the number of glaciations and extents across northern Quebec remains poorly understood in this area which is generally thought to be a key area in the onset of glaciations. A recent radiocarbon date of 24,250 plus or minus 600 years obtained from a well preserved twig at a depth of 20 metres below the current surface indicates that two events of glaciation have occurred in the Howse deposit area since that date (Granberg and Krishnan, 1984). The Howse iron ore deposit lies near Irony Mountain, some 25 km NW of Schefferville.

The Schefferville area lies within the zone of discontinuous permafrost (Brown, 1970, 1978). Features produced by frost sorting (e.g. stony earth circles, mud circles), frost shatter, and downslope movement (e.g. solifluction lobes, gelivation valleys, nivation hollows, altiplanation terraces) have all been observed within the area (Twidale, 1957; Andrews, 1961; Williams, 1962; Gardner, 1964; Brown, 1975). String bogs, palsas, earth hummocks, peat plateaux and pipkrake or needle ice have also been documented (Gardner, 1964; Brown, 1975).

1.5 DRILL LOGS FOR THERMOCABLE SITES

1.5.1 INTRODUCTION

Volumes VIII, IX, X and XI contain the drill logs for thermocable sites in the Schefferville area. Included is also a description of the drill logs and the different types of drilling methods used by the Iron Ore Company of Canada since 1944 for sampling the iron ore deposits. The drill logs are arranged in order of ore deposit and can vary from one to several pages in length.

1.5.2 DESCRIPTION OF THE DRILL LOGS

Each drill log is identified by an IOCC hole number, location or deposit, section, ground elevation and co-ordinates. The drilling method used is mentioned under the drill type and/or drilling data (drilling methods are explained in Section 8.3). The start and completion date of the hole, its total depth, water table depth, overburden depth, permafrost data information and comments from the geologists may also be included on the drill log.

Petrographic descriptions and remarks regarding the various samples collected from the holes are made at interval of approximately 3 metres. The nature, color and type of material found at varying intervals are reported, and in some cases the abbreviations of stratigraphical units (Table 8.1 and 8.3) are inserted. A brief description of the stratigraphic units for two main ore bearing horizons is described in Table 8.2. Head assays indicating the percentages of iron, phosphate, manganese, silica and alumina in samples are also included on the drill logs.

1.5.3 DRILLING METHODS USED TO COLLECT SAMPLES

Eight different drilling methods were employed by the Iron Ore Company of Canada from 1944 to 1979. Due to the nature of the bedrock and its varying physical properties, no one drilling method was found to be suitable to obtain reliable samples. This led to several experimental drilling methods such as standard diamond drilling, chop-and-drive drilling, 50-R rotary drilling, mud drilling, coring with fuel oil, triple-tube wireline coring, water tricone and the dual-tube method. These will be briefly reviewed.

1 - Standard diamond drilling was found to be not only uneconomical for the IOCC, but also unreliable due to poor core recovery. As a result, this method was discontinued early in the drilling history of the Schefferville area.

2 - The chop-and-drive drilling method began in 1946. It allowed drill cuttings to be collected in a sludge box and then split using the cross splitter. The slow rate of drilling along with loss of sample during the sample collection process and high cost was also unsuitable for routine drilling.

3 - The Bucyrus-Erie electric 50-R rotary drill (a standard blasthole drill) was used in 1957 and 1958. This method allowed drill cuttings to be collected at 3 metre intervals. However, this method was also discontinued due to problems with hole stability, sample accuracy, contamination and logistic problems associated with the drill.

4 - Mud drilling was started in 1959 and consisted of tricone chip drilling with a low viscosity, low density mud. The samples, each representing a 3 metre increment, were collected in wash tubs, allowed to settle for 30 minutes and then collected for chemical analysis. Improvements in terms of lower costs and better samples were made over the chop-and-drive method.

Nonetheless, such problems as the loss of some fine drill cuttings in the settling anf flocculation process and contamination of the contents of the mud were still present and the method was discontinued.

5 - Coring with fuel oil was an experimental freezing technique back in 1968. In this case, the oil was cooled below the ambient air temperature for the purpose of freezing the rock formations ahead of the drill bit. The cooled oil prevented the thawing of the rock and permafrost during drilling. This method revealed a core recovery of 97%, however temperature differences, loss of drilling fluid and contamination of samples by the fuel oil led to high costs of drilling and the method was discontinued.

