TK Smithers 81(1)A

93L/3,6,11,13

"Smithers Area Coal Prospects 1981 Geological Report

Shell Canada Resources Ltd

D Handy
S Cameron
Dec 15/81

For C L #s, see front page

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1 of 2

TK Smithers 81(1)A

SMITHERS AREA COAL PROSPECTS

1981 GEOLOGICAL REPORT

Property	N.T.S. Map Sheet	Lat./Long.	Coal Licences
Telkwa River Area	93L/11	54°35'/127°08'	Group 325 - (Telkwa South) 4260-62, 4264, 4265, 5839,4267,~~4626~~, 4270. 4269 Group 327 - (Telkwa North) 4271,4272,4274-428~~1~~2,428 3,5305-5307,6040. Bulkley Valley Coal Option - 3875-3885, 3709,3710
Zymoetz River	93L/13	54°30'/127°45'	Group 322 4252 - 4255, 4257
Deny's Creek	93L/6	54°25'/127°15'	Group 324 4246-4250,688~~5~~4-6889
Thautil River see open file TK-Thautil River 81(1)A	93L/3 93L/6	54°16'/127°20'	Group 326 4229-4240 (surrendered)
Chisholm Lake see open file TK-Chisholm Lake 81(1)A	93L/3	54°14'/127°13'	5185, 5190 (surrendered)

Held by Shell Canada Resources Limited

Operated By Crows Nest Resources Limited

Exploration Period: May - August 1981

Report Date - December 15, 1981

Project Geologist - Dave Handy

Geologist - Steve Cameron

2/BYa.1

00233

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 8, 1981

Ministry of Energy, Mines and Petroleum Resources
British Columbia

Enclosed please find our report on the Smithers Area Coal Prospects.

This report has been prepared by Mr. D. Handy and Mr. S. Cameron, both of whom are employed by Crows Nest Resources Limited as geologists.

Mr. D. Handy, Honours B.Sc., graduated in Geology from the University of Waterloo in 1977. Prior to his graduation, Mr. Handy worked as an assistant for two geotechnical companies and after graduation as a geologist for a major exploration company in Saskatchewan. Mr. Handy has been employed by Crows Nest Resources Limited as a Project Geologist since 1979.

Mr. S. Cameron, B.Sc., in Geology graduated from the University of Calgary in 1981. Prior to graduation Mr. Cameron worked as an assistant for a major exploration company in the North West Territories. He also worked for Crows Nest Resources Limited as a geological assistant in 1980. Mr. Cameron has been employed by Crows Nest Resources Limited as a Geologist since May 1981.

Their work was carried out under the supervision of our District Manager, British Columbia, Mr. Frank Martonhegyi.

In my opinion, all of these personnel are fully qualified, by training and experience to prepare this report and this account of work done under their direct supervision.

Yours very truly,

H.G. Rushton, P. Geol.
Vice-President - Exploration.

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 8, 1981

Dear Sir:

The following four volumes contain the geological reports for the Smithers Area Coal Prospects. These include the Telkwa, Deny's Creek, Zymoetz River, Thautil River and Chisholm Lake Prospects.

Crows Nest Resources feels that due to similar geological setting and close proximity of the various prospects, it is appropriate to include them in one overall report. It should be stressed that each report in the following volumes is complete and accurate in its own right.

Yours truly,

Steve Cameron, Geologist
for
Dave Handy, Project Geologist

SC/nmd

SMITHERS AREA COAL PROSPECTS

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5/BYa.10

Volume 4

LIST OF APPENDICES

1.0 Summary

The Smithers Area Coal Prospects are contained within 58 B.C. Coal Licences which cover 14,236 hectares. In addition Shell/CNRL hold 3,886 hectares under option agreements. The licences are held by Shell Canada Resources Limited and are operated by its wholly-owned subsidiary, Crows Nest Resources Limited.

The area in general, and the Telkwa licences in particular, lie in proximity to the Canada National Railway, 360 km east of the port of Prince Rupert. Existing infrastructure, the proximity of a coal handling port and the good quality of the coal make some of these prospects attractive.

Lower Cretaceous sedimentary rocks of the Hazelton Group include significant thicknesses (aggregate up to 20 metres, single seams of possibly 10 metres) of low ash, high grade, high volatile "A" bituminous coal amenable for thermal use. Coal of metallurgical grade also exists in places. Lack of outcrop exposure and complex geological structure hinder exploration in the area.

The primary objective of the exploration program was to locate and delineate areas of large reserves amenable to mining.

The 1981 exploration program entailed mapping of all the project areas at a 1:10,000 scale. The Telkwa area along Goathorn Creek and the Telkwa River was mapped at a 1:5,000 scale. Seven diamond and eleven rotary drill holes were completed. One bulldozer trench was excavated.

Based on the 1981 exploration the Thautil River and Chisholm Lake licences have been surrendered.

Shell/CNRL continue to hold and operate coal properties at Deny's Creek, Zymoetz River and at Telkwa River.

The total field expenditure for 1981 was $757,762.

2.0 Introduction

2.1 Location and Access

Enclosure 1-1: Index Map

Enclosure 1-2: Location Map

2/BYa.13

The Smithers area coal prospects are located within a 65 km radius south-west of the town of Smithers in West-Central British Columbia; Coast Land District 5, NTS Map sheets 93L/3, 93L/6, 93L/11, 93L/13.

It consists of five prospect areas as follows:

Telkwa River (including Telkwa North, Telkwa South, Bulkley Valley Coal Option)	N.Lat54°35' N.Long.127°8'	-	north of the Tekwa River and east of Pine Creek
		-	south of the Telkwa River along Goathorn Creek and Cabinet Creek
Zymoetz River	N.Lat.54°30' N.Long.127°45'	-	straddles Coal Creek upstream from its confluence with the Zymoetz River
Deny's Creek	N.Lat.54°25' N.Long.127°15'	-	along Deny's Creek north of its confluence with the Thautil River
Thautil River	N.Lat.54°16' N.Long.127°20'	-	along the Thautil River north of its confluence with the Morice River

Chisholm Lake N.Lat.54°14' - immediately north of Chisholm Lake
N.Long.127°13'

Smithers is 360 km from the port of Prince Rupert along the CNR line and Highway 16. The Telkwa prospect is 10 km from this rail line and mostly accessible by good gravel road.

Exploration roads were constructed in the past to the other prospects, except Thautil River and Chisholm Lake. These roads are in very poor condition and were not used in 1981.

The Chisholm Lake and Thautil River prospects are approximately 10 km from an existing good logging road on the south side of the Morice River which runs east for 50 km to the town of Houston.

During the 1981 program all properties, except Telkwa, were accessible by helicopter only.

2/BYa.15

2.2 Tenure

In 1981 Shell Canada Resources Limited/Crows Nest Resources Limited surrendered all licences in the Thautil River and Chisholm Lake areas.

The Telkwa River area licences are further subdivided into the following areas:

- Telkwa North
- Bulkley Valley Coal Option
- Telkwa South

Such subdivision is necessary for land tenure purposes because the Bulkley Valley Coal Option separates Telkwa North from Telkwa South.

The report title page lists the licences belonging to the separate groups. All licences are operated by Crows Nest Resources Limited. All licences are held by Shell Canada Resources Limited with the exception of those optioned from Bulkley Valley Coal Limited.

Appendix 1 of this report contains "Coal Land Disposition Maps". Appendix 2 contains a tabulation of "B.C. Coal Land Tenure Standing" for each group of licences being renewed.

3.0 Regional Geology

3.1 Stratigraphy

The sedimentary rocks in the Smithers area consist of thin, interbedded mudstones, sandstones, shales and coal seams. This sequence overlies a thick series of volcanic rocks composed chiefly of tuffs, agglomerates, andesites, and other flow rocks. Both of these horizons are cut by a series of younger intrusives consisting of crystalline porphyritic rocks. All three form part of the Hazelton Group of Jurassic - Cretaceous age.

The surface of the volcanic basement is irregular suggesting an erosional period preceded deposition of the sedimentary sequence. Subsequent erosion removed the soft coal-bearing sediments from higher ridges leaving relatively small isolated sedimentary basins in the mountain valleys. Sedimentary exposures are found only in certain low lying stream valleys which have cut through the glacial drift cover. Few exposures are away from the creeks until the higher ridges are reached and invariably these are composed of volcanic rocks. The volcanic sedimentary contact over most of the prospect areas is drift covered and heavily timbered making accurate delineation of the areal extent of the coal-bearing sediments very difficult.

The thickness of the coal measures in the Smithers area is quite variable but probably does not exceed 350 metres. Correlation of stratigraphic sections between properties is difficult and probably not meaningful. A basal conglomerate unit does exist at the Thautil River, Zymoetz River, Deny's Creek and Telkwa properties.

Coal seams are generally quite hard and competent, usually more so than the accompanying siltstones, mudstones and shales (Photograph 1). Post sedimentary, igneous activity is evidenced by several dykes and sills which have intruded the sedimentary sequence (Photograph 2). Drill hole data suggest sedimentation and volcanism also occurred contemporaneously (drill hole TK-78-3), especially in the Telkwa area.

2/BYa.18

Photograph 1

Coal exposure near the former Avelling Mine - north side of the Telkwa River

Photograph 2

Vertical igneous dyke cutting sedimentary strata (same area as Photograph 1)

3.2 Structure

The geological structure of the sedimentary rocks in the Smithers area is complex.

Normal faulting appears to be the dominant structural mechanism (Photograph 3). Bedding plane faults are also common, with carbonate stringers filling the fractures. Bedding attitudes can vary considerably over short distances.

2/BYa.21

Photograph 3

Normal fault evident in a coal seam - north side of the Telkwa River west of the former Avelling Mine.

2/BYa.22

4.0 Telkwa Property

4.1 Summary of previous work

During the 1979 field season the following exploration work was performed:

- o 1:10,000 scale geological mapping
- o bulldozer trenching
- o road upgrading
- o rotary drilling
- o drill site reclamation

No exploration work was performed during 1980.

4.2 Work done in 1981

Field operations were supervised by Dave Handy and Steve Cameron of Crows Nest Resources Limited.

Exploration included:

- o reconnaissance geological mapping (1:10,000)
- o detailed geological mapping (1:5,000)
- o road upgrading

- bulldozer trenching
- rotary and diamond drilling
- 1:5,000 scale topographic maps constructed
- geodetic location survey
- geophysical survey
- drill site reclamation

Field mapping was conducted over those parts of the property that had been omitted in 1979. Special emphasis was placed on the Goathorn Creek area and the Telkwa River area.

One old bulldozer cut was trenched and mapped.

1.8 km of existing road was upgraded to provide access for drilling.

Eleven rotary drill holes were completed totalling 1345 metres using a Schramm T985H truck mounted drill (Photograph 4).

One diamond drill hole was completed to a depth of 235 metres using a Boyles 25A diamond drill (Photograph 5). Two of these diamond drill rigs were also utilized for the helicopter drilling on the other Smithers prospects. Coal samples were sent to CNRL's Fernie lab for analyses. All pertinent drill holes were surveyed and ground control was established for photogrammetric construction of 1:5,000 scale topographic maps. A geophysical survey using several electrical methods was performed in an attempt to map the extent and thickness of the sedimentary rocks.

The total cost of the 1981 exploration work was $341,000. Apendix 1 contains a copy of the Application to Extend Term of Licence which gives a detailed account of the amount and nature of expenditures applied to Groups 325, 327 and 221.

2/BYa.25

Photograph 4

Schramm T985H rotary drill rig - used in the Telkwa Area

Photograph 5

Boyles 25A diamond drill - used at Telkwa and at other Smithers area prospects.

2/BYa.27

4.3 Telkwa Stratigraphy

General

In the Telkwa area the basement rocks consist of upper Jurassic/lower Cretaceous volcanics of the Hazelton Group composed mainly of andesite, rhyolite, trachyte, basalt, and related breccia and tuff. These rocks are unconformably overlain by sediments composed of conglomerate, sandstone, siltstone, shale, mudstone, argillite, quartzite, tuff, minor lava and coal.

Younger intrusive rocks in the form of dykes and possibly sills often occupy fault zones and mainly trend northeasterly.

The stratigraphic section varies in thickness over the Telkwa area from 0 to at least 300 metres. Individual beds appear to lens and pinch out making correlation over large areas difficult. In the upper part of the section a coal seam exhibits relatively high natural gamma radiation and could be used as a marker bed east of Goathorn Creek. A basal conglomerate was found overlying the volcanics in outcrops on the Telkwa River.

Coal Stratigraphy

The number of coal seams varies over the Telkwa area. East of Goathorn Creek as many as 15 seams were intersected by drilling. Maximum aggregate coal thickness is 20.7 metres with the thickest seam 2.6 metres and the thinnest 0.3 metres (all drilled thicknesses).

West of Goathorn Creek a 7.6 metre seam (drilled thickness) was intersected. This is the thickest coal intersection encountered in the Telkwa area to date.

4.4 Telkwa Structure

In the area north of the Telkwa River normal faulting predominates and is visible in outcrops along the Telkwa River. South of the Telkwa River a decollement zone is evident as shown in Photograph 6.

All of the old underground workings in the Bulkley Valley Collieries area encountered faults during their drivage.

4.5 Mineability

East of Goathorn Creek the upper 8 coal seams are correlatable over a strike length of at least one mile and maintain workable thicknesses. Structurally the coal measures appear relatively undisturbed by faulting and the strata dip at a shallow angle. The area has fairly gentle topographical relief and the coal seams have relatively moderate cover. This area appears amenable to open pit mining. More drilling is necessary, however, to calculate coal reserves.

2/BYa.30

Photograph 6

Décollement zone south of Bulkley Valley Collieries - east side of Goathorn Creek.

2/BYa.31

West of Goathorn Creek in the same general area, 7.6 metres of coal was intersected at a shallow depth (approximately 20 metres). If additional drilling indicates these measures occur over a large enough area, with workable structure, then this area would be amenable to open pit development also.

4.6 Coal Quality

Telkwa coal samples were obtained from rotary drill cuttings and diamond drill core. Analyses of the 1981 samples have not been done at the time of writing this report. These results will be submitted in a subsequent report covering exploration work done for the following term of the coal licences. Based on previous data from the Bulkley Valley Coal mining operation in 1967, the coal is of thermal grade with the following average quality parameters.

Clean Coal, Dry Basis

Ash:	8.3%
V.M.:	33.5%
F.C.:	58.2%
Sulphur:	0.98%
FSI	3
K.Cal/kg:	8428 (dmmfb)
Rank (ASTM):	High Volatile A Bituminous

5.0 Deny's Creek Property

5.1 Summary of Previous Work

During the 1979 field season the following exploration work was performed:

- o 1:10,000 scale geological mapping
- o hand trenching

No exploration work was performed during 1980.

5.2 Work done in 1981

The 1981 field operations were supervised by Dave Handy of Crows Nest Resources Limited. The following exploration work was performed.

- o 1:10,000 scale geological mapping
- o diamond drilling
- o location survey of diamond drill holes
- o drill site reclamation

Field mapping was done on parts of the property that had been omitted in 1979.

Three diamond drill sites were prepared in 1981, however holes were drilled on only two of these sites. These two drill holes totalled 400 meters in depth. Coal samples were sent to CNRL's Fernie lab for analysis.

A location survey of the drill holes was carried out by Watson Surveying in July of 1981.

The total cost of the 1981 exploration work was $139,801. Appendix 1 contains a copy of the Application to Extend Term of Licence which gives a detailed account of the amount and nature of the expenditures applied to Group 324.

5.3 Deny's Creek Stratigraphy

General

The basement rocks of the Deny's Creek property consists of upper Jurassic/lower Cretaceous volcanics of the Hazelton Group. These volcanics consist mainly of basalt, andesite, trachyte, rhyolite and agglomerate.

The volcanics are unconformably overlain by upper Jurassic/lower Cretaceous sediments of the Hazelton Group. These sediments are composed of conglomerate, sandstone, siltstone, shale, mudstone, coal and minor lava flows.

Young intrusive rocks in the form of dykes and sills will often occupy fault zones. The intrusives are often oriented parallel to joints and mainly trend northeasterly.

The sedimentary section varies greatly in thickness over the Deny's creek area, from 0 metres to at least 250 metres. Individual beds tend to lens and pinch out over relatively short distances making correlation difficult. A basal conglomerate sandstone often overlies the basement volcanics, whereas the upper part of the section is dominated by shales and siltstones.

Coal Stratigraphy

In the Deny's Creek area the number of coal seams is variable. Diamond drilling and mapping indicate that four seams may be present in the south-central part of the property. Aggregate thickness of the seams in the south ranges from 3 meters to greater than 6 meters. In the northern part of the property fewer seams are present. It is not known whether the seams present in the south are truncated by the unconformity or pinch out stratigraphically toward the north.

5.4 Structure

On the basis of photogeology, a northeasterly trending normal fault has been interpreted. Two small synclines southeast of this fault have also been interpreted by photogeology. The presence and magnitude of these synclinal structures on the northwest side of the fault is unknown. The general dip of the sediments on the northwest side of the fault ranges from 15 to 35 degrees, in a northwesterly direction.

5.5 Mineability

Present geological information indicates that the Deny's Creek property has limited potential for open pit mining due to high overburden ratio. However the eastern part of the property is relatively unexplored and the overall structure of the coal bearing section is poorly defined.

5.6 Coal Quality

Deny's Creek coal samples were obtained from diamond drill core. Analyses of the 1981 samples have not been completed at the time of writing this report. These results will be submitted in a subsequent report covering exploration work done for the following term of the coal licences.

2/BYa.37

6.0 Zymoetz Property

6.1 Summary of Previous Work

During the 1979 field season the following exploration work was performed.

- o 1:10,000 scale geological mapping
- o Diamond drilling (two holes)
- o Location survey of diamond drill holes
- o Drill site reclamation

No exploration work was performed during 1980.

6.2 Work Done in 1981

The 1981 field operations were supervised by Dave Handy of Crows Nest Resources Limited. the following exploration work was performed.

- o 1:10,000 scale geological mapping
- o additional reclamation of 1979 drill sites

Field mapping was done on parts of the property that had been omitted in 1979. Specifically this was the area along Sandstone Creek and the Zymoetz River.

The total cost of the 1981 exploration work was $18,452. A detailed account of the amount and nature of the expenditures applied to Group 322 will be submitted on or before the anniversary date.

6.3 Zymoetz Stratigraphy

General

The basement rocks of the Zymoetz property consist of upper Jurassic/lower Cretaceous volcanics of the Hazelton Group. These volcanics consist mainly of basalt, andesite, trachyte, rhyolite and agglomerate.

The volcanics are unconformably overlain by upper Jurasic/lower Cretaceous sediments also of the Hazelton Group. These sediments are composed of conglomerate, sandstone, siltstone, shale, mudstone, coal and minor lava flows.

Younger intrusives in the form of dykes, sills and stocks are often present. The intrusives are frequently oriented parallel to joints.

The sedimentary section at Zymoetz River varies in thickness from 0 to over 250 metres. Individual beds tend to lens and pinch out over relatively short distances making correlation difficult. A basal conglomerate often overlies the basement volcanics.

On the Zymoetz River property at least five coal seams are present. In the area around Coal Creek average aggregate coal thickness ranges from 4 metres to 8 metres.

6.4 Zymoetz structure

In the Coal Creek area of the Zymoetz property, the sedimentary section dips to the northwest at an average of 24°. No major faults or folds have been encountered in this area.

Normal faulting has been interpreted with the use of photogeology near the southern perimeter of the coal licences.

2/BYa.40

6.5 Mineability

On the Zymoetz property five seams can be correlated over a distance of at least half a kilometre, with an aggregate thickness between 4 and 8 metres. Feasible open pit mining potential of the Zymoetz property appears to be limited because the coal seams are dipping at an average of 25° into the topography. However the northwest part of the coal licences is relatively unexplored.

6.6 Coal Quality

Zymoetz River coal samples were obtained from diamond drill (hole number D-ZZ-1) core in 1979. Proximate analysis and FSI test results of this core follow:

Clean Coal, Air Dried Basis

Washed at S.G. 1.5

Moisture:	1.98%
Ash:	9.58%
V.M.	34.35%
F.C.	53.92%
FSI	1 1/2
Rank	High Volatile Bituminous A

9.0 Bibliography

Dowling, D.B. — 1915, "Coal Fields of British Columbia"; Memoir 69, Canada Department of Mines No. 57, Geological Series, pp. 167-189.

Handy, D.L. — 1979, Geological Report - Smithers Area Coal Prospects - Crows Nest Resources Limited

2/BYa.48

CROWS NEST RESOURCES LIMITED (Exploration)

B.C. COAL LICENCES TENURE STANDING

BLOCK: SMITHERS
GROUP: # 327
PROJECT: TELKWA NORTH
YEAR: 1980 - 81
DATE: DECEMBER 1981

LICENCE NO.	LICENCE LEGAL DESCRIPTION	LICENCE AREA TOTAL AC/HA.	ACQ/ADM YEAR	ACQ/ADM FEES $	RENTALS ANNUAL $	RENTALS TOTAL TO NEXT ANN. $ 10^3	REQUIREMENT WORK EXPIRED $ 10^3	CURRENT YEAR LIC. YEAR	CURRENT YEAR $	PRE-FULFILMENT YEAR	PRE-FULFILMENT $	ANNIVERSARY DATE	BUDGET CURRENT YEAR AFE	BUDGET CURRENT YEAR $ 10^3	EXP TOTAL $ 10^3	POTL SHELL CLASS.	REMARKS
15 LICENCES		3,756.		150.	18,780	69.9	63.7		46,950		217,741.2	DECEMBER 31	-	-	334.7	Y	THE LICENCES ARE
4271	LOT 248	259	78				5,180.	3rd	3,237.5	1½	17,088.5						IN GOOD STANDING
4272	LOT 222	259	78				5,180.	3rd	3,237.5	1½	17,088.5						ON DECEMBER 31st
4274	LOT 225	259	78				5,180.	3rd	3,237.5	1½	17,088.5						1981. THE EXCESS
4275	LOT 224	259	78				5,180.	3rd	3,237.5	1½	17,088.5						CREDITS ARE FOR THE:
4276	LOT 411	259	78				5,180.	3rd	3,237.5	1½	17,088.5						78' LIC. 65.98/H.A.
4277	LOT 410	259	78				5,180.	3rd	3,237.5	1½	17,088.5						79' LIC. 32.82/H.A.
4278	LOT 228	259	78				5,180.	3rd	3,237.5	1½	17,088.5						80' LIC. 32.82/H.A.
4279	LOT 229	259	78				5,180.	3rd	3,237.5	1½	17,088.5						
4280	LOT 238	259	78				5,180.	3rd	3,237.5	1½	17,088.5						
4281	LOT 244	259	78				5,180.	3rd	3,237.5	1½	17,088.5						
4283	1MILE N. L. 244	259	78				5,180	3rd	3,237.5	1½	17,088.5						
5305	LOT 239	259	79				1,942.5	2nd	3,237.5	1½	8,500.3						
5306	LOT 243	259	79				1,942.5	2nd	3,237.5	1½	8,500.3						
5307	1MILE N. L. 243	259	79				1942.5	2nd	3,237.5	1½	8,500.3						
6040	NORTH ½ L. 221	130	80				975	2nd	1,625.	1½	4,266.6						
				WORK DONE	1978-79	1979-80	1980-81										
				$	165,225.	-	170,204.										

CROWS NEST RESOURCES LIMITED (Exploration)

B.C. COAL LICENCES
TENURE STANDING

BLOCK: BULKLEY VALLEY COAL LIMITED (LICENCEE)
GROUP: # 221
PROJECT: TELKWA
YEAR: 1980 - 1981
DATE: DECEMBER 1981

LICENCE			ACQ/ADM		RENTALS		REQUIREMENT WORK						BUDGET		EXP	POTL	REMARKS
NO.	LEGAL DESCRIPTION	AREA TOTAL AC/HA.	YEAR	FEES $	ANNUAL $	TOTAL TO NEXT ANN. $ 10^3	EXPIRED CURRENT YEAR $ 10^3	LIC. YEAR	$	PRE-FULFILMENT YEAR	PRE-FULFILMENT $	ANNIVERSARY DATE	CURRENT YEAR AFE	$ 10^3	TOTAL $ 10^3	SHELL CLASS.	
13 LICENCES		3367		130	16,835	69.9	122.3	38.4	48,562.5	1½ & 2	168,177	SEPTEMBER 20	-	-	360.3	Y	THE WORK CREDIT
3709	LOT 390	259	77					4	6,475.	1½							ON THESE LICENCES
3710	LOT 227	259	77					4	6,475.	1½							(FROM SEPT. 20th
3875	LOT 246	259	78					3	3,237.50	2							1981) IS
3876	LOT 392	259	78					3	3,237.50	2							49.95 / HECTARES
3877	LOT 388	259	78					3	3,237.5	2							
3878	LOT 223	259	78					3	3,237.5	2							
3879	LOT 226	259	78					3	3,237.5	2							
3880	LOT 221	259	78					3	3,237.5	2							
3881	LOT 232	259	78					3	3,237.5	2							
3882	LOT 379	259	78					3	3,237.5	2							
3883	LOT 380	259	78					3	3,237.5	2							
3884	LOT 400	259	78					3	3,237.5	2							
3885	LOT 393	259	78					3	3,237.5	2							
				WORK DONE	1977-78	1978-79	1979	1980	1981								
				$	3885	127,863.5	30,411	_	128,379.78								
						CYPRUS	ANVIL										
						MINING	CO.										

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CROWS NEST RESOURCES LIMITED (Exploration)

B.C. COAL LICENCES
TENURE STANDING

BLOCK: SMITHERS
GROUP: # 324
PROJECT: DENY'S CREEK
YEAR: 1980 - 81
DATE: DECEMBER 1981

LICENCE			ACQ/ADM		RENTALS		REQUIREMENT WORK						BUDGET		EXP	POTL	REMARKS
NO.	LEGAL DESCRIPTION	AREA TOTAL AC/HA.	YEAR	FEES $	ANNUAL $	TOTAL TO NEXT ANN. $ 10^3	EXPIRED $ 10^3	CURRENT YEAR LIC. YEAR	CURRENT YEAR $	PRE-FULFILMENT YEAR	PRE-FULFILMENT $	ANNIVERSARY DATE	CURRENT YEAR AFE	CURRENT YEAR $ 10^3	TOTAL $ 10^3	SHELL CLASS.	
11 LICENCES		2849		110	14,245	41.4	25.9	1 & 3	27,842.5		111,958.5	DECEMBER 31st	-	-	207.1	Y	THE LICENCES ARE
4246	LOT 139	259	78				5,185	3rd	3,237.5	1½		DECEMBER 31st					IN GOOD STANDING
4247	LOT 4806	259	78				5,185	3rd	3,237.5	1½		DECEMBER 31st					ON DECEMBER 31st,
4248	LOT 4808	259	78				5,185	3rd	3,237.5	1½		DECEMBER 31st					1981. THE EXCESS
4249	LOT 4809	259	78				5,185	3rd	3,237.5	1½		DECEMBER 31st					CREDIT FOR THE SUB-
4250	LOT 4811	259	78				5,185	3rd	3,237.5	1½		DECEMBER 31st					SEQUENT TERMS IS
6884	LOT 4807	259	81				-	1st	1,942.5	2½		DECEMBER 31st					39.30 PER HECTARES
6885	LOT 4810	259	81				-	1st	1,942.5	2½		DECEMBER 31st					
6886	LOT 4812	259	81				-	1st	1,942.5	2½		DECEMBER 31st					
6887	LOT 4813	259	81				-	1st	1,942.5	2½		DECEMBER 31st					
6888	LOT 4814	259	81				-	1st	1,942.5	2½		DECEMBER 31st					
6889	LOT 4815	259	81				-	1st	1,942.5	2½		DECEMBER 31st					
				WORK DONE	1978 - 79	1979 - 80	1980 - 81										
				$	25,994	455	139,801										
				CASH IN LIEU		12,267											

BA - 312

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CROWS NEST RESOURCES LIMITED (Exploration)

B.C. COAL LICENCES
TENURE STANDING

BLOCK: SMITHERS
GROUP: # 325
PROJECT: TELKHA SOUTH
YEAR: 1980 - 81
DATE: DECEMBER 1981

LICENCE			ACQ/ADM		RENTALS		REQUIREMENT WORK						BUDGET		EXP	POTL	REMARKS
NO.	LEGAL DESCRIPTION	AREA TOTAL AC/HA.	YEAR	FEES $	ANNUAL $	TOTAL TO NEXT ANN $ 10^3	EXPIRED $ 10^3	CURRENT YEAR LIC YEAR	CURRENT YEAR $	PRE-FULFILMENT YEAR	PRE-FULFILMENT $	ANNIVERSARY DATE	CURRENT YEAR AFE	CURRENT YEAR $ 10^3	TOTAL $ 10^3	SHELL CLASS.	
10 LICENCES		2590		100.	12,950.	49.1	48.5	2 & 3	32,375.	-	-	DECEMBER 31	-	-		Y	THE LICENCES
4260	LOT 631	259	78				5,180.	3rd	3,237.5								ARE IN GOOD
4261	LOT 628	259	78				5,180.	3rd	3,237.5								STANDING ON
4262	LOT 627	259	78				5,180.	3rd	3,237.5								DECEMBER 31st
4264	LOT 625	259	78				5,180.	3rd	3,237.5								1981, THERE IS
4265	LOT 624	259	78				5,180.	3rd	3,237.5								NO EXCESS CREDIT
4267	LOT 245	259	78				5,180.	3rd	3,237.5								ON THESE LICENCES
4269	LOT 233	259	78				5,180.	3rd	3,237.5								
4270	LOT 234	259	78				5,180.	3rd	3,237.5								
4282	1 MILE S. L. 627	259	78				5,180.	3rd	3,237.5								
5839	1 MILE S. L. 245	259	80				1,942.5	2nd	3,237.5								
				WORK DONE	1978-79	1979-80	1980-81										
				$	18,730.	494.	31,451										
				$	9,480.	984.											
				CASH IN LIEU		$17,966	$ 925.										

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Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources

APPLICATION TO EXTEND TERM OF LICENCE

I, LLOYD GETHING (Name) agent for BULKLEY VALLEY COAL LIMITED (Name)

R.R. 1, TELKWA (Address)
BRITISH COLUMBIA, V0V 2X0

(Address)

Valid FMC No. 179 124

hereby apply to the Minister to extend the term of Coal Licence(s) No(s). 3709, 3710, 3875 to 3885,
13 Coal Licences 3367 Hectares
for a further period of one year.

2. Property name Telkwa
3. I am allowing the following Coal Licence(s) No(s). to forfeit N/A
4. I have performed, or caused to be performed, during the period September 20, 1980 to September 19, 1981 work to the value of at least $128,379.78 on the location of coal licence(s) as follows:

CATEGORY OF WORK

	Licence(s) No(s).	Apportioned Cost
Geological mapping	3877, 3883, 3875, 3709	12,360.00
Surveys: Geophysical		
Geochemical		
Other Land Survey	3709, 3877, 3876	3,462.00
Road construction		-
Surface work		2,250.00
Underground work		-
Drilling	3709, 3876, 3877	77,788.78
Logging, sampling, and testing	3709, 3876, 3877	24,099.00
Reclamation	3709, 3876, 3877	7,520.00
Other work (specify)		
Off-property costs		900.00

5. I wish to apply $128,379.78 of this value of work on Coal Licence(s) No(s). 3709, 3710, 3875 to 3885
6. I wish to pay cash in lieu of work in the amount of $ N/A on Coal Licence(s) No(s).
7. The work performed on the location(s) is detailed in the attached report entitled The Geological Report will be submitted in 90 days.

Sept 16th, 1981 (Date)

Lloyd Gething (Signature)

PRESIDENT (Position)

(FORMS AND REPORT TO BE SUBMITTED IN DUPLICATE)

CATEGORY OF WORK

GEOLOGICAL MAPPING Yes [x] No [ ]

		Area (Hectares)	Scale	Duration
Reconnaissance		1000	1:10,000	6 man days
Detail:	Surface	1000	1: 5,000	16 man days
	Underground			

*Other (specify)

Total Cost $ 12,360

GEOPHYSICAL/GEOCHEMICAL SURVEYS Yes [x] No [ ]

Method

Grid

Topographic location surveys of drill holes

*Other (specify) Ground control surveys for photogrammetric mapping

Total Cost $ 3,462.

ROAD CONSTRUCTION Yes [ ] No [x]

Length Width

On Licence(s) No(s).

Access to

Total Cost $

SURFACE WORK Yes [x] No [ ]

	Length	Width	Depth	Cost
Trenching Bulldozer	30m	5m	3m	2,250
Seam Tracing				
Crosscutting				
*Other (specify)				

Total Cost $ 2,250

UNDERGROUND WORK Yes [ ] No [x]

	No. of Adits	Maximum Length	No. of Holes	Total Metres	Cost
Test Adits					
*Other workings					

Total Cost $ -

DRILLING Yes [x] No [ ]

		Hole Size	No. of Holes	Total Metres	Cost
Core:	Diamond				
	Wireline	NQ	1	235	37,934
Rotary:	Conventional	6"	5	613	39,854.78
	Reverse circulation				
*Other (specify)					

Contractor NIELSEN DRILLING/MIDWEST, DIMOND DRILLING

Where is the core stored? SMITHERS TRANSPORT

Total Cost $ 77,788.78

LOGGING, SAMPLING AND TESTING Yes [x] No [ ]

Lithology: Drill samples [x] Core samples [x] Bulk samples [ ]

Logs: Gamma-neutron [x] Density [x]

*Other (specify) Directional, Electric

Testing: Proximate analysis [ ] FSI [ ] Washability [ ]

Carbonization [ ] Petrographic [ ] Plasticity [ ]

*Other (specify) Logging core and rotary cutting

TOTAL COST 24,099

OTHER WORK (specify details) Cost

RECLAMATION

Total Cost $ 7,520.00

To date

On-property costs 127,479.00

Off-property costs 900.00

Total Expenditures 128,379.78

September 14th, 1981
(Date)

(Signature)

MANAGER, ACCOUNTING - CNRL
(Position)

*A full explanation of other work is to be included.

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Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources

APPLICATION TO EXTEND TERM OF LICENCE

I, LESLIE GRAMANTIK (Name) agent for SHELL CANADA RESOURCES LIMITED (Name)

P.O. BOX 100 (Address) CALGARY (Address)

ALBERTA T2P 2H5

Valid FMC No. 207568

hereby apply to the Minister to extend the term of Coal Licence(s) No(s). 4271, 4272, 4274, TO 4281, 4383, 5305 TO 5307 AND 6040, FIFTEEN LICENCES, GROUP #327, 3756 HECTARES

for a further period of one year.

2. Property name TELKWA NORTH, RANGE 5 COAST LAND DISTRICT

3. I am allowing the following Coal Licence(s) No(s). to forfeit N/A

4. I have performed, or caused to be performed, during the period SEPTEMBER 1980 to DECEMBER 31st, 19 81, work to the value of at least $ 170,204.00

on the location of coal licence(s) as follows:

CATEGORY OF WORK

	Licence(s) No(s).	Apportioned Cost
Geological mapping	4271, 4272, 4274 - 4276, 6040	14,932.00
Surveys: Geophysical	6040, 4271, 4272, 4274-4278, 4283 5307	50,392.00
Geochemical	-	-
Other	LAND SURVEY, 4271, 4276, 4279, 5307	8,825.00
Road construction	-	-
Surface work	4276, 4277, 4278, 6040	12,400.00
Underground work	-	-
Drilling	4271, 4272	58,694.00
Logging, sampling, and testing	4271, 4272	22,682.00
Reclamation	4271, 4272	747.00
Other work (specify)		
Off-property costs	GEOLOGICAL REPORT	1,532.00

5. I wish to apply $ 170,204.00 of this value of work on Coal Licence(s) No(s). 4271, 4272, 4274 TO 4281, 4283, 5305 TO 5307 AND 6040

6. I wish to pay cash in lieu of work in the amount of $ N/A on Coal Licence(s) No(s).

7. The work performed on the location(s) is detailed in the attached report entitled SMITHERS AREA COAL PROSPECT, 1981 GEOLOGICAL REPORT

DECEMBER 7, 1981 (Date) L. Gramantik (Signature)

ASSISTANT LANDMAN (Position)

(FORMS AND REPORT TO BE SUBMITTED IN DUPLICATE)

CATEGORY OF WORK

GEOLOGICAL MAPPING

Yes ☒ No ☐

		Area (Hectares)	Scale	Duration
Reconnaissance		1544	1:10,000	5½ MAN DAYS
Detail:	Surface	500	1:5,000	8 MAN DAYS
	Underground			

*Other (specify)

Total Cost $14,932.00

GEOPHYSICAL/GEOCHEMICAL SURVEYS

Yes ☒ No ☐

Method EM 37 VLF SCHLUMBERGER SOUNDINGS 50,392.00

Grid

Topographic

*Other (specify) HOLE LOCATION SURVEY 8,825.00

Total Cost $59,217.00

ROAD CONSTRUCTION

Yes ☐ No ☒

Length ... Width

On Licence(s) No(s).

Access to

Total Cost $

SURFACE WORK

Yes ☒ No ☐

	Length	Width	Depth	Cost
Trenching				
Seam Tracing				
Crosscutting				
*Other (specify)	ROAD UPGRADING 1.8km			

Total Cost $12,400.00

UNDERGROUND WORK

Yes ☐ No ☒

	No. of Adits	Maximum Length	No. of Holes	Total Metres	Cost
Test Adits					
*Other workings					

Total Cost $

DRILLING

Yes ☒ No ☐

		Hole Size	No. of Holes	Total Metres	Cost
Core:	Diamond				
	Wireline				
Rotary:	Conventional	6 INCH	3	308.7	
	Reverse circulation				
*Other (specify)					

Contractor NIELSEN DRILLING

Where is the core stored?

Total Cost $58,694.00

LOGGING, SAMPLING AND TESTING

Yes ☒ No ☐

Lithology: Drill samples ☒ Core samples ☐ Bulk samples ☐

Logs: Gamma-neutron ☒ Density ☒

*Other (specify) DIRECTIONAL SURVEY

Testing: Proximity analysis ☒ FSI ☒ Washability ☐

Carbonization ☐ Petrographic ☐ Plasticity ☐

*Other (specify) LOGGING CORE & CUTTINGS

TOTAL COST 22,682.00

OTHER WORK (specify details)

	Cost
RECLAMATION	747.00
GEOLOGICAL REPORT AND FIELD PREPARATION	1,532.00
Total Cost	$ 2,279.00
On-property costs	168,672.00
Off-property costs	1,532.00
Total Expenditures	$ 170,204.00

Dec. 7/81
(Date)

(Signature)

MANAGER, ACCOUNTING, C.N.R.L.
(Position)

*A full explanation of other work is to be included.

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Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources

APPLICATION TO EXTEND TERM OF LICENCE

I, LESLIE GRAMANTIK (Name) agent for SHELL CANADA RESOURCES LTD. (Name)

P.O. BOX 100 (Address) CALGARY (Address)

ALBERTA T2P 2H5

Valid FMC No. 207 568

hereby apply to the Minister to extend the term of Coal Licence(s) No(s). 4260, 4261, 4262, 4264, 4265, 4267, 4269, 4270, 4282, 5839, TEN LICENCES, GROUP # 325, 2590 HECTARES

for a further period of one year.

