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THE LOVISA PROJECT

1985-1986

(Volume 1)

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Håksberg 1987-04-13

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SUMMARY AND RECOMMENDATIONS

Reassessment of older drill data in early 1985 led LKAB-BPMIL Stråssa Project leader Stig Bjurstedt and geologist Hans Persson to initiate a drilling programme, south-west of the abandoned Lovisa iron-ore mine/trial, in May 1985. Drilling intersected massive, sphalerite rich, zinc-lead-silver sulphide mineralisation which has been investigated by ground geophysics and diamond drilling during 1985-1986.

All drillcores were re-logged during autumn 1986 (by CJC) and detailed geological investigations carried out to better understand the nature of the mineralisation and its economic potential.

To end 1986, 46 diamond drillholes have been completed in the project area, totalling 8696.05 m. Thirty of these holes intersect a characteristic sequence of lithological units including a zone containing massive, laminated and veinlet zinc-lead-silver sulphides. An earlier drillhole, drilled in late 1962 by Ställbergsbolagen for iron ore, (Jönshyttan No 8.) also intersects the same mineralisation.

The sulphides occur in layers 0.5-1.00 m thick, occasionally up to 2.00 m thick. These are spread over a vertical thickness of 15 m within the host rocks, but the main concentration, as 2-3 massive and banded sulphide layers, averages 6.00 m in thickness.
The mineralisation always lies within the same lithological unit, overlain and underlain by a characteristic lithological sequence. It forms a sheet, dipping at 56-60^{o} E, and drill indicated over a strike length of 1,100 m to a maximum tested vertical depth of 425.00 m.

Drilling on the northern extension of the mineralisation intersected the footwall sequence, while to the south the holes stopped in the hangingwall, above the deposit.

The mineralisation is therefore untested and open to the north and south, and is still present at 425 m depth to the east being open also in this direction. To the west it may be repeated by tectonics and has been only partly tested. The sulphides appear folded around and parallel to an S_1 foliation, are cut and folded around an S_2 foliation, appear to predate the main tectonic and metamorphic events and be remobilised by them into massive lithoclastic "ball-ores" and veinlet sulphides.

Mineralogy is simple, dominantly pale beige brown, pale brown or red-brown sphalerite with a low iron content (mean 2wt % Fe). Galena and pyrite form the main subordinate minerals. Minor chalcopyrite, sphene, rutile and native silver occur, and trace arsenopyrite, pyrrhotite, chalcocite, cerussite, pyrargyrite, freibergite, dyscrasite, argentite, molybdenite and cobaltite are noted. Quartz and feldspar form the main non-metallic components, with minor graphite, chlorite and biotite and trace fluorite, tourmaline and scapolite.

Metal grades are variable but high, with metal contents in the range: Zn 1-29.6%, Pb 0.5-20.0% and Ag 2-120 g/t.

Preliminary ore calculations at the end of 1985 gave a drill indicated reserve of about 650,000 tonnes of 8% Zn, 3% Pb and 20 g/t Ag. Drilling in 1986 has increased this to 1.65 million tonnes of 14.60% Zn, 5.10% Pb, 21 g/t Ag or 2.50 million tonnes of 5.5% Zn, 2.00% Pb. The mineralisation is easily milled, and beneficiation bench tests suggest that a collective flotation process as currently used at the Zinkgruvan mill on zinc rich fine grained ores, would be most suitable for the Lovisa mineralisation.

A magnetite-skarn zone, occurring parallel to and 40-50 m below the main sulphide horizon, contains a sporadic sulphide mineralisation with up to 4% Pb and 320 g/t Ag. It appears to have limited tonnage potential.

It is concluded that potential exists at Lovisa for an economic massive sulphide deposit, and that definition of the limits of mineralisation will identify a mineable tonnage-grade zinc-lead-silver deposit, of relatively simple mineralogy amenable to beneficiation.

It is recommended that:

1. Further drilling be undertaken to define the limits of potentially mineable, economic mineralisation, and 'infill' between existing and planned holes to permit tighter geological, technical and grade control over the deposit.

2. Drilling to test the northern, southern and easterly depth extensions, guided, as in 1985-86 by ground geophysics and existing drill data.

3. Re-logging of the Nya Backadahl zone drillcore to assess the possibility of the target zone being repeated tectonically to the east.

4. The use of lithogeochemistry to define the chemical signature of the target mineralised zone and indicate the possibility of using any 'halo-effects' as an exploration tool.

5. Additional ground geophysics, particularly dipole-dipole array IP surveys, to identify the position of the mineralisation at shallow depth and aid selection of drill targets.

6. Reassessment of standardised, diurnally corrected total field magnetic ground survey data in the light of the geological observations from drilling to better define the bedrock structure and position of the mineralised target zone.

A separate work proposal has already been produced (Carlon and Bjurstedt 1986), Appendix 6. This report, which covers all the main aspects of the geology and mineralisation is presented to compliment the geophysical report on Lovisa produced by Anders Engvall, Report No: B 86-17.

The data for the Lovisa Project is presented in two volumes:

Volume 1 (this volume) describes the project background, the exploration undertaken prior to and during the period 1985-86 and the nature of the geology and mineralisation in the Lovisa discovery area as currently understood (January 1987). In addition, the main conclusions from bench test beneficiation ore trials and initial ore calculations are presented.

Volume 2 presents summary drill logs for all 46 1985-86 drillcores, including the 1962 Jönshyttan No 8 and 9 holes, and notes the main features and intersections of each drillhole.

Additional references and appendices complete the data, and are given in Volume 1 (this volume).

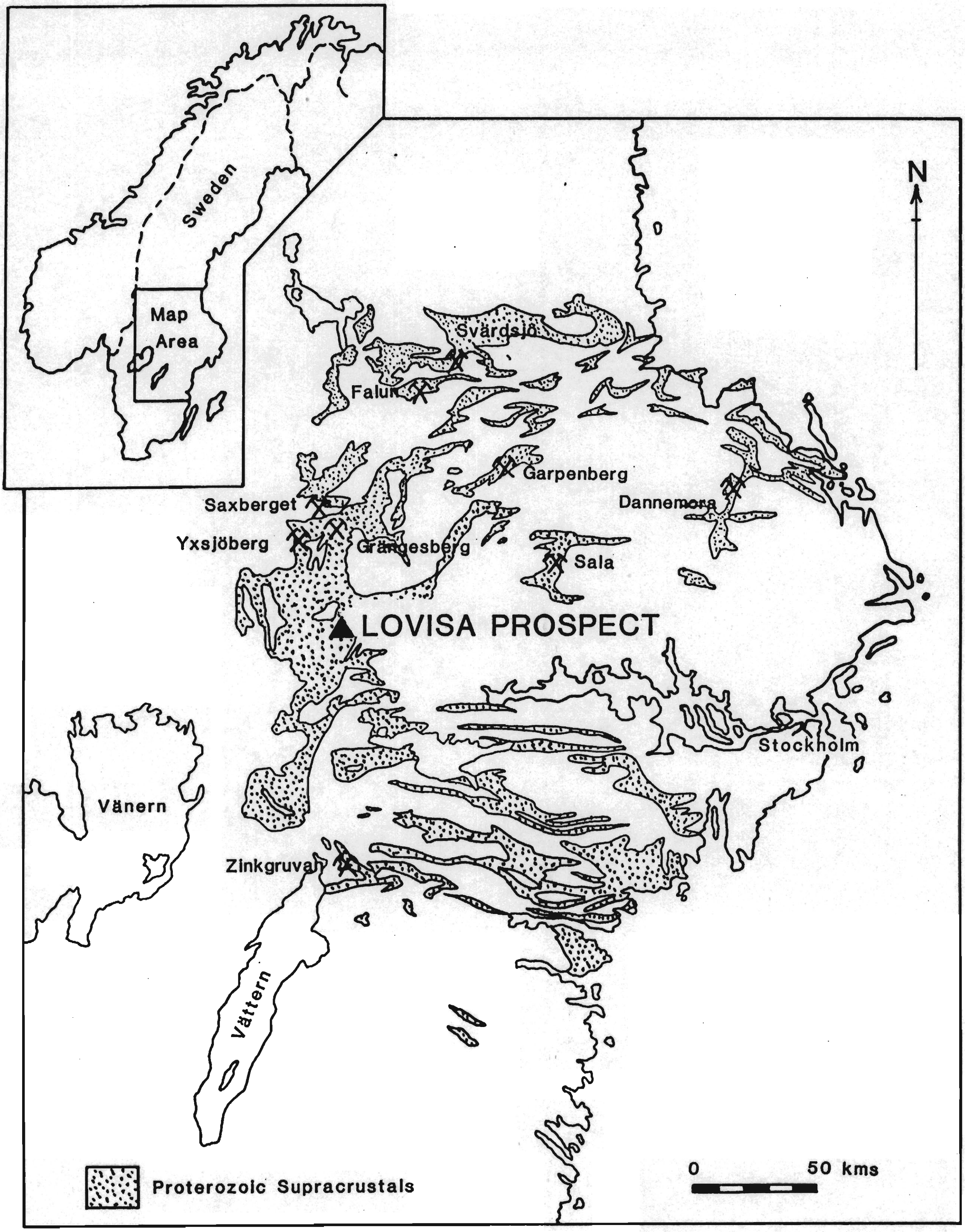

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Fig.1

LOVISA PROSPECT - Regional Location

Author CJCarlon	Date Jan 1987
Revised	

A 1 INTRODUCTION

1.1 Project Background

LKAB Prospektering began exploration in the L. Proterozoic supracrustal sequence extending SW from Stråssa to Nora, in the early 1980's. Mining claims and data were obtained from Svenskt Stål (SSAB) in 1980. Aimed at investigating argentiferous, lead rich sulphide mineralisation to supply to the AB Statsgruvor Stollberg Mine, exploration was centred on known sulphide occurrences spatially associated with magnetite horizons.

Drilling commenced in 1982, testing initially the magnetite zone at the abandoned Nya Backadahl mine east of Storå, and to the SW in the Fanthyttan area at Siggeboda (Figs 1. and 2). In 1983 the area was incorporated into the BPMIL-LKAB Joint Venture as the Nora-Stråssa Project area. Drilling was then underway at Nya Backadahl, and in November 1983 re-commenced in the Siggeboda area at the Leja prospect, the target being zinc-silver mineralisation.

In 1982 a drillhole was sited at the abandoned Lovisa iron mine-trial, to test the magnetite-diopside 'skarn' occurring there, interpreted as the western continuation of the folded Nya Backadahl skarn-magnetite-sulphide zone. As no argentiferous mineralisation was noted, no further work was undertaken until August 1984 when a second hole was drilled, but this also proved negative, drilling into a diabase dyke.

Following mapping and logging of older drillhole material in late 1984 - early 1985 a 3 hole drilling programme was commenced in May 1985, to test the southern continuation of the Lovisa magnetite horizon. Holes were sited on a target defined by ground magnetics. This programme intersected a massive Zn-rich mineralisation subsequently investigated throughout the remainder of 1985 and 1986, and the subject of this report.

1.2 Location

The Lovisa zinc-lead-silver discovery is situated in W.Bergslagen, Central Sweden (fig. 1), 45 kms due south of Ludvika and 170 kms WNW of Stockholm. It lies in the former iron mining area around Stripa, Storå and Stråssa, and is adjacent to the Håkansboda Project area of the BPMIL-LKAB Joint Venture (Report No: B 86-7 Håkansboda 1986), in the Nora-Stråssa area (fig. 2).

The mineralisation occurs in L.Proterozoic supracrustal rocks under complete glacial cover, in a forested area on the eastern flank of the Storå valley, 2 kms east of Storå village at a height of 140 m a.s.l. Neither the mineralisation nor its host bedrock is exposed in the discovery area, and traces of mineralisation as boulders in the overlying glacial overburden have not been found and are previously unrecorded.

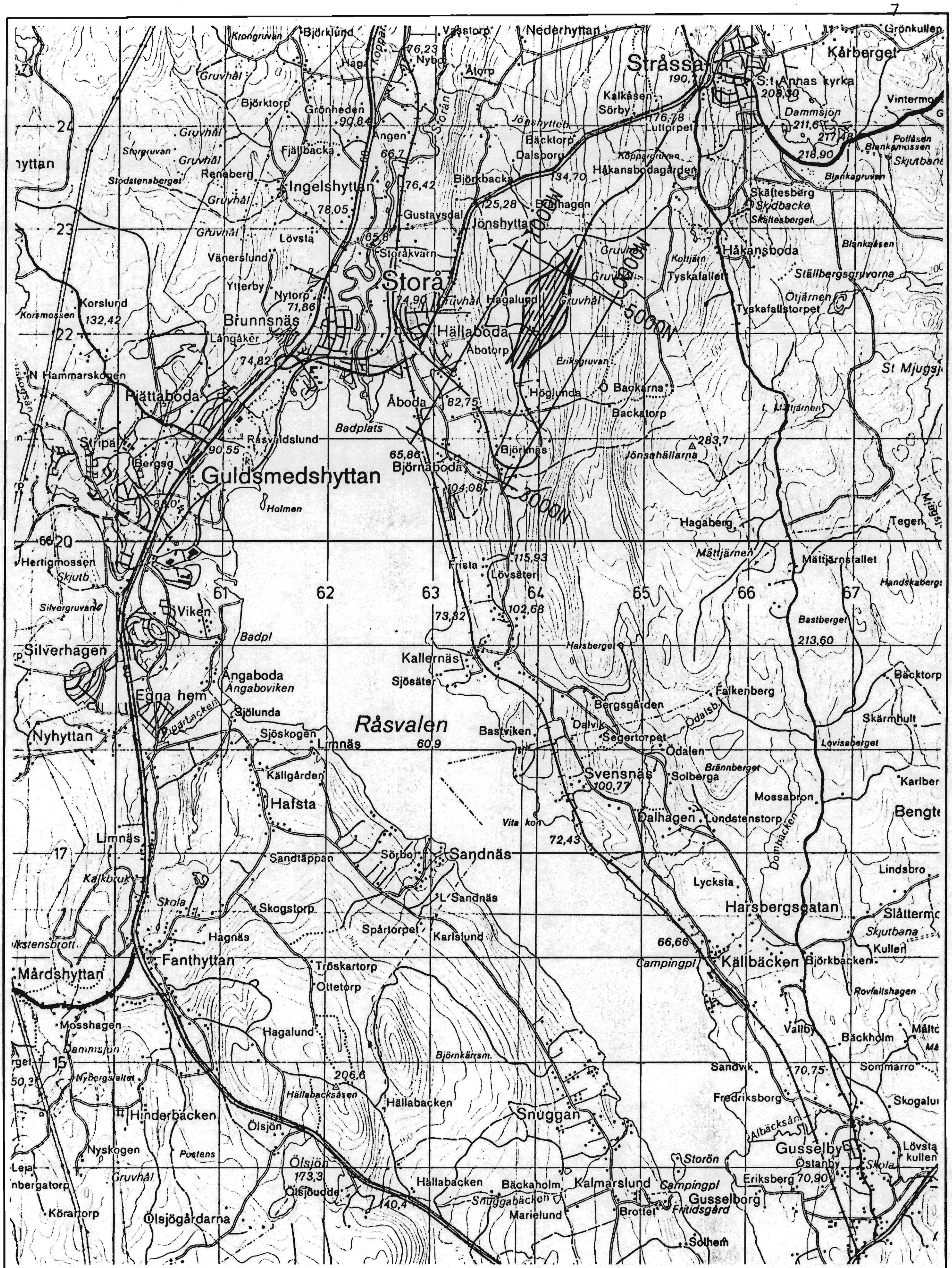
The main rail and road (RV60) links between Örebro to the south, and Ludvika, Falun and Gävle to the north, run through the Storå valley, immediately west of the discovery.

The prospect is located on topographic map sheets 11F SV (Lindesberg) at 1:50,000 scale, and economic map sheet 11F 4c at 1:10,000 scale.

1.3 Current land holding

The site of the discovery mineralisation and a large area around it are covered by exploration licences (inmutningar), held by the JV partners on a 50%-50% basis, BPMIL-LKAB. In addition LKAB owns a number of mining licences (utmål) purchased from Svenskt Stål (SSAB) in 1980.

Land holding is shown in Fig. 3 and listed in Table 1. There is no competitor activity in the area.



0 1 2

kilometres

Area currently known from drilling to be underlain by the Lovisa sulphide zone

Note also the position of Lovisa Grid lines: 0000W (origin) and 1000W ; 3000N and 5000N

BP MINERALS INTERNATIONAL LTD	
Fig.2.	
LOVISA PROSPECT - Area location	
Author CJ Carlon	Date Jan 1987
Revised	

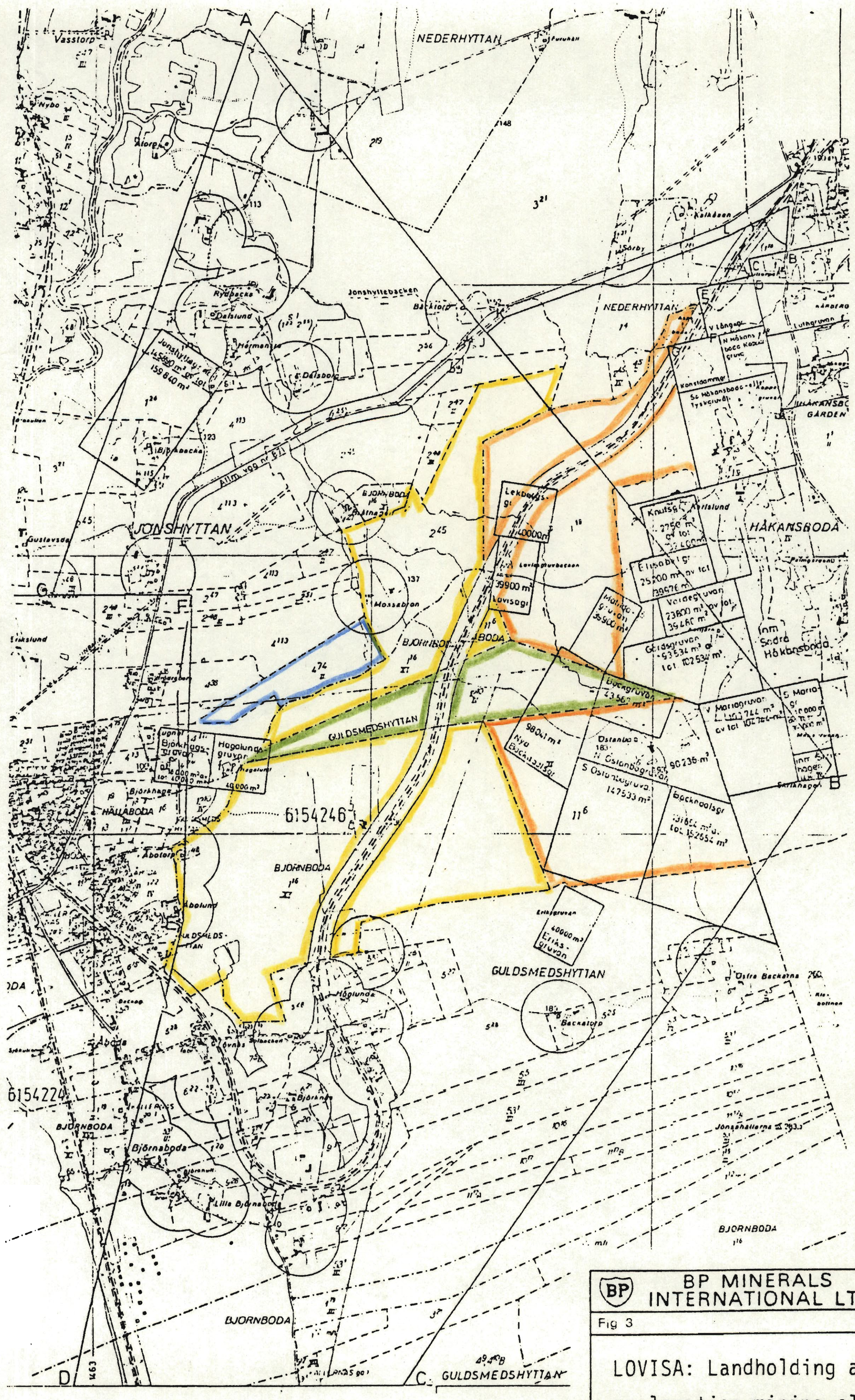


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Fig 3

LOVISA: Landholding and exploration-mining claims

Author CJCarlon | Date Jan 1987

Revised

TABLE 1: LOVISA - Landholding and claims

A. Landowners

Västerås Kyrkliga Samfällighet
Stiftsnämnden i Västerås
Karin Nordfeldt-Elvenfalk och
Karl-Gunnar Elvenfalk
Doris Alfredsson

B. Mining claims (utmål)

Name	Owner	Expiry
Björkhagsgruvan	LKAB/PAB	1999-12-31
Hagalundsgruvan	-"-	-"-
Lekbergsgruvan	-"-	-"-
Lovisagruvan	-"-	-"-
Nya Backadahlgruvan	-"-	-"-
Eriksgruvan	-"-	-"-
Matildagruvan	-"-	-"-
Bäckgruvan	-"-	-"-
N. Östanbogruvan	-"-	-"-
S. Östanbogruvan	-"-	-"-

C. Exploration claims (inmutningar)

Leja 3 (area A-G)	LKAB-BPMIL	1990-03-27
Leja 4 (area A-L)	-"-	1987-10-26

A 2 BPMIL-LKAB EXPLORATION

2.1 Exploration prior to 1985

Numerous small sulphide occurrences are known in the Stråssa-Storå area, usually associated with massive and disseminated magnetite in diopside-amphibole-garnet layers ('skarns') of variable mineralogy. Copper-iron sulphides occur in mafic serpentinised porphyroblastic, dolomite-calcite marble. The sulphide mineralisation at Håkansboda (Carlon 1986a, 1986b), the largest known deposit in the area prior to the Lovisa discovery, is of the marble hosted type.

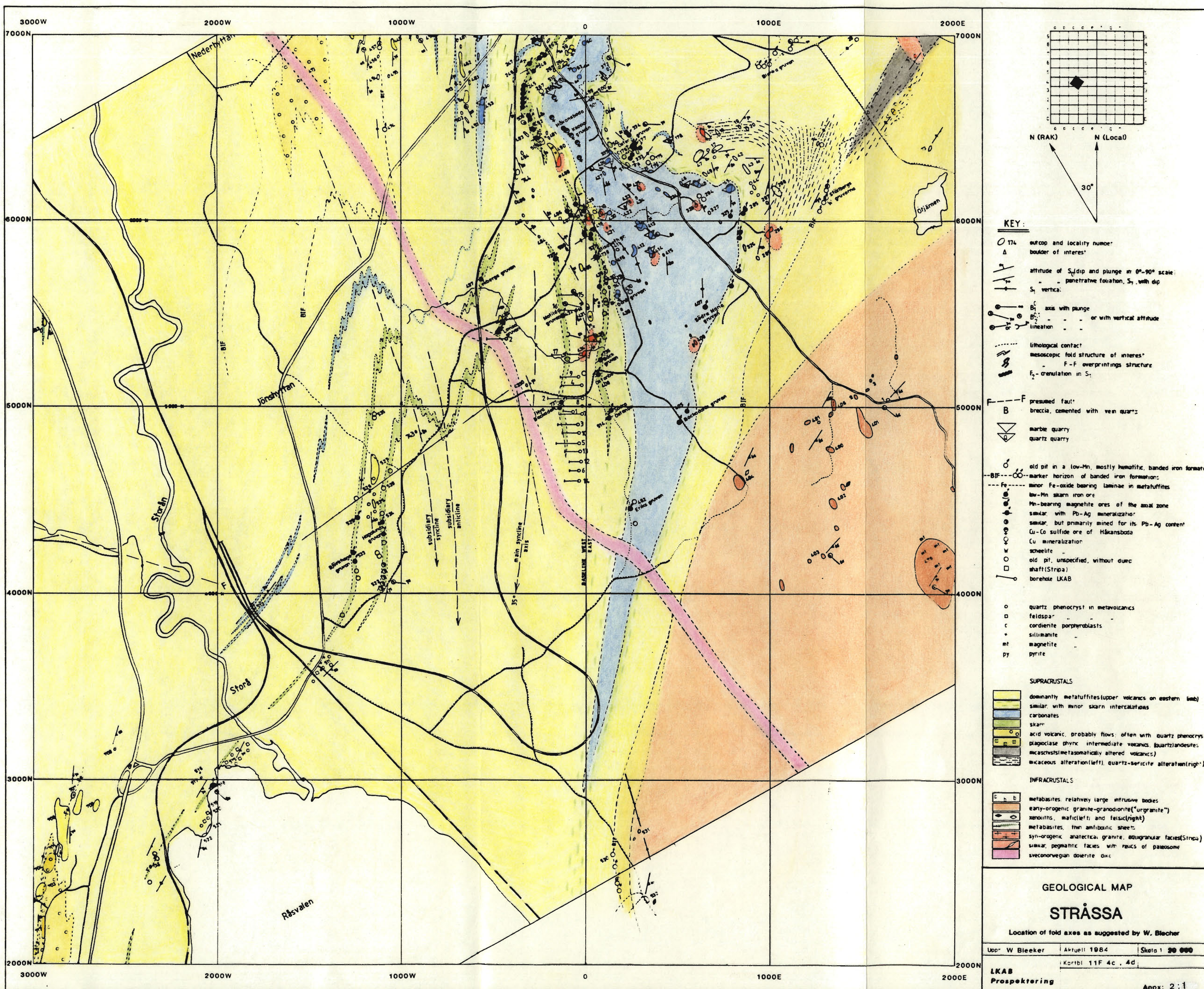
Exploration during the 1950's and 60's was concentrated on the magnetite 'skarn' horizons as targets for large iron ore bodies. Mining was then underway at the Stripa and Stråssa iron ore deposits, and Stora Kopparberg, Gränges International Mining and the Ställbergs Company explored the area during this period. Gränges also undertook regional prospecting in the 1960's and early 1970's specifically for base metal sulphides. In the Stripa-Stråssa area airborne magnetic and limited helicopter EM surveys were made, but not airborne INPUT EM surveying as elsewhere in Bergslagen during their 1970's exploration.

Regional exploration data available in the early 1980's was rather limited. A geological map, regional magnetic map, structural interpretation and short description was published by SGU in 1983 (Lundström 1983). Geological mapping was based essentially on the work of Koark and collegues made in the 1960's for Gränges.

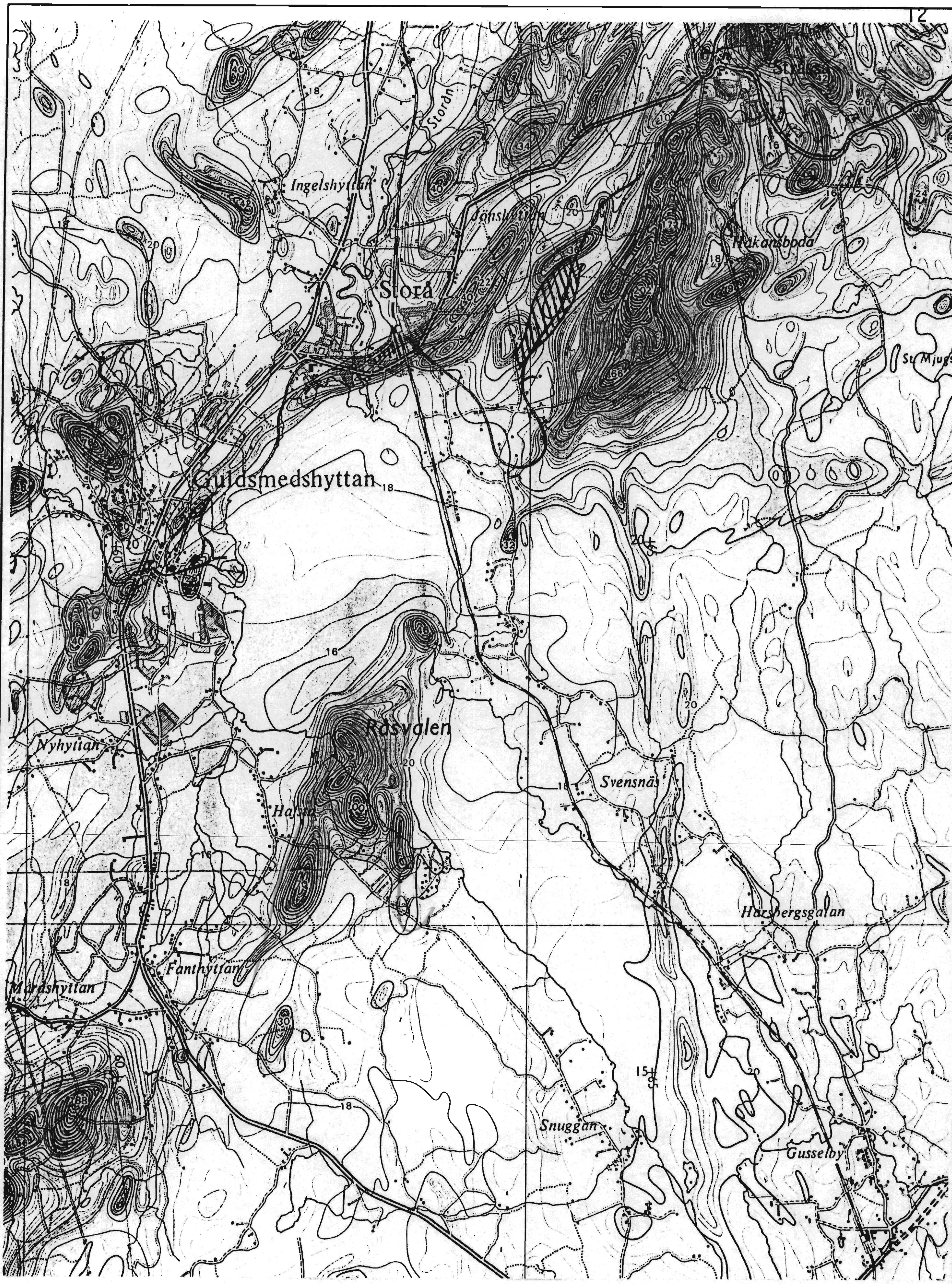
LKAB Prospektering reviewed all regional exploration, airborne magnetic, EM, and ground geological data, undertook ground investigations and reached agreement with SSAB (Svenska Stål) for the acquisition in 1980 of 38 mining licences over old and abandoned mine workings.
Examination of available data identified several targets in the magnetite-skarn zones as hosts for sulphide mineralisation. Investigation of dump material indicated a widespread association of pyrrhotite-pyrite-trace chalcopyrite with magnetite, and in specific cases, galena-silver mineralisation with or without sphalerite. Occurrences of argentiferous galena mineralisation were identified in the Håkansboda area, at Nya Backadahl and further to the SW in the Siggeboda and Leja areas, all associated with manganiferous "skarn-magnetite" horizons.

Drilling was commenced at Nya Backadahl in 1982 and at Siggeboda later in the same year. One hole, drilled at the site of the old Lovisa pit, intersected two magnetite-skarn-marble horizons, but neither contained lead-silver mineralisation.

In 1983 the area was included in the BPMIL-LKAB JV as the Nora-Stråssa Project. Drilling continued at Nya Backadahl, and in November 1983 commenced at Leja on a zinc-silver mineralisation. During summer 1983 Dutch geologist Wouter Bleeker was employed to map the Stråssa-Torrsjöboda area. He continued mapping westwards over Håkansboda, Lovisa and Guldsmedshyttan during summer 1984.



3000W
2000W
1000W
0
1000E
2000E
7000N
6000N
5000N
4000N
3000N
2000N
Nederbyttan
Jönshyttan
Storån
Storå
Råsvalen
Ojärnen
BIF
subsidiary syncline
subsidiary anticline
main syncline axis
BASELINE WEST EAST
N (RAK)
N (Local)
30°
KEY:
outcrop and locality number
boulder of interest
attitude of S_0 (dip and plunge in 0°–90° scale)
penetrative foliation, S_1, with dip
S_1 vertical
B_1^C axis with plunge
B_2^C or with vertical attitude
lineation
lithological contact
mesoscopic fold structure of interest
F-F overprintings structure
F_2-crenulation in S_1
presumed fault
breccia, cemented with vein quartz
marble quarry
quartz quarry
old pit in a low-Mn, mostly hematitic, banded iron formation
marker horizon of banded iron formations
minor Fe-oxide bearing laminae in metatuffites
low-Mn skarn iron ore
Mn-bearing magnetite ores of the axial zone
similar, with Pb-Ag mineralization
similar, but primarily mined for its Pb-Ag content
Cu-Co sulfide ore of Håkansboda
Cu mineralization
scheelite
old pit, unspecified, without dump
shaft (Stripa)
borehole LKAB
quartz phenocryst in metavolcanics
feldspar
cordierite porphyroblasts
sillimanite
magnetite
pyrite
SUPRACRUSTALS
dominantly metatuffites (upper volcanics on eastern limb)
similar, with minor skarn intercalations
carbonates
skarn
acid volcanic, probably flows; often with quartz phenocrysts
plagioclase phyric intermediate volcanics, (quartz)andesites
micaschists (metasomatically altered volcanics)
micaceous alteration (left), quartz-sericite alteration (right)
INFRACRUSTALS
metabasites, relatively large intrusive bodies
early-orogenic granite-granodiorite ("urgranite")
xenoliths, mafic (left) and felsic (right)
metabasites, thin amfibolitic sheets
syn-orogenic anatectical granite, equigranular facies (Stripa)
similar, pegmatitic facies with relics of paleosome
sveconorvegian dolerite dike
GEOLOGICAL MAP
STRÅSSA
Location of fold axes as suggested by W. Blecher
Uppr W Bleeker
Aktuell 1984
Skala 1 20 000
Kortbl 11F 4c, 4d
LKAB Prospektering
Appx: 2:1



Regional magnetic map at 1:50,000 scale
Area shown is the same as fig 2.

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Fig.5	
LOVISA PROSPECT - Regional Magnetic Map	
Author CJCarlon	Date Jan 1987
Revised	

Drilling resumed at Backadahl in 1984, with completion of a further 8 holes. In August 1984 a second hole was drilled at Lovisa to test the magnetite-skarn zone for sulphides. Unfortunately this hole ran into a diabase dyke at 21.60 m downhole and an attempt to drill through the dyke failed. The hole stopped at 139.80 m still in diabase.

The lack of outcrop and detailed geophysical data in the Lovisa area led Bleeker (1984) to base his interpretation of the geology on the regional 1:50,000 magnetic map and the SGAB 1983 magnetic data (1:10,000) and extrapolate structures mapped in outcrops to the east and west. Bleekers map for the Lovisa area is shown in fig. 4. The regional magnetics in fig. 5.

Ground magnetic surveying was extended from Nya Backadahl over and to the SW of Lovisa defining the positions of known magnetite-skarn zones in the Lovisa and Storå area. Assessment of this and SGAB magnetic data by A. Engvall and the geological data by S. Bjurstedt and H. Persson led to the re-logging of the Ställbergsbolagen 1962 Jönshyttan No 8 drillcore. The structure of the Lovisa area was subsequently re-defined (Engvall 1985). (See Section 3.4.2).

Logging of the Jönshyttan No 8 drillcore noted massive magnetite and diopside-garnet 'skarn' at a downhole depth of 202.90 m. This horizon was correlated with the Lovisa magnetite horizon, a correlation in full agreement with Wouter Bleekers mapping (1984) and Anders Engvalls later structural model (1985). However, some 40 metres above the magnetite skarn a fine grained, grey, siliceous 'chert' with thin chlorite-amphibole-skarn bands was found to contain massive and disseminated sphalerite-galena mineralisation. On analysis the interval proved:-

166.55-168.90 m:	2.35 m of 4.78% Zn, 0.81% Pb, 12 g/t Ag
including	1.55 m of 6.75% Zn, 1.12% Pb, 14.5 g/t Ag

A decision was made to test this new target in the area between the Jönshyttan No 8 hole and the Lovisa pit, 1.2 kms to the NE. Drilling commenced in May 1985.

2.2 The Nya Backadahl Project 1982-1984

The exploration activity and results of drilling at Nya Backadahl have not previously been reported. As this mineralisation and its host rocks are close to the Lovisa discovery (fig. 4), and early ideas on Lovisa were based on Nya Backadahl, it is worth nothing here the main points with regard to this project.

Dump material at Nya Backadahl, examined in the early 1980's by LKAB Prospektering, indicated potential for argentiferous galena mineralisation in a magnetite-skarn horizon previously worked for iron ore in the small mine workings of the Nya Backadahl and Matilda mines.

Two holes were drilled into this magnetite skarn horizon in 1982.

Hole 1/82 intersected:-

24.75-28.50 m: 3.75 m of 66 g/t Ag
including 25.85-27.20 m: 1.35 m of 119 g/t Ag

Hole 02/82, drilled about 100 metres further north, intersected

56.00-57.15 m: 1.15 m of 0.64% Pb, 0.02% Zn, 61 g/t Ag

These holes intersected negligible Pb-Zn sulphides and suggested that a separate silver mineralisation was associated with the magnetite skarn.
A drilling programme commenced in 1983 to test the magnetite skarn horizon over 600 metres of strike length. All the 9 holes drilled intersected silver mineralisation, often with galena and trace sphalerite. The programme was completed in December 1983.

Drillhole locations are shown in fig. 6 and intersections are listed in Table 2.

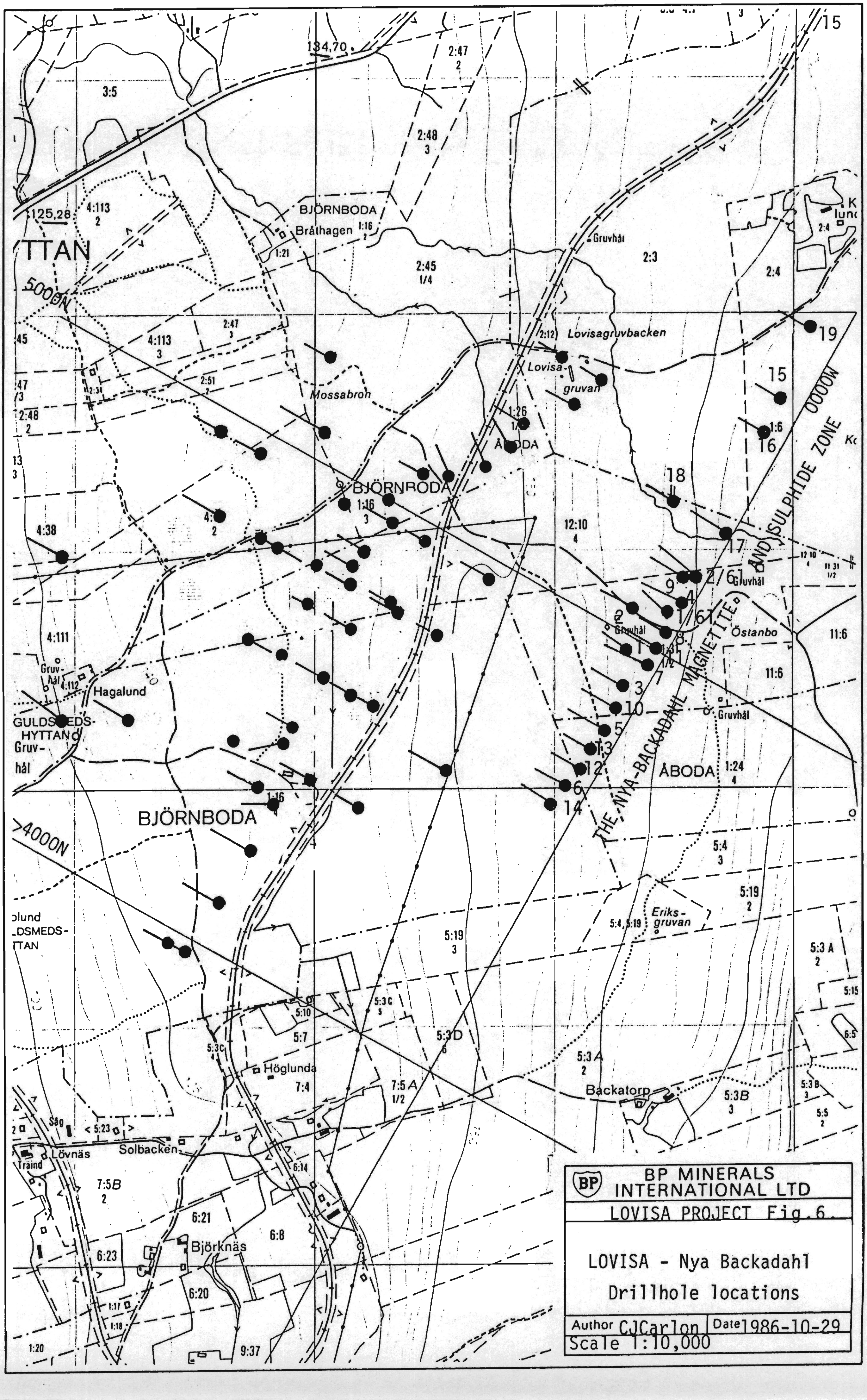
In addition to the drilled holes, the cores from two holes, drilled in 1961 for iron ore, were also logged and analysed proving the same mineralisation (see Table 2).