6 - Triple-tube wireline coring was carried out during 1970 and 1971. This system consisted of a double tube, swivel-type core barrel with a third central split-tube core holder and different types of mud for circulation. Hole stability and drilling fluids improved the system, but low core recovery (50 to 80%) and a slow rate of drilling hampered the triple-tube coring method.

7 - The water tricone method was a combination of the chop-and-drive and mud tricone systems. In this case, water was used as drilling fluid and provided uncontaminated samples suitable for flotation tests. The rate of drilling, however, was slow and the costs high.

8 - The dual-tube method utilized both water and air as the circulation media to a maximum depth of 76 metres and mud and air for deeper drilling. The latter increased the rate of penetration and quality of the sample above all the other seven experimental methods used. This dual-tube provided a clean and uncontaminated 3 metre sample.

The drilling method may affect thermocable temperatures measured shortly after the hole was drilled. It may also affect the thermal properties determined from the drill core or drill chippings.

1.5.4 MISSING DRILL LOGS

A few drill logs could not be located. They represent a small percentage of the total number of drill logs and are listed in Table 1.5.1 below:

TABLE 1.5.1

LIST OF MISSING DRILL LOGS

ORE DEPOSIT	THERMOCABLE SITE HOLE NO.
BARNEY 1	B-1048DG
	B-1051DG
	B-1053DG
	B-1054DG
BARNEY 2	B-1046DG
	B-1047DG
FERRIMAN 1	F-1102C
FLEMING 7	X-1664C
	X-1665C
	X-1666C
KNOX MINE	FL-8070C
	FL-8071C
	FL-8073C
REDMOND 5	RE-5001CC
	RE-5012CC

1.6 ERROR ANALYSIS, ANNOTATIONS AND ADDENDA

1.6.1 ERROR ANALYSIS

Part of the work under the present contract was directed towards removing such errors that could easily be removed from the thermocable data file and to assess, at least qualitatively, what possible problems might exist in the data set. This was accomplished by visual inspection of the data file and of screen plots of the data file. The data file was screened for obvious typographical and other errors and corrections were applied where possible. In some cases where the error was obvious and large and where correction was not possible, the error code (99) was inserted to replace the erroneous value. A listing of corrections to the data file is given in Volume XV together with a set of annotations to the thermocable data plots.

It is obvious from the plots in Volumes XII to XIV inclusive that the data file still contains many errors. Their correction will require a more careful analysis of the data set than was possible under the present contract.

In general, the file contains a large number of cables with useful data. Unfortunately, it appears that some, as yet undetermined, problem affects the data from most of the cables installed after 1976. The problem may be related to a calibration mixup or, worse, may have resulted from faulty practise in the manufacturing of the cables. The attempt to assess and possibly correct this problem continues.

1.6.2 ANNOTATIONS

The plots of thermocable data were analysed visually and a set of comments were produced to aid future users of the data set. The comments are found in Volume XV of this report which also contains annotations of the permafrost prediction maps contained in Volume XXV of Granberg et al (1983). Permafrost prediction methods were reviewed by Granberg et al (1983). The annotations to the permafrost prediction maps contain reference to the methods used and, where possible, to the originator and to associated reports.

1.6.3 ADDENDA

In addition to the background information already mentioned, it was possible to add data sets from 33 thermocables to the Schefferville Permafrost Data File. This was accomplished by locating thermistor calibrations for data sets where previously only resistance readings were available. A list of cables thus added is given in Appendix I under the table of contents for Volume XIV. Plots of these data sets are found in Volume XIV and annotations to these plots are given in Volume XV.

Further search of Iron Ore Company of Canada files and of McGill files produced several items of interest to researchers of Schefferville permafrost. They include instruction manuals on thermocable manufacture and installation and manuals dealing with geophysical techniques for permafrost detection. They also include several pieces of correspondance relating to thermistor cables and their use at Schefferville. Through personal communication with Dr. M.K. Seguin of Laval University it was possible to upgrade the file with respect to information on geophysical techniques that were used for permafrost delineation at Schefferville.

1.7 CONCLUSIONS AND RECOMMENDATIONS

1.7.1 CONCLUSIONS

The material presented in this report includes both a set of thermocable data which was retrieved by locating calibrations for thermistor resistance data in McGill and IOCC files and a set of essential background information that is necessary for users of the Schefferville Permafrost Data File. The File is now relatively complete with two notable exceptions. One is the paucity of information regarding the thermal properties of the bedrock of the Schefferville area. Only a limited amount of such information is currently available. Information about the thermal properties of the bedrock at thermocable locations may, however, be derived from drill cores and drill chippings. It is recommended that an effort be made to secure information about the thermal properties of the Schefferville bedrock. Ideally, samples from thermocable drill holes should be used. The cores and chippings are currently stored at Schefferville. In view of the closing of I.O.C.C. operations at Schefferville it would be desirable to secure this information relatively soon, before deterioration of storage facilities and core-identifying documentation occurs.

The second set of essential information concerns the snow cover. Snow depth variations to a large extent control the surface energy balance and snowcover information has been found very useful in permafrost delineation. There exist, in McGill files, several sets of aerial photographs that have been flown at intervals during the snowmelt season. This information could be digitized, at least for some of the permafrost research sites and would be very useful in the further analysis of the Schefferville Permafrost Data Set.

The stage is now set for analysis of the thermocable data set. A considerable amount of knowledge has already been derived from the data, knowledge that has given ample economic remuneration for the research efforts. The thermocable data set, however, contains much more information than what could initially be derived using the means that were available to researchers at Schefferville. When coupled with weather data and terrain information the more than 200 temperature profiles represent an exciting modelling opportunity that should be of great interest not only to permafrost researchers but also to microclimatologists and hydrologists. Some both temporal and spatial modelling has already started but - particularly in view of the educational aspects of modelling - more resources should be allocated to ensure a rapid development in this area.

The stage is now set also for analysis of other materials in the Schefferville Permafrost Data File. This multi-faceted collection of data relating to mining in discontinuous permafrost is unique and contains much valuable information about permafrost and about a wide variety of problems encountered during the exploration and mining in partially frozen ground. It also contains a fascinating story about the development of permafrost research in response to the direct needs of a mining operation. Much can be learned from this story about the needs for research coordination and educational needs on a national level. While many successes were scored in Schefferville Permafrost Research, one cannot but feel a pang of regret at the many glorious but lost opportunities to learn more about a topic that is of a prime Canadian national concern.

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14-15N	18-13
15-14N	19-12
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16-13N	19-14
16-13S	20-12
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17-13N	21-15
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17-13S	
17-14E	
18-12N	
18-12E	
18-13N	
18-13E	
19-12N	
19-13W	
20-12S	
20-12W	
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20-15W	
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ORE DEPOSIT	THERMOCABLE SITE HOLE NO.	CROSS-SECTION NO.
Barney 1	Z-2223CC	743
	Z-2237CC	739
	B-1048DG	699
	B-1051DG	705
	B-1053DG	718
	B-1054DG	718
	B-1055CC	708
	B-1056CC	711
Barney 2	B-1046DG	684
	B-1047DG	687
	B-2001CC	690
	B-2006CC	683
Ferriman 1	RL-707	79
	F-147	142SW

	F-149	115
	F-193C	123SW
	F-197C	120SW
	F-1104	136SW
	F-1105R	133NE
	F-1114	130SW
	F-1115RD	133NE
	F-122	85
	F-1283CC	142
	F-1285CC	145
	F-1288CC	151
	F-171C	106
	F-173C	94
	F-175	97
	F-177	94
	F-178	109SW
	F-1172R	123NE
	F-1102C	136SW
	F-187C	148NE
	F-128	145SW
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ORE DEPOSIT	THERMOCABLE SITE HOLE NO.	CROSS-SECTION NO.
Fleming 3	FL-3039CC	401
	FL-3042CC	422
	FL-3045CC	432
	FL-3050CC	437
	FL-3060CC	443
	FL-3084CC	405
	FL-3089CC	394
	FL-3090CC	394
	FL-3092CC	403
	FL-3093CC	406
	FL-3101CC	403
	FL-3103CC	405
Fleming 5	FL-590C	380
Fleming 7	X-1638C	493
	X-1639C	493
	X-1640C	493
	X-1641C	493
	X-1643C	503
	X-1644C	503
	X-1645C	503
	X-1646C	498
	X-1647C	498
	X-1649C	488
	X-1650C	488
	X-1651C	488
	X-1652C	488
	X-1653C	483
	X-1654C	483
	X-1655C	483
	X-1656C	483
	X-1657C	483
	X-1658C	478
	X-1659C	478
	X-1660C	478
	X-1661C	493
	X-1664C	473
	X-1665C	473
	X-1666C	473
	Z-2124C	461
	Z-2127C	461
	FX-7004CC	437
	FX-7007CC	437
	FX-7008CC	433
	FX-7009CC	439
	FL-7020CC	493
	FL-7021CC	496
	FL-7025CC	456
	FL-7031CC	470
	FL-7032CC	474
	FL-7047CC	483
	FL-7059CC	488
	FL-7064CC	490
Fleming 9	FL-9010CC	459
Howse	X-1869CC	676
	HW-1004CC	679
	HW-1007CC	684
	HW-1008CC	691
	HW-1013CC	696
	HW-1016CC	671
	HW-1018CC	691
	HW-1019CC	701
	HW-1024CC	706
	HW-1027CC	706
	HW-1030CC	716
	HW-1038CC	671
	HW-1046CC	692
	HW-1047CC	696
	HW-1049CC	696
Knox Mine	FL-8082CC	44

	FL-8083CC	44
	FL-8084CC	44
Lance Ridge	LR-1017CC	293
	LR-1023CC	284
Redmond 5	RE-5001CC	141
Ruth Lake	RL-8037CC	166
	RL-8040CC	161
	RL-8045CC	158
	RL-9004CC	43
	RL-9012CC	43
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ORE DEPOSIT	THERMOCABLE SITE HOLE NO.	CROSS-SECTION NO.
Timmins 1	FL-1029M	549
	FL-1049M	571
	FL-1055M	560
	FL-1062M	558
	FL-1066M	529
	FL-1072M	540
	FL-1085M	559
	FL-1092M	573

Timmins 3	FL-2027CC	461
	FL-2028CC	473
	FL-2029CC	497
	FL-2031CC	497
	FL-2033CC	486
	FL-2035CC	482
	FL-2036CC	484
	FL-2038CC	490
	FL-2040CC	494
	FL-2041CC	499
	FL-2042CC	499
	FL-2043CC	499
	FL-2044CC	505
	FL-2045CC	509
	FL-2047CC	514
	FL-2052CC	522
	FL-2053CC	503
	FL-2054CC	492
	FL-2055CC	480
	FL-2058CC	507
	FL-2064CC	500
	FL-2070CC	481
	FL-2075CC	461
	FL-2078CC	531
Timmins 4	EL-1002M	640
	EL-1003M	625
	EL-1004M	625
	EL-1005M	618
	EL-1006M	614
	EL-1007M	621
	EL-1008M	625
	EL-1009M	625
	EL-1010M	631
	EL-1011M	646
	EL-1012M	638
	EL-1013M	635
	EL-1014M	631
	EL-1015M	627
	EL-1016M	625
	EL-1017M	624
	EL-1018M	618
	EL-1021CC	629
	EL-1023CC	618
	EL-1024CC	621
	EL-1025CC	627
	EL-1026CC	630
	EL-1028CC	644
	EL-1029CC	647
	EL-1030CC	633
	EL-1031CC	624
	EL-1032CC	638
	EL-1033CC	616
	X-1020C	446
	X-1611C1	625
	X-1612C1	625
	X-1613C1	625
	X-1614C	622
	X-1615C	622
	X-1616C	614
Timmins 6	FX-1042M	633
	FX-1044CC	622
	FX-1046CC	624
	FX-1047CC	621
	FX-1048CC	620
	FX-1049CC	619
	FX-1051CC	616
	FX-1056CC	631
Timmins 7	TM-7009CC	565
	TM-7010CC	552
	TM-7012CC	556
Wishart Mine	X-1620C	127
	X-1621C	129

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ORE DEPOSIT	THERMOCABLE SITE HOLE NO.	MAP NO.
Barney 1	Z-2223CC	21-15S
	Z-2237CC	21-15S
	B-1048DG	20-15W
	B-1051DG	20-15W
	B-1053DG	20-15W
	B-1054DG	20-15W
	B-1055DG	20-15W
	B-1056DG	20-15W
Barney 2	B-1046DG	20-15S
	B-1047DG	20-15W
	B-2001CC	20-15W
	B-2006CC	20-15S
Ferriman 1	RL-707	11-14W
	F-147	12-13N
	F-149	12-13E
	F-193C	12-13N
	F-197C	12-13N
	X-641C	12-13W
	X-642C	13-13S
	F-1104	12-13N
	F-1105R	12-14W
	F-1114	12-13N
	F-1115RD	12-14W
	F-122	12-14S
	F-1283CC	12-14W
	F-1285CC	12-14W
	F-1288CC	12-14W

	F-171C	12-13E
	F-173C	12-14S
	F-175	12-14S
	F-177	12-14S
	F-178	12-13E
	F-1172R	12-14W
	F-1102C	12-13N
	F-187C	11-14W
	F-128	12-13N
Ferriman 7	FE-7001	12-13W
	FE-7002	13-13S
	FE-7003	12-13W
	FE-7004	12-13W
	FE-7005	12-13W
	FE-7006	12-13N
Fleming 3	FL-3039CC	16-13S
	FL-3042CC	16-13W
	FL-3045CC	16-13W
	FL-3050CC	16-13W
	FL-3060CC	17-13S
	FL-3084CC	16-13W
	FL-3089CC	16-13S
	FL-3090CC	16-13S
	FL-3092CC	16-13W
	FL-3093CC	16-13W
	FL-3101CC	16-13W
	FL-3103CC	16-13W
Fleming 5	FL-590C	16-14S
Fleming 7	X-1638C	17-13N
	X-1639C	17-13N
	X-1640C	17-13N
	X-1641C	17-13N
	X-1643C	17-13N
	X-1644C	17-13N
	X-1645C	17-13N
	X-1646C	17-13N
	X-1647C	17-13N
	X-1649C	17-13N
	X-1650C	17-13N
	X-1651C	17-13N
	X-1652C	17-13N
	X-1653C	17-13N
	X-1654C	17-13N
	X-1655C	17-13N
	X-1656C	17-13N
	X-1657C	17-13N
	X-1658C	17-13N
	X-1659C	17-13N
	X-1660C	17-13N
	X-1661C	17-13N
	X-1664C	17-13N
	X-1665C	17-13N
	X-1666C	17-13N
	Z-2124C	17-13E
	Z-2127C	17-13E
	FX-7004CC	16-13N
	FX-7007CC	16-13N
	FX-7008CC	16-13N
	FX-7009CC	17-13E
	FL-7020CC	17-13N
	FL-7021CC	17-13N
	FL-7025CC	17-13E
	FL-7031CC	17-13E
	FL-7032CC	17-13N
	FL-7047CC	17-13N
	FL-7059CC	17-13N
	FL-7064CC	17-13N
Fleming 8	FL-849C	15-14E
Fleming 9	FL-9010CC	17-14E
Howse	X-1869CC	20-12S
	HW-1004CC	20-12S
	HW-1007CC	20-12S
	HW-1008CC	20-12W
	HW-1013CC	20-12W

	HW-1016CC	20-12S
	HW-1018CC	20-12W
	HW-1019CC	20-12W
	HW-1024CC	20-12W
	HW-1027CC	20-12W
	HW-1030CC	20-12W
	HW-1038CC	20-12S
	HW-1046CC	20-12W
	HW-1047CC	20-12W
	HW-1049CC	20-12W
Knox Mine	FL-8070C	15-14N
	FL-8071C	15-14N
	FL-8073C	15-14N
	FL-8082CC	15-14N
	FL-8083CC	15-14N
	FL-8084CC	15-14N
Lance Ridge	LR-1017CC	14-15N
	LR-1023CC	14-15N
Pinette Hole	X-1717CC	20-12S
	X-1718CC	20-12S
Redmond 5	RE-5001CC	5-12W
	RE-5012CC	6-12S
Ruth Lake	RL-8037CC	10-14S
	RL-8040CC	10-14S
	RL-8045CC	10-14S
	RL-9004CC	11-14S
	RL-9012CC	11-14S
	RL-9013CC	11-14S
	RL-9018CC	11-14S
	RL-9023CC	11-14S
Star Creek 1,3	SC-321C	14-14N
	SC-3075CC	15-14E
Timmins 1	FL-1029M	18-12N
	FL-1049M	18-12N
	FL-1055M	18-12N
	FL-1062M	18-12N
	FL-1066M	18-12E
	FL-1072M	18-12E
	FL-1085M	18-12N
	FL-1092M	18-12N
Timmins 3	FL-2027CC	17-13E
	FL-2028CC	17-13N
	FL-2029CC	17-13N
	FL-2031CC	17-13N
	FL-2033CC	17-13N
	FL-2035CC	17-13N
	FL-2036CC	17-13N
	FL-2038CC	17-13N
	FL-2040CC	17-13N
	FL-2041CC	17-13N
	FL-2042CC	17-13N
	FL-2043CC	17-13N
	FL-2044CC	17-13N
	FL-2045CC	18-13E
	FL-2047CC	18-13E
	FL-2052CC	18-13E
	FL-2053CC	17-13E
	FL-2054CC	17-13N
	FL-2055CC	17-13N
	FL-2058CC	17-13N
	FL-2064CC	17-13N
	FL-2070CC	17-13N
	FL-2075CC	17-13E
	FL-2078CC	18-13E
Timmins 4	EL-1002M	19-12N
	EL-1003M	19-12N
	EL-1004M	19-12N
	EL-1005M	19-12N
	EL-1006M	19-12N
	EL-1007M	19-12N
	EL-1008M	19-12N
	EL-1009M	19-12N
	EL-1010M	19-12N
	EL-1011M	19-12N

	EL-1012M	19-12N
	EL-1013M	19-12N
	EL-1014M	19-12N
	EL-1015M	19-12N
	EL-1016M	19-12N
	EL-1017M	19-12N
	EL-1018M	19-12N
	EL-1021CC	19-12N
	EL-1023CC	19-12N
	EL-1024CC	19-12N
	EL-1025CC	19-12N
	EL-1026CC	19-12N
	EL-1028CC	19-12N
	EL-1029CC	19-12N
	EL-1030CC	19-12N
	EL-1031CC	19-12N
	EL-1032CC	19-12N
	EL-1033CC	19-12N
	X-1020C	17-13S
	X-1598C	20-13S
	X-1605C	20-12S
	X-1611C1	19-12N
	X-1612C1	19-12N
	X-1613C1	19-12N
	X-1614C	19-12N
	X-1615C	19-12N
	X-1616C	19-12N
Timmins 6	FX-1042M	19-13W
	FX-1044CC	19-13W
	FX-1046CC	19-13W
	FX-1047CC	19-13W
	FX-1048CC	19-13W
	FX-1049CC	19-13W
	FX-1051CC	19-13W
	FX-1056CC	19-13W
Timmins 7	TM-7009CC	18-13N
	TM-7010CC	18-13N
	TM-7012CC	18-13N
Wishart Mine	X-1620C	9-12W
	X-1621C	9-12W

TOPOGRAPHIC MAPS SCALE 1:10 000

MAP NO.

56-1112
910-1112
910-1314
1112-1314
1314-1314
1314-1516
1516-1314
1718-1112
1718-1314
19-12
1920-1112
1920-1314
1920-1516
2122-1516

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ORE DEPOSIT	THERMOCABLE SITE HOLE NO.
BARNEY 1	Z-2223CC
	Z-2237CC
	B-1055CC
	B-1056CC
BARNEY 2	B-2001CC
	B-2006CC
FERRIMAN 1	RL-707
	F-147
	F-149
	F-193C
	F-197C
	X-641C
	X-642C
	F-1104
	F-1105R
	F-1114
	F-1115RD
	F-122
	F-1283CC
	F-1285CC
	F-1287CC
	F-171C

	F-173C
	F-175
	F-177
	F-178
	F-1172R
	F-187C
	F-128
FERRIMAN 7	FE-7001
	FE-7002
	FE-7003
	FE-7004
	FE-7005
	FE-7006
FLEMING 3	FL-3039CC
	FL-3042CC
	FL-3045CC
	FL-3050CC
	FL-3060CC
	FL-3084CC
	FL-3089CC
	FL-3090CC
	FL-3092CC
	FL-3093CC
	FL-3101CC
	FL-3103CC
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FLEMING 7	X-1638C
	X-1639C
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	X-1655C
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	HW-1013CC
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	HW-1018CC
	HW-1019CC
	HW-1024CC
	HW-1027CC
	HW-1030CC
	HW-1038CC
	HW-1046CC
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KNOX MINE	FL-8082CC
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LANCE RIDGE	LR-1017CC
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PINETTE HOLE	X-1717CC
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RUTH LAKE	RL-8037CC
	RL-8040CC
	RL-8045CC
	RL-9004CC
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	FL-1049M
	FL-1055M
	FL-1062M
	FL-1066M
	FL-1072M
	FL-1085M
	FL-1092M
TIMMINS 3	FL-2027CC
	FL-2028CC
	FL-2029CC
	FL-2031CC
	FL-2033CC
	FL-2035CC
	FL-2036CC
	FL-2038CC
	FL-2040CC
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	EL-1016M
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	EL-1025CC
	EL-1026CC
	EL-1028CC
	EL-1029CC
	EL-1030CC
	EL-1031CC
	EL-1032CC
	EL-1033CC
	X-1020C
	X-1598C
	X-1605C
	X-1611C1
	X-1612C1
	X-1613C1
	X-1614C
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	X-1616C
TIMMINS 6	FX-1042M
	FX-1044CC
	FX-1046CC
	FX-1048CC
	FX-1049CC
	FX-1051CC
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FROM:	TO:	DATE:	SUBJECT:
Dagenais	Martin	30.03.70	Permafrost RL7 and Fe S
Garg	Stacey	08.09.70	Report on Ottawa meeting, September 2-6, 1970
Garg	Stacey	18.12.70	Thermistors vs. thermocouples
Garg	Stacey	13.12.71	Priority on work for 1971-72 winter
Garg	Lemelin	30.06.72	Fieldwork progress report May 20 to June 30, 1972
Garg	Stacey	08.08.73	Permafrost prediction for Rowe Mine Lifts 2350 and 2312
Garg	Lancaster	22.10.74	Review of permafrost work by the Geotechnical Section (IOC)
King	Devon	14.05.74	Letter & article on "Electrical resistivity and acoustic velocity tests on frozen rock samples from the Schefferville area"
Lowe	Stacey	04.12.70	Thermistors and thermocouples as temperature measuring devices
Martin	Campbell	10.04.70	Permafrost - Ruth Lake No. 7 and Ferriman S Mines
Nichols	Mayer	--------	Geotechnical engineering project #1 - Permafrost investigations at Knob Lake
Petch	Stacey	19.08.70	Permafrost in mine dumps

Stacey	Campbell	22.08.70	Permafrost in mine dumps
Stacey	Campbell	04.01.71	The use of thermistors & thermocouples in permafrost measurements
Stacey	Campbell	15.04.71	The geotechnical engineering section's approach to the permafrost problem - a proposal
Stacey	Campbell	15.12.71	The study of bank stability in permafrost
Stacey	Garg	18.07.72	Regional permafrost appraisal
Stacey	Krueckl & Nichols	01.05.73	Instrumentation of deep drill holes for geothermal gradient measurements
Thom	Nichols	12.12.69	Principles of temperature change in permafrost and preliminary suggestions of techniques for change
Thom	Dagenais	24.03.70	Permafrost possibilities at Ferriman S-Ruth Lake No. 7
Thom	Stacey	11.09.70	Visit to Ottawa, September 3-4, 1970
Thom	Stacey	27.09.70	Geotechnical's contribution to permafrost investigations in pits
Thom	Stacey	10.07.70	Potential deposits with permafrost

16.3 Reports and Notes.. 101

Notes on field operations of Honeywell potentiometer for soil and permafrost temperature measurements under Sub-arctic conditions. J.L. Franks (McGill University) 1970.

Notes and problems on putting plastic pipe in drill holes. J. Hankin (McGill University) August 1974.

Procedure for the installation of water table observation pipe, permafrost + thermistor cable. G. Mihalovic (I.O.C.C.) April 1980.

Geotechnical field procedures. G. Mihalovic (I.O.C.C.) April 1980.

Thermal amelioration of permafrost by modifying the natural heat budget project based upon Timmins 4 permafrost experimental site. F.H. Nicholson (McGill University) August 1971.

Uses of applied geophysics in the Schefferville mining district in the late 1960's. M.K. Seguin (Laval University).

Geophysical investigations in the Labrador Trough and in the Knob Lake area in particular. M.K. Seguin (Laval University).

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Volume XVII contains the updated thermocable data file on a set of flexible discs (HP16 compatible 3.5 inch micro flexible disc).

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