2. Property name TELKWA SOUTH, RANGE 5 COAST LAND DISTRICT

3. I am allowing the following Coal Licence(s) No(s). to forfeit N/A

4. I have performed, or caused to be performed, during the period SEPTEMBER 1980 to DECEMBER 31st, 1981, work to the value of at least $ 31,451.00 on the location of coal licence(s) as follows:

CATEGORY OF WORK

	Licence(s) No(s).	Apportioned Cost
Geological mapping	ALL THE LICENCES	4,650.00
Surveys: Geophysical	-	-
Geochemical	-	-
Other	LAND SURVEY 4262, 4267	6,000.00
Road construction	-	-
Surface work	4262, 4264	3,600.00
Underground work	-	-
Drilling	4267	10,376.00
Logging, sampling, and testing	4267	4,220.00
Reclamation	-	-
Other work (specify)	-	-
Off-property costs	GEOLOGICAL REPORT	2,605.00

5. I wish to apply $ 31,451.00 of this value of work on Coal Licence(s) No(s). 4260, 4261, 4262, 4264, 4265, 4267, 4269, 4270, 4282, 5839

6. I wish to pay cash in lieu of work in the amount of $ 925.00 on Coal Licence(s) No(s). ALL OF THE ABOVE

7. The work performed on the location(s) is detailed in the attached report entitled SMITHERS AREA COAL PROSPECTS, 1981 GEOLOGICAL REPORT

DECEMBER 7, 1981 (Date) — [signature] (Signature)

ASSISTANT LANDMAN (Position)

(FORMS AND REPORT TO BE SUBMITTED IN DUPLICATE)

CATEGORY OF WORK

GEOLOGICAL MAPPING Yes ☒ No ☐

		Area (Hectares)	Scale	Duration
Reconnaissance		2600	1:10,000	4½ MAN DAYS
Detail:	Surface			
	Underground			
*Other (specify)				

Total Cost $ 4,650.00

GEOPHYSICAL/GEOCHEMICAL SURVEYS Yes ☒ No ☐

Method

Grid

Topographic

*Other (specify) GROUND CONTROL SURVEY FOR PHOTOGRAMMETRIC MAPPING

Total Cost $ 6,000.00

ROAD CONSTRUCTION Yes ☐ No ☒

Length ... Width

On Licence(s) No(s).

Access to

Total Cost $

SURFACE WORK Yes ☒ No ☐

	Length	Width	Depth	Cost
Trenching				
Seam Tracing				
Crosscutting				
*Other (specify) ROAD UPGRADING 0.5 KM				

Total Cost $ 3,600.00

UNDERGROUND WORK Yes ☐ No ☒

	No. of Adits	Maximum Length	No. of Holes	Total Metres	Cost
Test Adits					
*Other workings					

Total Cost $

DRILLING Yes ☒ No ☐

		Hole Size	No. of Holes	Total Metres	Cost
Core:	Diamond				
	Wireline				
Rotary:	Conventional	6 INCH	1	169.8	
	Reverse circulation				
*Other (specify)					

Contractor NIELSEN DRILLING LTD.

Where is the core stored?

Total Cost $ 10,376.00

LOGGING, SAMPLING AND TESTING Yes ☒ No ☐

Lithology: Drill samples ☒ Core samples ☐ Bulk samples ☐

Logs: Gamma-neutron ☒ Density ☒

*Other (specify) DIRECTIONAL SURVEY

Testing: Proximity analysis ☐ FSI ☐ Washability ☐

Carbonization ☐ Petrographic ☐ Plasticity ☐

*Other (specify) LOGGING CORE AND CUTTINGS

TOTAL COST 4,220.00

OTHER WORK (specify details) Cost

FIELD PREPARATION AND GEOLOGICAL REPORT

Total Cost $ 2,605.00

On-property costs 28,846.00

Off-property costs 2,605.00

Total Expenditures $ 31,451.00

Dec 7/81
(Date)

[signature]
(Signature)

MANAGER ACCOUNTING C.N.R.L.
(Position)

*A full explanation of other work is to be included.

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Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources

APPLICATION TO EXTEND TERM OF LICENCE

I, LESLIE GRAMANTIK (Name) agent for SHELL CANADA RESOURCES LIMITED (Name)

P.O. BOX 100 (Address) CALGARY (Address)

ALBERTA T2P 2H5

Valid FMC No. 207 568

hereby apply to the Minister to extend the term of Coal Licence(s) No(s). 4246, TO 4250, 6884 TO 6889, ELEVEN LICENCES, GROUP #324, 2849 HECTARES

for a further period of one year.

2. Property name DENY'S CREEK, RANGE 5 COAST LAND DISTRICT

3. I am allowing the following Coal Licence(s) No(s). to forfeit N/A

4. I have performed, or caused to be performed, during the period SEPTEMBER 1980 to DECEMBER 31st, 19 81, work to the value of at least $ 139,801.00

on the location of coal licence(s) as follows:

CATEGORY OF WORK

	Licence(s) No(s).	Apportioned Cost
Geological mapping	4248, 4250, 6884, 6886	9,495.00
Surveys: Geophysical	-	-
Geochemical	-	-
Other	DRILL HOLE LOCATION	1,000.00
Road construction	-	-
Surface work	6886, 4247	5,500.00
Underground work	-	-
Drilling	6886, 4247	93,755.00
Logging, sampling, and testing	6886, 4247	22,531.00
Reclamation	6886, 4247, 6884	3,550.00
Other work (specify)	-	-
Off-property costs	GEOLOGICAL REPORT	3,970.00

5. I wish to apply $ 139,801.00 of this value of work on Coal Licence(s) No(s). 4246 TO 4250, 6884 TO 6889

6. I wish to pay cash in lieu of work in the amount of $ N/A on Coal Licence(s) No(s).

7. The work performed on the location(s) is detailed in the attached report entitled SMITHERS AREA COAL PROSPECTS, 1981 GEOLOGICAL REPORT

DECEMBER 7, 1981 (Date) — (Signature)

ASSISTANT LANDMAN (Position)

(FORMS AND REPORT TO BE SUBMITTED IN DUPLICATE)

CATEGORY OF WORK

GEOLOGICAL MAPPING Yes ☒ No ☐

		Area (Hectares)	Scale	Duration
Reconnaissance		1036	1:10,000	16 MAN DAYS
Detail:	Surface			
	Underground			

*Other (specify)

Total Cost $ 9,495

GEOPHYSICAL/GEOCHEMICAL SURVEYS Yes ☒ No ☐

Method
Grid
Topographic
*Other (specify) DRILL HOLE LOCATION SURVEY

Total Cost $ 1,000.00

ROAD CONSTRUCTION Yes ☐ No ☒

Length Width
On Licence(s) No(s).
Access to

Total Cost $

SURFACE WORK Yes ☒ No ☐

	Length	Width	Depth	Cost
Trenching				
Seam Tracing				
Crosscutting				
*Other (specify)	SLASHING DRILL SITES			

Total Cost $ 5,500.00

UNDERGROUND WORK Yes ☐ No ☒

	No. of Adits	Maximum Length	No. of Holes	Total Metres	Cost
Test Adits					
*Other workings					

Total Cost $

DRILLING Yes ☒ No ☐

		Hole Size	No. of Holes	Total Metres	Cost
Core:	Diamond	NQ	2	400	
	Wireline				
Rotary:	Conventional				
	Reverse circulation				
*Other (specify)					

Contractor MIDWEST DIMOND DRILLING
Where is the core stored? SMITHERS TRANSPORT

Total Cost $ 93,755.00

LOGGING, SAMPLING AND TESTING Yes ☒ No ☐

Lithology: Drill samples ☐ Core samples ☒ Bulk samples ☐
Logs: Gamma-neutron ☒ Density ☒
*Other (specify) FOCUSED BEAM ELECTRIC, DIRECTIONAL SURVEY CALIPER
Testing: Proximity analysis ☐ FSI ☐ Washability ☐
Carbonization ☐ Petrographic ☐ Plasticity ☐
*Other (specify)

TOTAL COST 22,531.00

OTHER WORK (specify details)

	Cost
RECLAMATION	3,550.00
GEOLOGICAL REPORT	3,970.00
Total Cost	$ 7,520.00
On-property costs	135,831.00
Off-property costs	3,970.00
Total Expenditures	$ 139,801.00

Dec 7/81
(Date)

W.V.J. Kanuchi [signature]
(Signature)

MANAGER ACCOUNTING - C.N.R.L.
(Position)

*A full explanation of other work is to be included.

93L

CP21035

GEOPHYSICAL TRIALS ON

COAL PROPERTIES NEAR SMITHERS, B.C.

Prepared For

CROWS NEST RESOURCES LIMITED
CALGARY, ALBERTA

Prepared By

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

June, 1981
81-20

TABLE OF CONTENTS

1.0 INTRODUCTION

In May, 1981, for a period of 10 field days, geophysical trials were conducted in the Telkwa and Thautil River area near Smithers, B.C. In these trials the electrical properties of the subsurface were measured by four different techniques. The purpose of the trials was to determine if several important geologic mapping objectives could be derived from surface geophysical measurements. These geologic mapping objectives were:

a) the boundary of volcanic (eruptives) and sedimentary rocks

b) the thickness of sedimentary sections

c) the presence of faulting

d) the thickness of overburden

e) the presence and continuity of coal seams

The four geophysical techniques that were tested were conventional d.c. (Schlumberger) soundings, profiling with fixed frequency magnetic dipoles, transient electromagnetic sounding, and VLF audio-magnetotelluric. These techniques differ in effective exploration depth, lateral resolution and cost of surveying.

The results show that the exploration objectives that were derived from surface electrical measurements are: i) the mapping of boundaries of volcanic and sedimentary rock, ii) the thickness of sedimentary sections and, iii) the presence of faulting. The best method for achieving these objectives proved to be transient electromagnetic sounding with the Geonics EM37.

There is no evidence in the data that surface electrical measurements can be used to map the presence or continuity of coal seams. The thickness of overburden can probably, in many instances, be obtained from electrical measurements. However, seismic refraction methods are probably better suited for that purpose.

The geophysical trials were authorized by Mr. F. Martonhegyi of Crows Nest Resources Ltd.

2.0 GEOPHYSICAL METHODS AND PRINCIPLES

2.1 Electrical Properties of Soils and Rocks

The basis of subsurface exploration by electrical methods is the fact that soil and rock types generally have a characteristic range of electrical resistivity values. Figure 1 shows typical ranges of electrical conductivity (resistivity) for soils. The dominant parameter influencing conductivity of soils generally is the clay content of the soil. High pore water salinities may alter the relation shown in Figure 1. High pore water salinities in soils, however, are not expected in the Smithers area.

The relation between rock types and electrical resistivity is more difficult to generalize. It is more common to have high pore water salinities in rocks than in soils, so that correlations of resistivity with rock types generally have only a regional validity. Figure 2 shows the ranges of resistivity derived from this survey for the rock types in the Smithers area. Most of the volcanic rock was found to have resistivities in excess of 40 ohm- metres. However, a few local pockets of less resistive volcanic rock were observed in the surface geophysical measurements, as well as in borehole resistivity logs.

2.2 Methods of Measuring the Electrical Properties of the Subsurface

Four methods of electrical resistivity (conductivity) mapping were used in the Smithers area, i.e. Schlumberger soundings, profiling with fixed frequency magnetic dipoles, transient soundings, and VLF audio-magnetotelluric.

2.2.1 Schlumberger Soundings

In Schlumberger soundings, d.c. current is driven into the ground between two current contacts, I_1 and I_2 (Figure 3). The current flow in the ground causes a potential field and the potential differences at the surface are measured between two voltage probes, P_1 and P_2. The depth of exploration is altered by changing the spacing between the current electrodes. From the ratio of voltage and current the apparent resistivity of the ground is computed. Figure 4 shows a computer modeled apparent resistivity curve over two-layered ground e.g. gravel overburden over volcanic rock. At close electrode spacing all currents are concentrated in the surface layer and the apparent resistivity corresponds to the resistivity of the surface layer. At large electrode spacing most of the current flows in the lower layer and the apparent resistivity closely corresponds to the true resistivity of the second layer. At intermediate values of electrode spacings the apparent resistivity assumes values between that of the true resistivity of the first and second layer. In the field the apparent resistivities are measured over a range of electrode spacings, and inverse solutions or fitting of models are used to derive the resistivity layering from the experimental data.

The modeled data of Figure 4 shows that in order to get sufficient data to resolve a two-layer structure from the experimental data requires a L-spacing of approximately 4 times the thickness of the first layer. To determine thickness of a 250 m deep sedimentary section would require a wire length of 2 km (2 x L). The equipment ued for Schlumberger soundings at Smithers was the Syntrex RAC-8. Manufacturer's specifications on that equipment are given in Appendix A.

2.2.2 Profiling with Fixed Frequency Magnetic Dipoles

In the magnetic induction method current flow is induced in the ground by the varying magnetic field of vertical or horizontal magnetic dipole transmitters. A magnetic dipole transmitter consist of a loop antenna through which alternating electrical current is forced; similarly, a magnetic dipole receiver is a loop antenna in which an electromotive force is measured in the presence of a varying magnetic field.

Figure 5 illustrates the interaction of subsurface current flow and magnetic fields. The primary field from the transmitter induces horizontal eddy current flow in the subsurface. The amount of eddy current flow at each point in the ground is proportional to the product of primary field intensity and local conductivity. The primary field rapidly decreases with depth so that in ground, uniform in conductivity with depth, the amount of eddy current flow also decreases with depth. Ground, however, is seldom uniform in conductivity with depth and an important objective in exploration is to map layers of different conductivity. Knowledge about conductivity stratification in the ground is derived from measurements with instruments with different effective depths of exploration. The exploration depth is mainly increased by increasing the distance between transmitter and receiver dipoles.

Figure 6 schematically illustrates eddy current flow in homogeneous and layered ground for instruments with two different dipole transmitter and receiver separations. Figure 6a illustrates the eddy current distribution for two dipole separations over layered ground with a conductor at depth. Since there is a higher primary field strength at the depth of the conductor in the deep exploration instrument, more eddy current flow (product of primary field strength and local conductivity) is induced in the conductive layer in the deep exploration instrument than in the shallow exploration instrument. The eddy currents in the conductor will, therefore, contribute substantially to the readings of the deep exploration receiver but little to the shallow one. By comparing and using readings at different exploration depths, the conductivity stratification can often be derived.

An important concept in the interpretation of magnetic induction measurements with the EM31 and EM34-3 are geometric factors. The concept of geometric factors is that the secondary magnetic field measured at the surface (by the receiver) can be considered as a simple summation of contributions of horizontal strata (see Figure 7). The summation is given by:

$$\sigma_a = \sum_{0}^{n} \sigma_i \quad G_i$$

where σ_a is the apparent conductivity indicated by the instrument

σ_i is the conductivity of the ith layer

and G_i is the geometric factor of the ith layer

The geometric factors are a function of the instrument only and two geometric factor functions, one for the EM31 and one for the EM34-3, (40 m) are shown in Figure 7. The vertical axis represents the cumulative geometric factor function and the horizontal axis depth below the surface. For example, the geometric factor for a horizontal layer from the surface to infinite depth would be 1.0; the geometric factor of a horizontal layer from the surface to a depth of 5 metres would be 0.82 (1-0.18) and from 5 metres to infinite depth 0.18 (0.18-0.0) for the EM31; as another example the geometric factor for a horizontal layer between a depth of 3 metres and 5 metres would be 0.10 (0.28-0.18) for the EM31 and 0.08 (0.85-0.77) for the EM34-3 (40m).

It is also evident from Figure 7 that the contribution of surface layers is less for the EM34-3 than for the EM31. For example, the geometric factor for a horizontal layer between the surface and 5 metres is 0.82 for the EM31, but only 0.23 for the EM34-3 (40 m).

As a final example, the apparent conductivity is calculated in Figure 8 for a two-layer situation typical of those encountered over granular deposits over sedimentary rock. The apparent conductivities for the EM31 and EM34-3 (40 m) are computed as a function of the thickness of sand and gravel overlying bedrock.

The geometric factor approach to data interpretation in magnetic induction sounding is possible only when instrument parameters (frequency of operation, transmitter and receiver separation) are carefully selected. This was done in the design of the EM31 and EM34-3. Manufacturer's specifications for the instruments are given in Appendix A.

Since the principle objectives in the trials at Smithers were the mapping of rock type, only the EM34-3 was used. Its larger depth of exploration was expected to make its reading less dependent on variation in overburden thickness and type.

2.2.3 Transient Electromagnetic Sounding

In transient EM sounding a transmitter loop (Tx) is laid over the surface of the ground. In the Smithers survey, Tx loop of dimensions mainly of 100 m by 100 m and some of 200 m by 200 m were used (Figure 9). A function generator drives current pulses of peak amplitude up to 20 amperes through the loop. The current distribution as a function of time is shown in Figure 10a. The currents are sharply terminated by a linear ramp. The rapid termination of current causes a strong primary magnetic field pulse which induces eddy currents in the ground. The ground currents are not maintained (as in the fixed frequency method) and decay with time. The relative rapid decaying currents causes a decaying secondary magnetic (10c) field which is measured as an electromotive force in a small receiver coil (Rx) in the centre of the loop. From the measurements of the electromotive force as a function of time, the resistivity stratification in the ground is derived.

To briefly illustrate the manner in which a depth sounding is made, consider Figure 11. At time of turn-off all currents are concentrated near the surface directly under the Tx loop. *With time, the currents diffuse down and out and e.g. at time* t_3, the maximum current density would be at layer 3. However, the maximum current density would not be located under the Tx loop but some distances away. The electromotive force measured in the Rx reflects more the properties of deeper layers at later times. A depth sounding is made by making measurements as a function of time rather than as a function of spacing.

As with all other electrical and electromagnetic sounding methods, the measurements are converted to apparent resistivities. The definition of apparent resistivities adopted were those described in detail by the Russians. This has the additional advantage of making many "master curves" for interpretation available.

2.2.4 VLF Audio-magnetotelluric

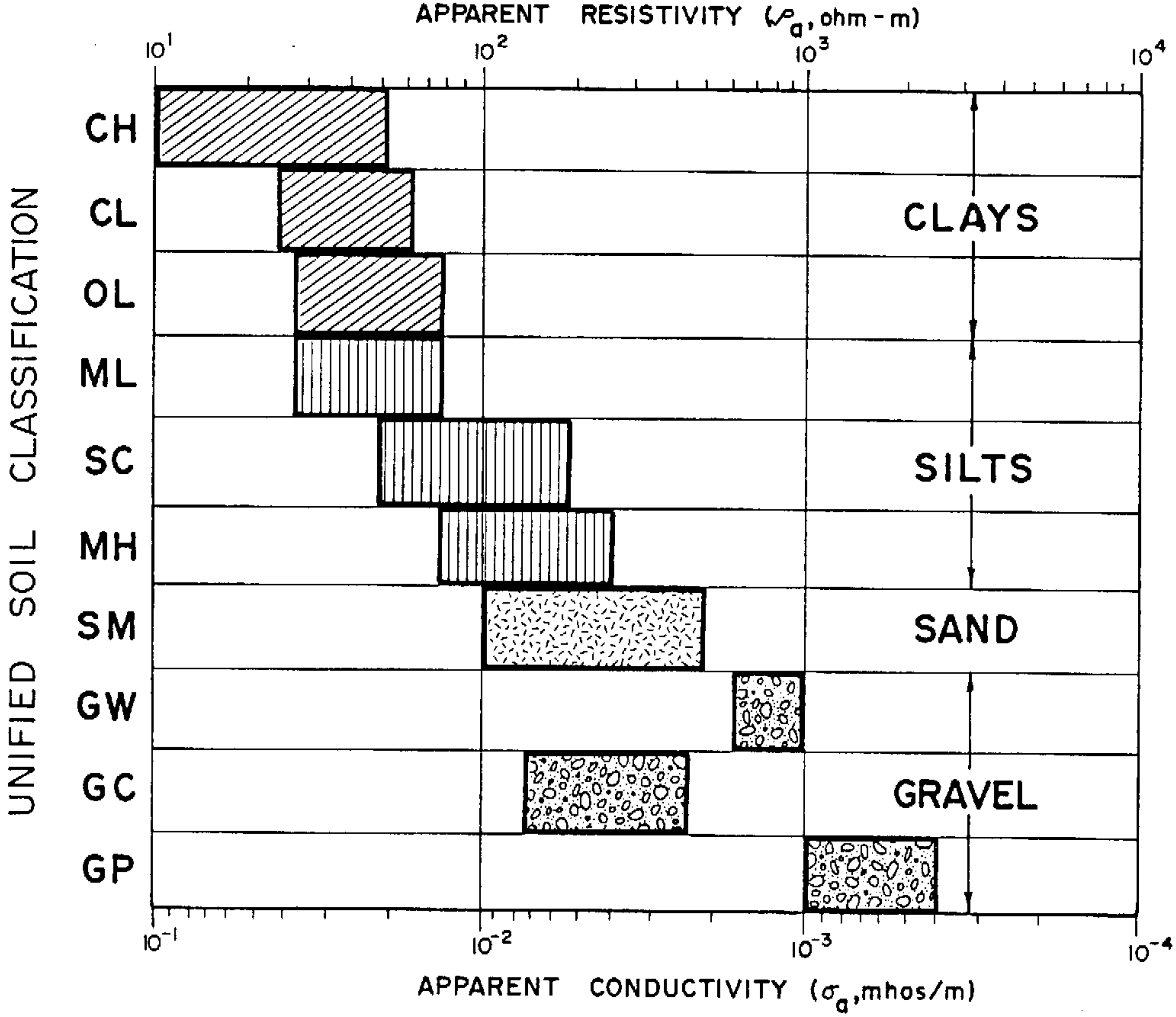
Radio waves propagating over the earth's surface are influenced by the nature of the subsurface and from measurements on the radio surface wave the resistivity of ground can be derived.

The electromagnetic field vectors a good distance from a radio transmitter are shown in Figure 12. At the ground surface there are three field vectors; a horizontal, radially oriented electric field, E_r, a horizontal, azimuthally oriented magnetic field, H_ϕ, and a vertical electric field, E_z. All three field vectors decay in amplitude with increasing distance from the transmitter and are also affected by daily changes in the cinosphere and the nature of the path between transmitter and measurement station. However, the evidence is that all three field vectors are equally influenced by propagation path and cinospheric events.

Because of the large refractive index of the ground at radio frequencies, a near vertical wave propagates into the ground with horizontal vectors H_ϕ and E_r. In the ground the amplitude of E_r and H_ϕ attenuate with depth, and the distance over which the field decays to 37 percent of its surface value is called the skin depth of the radiation. Figure 13 shows the skin depth at VLF frequencies as a function of resistivity. The effective depth of exploration is approximately one-half skin depth.

The basis of obtaining a local measurement of ground resistivity is illustrated in Figure 14, where a wave propagates over a change in subsurface conditions. Changes in local conditions cause perturbations in amplitude and phase of E_r, while local changes do not affect E_z and H_ϕ. Therefore, by measuring the ratio E_r/H_ϕ (called surface impedance) a measurement is obtained of the local electrical resistivity. The factors of path of propagation, and daily variations equally influence E_z, H_ϕ, and E_r.

Specifications on the instrument employed are given in Appendix A. In B.C. the instrument is tuned to station NAA located in Jim Creek, Washington, operating at 18.6 kilohertz.



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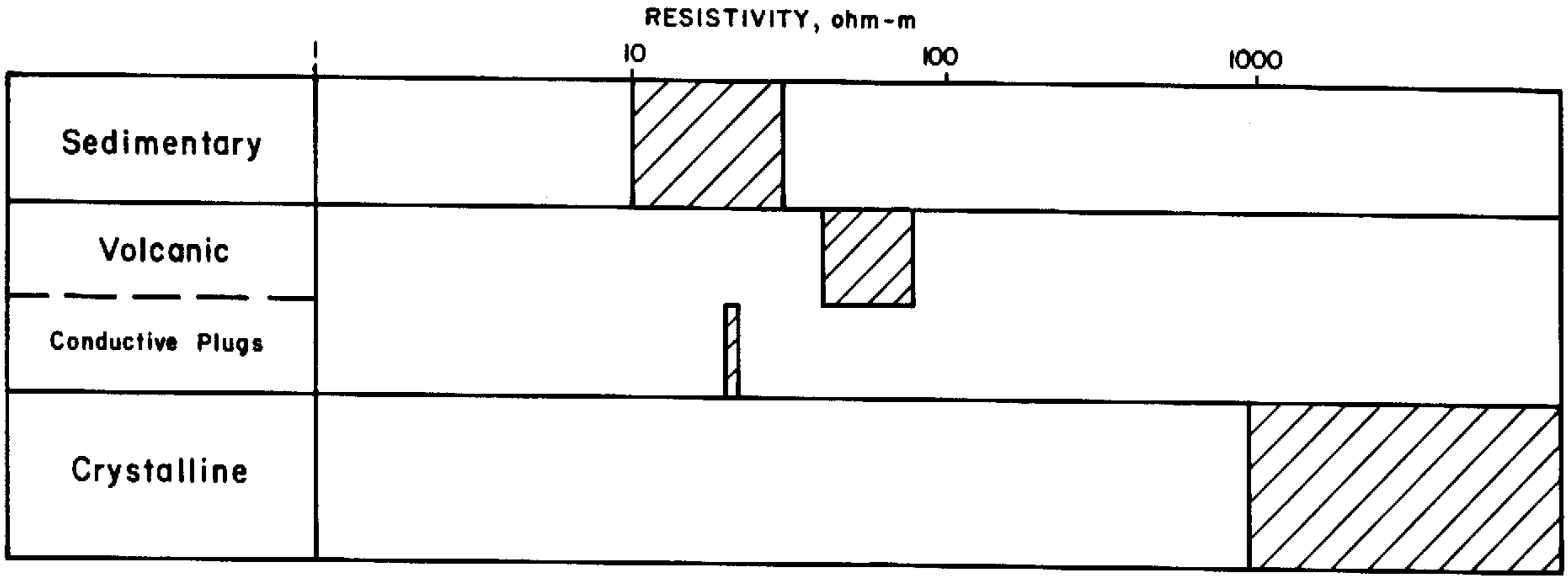
CONDUCTIVITY vs SOIL TYPE

81-20

Figure 1



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TELKWA AREA
RESISTIVITY vs ROCK TYPE
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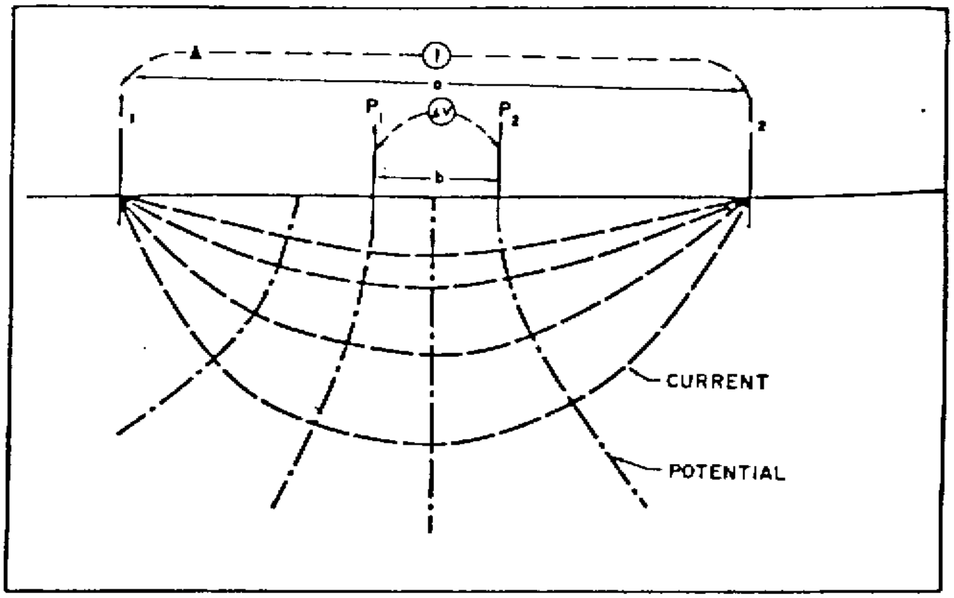
Figure 2



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SCHLUMBERGER ARRAY
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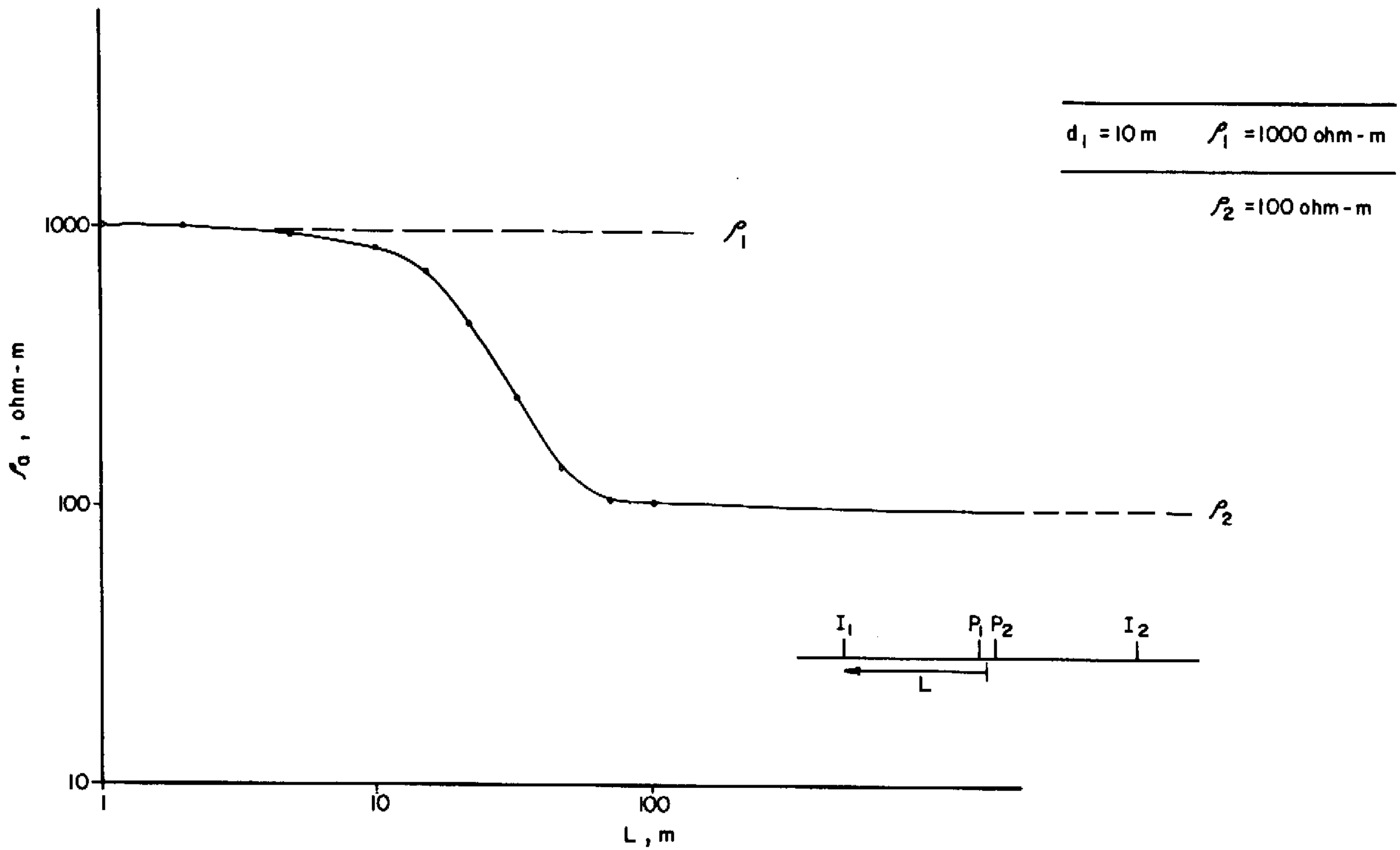
Figure 3



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TWO - LAYER
SCHLUMBERGER SOUNDING
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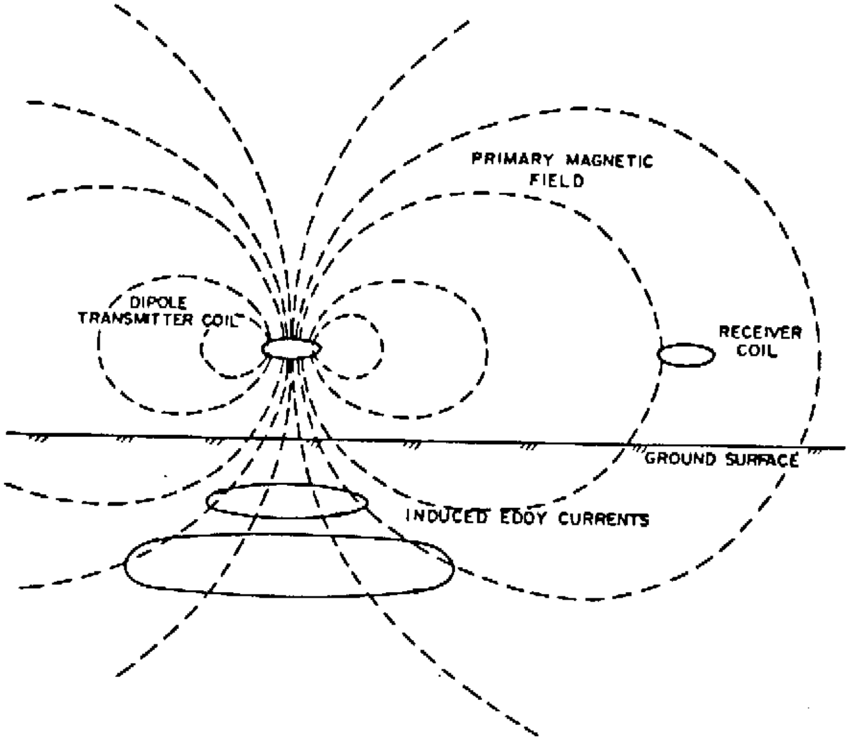
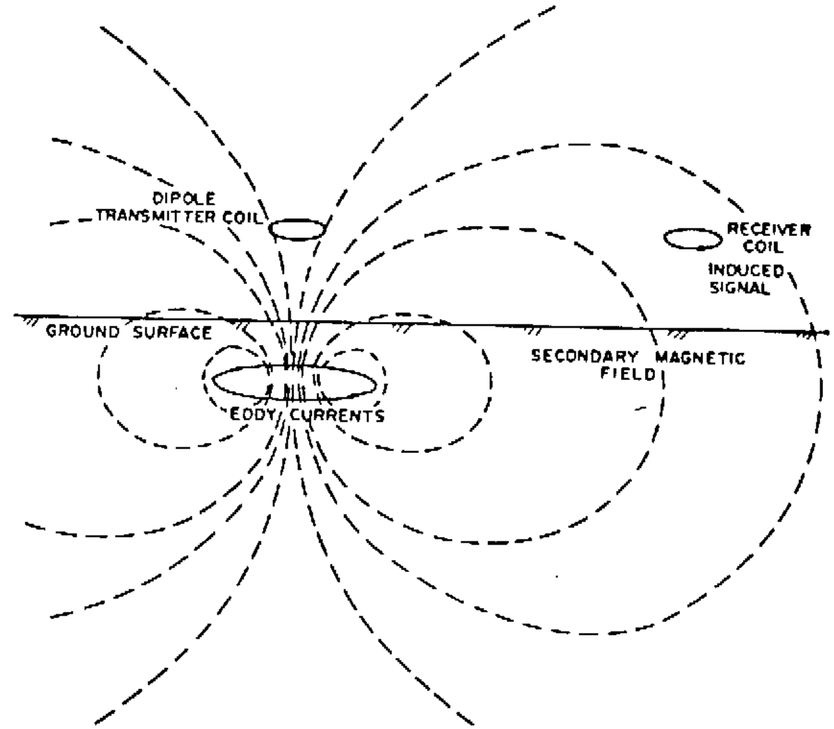
Figure 4



PRIMARY FIELD



SECONDARY FIELD

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PRINCIPLES OF MAGNETIC INDUCTION IN SOIL CONDUCTIVITY MEASUREMENTS

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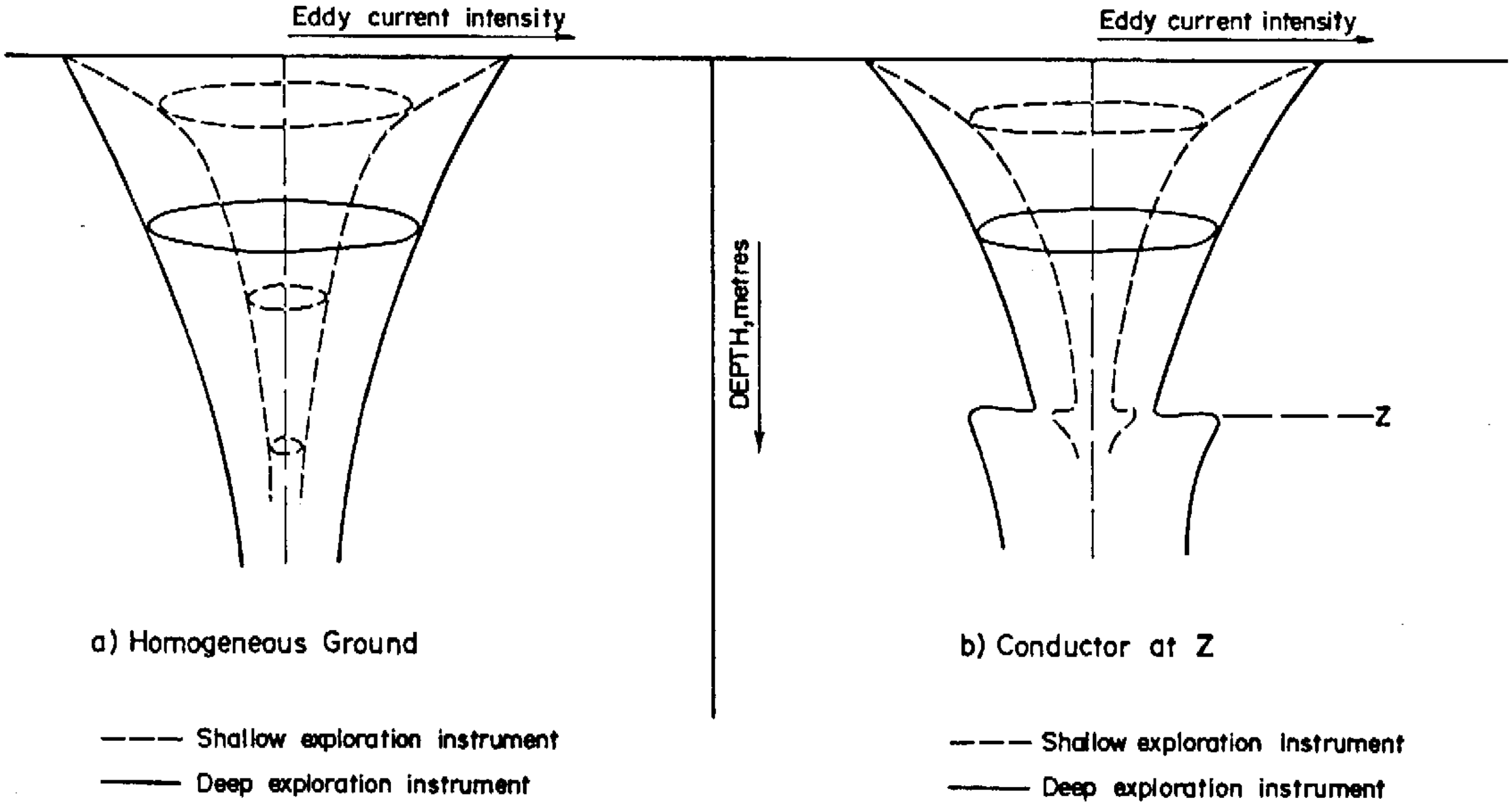
Figure 5



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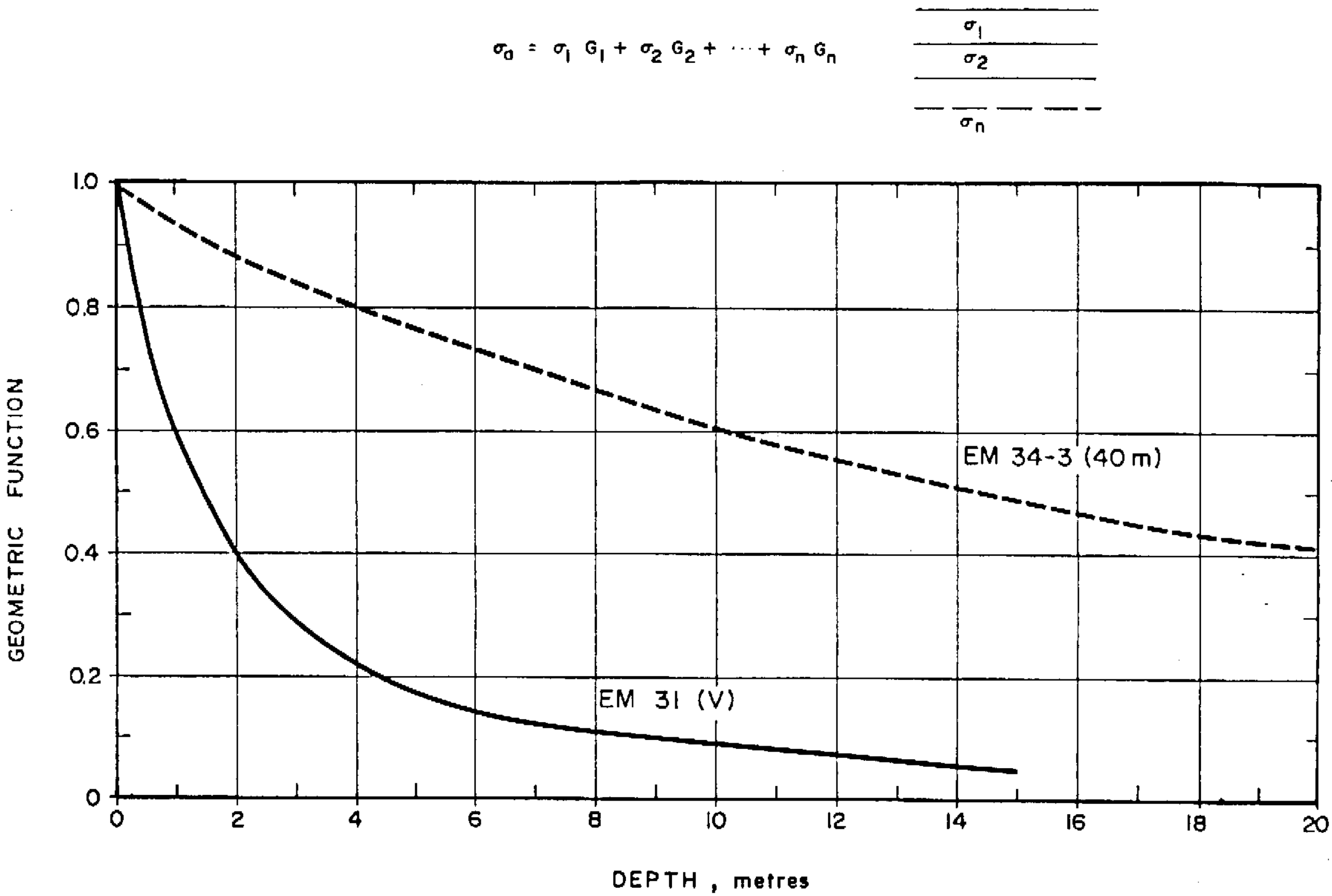
EDDY CURRENT DISTRIBUTION

81-20

Figure 6

$$\sigma_a = \sigma_1 G_1 + \sigma_2 G_2 + \cdots + \sigma_n G_n$$



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GEOMETRIC FUNCTIONS

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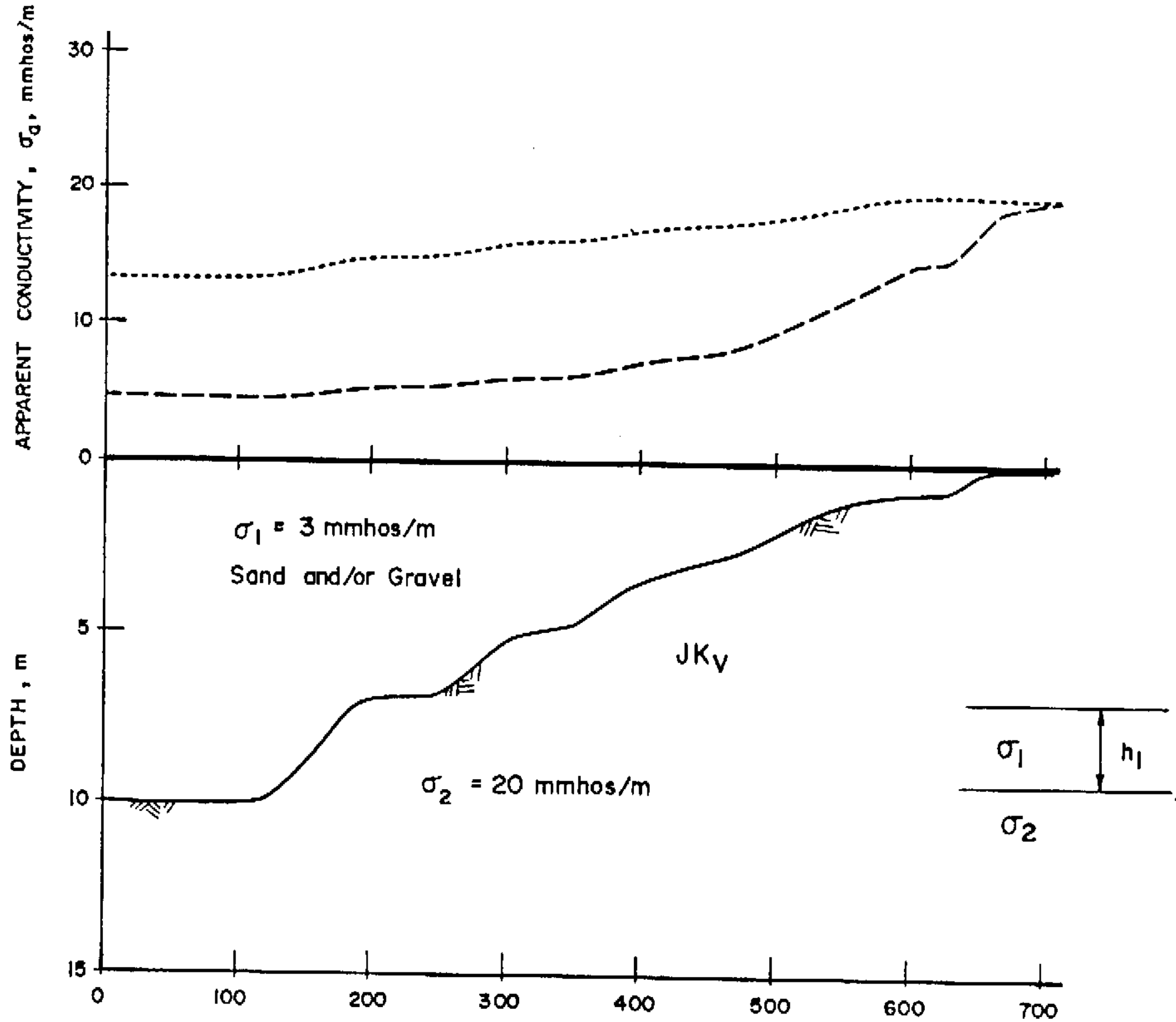
Figure 7



LEGEND

- – – – EM 31 (V)
- .... EM 34 (40)
- Interpreted top of bedrock

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APPARENT CONDUCTIVITY COMPUTED FOR TWO - LAYER GROUND

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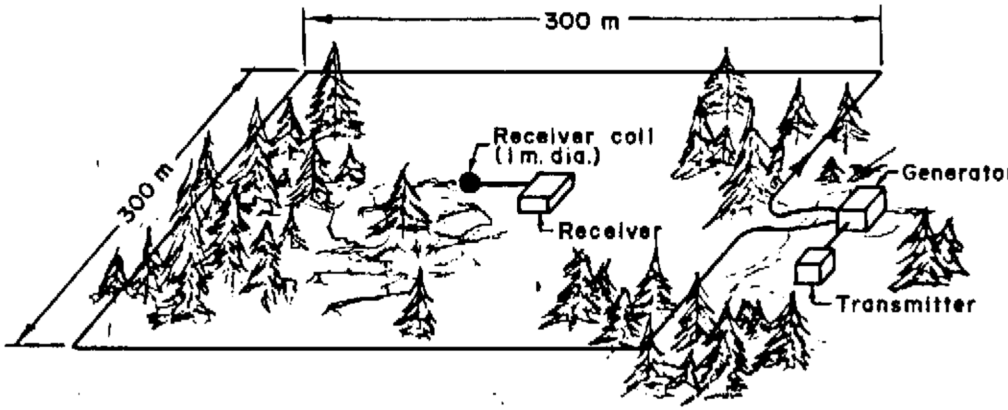
Figure 8



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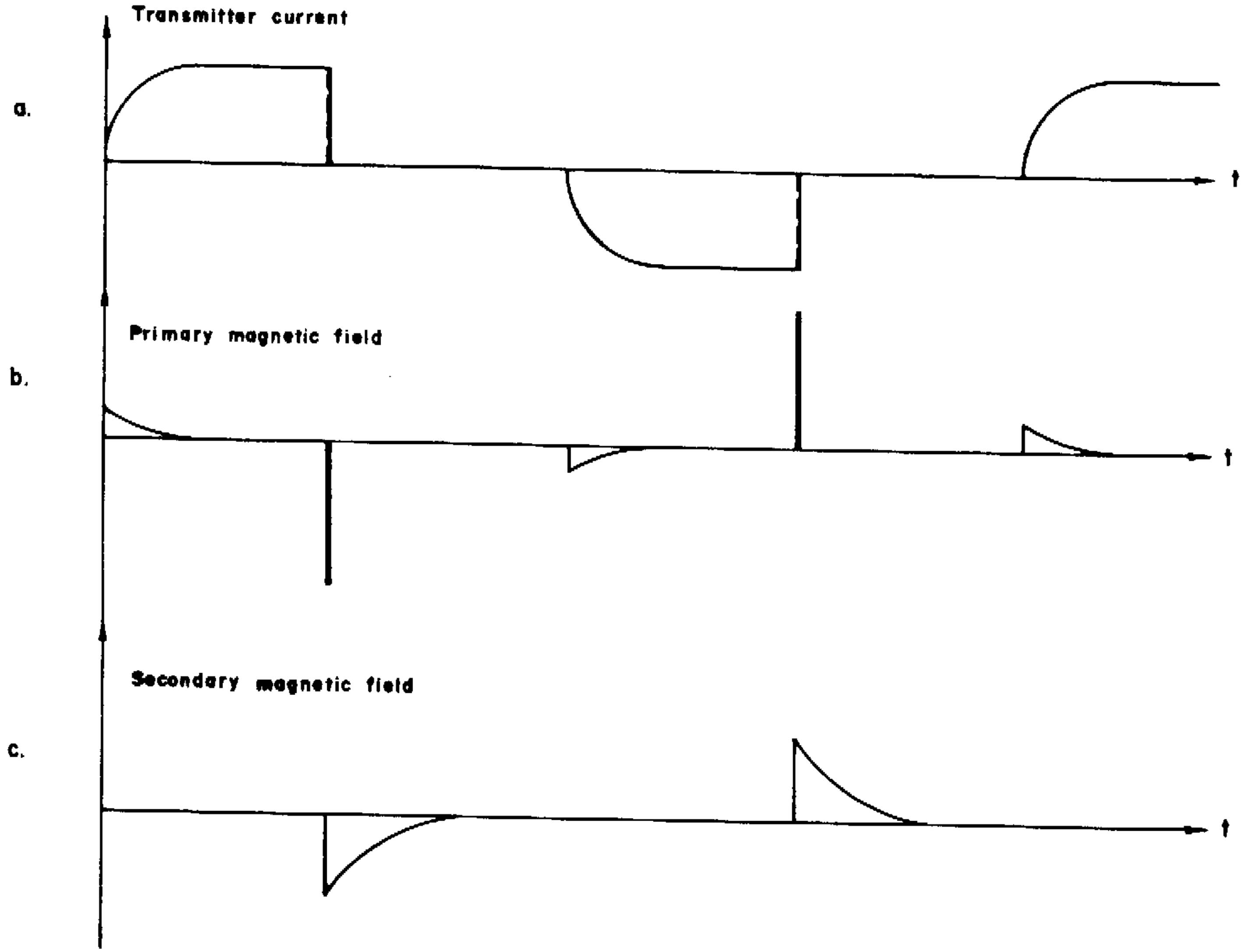
TRANSIENT ELECTROMAGNETIC SOUNDING

81-20

Figure 9



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SYSTEM WAVEFORMS

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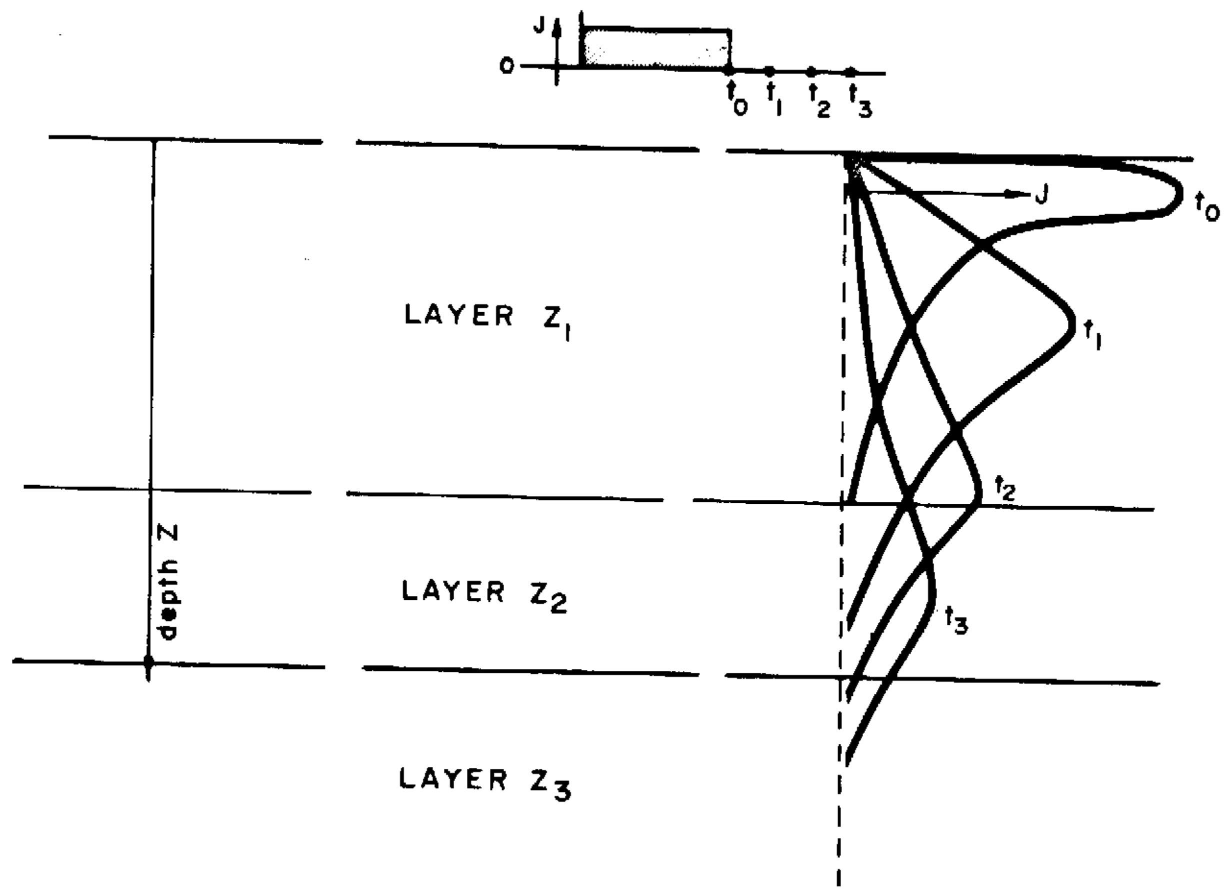
Figure 10



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EDDY CURRENT DISTRIBUTION AS A FUNCTION OF TIME

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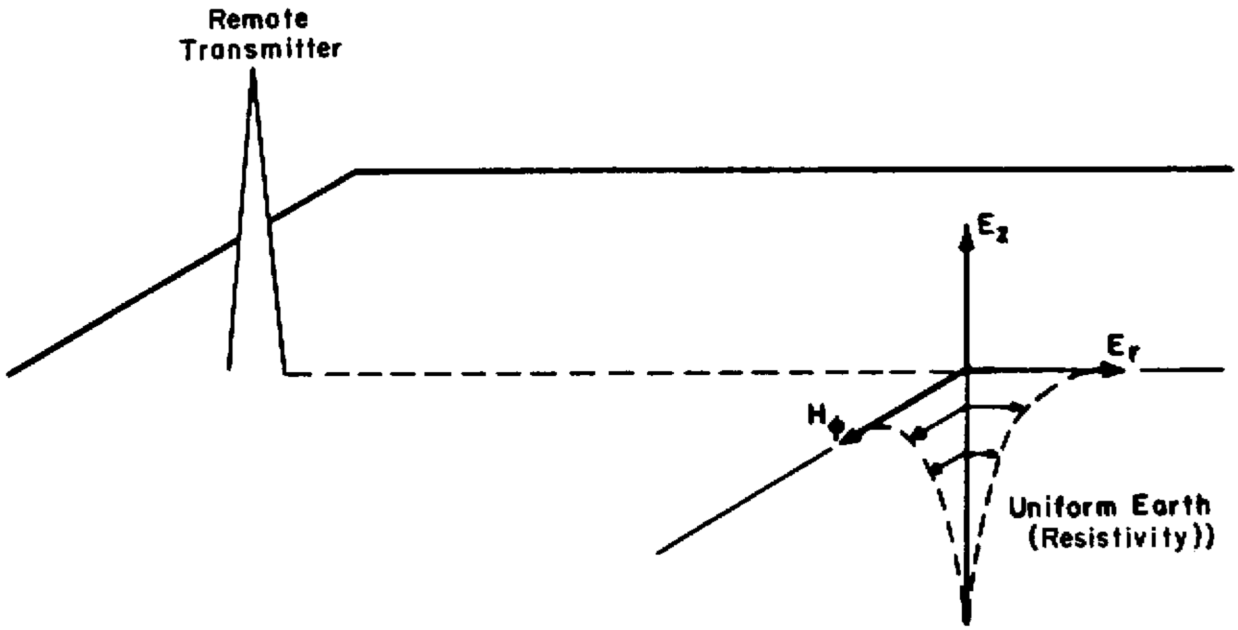
Figure 11



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ELECTROMAGNETIC FIELD
VECTORS OF A VERTICALLY
POLARIZED RADIO GROUNDWAVE

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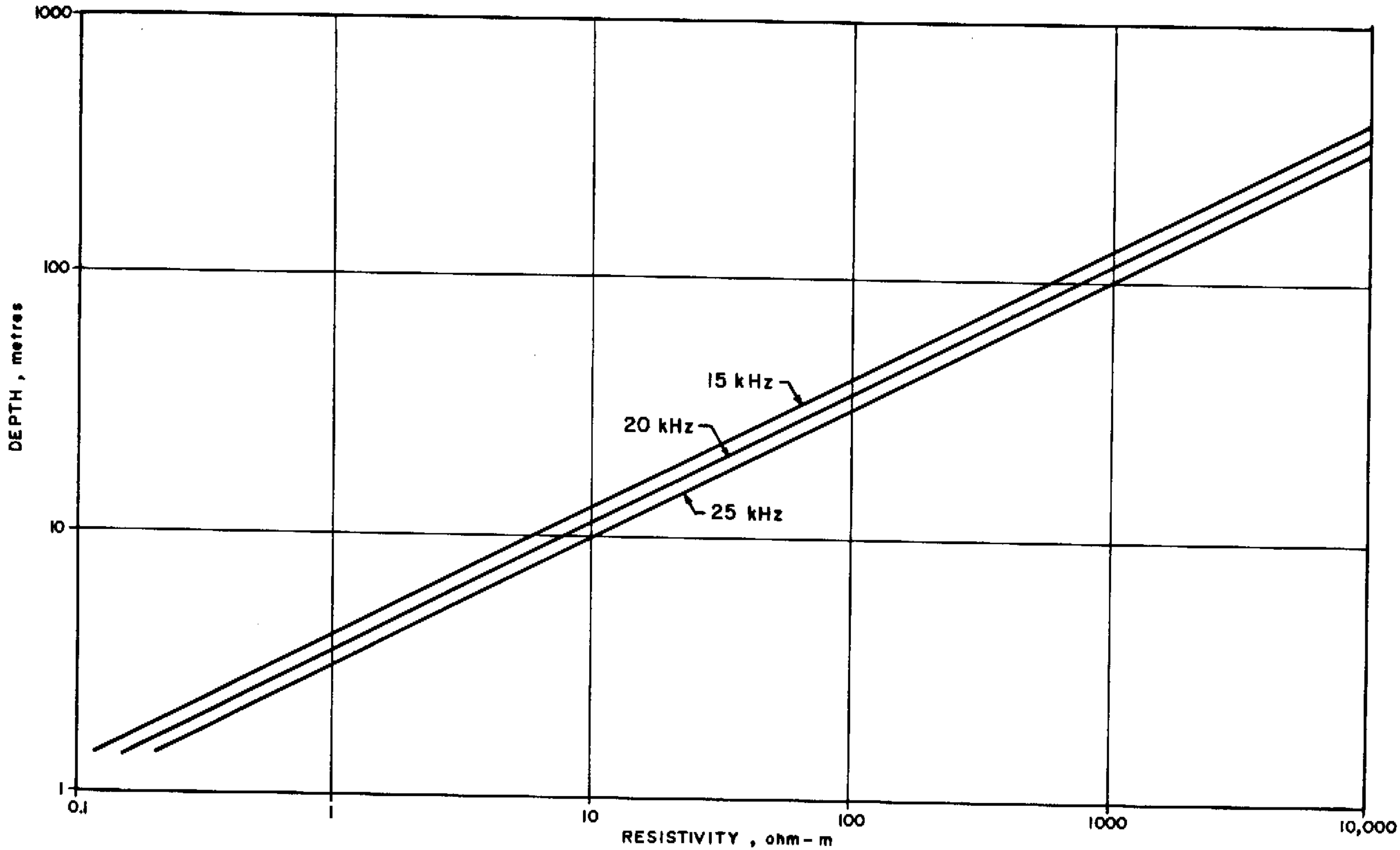
Figure 12



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SKIN DEPTH OF VLF
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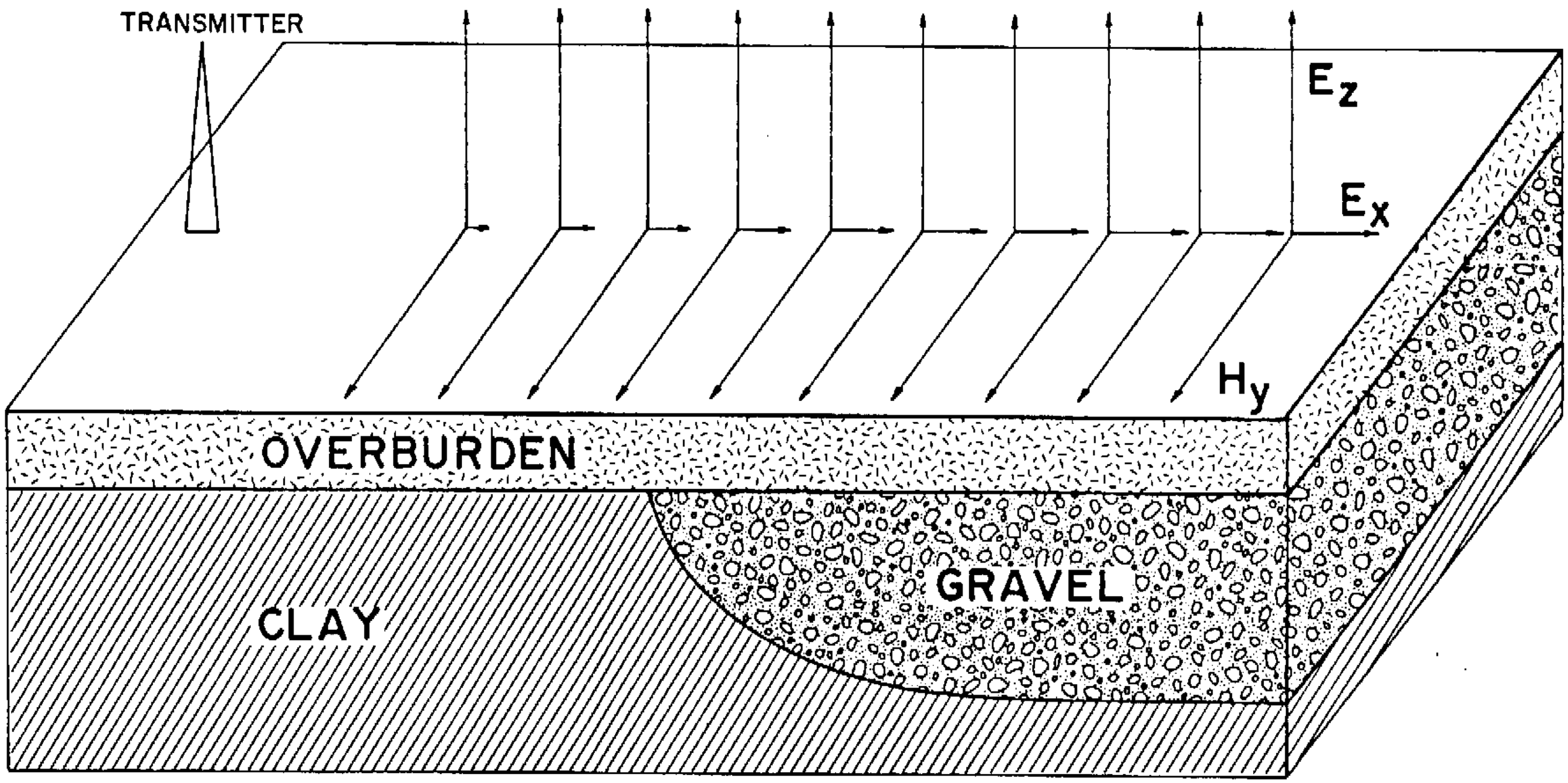
Figure 13



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FIELD VECTORS OF
VLF RADIO GROUNDWAVE

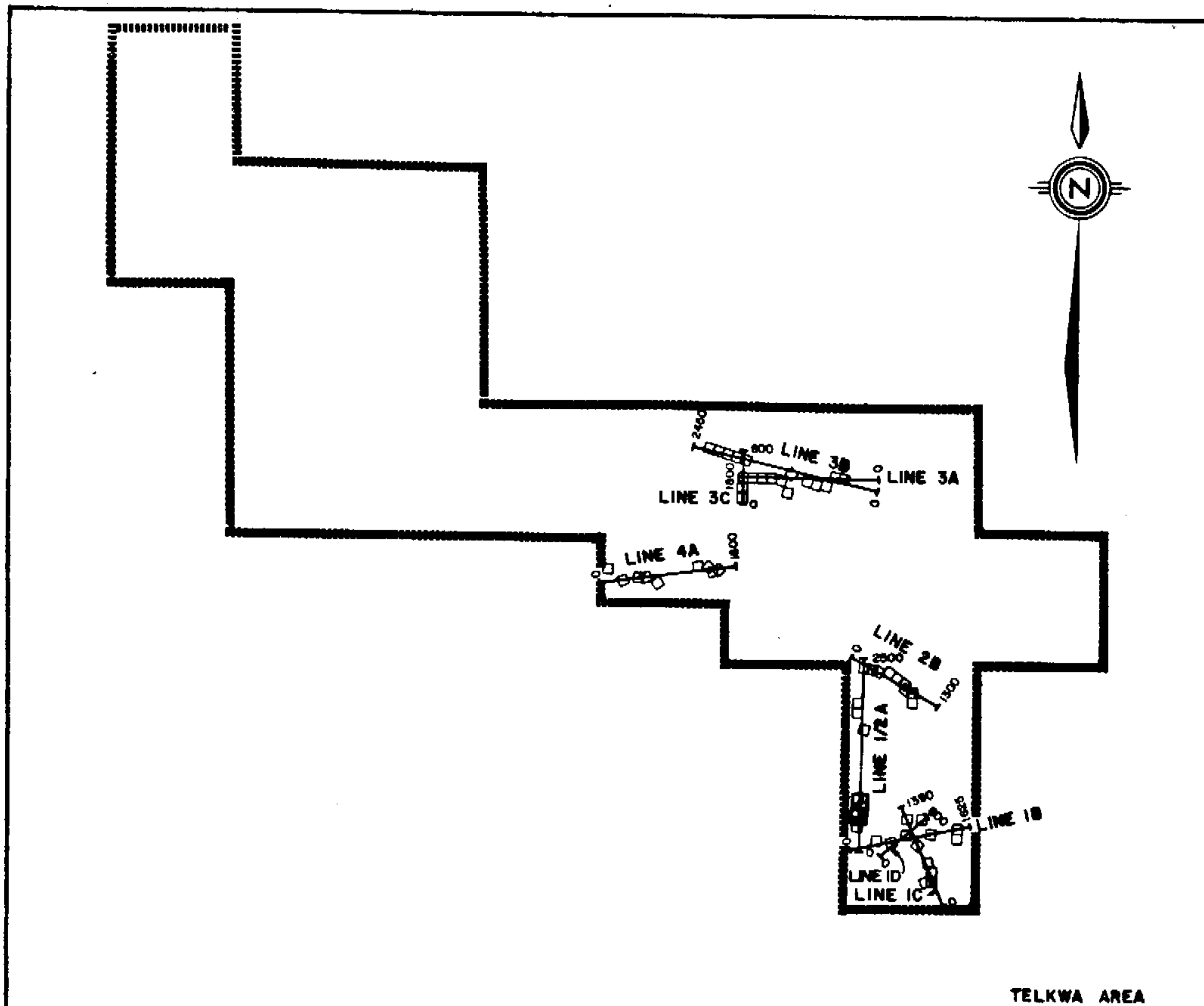
81-20

Figure 14

3.0 RESULTS

3.1 General - Location Maps

Geophysical measurements were made in the Telkwa and Thautil River areas. The location of the geophysical measurements are shown on Figure 15 for the Telkwa area and in Figure 16 for the Thautil River area. To present the data, cross-sections were made through the measurement points. The location and numbering of these cross-sections on the Telkwa area are shown on Figure 17.



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EM 37 - LINE LOCATION MAP
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81 - 20 Figure 17

3.2 De Hoog Property

The interpreted geologic cross-sections along Line 1A, 1B, 1C [illegible] are given on [illegible] 25, 26 and 27. Typical sounding data superimposed [illegible] master curves are shown for Stations 1-2, 1-6, 1-7, [illegible] 1-1[illegible] in Figures 25 through 26. [illegible] of the data [illegible] [illegible]te [illegible] layer model, a surface layer [illegible] of 3[illegible] ohm-m, an intermediate layer of about [illegible] ohm-m and [illegible] crystalline basement of high resistivity.

[illegible] computed was the average longitudinal resistivity of the [illegible] above the crystalline basement. The longitudinal [illegible] was computed from the relation:

ρ|c

$$\rho_L = \frac{H}{\frac{H_1}{\rho_1} + \frac{H_2}{\rho_2}}$$

where ρ_L is average longitudinal conductance above basement

H_1, H_2 thickness layer 1 and layer 2, respectively

H total thickness to basement

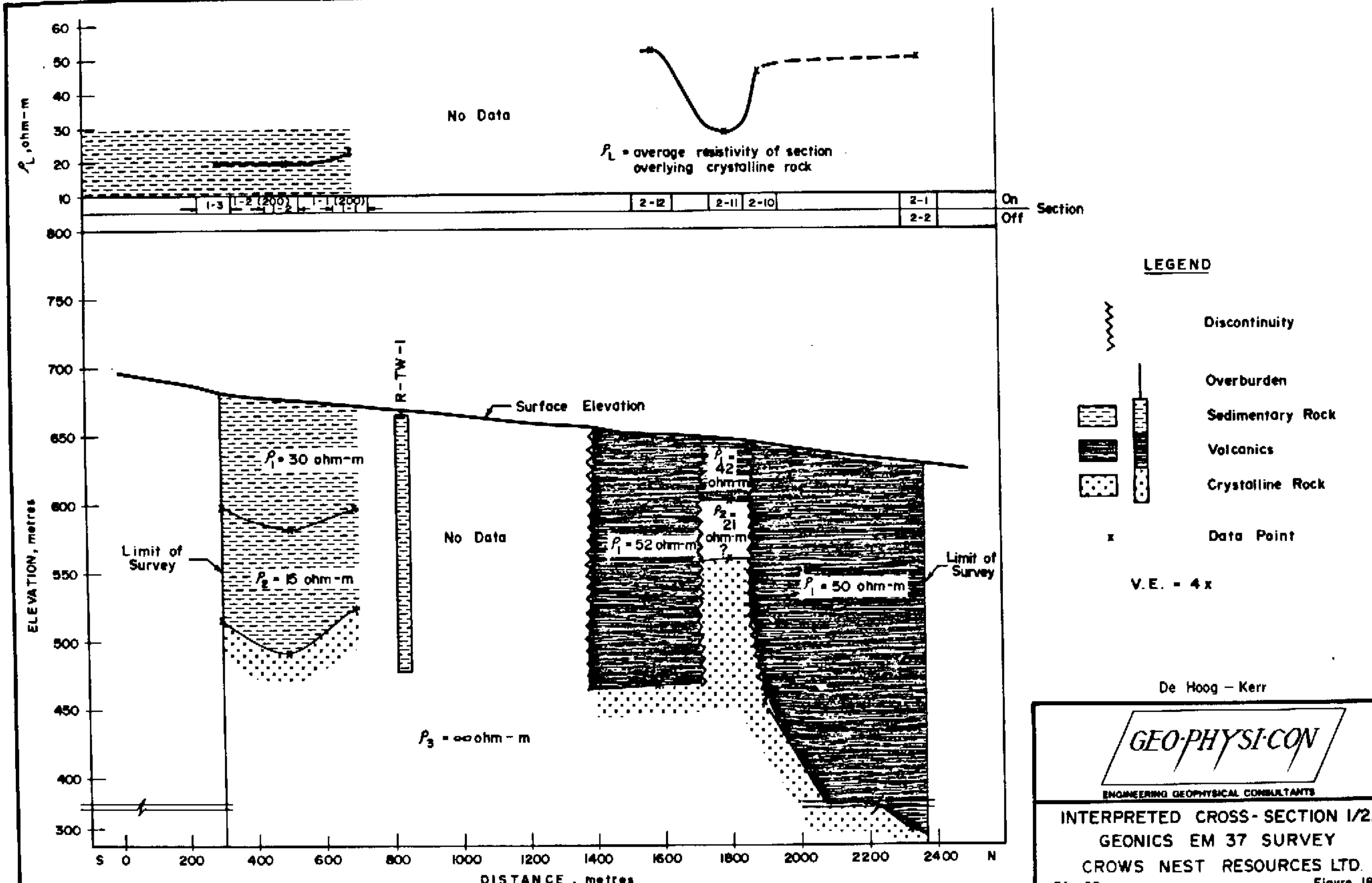
The data along sections 1A, B, C and D show ρ_L to be relatively uniform at a value of 20 ohm-m $\pm$ 3 ohm-m. This value in the Telkwa area was found to be characteristic of sedimentary sections. The deepest sections of sedimentary rock interpreted was at station 1-15, where a thickness of 270 metres was interpreted. Borehole R-TW-3 is located near Station 1-15 on cross-section 1C.

Figures 27 and 28 show the conductivity profiles measured with the EM34-3 (40m) and the ratio of the apparent conductivity measured with the EM34-3 at 40m and 20m (with horizontal dipoles). The ratio is greater than 1.0, which indicates that there is a more resistive surface layer. The more resistive surface layer is expected to be a till layer (drift). Since the ratio does not exceed 1.2, the thickness of till is expected to be less than 5 metres thick over De Hoog property.

On Figure 27, VLF readings are also shown. The apparent VLF conductivity gives a very noisy profile but particularly from Station 1800m on, the base value measured at VLF is in good agreement with the EM34-3 (40m) reading. The phase value is generally between 40 and 50 degrees. After the VLF measurements on the De Hog property, it was decided that VLF readings do not contribute additional information and further VLF readings were discontinued.

The apparent conductivity measured with the EM34-3 (40m) will mainly reflect the conductivity of the first 30 metres of the sedimentary rock. The conductivity for the first 30 metres derived from the transient soundings is about 28 milihmos/m (1/35), generally in good correspondence with the EM34-3 (40m) data. The EM34-3 (40m) along these profiles (1B, C and D) are directly useful in indicating that i) no boundary of rock type is expected and ii) that the overburden is relatively thin.

The cross-section 1-2A in Figure 18 runs from De Hoog into Kerr property; no data was obtained between De Hoog and Kerr property. This cross-section shows a factor 2 change in ρ_L from De Hoog to Kerr. The value of about 50 ohm-m for ρ_L is expected to represent volcanic rock. Section 2A is further discussed under the results at Kerr. It is evident from Figure 18 that the boundary between volcanic and sedimentary rock occurs between Station 800m and 1400m along cross-section 1/2A.



De Hoog – Kerr

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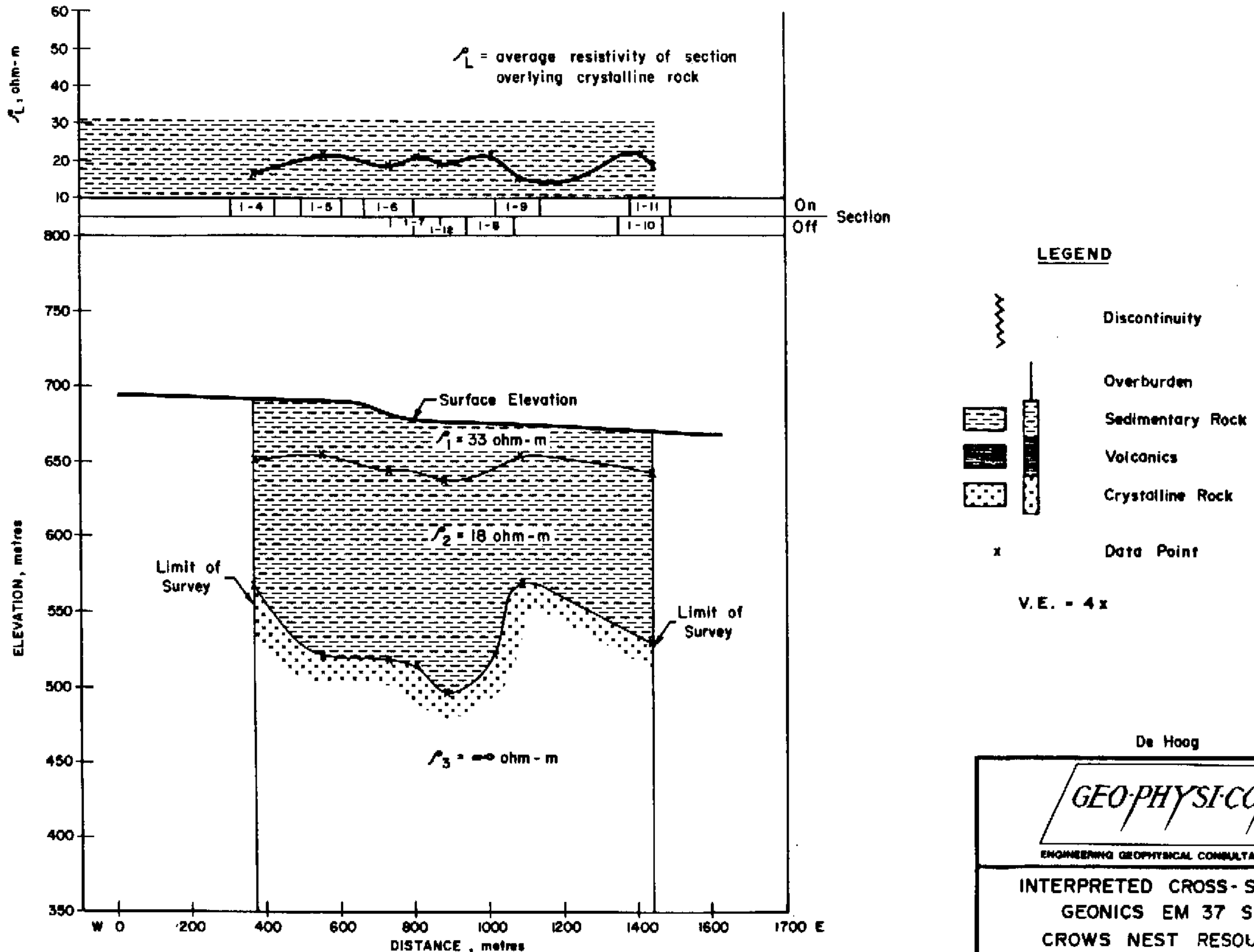
INTERPRETED CROSS-SECTION 1/2A
GEONICS EM 37 SURVEY
CROWS NEST RESOURCES LTD.

81 - 20

Figure 18



De Hoog

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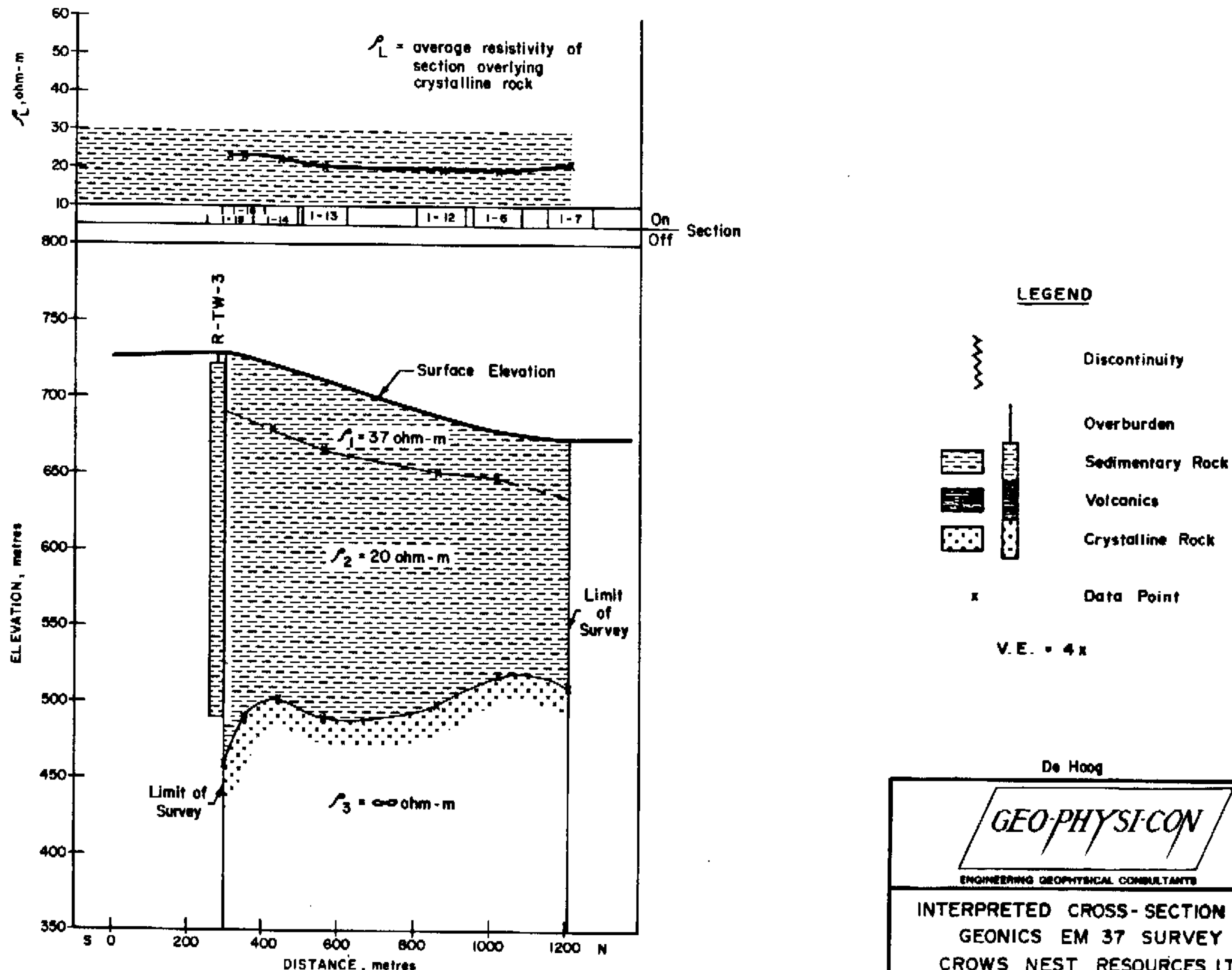
INTERPRETED CROSS-SECTION IB
GEONICS EM 37 SURVEY
CROWS NEST RESOURCES LTD.

81 - 20

Figure 19



De Haag

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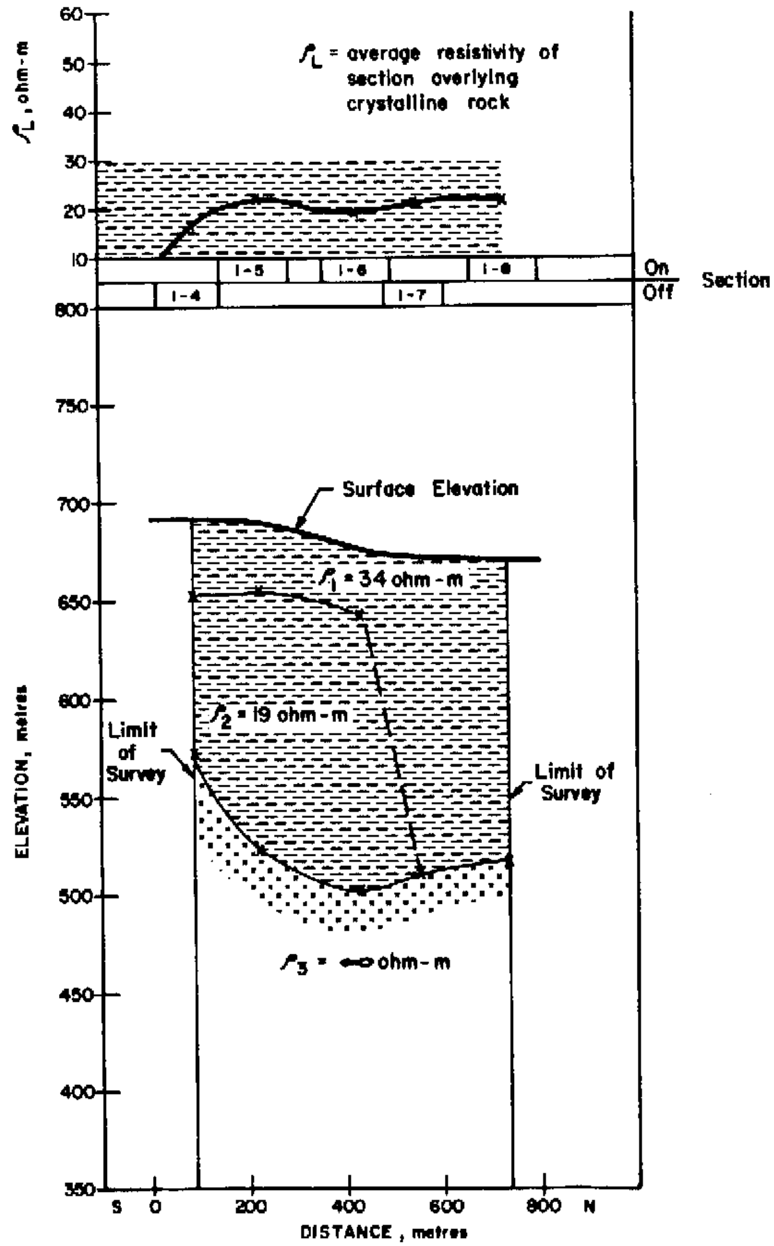
INTERPRETED CROSS-SECTION IC
GEONICS EM 37 SURVEY
CROWS NEST RESOURCES LTD.

81 - 20 Figure 20



LEGEND

Discontinuity

Overburden

Sedimentary Rock

Volcanics

Crystalline Rock

Data Point

V.E. = 4 x

De Hoog

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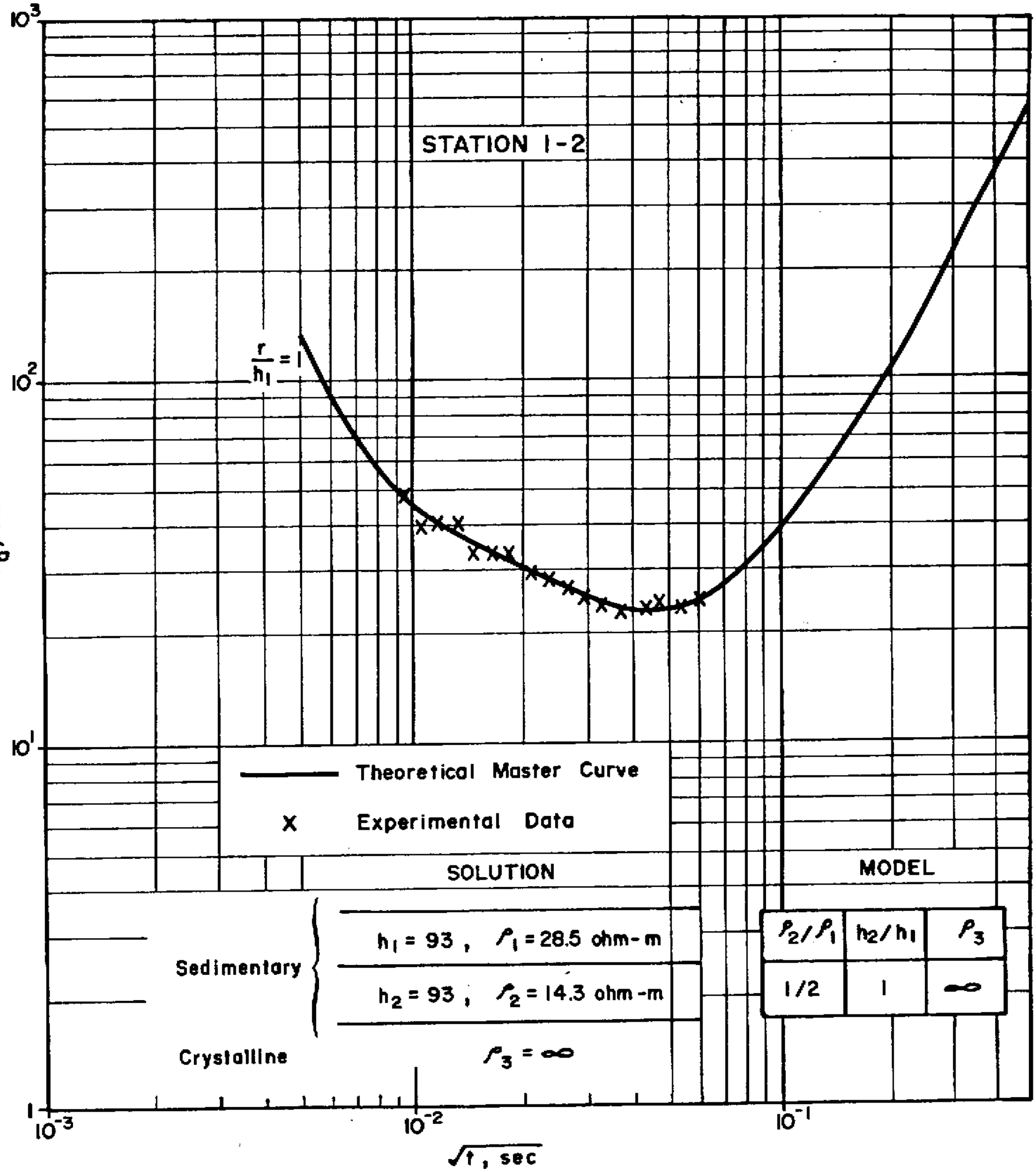
INTERPRETED CROSS-SECTION ID
GEONICS EM 37 SURVEY
CROWS NEST RESOURCES LTD.

81-20

Figure 21



ρ_2 / ρ_1	h_2 / h_1	ρ_3
1/2	1	∞

De Hoog

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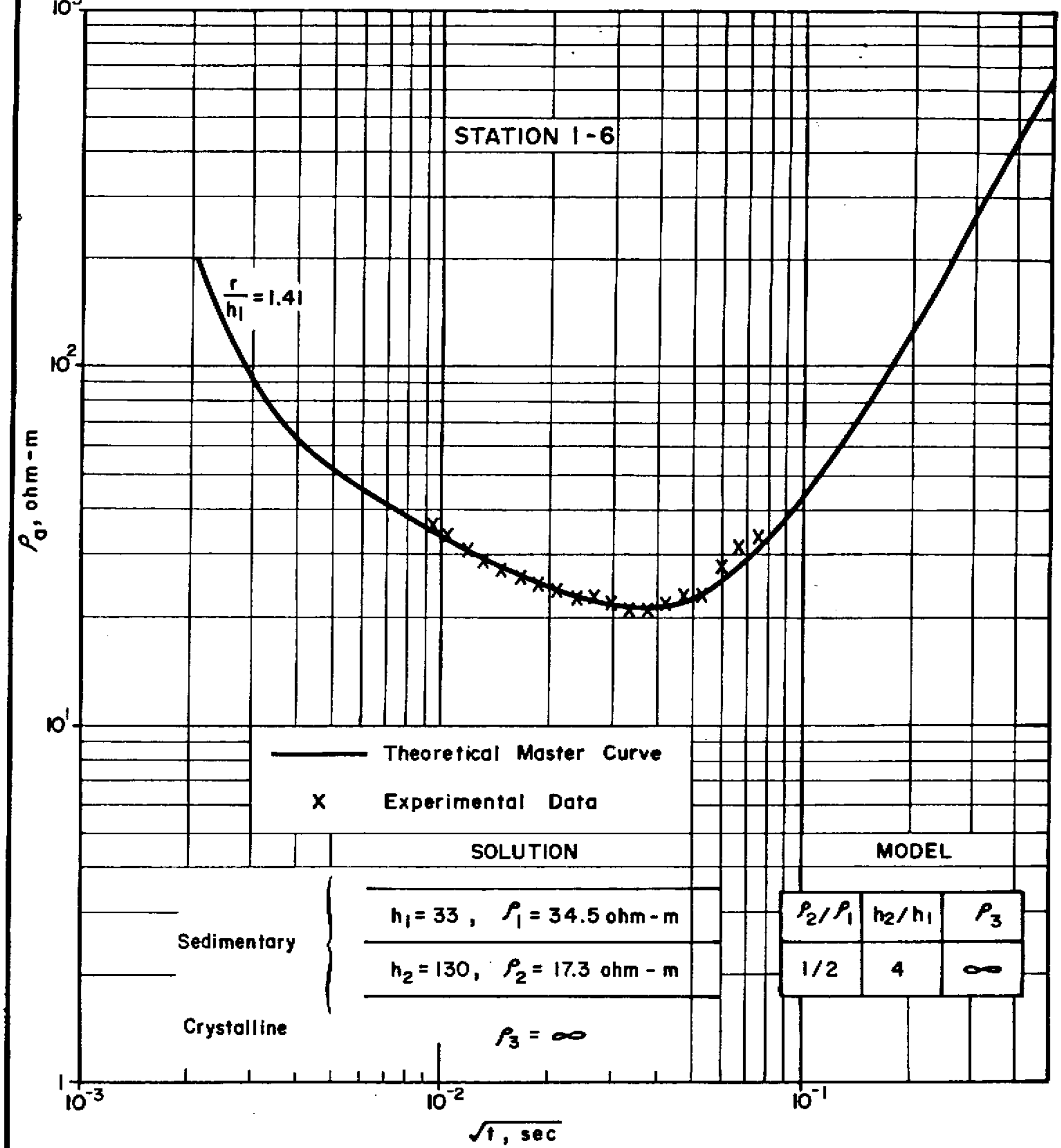
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs $\sqrt{\text{time}}$

81 - 20

Figure 22



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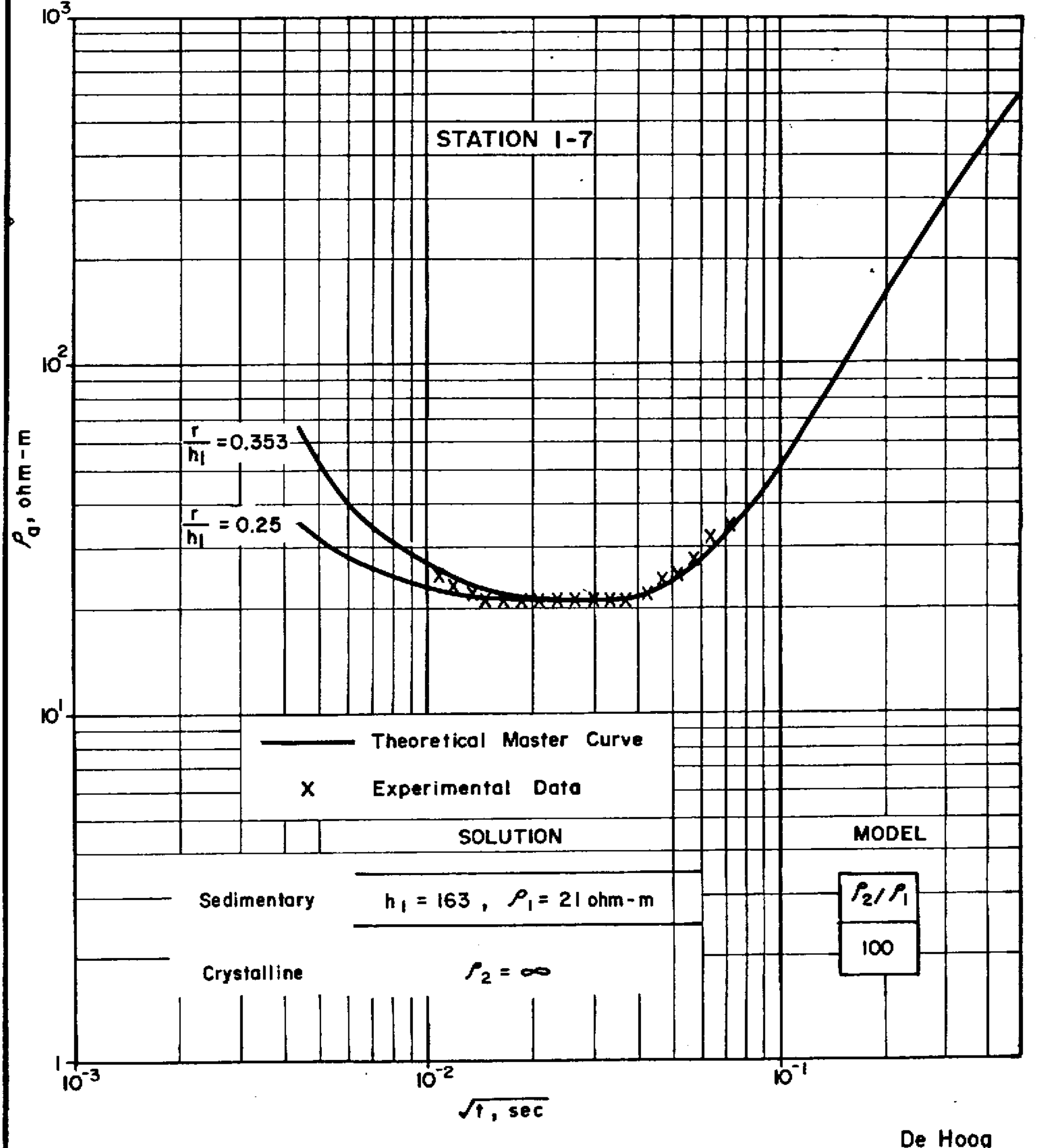
CROWS NEST RESOURCES LTD.

APPARENT RESISTIVITY vs $\sqrt{\text{time}}$

81 - 20

Figure 23



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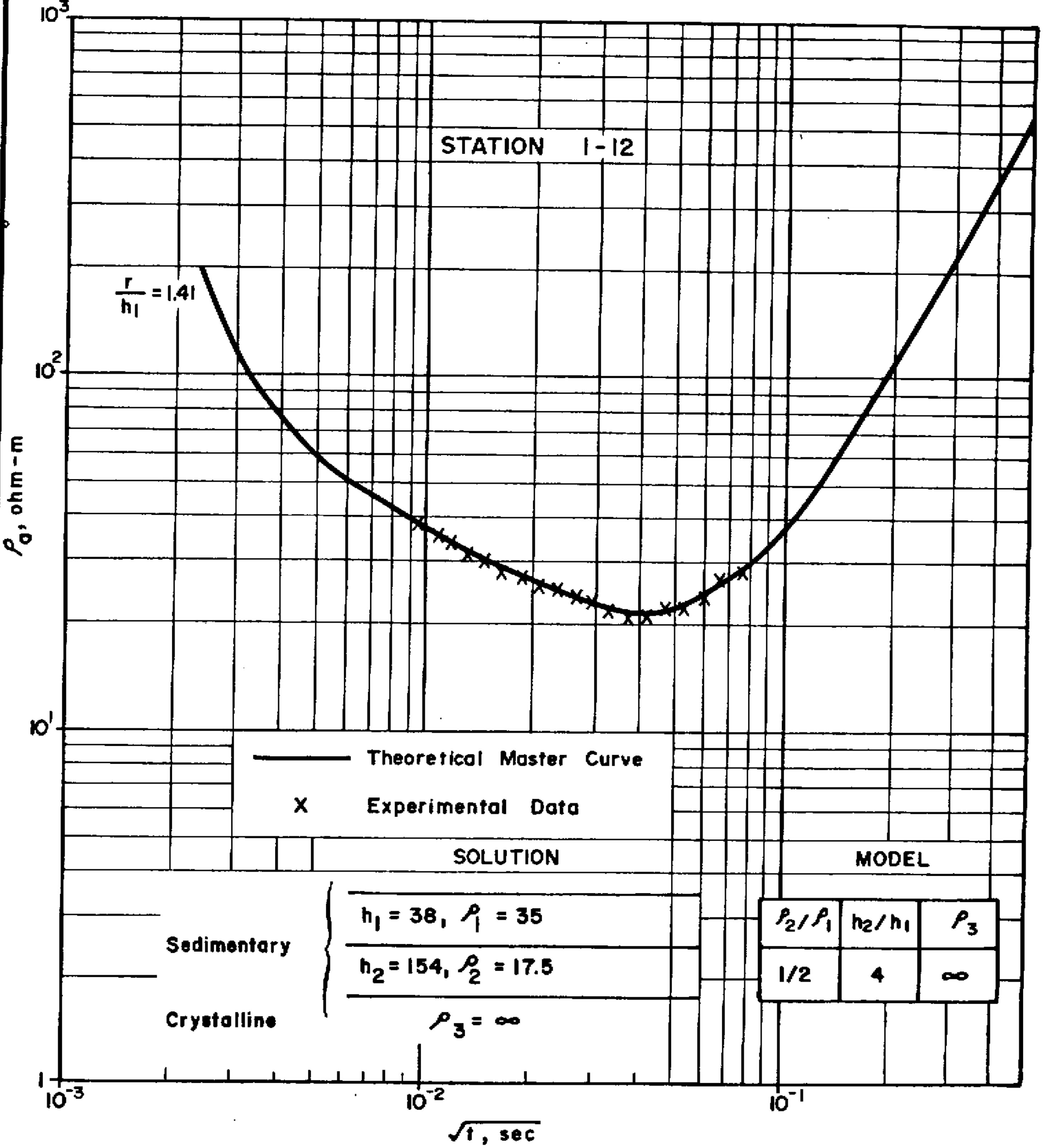
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs $\sqrt{time}$

81 - 20

Figure 24



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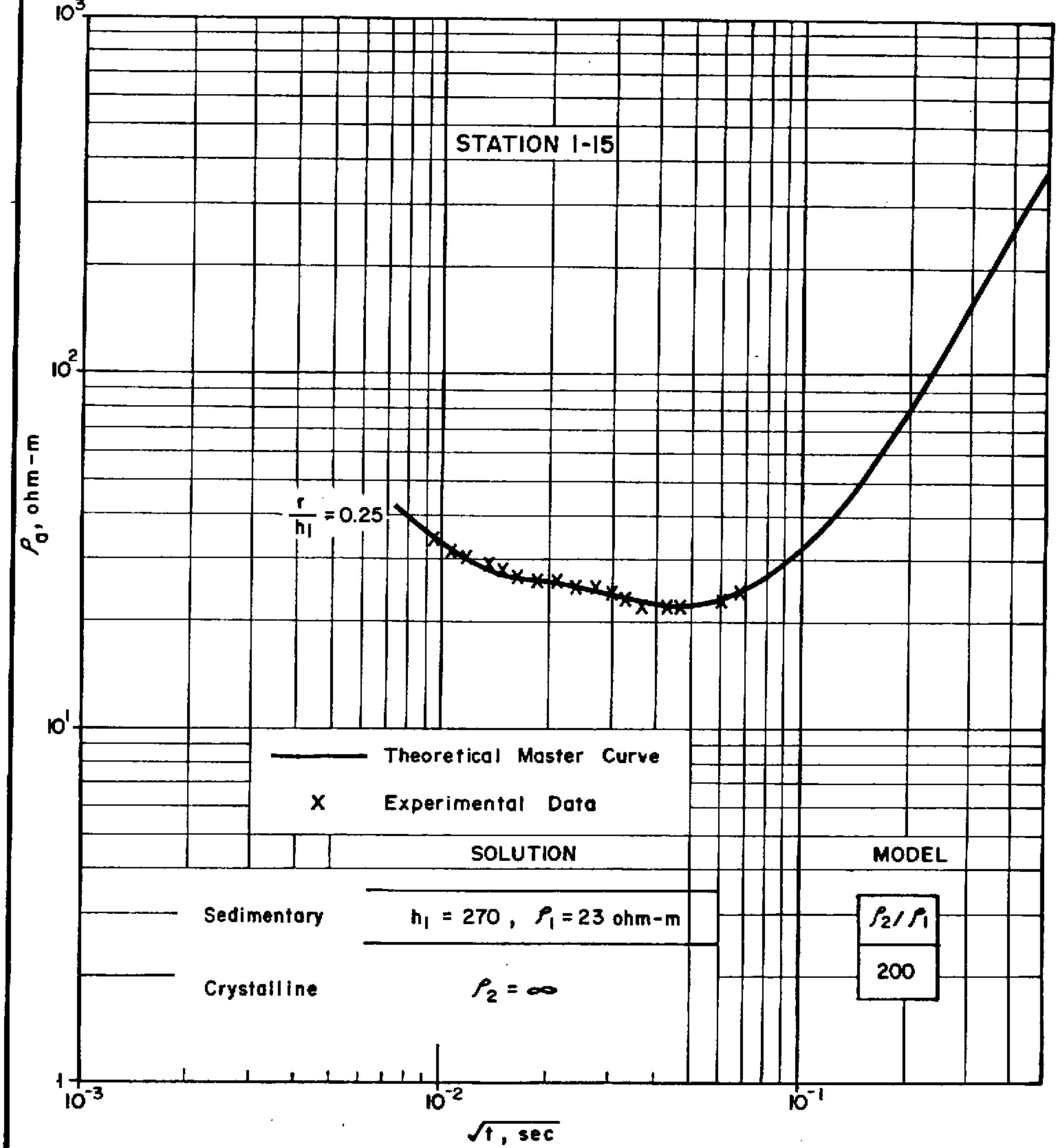
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs
$\sqrt{\text{time}}$

81 - 20

Figure 25



De Hoog

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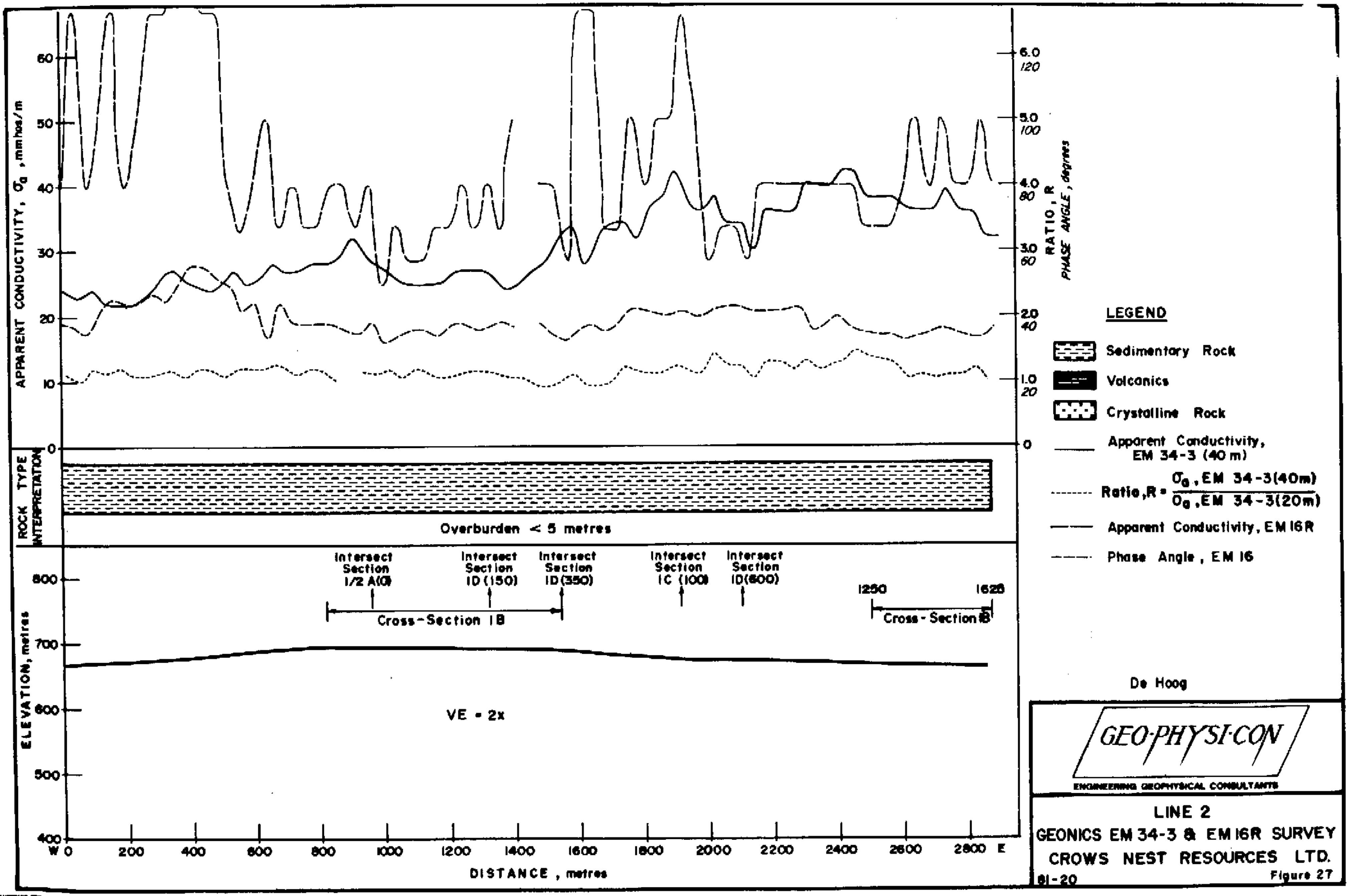
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs $\sqrt{\text{time}}$

81 - 20

Figure 26


APPARENT CONDUCTIVITY, σ_a, mmhos/m
RATIO, R
PHASE ANGLE, degrees
LEGEND
Sedimentary Rock
Volcanics
Crystalline Rock
Apparent Conductivity, EM 34-3 (40 m)
Ratio, R = σ_a, EM 34-3(40m) / σ_a, EM 34-3(20m)
Apparent Conductivity, EM 16R
Phase Angle, EM 16
ROCK TYPE INTERPRETATION
Overburden < 5 metres
Intersect Section 1/2 A(0)
Intersect Section 1D (150)
Intersect Section 1D (350)
Intersect Section 1C (100)
Intersect Section 1D(600)
Cross-Section 1B
1250
1626
Cross-Section 1B
ELEVATION, metres
VE = 2x
DISTANCE, metres
W
E
De Hoog
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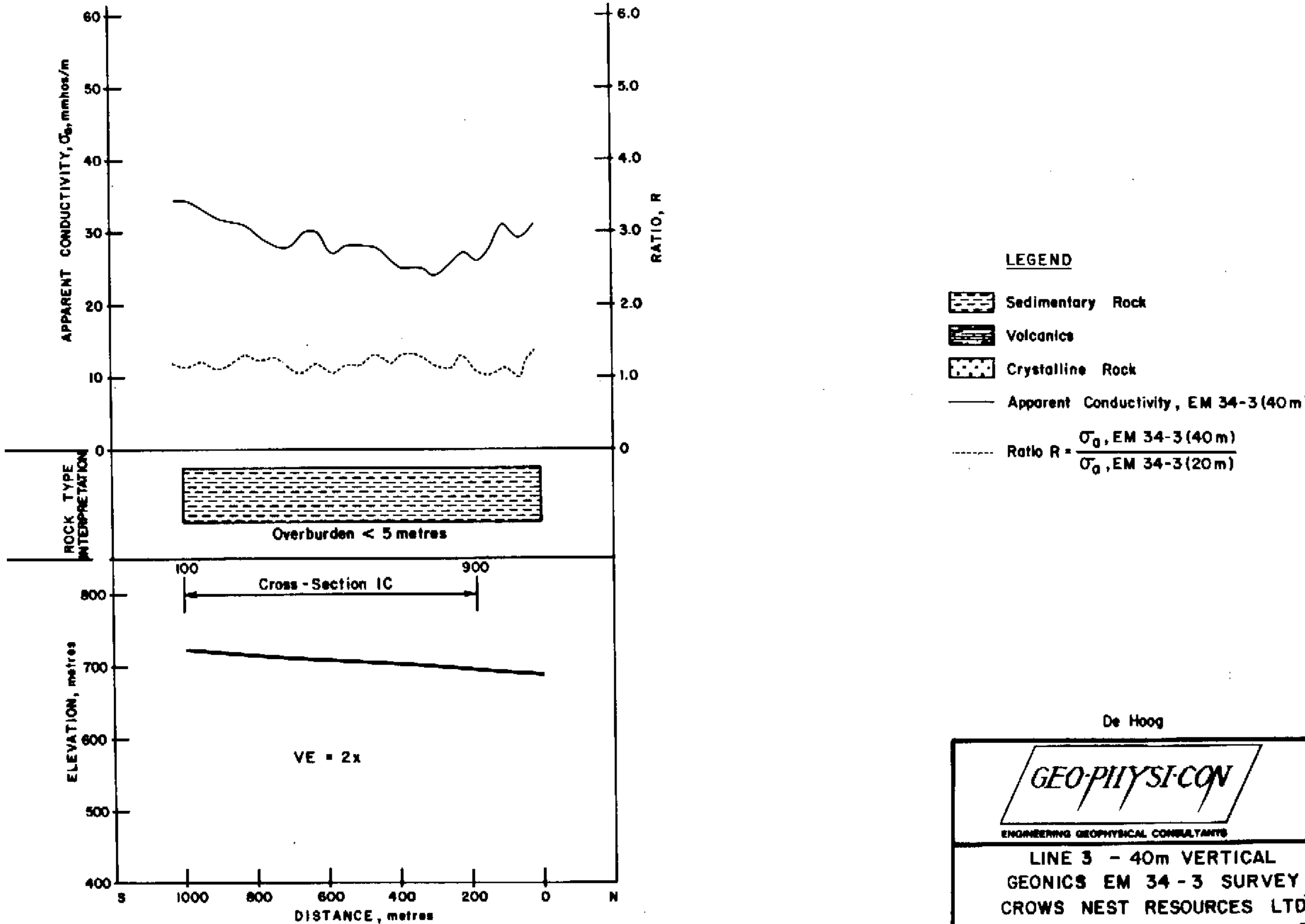
LINE 2
GEONICS EM 34-3 & EM16R SURVEY
CROWS NEST RESOURCES LTD.
81-20
Figure 27



De Hoog

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LINE 3 - 40m VERTICAL
GEONICS EM 34-3 SURVEY
CROWS NEST RESOURCES LTD.

81-20

Figure 28

3.3 Kerr Property

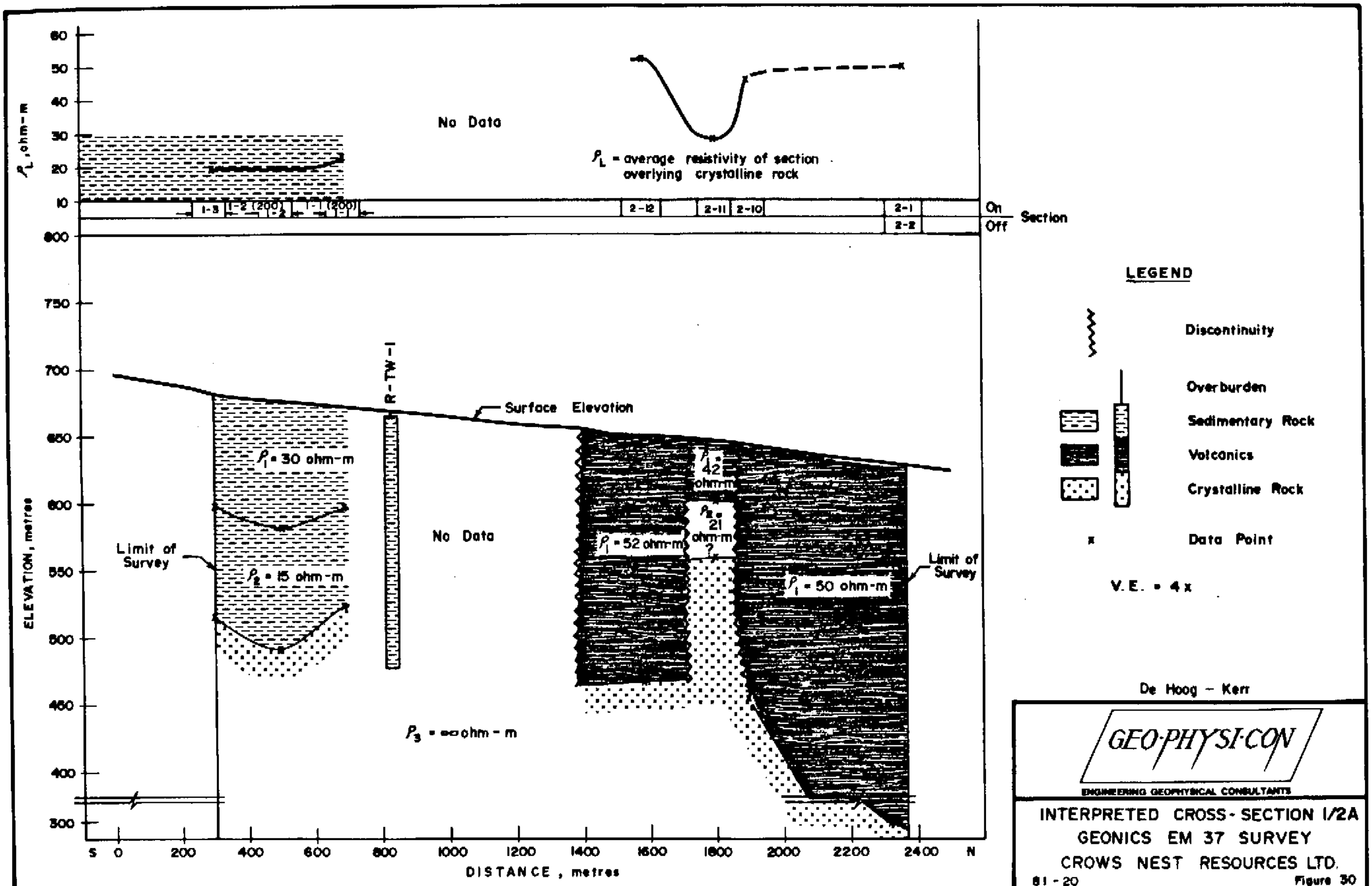
The results along cross-section 2A and 2B are given in Figure 30 and 31. Typical sounding data along these cross-sections are given in Figures 32 through 36. The data along cross-section 2A and 2B show:

i) a value for ρ_L in excess of 30 ohm-m, for most points ρ_L is in excess of 40 ohm-m. Values above 30 ohm-m are believed to be indicative of volcanic rock. At Station 2-11 (Figure 35) a conductive layer (21 ohm-m) was observed at depth. Although this could be a sedimentary section, it probably is conductive volcanic rock. In several of the borehole resistivity logs conductive volcanic rock was observed.

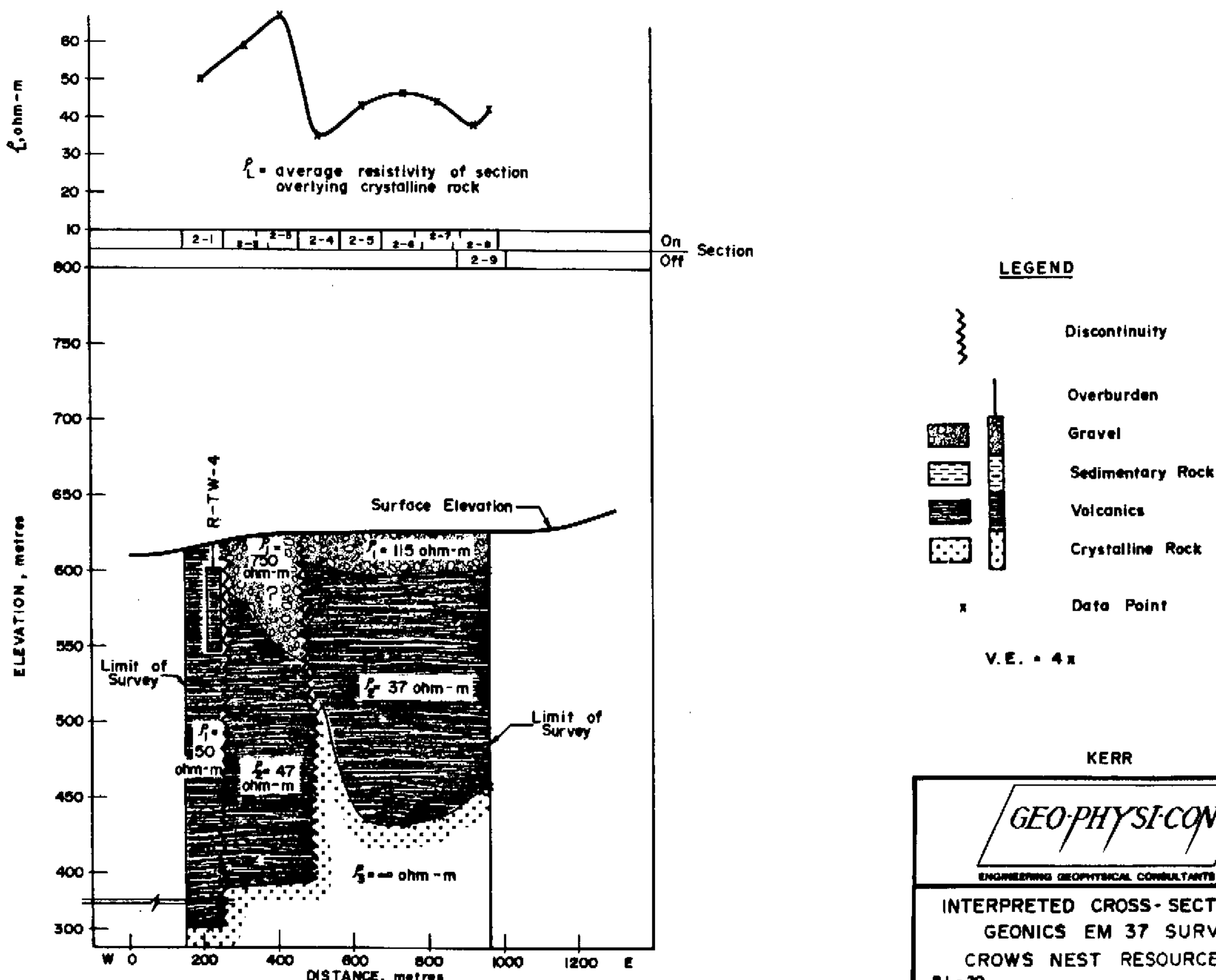
ii) the cross-section through the volcanic rock shows several discontinuities in the electric resistivity profiles, which have been interpreted as faults.

iii) along cross-section 2B resistive surface layers are encountered. Without test holes it is not possible to determine the nature of this layer. It could be gravel or volcanic rock.

Figure 37 shows the conductivity profile with the EM34-3 (40m) along cross-section 2B. The apparent conductivities along the profile are less than 20 mmhos/metre (>50 ohm-m). This further indicates the presence of volcanic rock; over sedimentary rock the EM34-3 (40m) values are higher than 30 mmhos/metre. The ratio of the values with the EM34-3 (40m) and the EM34-3 (20m) oscillates around 1.0. In this case, the ratio is probably not indicative of overburden thickness because major changes in the conductivity of rock are anticipated. Figure 38 shows the EM34-3 (40m) apparent conductivity profile along section 2A. This profile also shows the conductive plug between Stations 1600 and 2000.



No Data
ρ_L = average resistivity of section overlying crystalline rock
ρ_L, ohm-m
1-3
1-2 (200)
1-1 (200)
2-12
2-11
2-10
2-1
2-2
On
Off
Section
LEGEND
Discontinuity
Overburden
Sedimentary Rock
Volcanics
Crystalline Rock
Data Point
V.E. = 4 x
R-TW-1
Surface Elevation
ρ_1 = 30 ohm-m
ρ_2 = 15 ohm-m
No Data
Limit of Survey
ρ_1 = 42 ohm-m
ρ_2 = 21 ohm-m
ρ_1 = 52 ohm-m
ρ_1 = 50 ohm-m
Limit of Survey
ρ_3 = ∞ ohm-m
ELEVATION, metres
DISTANCE, metres
S
N
De Hoog – Kerr
GEO·PHYSI·CON
ENGINEERING GEOPHYSICAL CONSULTANTS
INTERPRETED CROSS-SECTION 1/2A
GEONICS EM 37 SURVEY
CROWS NEST RESOURCES LTD.
81 - 20
Figure 30



GEO-PHYSI-CON

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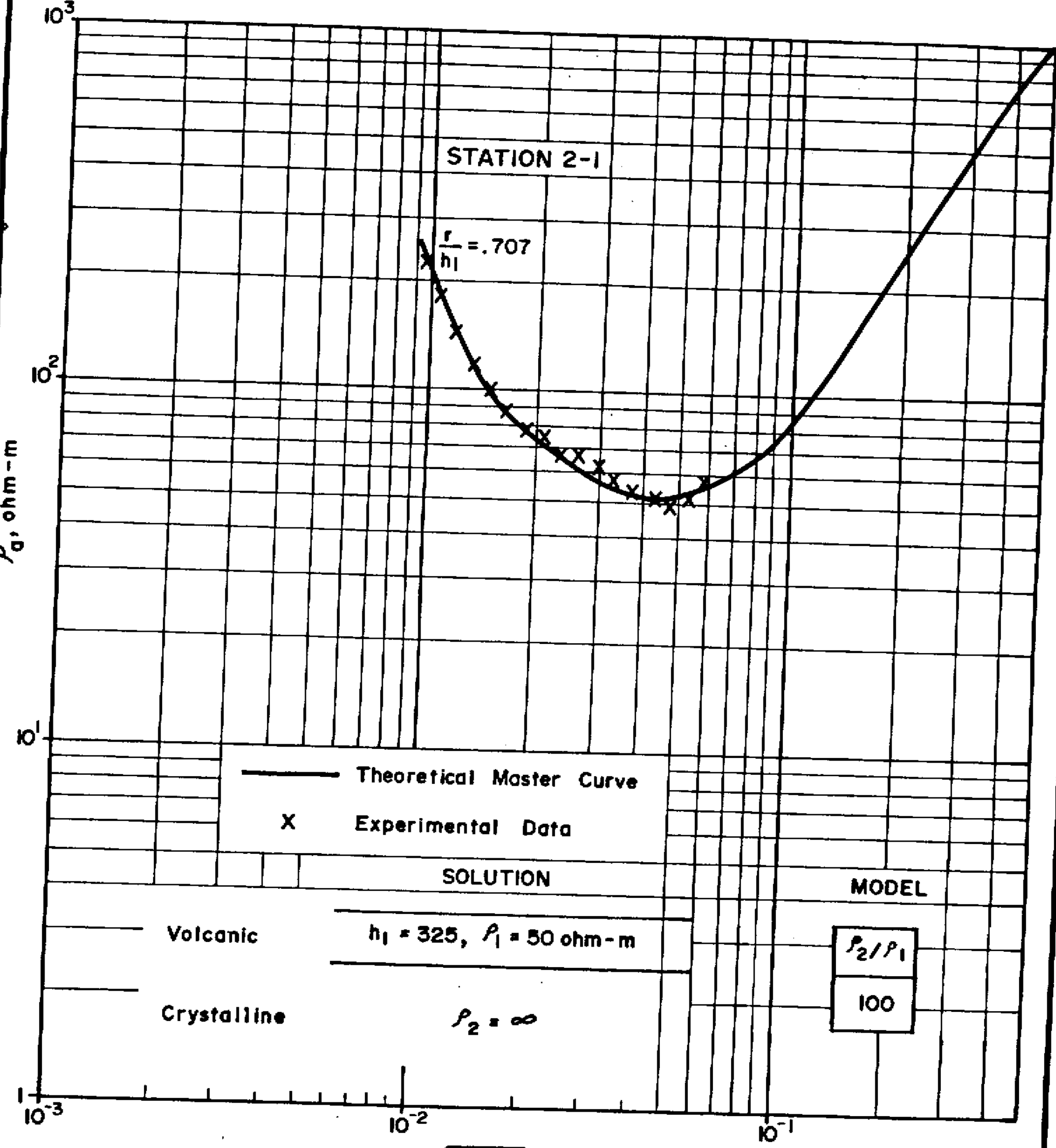
INTERPRETED CROSS-SECTION 2B

GEONICS EM 37 SURVEY

CROWS NEST RESOURCES LTD.

81-20 Figure 31



KERR

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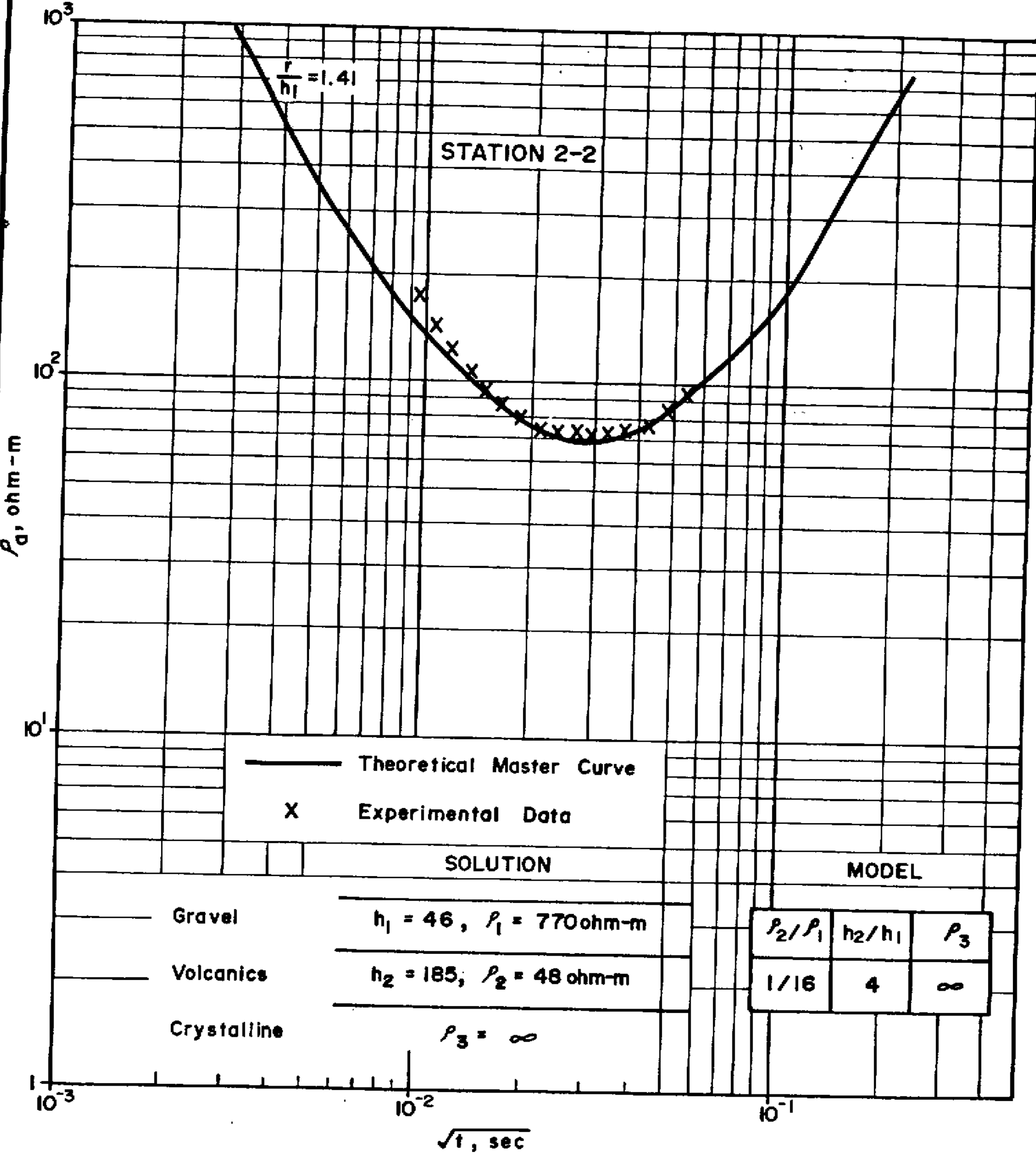
ENGINEERING GEOPHYSICAL CONSULTANTS

CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs
$\sqrt{\text{time}}$

81 - 20

Figure 32



KERR

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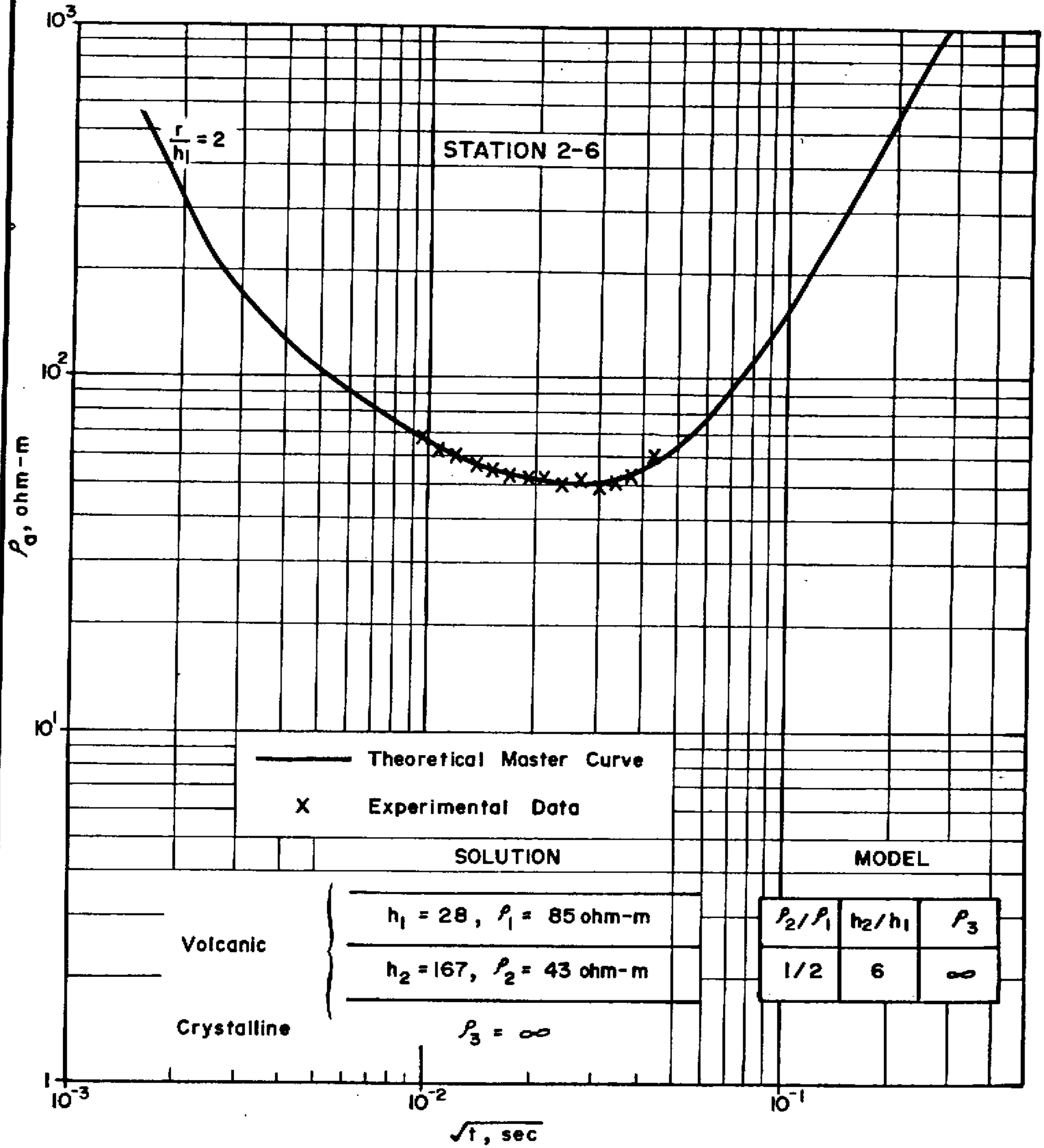
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs
$\sqrt{\text{time}}$

81 - 20

Figure 33



KERR

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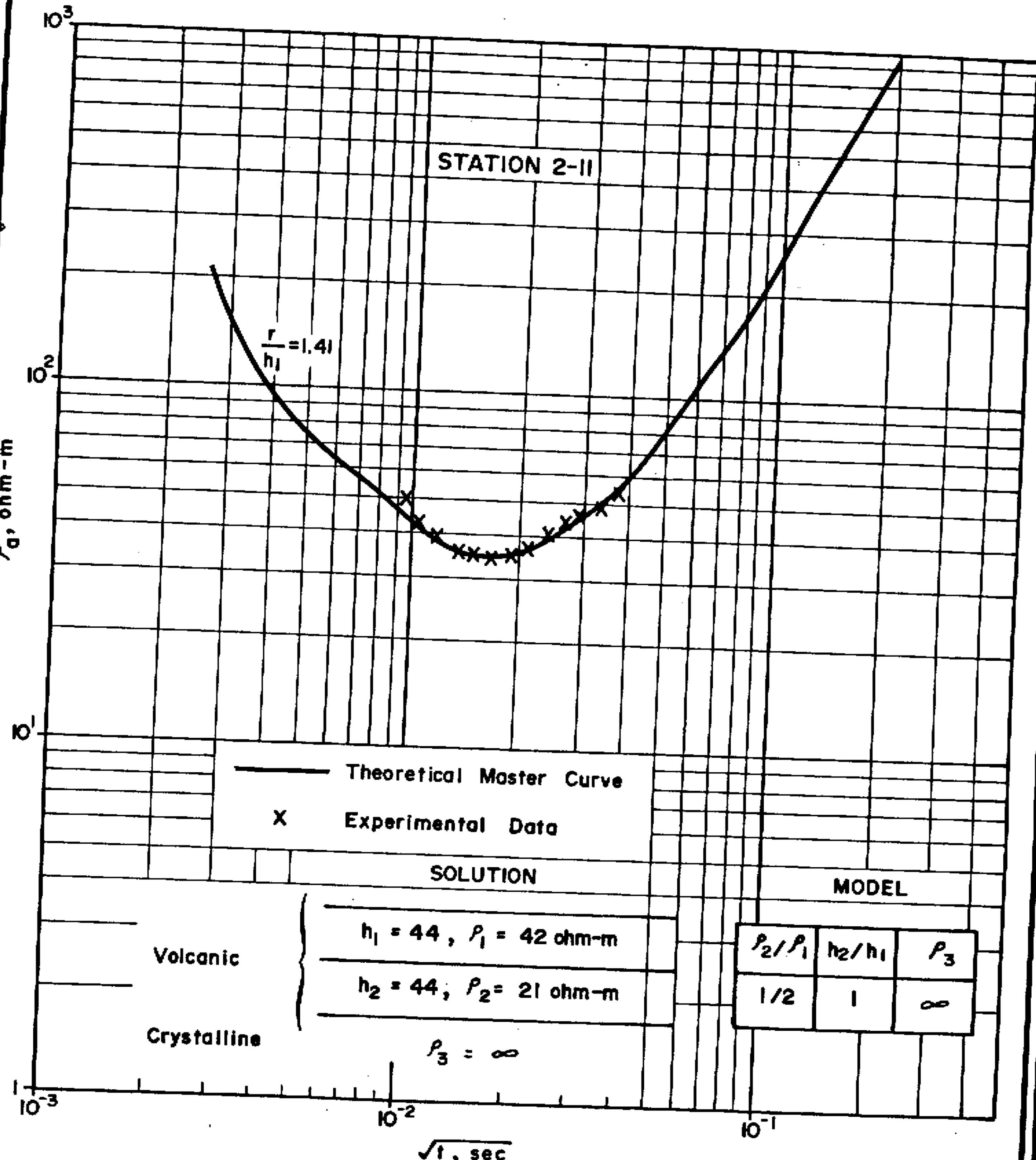
ENGINEERING GEOPHYSICAL CONSULTANTS

CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs $\sqrt{\text{time}}$

81 - 20

Figure 34



KERR

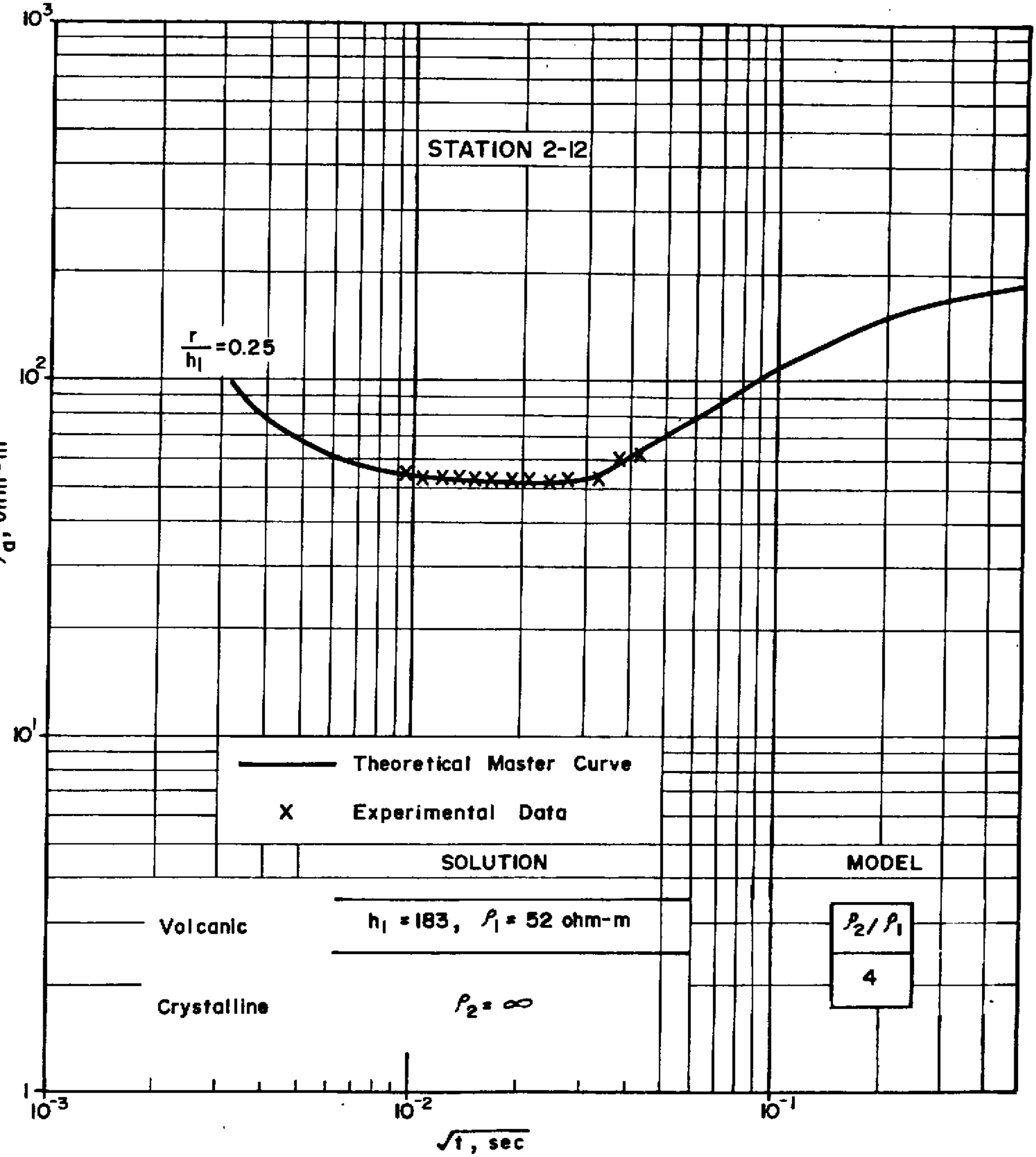
GEO-PHYSI-CON

ENGINEERING GEOPHYSICAL CONSULTANTS

CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs
$\sqrt{\text{time}}$

81 - 20

Figure 35



KERR

GEO-PHYSI-CON

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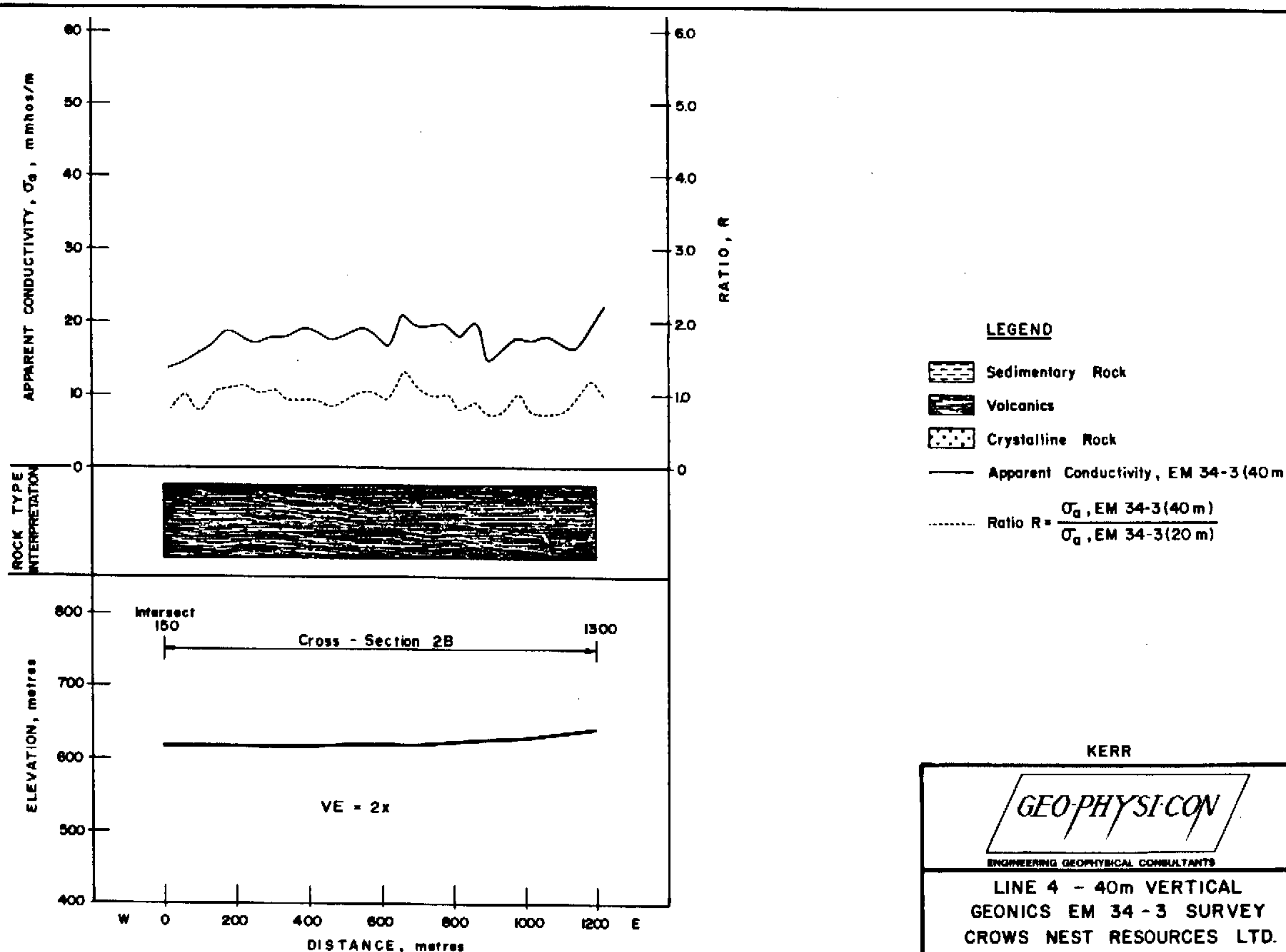
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs $\sqrt{time}$

81 - 20

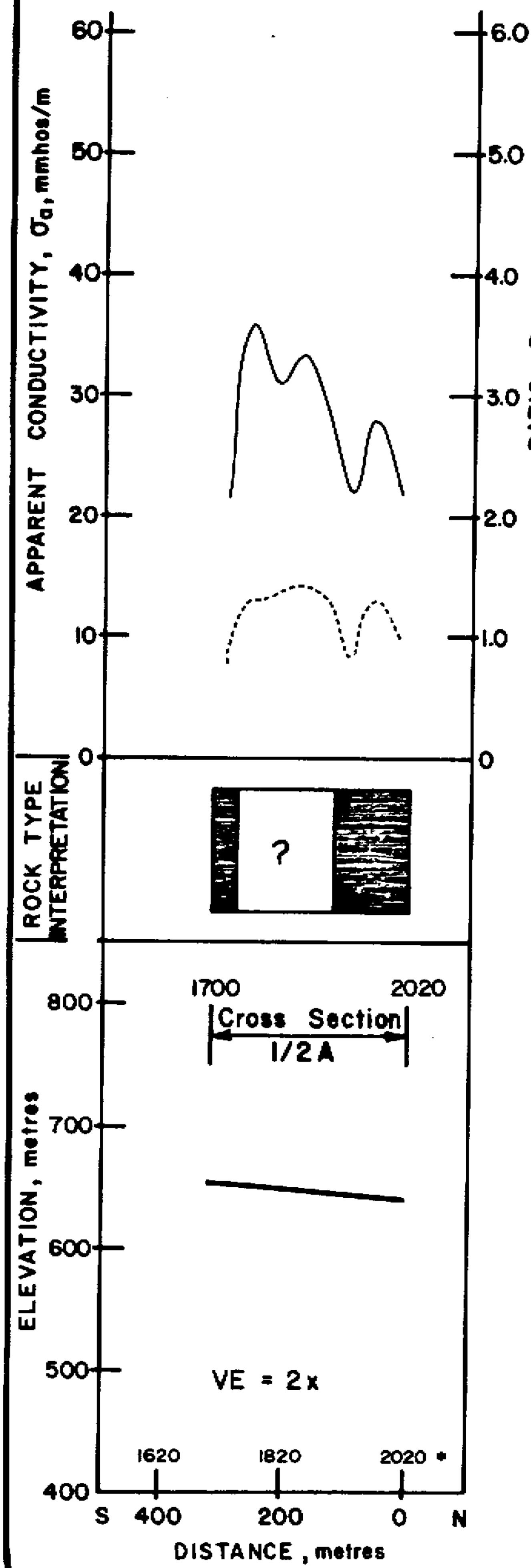
Figure 36



GEO-PHYSI-CON
ENGINEERING GEOPHYSICAL CONSULTANTS

LINE 4 - 40m VERTICAL
GEONICS EM 34-3 SURVEY
CROWS NEST RESOURCES LTD.

81-20 Figure 37



LEGEND

Sedimentary Rock

Volcanics

Crystalline Rock

Apparent Conductivity, EM 34-3 (40m)

Ratio $R = \frac{\sigma_a, \text{EM 34-3(40m)}}{\sigma_a, \text{EM 34-3(20m)}}$

* EM 37 Cross Section 1/2A Chainage

KERR

GEO-PHYSI-CON

ENGINEERING GEOPHYSICAL CONSULTANTS

LINE 5 - 40m VERTICAL
GEONICS EM 34-3 SURVEY
CROWS NEST RESOURCES LTD.

81-20

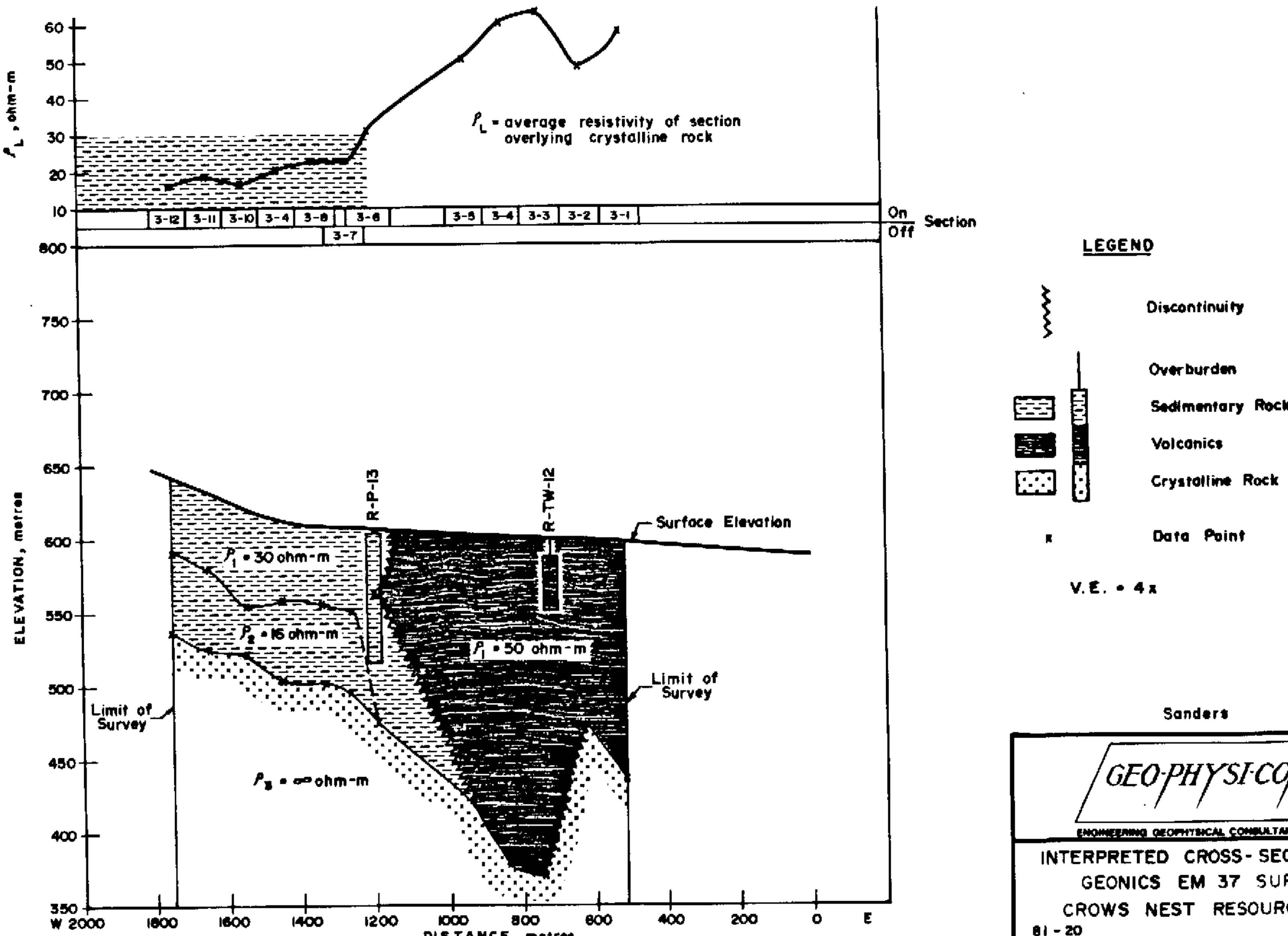
Figure 38

3.4 Sanders Property

The geologic cross-sections on Sanders property along Lines 3A, B and C are given in Figures 39, 40 and 41. Typical sounding data along these cross-sections are given in Figures 42 through 45. Along Line 3A and 3B a boundary of volcanic and sedimentary rock is traversed. This boundary is very evident in the values of ρ_L plotted above the geologic cross-section. The sedimentary rock generally has values around 20 ohm-m, the volcanic rock values higher than 40 ohm-m. Drill hole R-P-13 appears to have been placed right at the boundary. The thickness of the sedimentary section at Station 2200m (Section 3B) was measured to be about 105 metres. The electrical section in the volcanic rock again shows several discontinuities, interpreted as faults.

Figure 46 shows the conductivity profile measured with the EM34-3 (40m) along cross-section 3B. This profile extends further on the hill than the EM37 cross-section. The EM34-3 (40m) profile shows good agreement with the ρ_L profile of Figure 40. High conductivity (40 to 50 mmhos/metre) are observed over the sedimentary section and conductivities of about 20 mmhos/metre over the volcanic section. Higher on the hill crystalline rock is probably indicated by the low conductivities from Station 2500 m on.

The only Schlumberger sounding conducted during the 10-day survey was on the Sanders property. An equipment malfunction prevented making more measurements. The Schlumberger sounding was made with the centre of the array at station 5+20. The maximum L-spacing used was 150 metres. The experimental data points superimposed on a theorectical model are given in Figure 46a. The first layer, approximately 2 metres thick, is expected to be granular overburden, the resistivity of the volcanic rock of about 40 ohm-metres correspond well with the value of ρ_L obtained from the transient sounding and from the EM34-3 (40 m) readings.



Sanders

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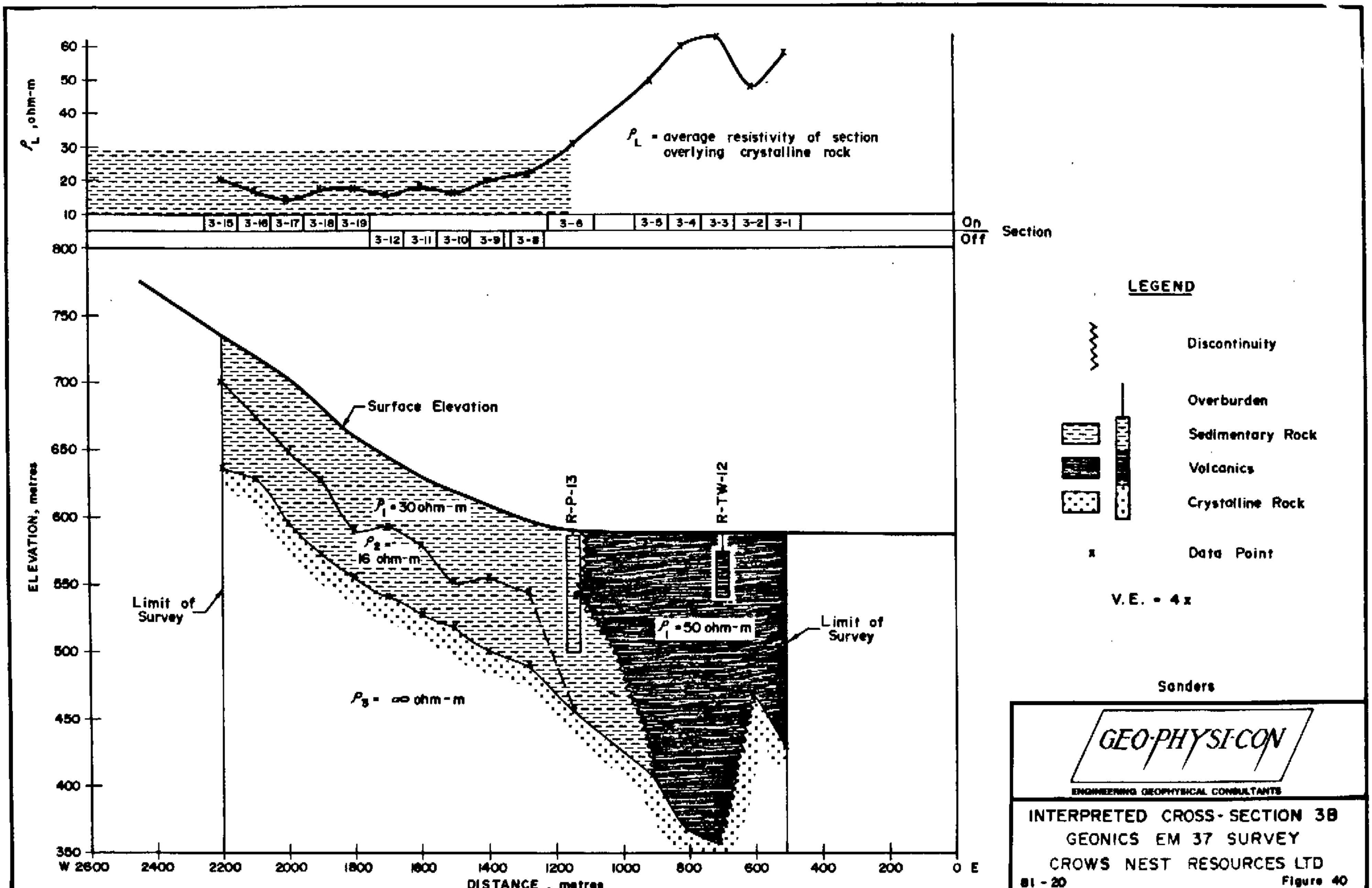
INTERPRETED CROSS-SECTION 3A

GEONICS EM 37 SURVEY

CROWS NEST RESOURCES LTD.

81-20

Figure 39



ρL , ohm-m
ρL = average resistivity of section overlying crystalline rock
3-15 3-16 3-17 3-18 3-19 3-6 3-5 3-4 3-3 3-2 3-1
3-12 3-11 3-10 3-9 3-8
On
Off
Section
ELEVATION, metres
Surface Elevation
ρ1 = 30 ohm-m
ρ2 = 16 ohm-m
ρ3 = ∞ ohm-m
ρ1 = 50 ohm-m
R-P-13
R-TW-12
Limit of Survey
Limit of Survey
W 2600
0 E
DISTANCE , metres
LEGEND
Discontinuity
Overburden
Sedimentary Rock
Volcanics
Crystalline Rock
Data Point
V. E. = 4 x
Sanders
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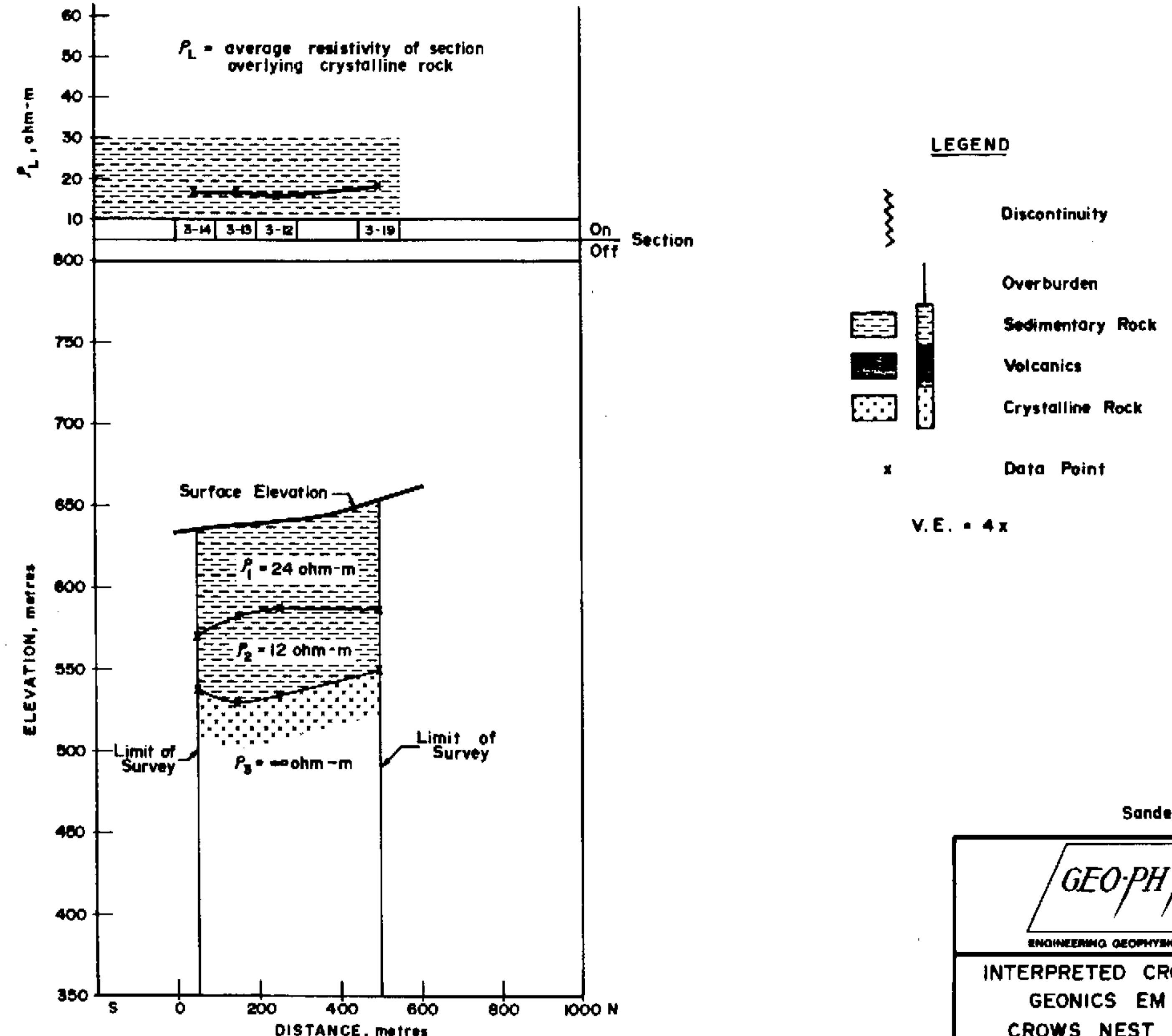
INTERPRETED CROSS-SECTION 3B
GEONICS EM 37 SURVEY
CROWS NEST RESOURCES LTD
81 - 20
Figure 40



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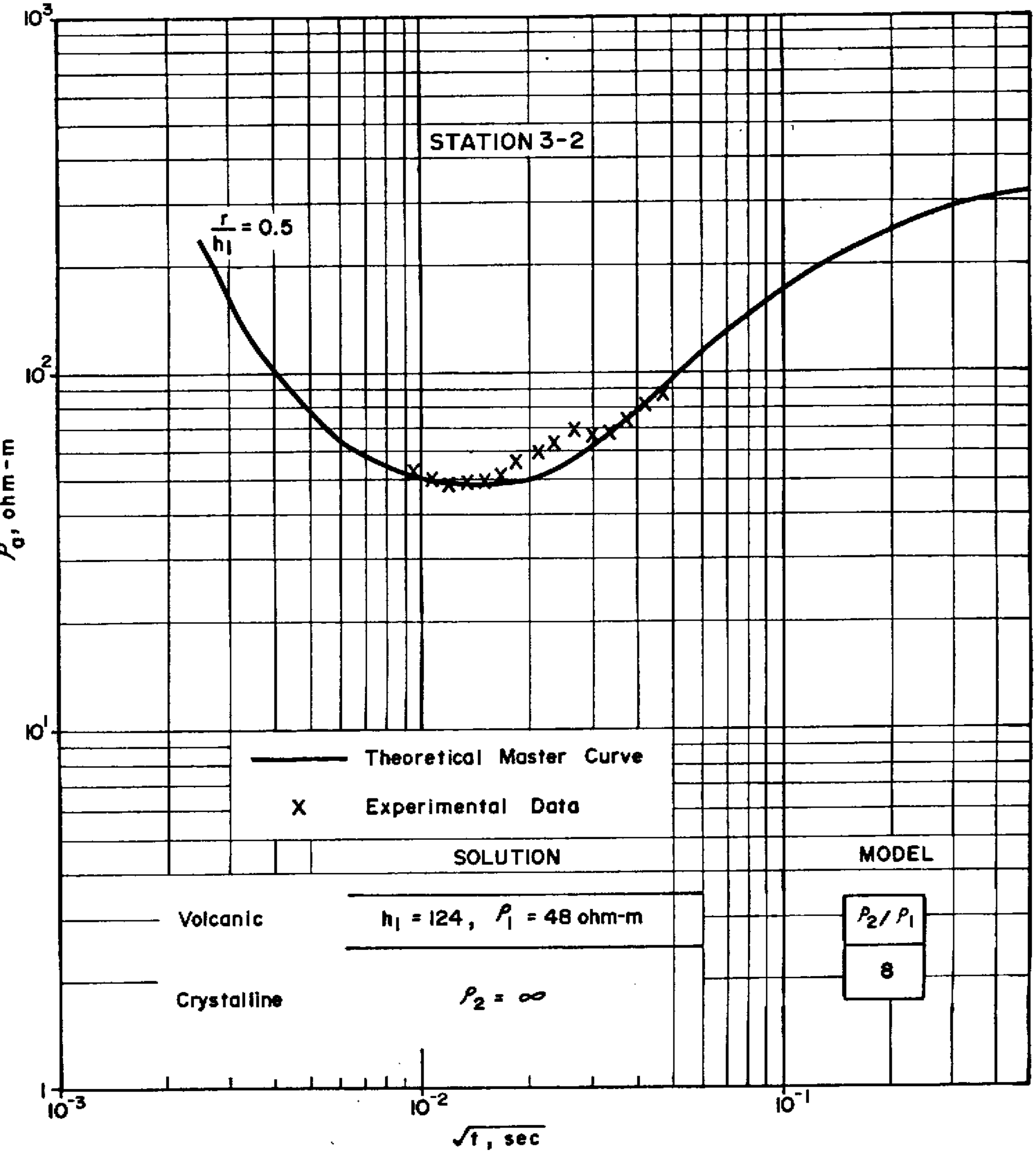
INTERPRETED CROSS-SECTION 3C
GEONICS EM 37 SURVEY
CROWS NEST RESOURCES LTD.

81 - 20

Figure 41



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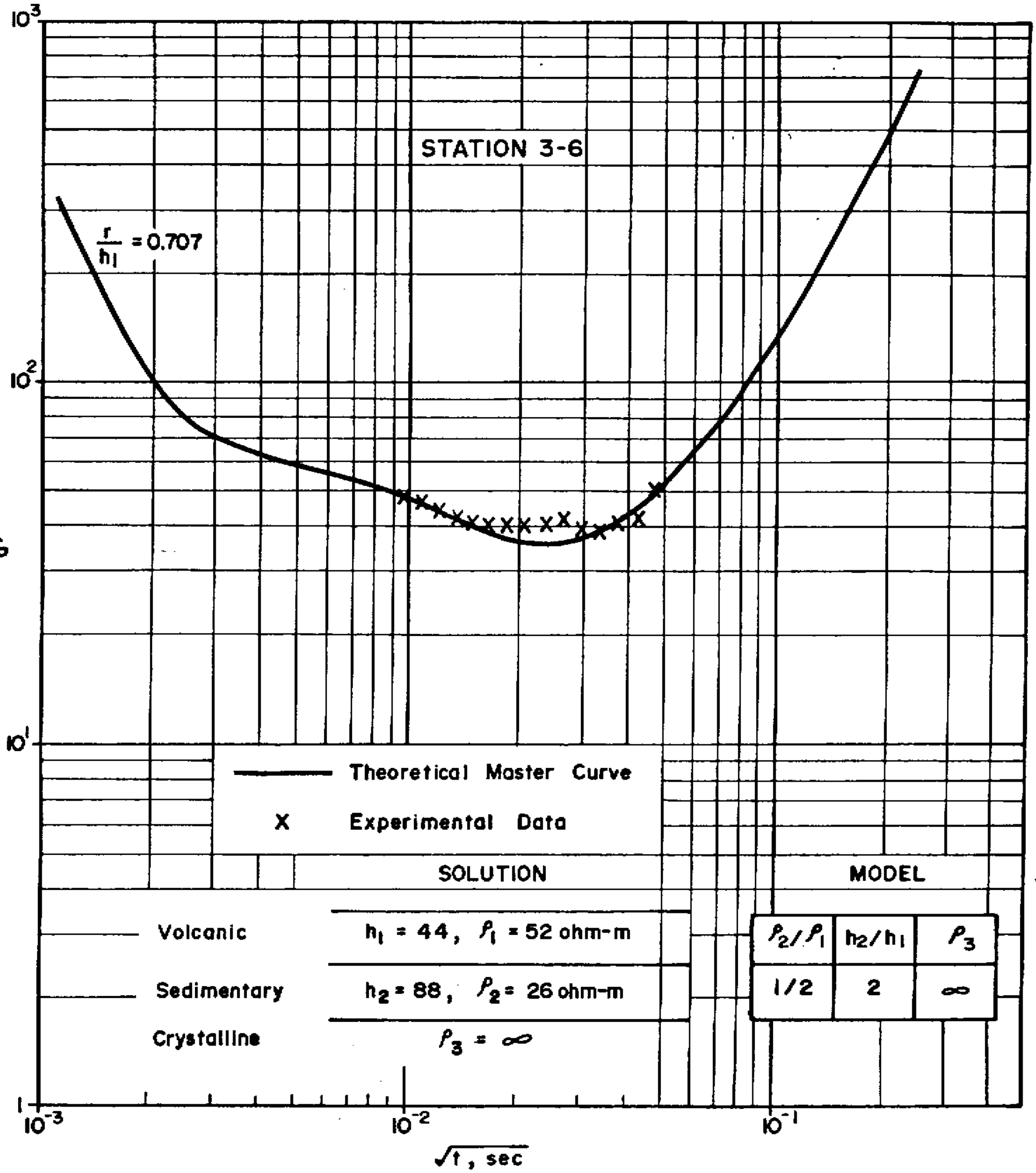
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs
$\sqrt{time}$

81 - 20

Figure 42



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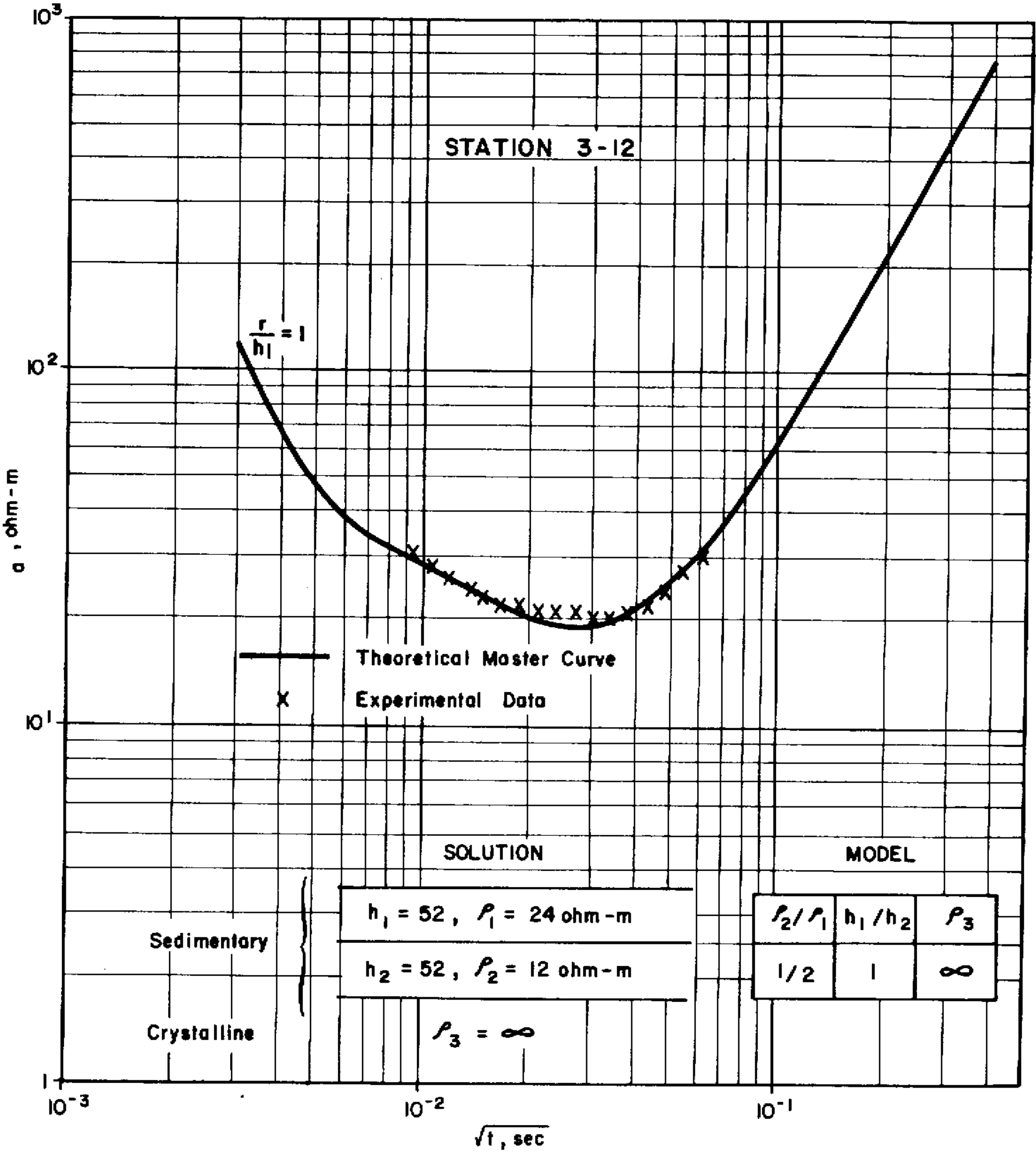
ENGINEERING GEOPHYSICAL CONSULTANTS

CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs $\sqrt{time}$

81 - 20

Figure 43



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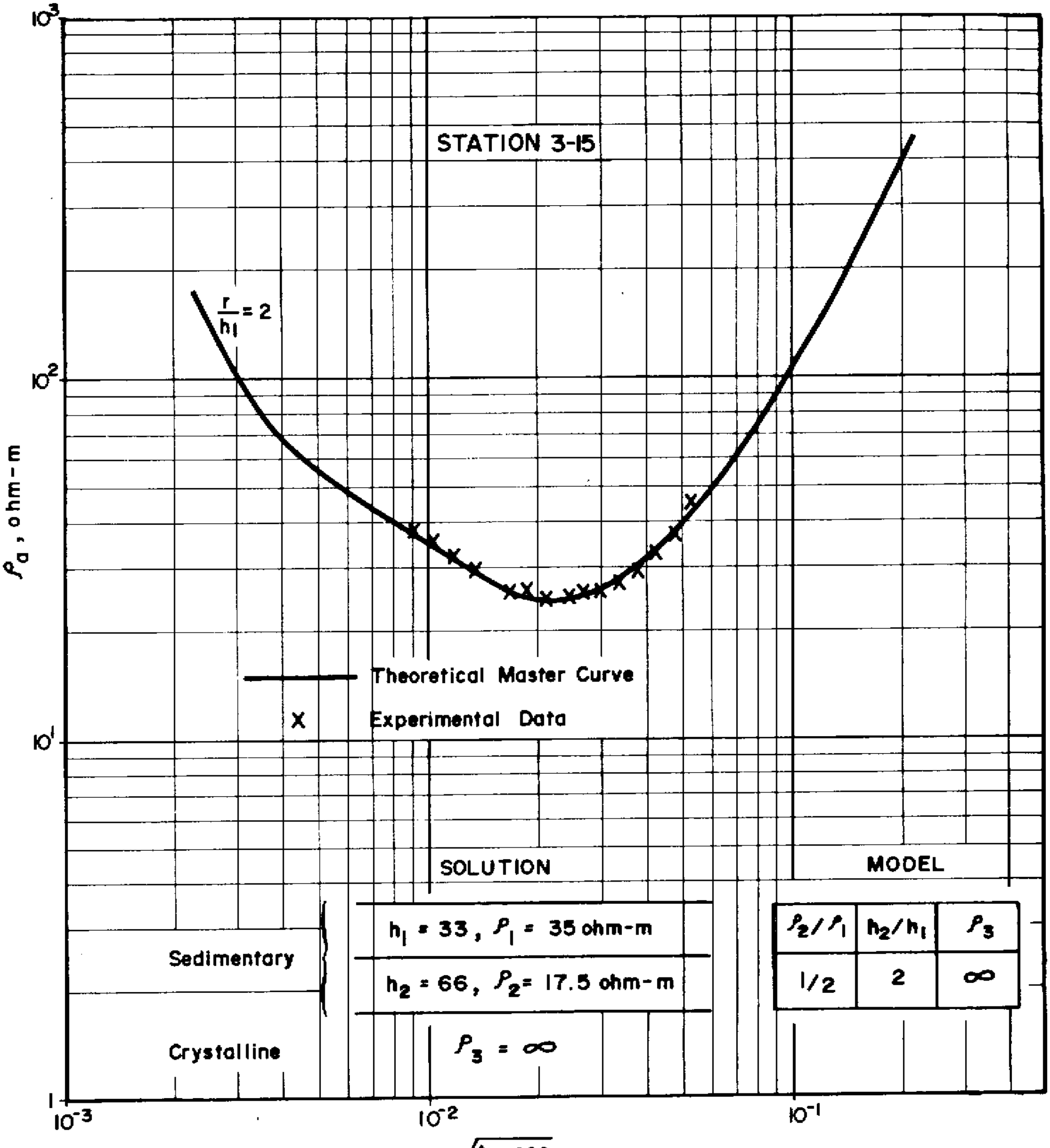
CROWS NEST RESOURCES LTD.

APPARENT RESISTIVITY vs $\sqrt{time}$

81-20

Figure 44



Sanders

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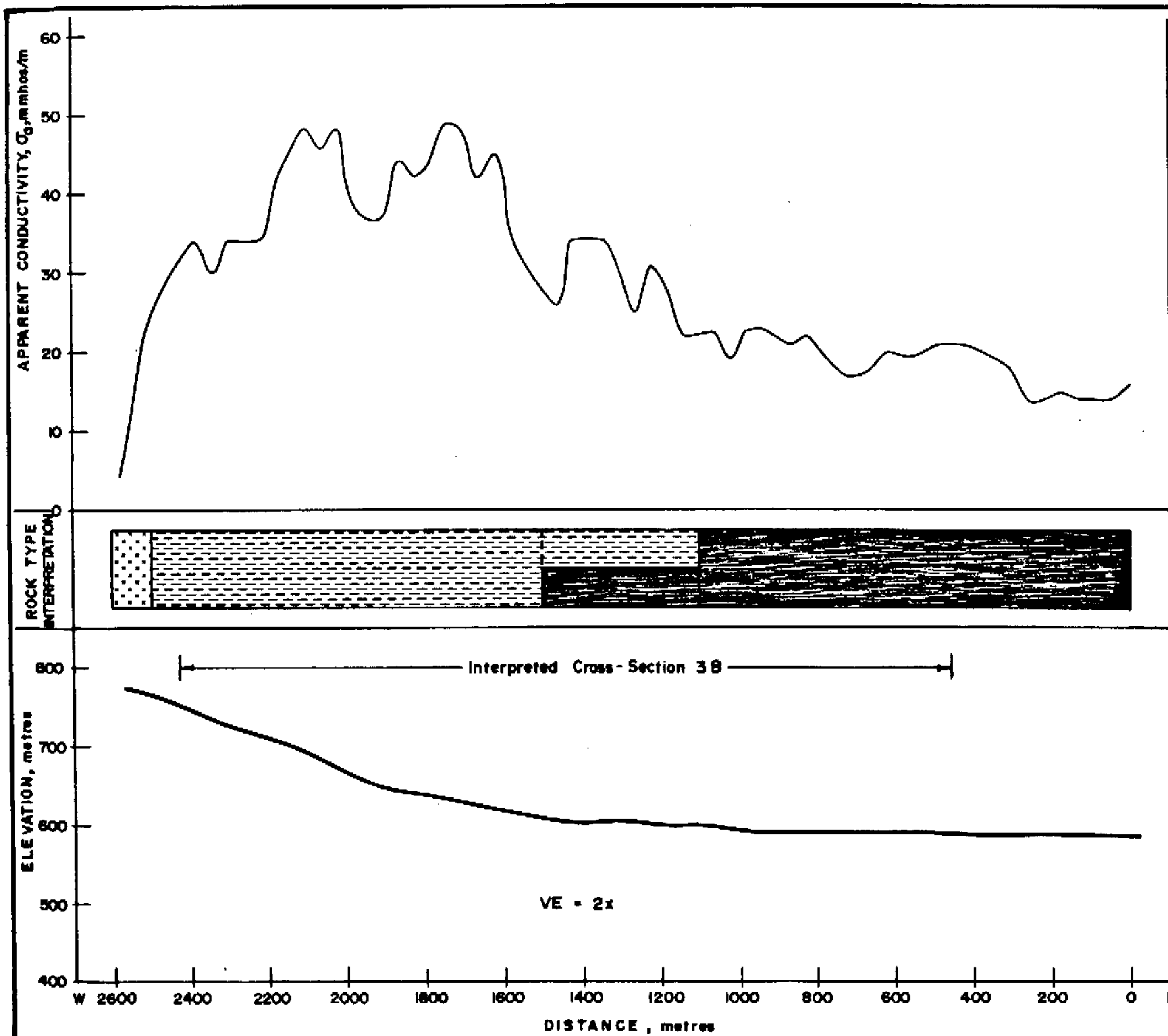
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs $\sqrt{time}$

81-20

Figure 45



LEGEND

Sedimentary Rock

Volcanics

Crystalline Rock

—— Apparent Conductivity, EM 34-3 (40m)

------- Ratio $R = \frac{\sigma_a\text{, EM 34-3 (40m)}}{\sigma_a\text{, EM 34-3 (20m)}}$

Sanders

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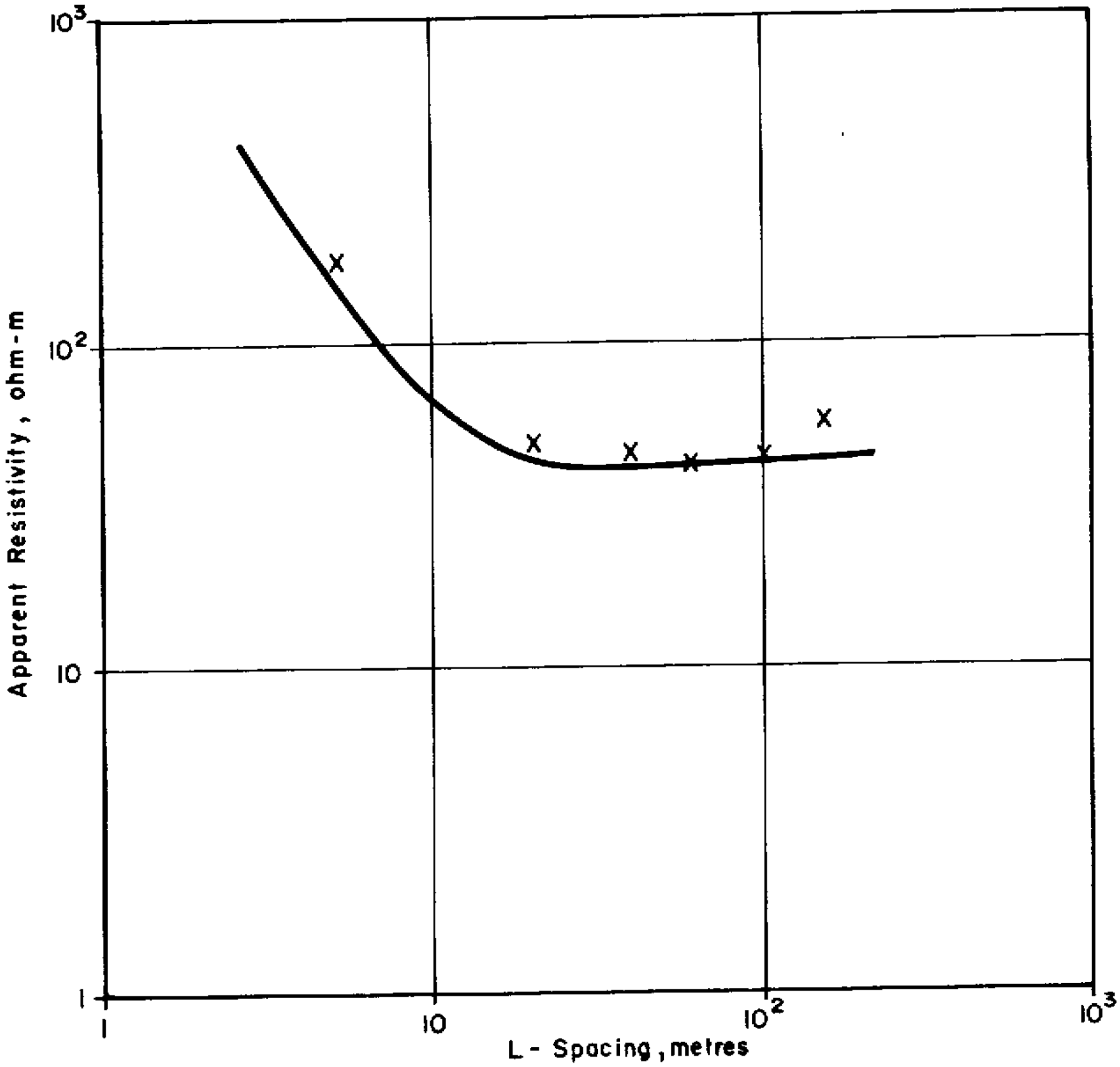
LINE 7 - 40m VERTICAL
GEONICS EM 34-3 SURVEY
CROWS NEST RESOURCES LTD.

81-20 Figure 46



X X Experimental Data

—— Theoretical Model

MODEL

$\rho_1 > 400$ ohm-m

h = 2 m, probably gravel

$\rho_2 = 40$ ohm-m,
volcanic rock

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SCHLUMBERGER SOUNDING
SANDERS - STATION 5+20
CROWS NEST RESOURCES LTD.

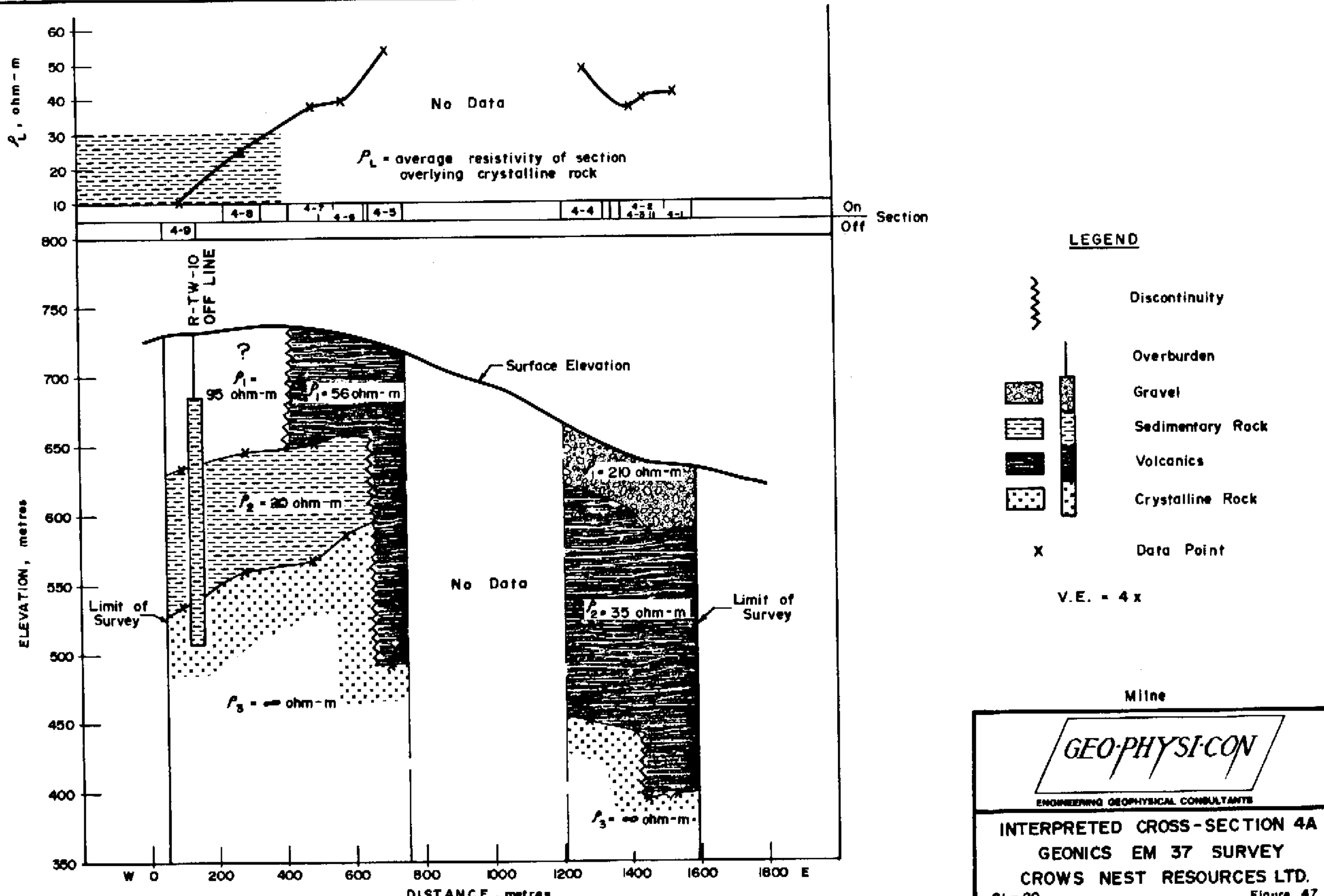
81 - 20

Figure 46a

3.5 Milnes Property

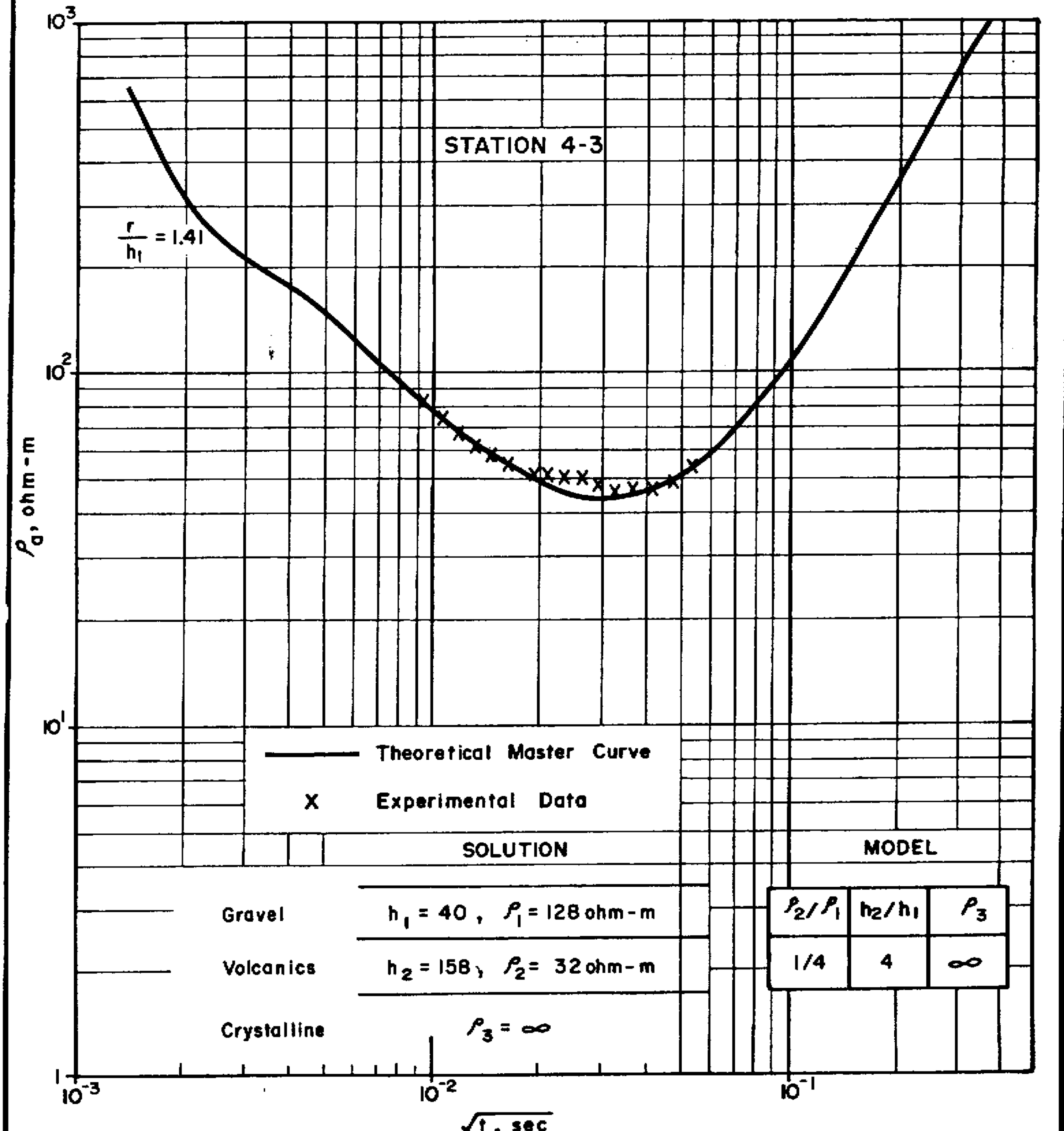
In Figure 47 the electrical and interpreted geologic cross-section, 4A, on the Milnes Property is shown. Typical sounding data along this cross-section are given in Figures 48 through 52. The sounding curves of Figures 51 and 52, Station 4-8 and 4-9 show a resistive layer overlying a conductive layer. At Stations 4-8 and 4-9, a resistive layer about 90 metres thick was interpreted to be underlain by about 90 metres of a conductive layer. *Because of the findings in a nearby test hole (R-TW-10),* the conductive layer has been interpreted as sedimentary rock. If it is sedimentary rock it would be underlain by deep overburden. A transition from conductive to more resistive rock occurs between Stations 400 to 600 m. Discontinuities are observed in the basement rock at Station 1400 m and 600 m.

Along this section, the interpretation in terms of overburden of sedimentary or volcanic rock is difficult because of the *many different values of resistivity encountered.* No EM34-3 (40 m) data was obtained along this cross-section.



INTERPRETED CROSS-SECTION 4A
GEONICS EM 37 SURVEY
CROWS NEST RESOURCES LTD.

81 - 20 Figure 47



Milne

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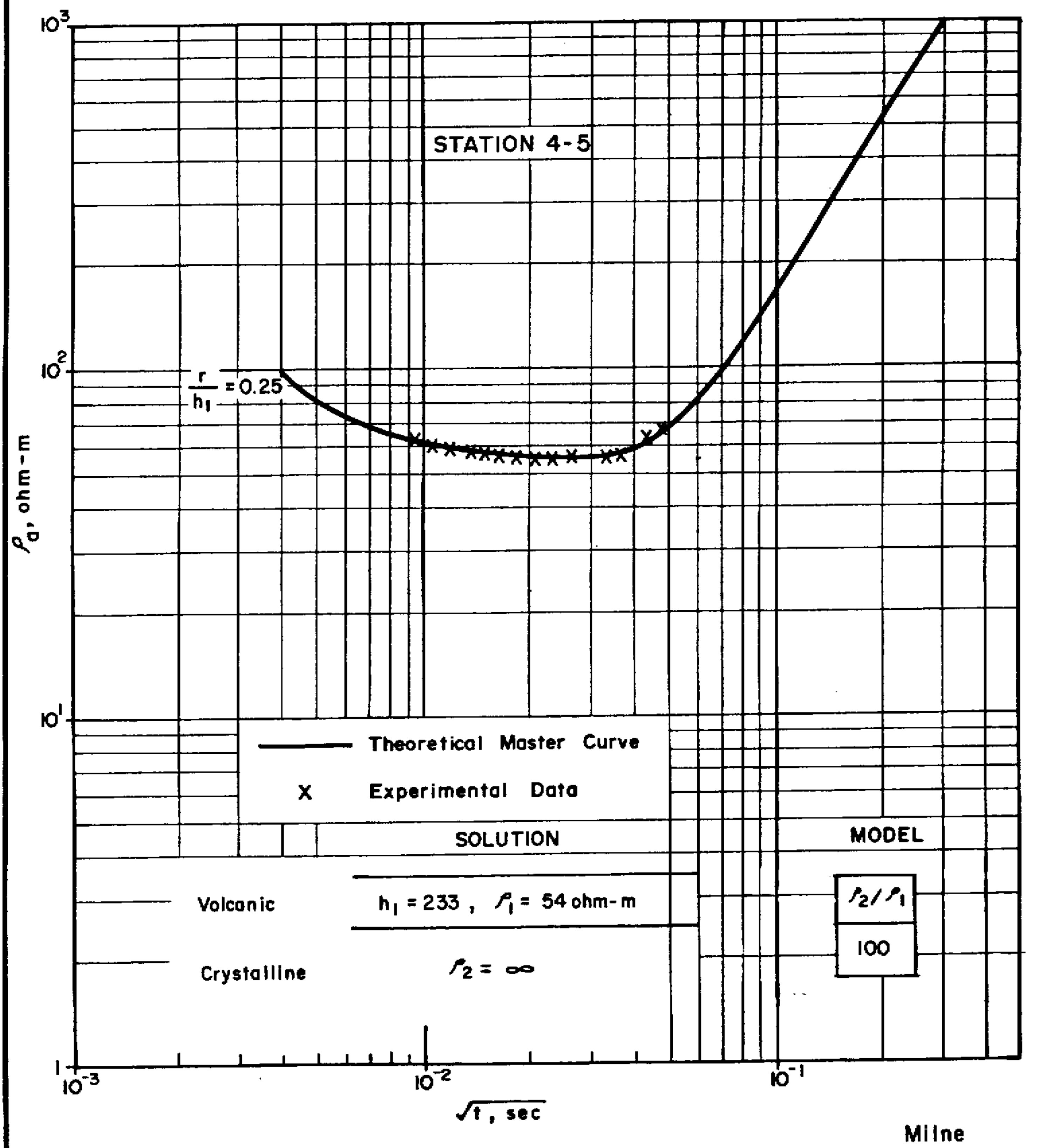
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs
$\sqrt{time}$

81 - 20

Figure 48



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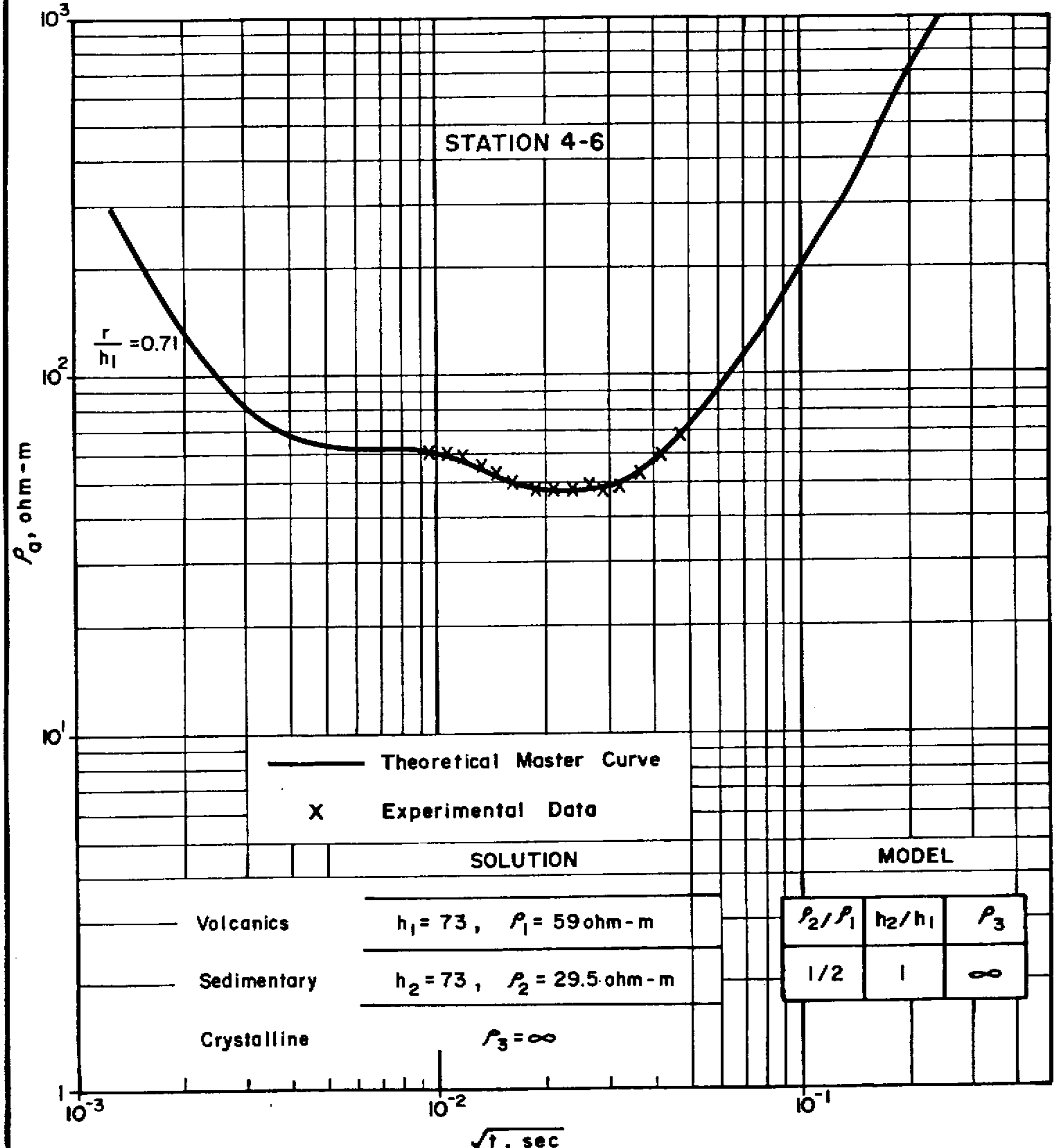
ENGINEERING GEOPHYSICAL CONSULTANTS

CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs $\sqrt{time}$

81 - 20

Figure 49



Milne

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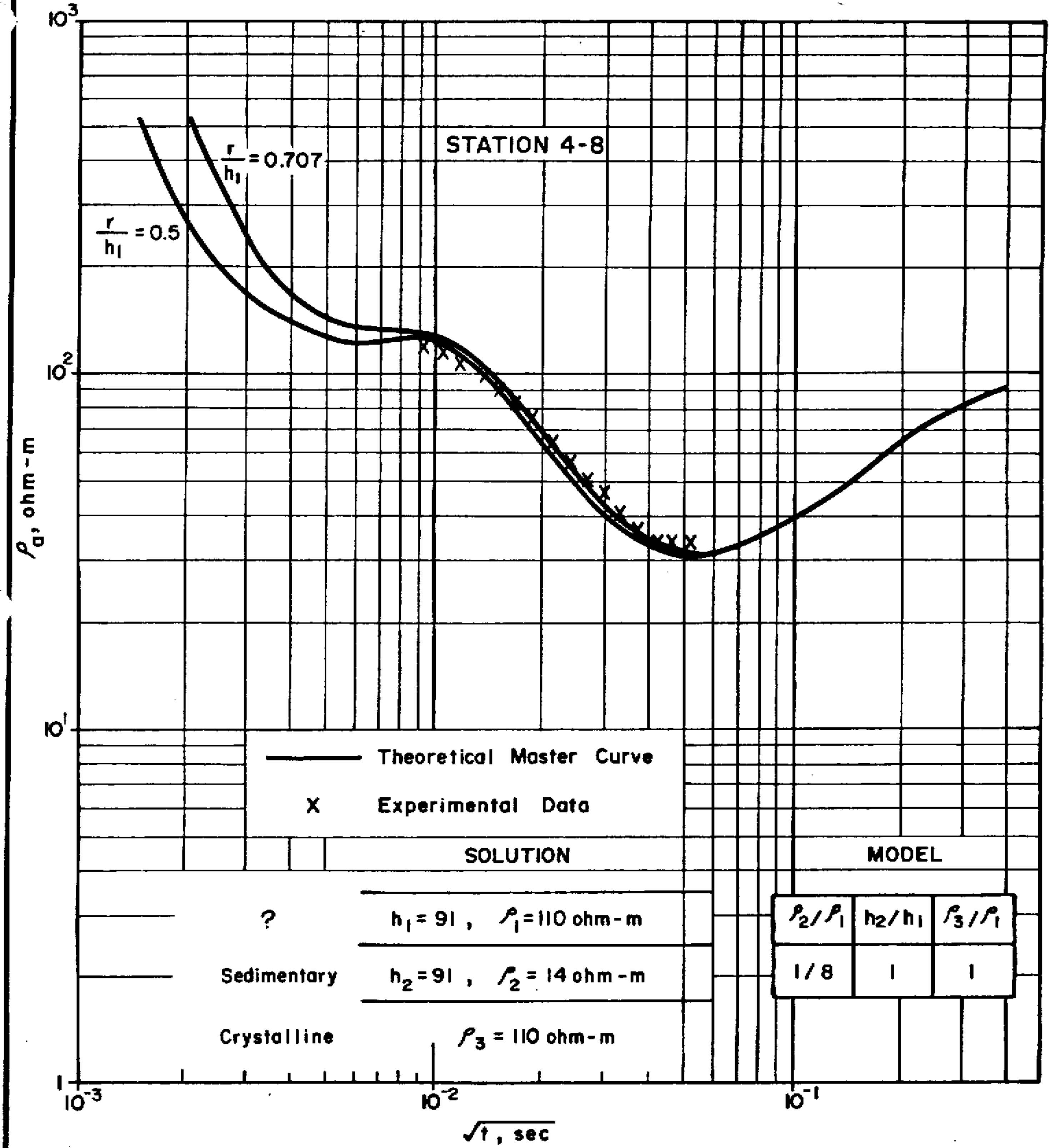
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs $\sqrt{time}$

81 - 20

Figure 50



Milne

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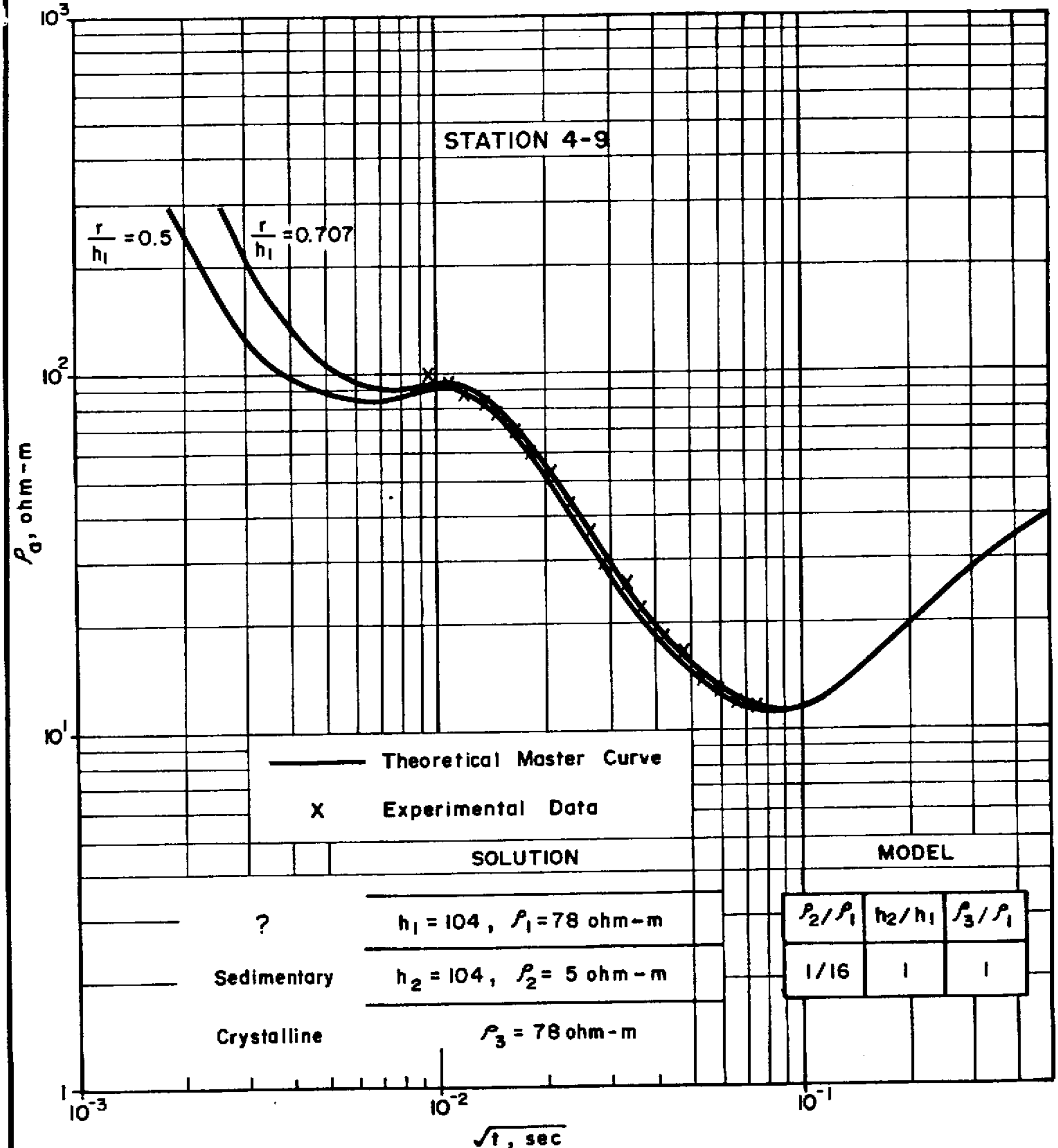
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs $\sqrt{time}$

81 - 20

Figure 51



Milne

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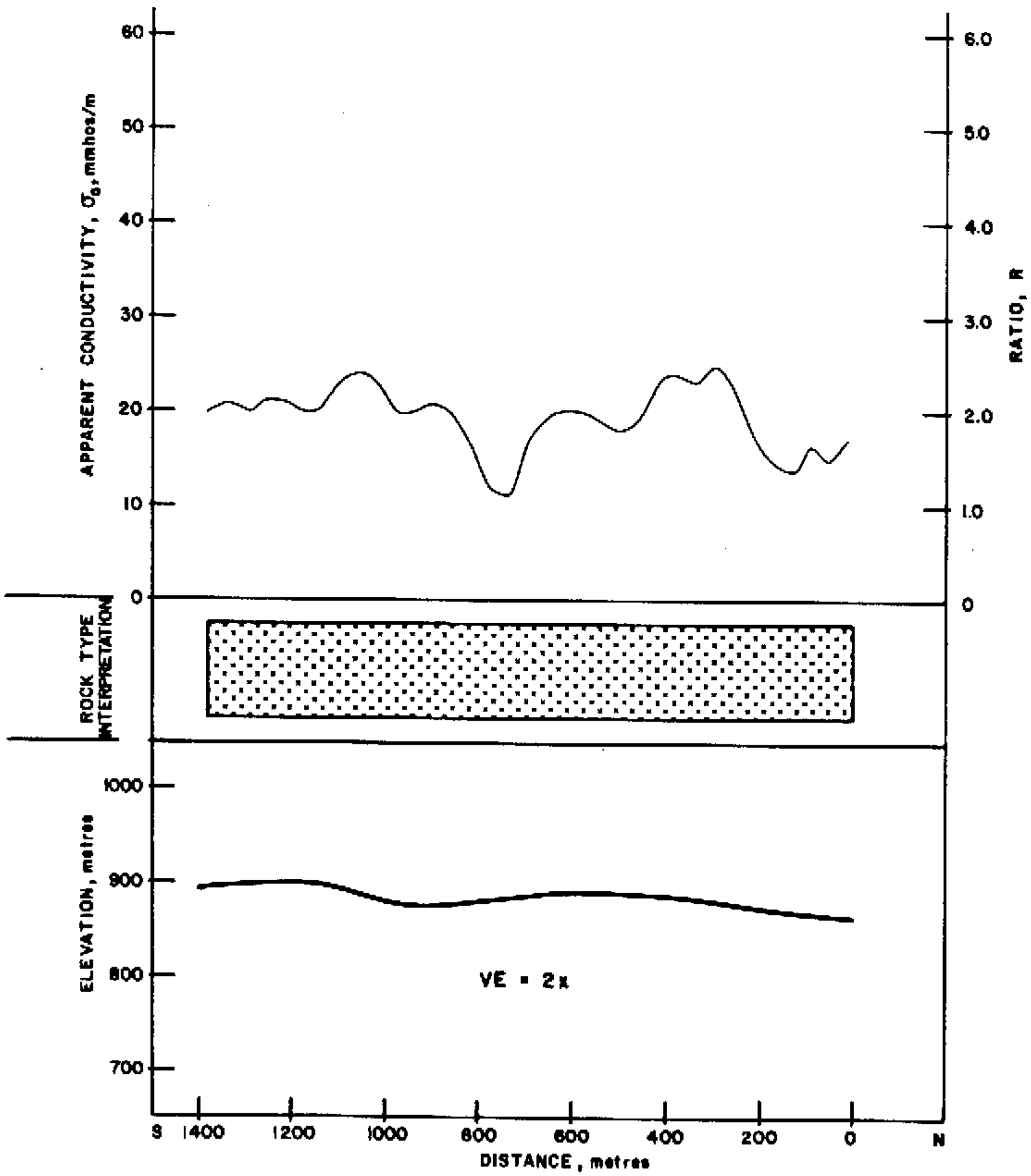
CROWS NEST RESOURCES LTD.
APPARENT RESISTIVITY vs
$\sqrt{time}$

81 - 20

Figure 52

3.6 Behind Ski Hill

Along Line 8 and 9, only EM34-3 (40 m) recordings were taken (Figures 53 and 54). The data have been interpreted in terms of rock type using the data of Figure 2. Conductivities in excess of 30 mmhos/metre are used to indicate sedimentary rock, values of less than 30 mmhos/m crystalline rock. Since no EM37 data were obtained it is not possible to calculate depths.



LEGEND

Sedimentary Rock

Volcanics

Crystalline Rock

Apparent Conductivity, EM 34-3 (40m)

Ratio $R = \frac{\sigma_a\text{, EM 34-3 (40m)}}{\sigma_a\text{, EM 34-3 (20m)}}$

Behind Ski Hill

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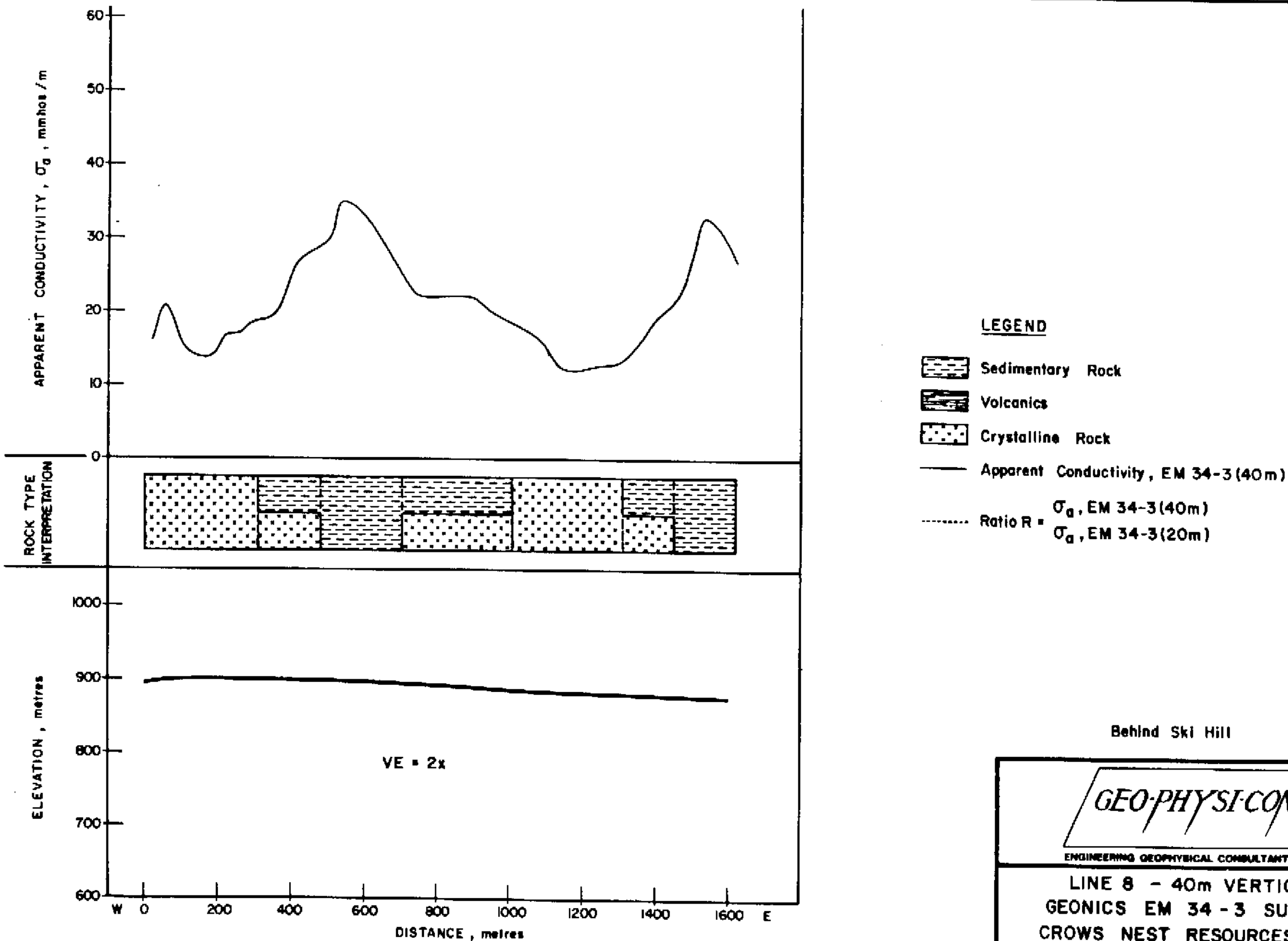
LINE 9 - 40m VERTICAL
GEONICS EM 34-3 SURVEY
CROWS NEST RESOURCES LTD.

81-20

Figure 53



Behind Ski Hill

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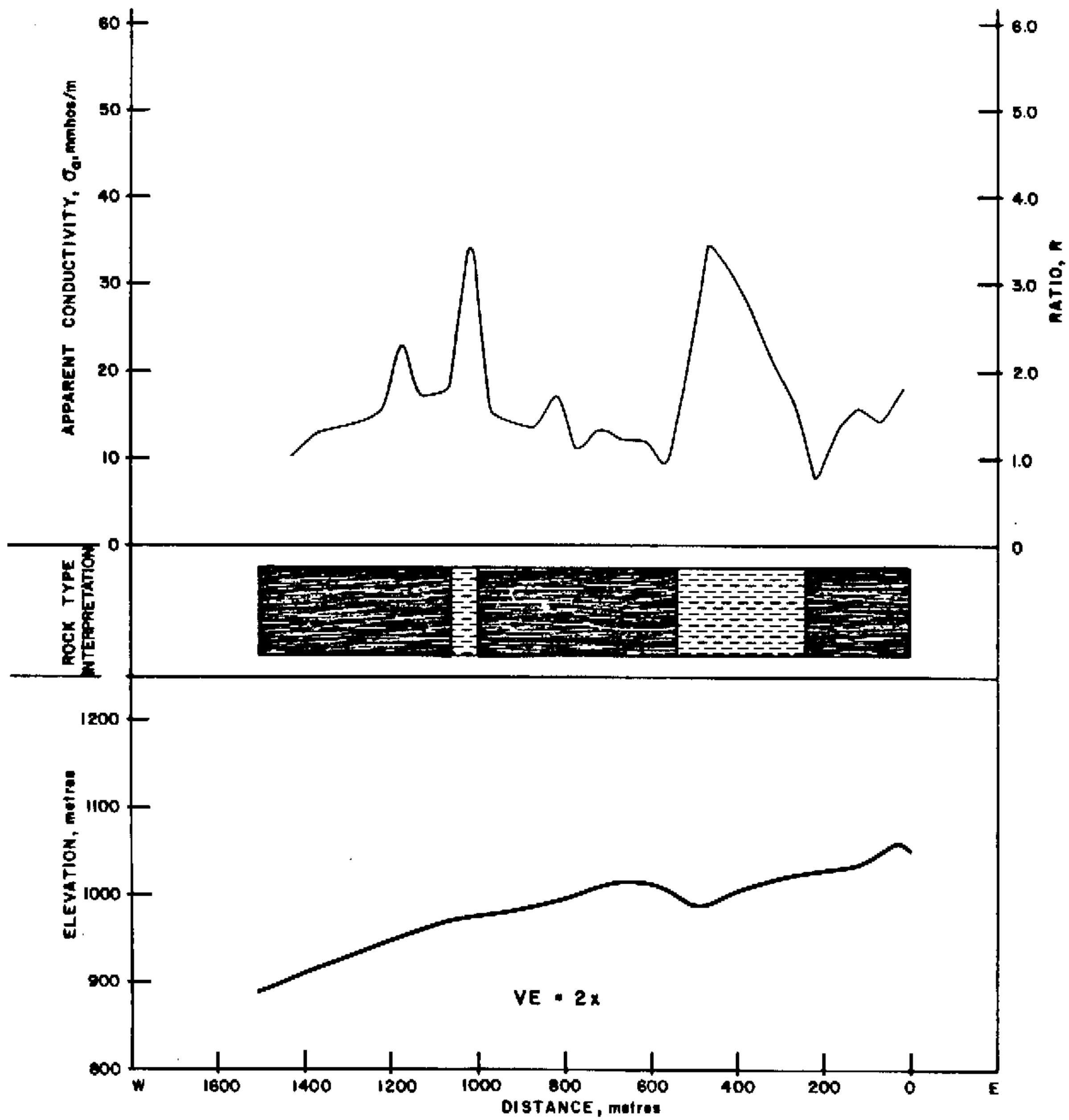
LINE 8 – 40m VERTICAL
GEONICS EM 34-3 SURVEY
CROWS NEST RESOURCES LTD.

81-20

Figure 54

3.7 Thautil River Area

Figure 55 shows the location of Line 6 in the Thautil River area. This site was reached by helicopter and only EM34-3 (40m) readings were taken at that location. The data has been interpreted in terms of rock type with the use of the data in Figure 2.



LEGEND

Sedimentary Rock

Volcanics

Crystalline Rock

Apparent Conductivity, EM 34-3 (40 m)

Ratio $R = \frac{\sigma_a, \text{EM 34-3(40m)}}{\sigma_a, \text{EM 34-3(20m)}}$

Thautil River

GEO-PHYSI-CON

ENGINEERING GEOPHYSICAL CONSULTANTS

LINE 6 – 40m VERTICAL - GEONICS EM 34-3 SURVEY

CROWS NEST RESOURCES LTD.

81-20

Figure 55

3.8 Summary Geophysical Data

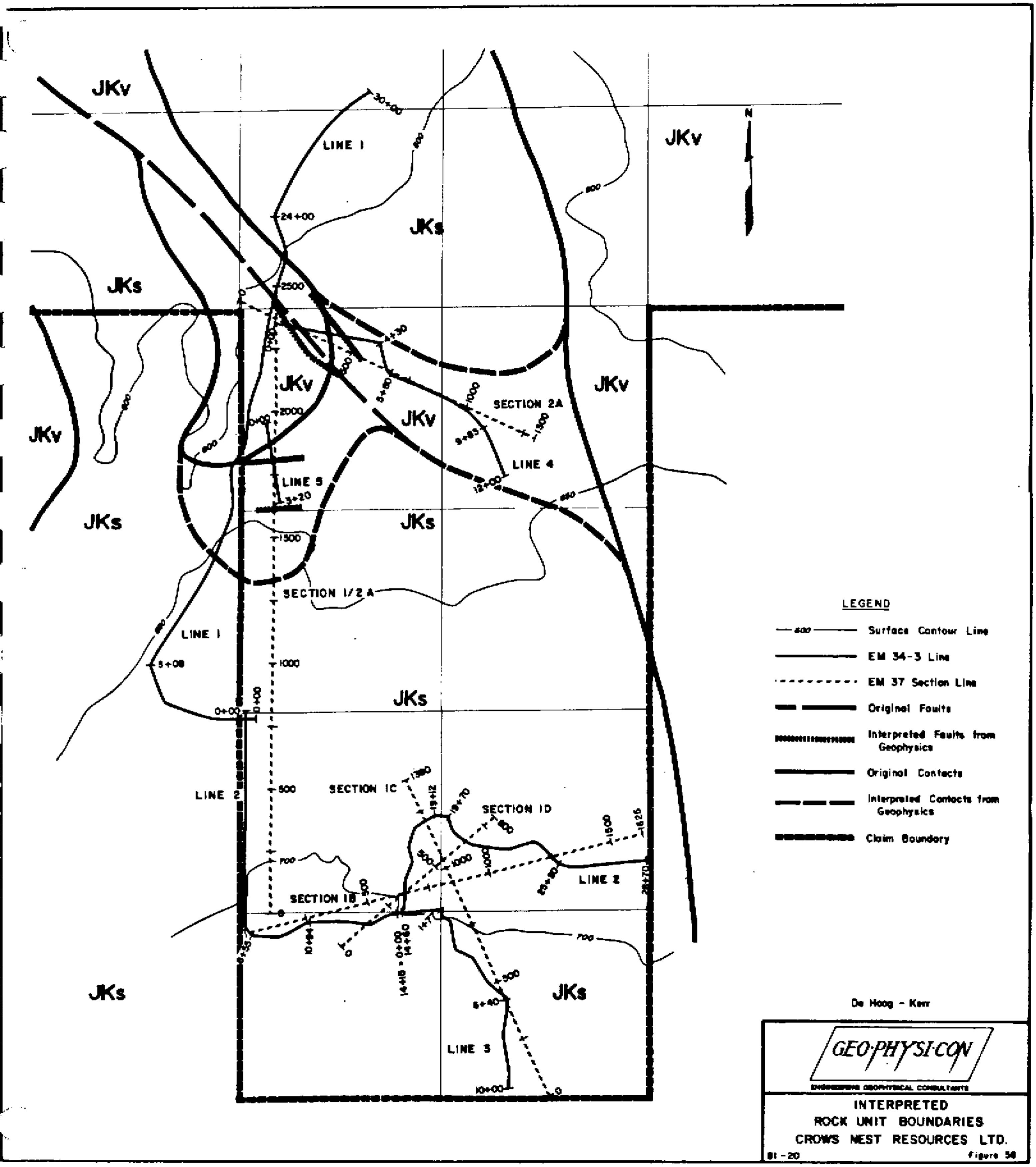
It appears that the interpretation of the geophysical data can be used to map sedimentary and volcanic contacts. Between the De Hoog-Kerr's properties (Figure 56), the geophysical interpretation would shift the boundary of sedimentary JKs and volcanic rock (JKv) further south. Also, it appears that the JKv unit to the east connects with the JKV unit to the west. Clearly, since geophysical measurements were made along lines, the boundaries have been interpolated relying heavily on existing mapped boundaries. Also, several faults interpreted from the geophysical surveys are shown.

On the Sander's Property the geophysical interpretation would shift the boundary of volcanic and sedimentary rock further west and east along Line 7 (Figure 57). Again, the new boundary has been interpolated using existing mapping.

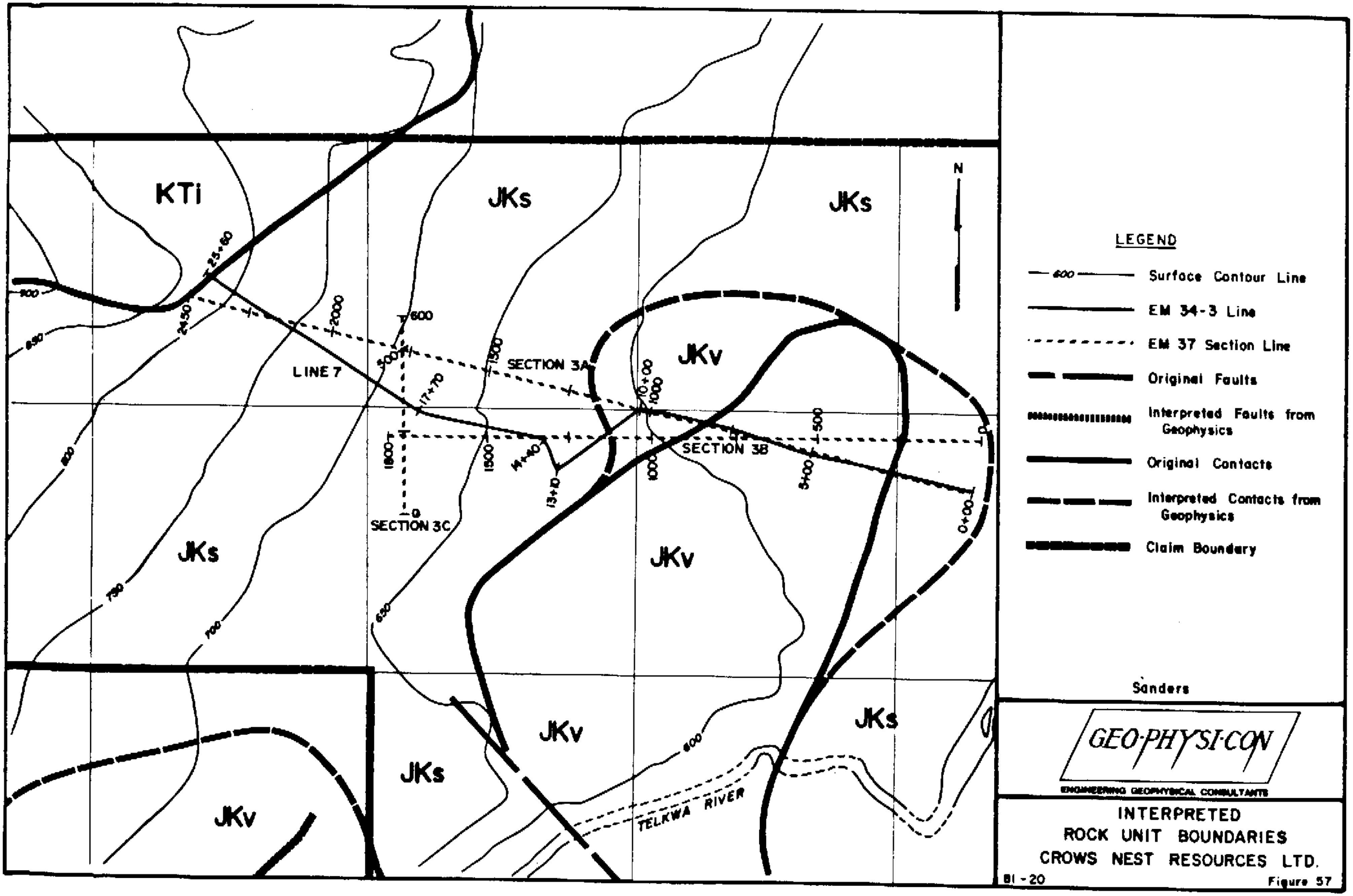
On the Milne's property, the geophysical interpretation would extend the boundary of volcanic and sedimentary rock to the north west and several faults were interpreted (Figure 58).

Behind the ski hill, the EM34-3 (40m) profiles would change the boundaries of crystalline and sedimentary rock substantially (Figure 59).

On Line 6, in the Thautil River area, it appears from the geophysical data that the sedimentary unit to the north and south are intersected by a volcanic unit (Figure 60). This appears the only way to reconcile the EM34-3 (40m) data.



INTERPRETED
ROCK UNIT BOUNDARIES
CROWS NEST RESOURCES LTD.
81-20 Figure 5B



KTi
JKs
JKs
JKs
JKv
JKv
JKv
JKs
JKs
JKv
LINE 7
SECTION 3A
SECTION 3B
SECTION 3C
25+60
2450
2000
600
500
1500
17+70
1800
1500
14+40
13+10
10+00
1000
1000
500
5+00
0+00
0
TELKWA RIVER
900
850
800
750
700
650
600
N
LEGEND
Surface Contour Line
EM 34-3 Line
EM 37 Section Line
Original Faults
Interpreted Faults from Geophysics
Original Contacts
Interpreted Contacts from Geophysics
Claim Boundary
Sanders
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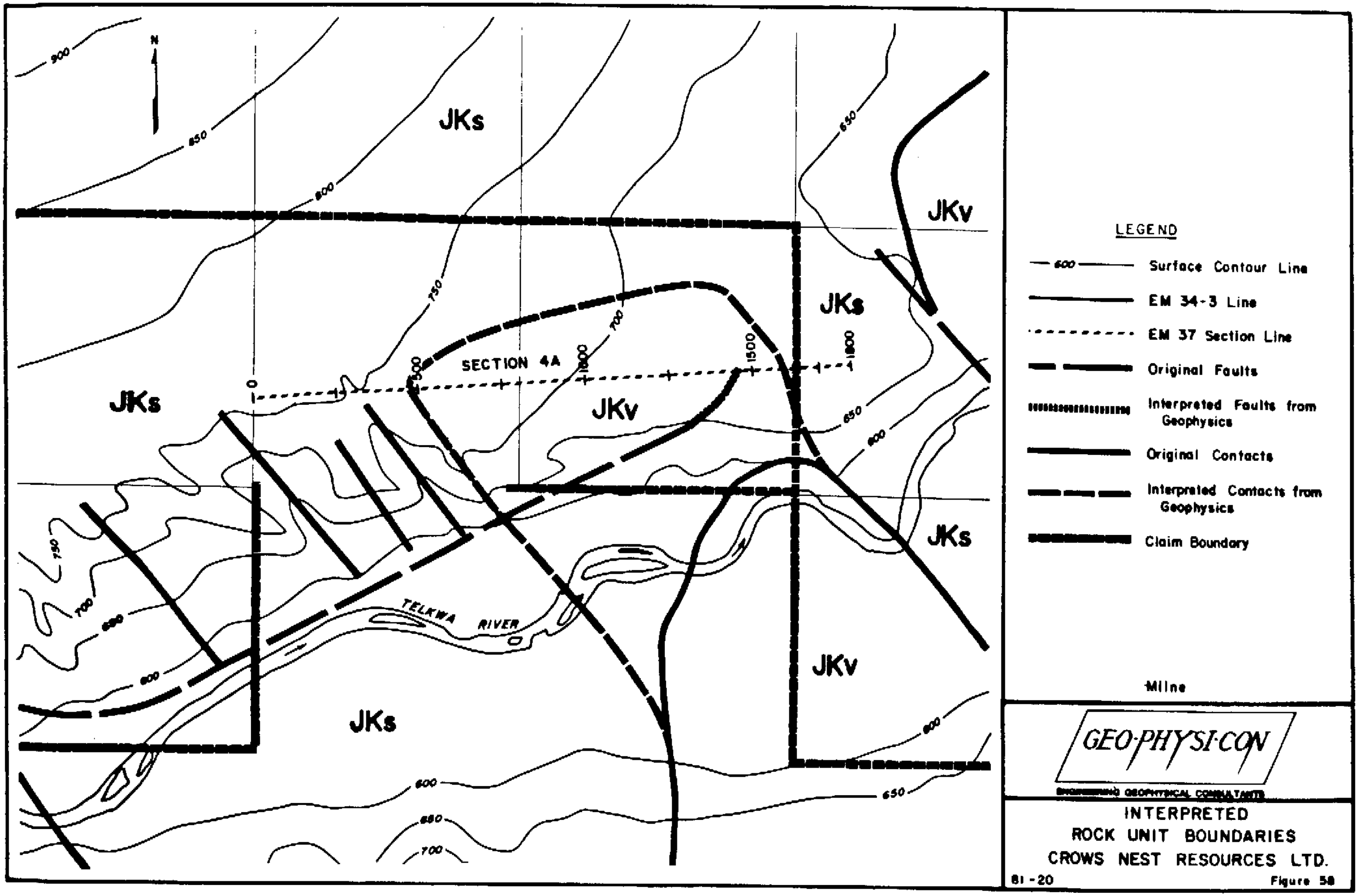
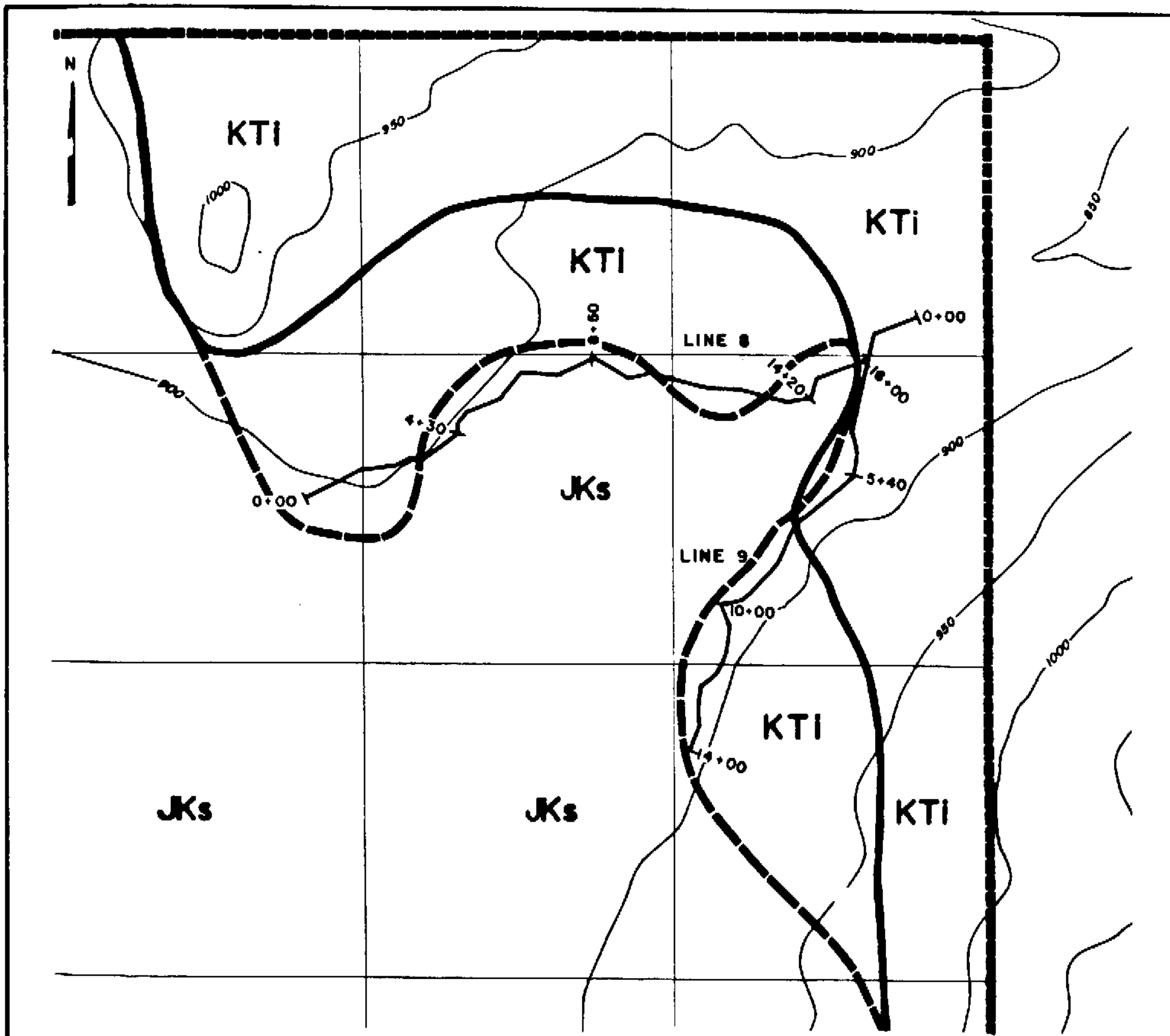
ENGINEERING GEOPHYSICAL CONSULTANTS
INTERPRETED
ROCK UNIT BOUNDARIES
CROWS NEST RESOURCES LTD.
81 - 20
Figure 57


N
JKs
JKv
JKs
JKs
JKv
JKs
JKv
JKs
900
850
800
750
700
650
600
SECTION 4A
0
1500
1800
TELKWA RIVER
LEGEND
600 Surface Contour Line
EM 34-3 Line
EM 37 Section Line
Original Faults
Interpreted Faults from Geophysics
Original Contacts
Interpreted Contacts from Geophysics
Claim Boundary
Milne
GEO·PHYSI·CON
ENGINEERING GEOPHYSICAL CONSULTANTS
INTERPRETED
ROCK UNIT BOUNDARIES
CROWS NEST RESOURCES LTD.
81-20
Figure 58



LEGEND

- Surface Contour Line
- EM 34-3 Line
- EM 37 Section Line
- Original Faults
- Interpreted Faults from Geophysics
- Original Contacts
- Interpreted Contacts from Geophysics
- Claim Boundary

Behind Ski Hill

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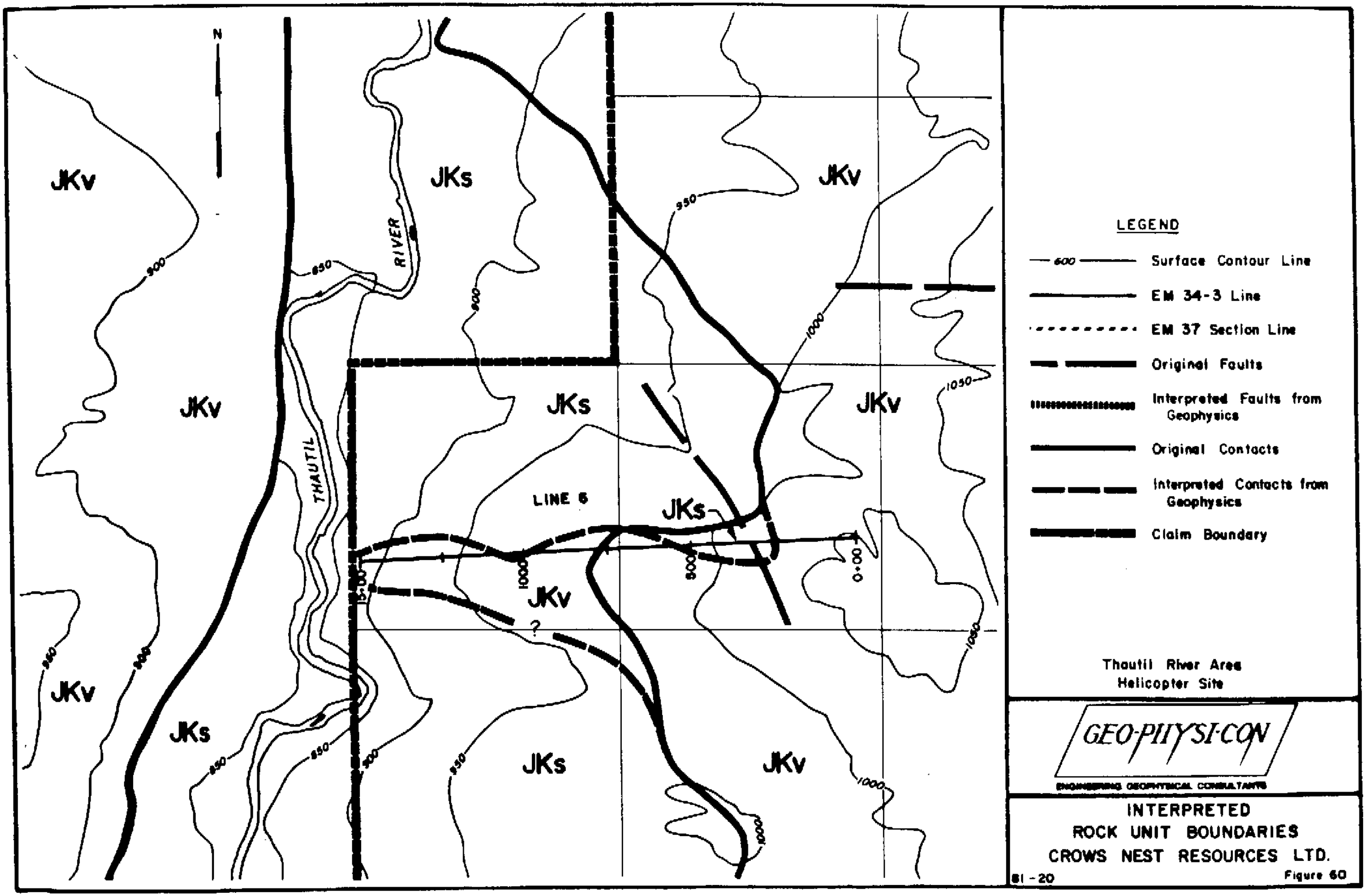
INTERPRETED
ROCK UNIT BOUNDARIES
CROWS NEST RESOURCES LTD.

81-20 Figure 59



INTERPRETED
ROCK UNIT BOUNDARIES
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Figure 60

4.0 CONCLUSIONS

From a comparison of the results of the geophysical interpretations with the limited geologic information, it can be concluded that the following mapping objectives were accomplished:

a) Mapping of the Boundary of Volcanic and Crystalline Rock from Sedimentary Rock

Although the volcanic rocks often only had a resistivity value twice that of sedimentary rock, it is constructive to consider the very large differences in electromotive force measured in various time gates. Table 1 lists the electromotive force at two stations over volcanic rock and at two stations over sedimentary rock at several time gates. The background noise in these measurements is about 0.5 units, so that the difference between volcanic and sedimentary rock is measured at a ratio of more than 100 of signal over noise in gate 7.

b) Determining Depth to Basement or Thickness of Sedimentary Rock

The typical sounding curves shown in the report generally show an excellent fit of theoretical master curves with experimental data. A solution of the resistivity layering is not only obtained from curve fitting but independent checks from emperical relations established by the Russians are also available. They show that for two-layer curves ($\rho_1 < \rho_2$) and three-layer H-type curves ($\rho_1 > \rho_2 < \rho_3$) the apparent resistivity and time at the position of the minimum is related to depth to basement by:

$$H = 360 \times \sqrt{2 \times \pi \times \rho_m \times t_m} \quad [1]$$

where H is depth to basement

t_m and ρ_m are values of time and apparent resistivity at minimum

In Table 2 a comparison is made of H derived from curve fitting and H derived from equation 1 along Section 3B for soundings over sedimentary rock. The data shows an agreement to within $\pm$ 10%.

Finally, for Station 1-12 (Figure 61), the experimental data is superimposed on three different master curves; curve 1 is the 3-layer best fit; for curve 2 the depth to basement has been decreased by 54 m, and curve 3 is a 2-layer with the resistivity of the first layer equal to the average resistivity of the first two-layers and the depth to basement equal to that in curve 1. The data shows that the points quite uniquely fit curve 1 for all 18 points.

From the experience gained on the Smithers job, it appears that depth to basement can be determined to ± 10% over sedimentary sections with a 100 m by 100 m loop up to a depth of 200 m. For greater depth it probably is better to increase loop size to 200 m by 200 m.

c) Determining Faulting

Because it appears that depth to basement can be determined to an accuracy of ± 10%, sharp off-sets in depth to basement between two measurement points can be interpreted as faulting. At faults, data interpretation was carefully evaluated and major discontinuities were interpreted to be present.

Several mapping objectives were not or not well accomplished by the present geophysical trials. They are:

a) Mapping of Coal Seams of Continuity of Coal Seams

There is no evidence in the data that coal seams can be detected, nor can it be expected from transient EM. In order to map a layer in a sedimentary section, its product of conductivity and thickness (conductance) should be a significant fraction (about 0.1) of the total conductance of the sedimentary section. Coal seams are most often more resistive than the surrounding host rock (except perhaps anthracite layer), which makes it virtually impossible to detect it by resistivity mapping from the surface. Some Australian surveys have shown transient EM to work well in mapping anthracite seams.

b) Overburden Mapping

Overburden can be mapped by electrical methods if there is a resistivity contrast between overburden and rock. The overburden does not show up in most of the profiles obtained with transient EM because it can not be used to map the first 10 metres. The reason is that the earliest time of measurement is 89 microseconds. Overburden was, therfore, mapped by transient EM only when it is deeper than 10m (Section 2B, Kerr; Section 4A, Milnes).

Shallow overburden can probably be mapped by the Schlumberger method in the environment of Smithers, B.C. An example is the data of Figure 46A. In general, however, shallow overburden is probably best mapped by seismic refraction techniques.

5.0 RECOMMENDATIONS

The geophysical trials at Smithers show that surface geophysics can be used in support of coal exploration. To select the proper geophysical method the objectives must be clearly defined since no one method can satisfy all objectives.

In Table 3 the objectives that can be accomplished, the equipment and technique best suited for mapping the particular objective and the approximate estimated cost are also listed.

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF ALBERTA
PERMIT NUMBER
P 2302
Geo Physi Con Co. Ltd.

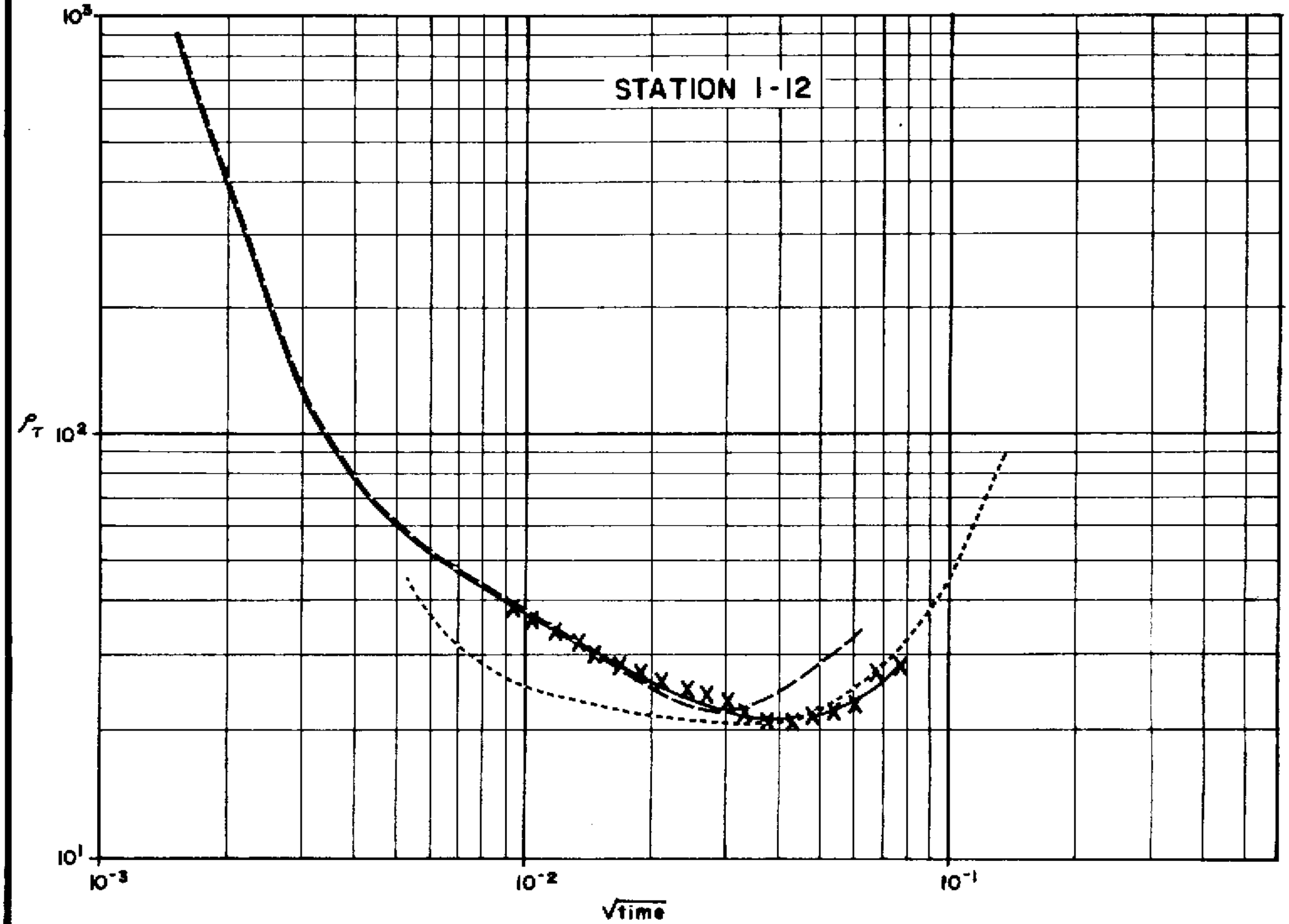
Respectfully submitted

GEO-PHYSI-CON CO. LTD.

Per:

Pieter Hoekstra, Ph.D.,P.Eng.

Calgary, Alberta
June 1981
81-20



Curve 1 (best fit)	$h_1 = 38$, $\rho_1 = 37$ ohm-m $h_2 = 154$, $\rho_2 = 17.5$ ohm-m $\rho_3 = \infty$	
Curve 2	$h_1 = 38$, $\rho_1 = 35$ ohm-m $h_2 = 100$, $\rho_2 = 17.5$ ohm-m $\rho_3 = \infty$	
Curve 3	$h_1 = 192$, $\rho_1 = 21$ ohm-m $\rho_2 = \infty$	

X X Experimental Data Points

De Hoog

GEO·PHYSI·CON

ENGINEERING GEOPHYSICAL CONSULTANTS

COMPARISON OF EQUIVALENCE OF MASTER CURVES

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Figure 61

TABLE 1

Comparison of emf in receiver coil over two stations on sedimentary rock and two stations over volcanic rock (normalized to gain 4)

Station	Rock type	emf, time gates arbitrary units* 1	3	5	7
3-10	sedimentary	5383	2174	809	264
3-8	sedimentary	3826	1504	563	182
3-4	volcanic	1717	1570	191	60
3-2	volcanic	2585	1935	293	75

* Background noise less than 0.5 units

TABLE 2

Comparison of depth to basement from fitting to master curves and from relation 1 at soundings over sedimentary rock along Section 3B

Station	H from master curves	H from relation 1	% difference
3-3	132	123	6.82
3-8	106	119	12.3
3-9	110	115	4.55
3-10	99	103	4.04
3-11	103	101	1.94
3-12	104	101	2.88
3-15	98	104	6.12
3-16	92	104	13.0
3-17	111	99	10.8
3-18	110	101	8.18
3-19	104	97	6.73

TABLE 3

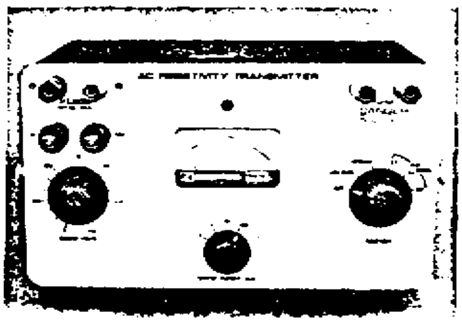
Recommended Use of Surface Geophysical Methods in Support of Coal Exploration

Exploration Objective	Recommended Technique	Auxillary Technique	Estimated Cost	Remarks
Outlining extent and thickness of sedimentary basin, mapping geologic rock boundaries	Transient EM	Deep Schlumberger Soundings	$300 per sounding	Surveys are probably best performed in winter with snow mobile access in the Smithers area. Each sounding requires a slashed walking trail, 400m in length. Schlumberger soundings cannot be performed in winter.
Reconnaissance surveys of near surface rock types to help locate drill holes	Profiling with EM34-3		$300 per kilometre stations every 50m	Surveys require slashed walking trails
Shallow overburden mapping (5-75m), depth to rock, competency of rock	Seismic Refraction Profiling	Schlumberger Soundings	$2000 per kilometre geophone spacing every 20m	Surveys difficult to perform in winter unless survey is along roads cleared of snow
Deep overburden mapping (>50m)	Transient EM	Seismic Refraction Schlumberger Soundings	$300 per sounding	see 1
Fault mapping	Transient EM	Schlumberger Soundings	$300 per sounding	see 1
Mapping coal seams and continuity of seams	?	high resolution, seismic reflection has sometimes worked	$5000 per kilometre	crews require vehicle access

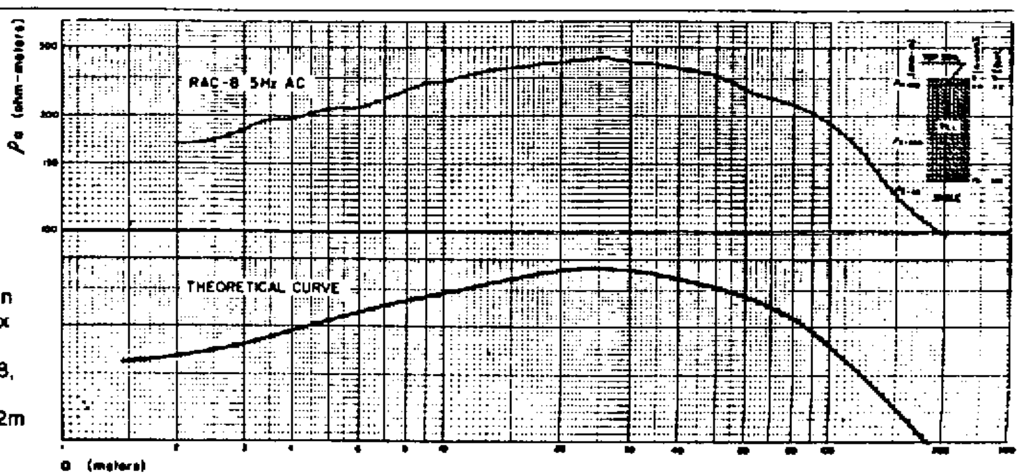
*Estimated costs are inclusive of salaries, equipment rental, meals and lodging, surface transportation in field, data processing and reporting.
Not included are mobilization, demobilization, clearing of survey trails, helicopter transport.

Technical Description of RAC-8 Low Frequency Resistivity System

Complete System	
Measurement Range	.0001 to 10,000 ohms
Accuracy	In range .0001 to .0003 ohms, ±5% In range .0003 to 10,000 ohms, ±2%
Operating Temperature Range	−10° to +50°C
Operating Frequency	5 Hz square-wave
Total Weight	11.8 kg
Receiver	
Range	.0001 to 1.0 volt
Input Impedance	10 Megohms
Instrument Noise	Less than 0.3 microvolt rms (about 1.5 microvolts peak-to-peak) on most sensitive range with input shorted.
Band Width	±0.185 Hz
Powerline Noise Rejection	An applied 50 or 60 Hz disturbance 150 times (43.5 dB) greater than a normal input signal will not affect the reading at any range. Both the signal and disturbance on the input should never exceed 3 V peak to peak in order to maintain accuracy ±2%. When ordering an RAC-8, the purchaser should specify the frequency of powerlines in the proposed survey area. For universal operation, a filter for the other frequency is offered as an option.
Common Mode Noise Rejection	A common mode voltage (applied between case and shorted "INPUT" terminals) of 1 volt peak to peak for a 5 Hz square-wave, or 7 volts peak to peak for a 50-60 Hz sine wave will not affect reading on any range.
Power Supply	Two 6V-1 Ampere-hour Globe GC 610-1 internally mounted, sealed lead acid accumulators. Connector provided for external charger. Batteries provide over 100 hours of operation in field work on a 25% duty cycle.
Dimensions	268 mm x 190 mm x 95 mm
Weight	3.2 kg
Transmitter	
Output Current Levels	0.1, 1, 10, 100, 333 mA, switch selectable
Current Stabilization	0.5%



Output Voltage	Maximum 1000 V peak-to-peak. Actual output voltage depends on the current level and load resistance.
Output Power	Maximum 80 W
Operating Frequency	5 Hz square-wave
Operating Position	Transmitter must be operated vertically within ±30° maximum. For transportation this is not required and instrument can be stored in any position.
Protection	Automatic circuit breaker turns off when the load on the "OUTPUT" terminals is interrupted, or if it is shorted while voltage is set over 60 V.
Load Precautions	Not more than one fully wound reel of wire (1000 m, inductance ±0.2 Henry) can be in series with the transmitter load, in order not to affect measuring accuracy. With large electrode separations (several km) no reeled wire should be in the transmitter circuit, particularly if a high current level is required, to prevent inductive surges.
Power Supply	The power supply is composed of two independent battery sets mounted in a common detachable compartment, which is attached to the bottom of the transmitter housing. Set No. 1: Two 6 V — 1 Ampere-hour Globe GC610-1 sealed lead-acid accumulators providing a supply for electronic circuits of the constant current regulator. Capacity is sufficient for over 100 hours of operation in the field. Set No. 2: Two 6 V — 6 Ampere-hour Globe GC660-1 sealed lead-acid accumulators providing a main power supply with 80 W maximum. This battery set limits actual field work duty of the instrument to maximum 40 hours.



enner array depth sounding using RAC-8 in electrically noisy industrial area near Scintrex plant in Concord, Ontario. The section is interpreted as a 3 layer case with ρ_1 = 158, ρ_2 = 290 and ρ_3 = 55 ohm-meters. The upper layer is 2.8 m of topsoil followed by 72m of till overlying shale.

TERRAIN CONDUCTIVITY METERS

ONE MAN - CONTINUOUS READING

EM31

The Geonics EM31 provides a measurement of terrain conductivity without contac- the ground using a patented inductive electromagnetic technique. The in- nent is direct reading in millimhos per meter and surveys are carried out simply by traversing the ground.

T tive depth of exploration is approximately six meters making it ideal for g geophysics. By eliminating ground contact, measurements are easily neu out in regions of high resistivity such as gravel, permafrost and bedrock. Over a uniform half space the EM31 reads identically with conventional resistivity and the measurement is analogous to a conventional galvanic resistivity survey a fixed array spacing. Interpretation curves supplied with each instrument permit an estimate of a layered earth.

The advantages of the EM31 are the speed with which surveys can be carried out, ability to precisely measure small changes in conductivity, and the continuous out which provides a previously unobtainable lateral resolution.

Specifications

ASURED QUANTITY	Apparent conductivity of the ground in millimhos per meter.
ARY FIELD SOURCE	Self-contained dipole transmitter
SOR	Self-contained dipole receiver
NTERCOIL SPACING	3.66 meters
PERATING FREQUENCY	9.8 kHz
ER SUPPLY	8 disposable alkaline 'C' cells (approx. 20 hrs life continuous use)
CONDUCTIVITY RANGES	3, 10, 30, 100, 300, 1000 mmhos/meter
SUREMENT PRECISION	±2% of full scale
SUREMENT ACCURACY	±5% at 20 millimhos per meter
NOISE LEVEL	<0.1 millimhos per meter
PERATOR CONTROLS	● Mode Switch ● Conductivity Range Switch ● Phasing Potentiometer ● Coarse Inphase Compensation ● Fine Inphase Compensation
NSIONS	Boom : 4.0 meters extended, 1.4 meters stored Console : 24 x 20 x 18 cm Shipping Crate : 155 x 42 x 28 cm
GHT	Instrument Weight : 9 kgm Shipping Weight : 23 kgm

TWO MAN - VARIABLE DEPTH

EM34-3

Operating on the same principles as the EM31, the EM34-3 is designed to achieve a substantially increased depth of exploration and a readily available vertical conductivity profile.

The underlying principle of operation of this patented non-contacting method of measuring terrain conductivity is that the depth of penetration is independent of terrain conductivity and is determined solely by the instrument geometry i.e. the intercoil spacing and coil orientation. The EM34-3 can be used at three fixed spacings of 10, 20, or 40 meters and in the vertical coplanar (as shown) or horizontal coplanar mode. In the vertical coplanar mode, the instrument senses to approx. 0.75 of the intercoil spacing. In the horizontal coplanar mode, the instrument can sense to 1.5 times the intercoil spacing. For the horizontal coplanar mode, however, coil misalignment errors are more serious than in the vertical mode so greater care must be exercised to achieve the maximum 60 meter depth.

Simple operation, survey speed and straight forward data interpretation makes the EM34-3 a versatile and cost effective tool for the engineering geophysicist.

Specifications

MEASURED QUANTITY	Apparent conductivity of the ground in millimhos per meter
PRIMARY FIELD SOURCE	Self-contained dipole transmitter
SENSOR	Self-contained dipole receiver
REFERENCE CABLE	Lightweight, 2 wire shielded cable
INTERCOIL SPACING & OPERATING FREQUENCY	● 10 meters at 6.4 kHz ● 20 meters at 1.6 kHz ● 40 meters at 0.4 kHz
POWER SUPPLY	Transmitter : 8 disposable 'D' cells Receiver : 8 disposable 'C' cells
CONDUCTIVITY RANGES	3, 10, 30, 100, 300 mmhos/meter
MEASUREMENT PRECISION	±2% of full scale deflection
MEASUREMENT ACCURACY	±5% at 20 millimhos per meter
NOISE LEVEL	< 0.2 millimhos per meter
DIMENSIONS	Receiver Console : 19.5 x 13.5 x 26cm Transmitter Console : 15 x 8 x 26cm Coils : 63cm diameter
WEIGHTS	Receiver Console : 3.1 kg Receiver Coil : 3.2 kg Transmitter Console : 3.0 kg Transmitter Coil : 6.0 kg Shipping Weight : 41. kg

EM37 Ground Transient Electromagnetic System Technical Specifications

Transmitter

Current Waveform	- See Fig. 1
Repetition rate	- 3Hz or 30Hz in countries using 60Hz power line frequency; 2.5Hz or 25Hz in countries using 50Hz power line frequency; all four base frequencies are switch selectable.
Turn-off time (Δt)	- fast linear turn-off of maximum 300 μsec. at 20 amps into 300x600m loop. Decreases proportionally with current and $(\text{loop area})^{1/2}$ to minimum of 20 μsec. Actual value of Δt read on front panel meter.
Transmitter loop	- any dimensions from 40x40m to 300x600m maximum at 20 amps. Larger dimensions at reduced current. Transmitter output voltage switch adjustable for smaller loops. Value of loop resistance read from front panel meter; resistance must be greater than 1 ohm on lowest voltage setting to prevent overload.
Transmitter protection	- circuit breaker protection against input overvoltage; instantaneous solid state protection against output short circuit; automatically resets on removal of short circuit. Input voltage, output voltage and current indicated on front panel meter.
Transmitter output voltage	- 150 volts (zero to peak) maximum; 20 volts (zero to peak) minimum
Transmitter output power	- 2.8 kw maximum
Transmitter wire supplied	- 1800m. #10 copper wire PVC insulated with nylon jacket; transmitter wire contained on 6 reels (supplied); 2 reel winders supplied.
Transmitter motor generator	- 5 HP Honda gasoline engine coupled to 120 volt, 3 phase, 400Hz alternator. Approximately 8 hours continuous operation from full (built-in) fuel tank.

Receiver

Measured quantity	-	time rate of decay of magnetic flux along 3 axes.
Sensors	-	two air cored coils of bandwidths 11 and 50 kHz respectively; each 66cm dia.x4x5cm cross-section. Low frequency coil for general use, high frequency coil for shallow sounding.
Time channels	-	20 time channels with locations and widths as shown in Fig. 2. Successive operation at 30Hz, then 3Hz, effectively gives 30 channels covering range from 80 μsec. to 80 msec.
Output display	-	4 figure digital LED plus sign; display also shows channel number and gain.
Integration time	-	2^n cycles at 30Hz; n=4,6,8,10,12,14 (switch selectable); similar integration times at other base frequencies.
Receiver noise	-	approximately 1.5×10^{-10} volt/m^2/turn of receiver coil at last gate at 30Hz with integration time of 34 seconds. Noise will be higher during intense local spherics activity.
Output connector	-	all 20 channels available in analogue format from output connector at 5 volts fsd level.
Synchronization to Tx	-	any of the following (switch selectable) (1) reference cable (2) primary pulse (3) 27 MHz radio link (40 channels) (4) high stability (oven controlled) quartz crystals.
Noise rejection circuitry	-	with any of (1)-(3) above, entire system is automatically synchronized to 50/60Hz power line frequency when such interference exists in survey area; selective clipping of atmospheric noise pulses at all times. Audio output of Rx coil (transmitter pulse blanked out) is available on built-in loud speaker for ready identificatio of interference.
Receiver batteries	-	12 volt rechargeable Gel-cells; either 9 hours continuous operating time at 17°C (battery weight

Receiver - Cont'd

Receiver batteries (continued) - battery weight 7.6 kg, 20 amp hour) or 2.5 hours continuous operating time (battery weight 2.6 kg, 6 amp hour). Two sets of batteries and a battery charger supplied to permit charging of spare set from transmitter motor-generator during survey.

Delivered Items

EM37 Ground Transient System consists of the following delivered items:

1 Transmitter Console

1 Transmitter ground power unit (GPU) consisting of motor and alternator

6 Reels transmitter wire

2 Reel winders

1 Receiver Console including batteries (specify amp-hours desired)

2 Receiver coils

1 Spare set receiver batteries

1 Battery charger

1 Set interconnecting cables

1 Set shipping boxes

2 Instruction and data interpretation manuals

LIST PRICE: (FOB Ex-factory).....$65,000.00 CDN

October, 1980

Component Dimensions

Transmitter Console	25x42x36 cm
GPU	35x74x48 cm
Wirewinder	42x38x35 cm each (2 off)
Wire reels (20 amp)	33x31(dia.)cm each (6 off)
Receiver Console	38x37x27 cm
Receiver coils	66 cm dia. 4x5 cm cross-section

Component Weights

Transmitter Console	20 kg
GPU	60 kg
Wirewinders and loaded reels (20 amp)	120 kg (total)
Receiver Console (incl.20 amp-hour battery)	21.8 kg
Receiver coils	4.1 kg (each)

Shipping Information

Shipment consists of 4 boxes

Two wire boxes	116x62x48 cm @ 186 kg (total)
GPU box	96x61x73 cm @ 90 kg
Receiver/transmitter box	96x75x73 cm @ 86 kg
Total shipping volume	1.65 cubic metres
Total shipping weight	362 kg

VLF EM

EM16

One of the most popular and widely used electromagnetic instruments, the EM16 VLF receiver makes the ideal reconnaissance EM. This can be attributed to its field reliability, operational simplicity, compactness and mutual compatibility with other reconnaissance instruments such as portable magnetometers and radiometric detectors.

The VLF method of EM surveying, pioneered by Geonics, has proven to be a simple economical means of mapping geological structure and fault tracing. The applications are many and varied, ranging from direct detection of massive sulphide conductors to the indirect detection of precious metals and radioactive deposits.

ATURES

- The EM16 is the only VLF instrument that measures the quad-phase as well as the in-phase secondary field. This has the advantage of providing an additional piece of data for a more comprehensive interpretation and also allows a more accurate determination of the tilt angle.
- The secondary fields are measured as a ratio to the primary field making the measurement independent of absolute field strength.
- The EM16 is the only VLF receiver that can be adapted to measure VLF resistivity.

Specifications

MEASURED QUANTITY	In-phase and quad-phase components of vertical magnetic field as a percentage of horizontal primary field. (i.e. tangent of the tilt angle and ellipticity)
SENSITIVITY	In-phase : ±150% Quad-phase : ± 40%
RESOLUTION	±1%
OUTPUT	Nulling by audio tone. In-phase indication from mechanical inclinometer and quad-phase from a graduated dial.
OPERATING FREQUENCY	15-25 kHz VLF Radio Band. Station selection done by means of plug-in units.
OPERATOR CONTROLS	On/Off switch, battery test push button, station selector switch, audio volume control, quadrature dial, inclinometer.
POWER SUPPLY	6 disposable 'AA' cells
DIMENSIONS	42 x 14 x 9 cm
WEIGHT	Instrument: 1.6 kg Shipping : 5.5 kg

VLF RESISTIVITY METER

EM16R

A simple, button-on attachment to the EM16 converts it to a direct reading terrain resistivity meter. The EM16R attachment interfaces a pair of potential electrodes to the EM16 enabling the measurement of the ratio of, and the phase angle between, the horizontal electric and magnetic fields of the plane wave propagated by distant VLF radio transmitters.

The EM16R is direct reading in ohm-meters of apparent ground resistivity. If the phase angle is 45°, the resistivity reading is the true value and the earth is uniform to the depth of exploration (i.e. a skin depth). Any departure from 45° of phase indicates a layered earth. Two layer interpretation curves are supplied with each instrument to permit an interpretation based on a two layer earth model.

This highly portable resistivity meter makes an ideal tool for quick geological mapping and has been used successfully for a variety of applications.

- Detection of massive and disseminated sulphide deposits
- Overburden conductivity and thickness measurements
- Permafrost mapping
- Detection and delineation of industrial mineral deposits
- Aquifer mapping

Specifications

MEASURED QUANTITY	• Apparent Resistivity of the ground in ohm-meters • Phase angle between E_x and H_y in denrees
RESISTIVITY RANGES	• 10 — 300 ohm-meters • 100 — 3000 ohm-meters • 1000 — 30000 ohm-meters
PHASE RANGE	0-90 degrees
RESOLUTION	• Resistivity : ±2% full scale • Phase : ±0.5°
OUTPUT	Null by audio tone. Resistivity and phase angle read from graduated dials.
OPERATING FREQUENCY	15-25 kHz VLF Radio Band. Station selection by means of rotary switch.
INTERPROBE SPACING	10 meters
ROBE INPUT IMPEDANCE	100 MΩ in parallel with 0.5 picofarads
DIMENSIONS	19 x 11.5 x 10 cm. (attached to side of EM16)
WEIGHT	1.5 kg (including probes and cable)