A further eight holes were drilled in 1984 to test the strike length over 1200 m. Intersections are listed in Table 2, hole locations (12/84-19/84) are shown in fig. 6. Bleeker (1984) made a reflected light and microprobe analysis of the mineralisation from an intersection in hole 007/83. His results are noted in appendix 1 and the mineral species noted listed in Table 3.

The occurrence of mineralisation associated with 'skarn', and the occurrence of mineralisation in "thin skarns" in the Jönshyttan No 8 core, led to the early assumption that the Lovisa sulphide zone or the Lovisa magnetite was the continuation of the Nya Backadahl mineralisation.
In addition, the thickness of mineralisation in the Nya Backadahl zone appeared to pinch and swell. As mineralisation in Bergslagen is frequently arranged in steeply plunging shoots (see Carlon 1986 a), it was supposed the Nya Backadahl mineralisation did the same, and resulted in a very close spaced drillhole plan. This same philosophy was applied to Lovisa and accounts for the close spacing of the early drillholes in the programme.

The cores from Backadahl have, at the time of writing this report, not been re-logged (by CJC). However, hole 19/84 the most northerly hole of the programme has been logged, and the intersected geology is clearly not comparable with Lovisa. The remaining cores will be examined in 1987.

Further comment with regard to Nya Backadahl is made in sections 3.3.4 and 3.4.1.



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LOVISA PROJECT Fig. 6.

LOVISA - Nya Backadahl

Drillhole locations

Author CJCarlon	Date 1986-10-29
Scale 1:10,000	

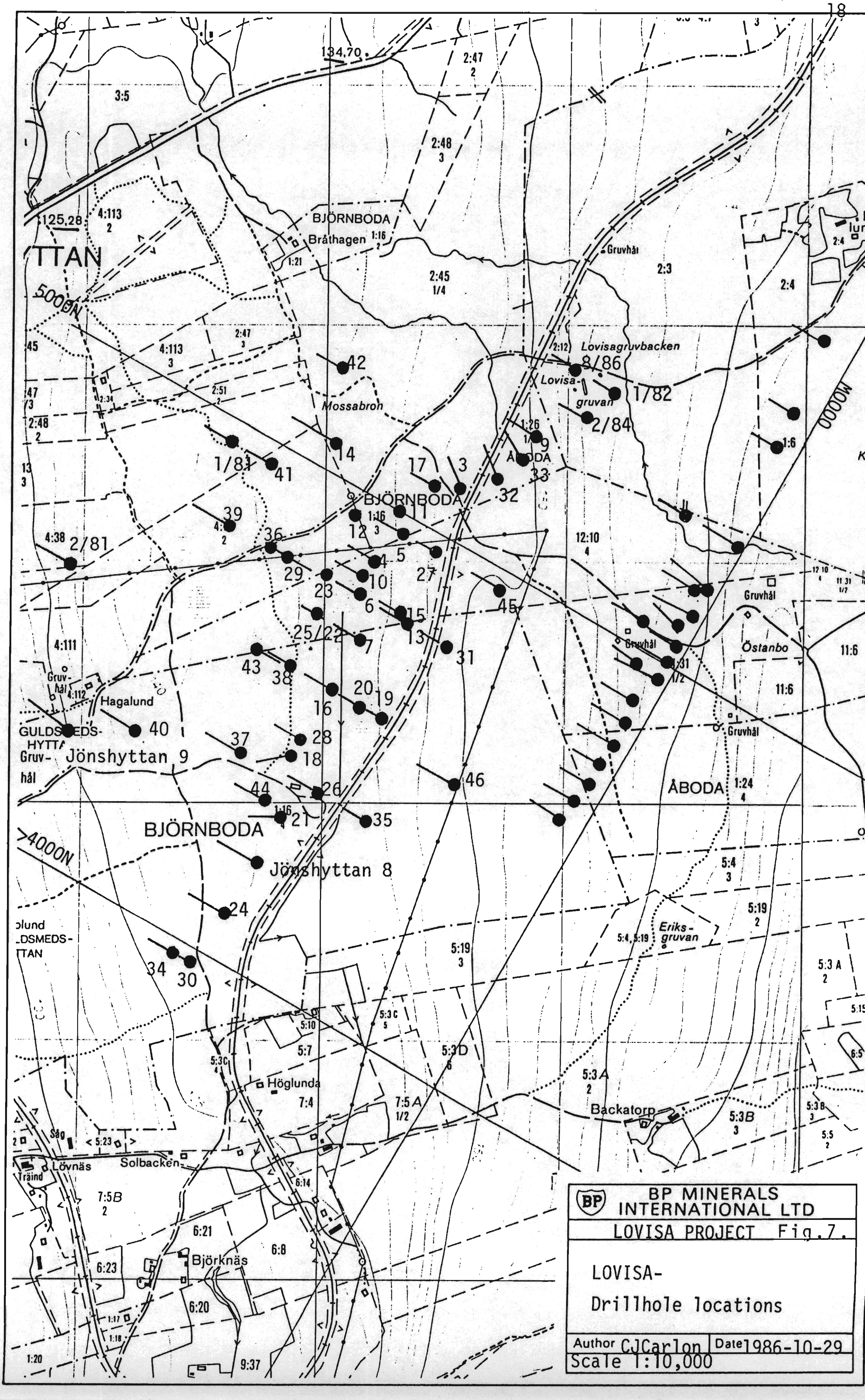
TABLE 2. DRILL INTERSECTIONS AND GRADES, NYA BACKADAHL

Borehole No.	Mineralised Section. (metres)	%Pb	g/t Ag	
001/82	3.75	-	66	inc.1.35m of 119
002/82	1.15	0.64	61	
003/83	3.45	2.60	100	
	1.00	2.00	127	
004/83	0.15	3.50	46	
	1.40	1.70	59	
	1.00	-	55	
005/83	2.50	-	49	
006/83	0.55	0.91	119	
	Hole terminated in mineralised ground due to drilling problems. Intersection could have been thicker.			
007/83	1.05	-	92	
	5.65	-	154	
	3.25	1.00	-	
008/83	1.85	0.70	84	+ (1.5%Zn)
	2.35	1.97	96	
	1.80	2.30	108	
	1.60	1.40	277	
009/83	1.25	1.30	45	
010/84	2.60	0.75	101	
011/84	3.95	0.81	119	
012/84	1.70	1.50	100	
	1.50	0.10	100	
	1.50	0.27	34	
	1.90	0.21	52	
013/84	1.90	0.60	42	
014/84	0.40	1.10	-	
015/84	1.00	2.00	130	
	0.70	-	60	
	1.70	0.20	130	
016/84	1.90	0.30	42	
	1.10	0.20	240	
	0.70	-	38	
017/84	1.20	2.40	123	
019/84	1.65	3.85	303	
	(which includes 0.05	6.40	520)	

TABLE 3. MINERALOGY OF THE NYA BACKADAHL SULPHIDE-MAGNETITE ZONE

Magnetite	Fe_3O_4
Pyrite	FeS_2
Pyrrhotite	$Fe_{1-x}S$
Galena	PbS
Sphalerite	ZnS
Chalcopyrite	$CuFeS_2$
Tetrahedrite	$(Cu_1Fe)_{12}Sb_4S_{13}$
Gudmundite	FeSbS
Native silver	Ag
Acanthite	AgS
Dyscrasite	Ag_3Sb
Allargentum	$Ag_{1-x}Sb_x$
Pyragyrite	Ag_3SbS_3

(after BLEEKER 1984 for a sample from Nya Backadahl hole 7/83, at 77.25 m).



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LOVISA PROJECT Fig. 7.

LOVISA-
Drillhole locations

Author CJCarlon Date 1986-10-29
Scale 1:10,000

2.3 The Lovisa Discovery and 1985 Exploration

Following assessment of available ground magnetic data and the total field magnetic map at 1:10,000 scale a re-examination of the Backadahl data and the results of the Jönshyttan core re-logging and assay, a three hole drilling programme was commenced, supervised by Stig Bjurstedt.

Hole 3/85, the first in the programme, began in May 1985. A massive sphalerite rich sulphide layer was intersected at 57.80-58.00 m downhole. Only 0.20 m thick it assayed 26.9% Zn, 5.60% Pb and lay 37 m above the Jönshyttan-Lovisa magnetite skarn, which was also intersected in the hole.

Hole 4/85, drilled 226 m S. of hole 3/85, intersected the magnetite skarn horizon at a depth of 88 m. This skarn layer is described in sections 3.3.2 and 4.3 as the Lower Magnetite Skarn, Unit 11. It contained galena mineralisation and assayed 0.95 m of 0.14% Zn, 0.72% Pb and 17 g/t Ag.
The most important intersection, however, occurred 38 m above the magnetite with a 0.65 m interval containing 18.20% Zn, 18.00% Pb and 56 g/t Ag.
A fault repetition (see Volume 2) gave a second intersection of massive sulphide at 57.00 m downhole, exhibiting a lithoclastic "ball-ore" or "kulmalm" texture (section 4.2.1) and assayed:-

0.52 m of 14.17% Zn, 10.14% Pb, 44 g/t Ag

The intersection in hole 5/85 indicated that the mineralisation could be sheet-like rather than in plunging shoots, with a minimum strike length of 280 m between holes 3 and 4, continuing through 5. Hole locations are shown in fig. 7.

As a result of these intersections the drilling programme was extended.

Hole 6/85 was drilled about 100 m south of hole 4 and again intersected the massive sulphide zone.
Hole 7/85 was drilled to test the southern extension and intersected the sulphide zone between 117.78-122.50 m, proving not only strike extension but also depth continuation.

Drilling was therefore continued throughout 1985 as follows:-

Hole 8 was drilled to re-test the Lovisa mine area but intersected only weak galena mineralisation in magnetite skarn
Hole 9 intersected similar lithostratigraphic intervals
Hole 10 was drilled to test whether the mineralisation was typically shoot-like in form. It was drilled mid-way between holes 4 and 6, and proved that in this area at least the mineralisation could be regarded as a stratabound or stratiform sheet.
Hole 11 drilled north of hole 5 indicated the same as hole 10.

Reassessment and more detailed ground magnetic surveys suggested that the area was an overfolded F_1 antiformal structure, plunging to the SSW and rising in an F_2 domed structure. A fault zone, with dyke emplaced, was inferred from the magnetics and drill data, and a structural interpretation made (Engvall 1985). See figs. 8 and 17.

The target was defined as a sheet-like zone of mineralisation, characterised by massive ball-textured and banded sphalerite with subordinate galena. The target displayed no geophysical features, subcropped below thick (>5 m) overburden, and lay approximately 40 m structurally above a characteristic magnetite-skarn marker which sporadically contained pyrite, galena and silver mineralisation.

The next 'phase' of the drilling attempted to identify the F_1 fold axial zone, and specifically to intersect the overfolded western limb, to identify the parallel-sub parallel dipping continuation of the sulphide zone on the western limb (figs 8 and 17). Holes were also set out to extend the strike continuation and the depth extension to the east. .

Hole 12: was drilled to test the supposed overfolded western limb of the "Lovisa antiform". No sulphide zone was intersected, but the hole did penetrate a magnetite skarn, and a major fault zone was also drilled with much crushing.
Hole 13: drilled to make a deeper intersection of the sulphide zone to the east, failed in a very brecciated and crushed zone marking a major fault.
Hole 14: was drilled to test the supposed western limb of the anticline and did intersect minor sulphide but the character was different to the main sulphide zone (see section 3.3.3)
Hole 15: was a second attempt to intersect the target at depth to the east. It eventually proved 2.00 m of 8.88% Zn, 8.23% Pb and 22 g/t Ag at a downhole depth of 151.40 m.

The progress and results of the Lovisa Project were presented at the BPMIL Budget Meeting for 1986 in September 1985. Further assessment of the data was made, and proposals made to step off to the south north and east to extend the deposit.

Exploration continued with the drilling of hole 16 to test the 'saddle' area between the supposed Lovisa antiformal subcrop to the north at 4800N and the 'dome' to the south at 4000N-4400N, seen in the magnetics (fig 16). The intersection in hole 16 was apparently fault repeated.

Hole 17 was set out to test the idea that the mineralisation changed in character between holes 11 and 3 from massive to more disseminated. A 1.00 m layer with 15.10% Zn, 6.2% Pb and 32 g/t Ag disproved this theory.

The mineralisation had, at this stage, been tested over a strike length of 500 m to a vertical depth of about 130 metres, dipping at 60-70° east. Initial calculations of mining capital and operating costs were made, and a preliminary economic evaluation made on the data available.

The project was discussed at the BPMIL-LKAB joint-venture meeting where a budget of 3.22 MSEK was allocated for the project in 1986. A request was made to use 2 drillrigs on the project, and again stress was laid on the drilling of extensions to increase tonnage as quickly as possible.

In the meantime hole 18 was drilled to test the zone southwards towards the original Jönshyttan No 8 hole (some 250 m further south). This hole intersected two sulphide layers in close proximaty, one being 3.76 m of 6.19% Zn, 0.29% Pb and 14 g/t Ag and the other 2.27 m with 9.66% Zn, 0.36% Pb and 11 g/t Ag.

Hole 19 was set out to test the downdip, eastern extension to the mineralisation located in hole 16. After two attempts failed in very broken and weathered bedrock, the site was moved 50 m grid W. and hole 20 commenced.

At year end, the two drillrigs were drilling holes 20 and 21, the latter set out to extend the mineralised zone towards Jönshyttan No 8.

During 1985 holes 3/85 to 19/85 were completed, a total of 17 holes, and 2613.45 metres (Appendix 2). On completion of hole 20/85 these totals were 18 holes and 2913.05 metres, and of the 18 holes drilled 12 intersected the massive sulphide zone (hole 14 intersection not included).

At year end the mineralisation was drilled over a strike length of 700 metres between holes 18/85 in the south and 3/85 in the north, and to a maximum vertical depth of 130 metres. With an average width of 2 metres an estimated 650,000 tonnes of about 8% Zn, 3% Pb, 20 g/t Ag had been drill indicated.

2.4 Exploration and Drilling 1986

The year commenced with the completion of holes 20/85 and 21/86, both of which intersected the target.

Hole 22/86 was set out to test the crest of the supposed Lovisa antiform, to find the axial zone and the position of the overfolded western limb. The hole intersected the target and the magnetite marker horizon below it, but the sequence was extensively broken and fractured. Hole 25 was drilled westwards from the same site and intersected sulphide but no magnetite.

Hole 23/86 was set out about 90 m north of 22/25, again with the intention of proving the fold axial zone. As in hole 25, the sulphide target was intersected but not the magnetite marker, and the core was extensively faulted and broken.
It seemed apparent that the simple overfolded antiform model was incorrect, and that there was no overfolded, sub-parallel or parallel sulphide sheet to the west. Hole 6/85 was re-opened and extended from 112.50 m where it had originally stopped, to 254.75 m. This proved conclusively that no overfold existed.

Hole 24 was drilled to test the sulphide zone south of Jönshyttan 8. It intersected banded and massive sulphide with an intersection of 2.15 m with 5.35% Zn, 0.87% Pb, and 10 g/t Ag.
Hole 26 was drilled to obtain a deeper intersection around 4400N, and hole 27 a deeper intersection around 4950N.
Hole 28 was an 'in-fill' hole placed to intersect the target between holes 16 and 18.

There was sufficient information to suggest that the structure was essentially monoclinal, dipping east, intersected by NE-SW fault zones, and possibly by NNW-SSE faults, and not a single layer of sulphide. However, hole 29 was set out to continue testing a supposed western limb. The hole intersected both the target sulphide and the magnetite marker, and was drilled in very broken ground.

Hole 30 was drilled to further extend the target zone to the south. It failed in very broken ground.
Hole 31 was set out at BPMIL's request to obtain a much deeper intersection on the mineralised zone. At this point in time most of the intersections were at shallow depth and concentrated by the drilling to a zone between 4600-5100N.
Hole 31 eventually intersected very good mineralisation at a down-hole depth of 292.85 m. Not only had the grade improved with depth, but also the thickness with 12.15 m of 4.13% Zn, 2.41% Pb and 13 g/t Ag. The best interval was 4.50 m of 9.24% Zn, 5.67% Pb and 35 g/t Ag.

BPMIL also requested that holes be set out to extend the zone in all directions.
Accordingly holes 32 and 33/86 were drilled to test the northern extension of the mineralisation. No mineralisation was intersected in hole 33, and the northern limit was taken at 5200N.
Similarly hole 34 was drilled to 232.40 m with no mineralisation. The southern limit of the main target zone was assumed to continue south from 5200N to around 4400N, change character to a weaker "banded-skarn" type mineralisation, and die out around 4400N.

Hole 35/86 was drilled to complete a profile of holes on line 4400N and make the then deepest intersection on the down-dip eastern extension. As in 31/86 the mineralisation proved to be wider with a very good grade, and was intersected at a downhole depth of 326.00-341.30 metres. The interval 328.00-341.31 m contains 13.31 metres of 4.78% Zn, 0.60% Pb and 8 g/t Ag, within which separate sulphide layers occur with 13.3% Zn, 2.70% Pb, 35 g/t Ag (over 1 metre), 22.40% Zn, 1.7% Pb, 20 g/t Ag (over 1.70 m) and 7.9% Zn, 0.19% Pb and 15 g/t Ag (over 0.89 m).

With the northern and southern limits to the mineralisation apparently identified, and with the deeper intersections indicating continuation down-dip to the east, hole 36 was drilled to test the extension westwards. Indications in holes 25 and 29 suggested proximaty to a major fault zone. This was drilled in hole 36, with completely brecciated core almost the whole length of this 181.60 m hole.

During August 1986 all the data from the Lovisa project was examined in detail by the writer (CJC) for BPMIL. A programme of core re-logging and additional core sampling was commenced.

Holes 37 and 38 were drilled to test the area between 4400N-4600N. At the writers request holes were then set out to test, what appeared from Bleekers mapping and A. Engvalls (1985) interpretation (fig 4, 15, 17), to be the continuation or possible repetition of the Lovisa 'skarn' zone with the possibility of a repeated sulphide zone. Hole 39 was drilled to test this hypothesis, 250 metres south and along strike from hole 14 and its sulphide intersection. Holes 40, 41 and 42 were similarly set out to test the same hypothesis (fig 7) None of these holes were mineralised, suggesting an incorrect hypothesis or more complex geology than suggested by either Bleeker or Engvall (see section 3.3.3).

Holes 43 and 44 were drilled to follow-up the good intersections in holes 38 and 37, both holes intersected the massive sulphide target.

Two final holes were set out in 1986, and are the latest holes drilled at Lovisa. Hole 45 was drilled to make an intersection at a depth of around 350 m down-dip from the mineralisation in holes 5 and 27. Hole 46 was set out as the deepest hole in the programme to intersect the target zone around 450.00 m and test its depth extension west of hole 20 and north-east of the hole 35 intersection. Due to faulting the intersection in hole 45 was up-thrown to 246.00 m downhole and proved to be very thin (only 0.09 m).

Hole 46 intersected a characteristic bedrock sequence to a thinned target zone at 429.50-431.54 m with 1.16 m of 8.59% Zn, 4.86% Pb and 15.5 g/t Ag. This is the deepest intersection at 425.00 m vertical depth.

During the 1985-86 exploration various geophysical surveys have been conducted, comprising ground gravity, VLF-EM, Slingram EM, Max-Min EM and magnetic measurements. In addition IP surveys using Wenner and dipole-dipole arrays have been used to attempt to locate the sulphide horizon.
Downhole IP and single probe measurements have been made in various drillholes and a mise-à-la-masse survey was attempted using drillhole 4 to deduce the structure of the sulphide layer.
This work is described and results discussed by A. Engvall (1986).
Reference is made to the geophysical surveys in the following sections of this report, where appropriate.

2.5 Current Status

During the last quarter of 1986 all the Lovisa data have been re-evaluated.

Geophysical survey results have been assessed and plotted. The magnetic data from 80 m line spacing surveys over the deposit and surrounding area have had diurnal corrections applied, where required, to standardise the data. Data has been re-plotted and more refined magnetic maps produced.

All the drillcores from 4000N to 5400N in the main target zone, have been logged or re-logged to determine detailed bedrock lithology, lithostratigraphy, bedrock correlation, structure and mineralisation. Holes in the western area have also been re-logged, and it is the intention to re-assess the Nya Backadahl cores in an attempt to relate the Lovisa mineralisation to the eastern area to locate possible extensions.

Most of the data set out in the following pages results from the relogging programme.

The original sampling of the mineralisation omitted gaps of apparantly unmineralised bedrock. These have been sawn and sampled to provide continuous assays across the mineralisation.
Downhole lithological logs have been drawn up and correlated with downhole chargeability and resistivity data (see Engvall 1986).
Structural features logged have been assessed in the light of corrected and re-plotted magnetic data, and extrapolated structural patterns for the sulphide zone have been compared and correlated with ground IP survey results, VLF and Slingram EM data.
Overburden data have been corrected, plotted and compared to bedrock structural features, weathered zones and gravity data (section 3.3.1).

Provisional ore calculations have been made by LKAB, (Ohlsson 1986), AB Statsgruvor (Zeidler and Månsson 1986) and BPMIL (Bahan 1986). (See section 5.2).

This report is based on data available to December 31st 1986.

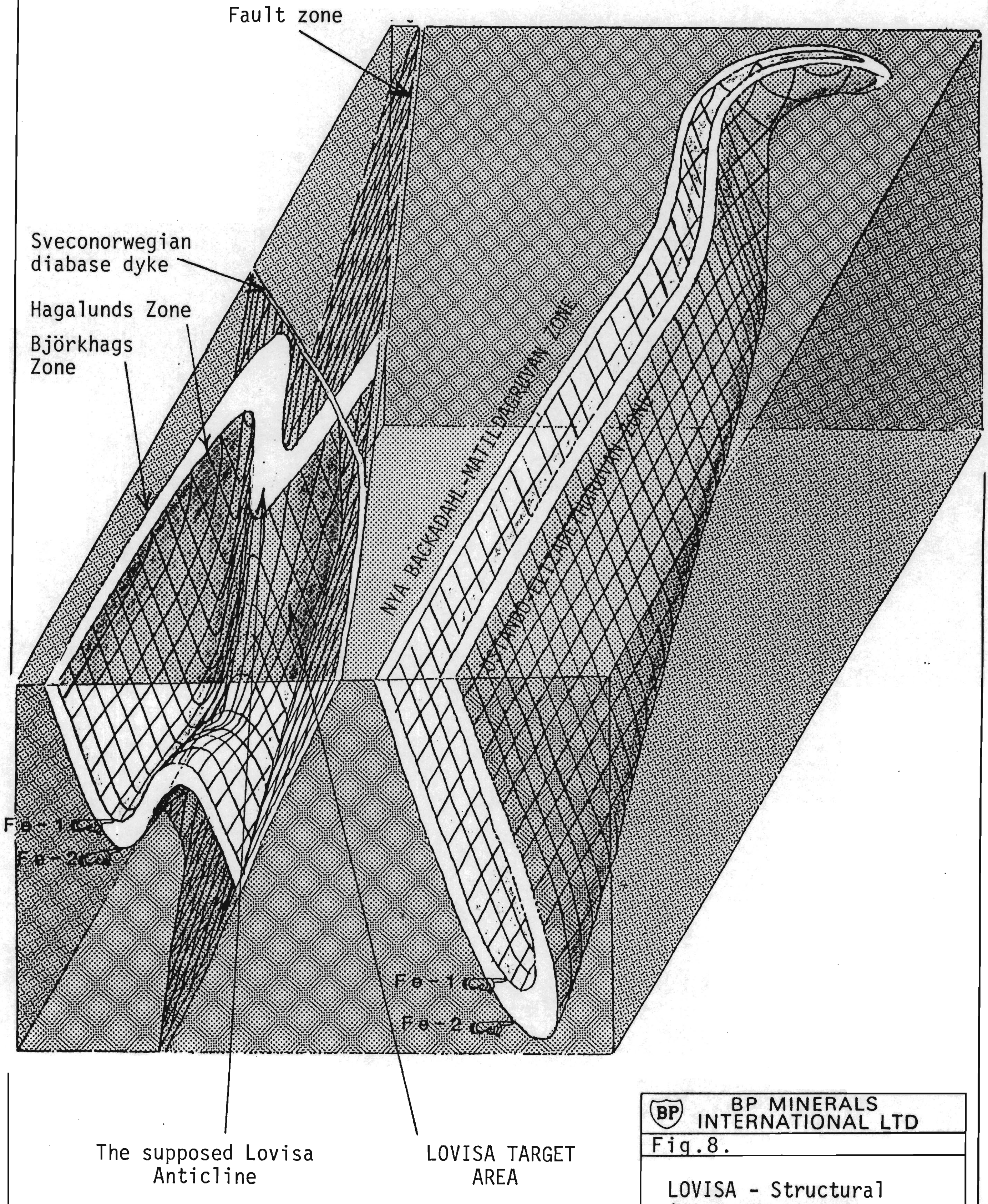

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Fig.8.

LOVISA - Structural interpretation after Engvall (1985)

Author CJCarlon | Date Jan 1987

Revised

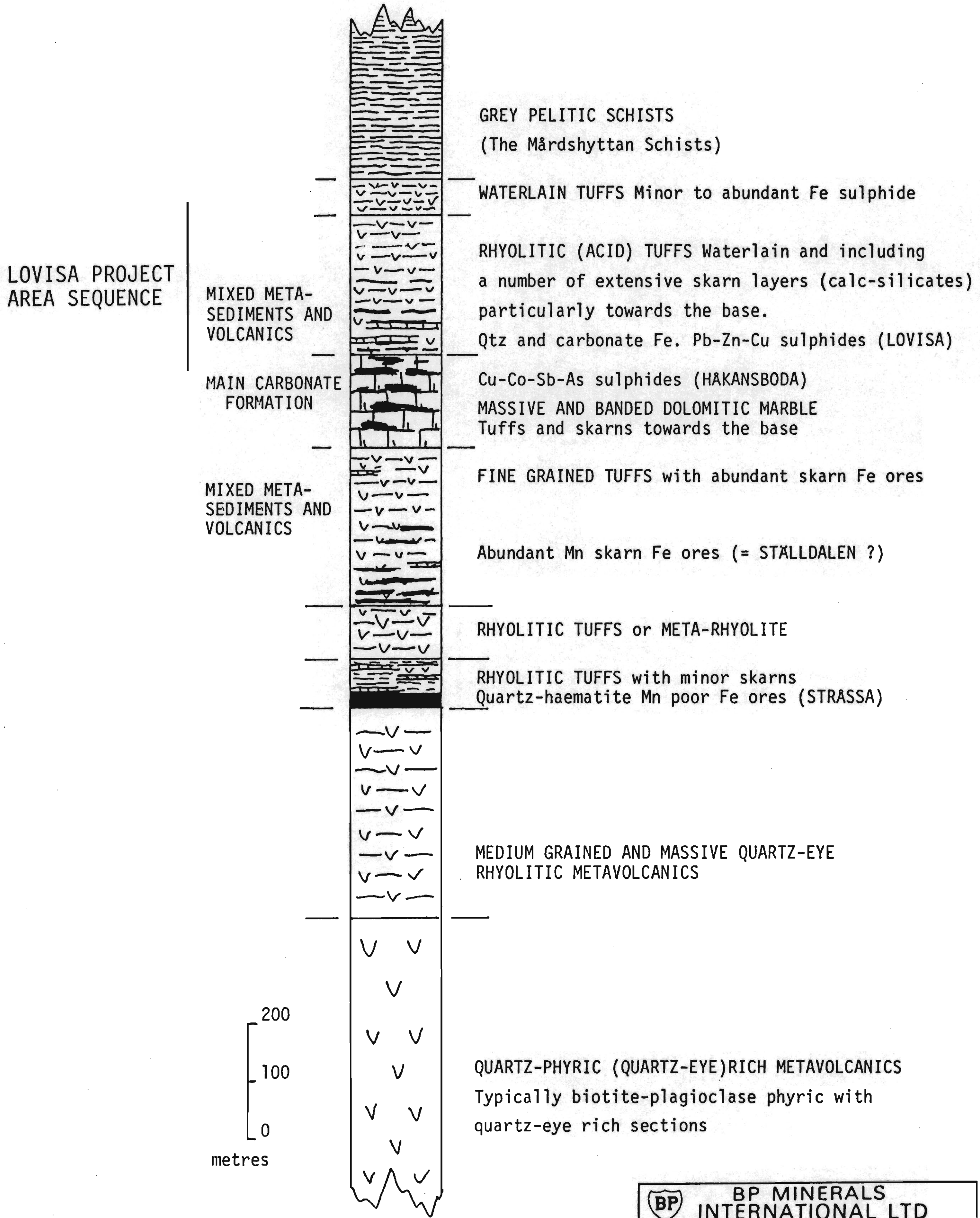

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Fig.9. LOVISA

LOVISA PROJECT -

Regional lithostratigraphy

Author CJCarlon | Date Jan 1987

Revised

(Carlon 1985 based on Bleeker 1984)

A 3 GEOLOGY

The following description is based on the mapping, carried out for the JV partners, undertaken during 1983-1984 by Wouter Bleeker, together with data obtained in the JV exploration projects at Håkansboda (Carlon 1986a, 1986b) Nya Backadahl and the recent re-logging/logging of the Lovisa core (CJC).
The Lovisa discovery lies on topographic map sheet 11F SV (1:50.000). SGU have published geological, aeromagnetic and structural maps of this 1F SV sheet, together with a short description (Lundström 1983). The published material presents insufficient detail to understand the geology and mineralisation except in the very broadest sense.

3.1 Regional Geology and Setting

An outline geological map of the area is shown in fig. 4 after Bleeker 1984. Outcrop is reasonable in the east of the area around Stråssa-Håkansboda, but is very poor or non-existent further west in the Lovisa area, where the overburden cover varies from 1.50-50.00m.

The Lovisa discovery lies within a 1.9-1.8 Ga Lower Proterozoic supracrustal sequence, which has a general NE-SW strike. At least two major fold episodes affect the supracrustal formations, producing a complex plunging synform with NE-SW axial trend, parasitic folding, and axial planar structures. This large scale structure is refolded around SE steeply plunging folds producing complex interference features (see section 3.4.1). In addition several sets of brittle fractures affect the target sequence, with low angle reverse high angle reverse and high angle normal displacemants (section 3.4.3).
The major structure is synformal, isoclinal and overfolded to the east producing a more or less consistent steep easterly dip. Metamorphism is at amphibolite facies.

3.2 Regional lithostratigraphy

The regional lithostratigraphy is shown in fig. 9 and can be summarised from E-W into the Lovisa project area as follows.

The oldest rocks lie to the east of Stråssa-Håkansboda, and due to the large scale regional folding pass north of Stråssa and round to the west of Stripa-Storå.
These are plagioclase (albite) phyric, sodic metavolcanics. They pass upwards into fine grained pink or grey, potassic metavolcanics (alkali-acid rhyolite-rhyodacitic parents). Quartz eye (quartz-phyric) relict phenocrysts are common, within a fine grained, quartzo-feldspathic matrix containing biotite, sericite, and occasionally cordierite-sillimanite. These units are at least 1100 m thick.
They are overlain to the west by a distinctive quartz rich haematitic 'jaspilitic' chemical sediment, which can be traced in surface exposures, trials and abandoned iron ore pits from the Blanka mine, east of Stråssa, through the Stråssa mine and round to the west side of the Storå valley. In areas of strong deformation haematite is transformed into magnetite. The unit can be considered a low manganese bearing, banded iron formation.

The strata above the haematite marker formation are generally fine grained and represent a mixed sequence of volcanic and sedimentary detritus including manganiferous iron horizons of probable chemical sedimentary origin. Lithologies represented include massive quartz-'eye' phyric metavolcanics, banded fine grained 'cherts' and quartzites, quartzo-feldspathic 'psammitic' beds, amphibole-diopside-feldspar-garnet and mixed calc-silicate rocks, massive manganiferous magnetite and garnet-biotite, garnet-biotite-amphibole and coarse hornblende-actinolite rocks.
Probable parents were waterlain siliceous, detrital sediments derived from volcanic processes peripheral to or within basins of sedimentation, waterlain tuffs, reworked-resedimented siliceous volcanic detritus, arkosic and feldspathic epiclastics, impure carbonates, calcareous, ferruginous and argillaceous sediments, silica, iron rich silicate, and iron-manganese oxide chemical sediments.

Dolomite marble, dolomite-serpentinised mafics (ophicalcite) and ophicalcite phlogopite rocks represent magnesium and calcium bearing impure and ferruginous carbonates with a potassium content, possibly reflecting early rock alteration.
Argillaceous rocks are represented by muscovite-biotite and garnet-biotite-cordierite gneiss. However, some rock types in the sequence may reflect rock alteration prior to metamorphism.
Quartz-sillimanite and quartz-sericite-chlorite rocks occur at several positions in the stratigraphy, often spatially associated with mineralisation, notably at Håkansboda, and may reflect increases in magnesium, iron and potassium associated with argillic alteration around sites of hydrothermal activity (Carlon 1986b).

The 300-400 m thick sequence is overlain in the Håkansboda-Eriksgruvan area (fig. 4) by a thick 60-250 m, intensely folded and sheared, dolomite marble. Thickness variations within this unit may be original, but are more likely due to multiphase deformation and plastic 'flowage' developed in the less competent carbonate formation.
This main carbonate formation is a complex Fe-Mg-Ca carbonate. It is dominantly a dolomitic marble with black serpentinised forsterite-clinohumite-amphibole-pyroxene crystals and minor amphibole and diopside 'skarn' layers. This unit hosts the copper-iron and complex sulphide deposit at Håkansboda (Carlon 1986a, 1986b).

The sequence that overlies the main carbonate is confined to the centre of the main synformal fold structure, and hosts the magnetite-diopside-garnet-amphibole horizons, often containing sulphide impregnations, which formed the exploration targets for the JV in the early 1980's. The Lovisa discovery occurs within this sequence, above the main carbonate formation, and below the andalusite bearing, black pelitic schists of the Mårdshyttan Schist Formation. An abrupt change in lithology occurs at the top of the main carbonate formation. Coarsely crystalline dolomitic marble and dolomite-serpentine marble passes into well layered and banded calc-silicates and quartzo-feldspathic 'cherts', probably originating from a mixed impure carbonate, calcareous and siliceous mudstone and waterlain volcanic tuff sequence.

The sequences pass upwards into fine-medium grained granoblastic quartzo-feldspathic and sericitic 'cherts' with quartz eye and feldspar phyric metatuffites, and occasional thin calcite marble and mixed marble-chert-diopside and garnetferous calc-silicates. These rocks appear to represent quartzo feldspathic detritus of probable volcanic origin, re-sedimented in an aqueous environment, in which carbonate production occurred periodically, throttled frequently by clastic input.

Thin, distinctly banded siliceous and quartzo-feldspathic 'cherts' occur with well banded, almost laminated siliceous chert-amphibole, diopside, garnet 'skarns'. The latter often contain magnetite-chert and magnetite-diopside bands, and apear to represent manganiferous, carbonate, ferruginous and siliceous chemical sediments. These "skarn iron ores" often contain sulphide laminae, remobilised into stratabound veinlets within 1-2 cm thick chert-skarn bands. The Lovisa mineralisation occurs within an associated mixed, fine grained, quartzo-feldspathic 'chert' and skarn unit. These rather well banded units are separated by massive, banded and thick siliceous, often quartz- and feldspar phyric metatuffites.

The detailed lithostratigraphy is described in section 3.3.2 and a further comment on the origin of the mineralisation is made in section 4-6.

3.3 Lovisa Prospect Geology

3.3.1 Overburden

There are no exposures of the mineralised target horizon or its enclosing host rocks in the Lovisa prospect area. No mineralised float is known and none has been located during the 1985-86 exploration.

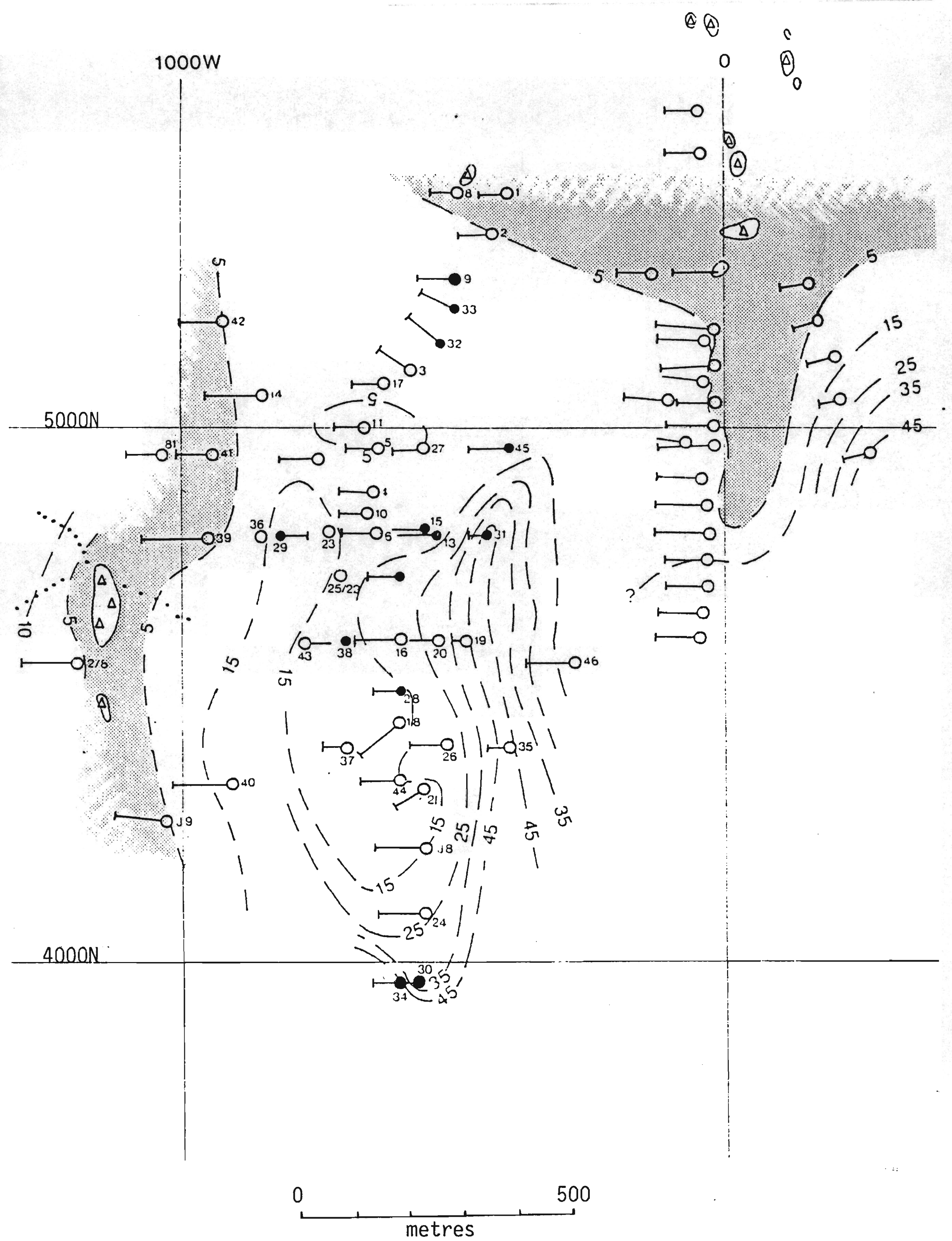
Within the currently drilled area, there is a considerable variation in overburden thickness from 1.48 m in hole 8 to 51.38 m in hole 34. A list of overburden thickness is given in appendix 3.

A map of the overburden thickness in the prospect area is given in fig. 10. The following points can be made:-

1. No excavations have been made through the overburden to the bedrock. The internal stratigraphy of the overburden is unknown. To the south-west in the Nora area up to four distinct layers occur in the overburden.

2. As no soil sampling has been done above the deposit subcrop nothing is known about the secondary geochemical dispersion (above the deposit) within the overburden.

3. It is supposed, particularly in the northern parts of the prospect, that the overburden is more or less similar to the material seen at surface. This is transported glacial detritus, clay-sand matrix with granitic and metavolcanic pebble and cobble clasts of minimal local derivation.



—5— Depth of overburden in metres

—O27 Drill hole position

—●13 Drill hole position intersecting weathered rock

Outcrop

..... Bedrock chip sampling site

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Fig.10

LOVISA PROSPECT AREA - Overburden depth map

Author CJCarlon | Date Jan 1987

Revised

4. Between 350-550 W and around 600W-4000N, thick overburden overlies weathered bedrock (fig. 10), in zones apparently corresponding to fracture zones in the bedrock (see section 3.4.3)

5. The variation in overburden thickness grid W-E across the target zone can adequately explain the gravity variation noted over the prospect area (see Engvall 1986).

6. Shallow depth to bedrock in the area 4500N-250W, in a zone trending NNW-SSE, appears to correspond to the subcrop of a diabase dyke (figs 4 and 24).

7. Overburden thickness is consistently less than 15 metres NE of 4900

3.3.2 Supracrustal Sequence - Discovery Zone

It is possible to correlate the lithological units drilled from hole 8/85 at 5441N southwards to hole 34/86 at 3920N, a strike distance of approximately 1,500 metres. Across strike holes can be correlated for 500 m on line 4600N.
Holes west of 900W are tentatively correlated with the sequence structurally underlying the target sulphide zone. The drilled intersections in the Nya Backadahl zone have not yet been re-logged, but hole 19/84 at Backadahl has been re-logged and appears to intersect a sequence lying structurally above the Lovisa target zone.

Correlations are further discussed in sections 3.3.3 and 3.3.4.

The sequence drilled is currently divided into 12 lithological units. The term 'unit' rather than 'formation' is used, because while it is clear some units are lithostratigraphic formations, some may be due to rock alteration and cannot be considered stratigraphic 'sensu-stricto'. (fig. 11).

While grain size variations are noted in some sequences it is unclear whether fining upward or coarsening upward volcaniclastic or epiclastic deposition has taken place. Porphyroblastic growth in some sections of the sequence also complicates the identification of grain size variations. Way-up directions cannot be deduced.

In the general sense it is assumed that the sequence, as deduced from the regional structure and broad lithostratigraphic divisions, is the correct way up, on the western limb of the major synformal limb. Structural down is therefore considered to be stratigraphic down, always remembering that parasitic isoclinal folds can locally invert this sequence, and that east of the main fold axis the sequence is inverted on the eastern limb.

The lithological-lithostratigraphic (?) units are described in the order they are usually encountered in the drillcore, that is assumed stratigraphically going down sequence.

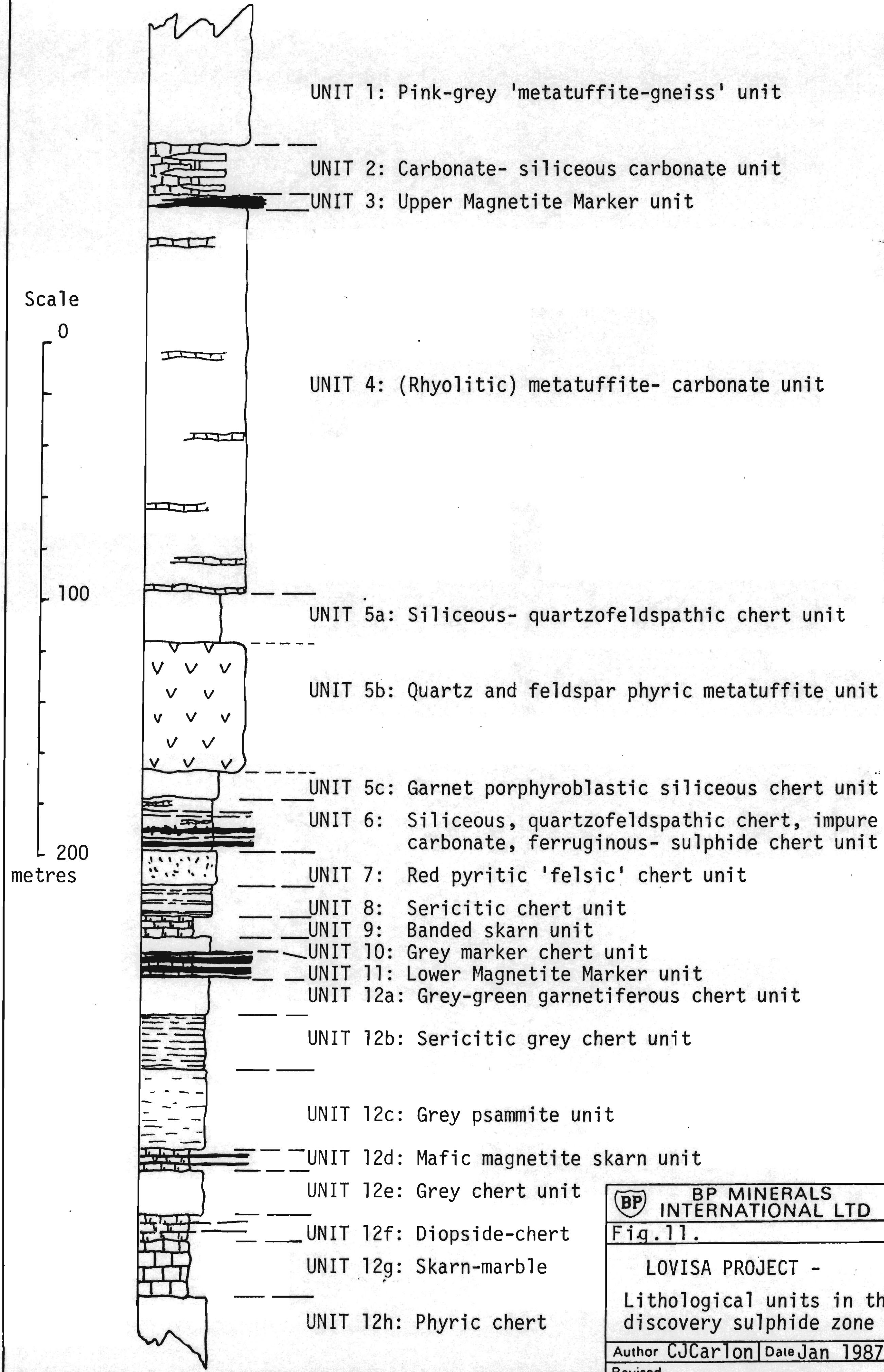

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Fig.11.

LOVISA PROJECT -

Lithological units in the discovery sulphide zone

Author CJCarlon | Date Jan 1987

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A summary "lithostratigraphy" is presented in fig. 11. These units are correlated from N-S along strike of the target horizon as shown in fig. 12, which folds out for comparison with the following descriptions. All formations described here lie in the "Usken Formation" of Lundström (1983). The Lovisa sulphide target zone always occurs in Unit 6 cherts and skarns.

Unit 1. Pink-grey metatuffite-'gneiss' unit

This unit is recognised in the top sections of holes 31, 34, 35 and 46. The thickest intersection occurs in hole 46, where it is at least 150 m thick. It is defined as the sequence lying above the carbonates in Unit 2.

Unit 1 is characteristically a red-brown, dark grey-brown or grey, fine grained, siliceous or quartzo-feldspathic 'chert'. This type of lithology is generally referred to as 'leptite' in Swedish literature. However, several distinct lithologies occur, namely:

i. Fine grained, siliceous, weak to non-foliated brown and/or grey chert.

ii. Dark grey-brown and grey, weakly sericitic and chloritic, feldspar phyric-porphyroblastic, quartz-(eye) phyric, 'cherts' or streaky 'gneiss'. As the strain fabric clearly indicates a lack of shearing the grains appear to be relic phenocrysts, and the parent a rhyolitic or rhyodacitic tuff.

iii. Mixed grey siliceous cherts and pink, feldspathic, biotite-chlorite spotted 'felsic' bands. These have a characteristic 'leopard-skin' texture, and form bands 10-30 cms thick. They are often garnet porphyroblastic and are sometimes epidote streaked.

The unit changes character downwards, generally becoming dominantly fine grained, pale pink-grey 'caramel' coloured cherts (fine grained, siliceous, non-foliated, banded rocks). Near the base of the unit, sericitic, foliated siliceous grey 'chert'-'gneiss' occurs. The lithology is a rather 'psammitic', quartzo-feldspathic, sericitic type.

In holes 46 and 31, thin 'skarn' (diopside- chlorite-chert) bands appear towards the base of the unit.

Unit 2. Carbonate-siliceous carbonate unit.

This occurs characteristically in hole 35, where it was first defined during core re-logging in autumn 1986.
In hole 35 a diopside streaked, dolomite-calcite marble and banded calc-silicate-chert-carbonate sequence forms a distinct unit some 26 metres thick.
Clean dolomite and calcite marbles occur, together with serpentinised mafic porphyroblastic calcite marble, sericite, amphibole-diopside porphyroblastic calcite marble, diopside-amphibole 'skarn' and interlayered fine grained siliceous 'chert' and diopside-feldspar-mafic-calcite marble.

In hole 34 a similar lithology occurs, but the proportion of fine grained dark grey-brown siliceous 'chert' has increased and forms the dominant lithology with subordinate banded chert-calcite marble, and coarse garnet-diopside 'skarn'.

A similar mixed chert-carbonate horizon, some 30 metres thick, occurs in hole 46 at a depth of 259.35 m. This may be the same horizon, but it appears to lie too far down sequence. However, in the same position in hole 31 14 metres of mixed chert-skarn correlates well with the hole 46 sequence.

Unit 3. Upper Magnetite Marker unit

Defined by core-re-logging and first identified in hole 35, this mixed magnetite-chert-calcite marble unit also occurs in holes 31 and 34 but does not occur east of grid line 400W in hole 46. It therefore has a restricted destribution and cannot be considered a reliable 'marker' horizon.

In hole 31 1-5 cm bands of massive magnetite occur in a 2-3 m thick interbanded grey-black and red-brown siliceous chert with diopside-calcite skarn-marble. A similar lithology is seen in hole 35, where the unit is about 5 m thick.
In hole 34 the carbonate-chert bands are disrupted, with interbedded massive magnetite.
The unit can be summarised as a pink-grey, grey-black, fine grained siliceous chert, banded 'felsic' caramel coloured 'chert', red-brown' ferruginous' or jaspilitic chert, impure grey-white calcite marble, diopside, amphibole (hornblende-actinolite?), garnet porphyroblastic mixed sequence. 1-5 cm massive, fine grained magnetite bands occur, and in all intersections stress induced disruption, fragmentation and ruckling of the 0.5-5 cm compositional (lithological) bands occurs (see also 3.4.2).

The unit occurs at:- 160.06-163.00 m (Hole 31)
76.70- 78.10 m (Hole 34)
133.70-138.76 m (Hole 35)

Unit 4. Metatuffite-carbonate unit.

Below Unit 3 in holes 31, 34 and 35, and between 160.50-327.60 m in Hole 46 a sequence of fine grained siliceous cherts occur with thin disrupted carbonate bands.
The same sequence occurs in the top of holes 26, 44, 21, 24 and 30 in the southern part of the discovery area, and in the upper part of hole 45 in the northern section. In most intersections the unit is about 100 m thick, though it may be up to 120 m thick in hole 46.
A very fine grained grey, grey-brown and red-brown siliceous or quartzo-feldspathic 'chert' is the dominant lithology, with sporadic sections containing feldspar and quartz (eye)-phyric units. The sequence appears to represent rhyolitic tuffs, deposited and possibly fragmented by epiclastic processes. Thin, banded chert-calcite marble and chert-marble-diopside skarn bands occur sporadically through the sequence.
Biotite flakes frequently pick out a foliation, usually parallel or at a low angle to the mineralogical banding. Minor biotite-chlorite streaks and thin partings occur.
Sections containing 'phyric' grains show 1-2 mm bluish quartz-eyes embedded in very fine grained grey-brown 'chert' and siliceous-chloritic streaky chert. Feldspar porphyroblasts (crystal tuff or rhyodacitic phenocrysts?) also occur. Garnet porphyroblasts are occasionally seen, often concentrated along certain laminae.

In hole 34 at 129.00 m orange-red, fine grained, quartzo-feldspathic 'cherts' identical to the Rektor Porphyry lithology of the Kiruna district, suggest the parent rock of part of the Unit 4 sequence may have been subaerial and ignimbritic (an origin deduced for the Rektor Porphyry).

The mixed calcite marble-chert bands are invariably ruckled or intensely folded. Chert layers are frequently fragmented or disrupted into clasts forming a 'ball-texture'in recrystallised, plastic deformed carbonate. Boudinaged chert layers are very common in the carbonate bands, which are up to 2 metres thick (section 3.4.2). The base of the unit is placed at the last prominent chert-marble band.

Unit 5. Rhyolite-metatuffite unit

Nearly all the drillholes intersect part of this unit, with complete sections in holes 18, 20, 21, 24, 26, 27, 31, 35, 45, 46 and Jönshyttan No 8. In hole 24 the unit is 62 m thick, but this increases to 94 metres in hole 46 and 140 m in hole 45 from south to north-east.

The unit can be divided into three sub-units with minor variations. Type section occurs in hole 26.

Sub-unit 5a: Unit 4 base is placed at the lowest carbonate band. In hole 26 this is at 89.90-90.80 m. Below this is a sequence of medium to dark grey, fine grained, quartzo-feldspathic or siliceous, often sericite streaked 'cherts'. A characteristic feature of this 5a sub-unit is the presence of thin, siliceous, milky white 'marbly' looking bands, with epidote streaks and garnet porphyroblasts. In hole 26 these bands are particularly common between 114.00-126.00, an interval of 12 metres, but in other sections they are dispersed over a wider interval. Individual bands are 10-29 cms thick.

In some sections there is no 'marker' basal carbonate to define the top of Unit 5. In these cases, for example, in holes 13 and 18, the top is defined by:-

1. The absence of 'leopard skin' felsic bands
2. The absence of skarn streaks and bands
3. The appearance of white 'marbly' bands with epidote and garnet

Sub-unit 5a varies in thickness but is generally 14-60 metres thick, averaging around 25 m.

Sub-unit 5b: A very characteristic lithology, occurring from hole 32 in the area around 5150N, to hole 34 at 3900N. This lithology is a quartz-eye and feldspar phyric (1-3 mm grains), rhyolitic metatuffite. It is a streaky or planar banded, medium to dark grey, fine grained siliceous matrix, streaky sericitic-chloritic, quartz-eye and often quartz-feldspar phyric 'metatuffite'. Dispersed (0.2-0.5 cm) garnet porphyroblasts are common, particularly within the chloritic-sericitic streaky matrix sections. This sub-unit varies in thickness from 24-96 m, and splits into an upper and lower unit, separated by grey 'chert', in drillholes 44 and 21. Hole 34 stops in sub-unit 5b at the current southern limit of drilling.

Sub-unit 5c: In most intersections a thin (8-30 m) sequence of non-phyric, sericitic, planar or non-foliated grey-black 'cherts' with 1-2 mm irregular shaped garnet porphyroblasts occurs under the phyric metatuffite of sub-unit 5b. In Hole 15, 5c is absent.

<u>Unit 6.</u> Chert, ferrugenous chert, impure carbonate, sulphide unit

Unit 6 hosts the main target sulphide mineralisation in all the drilled intersections. The description in section 4.2 regarding the mineralisation compliments the description given here for the host rocks.

In every intersection the top of the unit is placed at the first thin mafic-garnet, or chlorite-garnet skarn band. Nearly all intersections have the lower boundary placed at a similar skarn, or the change into the bright red cherts of Unit 7 below.

Within Unit 6 two main lithogies are present:

i. A very fine grained, often planar banded or planar foliated, siliceous or quartzo-feldspathic chert. This is invariably fine grained, though occasionally containing biotite-chlorite flakes or minor sericite.
Sections of 'chert' are pale grey-pink or 'caramel'coloured with disseminated pyrite.
Fine colour laminations are not uncommon, and sulphide, garnet porphyroblasts and chloritic bands are frequently planar laminated within the fine grained 'chert'. Colour varies from fawn, pale pink-grey, pink-brown, red-orange, red-brown, grey-brown, dark grey-brown, dark grey and grey-black. Rounded and irregular shaped 1-3 mm red-brown garnets are common. Low angle reverse faults are frequently observed dislocating the fine banding, which appears sedimentary, but may be a metamorphic banding. Trace fluorite, tourmaline and scapolite occur in this lithology, and up to 3% graphite has been noted.

ii. Dark grey-green, chlorite-amphibole-diopside, minor feldspar, garnet bands ('skarns'), 1-40 cms thick occur throughout the unit. They are predominantly chloritic, though diopside bands and diopside-calcite marble laminae are occasionally seen (hole 27).

The sulphides are an integral part of the unit. Sphalerite and pyrite occur as thin laminae in zones of chert and 'skarn' separating the more massive, laminated, banded and lithoclastic sulphide-chert breccia layers. These pass, usually fairly abruptly at planar boundaries, into thin laminated sulphide.

Galena is frequently observed as cross-cutting veinlets within sphalerite and the host chert-skarn sequence, suggesting remobilisation into stress produced hairline fractures.
Unit 6 varies in thickness from 10-30 m but is frequently thinned or repeated by faulting. The unit is further discussed in sections 4.2.1, 4.2.2 and 4.2.3.

<u>Unit 7.</u> Red pyritic 'felsic' chert unit.

In all intersections Unit 6 passes down into very characteristic red-brown fine grained 'cherts', forming a unit 10-16 m thick, but often partly cut out or repeated by faulting. These are typically red-brown or foxy-red in colour, often passing downwards into mixed red and pale grey cherts. They are weak to well foliated, weakly sericitic, often 'jaspilitic', and invariably contain a fine grained pyrite mineralisation, as discrete, dispersed grains. In many sections fine grained magnetite porphyroblasts occur, together with fine grained mafics. With the change into red-grey and grey cherts, and the appearance of sericite, Unit 7 passes down into:-

<u>Unit 8.</u> Sericite chert unit.

Grey fine grained chert with dispersed sericite in the lower part of Unit 7 passes into sericitic cherts and sericitic schist bands in Unit 8. Foliation is well developed, and the schist bands are generally 5-10 cms thick with selvages and streaks of pale grey siliceous 'chert'. Minor garnet porphyroblasts are not uncommon. Several schistose bands contain quartz-grains which appear to be quartz-eyes, but are most likely due to shearing and tectonic 'grinding' of the chert laminae.

Downwards the sericite becomes finer grained and dispersed. The sericite schist bands disappear, and the chert changes into a micaceous grey psammite. Unit 8 is usually 10-14 metres thick but often tectonically thinned or thickened by faulting.

Unit 9. Banded 'skarn' unit

The top of unit 9 is marked, usually, by an abrupt change into planar and undulose banded diopside-chlorite-amphibole-grey chert - - red chert - calcite marble. Banding is at the 0.5-1 cm scale and gives rise to a characteristic 'striped' appearance. Garnet porphyroblasts are common, and frequently occur as garnet laminae or porphyroblast rich layers. Feldspar 'streaks' and epidote are occasionally seen.
The bright red cherts appear to be jaspilitic, but the unit can also contain magnetite. Where it does occur, in holes 3, 7, 9, 12, 16, 17, 18, 21, 22, 24, 26, 28, 31, 37, 38, 44, 45 and 46 it is as thin 1-5 cm laminae within diopside and diopside-chert laminae.
Actinolite is sometimes observed, and in holes 7, 12, 16, 22, 31 and 44 pyrite disseminations, 'clots' and streaks occur associated with magnetite layers.
In holes 23, 35, 43 and 44 pyrite occurs in fractures in the diopside laminae, but magnetite is absent.

Unit 9 averages 5-10 metres in thickness.

Unit 10. Grey Marker chert unit.

A thin 'chert' of variable lithology occurs at the base of Unit 9, but is so consistent in all drilled intervals it is a conspicuous marker.
The unit is 3.50-8 metres thick and is usually a grey fine grained, garnet porphyroblastic, minor chlorite streaked, weakly sericitic, siliceous 'chert'. In Hole 4 thin diopside streaks occur. What appear to be sillimanite (fibrolite) porphyroblasts occur in the unit in hole 35.

Unit 11. Lower Magnetite Marker unit.

A second 'skarn' unit underlies the unit 10 chert. Characteristically this skarn always contains magnetite bands, and is predominantly a coarse crystalline diopside-garnet amphibole skarn, with minor grey siliceous chert, and occasionally calcite marble. Layers of massive magnetite up to 0.30 m thick occur within the unit, which is normally 5-10 metres thick.

In holes 3, 4, 5, 9, 11, 12, 15, 17, 20, 26, 31, 32, 35, 39, 45, and 46, sulphides, chiefly galena, occur, specially associated with the magnetite (see section 4.3).

The layers of carbonate, skarn and magnetite are often contorted and the unit is often repeated by faulting.
This magnetite bearing unit produces the anomalies seen in the local magnetic map in the main target zone.

Unit 12. Grey chert unit.

Below the Unit 11 Lower Magnetite Marker up to 150 metres of supracrustal rocks have been intersected. Holes 1, 2, 3, 4, 6, 8 and 24 penetrate well into this sequence, while most other holes intersect the upper 10-20 metres immediately below Unit 11. Section 3.3.3 discusses correlation with holes 42, 14, 41, 39 and 40.

The intersections in the holes noted above permit this part of the sequence to be sub-divided, and the following sub-units are recognised.

Sub-unit 12a: This is characteristically a grey-, grey-green fine grained siliceous 'chert'. Thin streaks and schlieren of chlorite occur, with pale grey-green chert (diopside?) rims. Rounded pale pink-brown garnet porphyroblasts, usually 1-4 mm across are dispersed through the rock, particularly within or around the chloritic schlieren. This sub-unit is of variable thickness up to 27 metres. It is absent in hole 17.

Sub-unit 12b: With the loss or decrease in number of the garnet porphyroblasts, and an increase in sericite 12a passes down into 12b. This rock is generally featureless, other than sericitic schlieren, producing a streaky appearance. If garnets are present they tend to be concentrated in laminae.
Minor phyric grains are noted in this sub-unit (eg. Holes 3 and 6) and bright orange siliceous veining occurs (Hole 4).
Thickness varies up to 40 metres.

Sub-unit 12c: The sericitic 'cherts' and metatuffite of 12b pass down into a sericite dispersed, non-streaky, granular fine grained siliceous 'psammite'. Garnet porphyroblasts occur, but are invariably small (<0.5 mm) and rounded or irregular in shape. Sub-unit 12c is up to 65 metres thick in hole 3, but appears absent, or suffers lateral lithofacies variation over the 200 m southwards to Hole 45. It is 14 m thick in hole 6.

Sub-unit 12d: Garnet porphyroblasts increase in abundance, and in some sections pass into sub-unit 12d.
In hole 45 this is marked by a garnet-amphibole-diopside-biotite-chlorite-magnetite skarn, about 4 m thick. The same unit, fault bound, occurs in hole 3 as a faulted slice 2 m thick. In Jönshyttan No 8, at 267.74 m a 2 m thick magnetite skarn zone appears to be sub-unit 12d, while in hole 4 complex folding increases the intersection in this sub-unit to 10 m. Hole 6 intersects sub-unit 12d, but there is no magnetite.

Strata apparently lower in the succession occur in holes Jönshyttan 8, 3/85, 4/85, 6/85 and 36/86 in the main zone, and holes 14, 39, 40, 41 and 42 to the west. These units are discussed below and in section 3.3.3.

Sub-unit 12e: In hole 45 below 12d, the succession passes into fine grained dark grey, weakly sericitic 'cherts' with dispersed garnet porphyroblasts. The same lithology is seen in Jönshyttan 8, as approximately 21 m of grey 'chert', and in hole 8 in the north of the main zone, but the latter is only a tentative correlation.

Sub-unit 12f: In Jönshyttan 8 the grey cherts of 12e pass into a thick (18 m) section of mixed diopside rich skarn bands, fine grained siliceous 'chert', and occasional thin magnetite laminae.

In hole 6 a 13 m section of mixed skarn and chert with calcite marble is provisionally correlated with 12f, and 12g, which is well displayed in hole Jönshyttan 8. Similarly, a 5.30 m interval of thin diopside calc-silicates and cherts occurs in hole 4 and is here provisionally correlated with 12f.

Sub-unit 12g: In Jönshyttan 8, 37 m of skarn banded (diopside--amphibole) grey dolomite and dolomite calcite marble occurs. A full thickness is not revealed as the base of the unit is faulted against 6 m of grey chert to the bottom of the hole.

Sub-unit 12h: 12m of phyric chert in the bottom of hole 4 may constitute a further sub-unit but this is not clear.

3.3.3 Supracrustal Sequence - Western Area

Mineralisation, of apparently the same type as the target sulphide zone, had been intersected in hole 14/85, with 1.50 m of 5.53% Zn and negligible Pb-Ag. It was considered that a synformal fold structure lay to the west of the main zone, and that the continuation of the target lay on the western limb of this fold, drilled in hole 14, and sub-cropping south-westwards, parallel to, and some 40 metres east of the Hagalund magnetite-skarn zone.
Consequently, during 1986, four holes (39-42) were drilled to test this possible continuation, and hole 40 was subsequently extended to test the Björkhags magnetite skarn and the bedrock immediately west of this succession (figs. 7 and 13). The Björkhags magnetite does not however appear to have been tested.
As previously noted, all holes between 8 and 30 in the main discovery zone can be correlated (fig. 12) including the deep holes to the east (35, 31, 45, 46). To the west correlation is possible to 821W, where hole 29 penetrates a sequence with lithological Units 5-11, repeated in part by faulting. Hole 29 also intersects the target mineralisation, with 9.65 m of 5.12% Zn, including two separate intersections of 3.40 m of 7.68% Zn, and 2.05 m of 10.00% Zn (see Section B).

Hole 36 drilled 181.60 m of almost continuously fractured, brecciated, steeply inclined, vertical, overturned, folded, veined, cracked and severly crushed bedrock in a major fault zone. Two main lithologies are present, a fine grained grey or grey-brown 'chert' and a chloritic, calcite-dolomite marble with minor diopside bands. These are provisionally correlated with Units 12f, 12g and 12h in Jönshyttan No 8, and considered to be an up-faulted sequence lying structurally below the target sulphide zone.

Several problems exist in correlating the discovery zone succession with the succession drilled in holes 42, 14, 41, 39 and 40. Holes 1/81, 2/81 and Jönshyttan 9/62 intersect the same sequence but have not yet been re-logged.
Problems correlating the discovery and western zones are:

i. In the western zone the dominant lithology is grey, siliceous, fine grained 'chert' and psammite with no characteristic markers.

ii. The sequence is not the same as the discovery zone as none of the characteristic lithological sequences occur.

iii. Magnetite skarns occur but are, as seen in hole 40, not extensive sheets rather lensoid masses passing laterally or downwards into non-magnetite bearing skarns, mixed skarn-chert or chlorite streaked 'chert'.

Two possibilities exist in correlating the western area with the main discovery zone:

1. The strata in the western area structurally underlie the target zone and are faulted up to the west of a major fault zone intersected in hole 36.

2. The strata are the same stratigraphic-lithological units as the target (discovery) zone, but lateral lithofacies variation occurs, marker horizons and sequences present in the discovery zone are lost and the target mineralisation is absent.

Both Bleeker (1984) and A. Engvall (1985) correlated in different ways the two western magnetite horizons with magnetite horizons to the east at Backadahl and Elizabethgruvan (figs 15 and 17). Bleeker also correlates the carbonate seen at Storå in outcrop, and possibly correlated with the carbonate in the bottom of hole 40, with the main carbonate seen in the Håkansboda-Eriksgruvan zone to the east. This discussion is developed further in section 3.4.1.

The main feature of the western area is that the mineralisation located in hole 14 does not occur 100 m along strike to the south in hole 41, and none of the holes in the western area contain the target mineralisation.

KEY :

HZ Haglund Zone W. Lovisa

1,2,3 etc: Lithological Units

Note All widths are as measured uncorrected in the drill cores, i.e. Not the true thickness.

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Fig. 12

L O V I S A

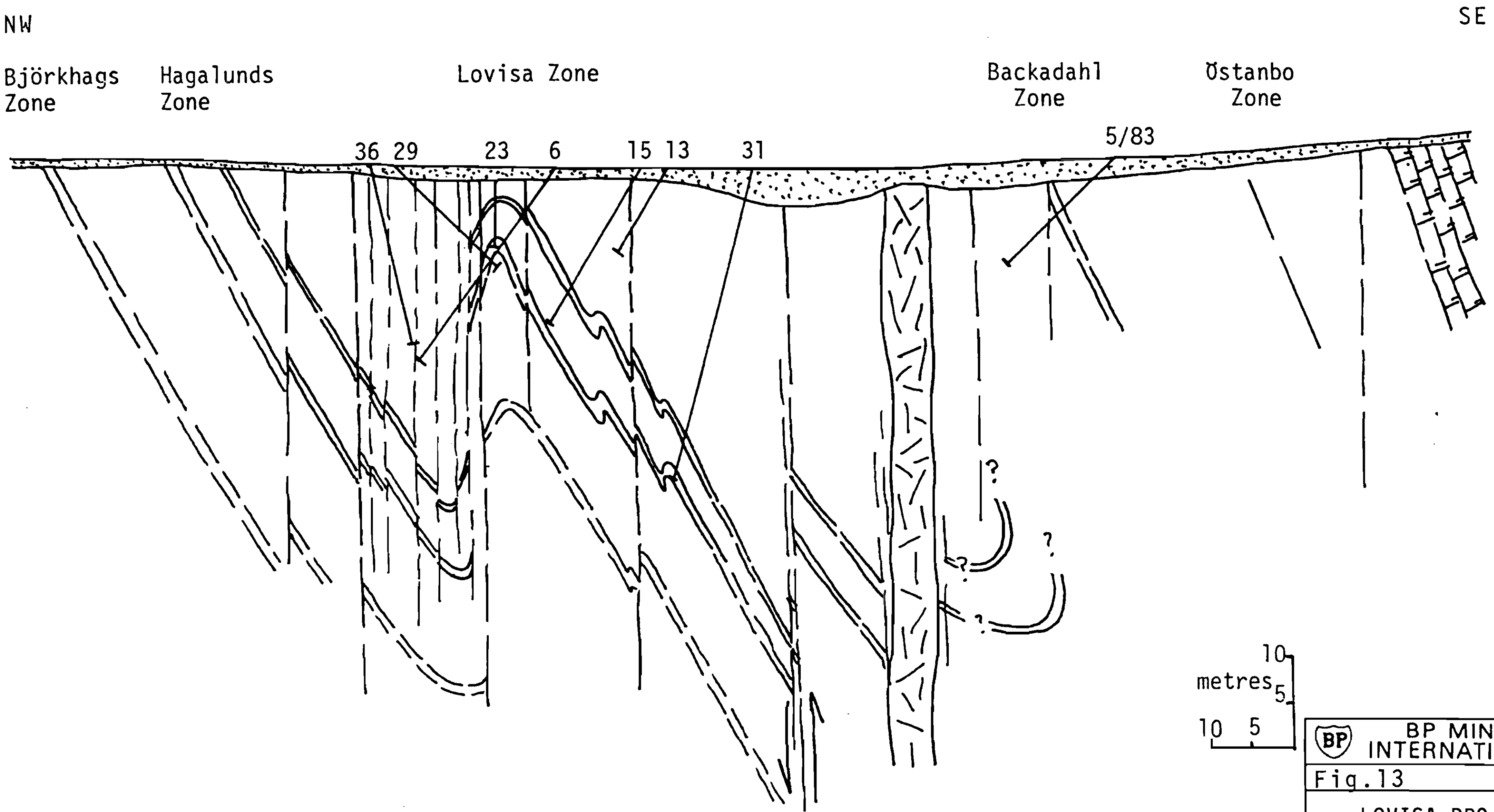
North - South correlation of the drillhole intersections.

Author C.J.Carlon | Date January 1987.

Revised

LOVISA PROJECT

INTERPRETIVE GEOLOGICAL SECTION ON LINE 4800N



Main Zn-sulphide zone

Magnetite-pyrrhotite calc-silicates

Diabase intrusive

Main carbonate formation

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Fig.13

LOVISA PROJECT - Interpretation of the structure on 4800W grid line (as of Aug.1986)

Author CJCarlon	Date Jan 1987
Revised	

3.3.4 Supracrustal Sequence - Eastern Area

The drillcores from the Nya Backadahl drilling programmes have not yet been re-logged. Examination of the logs produced by Hans Persson, and re-logging of hole 19/84 in the north of the zone, suggests the succession belongs to the same micaceous, sillimanite bearing schistose 'metasediment' sequence seen immediately above the main carbonate formation in the Håkansboda area.

It has been proposed that the Lovisa sulphide zone lying above the Lower Magnetite Marker (unit 11) dips eastwards to pass round the main synformal axis and appear on the western side of the Nya Backadahl zone (fig 13). This pre-supposes:

i. Bleekers main synformal axis lies between Lovisa and Nya Backadahl

ii. Unit 11 at Lovisa is the same horizon as the Nya Backadahl horizon.

Both suppositions are as yet unconfirmed, and the thick unrepeated succession in hole 46 tends to suggest that the synformal axis is not present where Bleeker supposed, a point already made by A. Engvall (1985) (see figs 8 and 17).

Further discussion on the correlation to the east requires re-logging of cores from Nya Backadahl and further east. An additional comment on correlation is made in section 3.4.1.

3.3.5 Intrusives

Two intrusive types can be noted:

i. A fine-coarse grained dolerite (diabase) dyke

ii. Minor, generally thin, simple granite pegmatites

Dolerite (Diabase) Dyke:

A major diabase dyke cuts the supracrustal sequence in the Lovisa area (figs 4 and 24). Trending NNW-SSE it probably belongs to the well defined basic dyke suite occurring in Bergslagen and dated at 900-1000 ma (Sveconorwegian).
Its position can be mapped from ground magnetics, with sufficient accuracy to have enabled positioning hole 46 to intersect its western contact. The generally symmetrical magnetic pattern suggests that the intrusion is vertical.
Drillholes 8 and 2 intersect the eastern contact, holes 33 and 46 the western contact.
A fault slice occurs in the top of hole 45. No hole penetrates right through the dyke, and hole 2 intersecting the contact at a low angle remains in diabase for 108.20 m. From drilling and ground magnetics the dyke appears to be approximately 80 metres thick.
Granoblastic textures are developed in the supracrustal sequences in the contact aureole, which is at least 6 m thick. A fine grained flinty hornfels occurs at the contact.

The dyke rock has a chilled zone of very fine grained diabase about 10 metres wide, the grain size slowly increasing to about 2 mm, 20 metres into the dyke. The coarser grained dolerite forming the bulk of the intrusion is a non-porphyritic, clinopyroxene-plagioclase rock with around 1-2% magnetite.

Chloritic 'mylonite' zones occur periodically in the hole 2 intersection in the dyke. Bleeker (1984) noted that some of these zones were folded and the result of post-intrusion tectonics. The contact zones also indicate post-intrusion tectonics. In holes 2 and 8 the eastern contact is faulted, brecciated and chloritic, and the western contact in holes 33 and 46 displays the same features. This feature is further discussed in section 3.4.3.

Pegmatites:

Minor, coarse grained, leucocratic, simple granite pegmatites are seen cutting all stratigraphic units without preference. They are however, uncommon, ranging in size from veinlets up to 20 cms thick to occasional 0.5-0.8 m thick bodies.
Mineralogy is principally coarse, glassy or milky quartz, muscovite and microcline. Pink microcline is also observed, sometimes with a perthitic structure.

Most of the intersected pegmatites cut the foliation and banding in the supracrustals, but some are parallel with the foliation and others are folded. These features suggest that most pegmatitic intrusives are post F_1 and either syn or post F_2. A small number are syn F_1, but these are usually pink feldspar, biotite granitoids occurring in the quartzo-feldspathic Unit 1 lithology, possibly of anatectic origin.

3.4 Structure and Metamorphism

3.4.1 Regional Structure

The Lovisa Prospect lies within a NE-SW trending belt of 1.9-1.8 Ga Lower Proterozoic, dominantly acid metavolcanic supracrustal rocks, up to 5 kms wide and 45 kms long. The large scale structure is a NE-SW trending, easterly dipping, isoclinal and synformal major F_1 structure. Mapping in the Stråssa-Storå area by Bleeker (1984) identified parasitic fold structures with Z and S form cut by an F_1 axial plane foliation which appears to confirm the presence of this major structure.

The major synform does not have a flat lying axis, but culminations and depressions on the axis give rise to north-east and south-west plunges. A major culmination on the main synformal structure, apparently over a buried ridge of younger intrusive syn-orogenic Fellingsbro Granite, produces a dome in the area immediately NE of Stråssa. In the Lovisa area. to the SW of this dome, dominant plunge is to the SW (fig 14). To the NE the culmination plunges NE into the Riddarhyttan supracrustal belt.

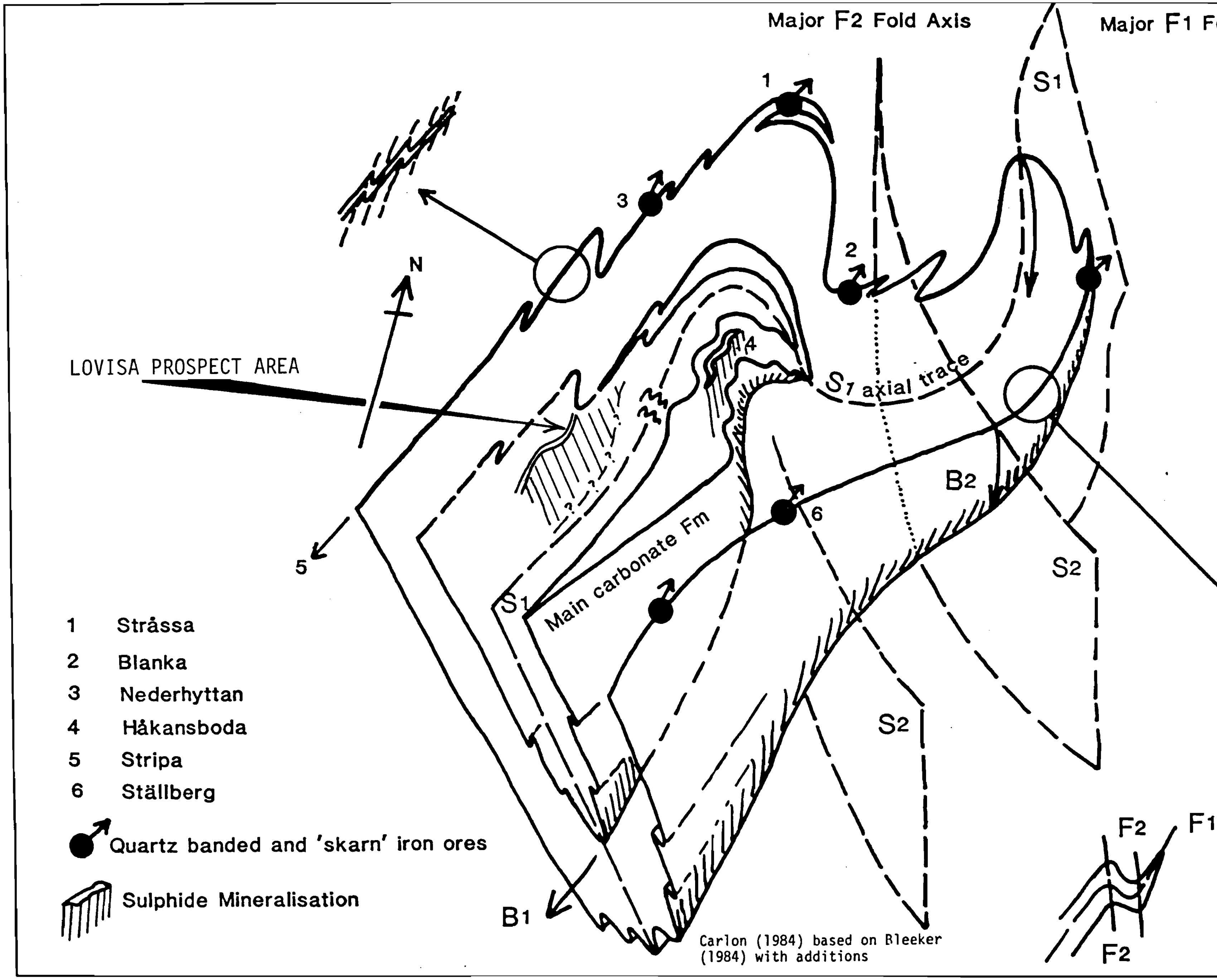

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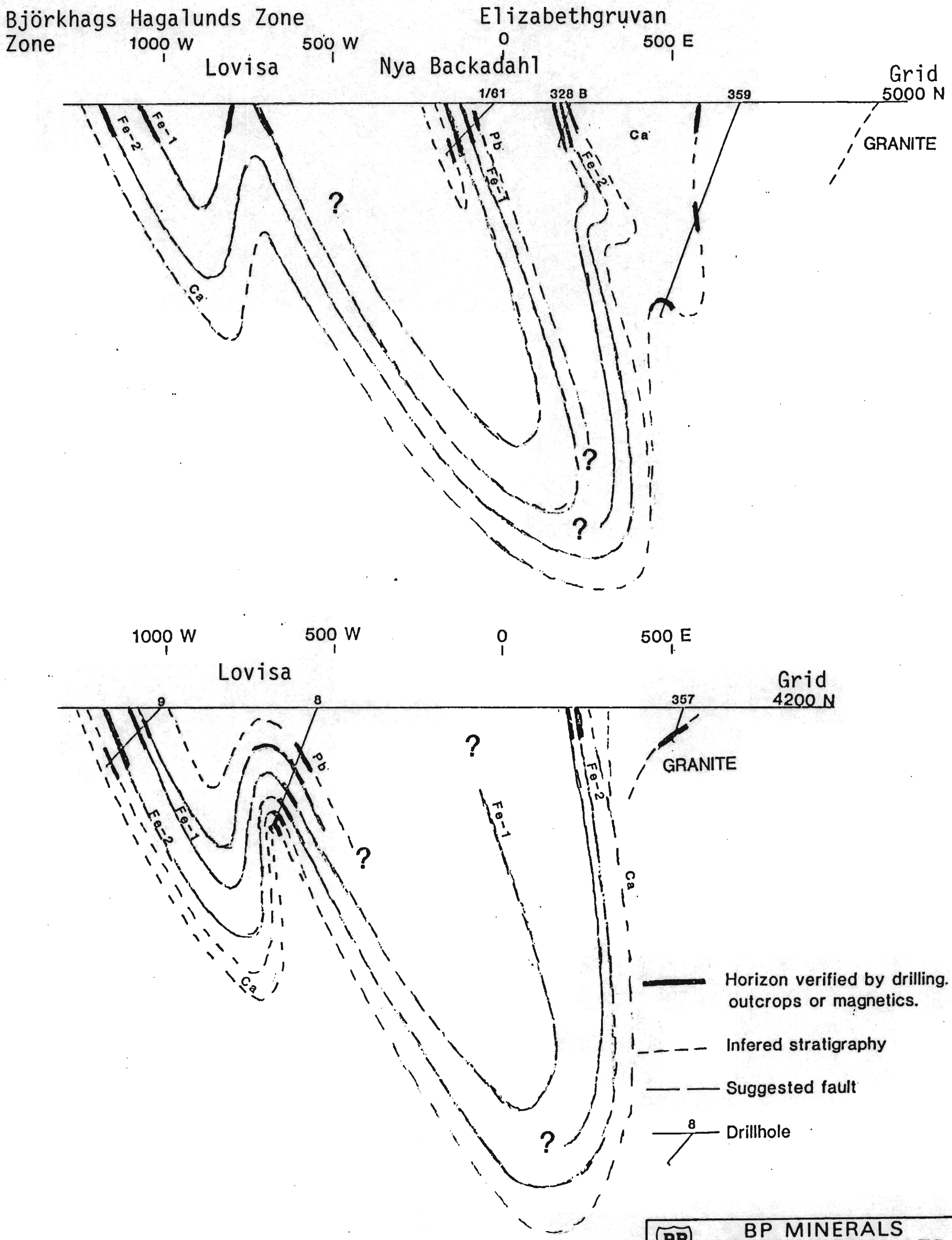
Fig.14

LOVISA PROJECT - The three-dimensional area structure

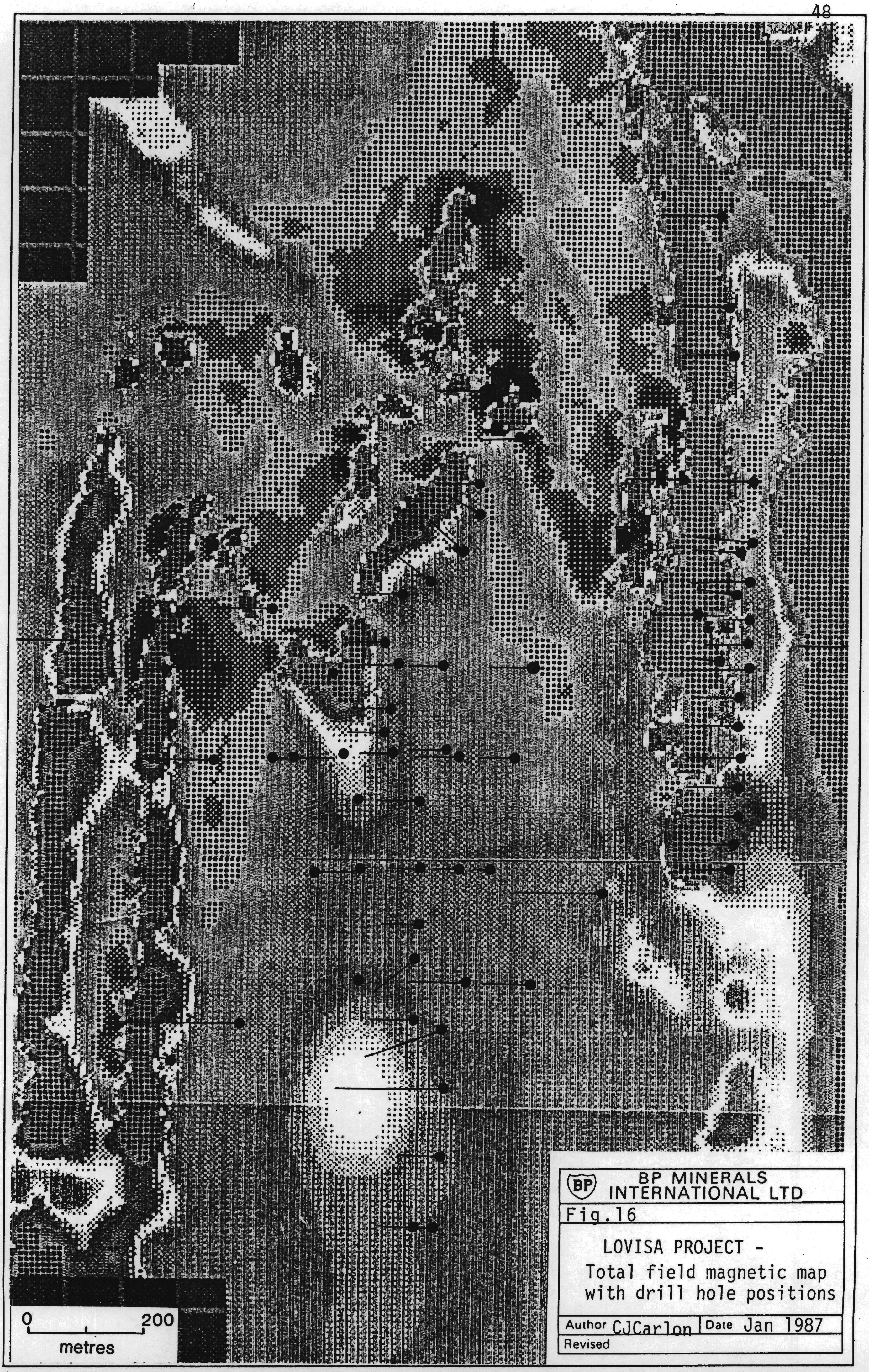
Author CJCarlon Date Jan 1987

Revised

GEOLOGICAL CROSS-SECTIONS
ACCORDING TO W. BLEEKER



BP MINERALS INTERNATIONAL LTD	
Fig.15	
LOVISA PROJECT - Bleekers (1984) inferred structure (Engvall 1985)	
Author CJCarlon	Date Jan 1987
Revised	


BP MINERALS INTERNATIONAL LTD
Fig.16
LOVISA PROJECT -
Total field magnetic map with drill hole positions
Author CJCarlon
Date Jan 1987
Revised
0
200
metres

GEOLOGICAL CROSS-SECTIONS
ACCORDING TO THE SUGGESTED MODEL

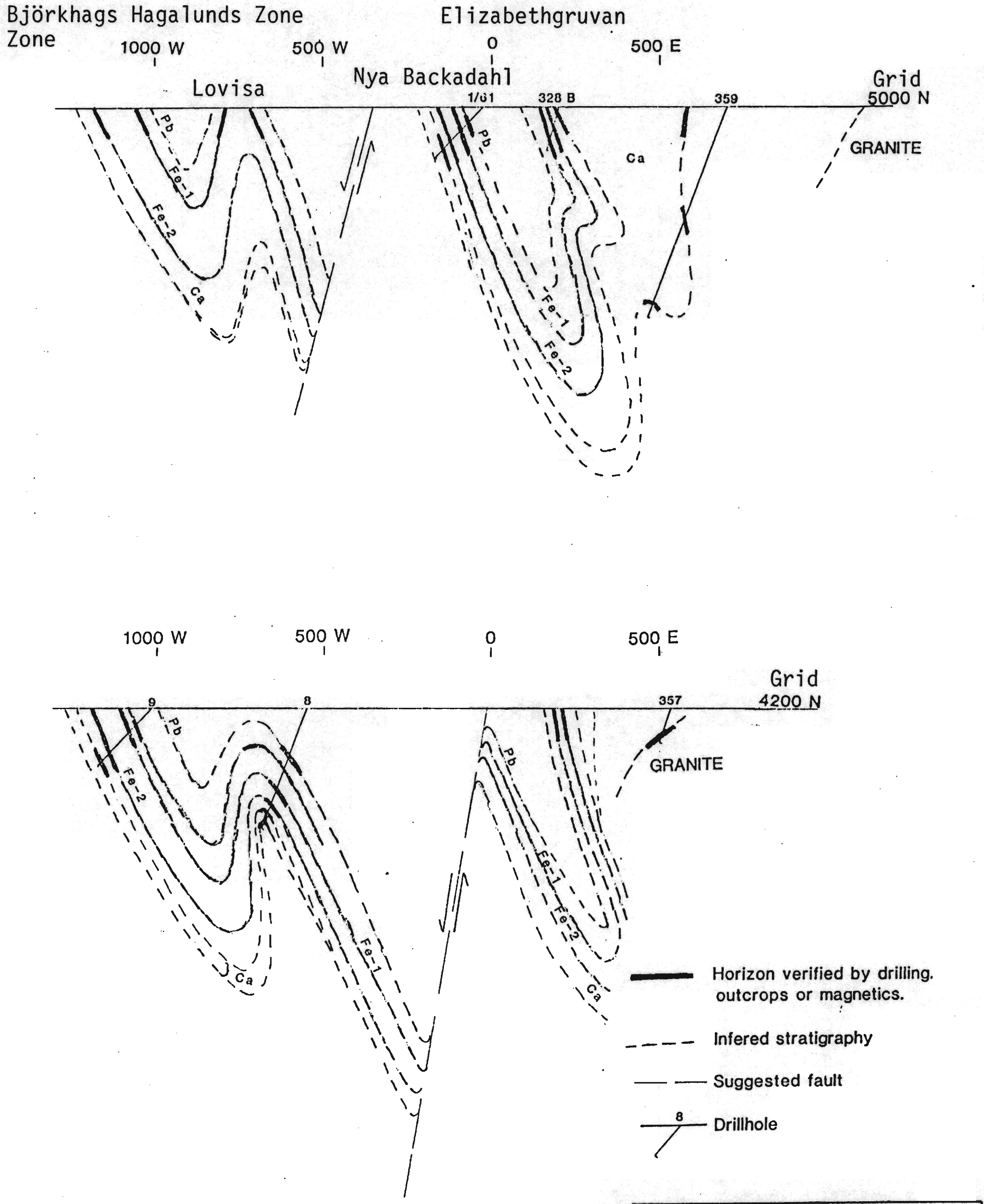


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Fig. 17

LOVISA PROJECT -

Inferred structure after Engvall (1985)

Author	CJCarlon	Date	Jan 1987
Revised			

A second structural fold set is superimposed upon the F_1 major structure. F_2 folds have NNW-SSE trending axes, plunge steeply to the SE, and produce interference structures re-folding F_1 folds and S_1 foliations. The axial trends of the F_2 folds parallel the buried ridge of Fellingsbro Granite and correspond to the rises and falls in the F_1 fold axis.

On a small scale parasitic, isoclinal F_1 folds with NE-SW axial trends and SW axial plunges display S_0-S_1 parallelism and a penetrative S_1 axial plane foliation. Small scale boudinage and shear structures accompany the F_1 folds, particularly in areas of mixed competent and incompetent strata.

F_2 folds in outcrop refold isoclinal axes, produce an interference steeply plunging S_2 foliation, transpose S_0 banding and are often accompanied by blasthesis, features which considered together with pegmatite form suggest that they all result from the culmination of the tectonic-metamorphic pro-grade development of the region.
The result of the F_1-F_2 structures in the Stråssa-Storå area is shown in fig. 14 after Bleeker (1985). Further discussion on the structural interpretation is given by Bleeker (1985) and Carlon (1986a).

In summary the regional structure is an elongate, NE-SW, non-cylindrical isoclinally folded, overturned and easterly dipping synform, with variable but generally SW plunge. This has been refolded about NW-SE trending, SE steeply plunging folds producing a variety of interference structures.

From outcrops in the area east of Lovisa Bleeker (1984) deduced the major and interference structural pattern and extrapolated it westwards using the then available regional magnetic data, his map is presented for the Lovisa area in fig 4.

Problems have subsequently arisen, as more data has accumulated, accepting the interpretation for the Lovisa area structure.

Bleeker correlated the dolomitic marble of the Håkansboda zone on the eastern limb of the synform, with a carbonate horizon exposed near Storå railway station (western limb). He noted that while the Håkansboda marble was dolomitic, the Storå marble was essentially calcitic.
The magnetite-skarn bands occurring in the Björkhags and Hagalunds zones were correlated respectively with the Lekberg and Lovisa magnetite skarns, and these in turn, around the major synformal axis, with the Elizabeth-Östanbo zone and the Nya Backadahl-Matilda zone (figs 4 and 15).
The main synclinal axis was placed between Lovisa and Nya Backadahl, and an F_1 synform-antiform fold couplet placed between Hagalund and Lovisa. The Lovisa plunging antiform seemed to be confirmed by ground magnetics (fig 16).

A reassessment of the magnetic data and comparison of strong magnetic anomalies with known magnetite horizons intersected in the early holes of the Lovisa drilling programme and the drilling at Nya Backadahl led Anders Engvall (1985) to propose a new structural interpretation (figs 8 and 17). This differs in three main ways from Wouter Bleekers interpretation:

i. The Hagalund and Björkhags magnetite skarns together from the Backadahl zone

ii. The main synformal axis is placed between Nya Backadahl and Elizabeth gruvan, not west of Nya Backadahl between this zone and Lovisa

iii. A major fault, inclined to the west with a major normal vertical throw of about 1000 m, is inferred between Lovisa and Nya Backadahl. This trends N-S (grid NNW-SSW).

Like Bleeker, Engvall correlates the western calcite marble with the Håkansboda dolomite marble, and in addition correlates both with Unit 12g in the bottom of Jönshyttan Hole 8 (fig 17).

Further data is now available to reassess the structure and produce a new interpretation, and the following structural observations can be made:

1. The validity of correlating magnetite skarn horizons on a one-to-one basis can be questioned due to lateral facies changes. Hole 40 demonstrates that the Hagalund magnetite zone dies out, changes character or thins downwards. Unit 3 in the discovery zone displays lateral facies changes.

2. The validity of correlating the Storå and Håkansboda marbles can be questioned. This is only valid if the over and under beds correlate taking structure into consideration. They do not appear to do so, although again an east-west facies change may take place.

3. There are numerous magnetite skarn horizons in the sequence, which can be noted from east to west as follows:-

   i. Magnetite bands within 20 metres of the main carbonate formation. Containing silver mineralisation (Luthgruvan, Håkansboda)

   ii. The Elizabeth-Bäcke-Östanbo zone, 50-80 metres west of the main carbonate formation

   iii. The Nya Backadahl-Matilda zone, 200 m west of the Elizabeth mine zone

   iv. A thin skarn with minor sulphide below the main Backadahl zone, located during drilling

v. The Upper Magnetite Marker (Unit 3) in the Lovisa zone, lying about 200 m west of the Backadahl zone

vi. The Lower Magnetite Marker (Unit 11) responsible for the strong magnetic response in the discovery zone and correlated with Unit 11 from holes 24 to Lovisa mine. Note that Unit 9 sometimes contains Fe 0 .

vii. Unit 12d magnetite skarn, approximately 120 metres below Unit 11.

viii Unit 12f magnetite marble-skarn, approximately 21 metres below Unit 12d

ix. The Hagalund magnetite-skarn, 350 m west of the Lovisa sulphide zone

x. A thin magnetite band some 90m west of the Hagalund zone

xi. The Björkhags magnetite-skarn, 160 m west of the Hagalund zone.

Sulphides are particularly common in i, iii, vi, and ix. as galena-silver mineralisation.
There is currently no unique interpretation for the correlation of these zones one with another.

4. Strata forming over and under 'beds' to these magnetite horizons suggest that similar sequences occur around the Backadahl and Elizabeth mine zones (sillimanite bearing, micaceous 'cherts' and schists of metasedimentary origin), around the Björkhags and Hagalund zones (mafic skarns, fine grained siliceous, quartzo-feldspathic 'cherts' and calcite-diopside marbles).
Lack of correlation of over- and under'beds' suggests that the Lovisa Unit 11 marker is not the same horizon as the Hagalund or Nya Backadahl zones. However, Units 12d and 12f could correlate with the Hagalund magnetite and the zone 90 m west of this on a basis of enclosing rock sequences.

5. The carbonate horizon in hole 40 may correlate with 12g in Jönshyttan 8, but appears to lie east of the Storå carbonate (calcite marble) and east of the Björkhags magnetite. Carbonate (calcite-dolomite marble) horizons occur in the Backadahl zone, immediately west of Backadahl, east of Lovisa (Unit 2), as impersistent bands in unit 4 at Lovisa, in Unit 12g below the target sulphide, and in at least two zones west of Björkhags zone.
Clearly a structural interpretation based solely on magnetite bands or marble horizons is unacceptable unless the 'package' of rocks in which they sit is also considered.

6. From hole 46 in the east to hole 36 in the west (fig 7), the main sequence of rocks hosting the Lovisa sulphide zone appears unrepeated by major folding and a continuous, characteristic sequence of recognisable lithofacies is seen constituting about 600 metres of strata.

A major fold structure repeating the sequence in inversion is not present west of hole 46 collar.
The sequence is totally unlike that seen in the Backadahl and Elizabeth zones to the east.
The lower part of the sequence is similar to that seen further west in the Björkhags and Hagalund zones.

7. In the northern part of the discovery zone, the Lovisa mine magnetite-skarn correlates with Unit 11, and the Lekbergs zone would appear to correlate with the Hagalund zone, not the Björkhags zone as supposed by Bleeker.

Structural interpretation is further considered in the following sections.

3.4.2 Lovisa Discovery Zone - Folding and Deformation

Folding and deformation in the Lovisa discovery zone can be considered on two scales, large and small.

Large scale fold structures have not been detected in the cores. Isoclinal F_1 fold structures undoubtably exist in the sequence, but no major synformal axis, repeating the strata, has been observed.

Mineralogical and compositional banding on a major and micro-scale appears, for the most part, to be or be the metamorphic equivalent of, original compositional banding. This appears particularly true of the colour banded, very fine grained quartzo-feldspathic and siliceous 'cherts' with mm-scale planar banding.

Throughout the main discovery zone banding dips at 56-66^{o} E, with notable exceptions.

In the area between 700-850W, particularly around 4800N a complex fold-fault structure is produced, suggesting that a monoclinal fold is developed, faulted to the west, and dipping to the east. The hinge zone occurs around 700W where complex fracturing is developed. (fig 18). A similar structure can be inferred from drillhole profiles at 4400, 4600 and 4920N (figs 19, 20 and 21), producing the three dimensional form shown in fig 22. This structure corresponds to the supposed 'Lovisa Antiform'. Where banding approaches certain faults dips shallow to 50^{o}, and in the monoclinal area are flat lying (if this interpretation is correct).

A rather different structure seems to exist in the western area. Dip is consistently to the east, but increases from south to north as follows:-

Hole 40 (south)	70^{o}E
Hole 39	74^{o}-85^{o}E
Hole 41	80^{o}-90^{o}E
Hole 42	90^{o}-80^{o}E

The interference of F_2 structures is suggested but insufficient data is available to give a unique solution.

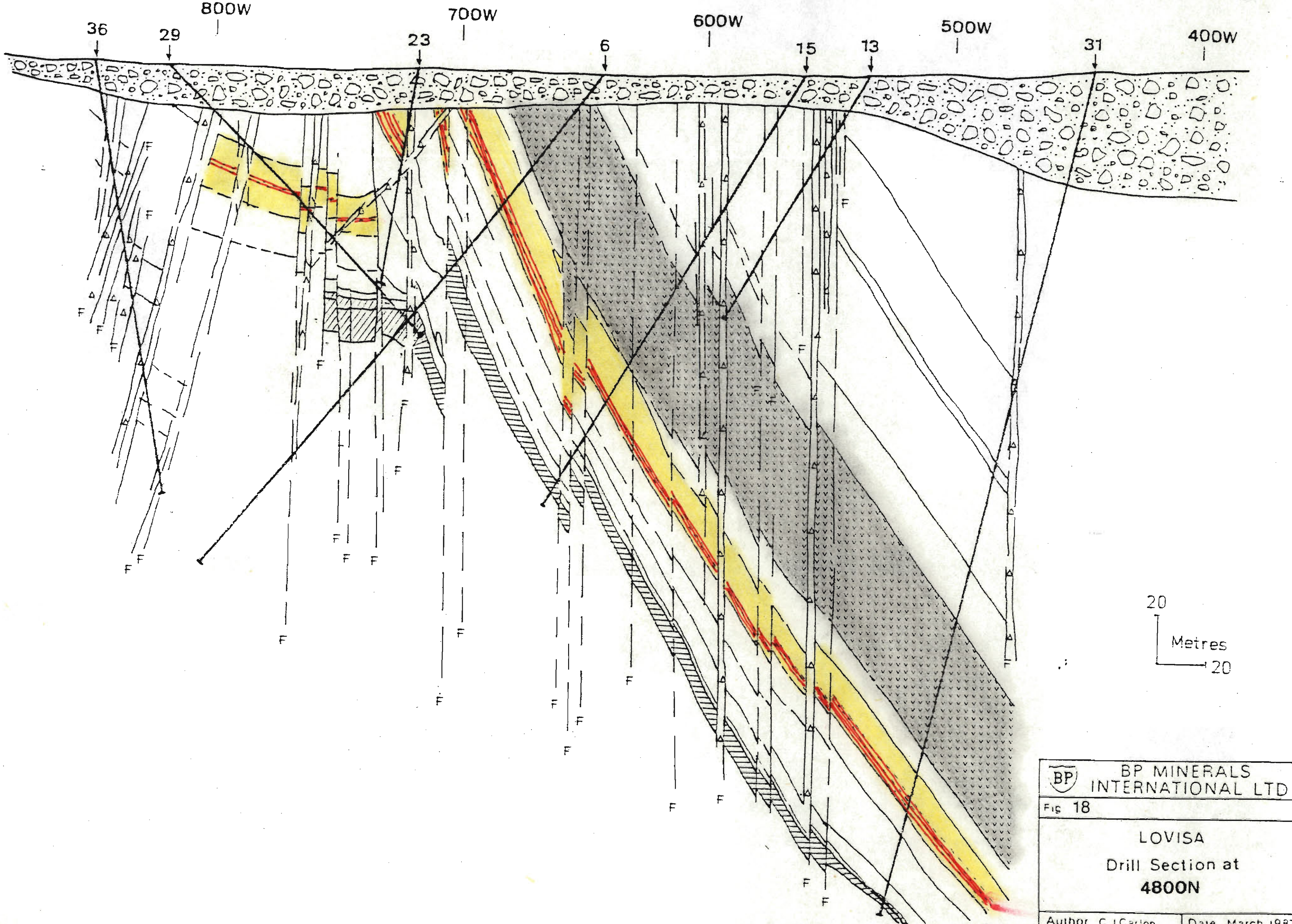

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Fig 18

LOVISA

Drill Section at

4800N

Author C J Carlon	Date March 1987
Revised	

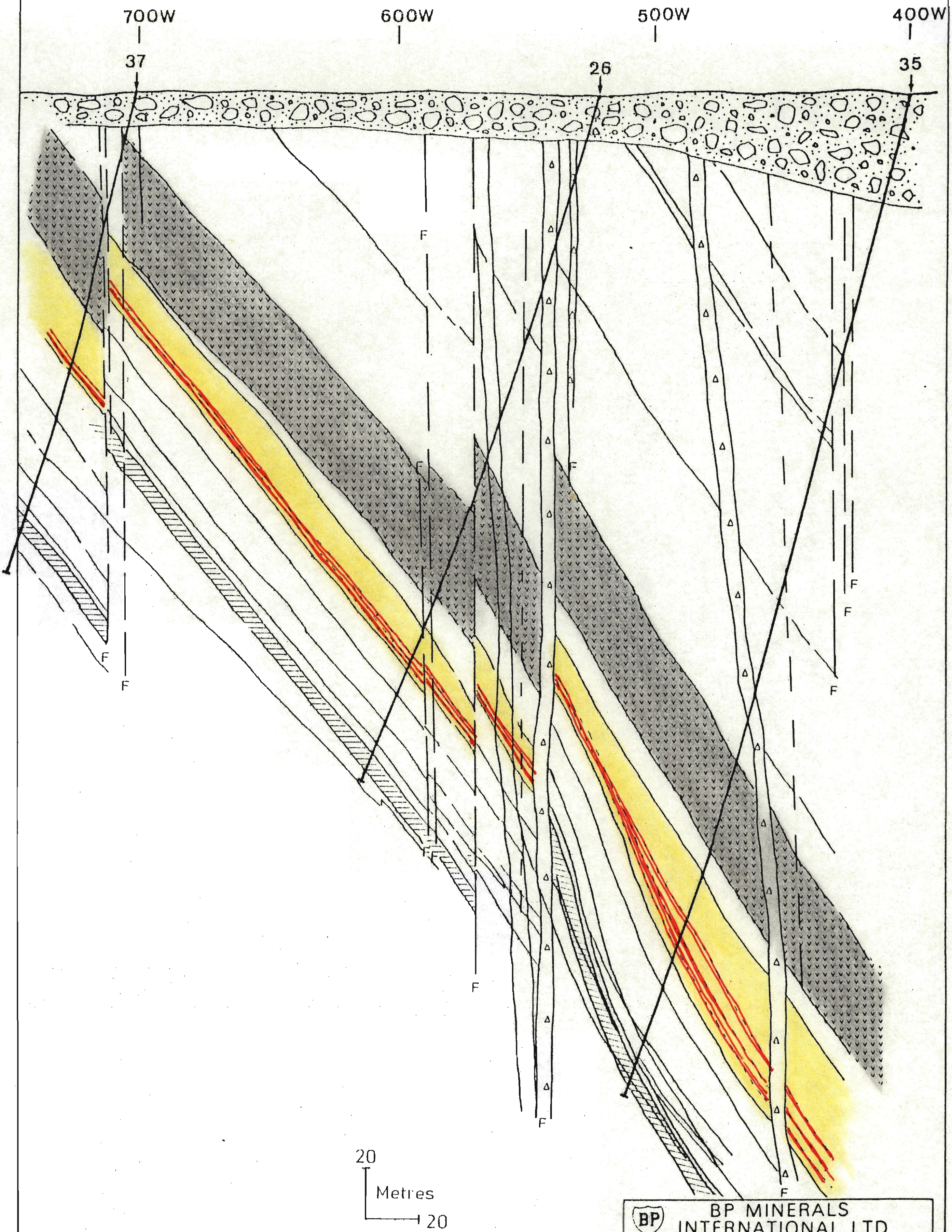

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Fig. 19

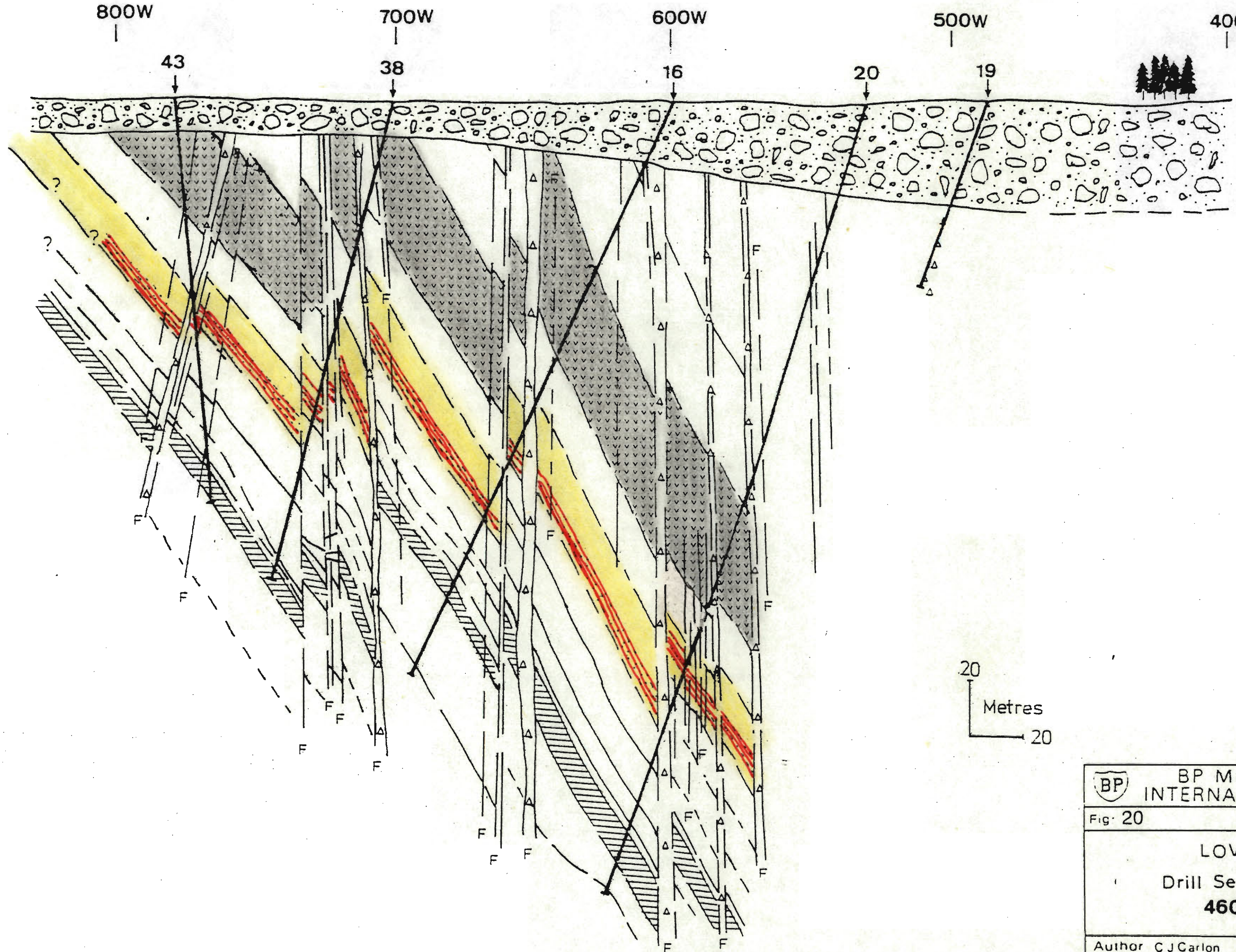
LOVISA

Drill Section at

4400N

Author C J Carlon | Date March 1987

Revised



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Fig· 20

LOVISA

Drill Section at **4600N**

Author C J Carlon	Date March 1987
Revised	

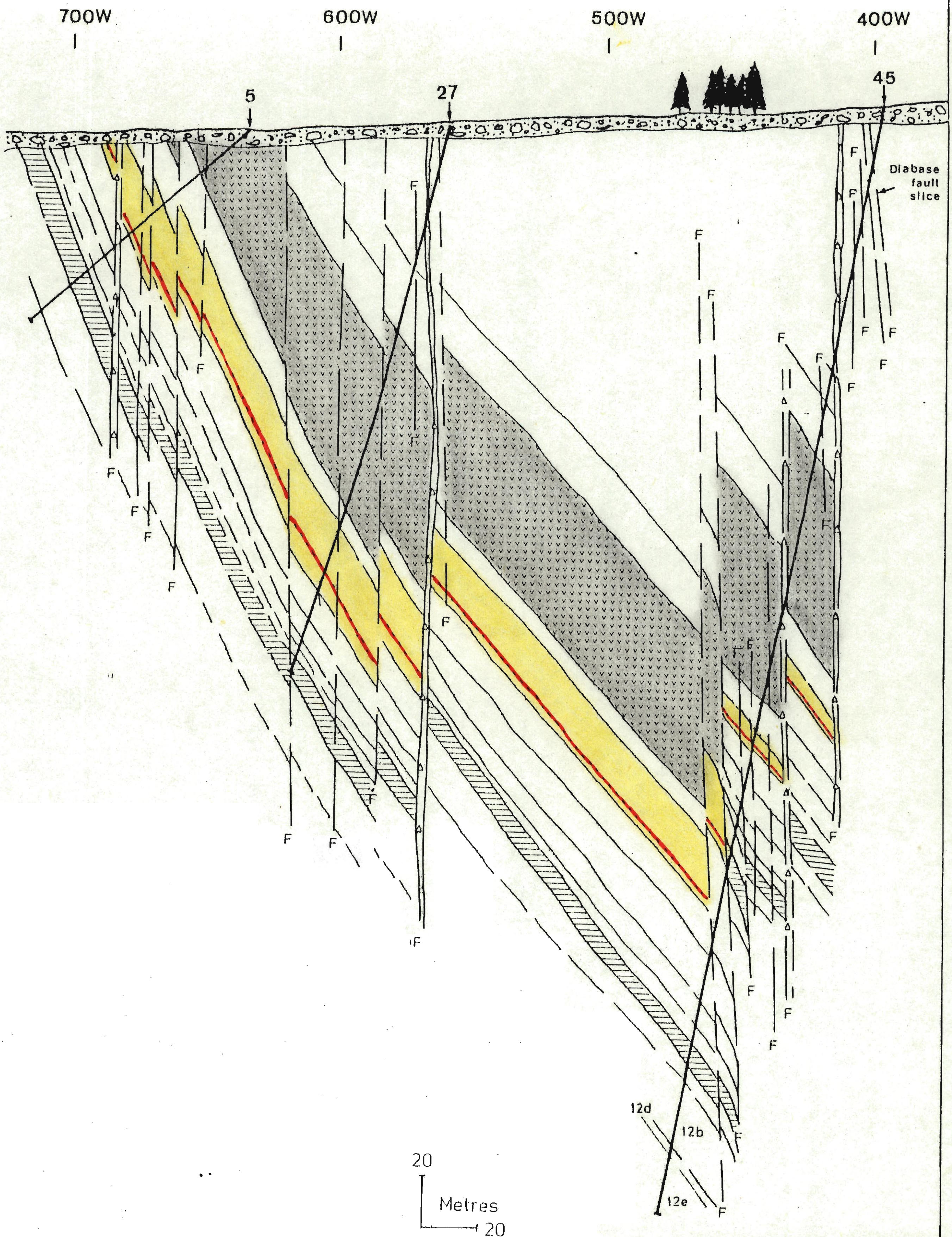

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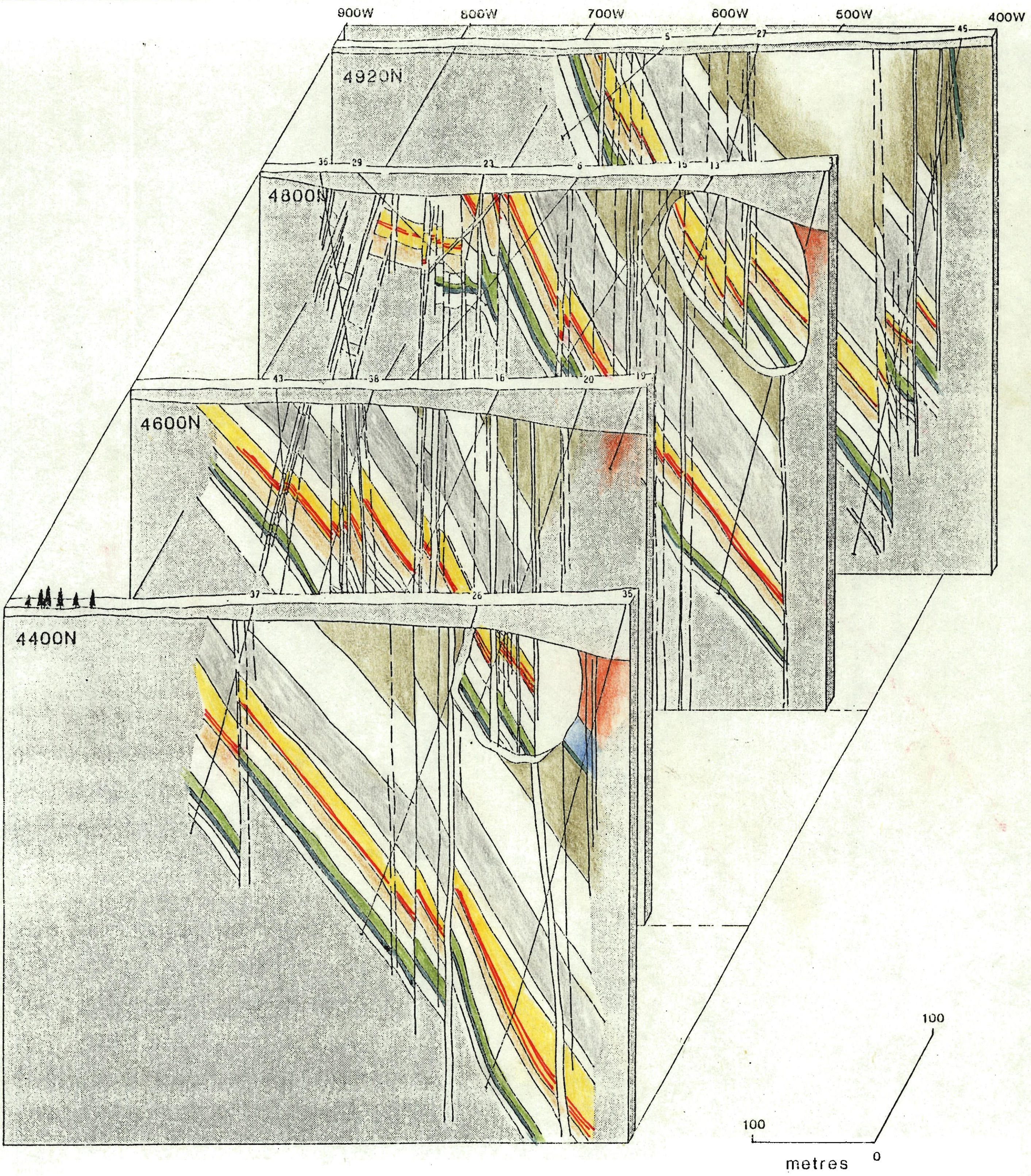
Fig 21

LOVISA

Drill Section at

4920N

Author C J Carlon	Date March 1987
Revised	



Target sulphide zone

Trees to scale

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Fig. 22

LOVISA PROJECT

Three dimensional diagram between 4400 - 4920N

Author	C. Carlon	Date	1987.03.18
Revised			

A prominent foliation is observed, particularly in the easterly dipping strata on the east flank of the 'Lovisa antiform'. Foliation is a consistent 74-86^{o}, averaging 79^{o}E, cutting the banding at a slight angle. There is some indication that it steepens at shallow depth, but is otherwise consistent.
A study of the small scale features indicates the nature of this foliation.

Koark in the 1960's and Bleeker in 1984 both observed that a high percentage of fold axes are apparently localised by least competent rock types, notably carbonate bands and sulphide layers. It is precisely these lithologies that display the most obvious ductile and plastic deformation, and where nearly all the small scale features can be observed.

The following points are the most relevant:

1. Small scale isoclinal structures in laminated sulphide lie parallel to mineralogical banding and suggest that S_1 foliations lie parallel with S_0, possibly original banding features.

2. The 79°E foliation, cuts the banding in the mineralised zones and produces a series of axial planar fold structures and brittle fractures. S_1 isoclinally folded structures are bent around the 70°E foliations which are here designated S_2 structures. (These do not necessarily correspond to Bleekers S_2 structures).

3. Small scale fold structures and remobilised sulphide structures are arranged around the S_2 foliations producing small scale F_2 folds and piercement structures (Maiden et al 1986). These features are shown in fig 23.

4. Comparable structures are seen in the mixed carbonate-chert bands of Units 4, 2 and 12g and the magnetite-chert-skarn layers of Unit 11.

5. Compressional and tensional features imposed upon F_1 structures by F_2 folding are seen in boudinaged chert bands, overlapping reverse faulted laminae and chaotic disharmonic folding, particularly in mixed chert (brittle) and calcite marble (ductile) bands.
   Highly contorted chert bands in carbonate layers show gradational break-up into chert clastic, "ball-textured" chert-marble. Exactly the same textures are seen in the sulphide bands (section 4.6).

6. The main period of sulphide remobilisation appears to relate to F_2 folding. Bleeker (1984) noted that cordierite blasthesis at Håkansboda, and pegmatite introduction in many areas, apparently accompanied F_2 tectonics. He suggested that F_2 was the culmination of tectonic and metamorphic events in the area. Sulphide remobilisation would presumably occur at the same period of maximum stress.

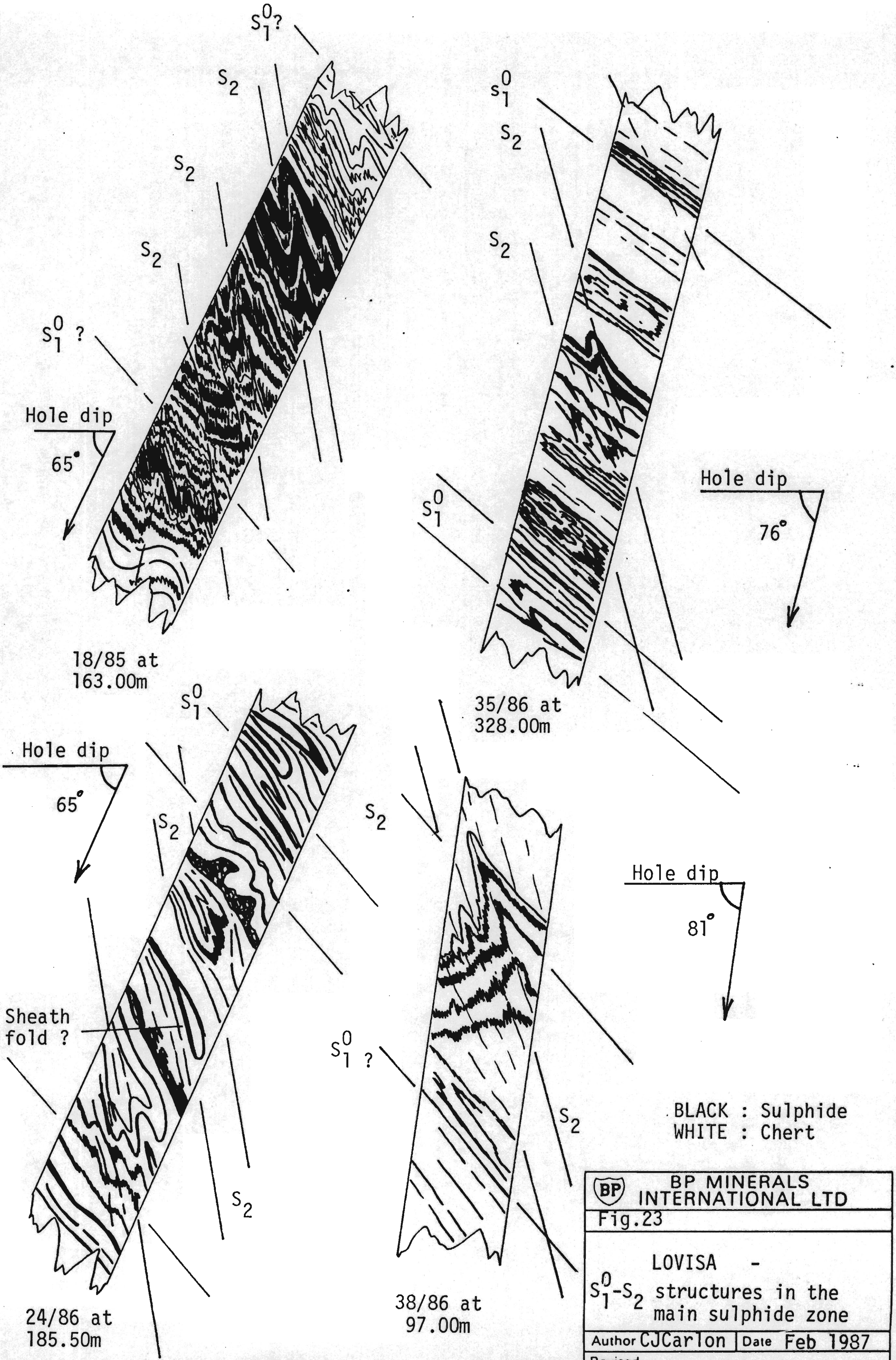

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Fig.23

LOVISA - S_1^0-S_2 structures in the main sulphide zone

Author CJCarlon	Date Feb 1987
Revised	

3.4.3 Lovisa Discovery Zone - Faulting and Brittle Fracture

All interpretations of the bedrock geology prior to drilling, underestimated the effects of faulting in the prospect area. Ground VLF-EM surveys using GBR failed to locate any major structures. Similarly NAA and GXZ were not able to define linear features. However, results using GXZ picked up weak N-S, and NNE-SSW structures previously noted by Slingram EM ground surveys. Electromagnetic surveying in the Lovisa prospect area is hampered by cultural interference. The results of the ground EM surveys are discussed by Engvall (1986).

Similarly, with the absence of outcrop, Bleekers map stresses ductile deformation rather than brittle fracture.
Drilling shows that the supracrustal sequence of the Lovisa Prospect is, in addition to the folding noted above, considerably fractured. This fracturing can be summarised as follows from the drilldata:

1. Faulting and brittle fracturing is confined mainly to well defined zones. Outside these zones fracturing is minimal, within the zones the bedrock is fractured, brecciated, crushed and in part ground to a sandy 'gouge'. Ochreous and discoloured, limonitic and manganese oxide-hydroxide stained bedrock, with rusty coloured fracture infills and manganese dendrites, occur to depths of 85 metres (hole 26). These surface alteration zones, when plotted together with overburden (bedrock erosion?) data suggest a close connection between zones of major fracture and faulting, ochreous alteration and increased overburden thickness (fig. 10).

Away from the alteration zones the bedrock is noticeable less fractured.

2. Faulting is recognised in the drillcore as:

   i. Hairline cracks and planar fractures displaying both reverse and normal fault movements.

   ii. Healed brecciated zones lying parallel with the compositional banding (parallel to S_1 ?) (low angle shear and thrust faults).

   iii. Zones of fracture and broken core, sometimes with graphitic or chloritic, slickensided, arcuate or planar fractures.

   iv. Crosscutting healed breccia zones.

   v. Zones of intense fracturing and broken core.

   vi. Totally brecciated, crushed, pulverised and 'gouge' zones.

   vii. Re-brecciated healed breccia zones.

3. Both reverse (compressional) and normal (tensional) faulting has occurred.

4. The intensely brecciated and non-healed crush zones are the latest fractures, and form the prominent fault zones that are associated with the features noted in 1. above.
   Drill data suggests that these major fractures trend grid NNW-SSE or N-S and their trend parallels the contacts of the Sveconorwegian dyke.
   It is suggested that the change in trend of this dyke in the area around 5300N could be due to an intersecting set of NNW-SSE and NE-SW faults.

5. Dyke introduction appears to have been passive along these pre-sisting NE-SW and NNW-SSE faults. Its trend follows these orientations.

6. Reactivation of these major NE-SW and NNW-SSE faults is seen by the re-brecciation of healed breccias and chloritic sheared zones within and at the contacts of the dyke in all sections drilled into it.

7. Fractures associated with these major fault zones dip at 65-81^{o} W. A few are vertical or steeply dipping to the W. Most dip at 78-81^{o} W and produce a normal throw, downthrowing W. A few faults appear to be reversed in character, dipping steeply to the E. and upthrowing to the E. (See figs. 18-22). Some (Hole 14) appear to predate the normal fault movements.

8. The hole 36 intersection, in a major fault zone, intersects more or less consistent 64-73^{o} W dipping fractures. However, near the base of the hole fractures rotate into the vertical.

9. Early zones of brecciation and shearing occur. In hole 10 at 53.90 m, the sericitic schists of Unit 8 contain 'quartz eyes'. However, the rock appears finely brecciated and mylonitic, and the 'eyes' may be pseudoclasts due to intense shear or crushing. Breccia zones lying parallel with the mineralogical-compositional banding in the host rock (So, S_1^o?) are normally 'healed' with dark grey silica and dip at 56-66^{o}E. Low angle, parallel to S_0 'stratabound' thrusting or shearing is suggested by these structures, which parallel F_1 (a D_1 structural style).

10. Breccia zones lying parallel with rock banding are often seen as the upper contacts of the main sulphide layers, veined with sulphide, and passing down into angular clastic breccias and lithoclastic 'ball-ores' (section 4.2.1). This suggested 'shearing' is most prevalent in zones of contrasting competence.

    Small scale planar or arcuate fractures often accompany the F_2? fold structures seen in the sulphide layers of the main zone, and noted in section 3.4.2 (fig. 23).

12. There is some evidence that 'syn-depositional' breccias may occur within the host rocks. However, as S_1 structures appear to lie parallel with, or at very low angles to the So features it is not clear whether apparently "syn-depositional breccias" are such early structural features.

3.4.4 Structural summary

The main structural observations and interpretations are:-

1. There is no overfolded antiform at Lovisa and the target zone is not repeated in an overturned parallel layer below and to the west of the original discovery zone.

2. The fold structure picked out by the ground magnetics is a faulted monoclinal structure with a complex fault-fold hinge zone at 700W to the east of which the strata dip eastwards at 56-66^{o}.

3. This fold structure terminates to the west against a major fault zone. The fault appears to uplift strata to the west, which brings up strata in Unit 12 to the west.

4. The main mineralisation lies to the east of 700^{o} W, dipping east and cut by F_1 and F_2 axial plane foliations. S_1 foliations lie parallel-sub-parallel to S_0 banding. S_2 foliations dip steeply (79^{o}) to the east, producing fold structures in the less competent sulphide and chert-carbonate layers.

5. Several sets of faults are present. Early fracture-fault zones lie generally parallel-sub-parallel to S_1^0, foliations. (Early D_1 brittle fracturing and folding). Later cross-cutting healed breccias lie parallel-sub-parallel with S_2 foliations and F_2 fold axial plans, the result of D_2 deformation.

   The latest fractures are large NE-SW and NNW-SSE trending faults, causing brecciation and disruption of the bedrock, and generally uplifting strata from W to E. They cause repetitions of the sequence in the drillcores.

6. Shearing and folding is most evident in the least competent beds, notably carbonates, mixed carbonate-chert layers, and the main sulphide zone, all of which display boudinage, plastic deformation remobilisation and re-crystallisation.

A new geological map based on the drill data, ground magnetics and EM surveys is presented in Fig 24 (Enclosure 1).

3.4.5 Metamorphism

The lower Proterozoic supracrustal sequence in the Lovisa area is metamorphosed to amphibolite facies, and displays a variable but generally high strain.
Argillaceous parent rocks have produced micaceous, sillimanite and cordierite porphyroblastic 'metasediments', frequenty garnetiferous. Sillimanite-cordierite 'schists' and quartzo-feldspathic metasediments of probable volcanic derivation, occur in the Elizabethgruvan and Nya Backadahl areas, but are not so obvious in hand specimen in the Lovisa sequence, and appear generally absent.
Andalusite porphyroblasts are common in the Mårdhyttan Schists to the SW. These grey pelitic schists are considered to lie in the major F axial zone, and form the youngest supracrustal unit in the sequence. They are not present in the Lovisa area.

Garnet porphyroblasts are common in the Lovisa sequence and often display pressure shadows. Irregular shaped garnets commonly occur alligned parallel to S_2 .

'Skarn'bands probably represent metamorphism of impure calcareous metasediment. They frequently pass laterally into impure mafic bearing calcite or dolomite marbles.

From observations across the area, Bleeker (1984) noted that the eastern area around Håkansboda was notable for its abundance of sillimanite. Such a feature could relate to pre-metamorphic clay-mineral alteration. The abundance of magnesium and iron in associated bedrock (forsterite-dolomite marbles) and the change from dolomite marble westwards to calcite marble suggests, together with the apparent decrease in sillimanite westwards, that hydrothermal activity could have induced rock alteration as an accompaniment to pre-metamorphic mineralisation in the eastern area. Rock alteration could be reflectd in the metamorphic products surrounding the sulphide mineralisation.

Porphyroblast growth, notably cordierite in the Håkansboda area, indicates that the culmination of regional metamorphism occurred syn- or post F_2. Remobilisation of pre-existing sulphides can be expected to have occurred at the same time.

The change from andalusite to sillimanite from W to E could indicate increasing metamorphic grade W-E. Granite occurs most abundantly to the east and may reflect an increase in original crustal depth in that direction.
Pegmatite introduction also appears to accompany F_2 folding and peak metamorphic conditions.

A 4 MINERALISATION

4.1 Main features

As previously noted (section 2.1), re-logging of the Jönshyttan No 8 drillcore led to the subsequent location of zinc-lead-silver massive sulphide in the area SW of the old abandoned Lovisa iron mine (trial). Drilling in the Lovisa prospect during 1985-1986 has defined the position of the massive sulphide zone, and in addition identified several distinct types of mineralisation.
Including the Lovisa sulphide zone, mineralisation in the area occurs as:-

i. Massive, lithoclastic, banded, laminated and veinlet zinc-lead-silver rich sulphide, confined to Unit 6 of the recognised lithological sequence. (The Lovisa Sulphide zone).

ii. Streaky, veinlet and disseminated lead-silver mineralisation with pyrite and subordinate pyrrhotite, sphalerite, and chalcopyrite in Unit 11. Sulphide mineralisation is spatially associated with massive magnetite layers. (The Lower Magnetite Marker zone).

iii. Disseminated pyrite and subordinate magnetite porphyroblasts within red and red-brown siliceous and quartzo feldspathic 'chert' of lithological Unit 7, structurally underlying the Lovisa sulphide zone.

iv. Disseminated, minor veinlet and schlieren galena, pyrrhotite, chalcopyrite, pyrite or purple fluorite mineralisation scattered apparently indiscriminately within the supracrustal sequence in the Lovisa project area.

Massive sphalerite rich mineralisation occurring in the diopside skarn bands in drillhole 14/85, can for reasons discussed below, be considered a further, apparently localised, mineralisation.
In addition, at the time of writing this report (Jan 1987) it is not known if the Nya Backadahl mineralisation is the lateral equivalent of the Lovisa sulphide zone, or the Lower Magnetite Marker. It appears from an examination of earlier drill logs to be a quite separate horizon occurring structurally above Lovisa. This relationship will be examined in 1987.

4.2 The Lovisa Sulphide Zone

Including the Jönshyttan No 8 drillhole, but excluding the intersection in hole 014/85, 31 of the 47 diamond drillholes in the Lovisa Prospect intersect a characteristic sequence of lithological units, including Unit 6 and its contained massive zinc-lead-silver sulphide mineralisation.

This mineralisation is currently drill indicated from hole 32/86 in the NE, to hole 24/86 in the SW, a strike distance of 1,100 m. The deepest intersection is at a downhole depth of 430.00-435.00 m in hole 46/86, a vertical depth of 425 metres.

Prior to the re-logging of the drillcore in autumn 1986 the lithological sequence containing the sulphide zone was not recognised in detail. For this reason the supracrustals intersected north of hole 32/86 and south of hole 24/86 were considered to represent the target sequence devoid of mineralisation.

However, hole 33/86 appears to drill a faulted succession at the position of the target sulphide zone, and all holes north of this position (5230N) intersect the footwall sequence.
South of hole 24/86, the sequence drilled in holes 30 and 34/86 lies in the hangingwall, and hole 34/86 stops approximately 30 m above the target (fig. 12).

The Lovisa sulphide zone is currently open to the north, south and in depth to the east. Its currently known area of occurrence is shown in fig. 25. Mineralisation is confined to a zone 10-30 m thick, corresponding to lithological Unit 6, which forms a sheet dipping east from around 700W, at an angle of 60-66^{o}E.
In all intersections it displays the same broad features and does not change character, noticeably or systematically, throughout that portion of the mineralisation currently drilled.
The main characteristics of the sulphide zone can be summarised with reference to the 31 intersections.

4.2.1 Nature and Form of the Mineralisation

The target sulphide zone, lying within Unit 6, is not a single mineralised layer. Thirty mineralised intersections, from the holes drilled in 1985-1986 are shown graphically in figs. 26-34.
From these it can be seen that the sulphide zone comprises a series of layers of massive sphalerite dominant, galena subordinate sulphide. These layers can be spaced over a vertical width of up to 15 m, but the main concentration is usually over 6 m and generally towards the base of Unit 6.

The width of mineralisation and the number of sulphide layers does not appear dependant upon the width of Unit 6 where this is over 10 m thick. There is no increase in the width of mineralisation with an increase in thickness of Unit 6 (compare 25 and 27/86 and 5/85, 15/85, 31/86 and 3/85). However, in holes 45/86 and 7/85, where Unit 6 is at its thinnest, without obvious tectonic thinning by faults, the mineralisation is also very thin.

Individual mineralised layers are normally 0.5-1.00 m thick, occasionally up to 2 m thick (see holes 32, 35, 44), and are grouped together to form the main intersection as 1-3 sulphide layers.
Several recognisable types of sphalerite-galena mineralisation can be seen:- (Plate 1).

i. Massive, fine grained, weak to well banded, fawn, pale beige, brown or red-brown sphalerite. Dispersed grains, schlieren, veinlets and 'clots' of galena occur, particularly in the darker sphalerite bands. (Plate 3).

PLATE 1 : The intersection in Hole 35/86 between 335.75 - 337.55m.

The sphalerite rich sulphide mineralisation is brown, and the intersection runs from top left to bottom right.

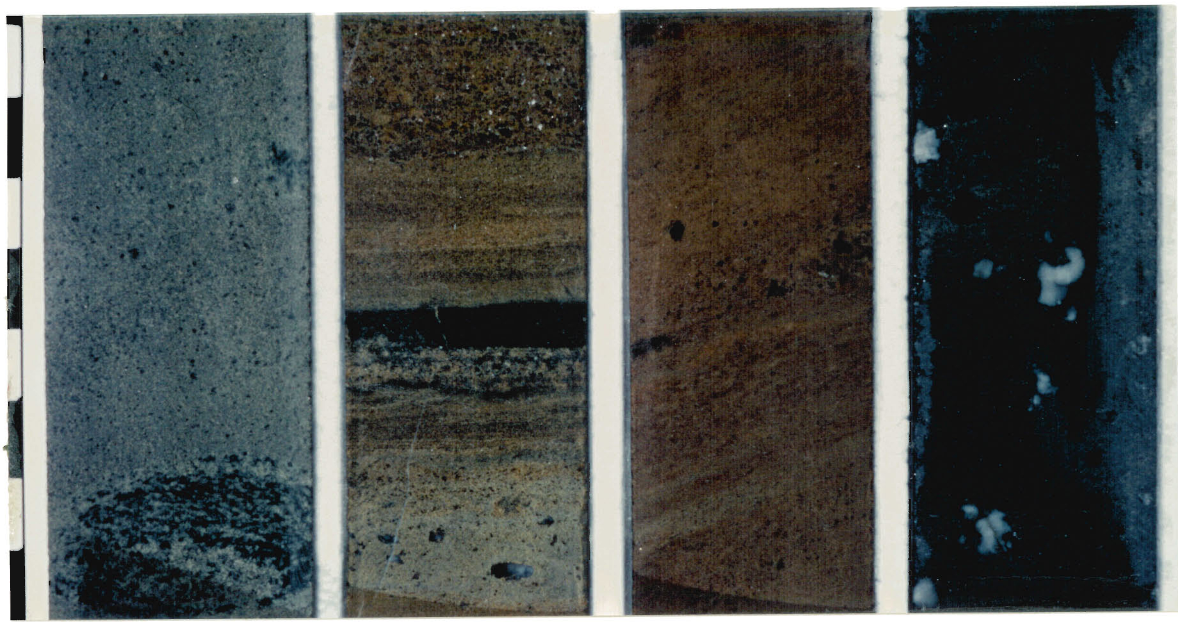

PLATE 2A : Colour variations in the massive sulphide zone.From left to right these are :

Hole 35/86 336.60m, pale brown-beige massive sphalerite
Hole 37/86 109.20m, banded brown sphalerite
Hole 44/86 148.86m, red brown 'micro-ball' textured and banded sphalerite
Hole 4/85 50.80m, grey, galena rich, galena-sphalerite massive'ball-ore' sulphide

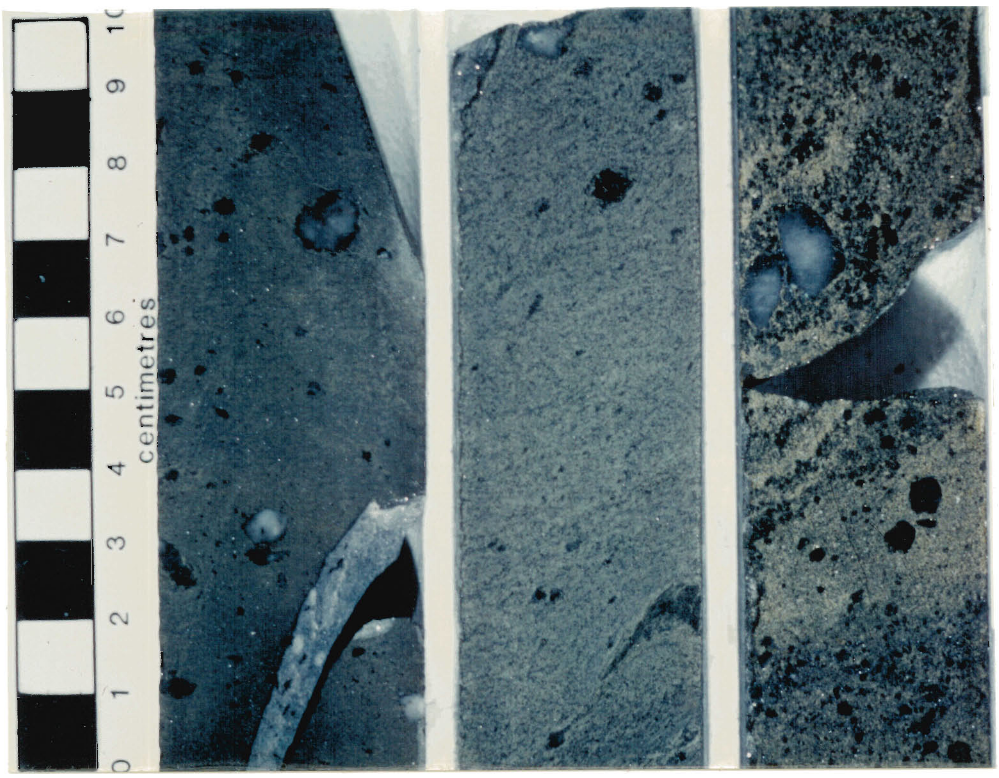

PLATE 2B : 'Ball-ores' of type ii. From left to right :
Holes 7/85 117.90m; 6/85 64.40m; 11/85 22.00m

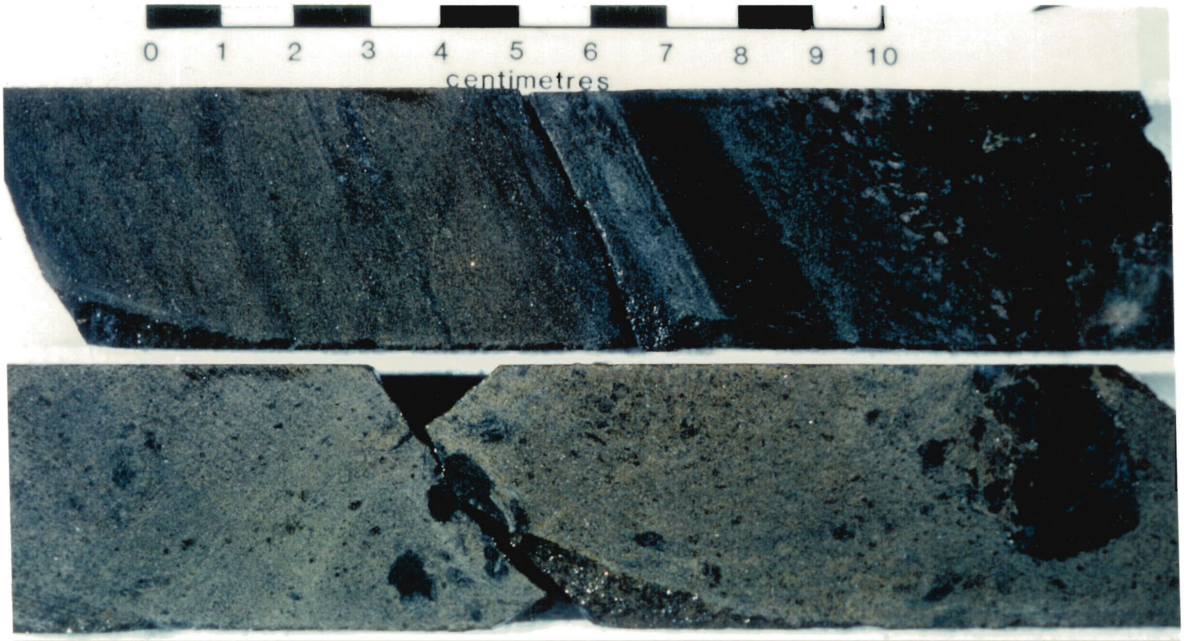

PLATE 3A : Banded sphalerite of type i passing down into chlorite 'skarn' and chert of unit 6. Hole 38/86, 107.70m (Top section)

'Ball-ore' mineralisation of type ii. Hole 38/86, 106.90m. (Lower section)

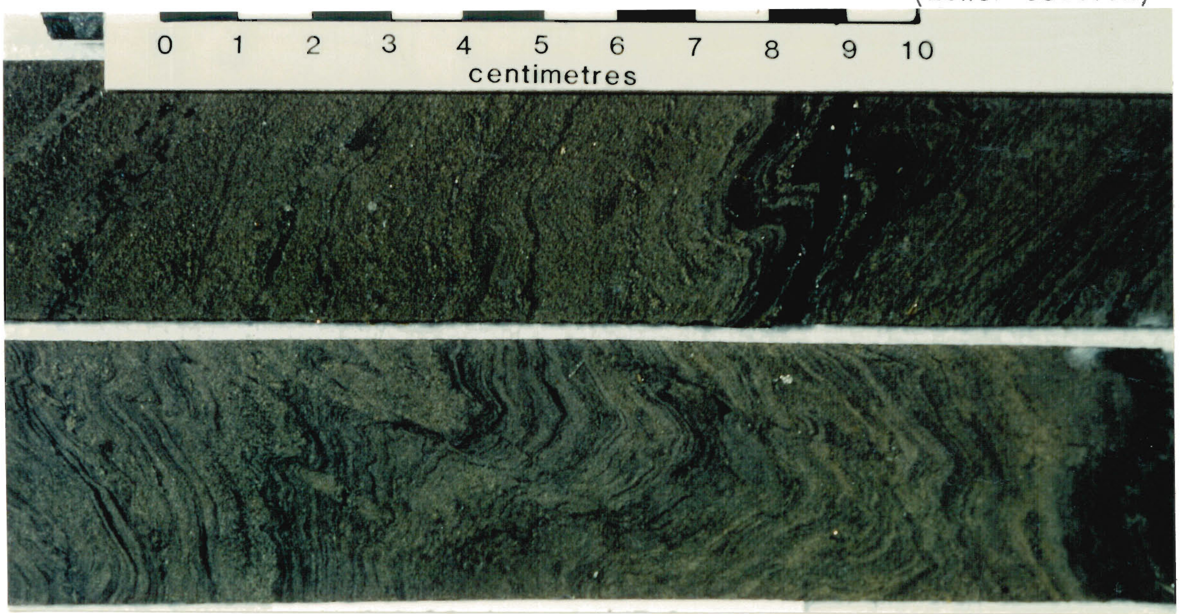

PLATE 3B : Deformed banded sphalerite rich sulphide of type i. Hole 18/85, two sections from the interval 162.15- 163.90m

ii. Sphalerite-galena forming the matrix of a rounded, sub-rounded, sub-angular and occasionally angular, lithoclastic, (medium-coarse grained), matrix supported, massive sulphide. ("Ball-ore" or 'kulmalm'). (Plate 2).

iii. Angular lithoclastic, clast supported, matrix sphalerite-galena ("Ball-ore")

iv. Veinlet galena, subordinate sphalerite

v. Laminated very fine grained siliceous-quartzo-feldspathic 'chert' with mm-cm thick sulphide laminae

vi. Irregular disseminated schlieren and veinlet sphalerite galena in diopside-chlorite 'skarn' bands

Gradational changes from one type of mineralisation to another are seen in nearly all intersections.
Upper contacts of massive sulphide layers are frequently brecciated and display cuspate or 'ragged' contacts with veinlets penetrating the host rock 'cherts' and 'skarns' (Maiden et al 1986). Veinlets on upper contacts are frequently galena rich.

Such cuspate and veinlet upper contacts pass down into massive sulphide of type i. or 'ball-ores' of type ii. or iii. Pale sphalerite massive and banded layers of type i. frequently have planar or gently undulose upper contacts.

Banding in the sulphide generally parallels mineralogical banding in the host rocks (section 4.2.3) or S_2 foliation (fig. 23). However, folds, brecciation, 'slide structures', tensional and compressional phenomena are common in most intersections.

'Ball-ores' of type ii. contain lithoclasts of the host rock 'cherts' and often pale grey or white silica clasts (brecciated quartz veins?). Clasts range in size up to 3-4 cms but are generally 1 cm or less. Coarse lithoclastic sulphide layers are interbanded with "micro-breccia", fine grained lithoclastic layers.
'Ball-ore' layers vary in thickness from a few centimetres up to 1 metre, averaging about 0.4-0.5 m.
They frequently pass upwards and/or downwards into 'chert' lithoclastic, clast supported, sulphides, which in turn become brecciated wallrocks veined with sulphide. Where non-brecciated contacts occur, they frequently cut across mineralogical banding and early foliation in the host rocks.

Mineralisation between the massive bands occurs as laminated sulphide-chert of type v. or 'skarn' mineralisation of type vi. With increasing laminae thickness type v. sphalerite passes into type i. massive, banded layers, and with an increase in thickness and clastic content type v. mineralisation becomes type ii. "micro-breccia" and lithoclastic "ball-ore".

The spatial association of the various types of mineralisation in the main sulphide zone is shown in figs 26-34.

In drillholes 4, 16, 23 and 29 faulting appears responsible for a repetition of the massive sulphide bands. In hole 16 this can be seen in the assay grades for repeated sulphide bands:-

Upper Zone: Band A 135.00-136.00: 1.00m, 23.60% Zn, 4.60% Pb, 60 g/t Ag
Band B 137.90-138.40: 0.50m, 25.00% Zn, 0.56% Pb, 11 g/t Ag

Fault Zone:
Lower Zone (repetition) Band A: 158.65-159.45: 0.80 m, 19.20% Zn 4.70% Pb, 23 g/t Ag
Band B: 160.65-160.90: 0.25 m, 25.10% Zn, 0.36% Pb, 22 g/t Ag

Note that Zn-Pb values are reasonably consistent, while Ag is variable.

In drillholes 20, 21, 22, 23, 24, 25 and 43, faulting in Unit 6 appears to cut out parts of the succession, and possibly a section of sulphide mineralisation, reducing the full width.
Faults could also be responsible for cutting out the mineralisation in the northern part of the zone in hole 33. Note, however, that the mineralisation was thin in hole 45, and that a gradual decrease in the sulphide zone width and grade is possible northwards.

4.2.2 Mineralogy

No systematic study has yet been made on the mineralogical content of the main sulphide zone. Selected samples have been examined by R.A. Schedler (BP Sunbury), M.A. Zakrzewski (Amsterdam University) and by LKAB Laboratory, Malmberget, This material is listed in Table 4, sample locations are also shown in figs 26-34.
9 different drillhole intersections have been examined over a strike length of ca 900 m from.hole 17, SSW to hole 24.

Data from the above studies is freely drawn on in the following notes, together with data from the core logging or re-logging.

The main and subordinate metallic mineral species are listed in Table 5.

By far the most important minerals are sphalerite and galena, with intersections in the massive sulphide layers up to 29.6% Zn and 20.0% Pb. In hand specimen both fine and coarse grained mixtures of the two minerals occur.

The massive sulphide layers vary greatly in colour, from very pale beige-brown or fawn, through red-brown, dark brown and dark grey-brown. The colour variation is due to:

1. The relative proportions of galena and sphalerite
2. The iron content of the sphalerite

There does not appear to be a systematic variation in the sphalerite iron content within the deposit, although 'ball-ore' bands tend to be paler than laminated sulphides where sphalerite rich. Plates 2A, 3A. There does appear to be a general variation in galena contents:-

TABLE 4. SAMPLES EXAMINED FOR MINERALOGICAL STUDY LOVISA - MAIN SULPHIDE

Hole No	Sample position	Method*	Source
4/85	50.60 m	PS-EP-XRD	Schedler (1986)
4/85	50.86 m	PS-EP-XRD	-"-
7/85	117.85-118.15 m	PS	LKAB (1986)
15/85	151.90 m	PS-EP-XRD	Schedler (1986)
16/85	135.30 m	PS-EP-XRD	-"-
16/85	138.20 m	PS-EP-XRD	-"-
17/85	42.60-43.60 m	PS	LKAB (1986)
20/85	218.13-218.18 m	PS-EP	Zakrezewski (1986)
23/86	26.35-26.38 m	PS-EP	-"-
23/86	32.75-32.80 m	PS-EP	-"-
23/86	34.76-34.80 m	PS-EP	-"-
24/86	197.65-197.72 m	PTS-EP	-"-
24/86	198.40-198.50 m	PTS-EP	-"-
24/86	203.05-203.10 m	PS-EP	-"-
26/86	229.95-230.05 m	PTS-EP	-"-
26/86	230.35-230.40 m	PS-EP	-"-
26/86	232.38-232.42 m	PTS-EP	-"-
26/86	234.18-234.21 m	PS-EP	-"-

* Method: PS Polished block (reflected light)
PTS Polished thin section (reflected/transmitted light)
EP Electron-probe micro-analysis
XRD X-ray diffraction

TABLE 5. LOVISA SULPHIDE ZONE-MINERALOGY

Metallic minerals:	SPHALERITE	(ZnS)
	GALENA	(PbS)
	PYRITE	(FeS_2)
Minor:	ARSENOPYRITE	($FeAsS$)
	CHALCOPYRITE	($CuFeS_2$)
	RUTILE	(TiO_2)
	ARGENTITE	(Ag_sS)
Rare :	ILMENITE	($FeTiO_3$)
	PYRRHOTITE	(FeS)
	CHALCOCITE	(Cu_2S)
	PYRARGYRITE	(Ag_3SbS_3)
	FREIBERGITE	$(Ag,Cu)_{12}$ $(Sb, As)_4S_{13}$
	NATIVE SILVER	(Ag)
	DYSCRASITE	(Ag_3Sb)
	COBALTITE	($CoAsS$)
	MOLYBDENITE	(MoS_2)
	CERUSSITE	($PbCO_3$)
Non-metallic minerals:	QUARTZ	
	PLAGIOCLASE	
	MICROCLINE	
	GRAPHITE	(up to 5%)
Subordinate:	ACTINOLITE-HORNBLENDE	
	BIOTITE-CHLORITE	
	SERICITE	
	GARNET	
	EPIDOTE	
	DIOPSIDE	
	TOURMALINE	
	FLUORITE	
	SCAPOLITE	
	CALCITE	

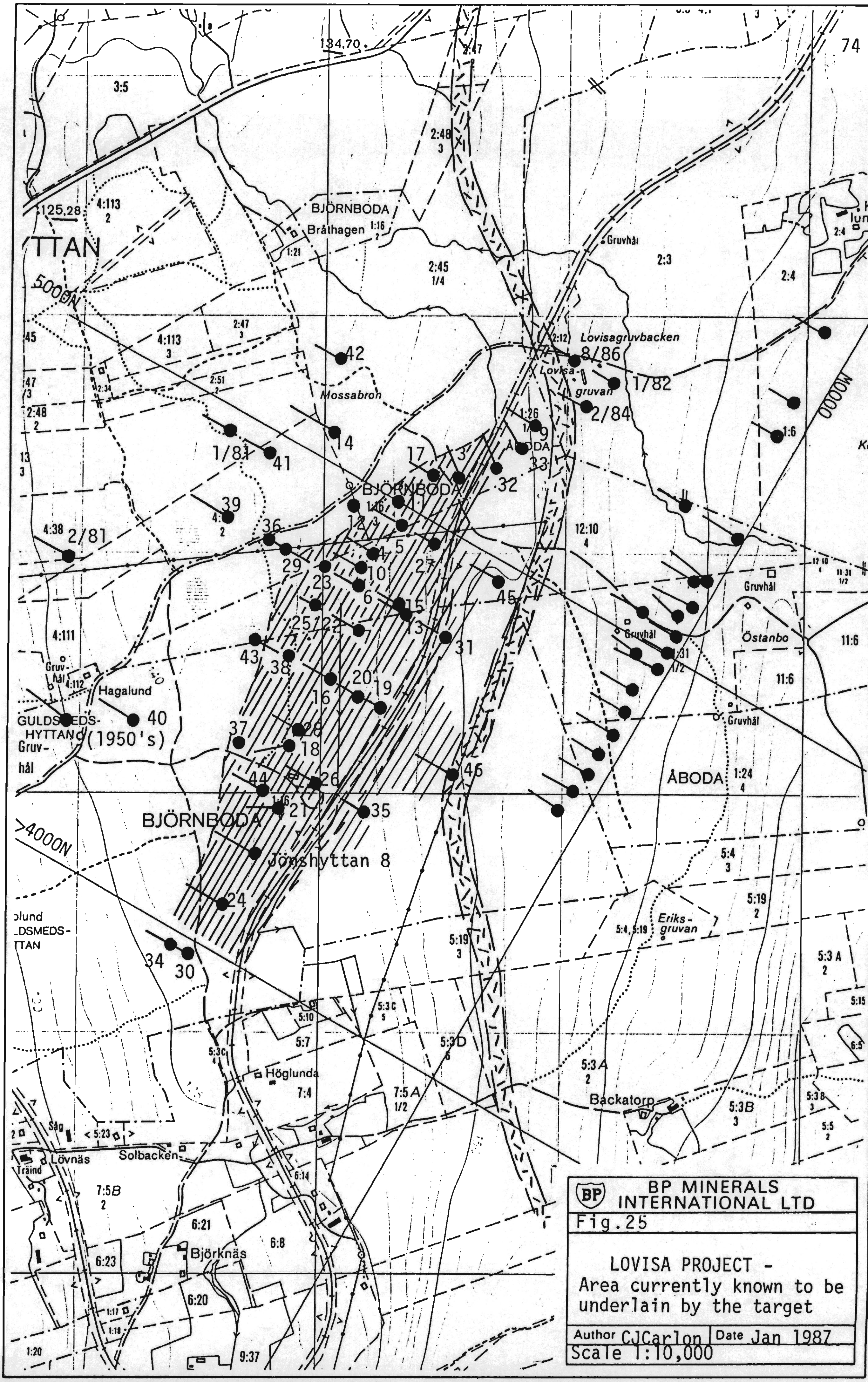

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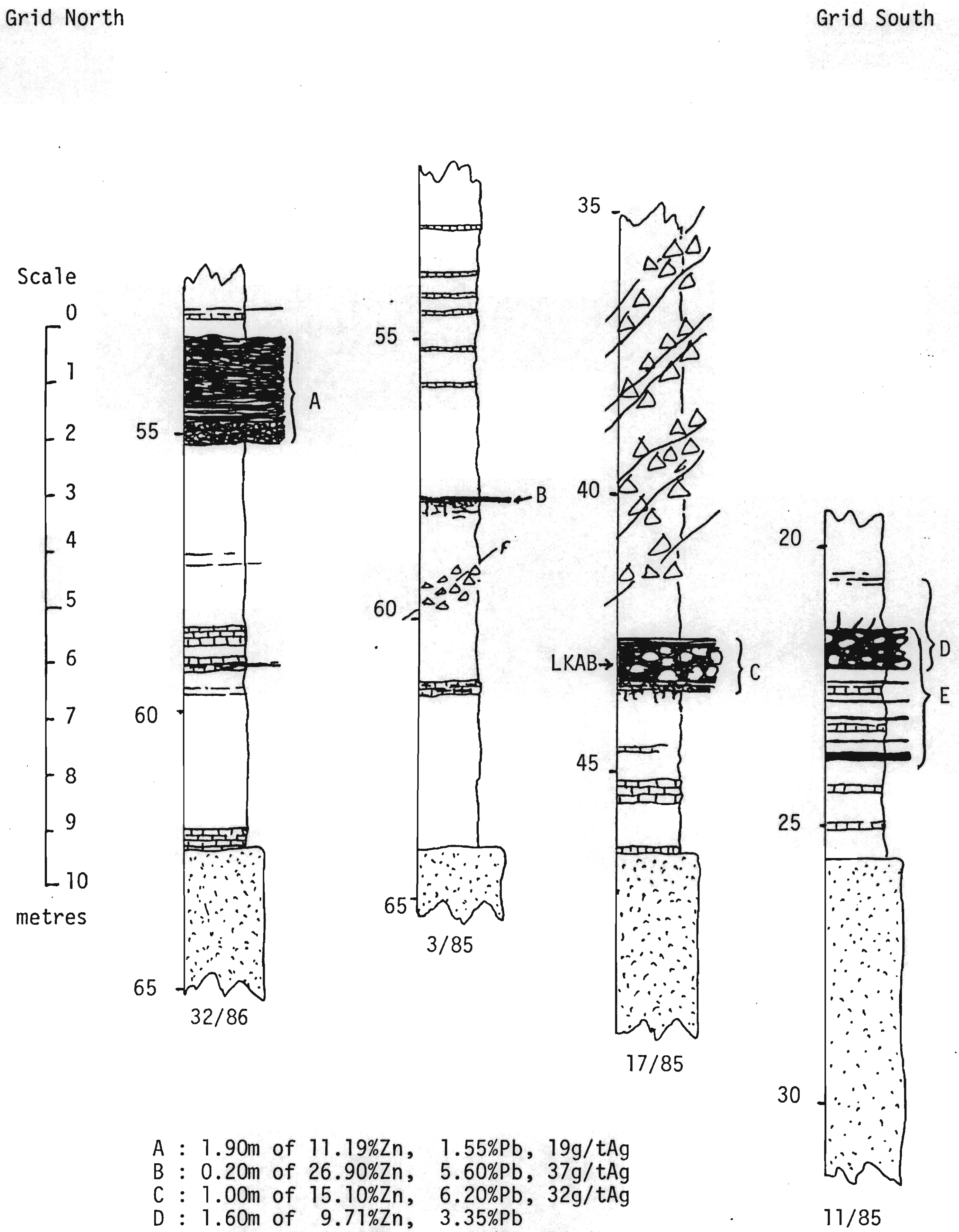
Fig.25

LOVISA PROJECT - Area currently known to be underlain by the target

Author CJCarlon | Date Jan 1987

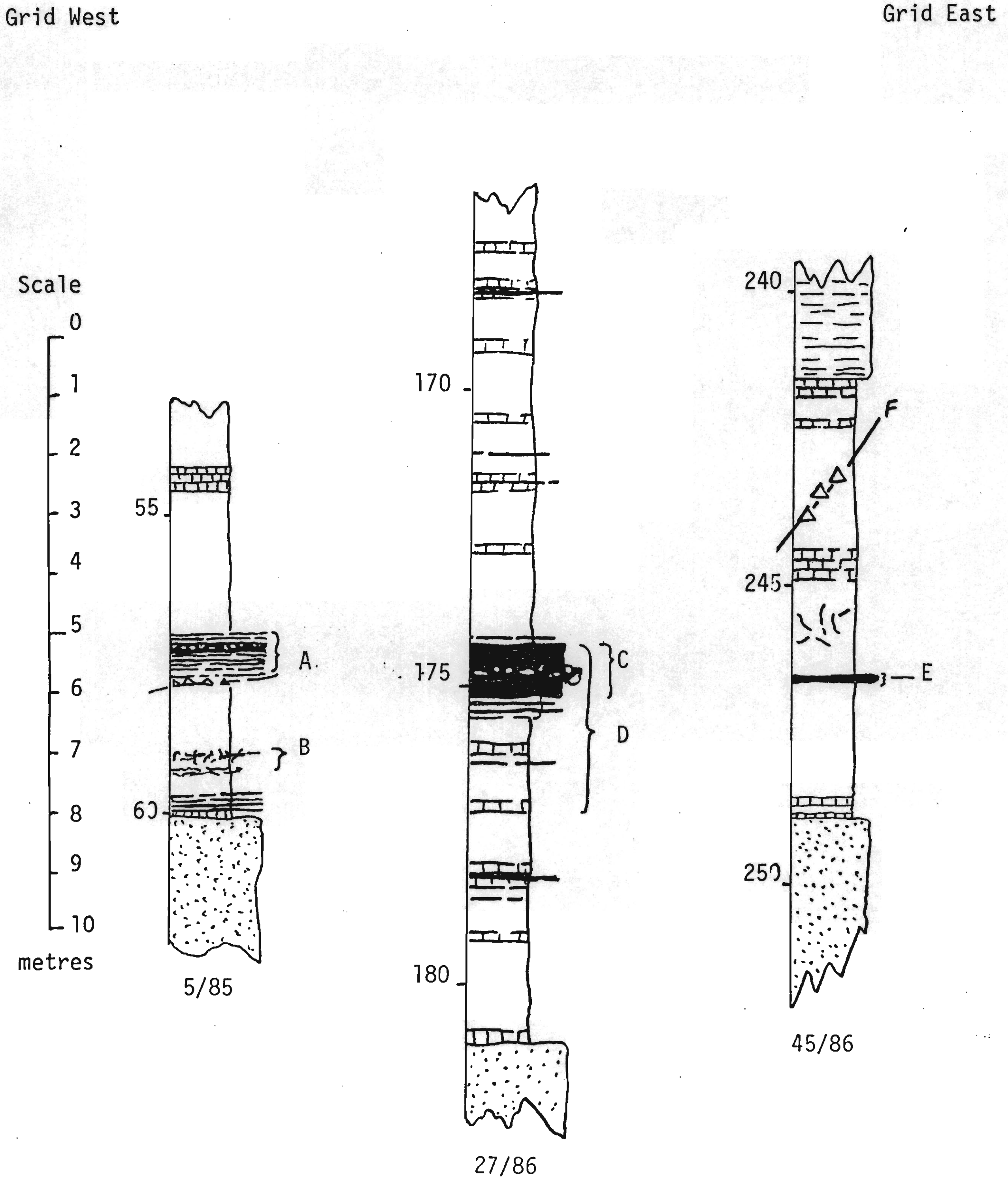
Scale 1:10,000



A : 1.90m of 11.19%Zn, 1.55%Pb, 19g/tAg
B : 0.20m of 26.90%Zn, 5.60%Pb, 37g/tAg
C : 1.00m of 15.10%Zn, 6.20%Pb, 32g/tAg
D : 1.60m of 9.71%Zn, 3.35%Pb
E : 2.65m of 6.92%Zn, 1.66%Pb, 13g/tAg

LKAB: Sample position. (See section 4.2.2)

BP MINERALS INTERNATIONAL LTD	
Fig.26	
SULPHIDE ZONE N. of 5000N Correlation of the main sulphide lenses	
Author CJCarlon	Date Jan 1987
Revised	



A : 0.52m of 17.98%Zn, 11.93%Pb, 55g/tAg
B : 0.35m of 6.10%Zn, 0.57%Pb
C : 1.10m of 22.40%Zn, 19.40%Pb, 21g/tAg
D : 2.90m of 9.30%Zn, 7.53%Pb, 8g/tAg
E : 0.09m of 8.20%Zn, 4.40%Pb, 54g/tAg

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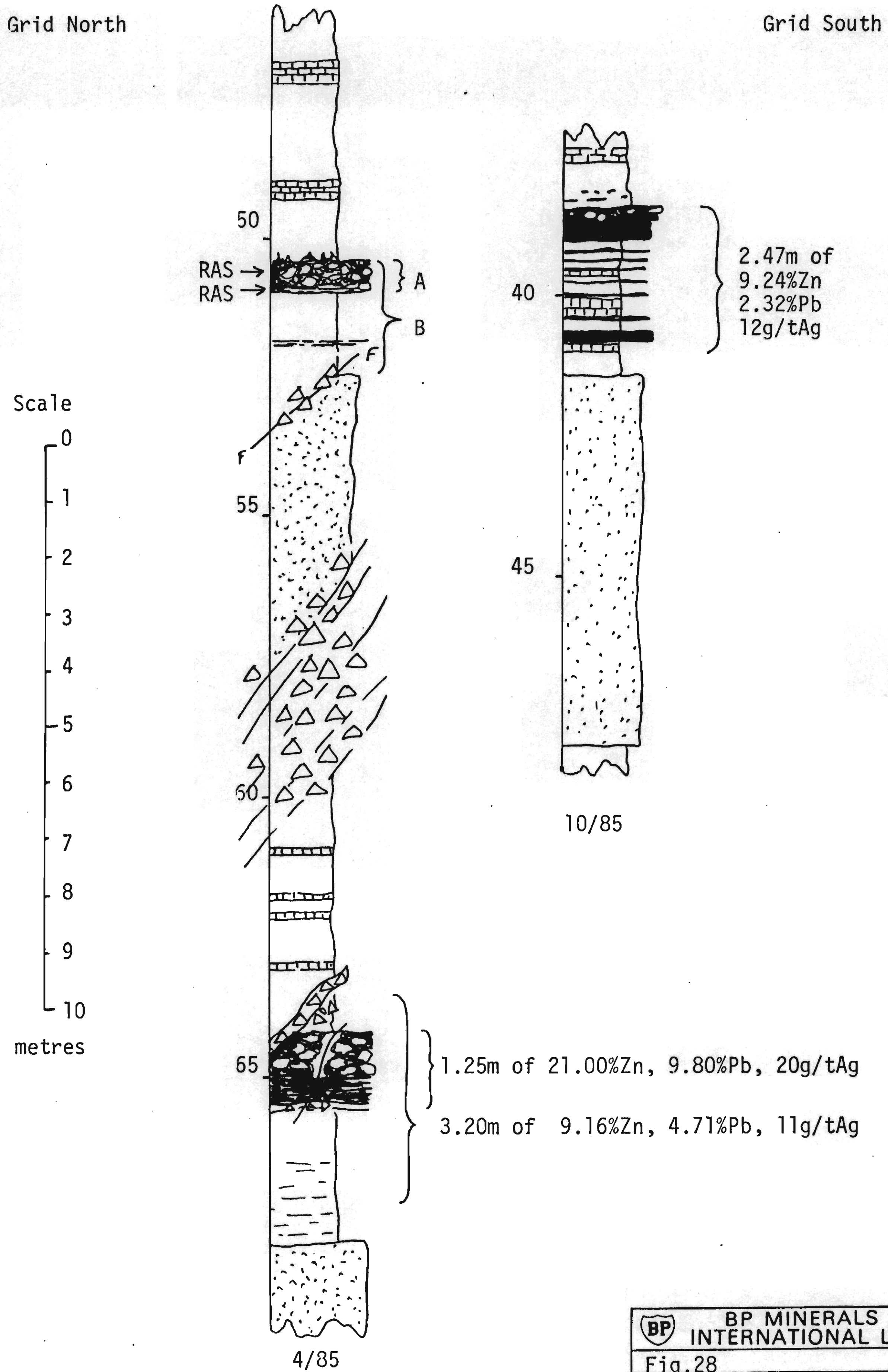
Fig.27

SULPHIDE ZONE ca. 4960N

Correlation of the main sulphide lenses

Author CJCarlon | Date Jan 1987

Revised

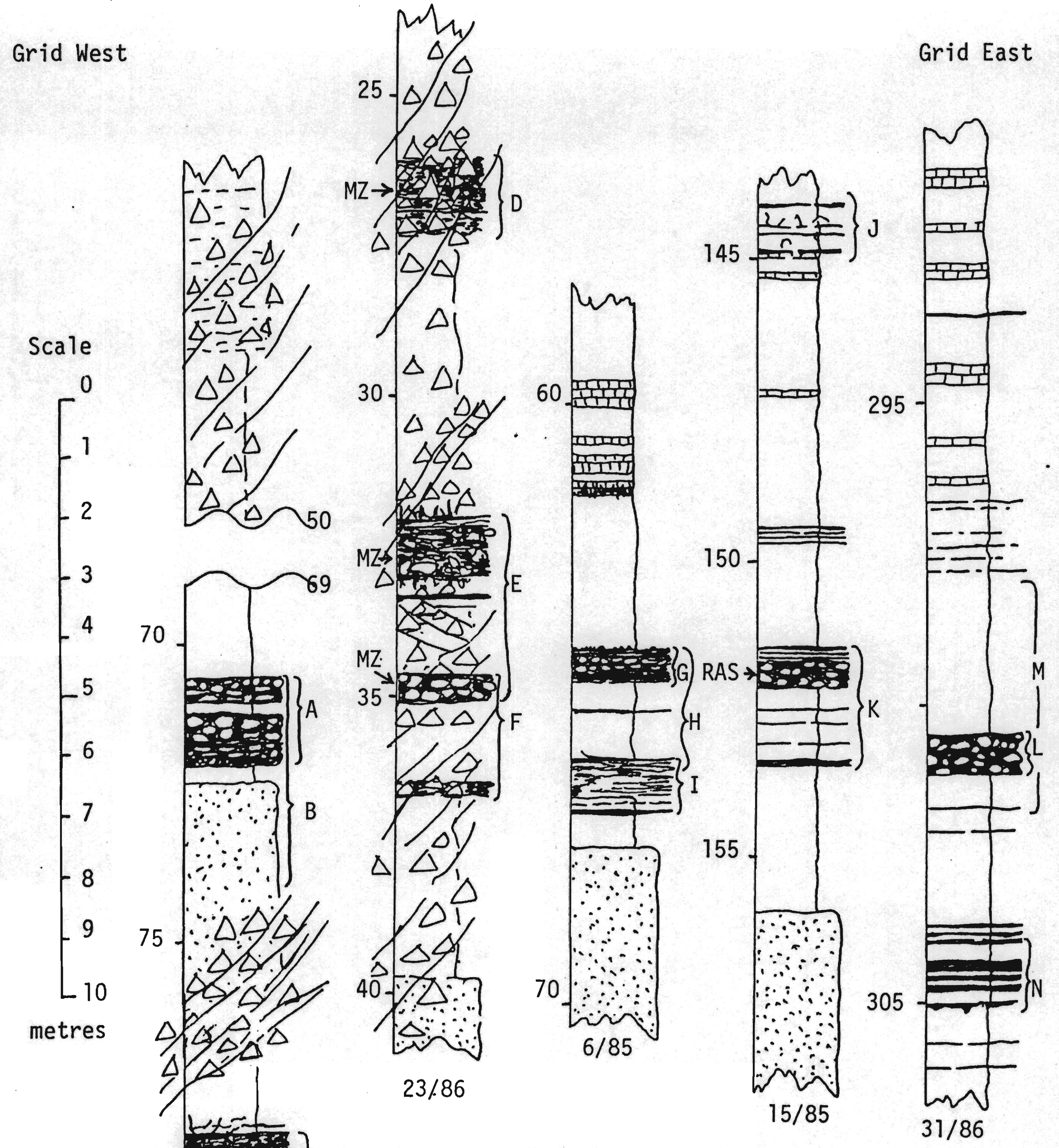


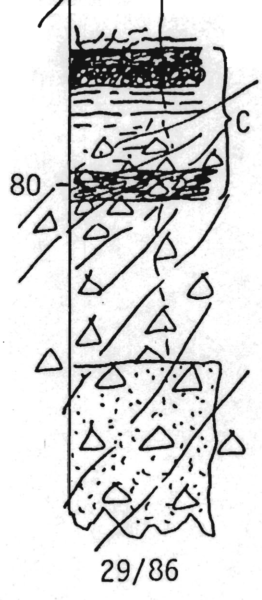
A : 0.65m of 18.20%Zn, 18.00%Pb, 56g/tAg

B : 2.20m of 5.69%Zn, 5.42%Pb, 18g/tAg

RAS : Sample position (see section 5.1.1.)

BP MINERALS INTERNATIONAL LTD	
Fig.28	
SULPHIDE ZONE BETWEEN HOLES 4 and 10 (4840-4881 N) Correlation of the main sulphides lenses	
Author CJCarlon	Date Jan 1987
Revised	





A: 1.80m of 14.10%Zn, 1.10%Pb, 12g/tAg
B: 3.40m of 7.68%Zn, 0.76%Pb, 12g/tAg
C: 2.05m of 10.00%Zn, 1.20%Pb, 14g/tAg
D: 1.45m of 4.80%Zn, 2.80%Pb, 65g/tAg
E: 3.40m of 6.80%Zn, 6.25%Pb, 9g/tAg
F: 2.05m of 6.40%Zn, 6.60%Pb, 11g/tAg
G: 0.45m of 25.60%Zn, 9.70%Pb, 32g/tAg
H: 2.02m of 7.58%Zn, 2.50%Pb, 12g/tAg
I: 1.05m of 4.41%Zn, 1.05%Pb, 4g/tAg
J: 1.00m of 2.50%Zn, 0.85%Pb, 3g/tAg
K: 2.00m of 8.88%Zn, 8.32%Pb, 22g/tAg
L: 1.25m of 29.10%Zn, 18.60%Pb, 27g/tAg
M: 3.65m of 11.54%Zn, 6.47%Pb, 9g/tAg
N: 1.00m of 3.40%Zn, 1.90%Pb, 120g/tAg

MZ and RAS are sample positions (see section 4.2.2)

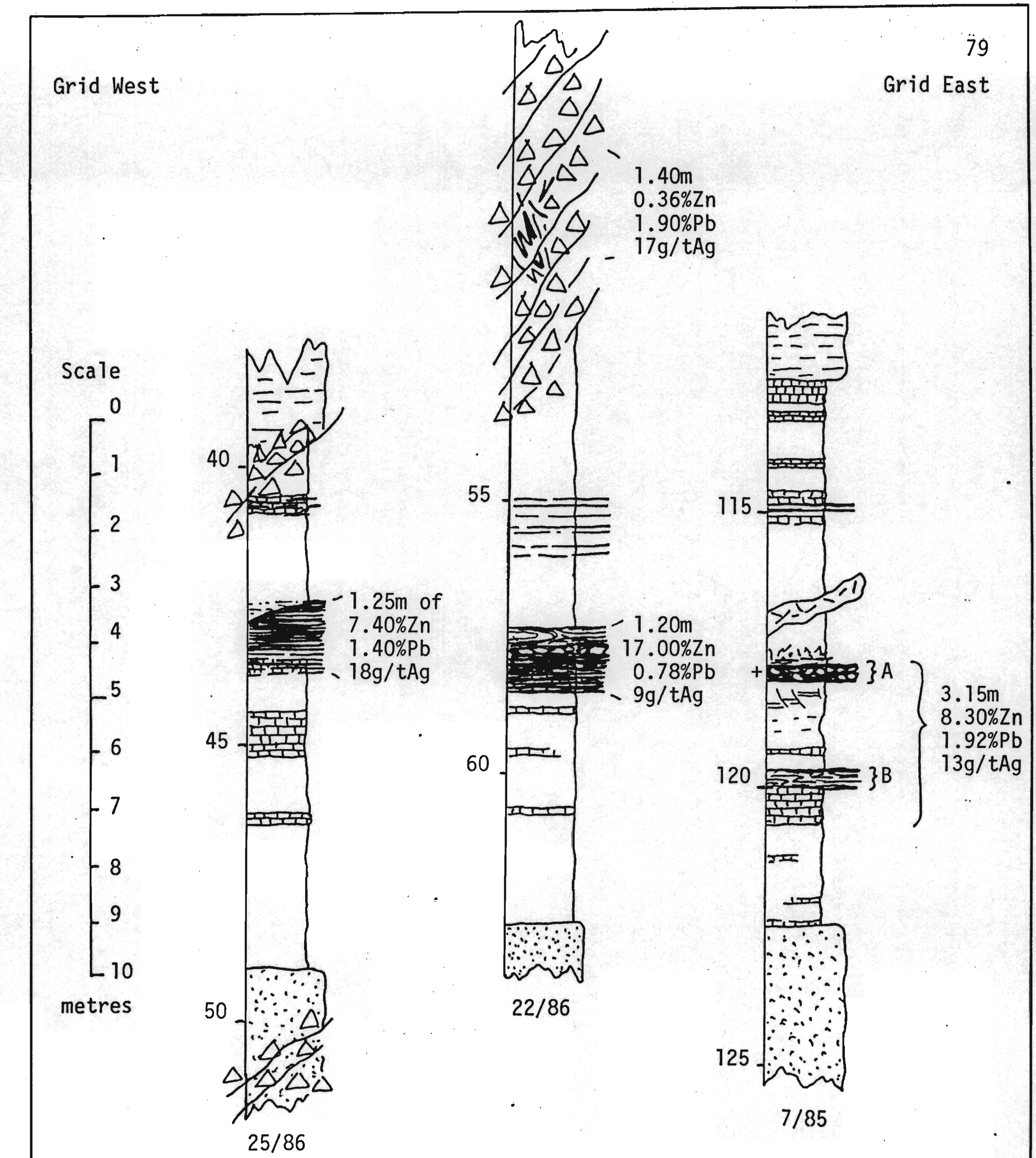
BP MINERALS INTERNATIONAL LTD

Fig.29

SULPHIDE ZONE 4800N
Correlation of the main sulphide lenses

Author CJCarlon | Date Jan 1987

Revised

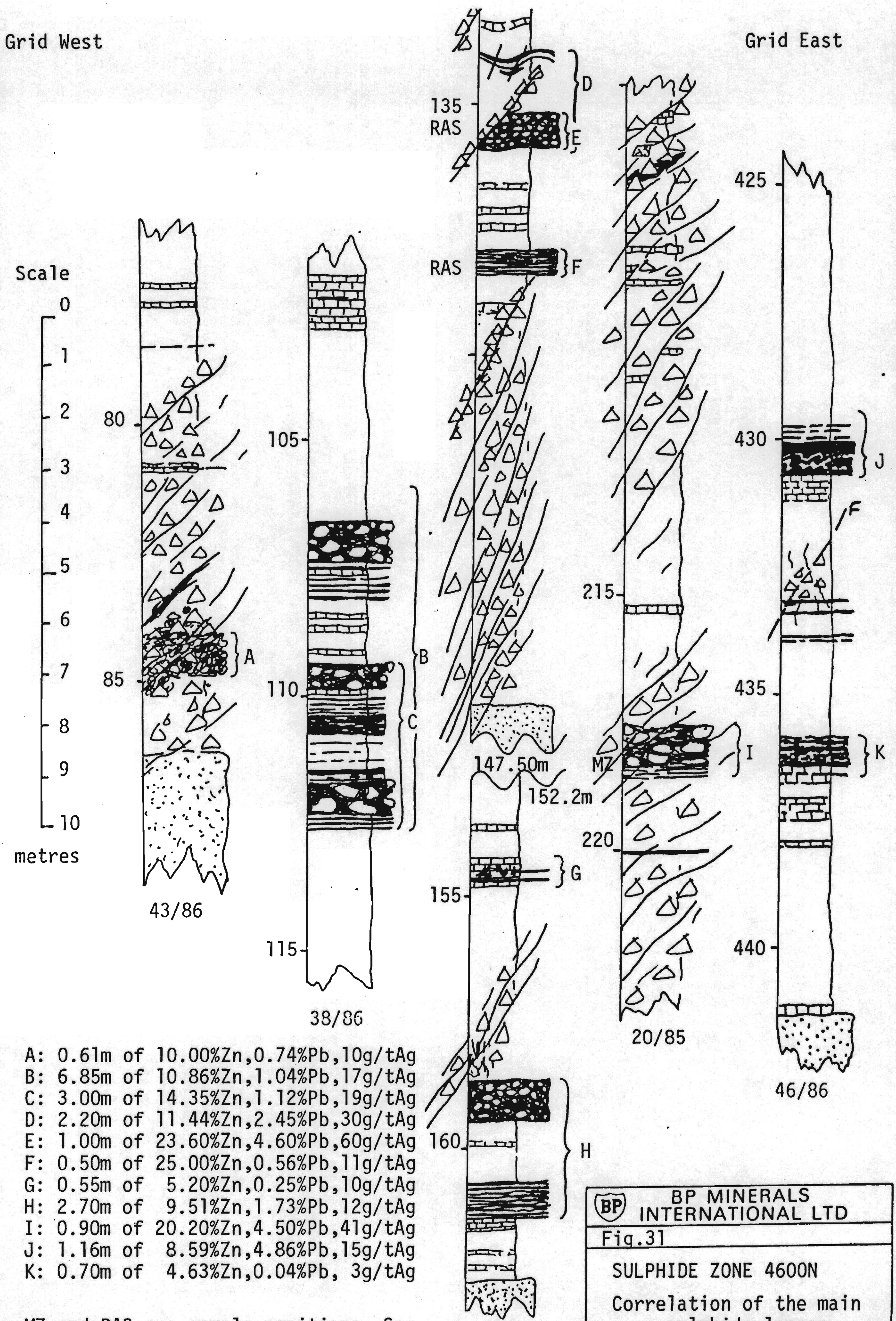


A: 0.30m of 29.60%Zn, 15.30%Pb, 57g/tAg

B: 0.35m of 29.80%Zn, 0.43%Pb, 19g/tAg

Position marked + (Hole 7/85) is the site of a sample examined by LKAB (see section 4.2.2)

BP MINERALS INTERNATIONAL LTD	
Fig.30	
SULPHIDE ZONE 4720N Correlation of the main sulphide lenses	
Author CJCarlon	Date Jan 1987
Revised	



A: 0.61m of 10.00%Zn,0.74%Pb,10g/tAg
B: 6.85m of 10.86%Zn,1.04%Pb,17g/tAg
C: 3.00m of 14.35%Zn,1.12%Pb,19g/tAg
D: 2.20m of 11.44%Zn,2.45%Pb,30g/tAg
E: 1.00m of 23.60%Zn,4.60%Pb,60g/tAg
F: 0.50m of 25.00%Zn,0.56%Pb,11g/tAg
G: 0.55m of 5.20%Zn,0.25%Pb,10g/tAg
H: 2.70m of 9.51%Zn,1.73%Pb,12g/tAg
I: 0.90m of 20.20%Zn,4.50%Pb,41g/tAg
J: 1.16m of 8.59%Zn,4.86%Pb,15g/tAg
K: 0.70m of 4.63%Zn,0.04%Pb, 3g/tAg

MZ and RAS are sample positions. See section 4.2.2.

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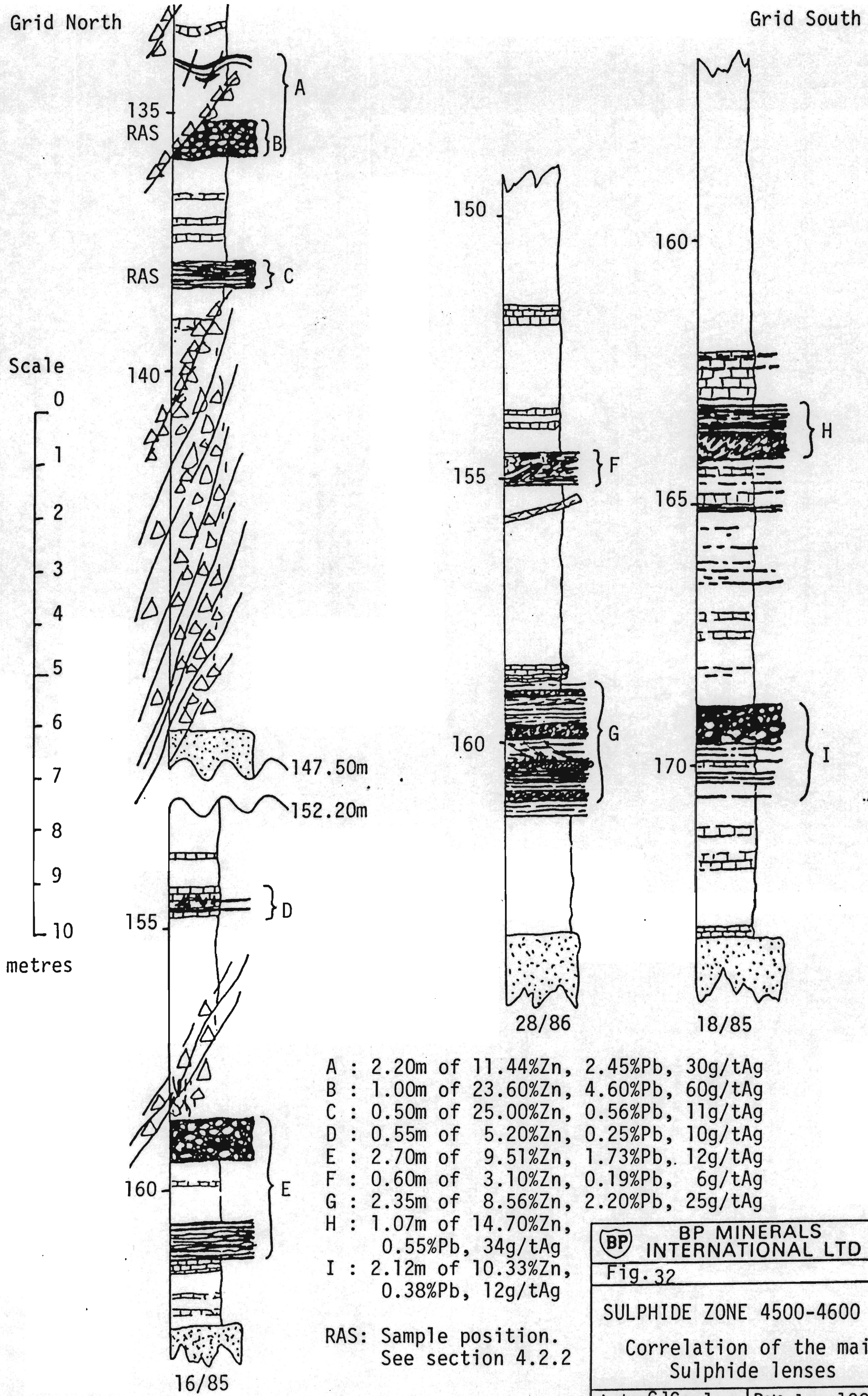
Fig.31

SULPHIDE ZONE 4600N

Correlation of the main sulphide lenses

Author CJCarlon | Date Jan 1987

Revised



A : 2.20m of 11.44%Zn, 2.45%Pb, 30g/tAg
B : 1.00m of 23.60%Zn, 4.60%Pb, 60g/tAg
C : 0.50m of 25.00%Zn, 0.56%Pb, 11g/tAg
D : 0.55m of 5.20%Zn, 0.25%Pb, 10g/tAg
E : 2.70m of 9.51%Zn, 1.73%Pb, 12g/tAg
F : 0.60m of 3.10%Zn, 0.19%Pb, 6g/tAg
G : 2.35m of 8.56%Zn, 2.20%Pb, 25g/tAg
H : 1.07m of 14.70%Zn, 0.55%Pb, 34g/tAg
I : 2.12m of 10.33%Zn, 0.38%Pb, 12g/tAg

RAS: Sample position. See section 4.2.2

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Fig. 32

SULPHIDE ZONE 4500-4600 N

Correlation of the main Sulphide lenses

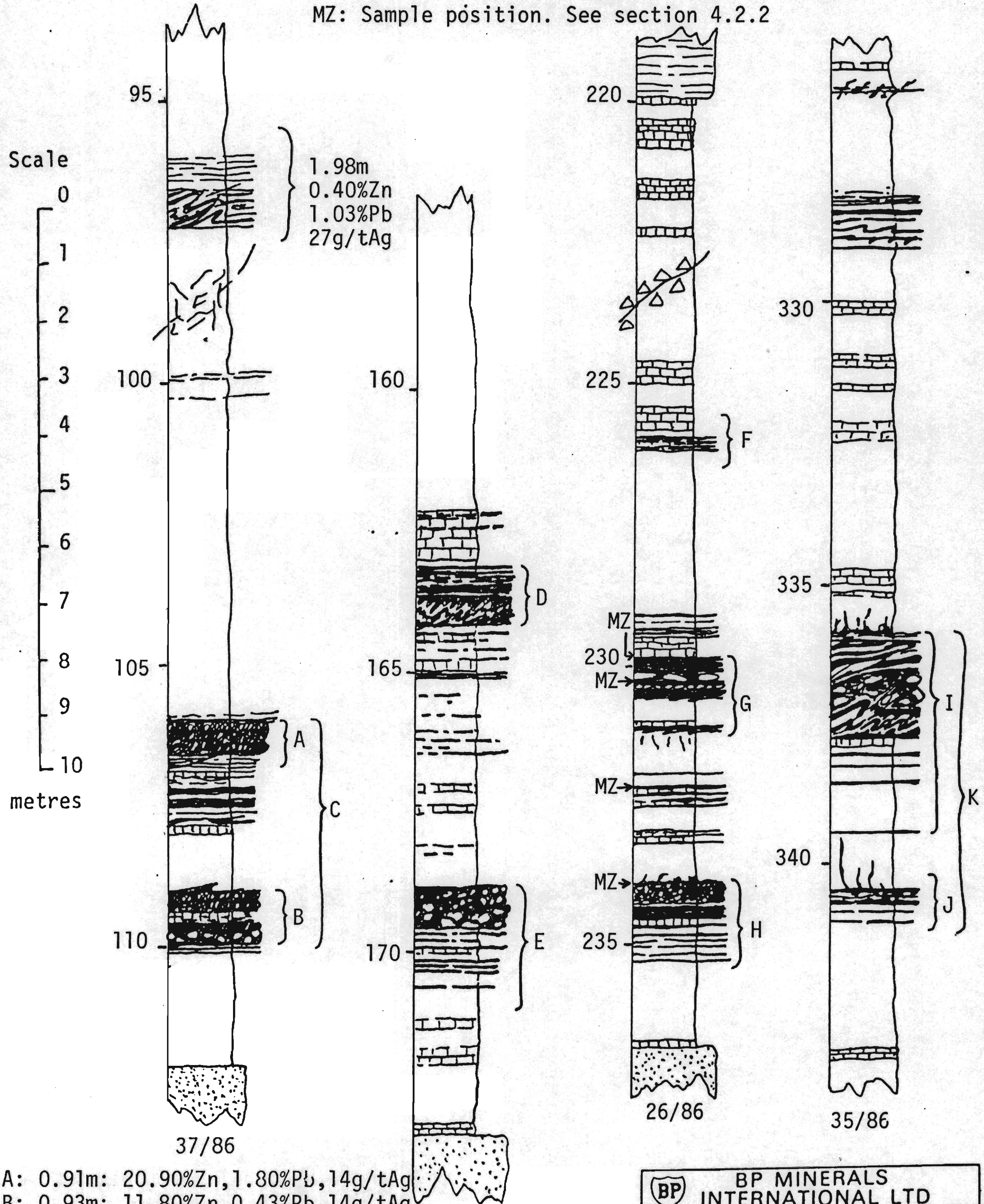
Author CJCarlon | Date Jan 1987

Revised

Grid West | Grid East

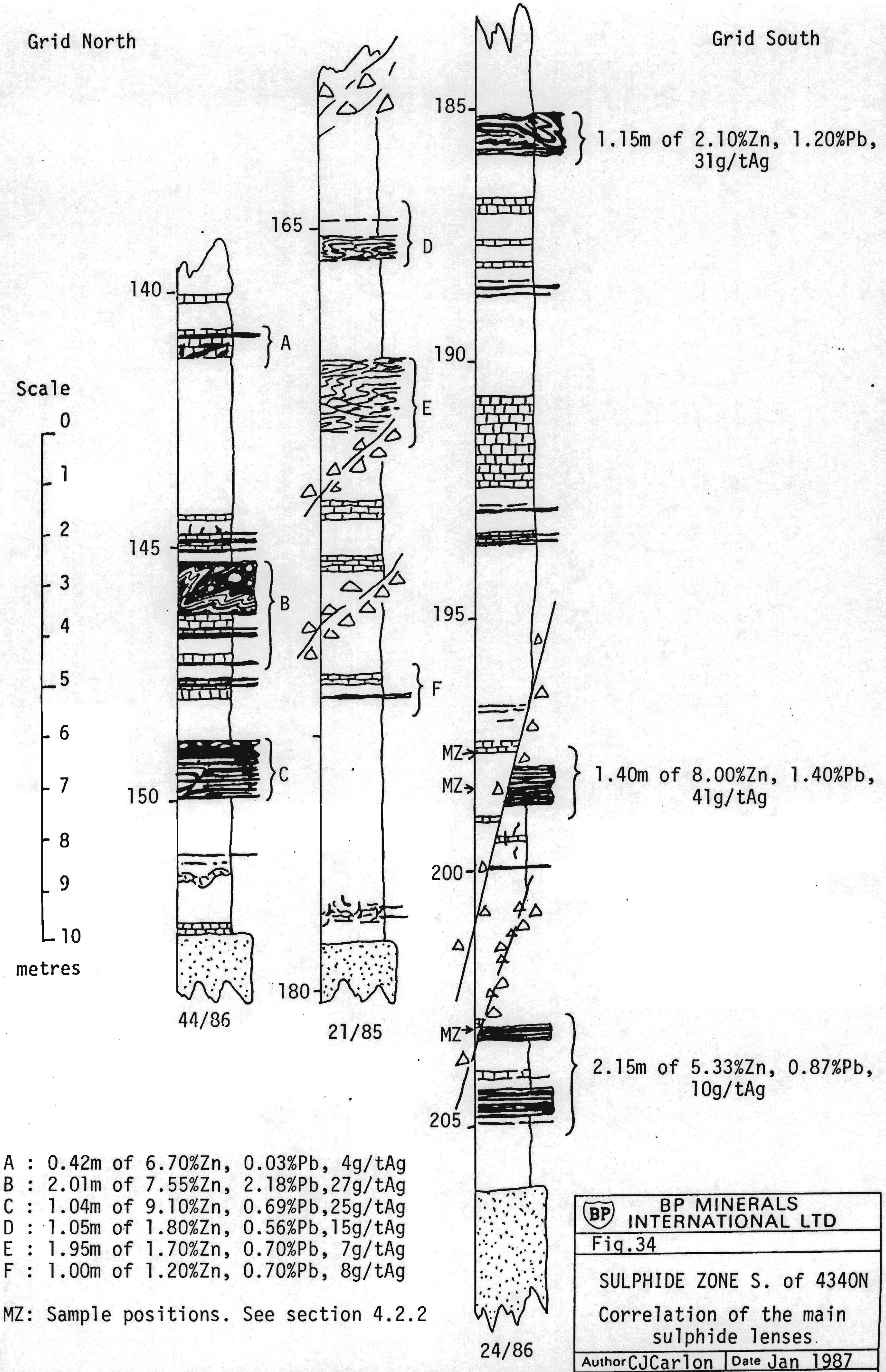
I: 3.55m: 11.19%Zn,0.86%Pb,20g/tAg
J: 0.99m: 7.14%Zn,0.82%Pb,14g/tAg
K: 5.48m: 8.60%Zn,0.72%Pb,10g/tAg

MZ: Sample position. See section 4.2.2



A: 0.91m: 20.90%Zn,1.80%Pb,14g/tAg
B: 0.93m: 11.80%Zn,0.43%Pb,14g/tAg
C: 4.12m: 8.13%Zn,0.70%Pb,10g/tAg
D: 1.07m: 14.70%Zn,0.55%Pb,34g/tAg
E: 2.12m: 10.33%Zn,0.38%Pb,12g/tAg
F: 0.75m: 2.70%Zn,0.12%Pb, 1g/tAg
G: 1.15m: 9.50%Zn,3.10%Pb,31g/tAg
H: 1.60m: 10.80%Zn,0.15%Pb, 8g/tAg

BP MINERALS INTERNATIONAL LTD	
Fig.33	
SULPHIDE ZONE 4400N Correlation of the main sulphide lenses	
Author CJCarlon	Date Jan1987
Revised	



A : 0.42m of 6.70%Zn, 0.03%Pb, 4g/tAg
B : 2.01m of 7.55%Zn, 2.18%Pb, 27g/tAg
C : 1.04m of 9.10%Zn, 0.69%Pb, 25g/tAg
D : 1.05m of 1.80%Zn, 0.56%Pb, 15g/tAg
E : 1.95m of 1.70%Zn, 0.70%Pb, 7g/tAg
F : 1.00m of 1.20%Zn, 0.70%Pb, 8g/tAg

MZ: Sample positions. See section 4.2.2

BP MINERALS INTERNATIONAL LTD	
Fig.34	
SULPHIDE ZONE S. of 4340N Correlation of the main sulphide lenses.	
Author CJCarlon	Date Jan 1987
Revised	

North of 5000N: mean 2.20% Pb
5000 - 4800N: -"- 5.80% Pb
4800 - 4600N: -"- 2.23% Pb
4500 - 4400N: -"- 1.09% Pb
4300 - 4100N: -"- 1.04% Pb

This variation is evident in the results of dipole-dipole IP surveys where the sulphide zone shows a general increase in resistivity, decrease in conductively southwards, with decreasing galena content. South of 4600N intersections in the main sulphide tend of be rich in pale beige sphalerite with minor galena.

a. Sphalerite

Sphalerite in the deposit contains between 1.6-2.2 wt-% Fe, averaging 2.0 wt-% Fe which is low. A few micro probe analyses of red sphalerites show higher Fe contents up to 6.5 wt-%, and increases in manganese (0.1-0.2 wt-%) while the pale beige sphalerite is Fe-Mn poor. Cadmium contents average 0.25 wt-%, and there appears to be an inverse concentration relationship between Fe-Cd. Occasionally high (0.31 wt-%) Cd values have been noted.
Both mercury and silver are below probe detection limits (0.01 wt-%) in all samples investigated.

In the massive 'ball-ore' mineralisation, sphalerite forms 5-10 micron grains, the larger grains often containing numerous silicate inclusions. Sphalerite is usually intergrown with silicates and galena. With increasing silicates a disseminated sphalerite mineralisation develops, with larger sphalerite grains 80-120 microns often containing rounded and elongate grains of chalcopyrite (less than 5 microns). Pyrrhotite inclusions occur in the Fe rich red sphalerite grains.
Massive banded, sphalerite rich sulphides of type i display compositional banding seen under the microscope. Dark bands average 20-50% sphalerite, lighter bands, silicate rich, average up to 15% sphalerite as dispersed interstitial grains. Macroscopic banding due to textural variation is also seen, with coarser grained (150-200 micron) sphalerite in the dark bands, and finer grained (5-80 micron) sphalerite in the paler bands.

Mobilisation of sphalerite is seen as laminae folded around F_2 structures (fig 23), coarse veinlets parallel to S_2, and microscopically as veinlet systems disrupting sphalerite laminae S_1^0 (?) in banded (type i) and laminated (type v) mineralisation.
Massive sphalerite (type ii) and banded sphalerite (type i) passing into laminated (type v) mineralisation sometimes contain 'spots' or 'patches' of sphalerite up to 8 mm long. The 'spots' are interstitial 10-100 micron sphalerite grains in granoblastic quartz-feldspar 'chert'. A remobilisation-recrystallisation process is suggested.

As a general observation sphalerite rich ores tend to be coarse grained (100-300 micron grains) while sphalerite poor 'ores' are fine grained (5-80 microns).

b. Galena

Galena occurs most abundantly, as intergrowths with sphalerite and silicates, forming grains up to 150 microns. It is typically in this form in massive and banded sulphide of type i. and common in ball-ores of types ii. and iii. However, in the 'clastic' 'ball-ores' it is also seen as rims around the silicate 'balls', and as a fine (5-10 micron) interstitial 'dust' between silicate grains.
Occasional single grains are also noted, particularly in massive sphalerite rich sulphide, and the partial replacement of sphalerite by galena is not uncommon.
Galena inclusions occur in pyrite, and galena veinlets are seen invading pyrite grains. Large sphalerite grains sometimes contain galena inclusions and galena forms inclusions in sphalerite more often than sphalerite forms inclusions in galena. Galena is rare in the banded-laminated sulphide of type v, but is particularly common in remobilised veinlets of type iv. Here it occurs as cross-cutting, remobilised (?) veinlets and vein stockworks cutting fine grained intergrown sphalerite and galena and veining adjacent silicates.
In hole 23 brecciation of the sulphide bands and cataclasis has produced brittle fractures in pyrite blasts. These are infilled by galena, often accompanied by chalcopyrite.
Trace element contents of galena for Bi, Ag and Sb are all at or below detection (0.01-0.03 wt%).

c. Pyrite

Pyrite occurs as euhedral grains in all the massive and disseminated types of mineralisation occurring in the sulphide layers. Concentrations up to 5% by volume have been noted, as grains regularly dispersed through the mineralisation.

In massive "ball-ores" of types ii. and iii. pyrite grains are up to 500 microns in size, often containing numerous galena inclusions, and partly replaced by sphalerite. They are regularly dispersed through the massive sulphide. Exactly the same features are seen in pyrite grains in mineralisation of type i.

In the laminated, sphalerite rich mineralisation of type v. scattered pyrite euhedral (porphyroblastic?) grains occur, invariably larger than 100 microns often typically 500 microns with galena inclusions.

In most cases the pyrite grains occurring in the Lovisa sulphide layers are cracked and veined by sphalerite, galena and chalcopyrite. The euhedral form and the galena inclusions suggest formation prior to remobilisation of later galena and sphalerite.

In thin pyritic laminae, pyrite grains are occasionally seen intergrown with pyrrhotite.

Sphalerite, galena and pyrite are the main metallic mineral species. However, minor species have been noted as follows:-

Chalcopyrite: As 'exsolution' spots in some sphalerite grains in banded sphalerite rich sulphide of type i.
As veinlets with galena cutting brecciated pyrite grains.

Chalcocite : As secondary supergene sulphide after, and associated spatially with, chalcopyrite.

Arsenopyrite: Discrete euhedral grains sometimes observed with the hand lens in laminated sulphide of type i.
Microscopic examination shows very minor development in euhedral grains up to 200 microns. Probe analysis gives 0.8 wt% Co and 0.1 wt% Ni.

Cobaltite : Observed by Zakrzewski in disseminated sphalerite of type i. as a myrmekitic intergrowth with galena.
Probe analysis indicates 5 wt% Co, 3 wt% Fe.

Mineralisation in hole 26/86 also contains:-

Dyscrasite : Associated with freibergite as small inclusions in galena

Freibergite : As a few isolated grains up to 10 micron size as inclusions in galena and sphalerite

Pyrargyrite : A single grain in type i. mineralisation in hole 26.

Pyrrhotite : An included grain in red, Fe-rich sphalerite, with pyrite in mineralisation of type i. in hole 26.

Molybdenite was noted as tabular flakes with graphite in the same sample as cobaltite from hole 24.(type i. mineralisation.).

Native silver: Grains of native silver greater than 1 micron were noted by Schedler in galena in massive mineralisation of type ii. in hole 16.Some grains up to 5-20 microns were also seen.

Argentite : Also noted by Schedler in the same association as native silver, but only one occurrence noted, in a chlorite-quartz association.

Cerussite : Occasionally seen as the white - grey-white oxidation product of galena in drillcores intersecting sulphides where a deep weathered zone is present in the subcrop. It occurs in hole 23 at 26.50 m and in hole 16 at 135.30 m.

Ilmenite : Single grains were found by Zakrzewski in pyrite.

Titanite-Rutile : Scattered grains observed in silicates by Zakrzewski.

The metallic minerals of the main sulphide zone occur within the fine grained, siliceous and quartzo-feldspathic 'cherts' and thin mafic skarn bands of lithological Unit 6. A limited amount of thin section petrography indicates the following major mineralogical features of the host rocks.

The main host for the mineralisation is a mid to dark grey, grey-brown or red-brown, fine grained, often garnetiferous, siliceous or quartzo-feldspathic chert. In thin section a granoblastic tecture is developed with quartz and grey or pink microcline. Minor sodic-feldspar is noted, and minor constituents are sericite, biotite and garnet.
Thin mafic 'skarn-bands' or laminae occur, with pale green actino-lite-hornblende, biotite, chlorite and calcite-dolomite. Diopside occurs in thicker bands. Minor scapolite, epidote, tourmaline and fluorite are noted.

Amphiboles and garnet show porphyroblastic growth. Biotite is frequently greenish in colour and chlorite occurs retrograde after biotite. Graphite is noted in some sections, up to 5% by volume, concentrated in the silicate portions of the mineralisation. It is rarely seen in the sulphides. Graphite is rare when carbonates are present suggesting an inverse relationship.

Rounded and angular 'clasts' in the type ii. and iii. 'ball-ores' are siliceous and quartzo-feldspathic lithologies of the wall rocks, and quartzite or quartz-sericite rocks, possibly due to alteration.

Mineralisation occurs in both lithologies but appears most abundant in the 'siliceous' host rocks.

4.2.3 Geochemistry and Grade

There are currently no whole rock analyses for the major litho-logical units. The bulk lithogeochemistry for the mineralised zone is unknown, and as a consequence the geochemical signature of the main sulphide target remains untested.
A lithogeochemical sampling programme, based on the 1985-86 drill-cores is planned for 1987, together with a full multielement examination of the sulphide zone and its surrounding wallrocks.

A limited sampling programme of 14 mineralised intersections gave the results presented in Table 6. LKAB Malmberget also undertook a multielement examination of the mineralisation (sulphide zone). The analysis is based on a representative sample of a 17.68 kg composite from 12 hole intersections (Table 7). Unfortunately the sample contains material from the Unit 11. magnetite skarn (1.76 kg in the full sample). The test material is therefore 'contaminated' with Unit 11 material.

Sulphide samples from holes 4-7, 10-11, 14-17 have been analysed for gold with all samples below the 0.02 ppm detection limit.
Schedler (1986) noted no gold in micro-probe scans of mineralisation from samples in hole 4.

TABLE 6. ICP MULTIELEMENT DATA - LOVISA UNIT 6 SULPHIDE ZONE

Element	Concentration Range
Ca	0.07-0.81 %
Mg	0.20-1.53 %
Al	2.37-6.79 %
Na	0.08-1.45 %
K	0.66-4.06 %
Mn	0.05-0.37 %
Ti	0.06-0.20 %
P	367 - 928 ppm
Ba	34 - 565 ppm
Sr	3 - 10 ppm
Ce	42 - 117 ppm
W	159 - 394 ppm

Based on 14 samples from 10 drillholes.

TABLE 7. LKAB MALMBERGET MULTIELEMENT DATA

GENERAL CHEMICAL ANALYSES FOR TEST MATERIAL CRUSHED TO -3 MM

Main element

Element	Assay %
Fe	6,12
P	0,045
S	8,45
Pb	5,50
Zn	13,4
Cu	0,01
C(tot)	0,38
C(gr)	0,28
MnO	0,655
CaO	1,15
MgO	1,67
Al2O3	7,36
SiO2	46,7
TiO2	0,176
V2O5	0,018
K2O	2,71
Na2O	0,54
LOI	5,48

Trace element

Element	Assay ppm
Be	<1
Sr	5
Ba	220
Sc	<2
Y	25
La	75
Ce	<100
B	75
Tl	<10
Zr	73
Ge	20
Sn	10
Nb	<10
As	<50
Sb	<15
Bi	<15
Cr	6
Mo	<20
Te	<50
Co	6
Ni	4
Ag	35

THE MATERIAL DENSITY IS 3.14 G/CM3

Note that 1.76Kg of the original 17.68Kg of material was from the Unit 11 magnetite-sulphide zone, the remainder from the Unit 6 main sulphide zone.

Further gold analyses are required on the magnetite-sulphide zones, the Unit 7 pyrite-chert and the sericitic zones of Unit 8. If the strata are the right-way up stratigraphically these zones would underlie the sulphide.

Metal grades within the sulphide layers are variable, with zinc in the range 1-29.6%, lead 0.5-20.0% and silver 2-120g/t Ag. Intersection grades for the main sulphide zone are given in Volume B, and in Appendix 4.
Main intersections and grades are shown graphically in figs. 26-34.

4.3 The Lower Magnetite Marker Sulphide Zone

A magnetite 'skarn' sequence occurs 28-40 metres below the main sulphide zone (Unit 6). In every intersection massive layers, streaks, 'spots' and disseminated grains of magnetite are found within banded and massive actinolite-hornblende, garnet, diopside, forsterite, and occasional calcite marbles and 'skarn' of lithological Unit 11.
The magnetite is typically planar banded, crystalline, massive black iron oxide in layers 1-50 cms thick.
Deformation frequently affects the Unit 11 lithologies, with steep dips, contorted banding and minor brittle fractures.

The Unit 11, Lower Magnetite Marker is 5-10 m thick, with the magnetite layers concentrated into 2-3 distinct bands. It is this magnetite bearing, characteristic marker horizon, which produces the magnetic feature over the Lovisa discovery. The unit is considered to represent a metamorphosed impure manganiferous iron chemical precipitate, deposited in a magnesian-ferruginous impure carbonate environment. It is therefore a stratiform horizon and the magnetic feature produced can be used to deduce the structure of the area, with careful interpretation (see section 3.4.1).
The Unit 11 magnetite skarn also acts as a footwall marker for the main sulphide zone.

As previously described in section 1.1, sulphides were known to be associated with magnetite horizons in the Stråssa area before discovery of the Lovisa sulphide zone. The Nya Backadahl zone has silver rich sulphide associated with magnetite (section 2.2, Tables 2 and 3). It is not yet clear if the Lower Magnetite Marker (LMM) Unit 11 is the same horizon repeated by folding (see section 3.4.1).

In 31 drillcores, Unit 11 contains sulphides in the magnetite layers, as disseminations, spots, streaks, patches, bands and veinlets. Pyrite, pyrrhotite, occasional sphalerite, galena and chalcopyrite are noted. A similar association at Nya Backadahl contains silver mineralisation (Tables 2 and 3, Appendix 1), and silver is noted in assays of the Unit 11 sulphides, particularly in galena rich sections.
Mineralisation is sporadic, with intersections up to 4.80m. Assays from this zone of mineralisation in Unit 11 are listed in App. 5.
Of note are: Hole 3 : 3.80 m of 4.48% Pb, 86 g/t Ag
including 1.60 m of 8.80% Pb, 140 g/t Ag

Hole 35 : 4.80 m of 6.31% Pb, 78 g/t Ag
including 0.84 m of 24.00% Pb, 237 g/t Ag

One polished section of Unit 11 sulphides from hole 3 noted magnetite, galena, pyrite and arsenopyrite: galena is penetrated by porphyroblastic amphiboles. None of the magnetite intersections have been assayed for Au, although it is planned to do so. Mineralisation can be high grade, but is so sporadic and unpredictable in distribution it is doubtful that an economic tonnage could be outlined.

4.4 Lithological Unit 7 Sulphides

Immediately below the target sulphide zone, Unit 6, a change occurs from mixed 'chert-skarn' into fine grained siliceous 'chert'. The strata are characteristically pink-red or red-brown, siliceous or quartzo-feldspathic, potassic(?) 'felsic' cherts with spots, grains and streaks of pyrite. The Unit 7 pyritic red-chert is 10-16 thick. Magnetite porphyroblasts occur lower down the sequence and sericite appears.

Samples have been taken for Au analysis and results are awaited.

4.5 Other Mineralisation

For completeness, mention can be made of the scattered, apparently unrelated, minor mineralisation that occurs within the project area.

i. Sulphides : Veinlet galena, minor pyrrhotite, trace chalcopyrite and pyrite are scattered throughout the supracrustal sequence in the Lovisa area.
Minor galena veinlets occur around the sulphide zone, and trace galena in parts of the major, brecciated fault zones may be remobilised from the 'stratabound' sulphides. Pyrite and pyrrhotite 'stringers' are also seen in some fault zones.
Pyrite disseminations, as a very minor trace component, are not uncommon in parts of the 'meta-tuffite' and 'chert' sequences. Minor pyrite, trace pyrrhotite-chalcopyrite is seen in several skarn bands within the sequence, apparently rather random in distribution.

ii. Fluorite : Purple fluorite, invariably infilling hair line cracks or as wider 1-5 mm fracture infills, is not uncommon in Unit 6 and there is a tendency to see it as an accompanyment to the sulphide mineralisation. In fact, on closer inspection, fluorite stringers and 'hair-line' veining is seen throughout the sequence on a very minor scale. Fluorite may originate from volatiles released during syn- or post F_2 pegmatite introduction and the emplacement of the 'younger' granite intrusives.
As scapolite and tourmaline also occur in Unit 6, it appears F, Cl and B are present in the sequence Breakdown of biotite in the presence of calcium might release F to form fluorite. The occurrence of halides might also indicate a 'saline' component of the parent rocks.

iii. 'Thucolite': A black vitreous 'anthracitic' mineral occurs cementing breccia veins at 93.70 m in hole 36 in a major fault zone. The same material is seen coating calcite scalenohedra in open crustiform veins at 102.00-103.80 m in hole 22.
The black resinous, brittle 'bituminous' material from hole 36 was tested with a gamma scintillometer.
Values of 17-20 µR/hr over a background 9-10 µR/hr show fairly normal readings for organic material. Uranium compounds are known from veins associated with pegmatites in the Stråssa, Blanka and Stripa areas around Lovisa.

4.6 Origin of the Lovisa Sulphide Mineralisation

It is not important at this stage to speculate on the origin of the Lovisa sulphide mineralisation. However, it is worth while to list the features which may indicate a possible origin in so far as this could affect the manner in which exploration progresses.

1. The sulphide zone is located in a specific lithological unit.

2. The host unit is overlain and underlain by a non-symmetrical, but characteristic sequence of lithologies.

3. Structurally above and below the sulphide zone and its host unit are lithologies characteristic of volcanic (pyroclastic-epiclastic) sediments and banded chemical sediments, apparently compositionally banded and lying parallel with the sulphide unit contacts and the sulphide layers.

4. Thin, acid metatuffite-metavolcanic rocktypes are mineralogically banded in fine detail. Such rock types suggest an origin in Plinian type eruptions, with deposition in an aqueous environment (Fisher and Schmincke 1984). Banding lies parallel to rocks of probable chemical sedimentary origin and these in turn are parallel to the sulphide layering. A syn-sedimentary or early pre-diagenetic origin for the sulphide is suggested.

5. Very fine grained, finely laminated 'cherts' contain sphalerite laminae apparently supporting a 'syn-sedimentary' deposition.

6. There is no obvious alteration phenomena around the sulphide zone, with the possible exception of silicification. There is no obvious magnesian, alumina or ferruginous enrichment giving the characteristic sericite, biotite, cordierite, anthophyllite, actinolite assemblages seen elsewhere with the sulphide deposits at Falun, Garpenberg and Silvberg, and a sucrosal quartz-pyrite "ore-quartzite" is absent.
Geochemical haloes, if present, have not yet been sought.

7. Structurally underlying the main sulphide are Units 7 and 8. Unit 7 is a pyritic 'chert' (potassic quartz-feldspar rock?), and Unit 8 is a sericitic, siliceous 'chert'.
These rocks could represent alteration phenomena, and if a major synclinal fold is inferred, the "alteration" would stratigraphically underlie the sulphide.

8. Structural observations suggest that mineralogical and compositional banding may be original (So), but that the major F_1 isoclinal structures parallel the So producing S_1^o features. Thin laminated sphalerite rich laminae display isoclinal fold structures with an axial plane orientation parallel to So.

9. Breccia zones are seen lying parallel to S_1^o , and may be the brittle late stage response to the ductile F_1 folding.

10. Some of the sulphide layers have brecciated contacts with wall-rock fragments veined by and sitting in the sulphide. There is a suggestion that some, if not all the sulphide, was introduced or partly remobilised during F_1 or post F_1 stress.

11. The passage of 'ball-ore' textured sulphide layers from matrix sulphide to clast supported zones, then veined host rock breccia suggest that the 'ball-ores' are tectonic and the product of differential brittle-plastic response in bedrock and sulphide, rather than sedimentary detrital deposits.
"Ball ore" zones often have cross-cutting contacts with the host rocks, truncating mineralogical banding and foliation.

12. The folding of F_1 isoclinal sulphide laminae around steeply inclined S_2 lineations, remobilisation of sulphide into cuspate and wedge veins along S_2, and F_2 axial planar sulphide folds indicates a second stage of sulphide mobilization.

13. Remobilization of sulphide is also indicated by apparent cataclasis of pyrite grains, veining by sphalerite and galena, replacement of sphalerite by galena and hairline cracks infilled with galena emanating from the sulphide layers.

14. Fold structures are most apparent in the sulphide zone and in mixed carbonate-chert bands where similar 'ruckling', disharmonic and F_2 folding and 'ball-textures' are developed. Such features suggest tectonism of already existing incompetent zones.

15. Banding in the sulphides is a function of grain-size and compositional variation. Gradational variations occur between granoblastic silicate-interstitial sulphide, laminated 'chert'-sulphide, banded sulphide and 'ball-ore' massive sulphide.

16. Grey-white quartz lithoclasts in the "ball-ores" could be disrupted and fragmented quartz-veins from an early period of quartz veining of the sulphide layers. Later tectonism brecciated the veins and produced 'clasts' of quartz set in the ductile and recrystallised sulphide.
Boudinaged and brecciated white quartz veins are not uncommon in the sequence, a good example occurring at 22.80m in hole 25, boudinaged perpendicular to the prominent S_2 foliation.

17. Variation in galena-sphalerite content, as noted in section 4.2.1 may be a function of differential remobilisation between PbS-ZnS.

18. Later NE-SW and NNW-SSE faulting has severely brecciated the sulphide in places, and caused local remobilisation of galena.

19. No 'feeder zone' mineralisation or alteration has been identified. Units 7 and 8 could represent a feeder system streaked out along S_1^o into parallelism with the sulphide, but this seems doubtful.

The evidence to date suggests that the mineralisation may originally have been a laminated and banded zinc-lead sulphide of 'distal' exhalative type, deposited in a mixed carbonate-silicate basin, periodically infilled by acid pyroclastics re-sedimented in an aqueous environment. Folding and brecciation during D_1 remobilised the sulphide and further remobilisation during D_2 produced the refolded sulphide laminae, cataclasis phenomena in the sulphides and 'ball-ores' currently seen. However, the sulphides do not appear to have moved far and seem to lack large B_2 plunging shoots, although this cannot be ruled out.

A 5 BENCH TESTS AND ORE CALCULATIONS

5.1 Bench test beneficiation

Samples from Lovisa have been examined for grain size, intergrowths, mineralogy and general characteristics by Schedler (1986), Zakrezewski (1986) and LKAB Malmberget (1986) (Table 4). Sala International offered to run a pilot study on Lovisa mineralisation in late 1985, and a further bench test was undertaken by LKAB at their Malmberget Laboratories in July-August 1986. These studies, when considered together, give an initial impression of the characteristics, recoveries and possible beneficiation problems with regard to the Lovisa 'ore'.
In all cases, due to the limited amount of available material (only the cored intersections), full tests could not be applied, similarly, characteristics may not be representative of the whole deposit. The following points arise from these studies:

5.1.1 BP-Schedler

5 samples from holes 4, 15 and 16 were examined by Dr. R.A. Schedler at BP Sunbury, in February 1986.
An examination of this material suggested (predicted):

1. Sphalerite grains containing galena disseminations would probably enter the lead concentrate, and that no matter how finely ground, the Zn concentrate would be contaminated by small amount of disseminated galena.

2. Material would have to be ground to at least -45 micron to achieve a 90% liberation of sphalerite, and particularly galena.

3. Silver minerals would report to the lead concentrate, but a minor proportion would go the the zinc concentrate, and a small amount to the tailings.

4. Sulphide intergrowths occur, are not complex and separation of the main mineral species should not create too many problems.

5. Recovery of the silver minerals should be satisfactory, or may be excellent.

5.1.2 Zakrzewski

11 samples from holes 20, 23, 24 and 26 were examined by microscopy, XRD, and microprobe analysis. The work was principally mineralogical and the characteristics of the 'ore' were considered:

i. Good due to simple mineralogy, high grade, low Fe content of sphalerite, and low pyrite content.

ii. Bad due to the fine grained nature of the sulphides, their complex intergrowths with each other and with silicates, and the high graphite content.

It was suggested that attention ought to be paid to separating not only the country rock from the mineralised 'raw feed', but also the sphalerite poor from the sphalerite rich 'ore' prior to grinding.

5.1.3 The Sala Bench Test

Two samples were sent to the Sala Laboratories in November 1985. They were sample pulps from the MinPro Analytical Laboratory at Stråssa, the ground material from core samples, and comprised a 650g sample with 18% Pb, 18.3% Zn (from hole 4) and a 1000g sample with 9.8% Pb and 21.0% Zn (also from hole 4). The 650g sample was actually from the same mineralised interval examined by R.A. Schedler (L3. and L4. Schedler 1986), from the interval 50.50-51.15 m (0.65 m) in hole 4. The 1000g sample was from the interval 64.25-65.50 m (1.25 m) in hole 4.

Both samples were first ground to -0.1 mm in a ball mill. The 1000g sample was procesed using a conventional selective flotation depressing the Zn minerals (sphalerite) with NaCN and $ZnSO_4$. The concentrate produced, when examined microscopically, was found to contain a high proportion of galena-sphalerite composite grains.

The concentrate was reground and re-cycled using NaOH and $ZnSO_4$ to depress the sphalerite, a method used in the Zinkgruvan concentrator. Recycling 3 times produced:

Pb concentrate:	43.4% Pb (49.1% recovery) with 23.9% Zn
Zn concentrate (1 pass):	34.1% Zn (18.3% recovery) with 2.1% Pb

In the Pb-concentrate 3. noted above 83.4% of the recovered galena had a grain size less than -38 µm.

The 650g sample was processed to first produce a Pb-Zn raw concentrate. This was ground with calcium carbonate (pH modifier) and flotated using Na_2CrO_3 to depress galena and flotate sphalerite.

The resulting Pb concentrate contained:	48.6% Pb (28% recovery) with 13.0% Zn
The Zn concentrate contained:	29.6% Zn (35.6% recovery) with 35% Pb

These results are as predicted by Schedler (1986).

Insufficient material was available for Sala to attempt improvements to the beneficiation process, and as a result the intial test work suggested problems would be met trying to separate such fine grained sulphides.

5.1.4 The LKAB Malmberget Test

A comprehensive beneficiation test was undertaken in August 1986 by LKAB Malmberget Laboratory, and reported, also extensively, in September 1986.
The main parts of the study were:

1. Material was tested from holes 3, 5-7, 10-11, 15-18, 22 and 24. All the samples were from the main sulphide zone except the sample from hole 3, which was a sulphide (galena)-magnetite from the LMM (Unit 11).

2. Two samples, from hole 6 and 25, were not tested as they contained ochreous, weathered material.

3. The total amount of sample (including 1.76 kg from Unit 11) was 17.68 kg, with a mean assay of 12.8% Zn, 4.4% Pb and 39 g/t Ag.

4. A grindability study on wet material was performed using both rod and ball milling. Grinding was easily accomplished and a size reduction to 30 microns was required to obtain an acceptable liberation of galena from sphalerite.

5. Three tests were performed:

   i. 1 kg material ground to 61 microns.
   3 stages of Pb flotation and 4 stages of Zn flotation.
   Pb recovery: 95.2%
   Ag recovery (to Pb concentrate): 83.9%
   However, 52.6% of the Zn reported to the Pb concentrate, indicating either non-liberation of intergrown PbS-ZnS grains, or insufficient Zn depressant ($ZnSO + 7H_2O$) in the process.

   ii. Repetition, with 1 kg feed ground to 43 microns.
   Pb recovery: 95.7%
   Ag recovery (to Pb concentrate): 87.7%
   Even more Zn (55.1%) reported to the Pb concentrate.
   However, the part Zn recovery to the Zn rough concentrate was 97.8% as opposed to 97.5% in test 1.

   iii. Size reduction had not improved the selectively between Pb and Zn, so a third test was attempted, doubling the concentration of Zn depressant, and grinding to 43 microns as in test ii.
   Pb recovery: 95.4%
   Ag recovery (to Pb concentrate): 83.6%
   46.6% Zn reported to the Pb concentrate, and the part Zn recovery to the Zn rough concentrate was 97.8% as in test ii.

A recleaning test on Pb and Zn raw concentrate was performed using sodium bisulphate and zinc sulphate as depressing agents. Little improvement was achieved.
As a result of these selective flotation tests it was suggested that good beneficiation results should result from selection of the right process parameters. It was further suggested that a collective flotation method, as employed at the Zinkgruvan mill, was a likely process to obtain good results on Lovisa 'ore'.

This process envolves:

1. Collective flotation of the sulphides
2. Regrinding of the bulk rougher concentrate
3. Recleaning of the bulk concentrate
4. Pb-Zn separation
5. Regrinding of the Pb-froth product
6. Recleaning

No attempt was made to test Lovisa material by this method. It was also pointed out that dilution of the sulphide layers by siliceous-quartzo feldspathic wallrocks would necessitate a pre-concentration, a point also noted by Zakrzewski (section 5.1.2).

No other beneficiation tests have yet been conducted. Owing to the depth of mineralisation either blind or at deep subcrop, the only material available for testing are the analytical pulps. A larger scale test would require more material, currently not available.

A review of the bench test results by BPMIL technical department suggests the following data from these initial tests:

Grades	Zn %	Pb %	Ag g/t
Zn concentrate	50.00	0.60	13.00
Pb concentrate	7.80	55.00	158.00

Recoveries	Zn %	Pb %	Ag g/t
Zn concentrate	85.0	2.9	15.0
Pb concentrate	4.0	80.9	57.7
Tailings	11.0	16.2	27.3

5.2 Ore calculations

5.2.1 LKAB-Statsgruvor

An initial ore calculation was prepared by Lars-Göran Ohlsson (LKAB Prospektering) for the Lovisa sulphide zone, in August 1986. Unfortunately, at the time, there was some confusion about the nature of the 'ore-zone', and gaps existed in the analyses for sections of the mineralisation.

In September 1986, Peter Zeidler and Stefan Månsson (AB Statsgruvor), using data provided by L-G Ohlsson and S. Bjurstedt (Project leader), made a preliminary ore calculation.
Based on 11 drillhole intersections from hole 4 in the north to hole 26 in the south, the calculation was based on a strike length of ca 500 m, to a depth of 300 m (hole 35) with a mining width of 3.0 m. Average grade was calculated at 5.5% Zn, 2.0% Pb, and with 15% dilution and a 0.9 correction factor 2-2.5 million tonnes was estimated.

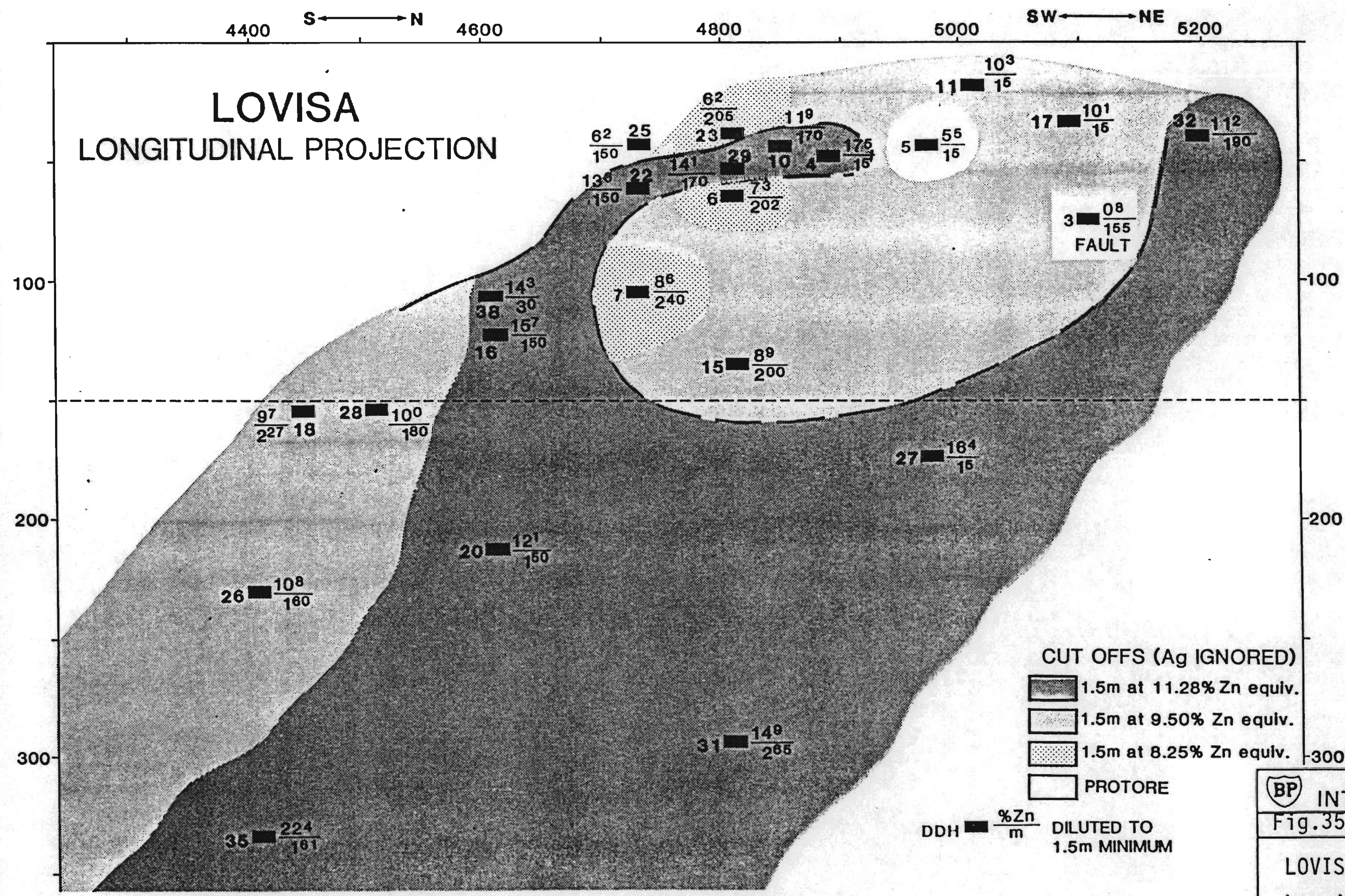
An additional calculation was made in consideration of 'small ore-body mining' (narrow vein mining) where a mining width of 1.5m was defined.
The grade would, as a consequence, be increased to an estimated 12% Zn, 4% Pb, and 16 g/t Ag.

5.2.2 BP Minerals

Various estimates of grade and tonnage have been calculated by BP Minerals as follows:-

i.	Strike length 1000 m from 4200-5200N Downdip for 300 m from 50-350 m levels Thickness of 1.90 m (arithmetic mean)	1.82 Mt of 13.7 % Zn equivalent
ii.	Strike length 1200 m from 4100-5300N Downdip to 350 m level Thickness minimum 1.5 m	1.65 Mt of 14.6% Zn, 5.1% Pb, 21 g/t Ag
iii.	Strike length 1400 m from 4000-5400N Downdip to 450 m level from 50 m Thickness 1.9 m to 350 m, 2.1 m from 350-500 m level	4 Mt or 3.75 Mt (diluted) of 11.34% Zn, 3.15% Pb, 14 g/t Ag

Intersection data for these calculations is shown in figs. 35 and 36.



(after M.Harris 1986)

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Fig.35

LOVISA PROJECT -

Longitudinal projection with drill intersections

Author CJCarlon Date Feb 1987

Revised

LOVISA LONGITUDINAL PROJECTION

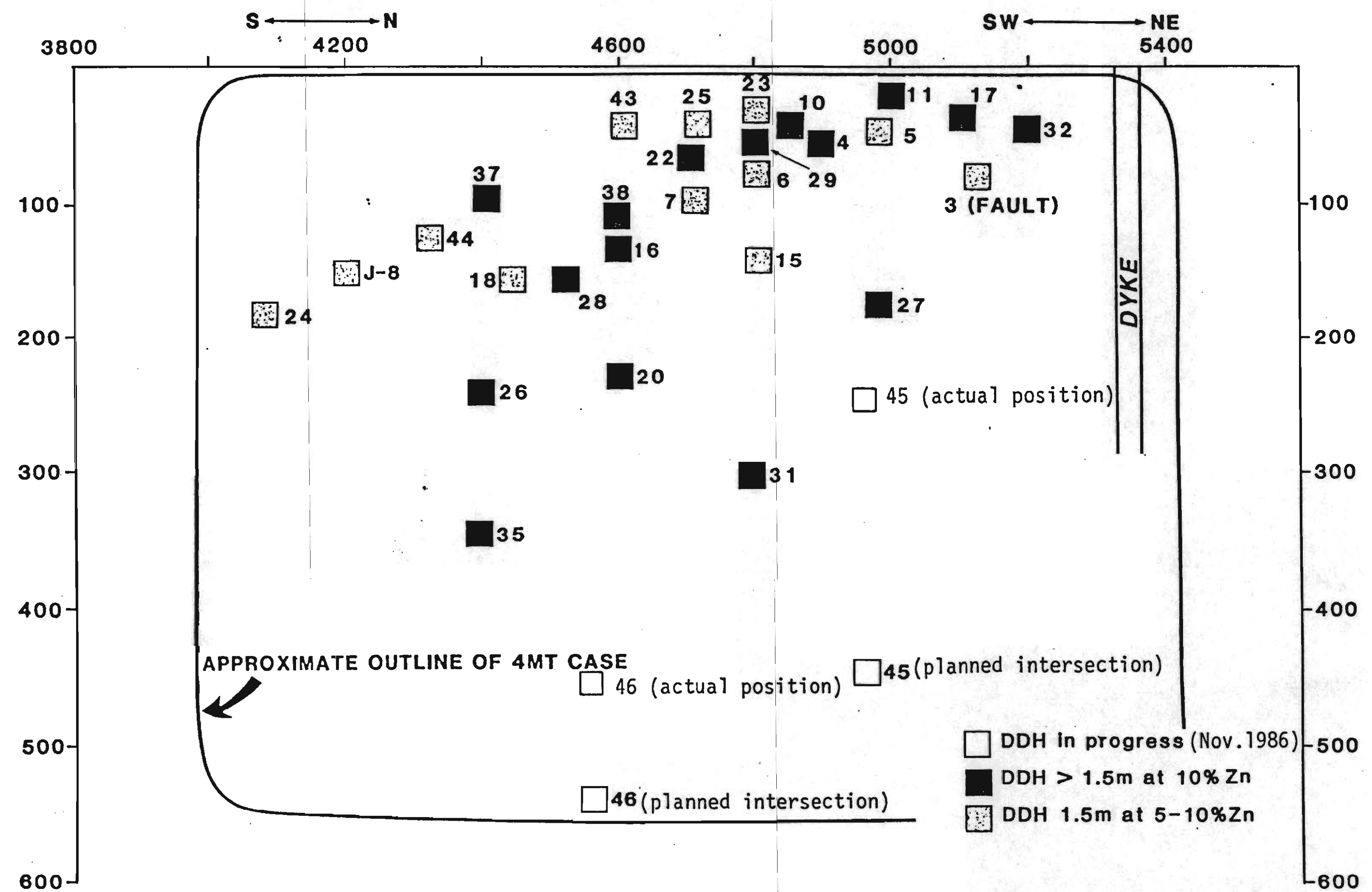

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Fig.36

LOVISA PROJECT - Longitudinal section with 4Mt case

Author CJCarlon | Date Feb1987

Revised

(after M.Harris 1986)

A 6 CONCLUSIONS

The main conclusions of the 1985-86 exploration at the Lovisa Prospect are:

1. That a deposit containing between 1.65-2.50 million tonnes of zinc-lead-silver mineralisation is present in the discovery area, with grades of 5.5-14.60% Zn, 2-5.10% Pb and up to 21 g/t Ag.

2. The mineralisation has been drill indicated over a strike length of 1,100 m to a depth of 430 m and is open to north, south and east. The general structure of the area suggests that folded or faulted repetitions of the mineralisation are probable, and that strike continuity is possible.

   Potential exists for an economic zinc-lead-silver deposit.

3. Mineralisation is confined to a distinct lithological unit, overlain and underlain by a characteristic lithological sequence. A faulted monoclinal to antiformal fold structure occurs in the discovery area, the main body of the drill indicated mineralisation occurring in a zone dipping 56-66^{o} E.

4. The main mineralised zone is up to 6 m thick containing 2-3 massive sulphide layers. Sphalerite-galena are the main constituents, the sphalerite having a low iron content (mean 2 wt%) and the galena having an associated silver mineralisation.

5. Drilled intersections show metal grades up to 29.6% Zn, 20.0% Pb and 120 g/t Ag.

6. The sulphide layers are laminated, banded or massive 'ball-ore' textured. Microscopic and hand specimen observations indicate remobilisation of the sulphide subsequent to deposition.

7. Structural features suggest that the sulphide pre-dates an early F_1 folding, and cuspate, veinlet and fold structures in the sulphide indicates at least two phases of plastic deformation and 'flowage'.

8. Features seen suggest that the sulphide horizon is a stratiform - stratabound zone of possible exhalative (distal) type, remobilised in a zone of incompetent strata. Differential brittle fracturing of the host rocks and plastic flowage of the sulphide produce the fold, clastic, banded and veining structures observed.

9. No clearly defined 'feeder-zone' has been identified, although pyritic and sericitic rock types underlie the sulphide zone structurally, and (from regional fold interpretation) probably stratigraphically.

10. A galena-silver mineralisation associated with a magnetite horizon occurs 40-50 m below the main sulphide. The magnetite forms a prominent geophysical marker (the Lower Magnetite Marker) producing a major magnetic feature in the discovery area.
The sulphide mineralisation in the magnetite contains up to 24% Pb and 320 g/t Ag. It is, however, sporadic and appears to have limited tonnage and hence economic potential.

11. A series of NE-SW and NNW-SSE faults cut the mineralisation and its host rocks. Throws are generally normal displacements, down to the west. These faults appear to be the youngest fractures and have been reactivated at least twice.

12. Earlier (healed) breccias define faults lying parallel, or at a steep angle to the compositional-mineralogical banding in the host supracrustal sequence, some of which may be low angle shears or thrust faults.

13. At least two fold events are indicated, with an early F_1 having a S_1 foliation parallel to So (original banding), and a later F_2 with a consistent 74-86^0 E foliation.

14. Small scale tectonic features are most obvious in layers of competency contrast, for example sulphide-'chert' layers and calcite marble-'chert' bands. Both display folding, boudinage, brecciation and recrystallisation phenomena.

15. Large scale structural interpretation is hampered by lack of outcrop. Initial interpretation of drilldata and surface magnetic results suggests:

    i. The area west of the discovery zone is either a lateral facies change in the supracrustal succession, or the strata in the footwall of the deposit.

    ii. No major F_1 fold axis occurs between hole 46 collar and the main discovery zone, neither is proximaty to a fold hinge indicated by a reduction of dip in depth.

    iii. A large Sveconorwegian dyke located between Lovisa and Backadahl is emplaced along a fault zone and has faulted contacts.

    iv. The Nya Backadahl magnetite zone does not appear to be the continuation of Unit 11 at Lovisa.

    v. The magnetic data can be interpreted as relatively simple fold structures. However, considerable brittle fracturing occurs in zones throwing different magnetic horizons (magnetite bands) into proximaty.

Most of the drillholes have been placed to make shallow intersections in the mineralisation between 4600-5100N (500 m of strike length). More information is required to the north, south and south east of the deposit, the latter area appearing to have the most potential.

16. Initial bench test concentration and grindability studies suggest fine grinding, easily accomplished, followed by a Zinkgruvan mill, collective flotation process would be suitable for the Lovisa 'ore'. Dilution with siliceous or quartzo feldspathic host rocks would perhaps necessitate a pre-concentration process.

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APPENDIX 1 : NYA BACKADAHL MINERALISATION (after W. BLEEKER 1984)

<u>Ore sample from Nya Backadahl</u>

I. Sample from drill core Nya Backadahl 007/83. A galena rich nest at 77.25 meter.

II. Bulk chemical analysis:

1.4	wt%	Pb
0.02	wt%	Zn
150	ppm	Ag

III. Macroscopic description:
A galena rich nest of about 1 cm wide, in magnetite rich skarn. The skarn consists of a forsterite+magnetite band and a green biotite+garnet+magnetite band. The galena nest occurs with magnetite on the contact between these two different compositional bands.

IV. Microscopic description:

Transparent phases: green biotite
garnet
forsterite 2V-: 80°.
zircon
chlorite

Opaque phases:

magnetite	very abundant. Exsolution lamellae of spinel.
galena	dominant sulphide.
pyrrhotite	not uncommon.
gudmundite	not uncommon.
chalcopyrite	accessory.
sfalerite	rare accessory.
tetrahedrite	most abundant silver mineral.
allargentum	
dyscrasite	
(silver)	
pyrargyrite	probably also other Ag-Sb sulphosalts.
acanthite	
graphite	accessory, between silicates and in magnetite.
pyrite	oxidation product of pyrrhotite.

Textures and intergrowth(see also the slides):
The galena nest is very irregularly intergrown with magnetite and silicates. Galena, with small amounts of associated silver minerals, occurs also dissiminated between magnetite and silicates. Late defor-

mation initiated redistribution of galena, into fractures and cleavages of biotite(see slide 1 and 2), into fractures of garnet and other minerals. Galena can also be observed to replace magnetite (see slide 1 and 2). Upto 10 vol% of the total galena content may occur in very fine intergrowth with magnetite and silicates.
Gudmundite is the third abundant sulphide, occurring as relatively large inclusions(upto 0.1 mm) in galena(see slide 3), or intergrown with magnetite. Allargentum and dyscrasite are often closely associated with gudmundite.
Chalcopyrite and sfalerite are relatively rare, and occur as small grains intergrown with pyrrhotite between the silicates or in magnetite.
Most of the silver is probably contained in allargentum-dyscrasite and Ag-rich tetrahedrite. Allargentum and dyscrasite occur as inclusions in galena. The two phases form sometimes composite grains, or exsolution lamellae in each other. The allargentum-dyscrasite inclusions range in size from more than 0.1 mm to a few mu(slide 4 and 5). Ag-rich tetrahedrite(microprobe analysis indicate 33 and 44 wt% Ag) occurs as inclusions in galena or along the contact of galena with magnetite, pyrrhotite or silicates(see slide 6 and 7).
Tetrahedrite forms grains of 100 mu down to only a few mu.
Pyrargyrite occurs intergrown with tetrahedrite or as exsolutions in galena.
Acanthite, together with pyrargyrite, tetrahedrite and probably other Ag-Sb-sulphosalts, occurs as late secondary fracture fillings, often in pyrrhotite(slide 8). These fractures are only a few mu wide.

Microprobe analyses:

Tetrahedrite:
(the two grains in slide 6)

Ag	33.25 wt%	44.56 wt%
Cu	14.68	8.94
Fe	6.08	3.17
Zn	0.00	0.38
Sb	26.44	24.80
S	19.44	17.93
Tot	99.82	99.78

Dyscrasite:
(slide 5)

Ag	86.33
Sb	15.35
Tot	101.68

Composite dyscrasite-allargentum grain:

	dyscrasite	allargentum
Ag	84.77	94.80
Sb	15.39	4.24
Tot	100.28	99.32

Fracture filling in pyrrhotite, probably acanthite:
(slide 8)

Ag	83.14
S	14.98
Tot	98.12

Description of slides:

1. 8x. Galena(white); magnetite(grey); silicates(dark grey to black): green biotite and garnet(slightly higher reflection). Note the fracturing of biotite, with galena being introduced along fracture and cleavage planes, and the replacement of magnetite by galena.
2. 16x. Close-up of slide 1.
3. 8x. Gudmundite(cream white); galena(light grey); magnetite(dark grey); pyrrhotite(pink); biotite(black). Note the small dyscrasite grain at the lower right corner of the gudmundite(tarnished with a green color).
4. 8x. Magnetite(dark grey); galena(white); pyrrhotite(pink); allargentum-dyscrasite(tarnished with a red color). One large allargentum grain in the lower left quadrant of the picture, several small allargentum grains just left of the pyrrhotite grain.
5. 8x. Tarnished dyscrasite grain(red) in galena. Microprobe analysis.
6. 8x. Two Ag-rich tetrahedrite grains(medium grey), intergrown with pyrrhotite(pink), galena(white) and magnetite(dark grey).
7. 16x. Close-up of slide 6. Note the pyrargyrite(bluish grey) occurring along fractures in tetrahedrite and pyrrhotite.
8. 16x. Pyrrhotite(pink) with Ag-rich phases along fractures: tetrahedrite(grey, slightly greenish), pyrargyrite(bluish grey) and acanthite(greenish grey). Microprobe analysis confirmed the presence of acanthite.

Wouter Bleeker, 30th of june 1984.

(Colour prints of the slides noted above are presented in Bleeker 1984)

DRILLHOLE PARAMETERS - LOVISA 198586 Drilling programme

Hole Number	Local grid co-ordinates north		west	Azimuth (Degrees)	Local grid(9)	Inclination (degrees)	Length (metres)	Height (ASL) (m)
	(to the nearest metre)							
Jönshyt-tan No 8	4211	-	556	306	307.2	58.3	354.07	135.6
001/82	5430	-	408	296	295.4	45.0	61.65	163.3
002/84	5353	-	429	298	298.0	43.7	139.80	160.2
003/85	5107	-	582	335	338.6	45.0	240.00	148.4
004/ "	4881	-	651	297	296.4	45.0	227.20	141.2
005/ "	4961	-	636	299	298.6	45.0	108.90	141.5
006/ "	4800	-	644	308	308.4	52.6	254.75	141.6
007/ "	4722	-	596	304	304.5	60.0	167.30	141.0
008/ "	5441	-	501	302	302.1	45.0	81.55	159.1
009/ "	5284	-	504	300	300.0	45.0	71.50	149.8
010 "	4840	-	665	300	300.9	45.0	116.80	141.1
011/ "	5001	-	666	300	299.6	45.0	61.40	140.9
012/ "	4943	-	752	294	292.7	45.0	99.45	140.7
013/ "	4800	-	535	300	300.0	60.0	109.40	ca 142.50
014/ "	5058	-	853	301	301.4	37.2	224.15	139.1
015/ "	4808	-	560	307	308.0	60.0	205.00	142.60
016/ "	4600	-	599	301	300.6	65.0	224.40	140.2
017/ "	5082	-	630	304	304.5	45.0	113.20	145.0
018/ "	4440	-	601	264	260.0	65.0	236.35	138.7
019/ "	4598	-	484	302	302.0	70.0	72.10	141.1
020/ "	4595	-	530	299	298.8	75.0	299.60	140.7
021/ "	4318	-	563	273	270.0	65.0	235.35	136.7
022/86	4719	-	710	102	80.0	88.0	115.30	139.6
023/ "	4808	-	718	296	294.8	79.9	85.85	140.9
024/ "	4086	-	563	304	304.1	65.0	255.10	134.8
025/ "	4720	-	710	294	293.2	70.0	69.50	139.4
026/ "	4394	-	521	309	310.3	75.0	282.00	138.6
027/ "	4961	-	561	296	295.3	80.0	213.20	145.4
028/ "	4499	-	600	294	293.0	70.0	201.90	139.0
029/ "	4800	-	821	118	98.1	43.4	148.40	141.9
030/ "	3920	-	560	300	300.0	65.0	122.70	ca 130.50
031/ "	4798	-	444	299	298.7	77.2	350.00	147.1
032/ "	5162	-	522	334	337.5	43.5	117.30	148.8
033/ "	5230	-	457	327	330.5	43.0	126.15	150.9
034/ "	3920	-	601	291	289.6	81.2	232.40	127.2
035/ "	4400	-	401	300	299.5	75.9	402.00	139.2
036/ "	4799	-	851	119	98.5	77.7	181.60	142.9
037/ "	4398	-	700	298	297.5	79.7	193.40	138.59
038/ "	4599	-	701	321	323.0	81.2	174.70	140.26
039/ "	ca 4800	-	950	ca 300	300	ca 45.0	154.10	ca 140.50
040/ "	4319	-	942	296	295.1	44.6	334.80	134.71
041/ "	4959	-	941	298	297.5	45.5	152.60	139.80
042/ "	5199	-	927	298	297.3	37.3	140.10	137.08
043/ "	4600	-	780	ca 120	100.0	85.0	145.60	141.16
044/ "	4340	-	600	302	302.6	63.8	202.80	137.72
045/ "	4953	-	396	299	298.5	79.0	425.40	151.89
046/ "	4560	-	280	293	291.8	81.5	519.30	148.30

OVERBURDEN THICKNESS AND DEPTH TO BEDROCK-LOVISA

Hole No	Downhole depth (metres)	Hole inclination (degrees)	True thickness of overburden (metres)	Weathered sub-crop
01	6.00	45	4.24	
02	7.30	43.7	5.04	
03	10.00	45	7.07	
04	10.35	45	7.32	
05	6.75	45	4.78	
06	14.80	52.6	11.75	
07	19.10	60	16.54	x
08	2.10	45	1.48	
09	12.00	45	8.48	x
10	14.80	45	10.46	
11	4.40	45	3.11	
12	14.55	45	10.29	
13	16.00	60	13.86	x
14	10.25	37.2	6.20	
15	16.00	60	13.86	x
16	22.50	65	20.38	
17	9.50	45	6.72	
18	13.30	65	12.05	
19	41.50	70	39.01	
20	34.60	75	33.42	x
21	12.60	65	11.42	x
22	14.60	88	14.58	
23	16.00	88	15.98	
24	26.15	65	23.69	
25	14.65	70	13.77	
26	20.50	75	19.80	
27	5.50	80	5.42	x
28	14.60	70	13.72	x
29	25.80	43.4	17.72	x
30	34.00	65	30.80	x
31	47.90	72.2	45.60	x
32	21.70	43.5	14.93	x
33	14.15	43	9.65	x
34	52.00	81.2	51.38	x
35	47.00	75.9	45.49	x
36	13.10	77.7	12.80	
37	14.20	79.7	13.97	
38	14.60	81.2	14.42	x
39	3.00	45.0	2.12	
40	25.50	44.6	17.90	
41	6.00	45.5	4.28	
42	8.40	37.3	5.09	
43	12.60	85.0	12.55	
44	17.00	63.8	15.25	
45	7.20	79.0	7.07	x
46	11.70	81.5	11.57	
Jönshyttan No 8	17.80	59.00	15.30	

MAIN DRILLED INTERSECTIONS, TARGET SULPHIDE ZONE LOVISA

Hole Number		Downhole interval (metres)	Downhole width (metres)	True width (metres)	% Zn	% Pb	g/t Ag
001/82	No intersection in the sulphide zone						
002/84	-"-		-"-				
003/85		57.80- 59.00	1.20		4.83	1.20	12
	inc:	57.80- 58.00	0.20		26.90	5.60	37
004/85		50.50- 52.70	2.20		5.69	5.42	18
	inc:	50.50- 51.15	0.65		18.20	18.00	56
		63.70- 66.90	3.20		9.16	4.71	11
	inc:	64.25- 65.50	1.25		21.00	9.80	20
005/85		57.03- 58.60	1.57		6.18	4.06	20
	inc:	57.03- 57.55	0.52		17.98	11.93	55
006/85		51.63- 52.35	0.70		1.00	0.75	6
		64.20- 66.22	2.02		7.58	2.50	12
	inc:	64.20- 64.65	0.45		25.60	9.70	32
	and:	66.00- 66.22	0.22		15.00	0.88	9
007/85		114.62-115.12	0.50		3.20	0.28	6
		117.85-121.00	3.15		8.30	1.92	13.5
	inc:	117.85-118.35	0.50		22.64	9.78	40
	and:	117.85-118.15	0.30		29.60	15.30	57
		119.65-121.00	1.35		10.10	0.59	15
008/85	No intersection. Hole drilled in stratigraphic footwall						
009/85	-"-		-"-				
010/85		35.50- 40.87	5.37		4.47	1.81	6
	inc:	38.40- 40.87	2.47		9.24	2.32	12
	and:	38.40- 39.10	0.70		25.60	7.10	34
		55.60- 58.30	2.70		7.62	1.11	8
011/85		20.60- 22.20	1.60		9.71	3.35	20
	inc:	21.55- 22.20	0.65		22.00	6.20	46
		21.55- 24.20	2.65		6.92	1.66	13
012/85	No intersection. Hole drilled in stratigraphic footwall						
013/85	No intersection. Hole stopped in the hangingwall in a fault zone						
014/85		165.55-167.05	1.50		5.53	0.05	<1
	inc:	165.55-166.25	0.70		10.60	<0.01	<1
015/85		149.30-153.40	4.10		4.62	4.13	11
	inc:	151.40-153.40	2.00		8.88	8.32	22
	inc:	151.40-152.05	0.65		25.00	20.00	58
		153.20-153.40	0.20		0.30	19.00	6
016/85		133.80-139.40	5.60		7.95	1.18	15
	inc:	133.80-136.00	2.20		11.44	2.45	30
	inc:	135.00-136.00	1.00		23.60	4.60	60
	and:	137.90-138.40	0.50		25.00	0.56	11

Appendix 4 contd.:

Hole Number	Downhole interval (metres)	Downhole width (metres)	True width (metres)	% Zn	% Pb	g/t Ag
016/85	158.65-160.90	2.25		10.25	1.88	13
(contd.)	inc: 158.65-159.45	0.80		19.20	4.70	23
	and: 160.65-160.90	0.25		25.10	0.36	22
017/85	41.60- 43.60	2.00		7.70	3.20	21
	inc: 42.60- 43.60	1.00		15.50	6.20	32
018/85	156.18-156.80	0.42		1.60	0.70	4
	159.10-159.33	0.23		1.80	0.50	3
	162.13-170.95	8.82		4.97	0.31	11
	inc: 162.13-164.17	2.04		9.30	0.39	20
	inc: 163.10-164.17	1.07		14.70	0.55	34
	168.83-170.95	2.12		10.33	0.38	12
019/85	No intersection. Hole stopped in a fault in the hangingwall.					
020/85	209.10-209.40	0.30		5.80	6.20	29
	217.55-219.80	2.25		8.85	1.95	19
	inc: 217.55-218.45	0.90		20.20	4.50	41
021/85	164.60-169.55	4.95		1.26	0.60	13
	inc: 164.60-165.65	1.05		1.80	0.56	15
	and: 166.65-169.55	2.90		1.28	0.58	16
022/86	55.00-58.50	3.50		7.53	0.64	8
	inc: 56.30-58.50	2.20		9.62	0.57	7
	inc: 57.30-58.50	1.20		17.00	0.78	9
023/86	25.95-27.40	1.45		4.80	2.80	65
	31.85-36.65	4.80		5.42	4.55	7
	inc: 31.85-35.25	3.40		6.80	6.25	9
	inc: 31.85-33.40	1.55		7.80	5.06	7
	34.60-36.65	2.05		6.40	6.60	11
	inc: 34.60-35.25	0.65		15.70	19.90	32
024/86	185.10-186.25	1.15		2.10	1.20	31
	196.70-205.10	8.40		3.23	0.65	12
	inc: 196.70-200.20	3.50		3.86	0.90	19
	inc: 197.50-198.90	1.40		8.00	1.40	41
	and: 202.95-205.10	2.15		5.33	0.87	10
025/86	40.80- 43.70	2.90		3.25	0.69	8
	inc: 42.45- 43.70	1.25		7.40	1.40	18
026/86	229.95-235.60	5.65		5.31	0.75	11
	inc: 229.95-231.10	1.15		9.50	3.10	31
	and: 234.00-235.60	1.60		10.80	0.15	8
027/86	163.30-167.60	4.30		1.09	0.44	1
	174.30-177.20	2.90		9.30	7.53	8
	inc: 174.30-175.40	1.10		22.40	19.40	21
028/86	158.85-161.20	2.35		8.56	2.20	25
	inc: 159.40-161.20	1.80		10.05	2.38	21

Appendix 4 contd.:

Hole Number	Downhole interval (metres)	Downhole width (metres)	True width (metres)	% Zn	% Pb	g/t Ag
029/86	70.60- 80.25	9.65		5.12	0.70	17
	inc: 70.60- 74.00	3.40		7.68	0.76	12
	inc: 70.60- 72.40	1.80		14.10	1.10	12
	and: 76.70- 80.25	3.55		5.98	1.05	17
	inc: 78.20- 80.25	2.05		10.00	1.20	14
030/86	No intersection. Hole stopped in the hangingwall.					
031/86	292.85-305.00	12.15		4.13	2.41	13
	inc: 300.50-305.00	4.50		9.24	5.67	35
	inc: 300.50-301.75	1.25		29.10	18.60	27
	304.00-305.00	1.00		3.40	1.90	120
032/86	53.00- 56.20	3.20		6.93	1.02	13
	inc: 53.20- 55.10	1.90		11.19	1.55	19
033/86	No intersection. Cut out by faulting?					
034/86	Hole stops above the target in the hangingwall.					
035/86	328.00-341.31	13.31		4.78	0.60	8
	inc: 328.00-329.00	1.00		13.30	2.70	35
	and: 335.83-341.31	5.48		8.60	0.72	10
	inc: 335.83-339.38	3.55		11.19	0.86	10.5
	inc: 335.83-337.55	1.72		22.40	1.70	20
036/86	No intersection. Hole intersects a faulted sequence in the footwall.					
037/86	106.00-110.12	4.12		8.13	0.70	10
	inc: 106.00-106.91	0.91		20.90	1.80	14
	and: 109.19-110.12	0.93		11.80	0.43	14
038/86	106.70-112.55	5.85		12.51	1.14	17
	inc: 109.55-112.55	3.00		14.35	1.12	19
039/86	No intersection					
040/86	-"-					
041/86	-"-					
042/86	-"-					
043/86	84.20- 87.70	3.50		2.58	1.05	8.5
	inc: 84.20- 85.80	1.60		4.99	2.13	16
	inc: 84.20- 84.81	0.61		10.00	0.74	10
044/86	144.75-149.90	5.15		5.24	1.12	18
	inc: 145.36-147.37	2.01		7.55	2.18	27
	and: 148.86-149.90	1.04		9.10	0.69	25
045/86	245.45-246.54	1.09		0.73	0.55	12
	inc: 246.45-246.54	0.09		8.20	4.40	54
046/86	429.50-430.66	1.16		8.59	4.86	15.5
	435.81-437.54	1.73		2.26	0.10	2
Jönshyt-	166.55-168.90	2.35		4.78	0.81	12
tan No 8	inc: 166.55-168.10	1.55		6.75	1.12	14.5

Appendix 5

LOWER MAGNETITE MARKER-SULPHIDE INTERSECTIONS - LOVISA

Hole Number	Downhole interval (metres)	Downhole width (metres)	True width (metres)	% Zn	% Pb	g/t Ag
001/82	No intersection					
002/84	-"-					
003/85	94.70- 98.50	3.80		0.36	4.48	86
	inc: 94.70- 96.30	1.60		0.07	8.80	140
	and: 96.95- 98.50	1.55		0.78	1.80	62
004/85	94.00- 94.95	0.95		0.14	0.72	17
005/85	81.55- 81.90	0.35		0.06	1.90	41
006/85	Negligible sulphide					
007/85	-"-					
008/85	-"-					
009/85	53.05- 54.10	1.05		0.12	1.10	26
010/85	Negligible sulphide					
011/85	47.35- 48.25	0.90		0.14	0.65	27
012/85	40.50- 42.15	1.65		0.32	0.22	14
013/85	No intersection					
014/85						
015/85	195.45-196.05	0.60		0.05	1.00	27
016/85	Negligible sulphide					
017/85	82.20- 83.40	1.20		1.40	6.60	92
018/85	No sulphide					
019/85	No intersection					
020/85	279.05-281.80	2.75		0.79	1.21	52
	inc: 280.60-281.80	1.70		1.70	2.10	96
021/85	Negligible sulphide					
022/86	-"-					
023/86	No intersection					
024/86	Negligible sulphide					
025/86	No intersection					
026/86	272.00-274.00	2.00		0.11	0.02	<1
027/86	No sulphide					
028/86	Negligible sulphide					
029/86	-"-					

Appendix 5 contd.

Hole Number	Downhole interval (metres)	Downhole width (metres)	True width (metres)	% Zn	% Pb	g/t Ag
030/86	No intersection					
031/86	339.50-340.70	1.20		0.04	0.04	2
	343.50-344.70	1.20		0.09	0.02	2
032/86	101.20-103.95	2.75		0.04	5.15	175
	inc: 102.50-103.95	1.45		0.04	9.30	320
033/86	112.90-114.10	1.20		0.04	2.20	38
034/86	No intersection					
035/86	392.10-396.90	4.80		0.55	6.31	78
	inc: 392.10-394.05	1.95		0.13	13.50	147
	inc: 392.10-392.94	0.84		0.10	24.00	237
	and: 394.98-396.90	1.92		1.18	1.92	42
	inc: 394.98-395.74	0.76		1.10	2.90	50
036/86	No intersection					
037/86	Negligible sulphide					
038/86	-"-					
039/86	Same horizon?					
	123.90-125.32	1.42		0.02	0.17	4
040/86	No intersection					
041/86	-"-					
042/86	-"-					
043/86	Negligible sulphide					
044/86	-"-					
045/86	Weak PbS	(not analysed)				
	(366.30-366.80)	(0.50)				
046/86	Weak PbS	(not analysed)				
	(504.00-504.20)	(0.20)				

Svenska BP Mineral AB -
LKAB Prospektering

To : L-G Ohlsson, M. Harris
From : C.J. Carlon, S. Bjurstedt
Subject: THE LOVISA PROJECT - SUMMARY EXPLORATION FEATURES AND WORK PROPOSAL 1987
Date : 27th October 1986

Summary

During September-October 1986 work has been progressing on the Lovisa Project from several different angles, by both BPMIL and LKAB. The drillcore has been, and is in the process of being, relogged and the geology, structure and mineralisation more fully investigated. At the same time initial feasibility studies have been made, and further budgetary estimations and considerations are under review.

In addition remaining 1986 exploration funds are being directed to the drilling of two deep boreholes, and initial discussions are taking place with possible third parties for their involvement in the project.

Data is here presented to review the latest observations with regard to the Lovisa discovery, and a work proposal is set out to assist budgetary discussions for the continuation of the exploration, and to define the aims of the proposed 1987 programme. A full geological report on the Lovisa exploration is in preparation, a summary is here presented as the basis of the 1987 (revised) work proposal.

Location

The Lovisa zinc-lead-silver discovery lies 170 kms WNW of Stockholm, 45 kms S. of Ludvika, in the Stråssa area of the LKAB-BPMIL Bergslagen Joint Venture Project. The site lies in forested ground on the eastern side of the Storå valley, 2 kms east of Storå village and close to the main road (RV 60) and rail (Örebro-Gävle) links.

Background

Exploration in the Storå-Stråssa area during 1984-85 led to the discovery of zinc-lead-silver mineralisation in May 1985, immediately south-west of the old abandoned Lovisa magnetite mine-trial. Subsequent ground geophysics and drilling has defined a stratiform-stratabound sheet of sulphide over a strike length of 1.1 kms, and to a maximum vertical depth of 330 m. It is currently open in all directions.

During 1985 19 diamond drillholes totalling 3148.40 m were completed, 13 of these holes intersected massive sulphide.

In 1986 an additional 23 diamond drillholes have been completed, and 2 holes are currently being drilled. 15 of these holes intersected the target sulphide.

Ground geophysics has guided the drilling programme during 1985-86 using a variety of geophysical techniques, chiefly magnetics.

Bedrock geology and structure

The discovery mineralisation lies within a sequence of felsic metavolcanics and associated epiclastic siliceous detritus, carbonate metasediments and siliceous-carbonate and ferruginous chemical sediments of lower Proterozoic age. The sequence can be divided into 12 characteristic lithostratigraphic divisions, the mineralisation occurring within a clearly defined stratigraphic interval. The sequence is metamorphosed to amphibolite facies, has been subject to at least two episodes of compressional stress and exhibits variable strain.

A dominant NNE-SSW fold orientation is recognised with 60 -70^{o} axial planar dips and overfolding to the east. Structures are isoclinal with constant easterly dips, and variable SW and NE axial plunges. Brittle fracturing follows two dominant lines: NNE-SSW and NW-SE.

The supracrustal sequence is intruded by basic (mafic) and granitic infracrustal bodies, most significant of which is a steeply inclined diabase dyke, which cuts the deposit and is apparently controlled by preexisting NNE-SSW and NW-SE fractures.

Mineralisation

The Lovisa discovery is a stratiform-stratabound sheet of zinc rich massive, laminated and disseminated sulphide. It is contained within a characteristic lithostratigraphic interval of fine grained grey-black and red-brown siliceous 'cherts' and thin diopside-biotite-chlorite-sericite-'chert'-epidote "skarns" with porphyroblastic garnets. Minor and trace fluorite and tourmaline also occur.

The main sulphide mineralisation occurs within its host stratigraphic interval with characteristic and well defined upper and lower contacts, giving a zone up to 10 metres thick in current drilled intersections, with massive, laminated and disseminated sulphide. Two or three massive and laminated ZnS rich, subordinate PbS layers, up to 1.50 m thick, are separated by barren intervals or sections containing thin sulphide laminae or disseminated grains and patches. Mineralisation occurs in both chert and skarn bands within the target host rock.

Deformation of the zone has resulted in brittle fracturing of the cherts and plastic deformation of the sulphide producing, in most drilled intersections, a massive sulphide, ZnS rich or ZnS-PbS lithoclastic "ball-ore" layer or layers. Veinlet PbS and porphyroblastic FeS_2 accompanies the ZnS.

Initial mineralogical studies indicate that the mineralogy is dominantly sphalerite of a low iron content (pale brown-beige), with subordinate galena and pyrite, minor chalcopyrite, arsenopyrite, sphene and rutile and trace pyrrhotite, chalcocite, pyragyrite, freibergite, native silver, dyscrasite, molybdenite and cobaltite. Quartz and feldspar, with minor graphite (up to 3%) form the main non-metallic components of the massive sulphide mineralisation.

Metal grades are variable but high. Zn content is normally in the range 4-26.8%, Pb 0.5-18%, Ag very variable between 2-50 g/t.

In two holes (004/85 and 016/85) a faulted repetition of the sulphide is intersected, while in some holes portions of the sulphide zone are faulted out.

A well defined magnetite-diopside-garnet-silica horizon, forming a stratigraphic and geophysical marker, occurs some 40-50 metres below the sulphide target. This "lower magnetite marker" always contains pyrite, and often contains appreciable argentferous galena or mixed Pb and Ag sulphides. Grades up to 10% Pb and 320 g/t Ag have been assayed from drilled intersections of this zone. It is very comparable in lithology and mineralogy to the sulphide occurrences of Nya Backadal, 400-600 m east of Lovisa, in a parallel stratigrphic zone.

Exploration Features

1. There are no bedrock exposures in the Lovisa area. Sandy and clayey overburden of glacial origin completely mask the deposit and its host bedrock. Overburden thickness is variable between 1.50-31.0 metres.

2. In the northern part of the discovery area the mineralisation subcrops below glacial overburden (north of 4600N), but southwards, due to folding, the deposit is blind below overlying unmineralised metavolcanics.

3. The character of the mineralisation and its enclosing bedrock remains constant from hole 032/86 (5162N) to 024/86 (4086N), a strike length of 1076 metres.

4. Three sections of the deposit can be defined:-

N. of 5200N:	Holes 1, 2, 8, 9 and 33.	(N. Section)
Between 4300N-5200N:	Most of the drillholes	(Central Section)
S. of 4300N:	Holes Jönshyttan 8, 24, 30, 34.	(S. Section)

5. In the central section massive sulphide mineralisation has been intersected from hole 032/86 south to 044/86, and indicates that the target is a sheet, probably folded and faulted, which dips eastwards at between 55-75^{o} towards a synformal axis lying in the area between 100-400W. Most of the drilling has been concentrated in this zone. Westwards the sheet rises over a faulted antiform and stops abruptly around 800-850W against a major NNE-SSW fault zone. Its extension westwards is still unknown.

6. In the northern section, massive sulphide of the target zone is absent, hole 033/86 intersecting a fault zone at the position of the target. All the holes north of this (001, 002, 008, 009) are drilled in rocks apparently in the footwall of the target sulphide.

7. In the southern section, the geology and mineralisation continues to hole 024/86, with the same form and geology. Holes 30 and 34/86 are drilled in the hangingwall of the target sulphide, and 034/86 appears to have stopped some 20-40 m short of the sulphide zone.

8. To the east, the Nya Backadal Pb-Ag zone, could be the continuation of the Lovisa "Lower Magnetite Marker". The Lovisa sulphide zone should then lie to the west of the Nya Backadal zone if a synformal structure is present.

9. A series of NW-SE fractures appear to intersect the mineralised zone, with persistent right lateral movement (or persistent southerly downthrow). The intersection in hole 032/86 may then shift eastwards to the north and remain untested, and the intersection in hole 024/86 shifts westwards to the south and remains untested.

10. To the west, holes drilled in the Björkhags and Haglunds zones have failed to intersect sulphide and need re-appraisal.

11. There is some indication that the massive sulphide layers increase in thickness downdip to the east, and to the southeast.

12. There is no evidence that the sulphide sheet passes over the central antiformal axis and due to overfolding forms a second parallel-subparallel sheet deeper and to the west of the target zone. A monoclinal structure is inferred from the drilling.

13. Deepest intersection to date is at 330 m (vertical) in hole 035/86.

14. Dips are consistent in the deeper holes and there is no evidence of proximaty to a fold hinge (reduction in dip). This is likely to occur very close to the hinge and be abrupt rather than progressive due to tight isoclinal axial zones.

15. Most holes have been drilled to investigate the deposit at shallow depth, a substantial part of the depth continuation remains untested. The few holes that penetrate below 300 m gave good intersections eg. 031/86 3.65 m of 11.54% Zn, 6.47% Pb, 9 g/t Ag.

16. The mineralisation of the target zone is currently open to the north, south and in-depth to the east. Its possible extension in the Nya Backadal area is untested, and its western continuation requires investigation as the stratigraphic sequence appears to be slightly different than the Lovisa zone.

Proposed work programme

1. Remaining 1986

i Completion of deep holes 045 and 046/86.

ii Completion of the core-logging and re-logging including an examination of the Nya Backadal zone.

iii Production of drill profiles and a geological map for Lovisa.

iv Additional geochemical analysis of material in the mineralised zone previously not analysed. (Core sections between the massive sulphide layers where fine grained and disseminated mineralisation occurs).

v Compilation of a comprehensive 1985-86 Lovisa Project report, complete with drilldata, sections and a full appraisal of the geological, geophysical and geochemical data. This has already commenced.

2. Work programme 1987

This can be summarized as follows:-

1. Additional extension and infill diamond drilling

2. Continuation of core logging - re-logging of Lovisa, Backadal, and older Jönshyttan core.

3. Further ground geophysical measurements and more detailed interpretive studies.

4. Additional bench-test beneficiation and metallurgical testing.

5. Land and legal including application for a mining licence.

With regard to timing, it is likely that most of the geophysical ground surveys will take place during the first 6-8 months, with concurrent interpretation.
The application for mining licences to cover the area will take place early in 1987.
Core-logging, with sampling and data analyses will be continued throughout the year with the additional and extension drilling programme, which is likely to be complete by mid-year. It is desirable that any further bench-test studies take place when additional intersections have been drilled to provide more and wider spaced sample points.

Additional drilling is proposed for the following reasons:-

1. To test the depth and strike extensions of the currently defined mineralised zone.

2. To give a sufficient sample density (intersections) for an ore-calculation within acceptable limits.

3. To obtain more detailed information on the geology, structure and mineralisation of the target zone and of the hangingwall and foot-wall geotechnical features for mine planning, depth of bedrock weathering, principal fault directions and throws.

4. To understand the variability in grade and width of the target zone for more-planning on vein or full-scale mining methods.

The drilling programme could take place as follows:-

<u>Stage 1:</u> Northern Extension. January

As noted above, all holes north of 033/86 appear to have been drilled in the footwall of the deposit. Right lateral movement may have moved the target eastwards in the Lovisa mine area.
Two holes should be sited at:- 5350N-300W
5500N-300W - mag feature.
and drilled at 55° to N300 to test this hypothesis.
Hole length ca 150 m each. Total 300 m.

<u>Stage 2:</u> Southern Extension. February-March-April

The southern extension needs testing in two ways, and can be undertaken following geophysical ground surveys in January.

1. The up-dip and down-dip extensions and variability

2. The strike extension south of 4000N.

This should be tested by:-

Tighten up on geophysics

1. Going back down 034/86 and drilling through the target zone (estimate 50-100 m extension).

2. If successful, holes at/or around 3800N-700W
and 3600N-600W
each ca 200 m long drilled to N300

3. If successful, 3 holes to test up-dip and down-dip extensions at:- 3900N-700W, 50 to N300 to 150m
4100N-700W, as above
3700N-600W, as above

Actual depths and positions depend on data obtained as programme progresses.

Stages 1 and 2 would aim by April to have proved up a possible strike length from 3600N to around 5600N (2 kms) with some depth extension.

<u>Stage 3:</u> Down-dip extensions. April-July (use of 1 drill-rig from January)

Following results from holes 045/86 and 046/86 further holes should be placed to infill the eastern depth extensions in the central zone to ca. 300 m, sites at 4900N-450W - needed in view of 045?
4700N-450W
could be considered.

Additional holes could be placed to test depth extensions in the northern and southern zones.

Stage 3 could continue with two drillholes set out to test the location of the Lovisa target in the area west of the Nya Backadal zone and its extension north of 5200N and south of 4600N. Many remaining meterage could be directed to infilling based on the above programme results, or to aid target defination in the western area following assessment of data W. of 900W.

Total drilling ca 3,000 metres. of 900W. A further estimated 1,800m of drilling will be required if extensions are proved and grid drilling is requested (0.8 MSEK).

In all cases where appropriate the Pb-Ag potential of the parallel-subparallel "lower magnetite marker" will be assessed and ore-reserves calculated.

Concurrent with the drilling programme work will be directed towards drilling control, core logging, sampling, result compilation, reporting and presentation of data.

Geochemical analysis will be directed towards testing the following:-

1. Full assay of all mineralised intervals.

2. Selective down core sampling to define, if present, any litho-geochemical halo effects whith could be used as an exploration tool for definition of target horizon proximal to drilled sections, or for recognition of the target interval in visually unmineralised core.

Geophysical surveys will involve laboratory measurement of core samples (density, conductivity, resistivity), field ground surveys with magnetics, VLF and possibly MAX-MIN EM to define structure. Additional downhole mise-ã-la-masse and resistivity surveys should be undertaken.

Downhole magnetic measurements will proceed in conjunction with bore-hole vertical and horizontal deviation (hole survey) measurements.

In addition all holes will be located accurately in the local grid, and their hole collars levelled in.

Additional costs will be incurred in the preparation of data for submission to the Mines Inspector for application for a mining licence, the application for State grant funding and negotiations with land owners with regard to environmental effects and compensation.

Consideration and funding should also be given, and time allocated, for compilation of data on the possible strike extensions of the target beyond the immediate Lovisa area in the Nora-Stråssa area, particularly the Mangruvan and Gränshyttan area, with additional geological, geochemical and geophysical follow-up. A budget of 0.54 MSEK has been estimated for this work.

It is planned to be in a position of data compilation and assessment during October-November 1987, with any outstanding targets then being tested to year end.

The goals are progressively:-

1. Extend the strike to the north
2. Extend the strike to the south
3. