Province of British Columbia

MEMORANDUM

TO: Claudia

FROM: Kim

SUBJECT: Onion Lake

DATE: 85-12-20

☐ For Your Information ☐ Please O.K. and Return ☐ Please Discuss With Me ☐ Per Your Request ☐ For Your Signature
☐ Please Process ☐ Return With More Details ☐ Investigate and Report ☐ Please Answer ☐ For Your File

These licences have forfeited. Please let me know if the report is OK. Thanks

Kim Bob.

Fold Here for Window Envelope

REPLY:

OPEN FILE

WRITE YOUR REPLY AND RETURN THIS SHEET

Crows Nest Resources LIMITED
Eau Claire Place, 525 - 3rd Avenue S.W., Calgary, Alberta (403) 232-4355
P.O. Box 2699, Station M, Calgary, Alberta T2P 2M7 Telex 03-822505

December 20, 1985

MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES
DEC 20 1985
MINERAL TITLES FILE ROOM

Ministry of Energy, Mines and
Petroleum Resources
525 Superior Street
Victoria, B.C.
V8V 1T7

Dear Sirs:

Enclosed please find our report on the Onion Lake Project.

This report has been prepared by Mr. B. McKinstry, an employee of Crows Nest Resources Limited.

Mr. B. McKinstry, M.Sc., graduated in Geology from Carleton University, Ottawa in 1971. Prior to graduation, Mr. McKinstry worked as an assistant for a major mining firm and after graduation as a geologist with a mining firm, a research assistant at Carleton University and a a geologist with a consulting firm. Mr. McKinstry has been employed by Crows Nest Resources Limited as a Staff Geologist, since 1981.

I consider the aforementioned geologist to be well qualified to undertake the responsibilities assigned on this project. I am satisfied that the attached report has been competently prepared and justly represents the information obtained from this project.

Yours very truly,

B.D. Ryan, P. Geol.
Manager - Geology

GEOLOGICAL BRANCH
ASSESSMENT REPORT

00 696

AREA	S	MEMBER	DATE	INIT.
MGRS		CGC		
		D.D.		
C.S.		S.P.		
FILE				
VICT		ATM		
		DGC		
COAL /				
MID		SUP.		
V.I.C.		ATM		

A12/u.1

ONION LAKE

N.E. B.C.

COAL EXPLORATION 1985

Coal Licences: Onion Lake Licences 4220 to 4223 (inclusive) and 4749

Group #242

PEACE RIVER LAND DISTRICT, NORTHEASTERN, B.C.

HELD BY: SHELL CANADA RESOURCES LTD.

OPERATED BY: CROWS NEST RESOURCES LIMITED

National Topographic Series: 93I/10 WAPITI LAKE

Location: 54° 44' NORTH LATITUDE
120° 48' WEST LONGITUDE

Authors: B. McKINSTRY

Field Work: AUGUST 19 TO AUGUST 26, 1985

Report Submitted: December 20, 1985

C2/e.1

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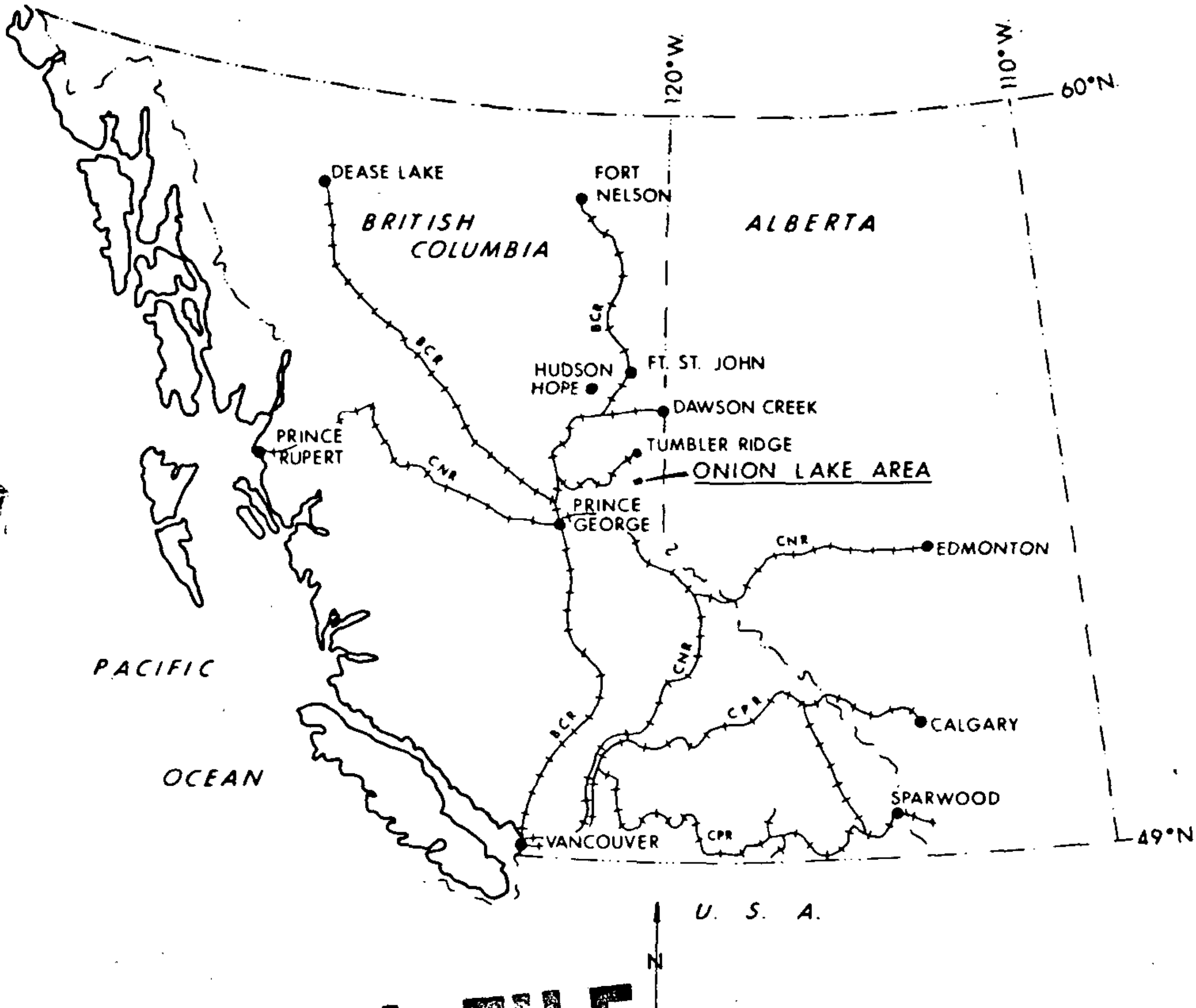
LIST OF ENCLOSURES

ENCLOSURE 1	REPORT ON SEISMIC PROFILING, ONION LAKE GEOPHYSICON LTD., 1985



Crows Nest Resources Limited

EXPLORATION

ONION LAKE

NE BC

LOCATION MAP

FIGURE 1

AUTHOR WHITE / FIETZ	SCALE AS SHOWN	ENCLOSURE No
DATE 84-12	REVISED	
To Accompany		DRAWING No AA-542

SUMMARY

Previous exploration in Crows Nest Resources' Onion Lake prospect indicate a potential for open pit mining of high volatile bituminous coal. Drilling results from 1981 suggest economical coal reserves are within the Gates member of the Commotion Formation, a division of the Cretaceous Fort St. John Group. Geology is complicated by regional folding and faulting associated with a Rocky Mountain Front Range thrust fault.

In 1984, on strike extrapolation of the coal measures southward was tested with a helicopter supported NQ diamond drillhole program. The hole was located approximately 1 kilometer south of previous drilling. Results were inconclusive as bedrock was not reached after penetration of 93 meters of overburden. A seismic refraction survey was conducted in 1985 to ascertain the limits and depth of this overburden. Results of the survey suggest considerable volumes of Gates member stratigraphy have been removed by previous glacial activity in the central portion of the licence block. It is considered that the economic potential of the Onion Lake coal prospect has been substantially diminished and the Licences are being relinquished to the Crown at this time.

1.0 INTRODUCTION

1.1 Coal Land Tenure

The Onion Lake property is comprised of five B.C. Coal Licences 4220-4223 inclusive and 4749 (Group #242) covering an area of 1425 hectares.

Shell Canada Resources Limited holds the licences and Crows Nest Resources Limited (a wholly owned subsidiary) acts as operator of the licences.

Owing to the results of the 1985 geophysical field survey, the licences will be surrendered to the Crown.

1.2 Location, Geography and Physiography

The Onion Lake property is located in the foothills of Northeastern British Columbia in the Peace River Land District. (Fig. 1) The property, covering 1425 hectares, is centered at approximately 54° 44' north and 120° 48' west on N.T.S. map sheet 931/10W (Wapiti Lake). Onion Lake to the south, Onion Creek on the east, Fellers Creek to the north and Bone Mountain to the west, bound the area covered by the Onion Lake licences.

The property is 45km south-southeast of the new town of Tumbler Ridge and 125km south-southwest of Dawson Creek.

Elevation of the area varies from 1300 to 1830m above sea level. The north and central portions of the licence area are of relatively gentle relief, rolling and climbing to the front slopes of Bone Mountain. To the south and east the topography drops off rapidly into steep wooded slopes. The extreme northeast corner of the property is cut by a deep (approx. 125m) narrow gorge.

Surface exposure of rock on the property is sparse and for the most part, scattered. Outcrop occurs on high barren knobs within licences 4222 and 4223, in the gorge, or along a northwest-southeast trending ridge on the eastern edge of the property. (Fig. 4)

Approximately 20m of glacial till are exposed in stream cuts, near the middle and south end of the property.

Vegetation within the licence is typical of the boreal and sub-alpine zones. Trees vary from spruce at lower elevations to alpine fir and balsam higher up. Open alpine meadows and barren lichen and moss covered areas occur on the highest slopes.

1.3 Access

Currently there is no road access to the Onion Lake property. During the 1985 exploration program access was obtained by helicopter.

Local forestry officials indicated there are hiking and horse trails which lead to the north end of Onion Lake 1km south of the property.

The closest road is the Kinuseo Falls Road 12km north of the property. Road building to the property would be very difficult because of rugged terrain and a large elevation gain between Kinuseo Creek and the licence area. The most probable location of future road access would be along a seismic line which comes from the east, behind Petro Canada's Duke Mountain coal licence block, then crossing Onion Creek and climbing to the higher more prospective ground of the licence area.

The Onion Lake area appears to support an extensive wildlife population. Mountain goats are known to live and calve on Bone Mountain in the winter and early spring. It is believed they then move down and cross the Onion Lake property in late spring/early summer, to get to the gorge near the northeast corner of the property.

The area also supports a large grizzly population. Grizzlies were occasionally seen by field crews during the 1980 mapping program.

2.0 EXPLORATION

2.1 Summary of Previous Work

Previous work on the Onion Lake property has consisted of 1:50,000 geologic mapping and 2 diamond drill holes as detailed in Table 1 below:

TABLE 1

SUMMARY OF PREVIOUS WORK

1979	1:50,000 reconnaissance geologic mapping (Hoffman, 1979)
1980	1:5000 geologic mapping (Bell, 1980)
1981	236m core drilling in 1-NQ size hole (Bell, 1981)
1982	NIL
1983	NIL
1984	93m core drilling in 1 NQ size hole (White & Fietz, 1984)

2.2 1984 Exploration Program

2.2.1 Scope and Objectives

Previous exploration (Bell, 1981) indicated potential coal reserves located within the Gates member of the Commotion Formation on the west flank of the Wapiti anticline on CNRL's Onion Lake property. Recommendations at the time included drilling along strike south to ascertain seam continuity and reserve potential. In 1984, it was decided to follow through with this recommendation and locate a diamond drill hole approximately 1150 meters along strike south from the 1981 drill hole. A diamond drill hole was triconed to a depth of 93.3 meters in gravel and sand. This extensive accumulation of overburden suggested that a substantial section of the coal bearing Gates has been removed by glaciation. Accordingly in 1985 a shallow refraction seismic survey was planned to evaluate extent and depth of overburden.

2.2.2 Results

Geophysicon Limited of Calgary was contracted to carry out a shallow refraction seismic survey over a grid network of pre-cut walking trails (approx. 1 meter wide). The grid was established by CNRL staff to properly evaluate overburden conditions overlying the Gates member of the Commotion Formation extrapolated south from BH81-1. A copy of their report (Enclosure 1) is included with this submission. In addition, data points from the four sections found in the Geophysicon report have been used to generate an overburden contour surface (Fig. 5) and an overburden isopach map (Fig. 6). These illustrations suggest overburden thicknesses reflect Pleistocene glacial activity. A north-south trending trough-like depression extends from BH 84-1 in either direction and appears to mimic local drainage patterns. Very abrupt variation in overburden thickness at the east end of Line 1 north is suggestive of ice scouring, with what appears to be a resistant cap of Torrens sandstone preserving the underlying strata from glacial effects. In any event, an examination of Figures 5 & 6 indicate that the Gates member of the Commotion Formation has been deeply eroded south of BH 81-1 and precludes any opportunity to establish substantial open-pit mining reserves for the Onion Lake licences.

2.2.3 Logistics

The survey crew stayed in Tumbler Ridge, B.C. At present, there is no road access within several kilometers of the project area and access is totally helicopter dependant. Crew/supply transportation originated from Tumbler Ridge using a Bell 206B helicopter contracted from Okanagan Helicopters.

Site preparation included slashing, limbing and bucking of timber along 4 kms of 1 metre wide walking trails. These trails were laid out in a grid fashion (Fig. 4) to facilitate movement of equipment during the seismic survey, with the grid laid in by compass and chain methods.

2.2.4 1985 Expenditures

Costs incurred for exploration activities for the 1985 field season are approximately $31,500.00.

3.0 GEOLOGY

3.1 Regional Geology (Figure 2)

Cretaceous marine and non-marine strata consisting of the Minnes, Bullhead and lower Fort St. John Groups are located in a belt trending northwest-southeast from Onion Lake, B.C. The strata have been folded into the regional Wapiti anticline - Onion syncline fold pair. The folds are developed in the footwall plate of a Rocky Mountain Front Range thrust fault separating Paleozoic carbonates from the Cretaceous sediments. This folding has created potential for dip-slope open pit mining of coal measures within the Cretaceous strata.

3.2 Onion Lake Stratigraphy

Figure 3 outlines the stratigraphy of the Cretaceous sediments in the Onion Lake area.

MINNES GROUP

The Minnes group is located stratigraphically beneath the Cadomin formation of the Bullhead Group. It typically is composed of sequences of marine and non-marine sediments. In addition, coal or coaly beds occur but they are rarely thicker than two meters and seem to have limited lateral continuity. Locally, the Minnes is exposed in the core of the Wapiti anticline and contains massive, thick conglomerates beneath the Cadomin Formation. These conglomerate units are distinguished from Cadomin conglomerates on the basis of brown colour, softer nature of the rock and absence of Cadomin-like pink and green pebbles.

CADOMIN FORMATION

This unit is 30-35 meters thick exposed as a marker unit outlining the Onion syncline and the west limb of the Wapiti anticline. The dominant rock-type is non-marine conglomerate with minor coarse sandstone. Outcrops are light grey weathering and contain distinctive pink and green pebbles and cobbles.

GETHING FORMATION

Conformably overlying the Cadomin Formation is the non-marine Gething Formation comprising sandstones, conglomerates, minor siltstone and coal. As a complication to stratigraphy, the Gething near Onion Lake contains almost 50% conglomerate as extensive strike length cliffs and ridges. Coal development within the Gething has been severely limited by the coarse clastic deposition. It is considered that only two thin seams may be present in the Onion area and little exploration has been undertaken in this unit. Stratigraphic thickness is estimated to be 80 meters on the Onion property.

MOOSEBAR FORMATION

The Moosebar Formation defines the base of the Fort St. John Group and indicates a change of facies from non-marine conditions of sedimentation. A 40 meter measurable section of the recessive weathering shales can be found in the Gorge at Onion Lake with the formation thinning southward to 25 meters at Secus Mountain and thickening northward toward Sukunka.

COMMOTION FORMATION (Gates Member)

Conformably overlying the Moosebar Formation and indicating a return to non-marine facies is the Gates member of the Commotion Formation. Rock types include sandstone, conglomerate, siltstone, mudstone and coal. In the Onion Lake area, the basal part of the Gates is known as the Torrens sandstone, a readily discernible marker unit of brown-grey, crossbedded sandstone considered to represent a transitional boundary between marine and non-marine deposition. Due to structural complications, thickness of the Gates on the west flank of the Wapiti anticline is unknown but estimates in other areas suggest 362 to 435 meters. Drilling evidence at Secus as well as the 1981 Onion Lake hole indicate that the thickest coal accumulation in the Gates is developed within the first 20 to 30 meters above the Torrens sandstone. The coal stratigraphy above this section is not well known due to poor exposure and lack of drilling. The Hulcross and Boulder Creek members of the Commotion Formation are not present on the Onion Lake property and will not be discussed.

3.3 Structural Setting

As discussed earlier and indicated on Figure 4, major structures within the Onion Lake property include the Wapiti anticline - Onion syncline fold pair and a regional west dipping thrust fault forming the western boundary to the property. This is best illustrated on Bell's cross-section in Appendix C of his 1981 report. It appears that the Wapiti anticline is an upright asymmetric structure plunging northward. The inconsistencies of core-bedding angles in the upper section of the Gates member in borehole ON81-1 as well as dip direction changes within the Gates on the west flank of the Wapiti anticline suggest subsidiary folding and possible faulting on the west limb as one approaches the Rocky Mountain front-range thrust fault. Thus, prospecting in the Gates member may be hampered by these structural complexities. In addition, the extensive gravel intersection in borehole ON84-1 suggests much of the Gates in the central area of the licence block has been removed by Pleistocene glacial activity.

3.4 Coal Geology and Quality

As no bedrock was encountered in borehole ON84-1, a discussion of the coal geology and quality information from borehole ON81-1 is required. A total of 8 zones or seams greater than 1.0 meter were intersected in the Gates member to the top of the Torrens sandstone. This was an aggregate thickness of 28.9 meters over 169.3 meters of apparent section and translates into a down the hole rock to coal ratio of 6:1. Two thick coal zones are evident in the section, the first immediately above the Torrens sandstone consisting of two seams (seams 1 and 2) 1.9 and 6.9 meters in apparent thickness inclusive. The second zone is immediately beneath the second conglomerate unit above the Torrens, consisting of 3 seams 8.5, 4.0 and 4.7 meters in apparent thickness (seams 6, 7, 8).

Coal quality analyses indicate volatile matter (air-dry basis) ranges from 27% to 31% with raw ash varying from 9 to 40%. Sulphur values are less than 1% and heat content ranges from 7300 to 7900 Kcal/Kg. Rank classification for these coals is high Volatile Bituminous 'A' on a dry ash-free basis.

4.0 RESULTS AND RECOMMENDATIONS FOR FURTHER WORK

The absence of bedrock in borehole ON84-1 severely limits the extrapolation of seams identified in borehole ON81-1 along strike southward. The seismic survey results of 1985 substantiate this limitation and generates a negative impact on reserve potential and mineability for the central and southern portions of the coal licence area. With this in mind, it is recommended that the Onion Lake licences be surrendered to the Crown.

5.0 SELECTED BIBLIOGRAPHY

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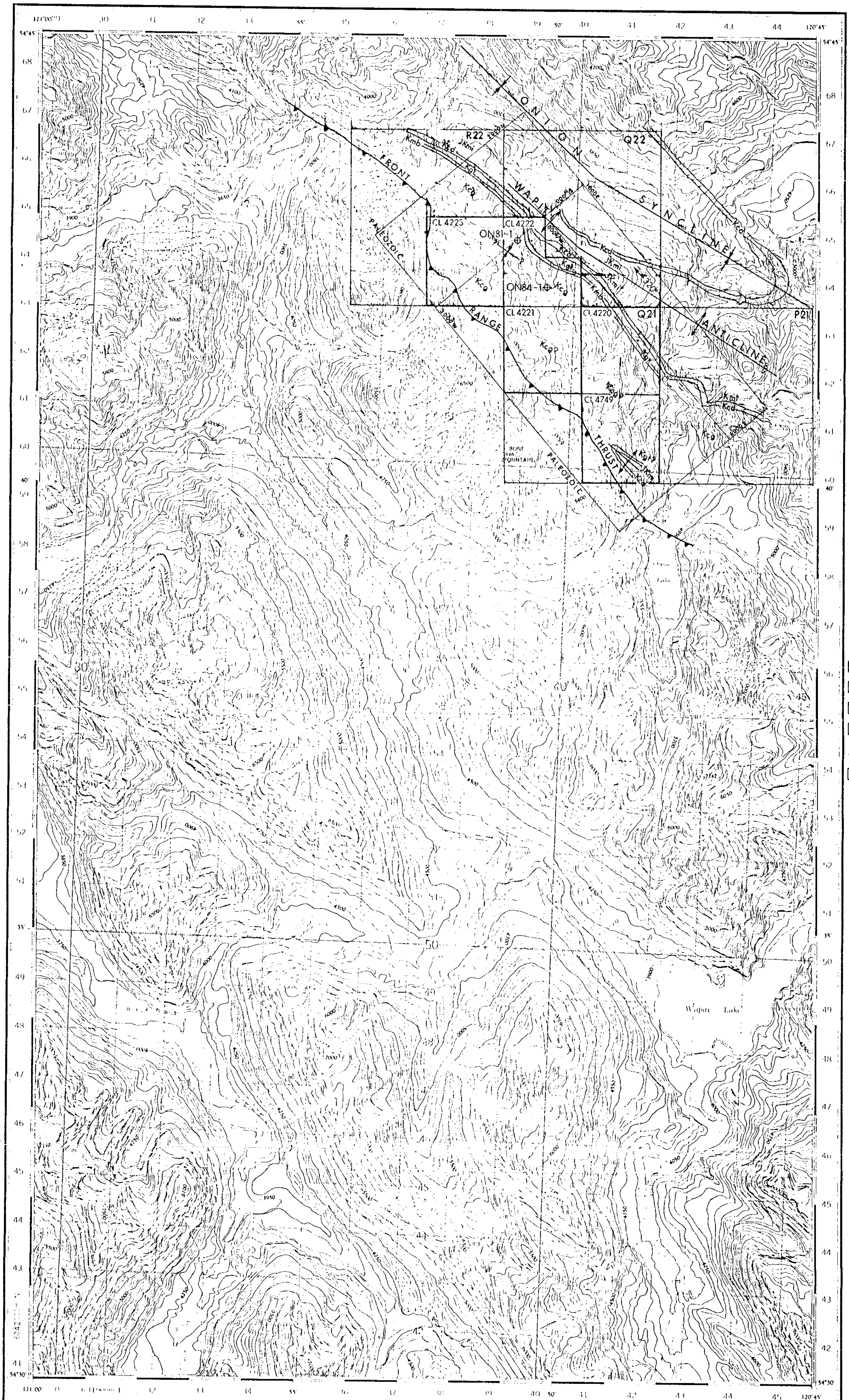


GEOLOGICAL LEGEND

LOWER CRETACEOUS

Kcg	COMMOTION FORMATION (Gates Member)	FORT ST. JOHN GROUP
Kmb	MOOSEBAR FORMATION	FORT ST. JOHN GROUP
Kgt	GETHING FORMATION	BULLHEAD GROUP
Kcd	CADOMIN FORMATION	BULLHEAD GROUP

JURRASSIC-CRETACEOUS

JKml	MINNES GROUP

GEOLOGICAL SYMBOLS

- ANTICLINE
- SYNCLINE
- THRUST FAULT
- 1981 DRILL HOLE

U.T.M. ZONE 10

INDEX MAP

121°15' 120°30' 55°00'

93I/14E	93I/15W	93I/15E
93I/11E	93I/10W	93I/10E
93I/6E	93I/7W	93I/7E

54°15'

WAPITI LAKE

PEACE RIVER DISTRICT

BRITISH COLUMBIA

SCALE 1:50,000 ÉCHELLE

CONTOUR INTERVAL 100 FEET Elevations in Feet above Mean Sea Level	ÉQUIDISTANCE DES COURBES 100 PIEDS Élévations en pieds au dessus du niveau moyen de la mer
Transverse Mercator Projection North American Datum 1927	Projection transverse de Mercator Réseau géodésique nord américain unifié 1927
MAGNETIC DECLINATION 26°15' EAST AT CENTRE OF MAP 1965 Annual change decreasing 4.1'	DÉCLINAISON MAGNÉTIQUE AU CENTRE DE LA FEUILLE EN 1965 26°15' EST Variation annuelle décroissante 4.1'

696

Crows Nest Resources Limited

EXPLORATION

ONION LAKE

N.E. B.C.

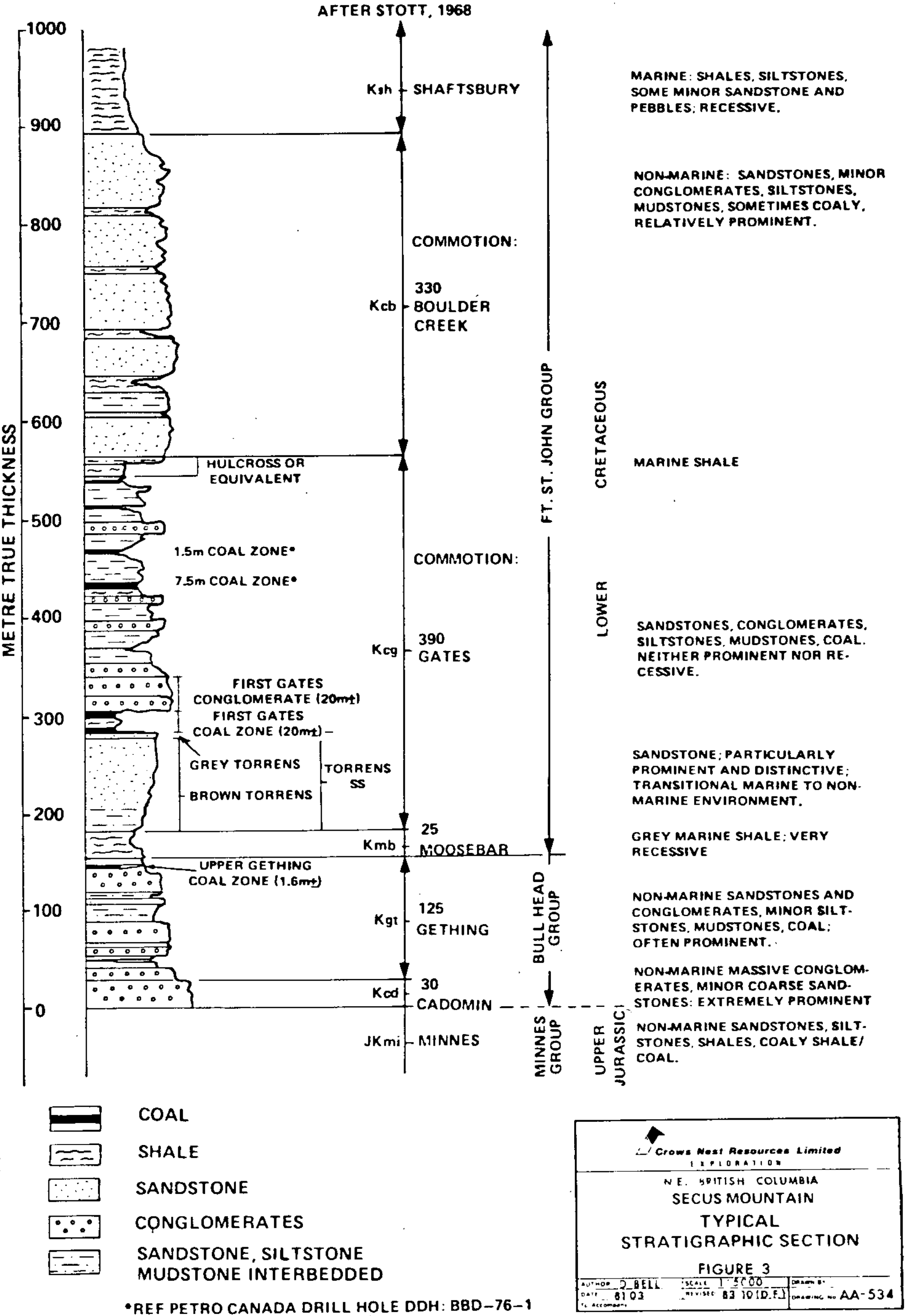
COAL LAND DISPOSITION, INDEX AND GEOLOGICAL COMPILATION MAP

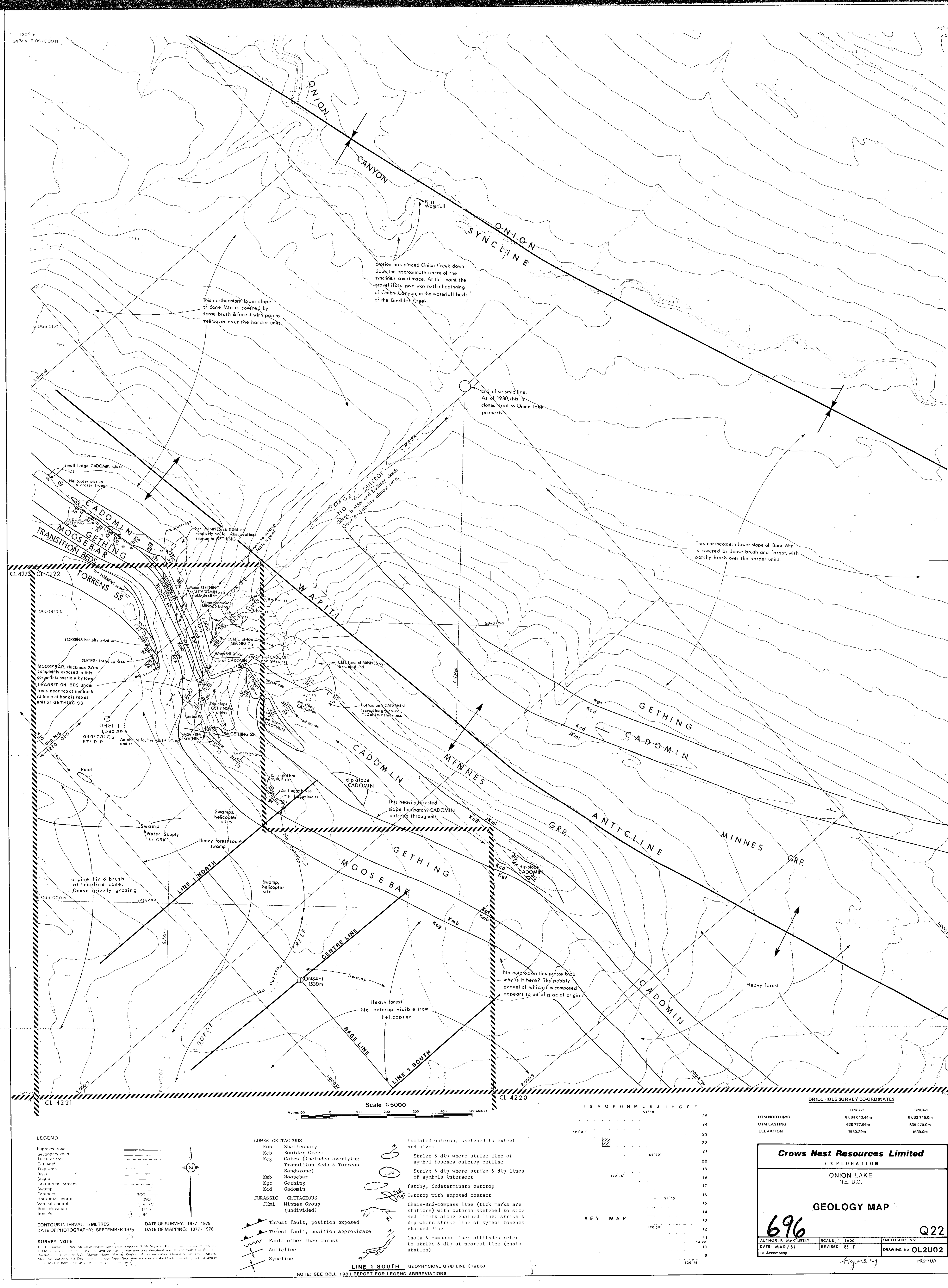
FIGURE 2

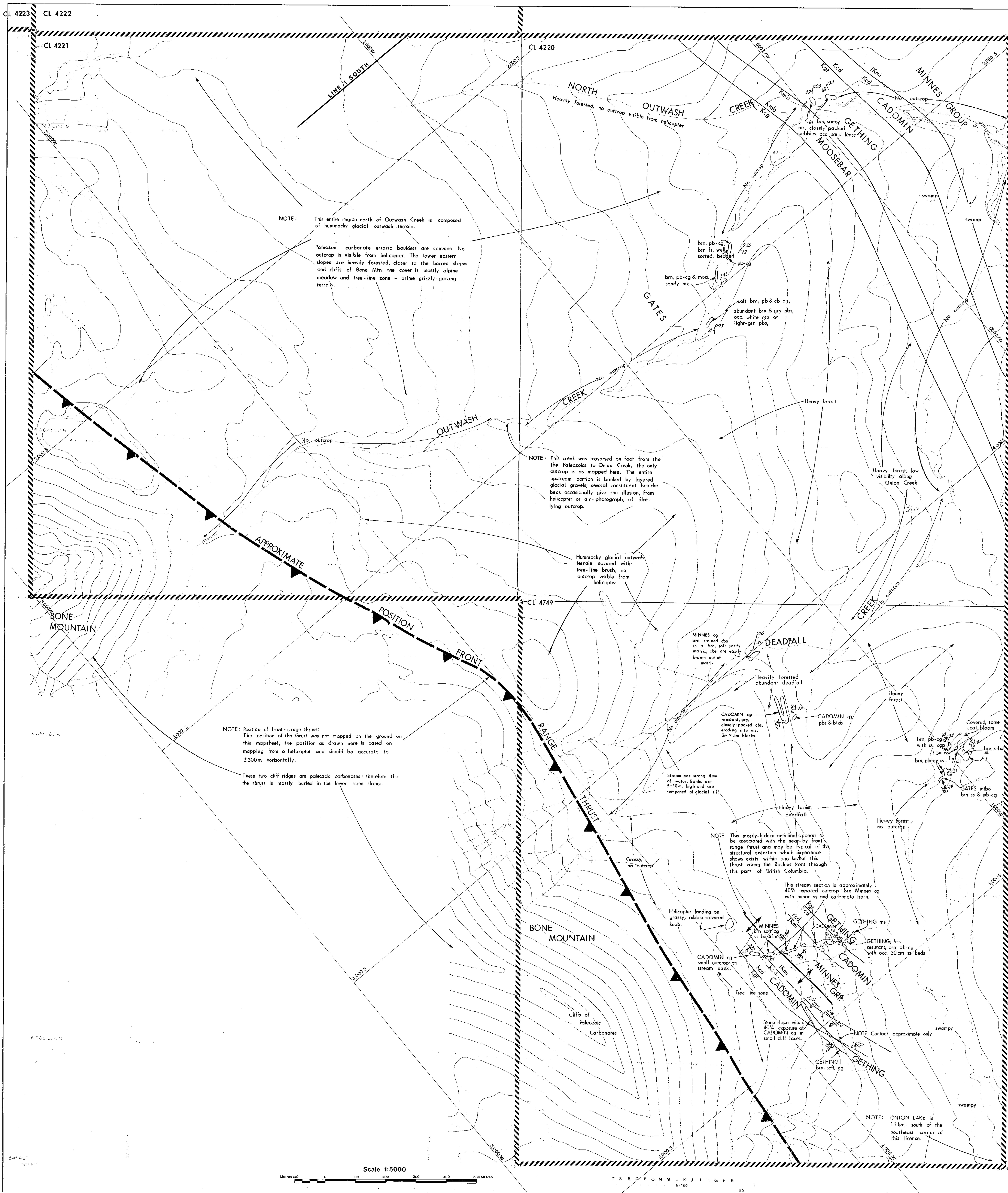
WAPITI LAKE 93I/10W

AUTHOR D. BELL	SCALE 1:50,000	ENCLOSURE No
DATE MARCH 81	REVISED 84-12	DRAWING No OL5U01
To Accompany		

HK-70A


AFTER STOTT, 1968
METRE TRUE THICKNESS
1000
900
800
700
600
500
400
300
200
100
0
Ksh SHAFTSBURY
MARINE: SHALES, SILTSTONES, SOME MINOR SANDSTONE AND PEBBLES; RECESSIVE.
NON-MARINE: SANDSTONES, MINOR CONGLOMERATES, SILTSTONES, MUDSTONES, SOMETIMES COALY, RELATIVELY PROMINENT.
COMMOTION:
330
Kcb BOULDER CREEK
HULCROSS OR EQUIVALENT
MARINE SHALE
FT. ST. JOHN GROUP
CRETACEOUS
1.5m COAL ZONE*
7.5m COAL ZONE*
COMMOTION:
LOWER
390
Kcg GATES
SANDSTONES, CONGLOMERATES, SILTSTONES, MUDSTONES, COAL. NEITHER PROMINENT NOR RECESSIVE.
FIRST GATES CONGLOMERATE (20m±)
FIRST GATES COAL ZONE (20m±)
GREY TORRENS
BROWN TORRENS
TORRENS SS
SANDSTONE; PARTICULARLY PROMINENT AND DISTINCTIVE; TRANSITIONAL MARINE TO NON-MARINE ENVIRONMENT.
25
Kmb MOOSEBAR
GREY MARINE SHALE; VERY RECESSIVE
UPPER GETHING COAL ZONE (1.6m±)
125
Kgt GETHING
BULL HEAD GROUP
NON-MARINE SANDSTONES AND CONGLOMERATES, MINOR SILTSTONES, MUDSTONES, COAL; OFTEN PROMINENT.
30
Kcd CADOMIN
NON-MARINE MASSIVE CONGLOMERATES, MINOR COARSE SANDSTONES: EXTREMELY PROMINENT
JKmi MINNES
MINNES GROUP
UPPER JURASSIC
NON-MARINE SANDSTONES, SILTSTONES, SHALES, COALY SHALE/COAL.
COAL
SHALE
SANDSTONE
CONGLOMERATES
SANDSTONE, SILTSTONE MUDSTONE INTERBEDDED
*REF PETRO CANADA DRILL HOLE DDH: BBD-76-1
Crows Nest Resources Limited
EXPLORATION
N.E. BRITISH COLUMBIA
SECUS MOUNTAIN
TYPICAL STRATIGRAPHIC SECTION
FIGURE 3
AUTHOR D. BELL
SCALE 1:5000
DATE 81 03
REVISED 83 10 (D.F.)
DRAWING No AA-534


ONION CANYON
ONION SYNCLINE
First Waterfall
Erosion has placed Onion Creek down down the approximate centre of the syncline's axial trace. At this point, the gravel flats give way to the beginning of Onion Canyon, in the waterfall beds of the Boulder Creek.
This northeastern lower slope of Bone Mtn is covered by dense brush & forest with patchy tree cover over the harder units
End of seismic line. As of 1980, this is closest trail to Onion Lake property
This northeastern lower slope of Bone Mtn is covered by dense brush and forest, with patchy brush over the harder units.
CADOMIN
GETHING
MOOSEBAR
TRANSITION BEDS
TORRENS SS
WAPITI
GETHING
CADOMIN
MINNES
MINNES GRP.
ANTICLINE
MINNES GRP.
CADOMIN
GETHING
MOOSE BAR
CADOMIN
GORGE OUTCROP CREEK
ON81-1
1,580.29m
049° TRUE at 57° DIP
ON84-1
1530m
LINE 1 NORTH
CENTRE LINE
BASE LINE
LINE 1 SOUTH
CL 4223
CL 4222
CL 4221
CL 4220
Heavy forest
No outcrop visible from helicopter
No outcrop on this grassy knob; why is it here? The pebbly gravel of which it is composed appears to be of glacial origin
This heavily forested slope has patchy CADOMIN outcrop throughout
alpine fir & brush at treeline zone. Dense grizzly grazing
Scale 1:5000
DRILL HOLE SURVEY CO-ORDINATES
	ON81-1	ON84-1
UTM NORTHING	6 064 643,44m	6 063 740,0m
UTM EASTING	638 777,06m	639 470,0m
ELEVATION	1580,29m	1530,0m
LEGEND
Improved road
Secondary road
Track or trail
Cut line
Tree area
River
Steam
Intermittent stream
Swamp
Contours
Horizontal control
Vertical control
Spot elevation
Iron Pin
CONTOUR INTERVAL: 5 METRES
DATE OF PHOTOGRAPHY: SEPTEMBER 1975
DATE OF SURVEY: 1977 - 1978
DATE OF MAPPING: 1977 - 1978
SURVEY NOTE
LOWER CRETACEOUS
Ksh Shaftesbury
Kcb Boulder Creek
Kcg Gates (includes overlying Transition Beds & Torrens Sandstone)
Kmb Moosebar
Kgt Gething
Kcd Cadomin
JURASSIC - CRETACEOUS
JKmi Minnes Group (undivided)
Thrust fault, position exposed
Thrust fault, position approximate
Fault other than thrust
Anticline
Syncline
Isolated outcrop, sketched to extent and size:
Strike & dip where strike line of symbol touches outcrop outline
Strike & dip where strike & dip lines of symbols intersect
Patchy, indeterminate outcrop
Outcrop with exposed contact
Chain-and-compass line (tick marks are stations) with outcrop sketched to size and limits along chained line; strike & dip where strike line of symbol touches chained line
Chain & compass line; attitudes refer to strike & dip at nearest tick (chain station)
LINE 1 SOUTH GEOPHYSICAL GRID LINE (1985)
NOTE: SEE BELL 1981 REPORT FOR LEGEND ABBREVIATIONS
KEY MAP
Crows Nest Resources Limited
EXPLORATION
ONION LAKE
N.E. B.C.
GEOLOGY MAP
696
Q22
AUTHOR: B. McKINSTRY
SCALE: 1 : 5000
ENCLOSURE No:
DATE: MAR / 81
REVISED: 85 - 11
DRAWING No OL2U02
To Accompany
HG-70A



Scale 1:5000

Metres 100 0 100 200 300 400 500 Metres

LEGEND

- Improved road
- Secondary road
- Track or trail
- Cut line
- Tree area
- River
- Stream
- Intermittent stream
- Swamp
- Contours
- Horizontal control
- Vertical control
- Spot elevation
- Iron Pin

CONTOUR INTERVAL: 5 METRES
DATE OF PHOTOGRAPHY: SEPTEMBER 1975
DATE OF SURVEY: 1977 - 1978
DATE OF MAPPING: 1977 - 1978

SURVEY NOTE

The Horizontal and Vertical Co-ordinates were established by D. W. Watson, B.C.L.S. using conventional and E.D.M. survey equipment. Horizontal and vertical co-ordinates and elevations are derived from Trig. Stations ... Hawk, Marcia, Knoseu. All co-ordinates referred to Universal Transverse Mercator Grid Zone 10. Elevations are above Mean Sea Level ... simultaneously.

LOWER CRETACEOUS

Ksh	Shaftesbury
Kcb	Boulder Creek
Kcg	Gates (includes overlying Transition Beds & Torrens Sandstone)
Kmb	Moosebar
Kgt	Gething
Kcd	Cadomin

JURASSIC - CRETACEOUS

JKmi	Minnes Group (undivided)

- Thrust fault, position exposed
- Thrust fault, position approximate
- Fault other than thrust
- Anticline
- Syncline

Isolated outcrop, sketched to extent and size:

- Strike & dip where strike line of symbol touches outcrop outline
- Strike & dip where strike & dip lines of symbols intersect

Patchy, indeterminate outcrop

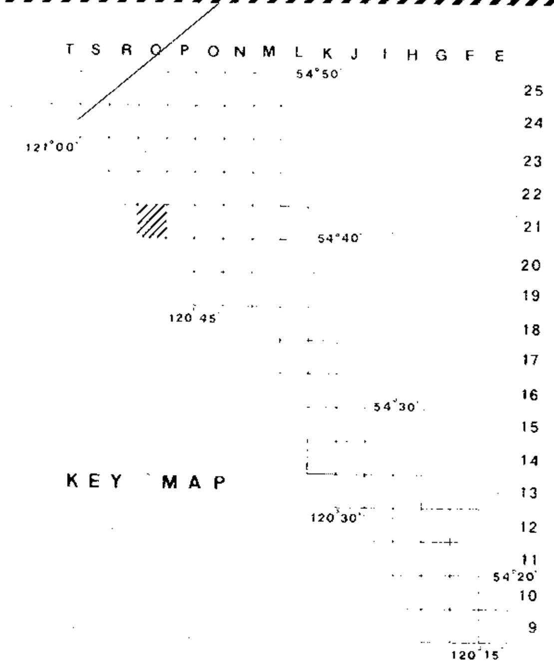
Outcrop with exposed contact

Chain-and-compass line (tick marks are stations) with outcrop sketched to size and limits along chained line; strike & dip where strike line of symbol touches chained line

Chain & compass line; attitudes refer to strike & dip at nearest tick (chain station)

LINE 1 SOUTH GEOPHYSICAL GRID LINE (1985)

NOTE: SEE BELL 1981 REPORT FOR LEGEND ABBREVIATIONS



Crows Nest Resources Limited
EXPLORATION

ONION LAKE
N.E. B.C.

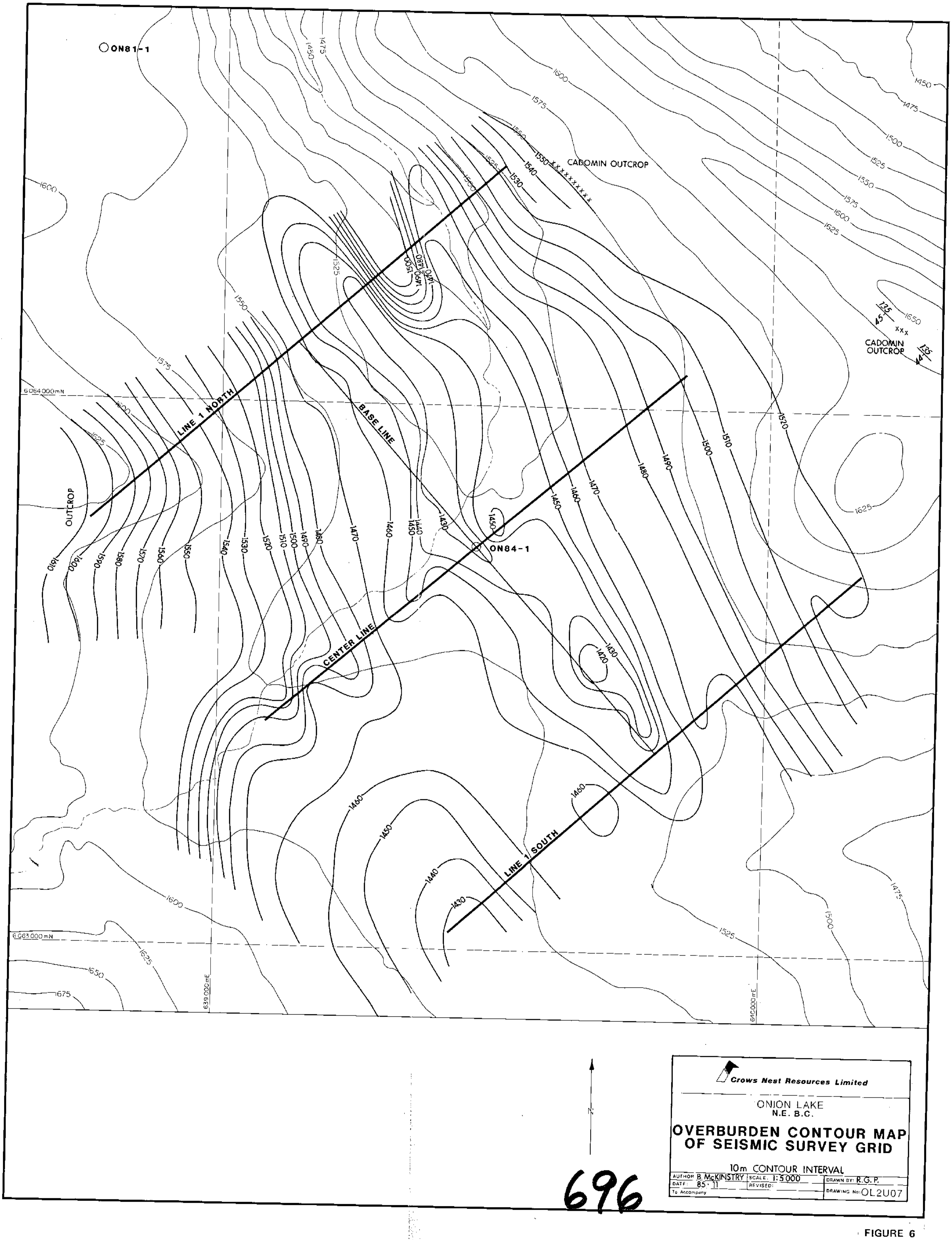
GEOLOGY MAP

696 Q21

AUTHOR: B. McKINSTRY	SCALE: 1 : 5000	ENCLOSURE No:
DATE: MARCH, 1981	REVISED: 85-11	DRAWI OL2U03
To Accompany		

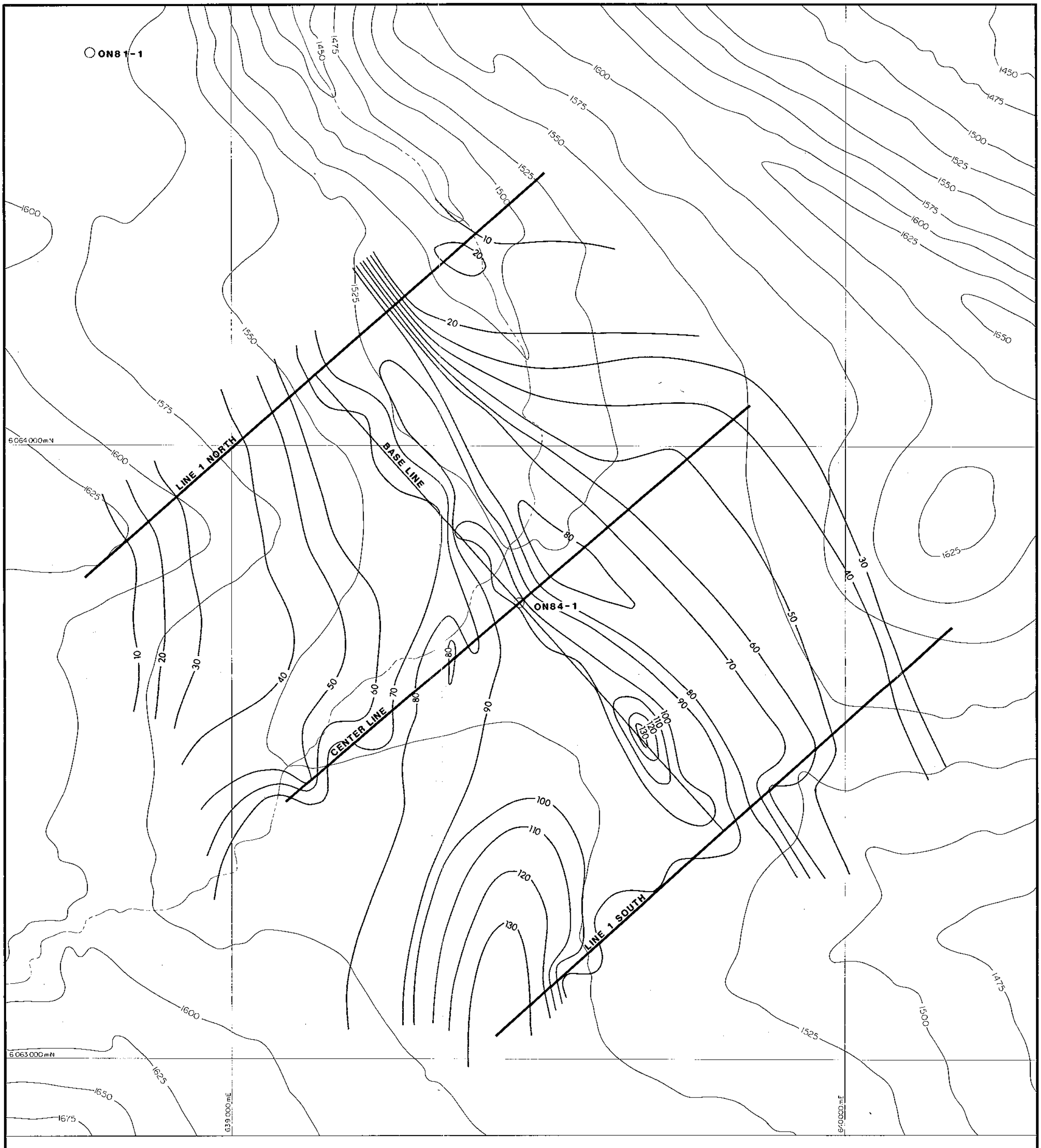
HG-70B

FIGURE 4



ON81-1
ON84-1
CADOMIN OUTCROP
CADOMIN OUTCROP
OUTCROP
LINE 1 NORTH
BASE LINE
CENTER LINE
LINE 1 SOUTH
6064000mN
6063000mN
639000mE
640000mE
Crows Nest Resources Limited
ONION LAKE
N.E. B.C.
OVERBURDEN CONTOUR MAP
OF SEISMIC SURVEY GRID
10m CONTOUR INTERVAL
AUTHOR B. McKINSTRY
SCALE 1:5000
DRAWN BY: R.G.P.
DATE: 85·11
REVISED:
DRAWING No: OL2U07
To Accompany
N
696

FIGURE 6



Crows Nest Resources Limited

ONION LAKE
N.E. B.C.

OVERBURDEN ISOPACH MAP

10m CONTOUR INTERVAL

AUTHOR: B. McKINSTRY	SCALE: 1:5000	DRAWN BY: R.G.P.
DATE: 85·11	REVISED:	DRAWING No: OL2U06
To Accompany		

696

FIGURE 7

696

GEO-PHYSI-CON

REFRACTION SEISMIC SURVEY
ONION LAKE PROJECT
TUMBLER RIDGE, BRITISH COLUMBIA

Prepared For

CROWS NEST RESOURCES LTD.
CALGARY, ALBERTA

Prepared By

GEO-PHYSI-CON CO. LTD.
CALGARY, ALBERTA

October, 1985
C85-27

696

GEO-PHYSI-CON

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2.0 LOGISTICS AND DATA ACQUISITION	1
3.0 DATA PROCESSING	4
4.0 RESULTS	5
4.1 Line 1 South	6
4.2 Centre Line	6
4.3 Line 1 North	7
4.4 Base Line	8
5.0 CONCLUSIONS	8

1.0 INTRODUCTION

This report presents the results of a refraction seismic survey to determine the depth to competent bedrock on a section of the Onion Lake project. The seismic survey was requested by Dr. B. Ryan of Crows Nest Resources Ltd. under P.O. number 24211. Field work was carried out under the supervision of Mr. Brian McKinstry also of Crows Nest Resources Ltd.

2.0 LOGISTICS AND DATA ACQUISITION

The field work was undertaken during the period August 21 to 26, 1985. The seismic survey was conducted by a four person crew from Geo-Physi-Con Co. Ltd. The crew lodged at commercial facilities in Tumbler Ridge, B.C., and travelled daily to the site by helicopter. Helicopter support was provided by Okanagan Helicopters under contract to Crows Nest Resources Ltd.

The geophysical survey was carried out on a grid consisting of three 1 km east-west lines, spaced at 500 metre intervals, and one 1 km north-south line. The total amount of line surveyed was 3900 metres. The locating and clearing of the survey lines was carried out by an independant contractor under the supervision of Crows Nest Resources Ltd. A location map of survey lines is presented in Figure 1.

Explosives and temporary storage magazines were supplied by Explosives Ltd. in Grande Prairie, Alberta. All explosives and detonators were stored at the site.

The seismic data was recorded with a GeoMetrics ES1210F, 12 channel signal enhancement seismograph. Manufacturer's specifications for this equipment are included in Appendix A.

Figure 2 illustrates the geophone and shot arrangement employed along two consecutive spreads of 12 geophones each. A geophone spacing of 25 metres was used. Shots were located 25 metres and 212.5 metres past the end geophones of each spread and at the one third points (interior shots) along each spread. The interior shots were placed to determine the velocity distribution in the shallow subsurface. End shots and shots located 212.5 metres beyond the end geophones were placed in order to record the arrival time of compression energy refracted along the competent bedrock surface at as many geophone stations as possible.

Explosives were detonated in shallow holes (less than 1 metre depth) to produce compression type energy. Generally, 7 to 15 sticks (@ 1 to 2 kilograms) of Forcite (75%) were used for this purpose. All explosives were detonated with instantaneous electrical blasting caps. The detonating device also controlled the turn-on of the timing function of the recording seismograph. Geophones, sensitive to vertical velocity and with a natural frequency of 14 hertz, were used to detect the onset and passage of seismic energy.

Figure 3 illustrates typical records obtained for an end and an offset shot, along the Base line. The compression wave arrives first at each geophone location, whether or not the travel path is direct or has been refracted. The first arrivals of compression type seismic energy are clearly visible on these records.

Elevations were determined using a hand held altimeter, and distances determined using the geophone cable. An altimeter setting of 1530 metres at drill hole ON84D-1 was used as a base for surface elevations.

3.0 DATA PROCESSING

The method of data processing for refraction seismic data requires that the times of the seismic energy arrival be measured at a number of geophones for locations of the source to both sides of the geophones. For any particular geophone recording arriving energy that travels a refracted path from a source at each side of the geophone, the difference in the arrival times is related to the velocity of the refracting surface. Additionally, the sum of the arrival times from each source to the geophone is related to the thickness of material above the refracting surface. This method is often referred to as the plus-minus or delay time method. Its use for a simple two layer structure is shown in Figure 4 and is described briefly below.

The first arrival times are plotted as a function of distance (Figure 4a). The difference in arrival times at each geophone from shots offset to either side of the geophone are also plotted as a function of distance (b). On this plot, the difference in arrival times for geophones recording refractions from each direction fall on a straight line. The slope of this line is $2/V_2$, where V_2 is the compressional velocity characteristic for the lower material. It is assumed that the velocity deter mined along the surface of the refractor is identical to the velocity within the refractor, i.e. the materials are isotropic. For each geophone that recorded arrivals refracted from the lower material, the delay time (defined and plotted in Figure 4d) is computed. The depth to the lower material is related to the delay time by the function shown in Figure 4c.

Critical to the accurate determination of depth to refractors are the delay time, the values of overburden velocity, and the travel time between the source locations (reciprocal travel time). These parameters are derived from the time distance plot (Figure 4a).

4.0 RESULTS

A three layer section is observed across most of the area surveyed. The upper materials along each spread are characterized by a velocity of about 500 metres per second. This relatively low velocity would indicate that the overburden materials consist of loosely compacted and unconsolidated soils. The intermediate layer has an average velocity of 2600 metres per second. This material is expected to correspond to saturated gravels, boulders and weathered bedrock. The lower layer has a compressional velocity ranging from 3400 to 4600 metres per second and corresponds to competent bedrock.

4.1 Line 1 South

The interpreted depth to bedrock profile along Line 1 South is shown in Figure 5. Competent bedrock is expected at depths of 135 metres at the west end of the line, rising to a depth of about 28 metres at the east end. Competent bedrock occurs at depths less than 70 metres between station 5+75 to 9+75. The velocities of competent bedrock increase from 3660 metres per second at the west end to 4440 metres per second at the east end of the line. The Base Line intersects Line 1 South at station 5+00.

4.2 Centre Line

The interpreted depth to bedrock profile along the Centre Line is shown in Figure 6. Competent bedrock along this line appears deepest in the centre section between stations 4+25 to 5+25. Drill hole ON84D-1 is located at station 5+00. The drill hole reached a depth of 93 metres without encountering bedrock. The interpreted depth to competent bedrock is 102 metres at this location. Areas where competent bedrock is less than 70 metres along this line occur between stations 0+00 to 0+75, 1+50 to 2+00 and 7+50 to 9+95. The velocities of competent bedrock are between 3420 and 3820 metres per second, increasing west to east. The Centre Line and Base Line intersect at drill hole ON84D-1.

4.3 Line 1 North

The interpreted depth to competent bedrock profile along Line 1 North is shown in Figure 7. Interpreted depths are generally less than 70 metres. A short section between stations 4+90 to 6+70 is the only portion of the line for which competent bedrock would be expected at depths greater than 70 metres. Bedrock velocities vary from 3680 metres per second at the west end of the line to 4610 metres per second at the east end of the line.

The intermediate layer does not appear to be continuous over the entire line. A thinning and pinching out of this layer occurs at the west end from station 0+00 to 0+25 and at the east end from stations 9+25 to 9+75. The Base Line intersects Line 1 North at station 5+00.

4.4 Base Line

The interpreted depth to bedrock profile along the Base Line is shown in Figure 8. The depth to competent bedrock along the entire line is not expected to be less than 70 metres. An average depth to bedrock of approximately 100 metres occurs from station 0+00 to 6+50, and decreases to 75 metres for the remainder of the line. The Base Line intersects drill hole ON84D-1 and the Centre Line at station 5+00.

5.0 CONCLUSIONS

Refraction seismic methods have been used to determine the depth to competent bedrock over a part of the Onion Lake project. Competent bedrock has been interpreted to correspond to materials exhibiting a seismic compression wave velocity in the order of 3400 to 4600 metres per second.

The accuracy of the interpreted depths to competent bedrock relies heavily on the contrast in velocity between competent bedrock and the overlying material, as well as the velocity of the overlying material. The velocity of materials overlying competent bedrock has been determined from the seismic data and the interpreted depths to competent bedrock are consistent with the findings at drill hole ON84D-1.

The interpretation of the seismic data indicates that competent bedrock occurs at depths of greater than 70 metres over about 65% of the survey site. Both the seismic results and ground topography indicate that bedrock becomes progressively deeper to the south and southwest. Over the eastern portions of the lines, where ground elevations increase, bedrock elevations also increase.

Respectfully submitted,

GEO-PHYSI-CON CO. LTD.,

Per:

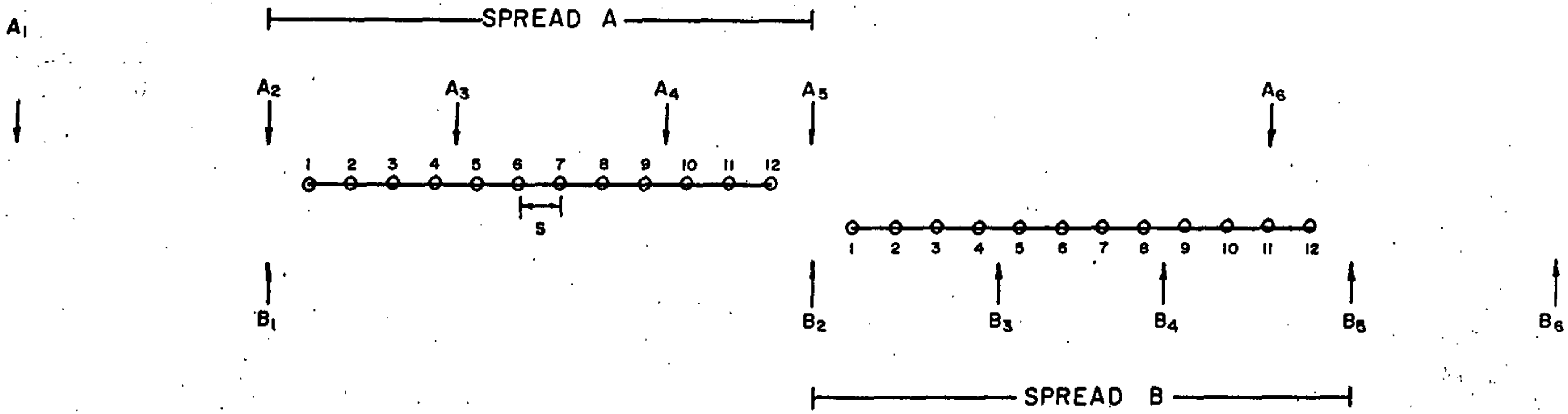
D. Becker

PERMIT TO PRACTICE
GEO-PHYSI-CON CO. LTD.
Signature [signature]
Date Oct 15/85
PERMIT NUMBER: P 2802
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

Reviewed by: [signature]

T. Sartorelli, P.Eng.,
Vice-President
Senior Engineer

Calgary, Alberta
October 1985
C85-27



LEGEND

O	Geophone Location
A_1, A_6, B_1, B_6	Far Shot Locations (2125moffset), Spread A, Spread B
A_2, A_5, B_2, B_5	End Shot Locations, Spread A, Spread B
A_3, A_4, B_3, B_4	Interior Shot Locations, Spread A, Spread B
s	Geophone spacing at 25 metres

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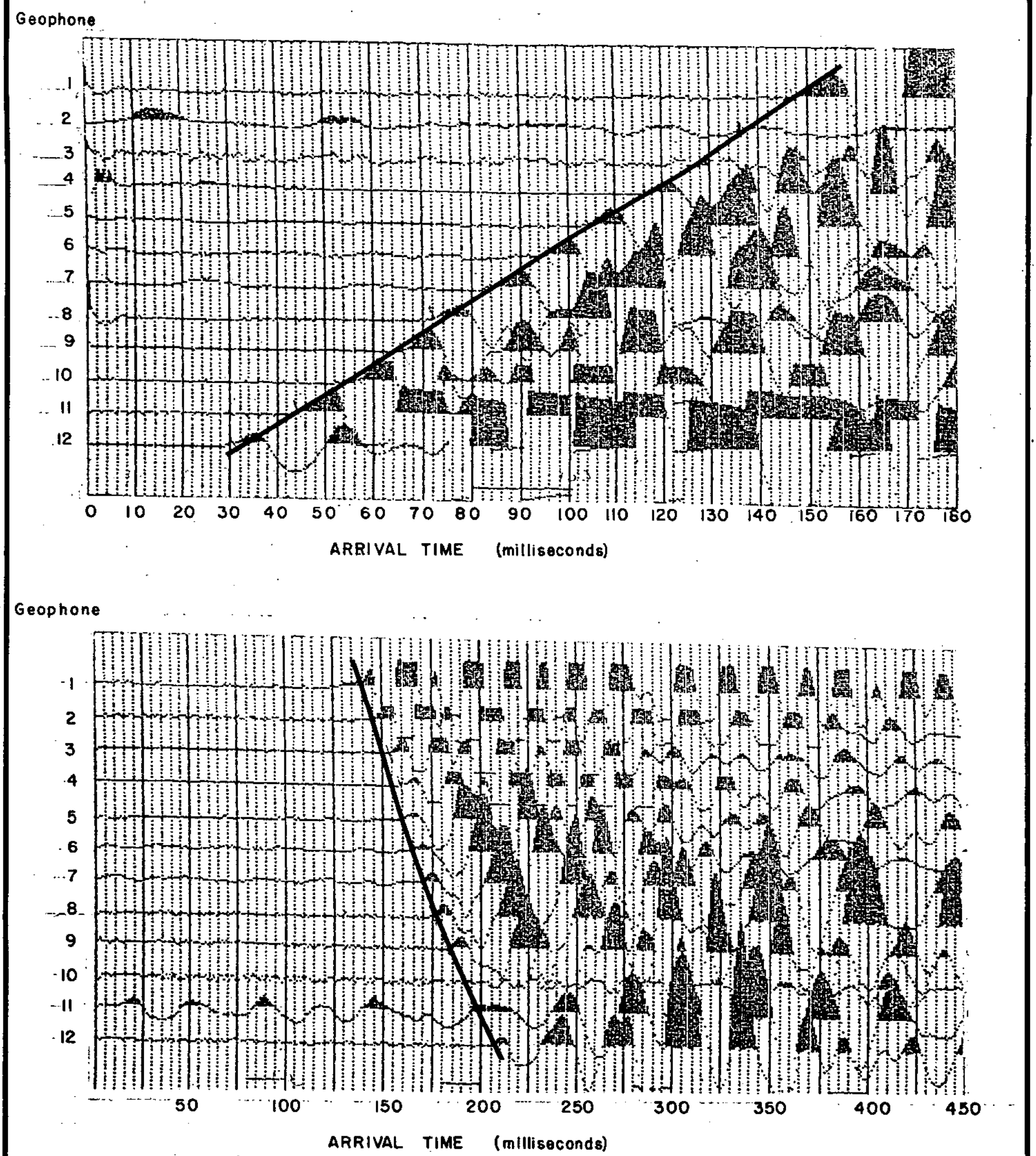
CROWS NEST RESOURCES
SHOT AND GEOPHONE LAYOUT
ALONG TWO ADJACENT SPREADS

C85-27

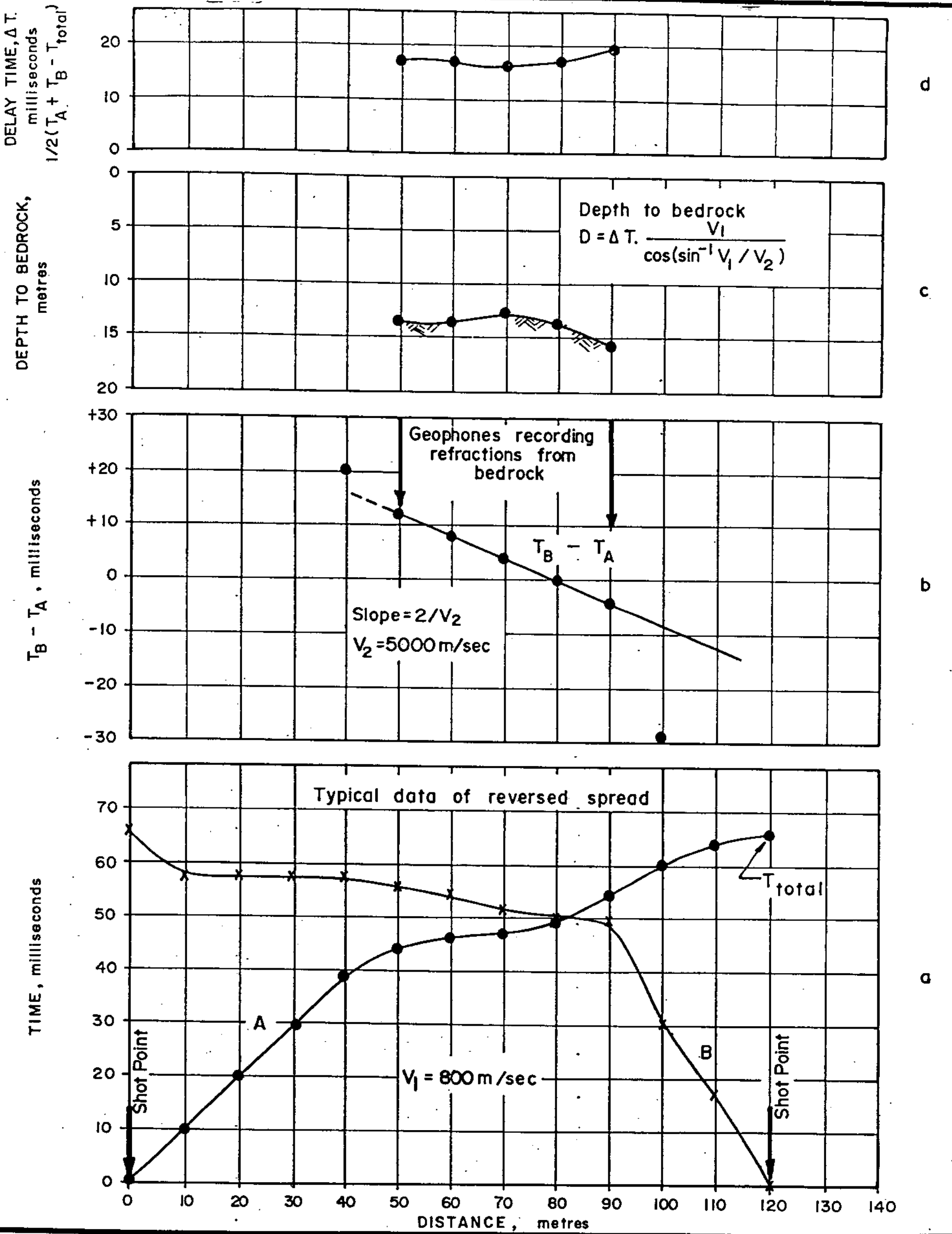
Figure 2



GEO-PHYSI-CON

CROWS NEST RESOURCES
Surface Seismic Sample
P-Wave (Base Line)

C85-27 696 Figure 3



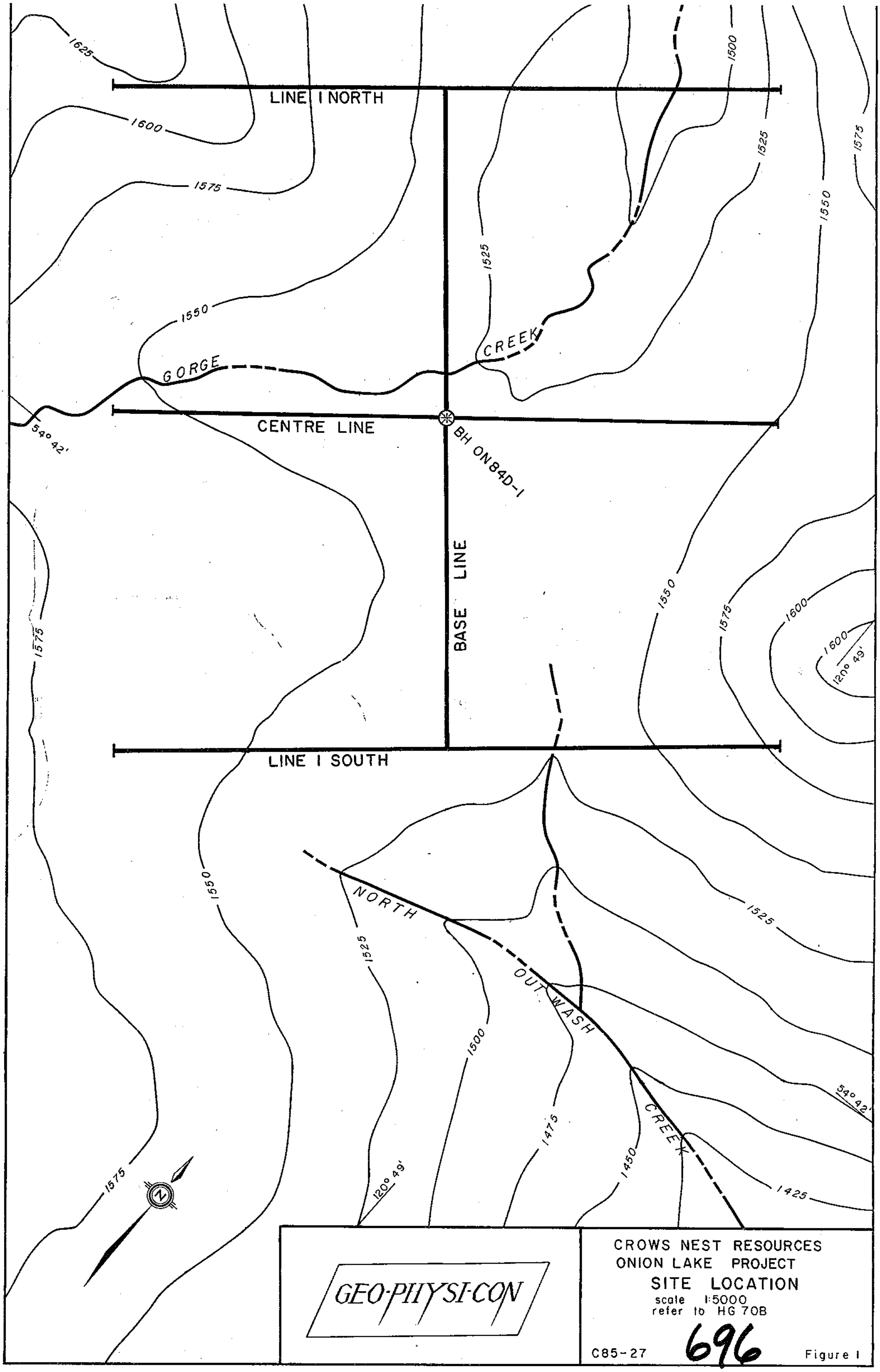
GEO-PHYSI-CON

ENGINEERING GEOPHYSICAL CONSULTANTS

TYPICAL
REVERSE SEISMIC REFRACTION DATA
AND ANALYSIS

C85-27 696

Figure 4



CROWS NEST RESOURCES
ONION LAKE PROJECT
SITE LOCATION
scale 1:5000
refer to HG 70B

C85-27 696 Figure I

geoMetrics/nimbus

MULTICHANNEL SIGNAL
ENHANCEMENT SEISMOGRAPH
MODEL ES-1210

Preliminary Data Sheet

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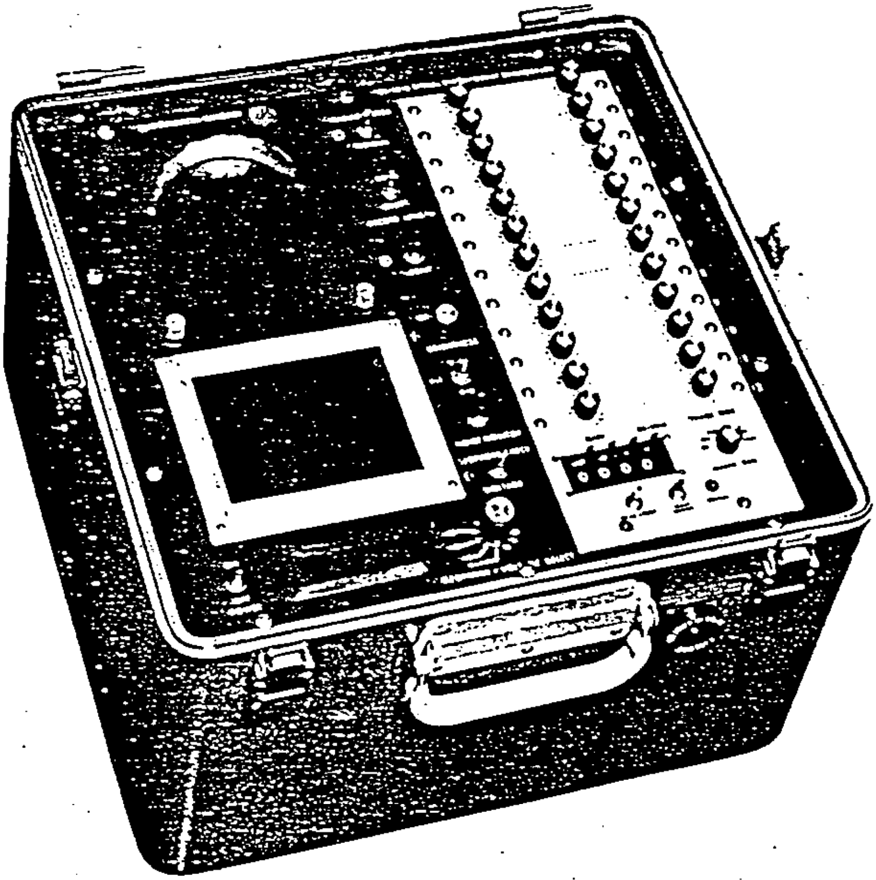


* *Signal enhancement* for greater sensitivity, improved waveform definition, and more accurate time measurements. Operates under high noise conditions and surveys to greater depths without explosives.

* *Multichannel oscillograph* provides permanent records on high-contrast, sunlight proof, reproducible paper with wiggle trace or variable area format.

* *Daylight-visible CRT monitor* displays the signal stored in memory.

* Compact, lightweight and portable. Ruggedly packaged in weatherproof case.

* Optional digital magnetic tape recorder for computer compatible data storage.

The Nimbus ES-1210 Multichannel Signal Enhancement Seismograph is unique in its combination of CRT display, signal enhancement and oscillograph recording in a single small field instrument. Simple to use yet powerful in performance, this new instrument is ideally suited for all shallow geologic investigations for mining, construction and geologic exploration.

Signal enhancement is a term used to describe the stacking process used in the ES-1210. The seismic signals for each hammer blow or shot are digitized and stored in a computer-like memory in the instrument. Unlike conventional analog seismographs, the record is not made at the instant of the hammer impact or explosion. Instead, it is held indefinitely and printed at the operator's convenience. If the impact or explosion is repeated, the seismograph will add the new signal and the old one, storing the sum back in the memory. As this process is repeated, the signal will grow larger and larger, thus enhancing its appearance on the display or oscillograph record. Seismic noise in the earth, which provides the most significant limitation in depth penetration, is random and does not add in the signal enhancement process at the same rate that the true signal does. As a result, surveys can be performed to about three times the depth that could be realized without enhancement using an equivalent energy source.

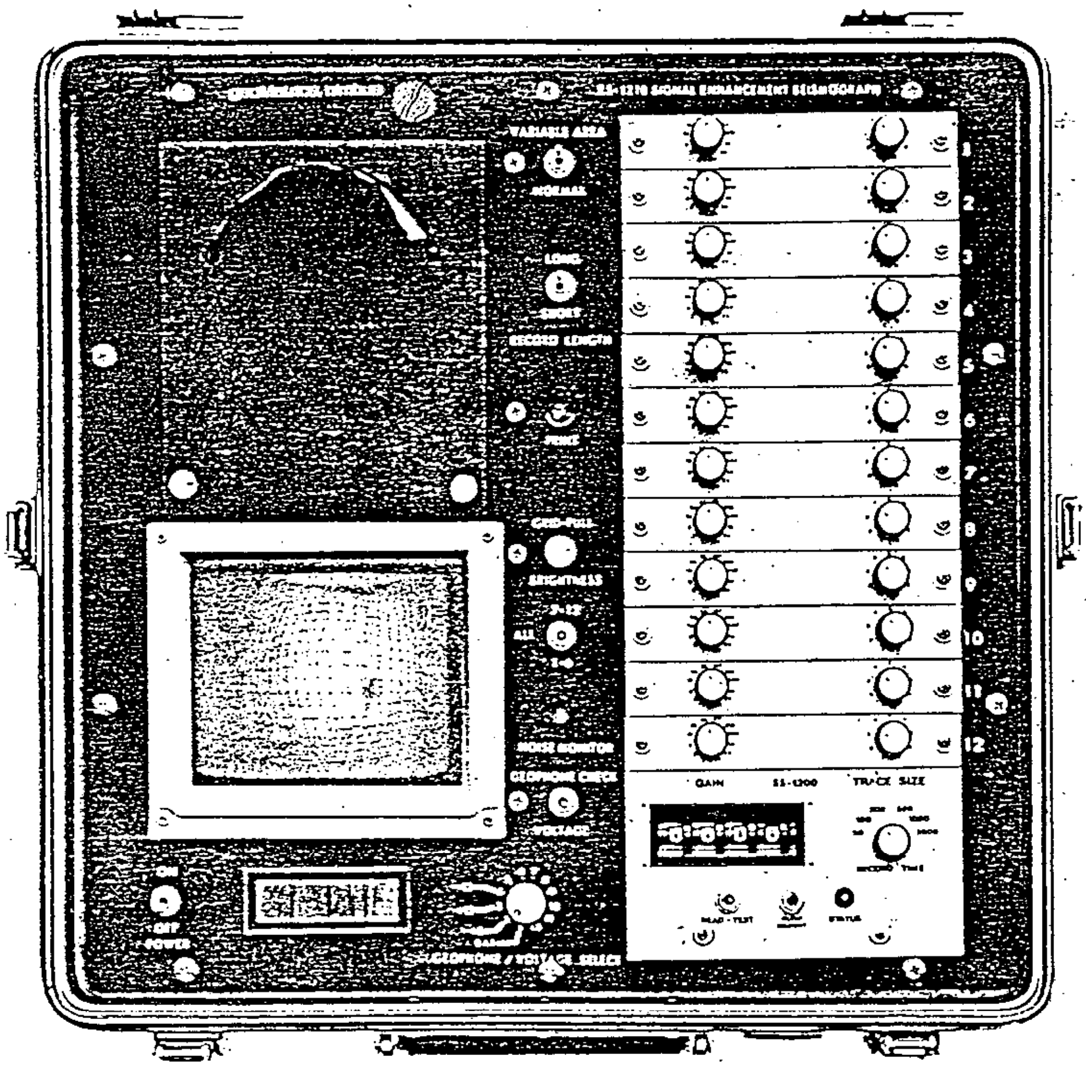
Signal enhancement is also a significant improvement in making shear wave velocity measurements. These types of surveys are important because of the dynamic parameters of foundations can be calculated from shear wave velocities, liquid saturation can be discriminated from other conditions with equivalent P-wave velocities, and shear strength can be estimated. The most reliable shear wave studies are made with mechanical sources, which means that signal enhancement is often a requirement.

Signal enhancement provides other, less obvious advantages, even when using explosive sources. Since the playback gain of the signal stored in memory is adjustable, there is less guess work involved in getting good records. Multiple copies can be made without reshooting the blast. Since the frequency response is not limited by galvanometers and paper speed, a higher time resolution is available, an important factor when working in high-velocity materials.

The signal stored in the memory is displayed on the built-in CRT monitor, and the display will have the same appearance as the paper record. A paper record can be made as often as necessary, at will, without disturbing the data stored in memory. The trace size control can be changed to optimize the record for an application. The gain may be set high for sharp breaks on the P-wave arrivals, and a hard copy made. Then the gain can be turned down for better shear waves or reflections and another copy made.

Both the CRT and oscillograph record in conventional wiggle trace and variable area. A wiggle trace record, like that of a conventional seismograph, would be selected for refraction and shear wave studies. Variable area recording (often seen on examples of petroleum reflection records) is best for reflection because that presentation emphasizes coherent events and resembles geologic structure.

The CRT display is especially important in three other situations. When working in areas with significant background noise, the display gives an instant observation of the signal quality so that it is immediately known whether to repeat impacts, freeze specific channels, or erase and start over. The other use is in shallow reflections. The instant examination of all the channels simultaneously is important in recognizing these events in the record. The third use of the CRT display is in gain selection. With the NOISE MONITOR switch depressed real time signals are shown on the CRT and the gain setting for each channel can be chosen appropriately.



CONTROLS AND FEATURES

Amplifier (input) GAIN is controlled by a 12-position switch, selectable from relative gain of 1 to 5000 in steps of 1-2-5-10 etc. Each amplifier has a 10 bit by 1024 sample memory which stores the digitized signal. Playback gain is controlled over a 20 to 1 range by the TRACE SIZE control. Pulling up the trace size control freezes the memory on that particular channel so that it will not further enhance or erase, thus saving the data while allowing operation on the other channels. Playback or display are not affected by memory freeze.

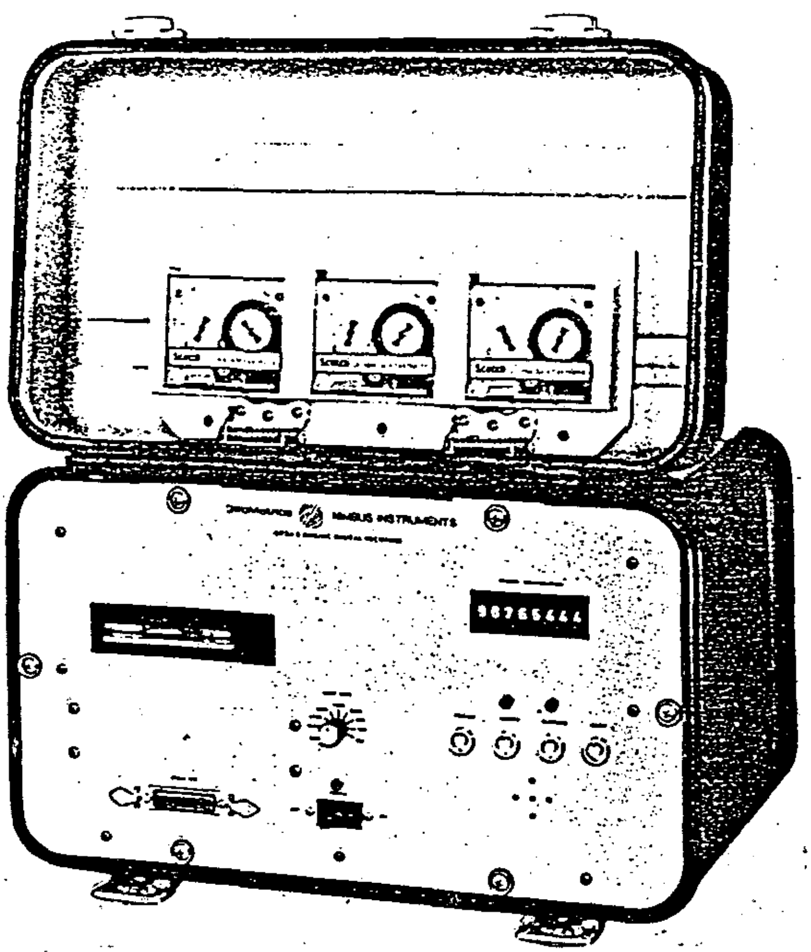
Enhancement control electronics include the RECORD LENGTH control, which selects total time of the record among 50, 100, 200, 500, 1000 or 2000 milliseconds. The record DELAY postpones the start of the record up to 9.999 seconds in one milli-seconds increments, allowing you to look later in time, delete unnecessary leading portions of the signal, and maintain faster sampling rates for later events. CLEAR MEMORY controls erases the data stored in the memory. An interlock is provided (both READ and CLEAR must be used) to prevent accidental erasure of valid data. TEST provides a start command to take a record in lieu of hammer switch or blaster.

The CRT display is five inches (13 cm) diagonal measurement. It displays all 12 channels simultaneously or switch selected combinations of six channels as desired. It has a special light filter to allow direct viewing in sunlight without special hoods. The bezel will fit standard oscilloscope cameras so that photographs may be made of the display if desired. Timing lines may be superimposed on the CRT at will by pulling up on the BRIGHTNESS control. The timing line intervals vary, depending on the record length, so that appropriate resolution and clarity is maintained.

A digital voltmeter is provided to measure the battery voltage, internal power voltages, and individual geophone resistances. The NOISE MONITOR, when selected, couples the amplified geophone signals to the CRT display. This allows monitoring the instantaneous background noise so that records may be made during quiet periods.

The data stored in the memory may be accessed externally. An optional digital tape recorder, the G-724S, is available to provide computer compatible storage of the data. The G-724S will store 10 full records (120 channels) in a reduced resolution, 8-bit format, or you can store 5 records (60 channels) in the full 10-bit format. The G-724S serves as its own playback device, outputting the data in an RS-232 format which is directly interfaceable to most computers including desk top models.

G-724S Digital Recorder



SPECIFICATIONS

Basic refraction and reflection system includes: 12-channel exploration seismograph, 12-volt battery pack, 110/220 volt charger, power cord, hammer switch, and instruction manual.

Signal Enhancement:	samples, digitizes, and stores signal in a random access memory. Repeated signals are added while random noise is cancelled or limited.
Memory Size:	10 bits by 1024 words on each channel.
Sample Interval:	switch selectable 50, 100, 200, 500, 1000, or 2000 microsecond
Record Length:	switch selectable 50, 100, 200, 500, 1000, or 2000 millisecond
CRT Display:	5" diagonal measurement CRT, daylight visible without hoods, switch selectable time lines, camera compatible, and displays wiggle trace or variable area record display.
Oscillograph:	permanent record of all 12 channels simultaneously on 4" wide electrosensitive paper. Record will not fade in light, and reproduces on copying machines.
Noise Monitor:	ambient vibrations displayed on CRT allowing timing of energy source during quiescent periods and the optimization of gain adjustments.
Timing:	crystal controlled, .01% accurate, time lines are switch selectable on CRT and high or low resolution on oscillographic record.
Precision Delay:	postpones start of record up to 9.999 seconds in one millisecond increments.
Digital Meter:	indicates battery voltage, geophone resistance on each channe power supply voltages.
Digital Output:	a panel connector to allow digital recording of signal stored in memory on optional digital recorder Model G-724S.
Record Initiation:	by contact closure, saturated NPN transistor, or negative 5-volt pulse.
Standard Size/Weight: (seismograph)	14 X 15 X 15 inches (36 X 38 X 40 cm) lid closed 38 pounds (17 kg)
Power Requirements:	12 volts, 3.5 amperes
Seismograph Case:	Heavy duty aluminum with lid and water tight seal.

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TELEX NO: 790-22[illegible]

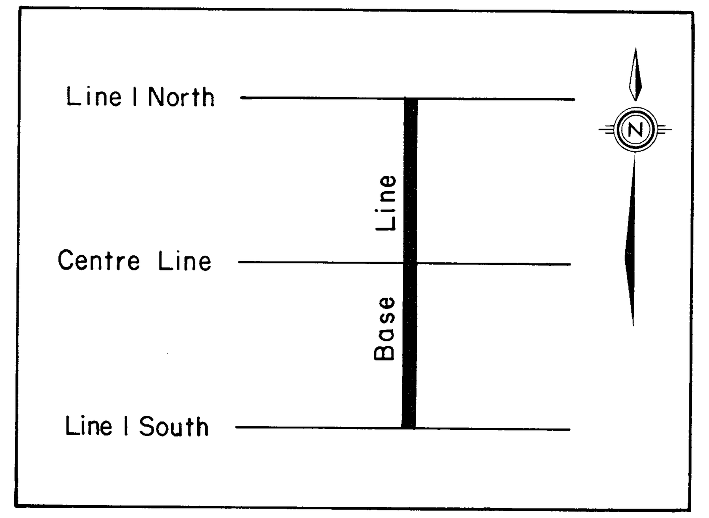
WORLD-WIDE AGENTS: EUROPE • SCANDINAVIA • UNITED KINGDOM • JAPAN • SO. AFRICA • SO. AMERIC

LEGEND

Ground Surface
Intermediate Layer
Bedrock Surface
520 m/s Seismic Velocity (metres/second)

SCALE

Horizontal 1:1000
Vertical 1:500



KEY PLAN

696

CROWS NEST RESOURCES
ONION LAKE PROJECT

BEDROCK PROFILE

BASE LINE

GEO-PHYSI-CON

SCALE	DRAWN BY	DATE
As Shown	JBO	Oct., 1985
N.T.S.	PROJECT NO.	FIGURE
	C 85-27	8

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CROWS NEST RESOURCES
ONION LAKE PROJECT

BEDROCK PROFILE

LINE 1 NORTH

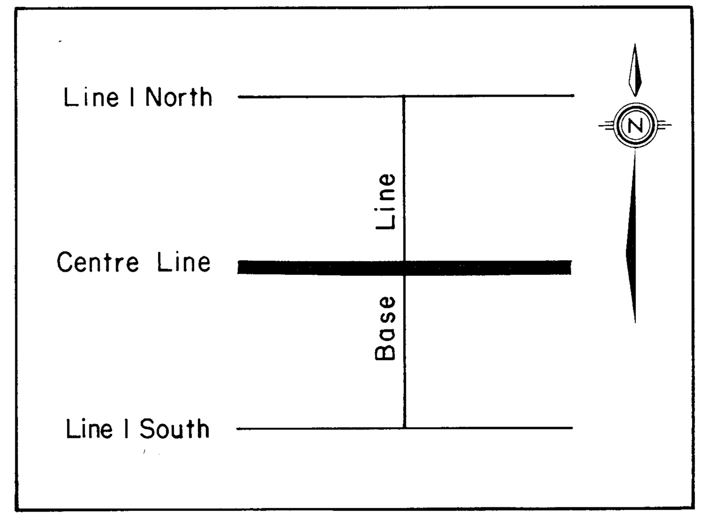
GEOPHYSICON	SCALE: As Shown	DRAWN BY: JBO	DATE: Oct., 1985
	N.T.S.	PROJECT NO.: C 85-27	FIGURE: 7

LEGEND

- Ground Surface
- Intermediate Layer
- Bedrock Surface
- 520 m/s — Seismic Velocity (metres/second)

SCALE

Horizontal 1:1000
Vertical 1:500



KEY PLAN

696

CROWS NEST RESOURCES
ONION LAKE PROJECT

BEDROCK PROFILE

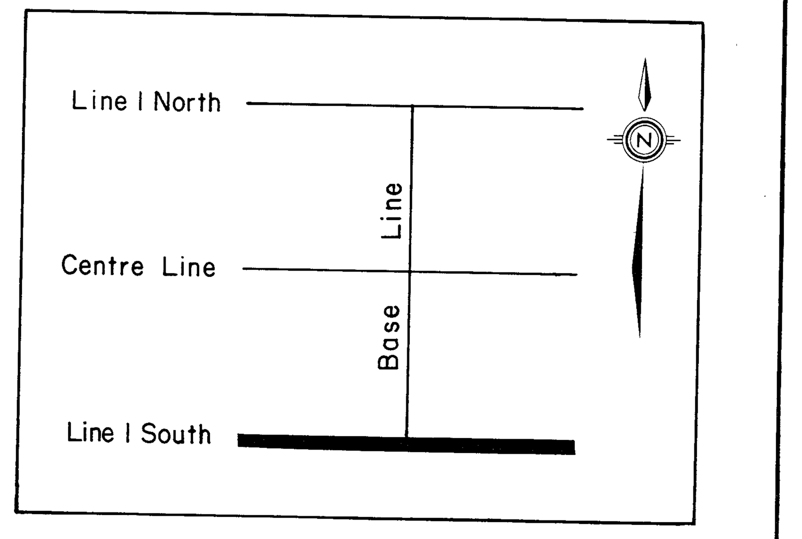
CENTRE LINE

GEOPHYSICON	SCALE: As Shown	DRAWN BY: JBO	DATE: Oct., 1985
	N.T.S.	PROJECT NO.: C 85-27	FIGURE: 6

LEGEND

Ground Surface
Intermediate Layer
Bedrock Surface
520 m/s Seismic Velocity (metres/second)

SCALE
Horizontal 1:1000
Vertical 1:500



KEY PLAN

696

CROWS NEST RESOURCES
ONION LAKE PROJECT

BEDROCK PROFILE

LINE I SOUTH

GEO-PHYSI-CON	SCALE: As Shown	DRAWN BY: JBO	DATE: Oct., 1985
	N.T.S.	PROJECT NO.: C 85-27	FIGURE: 5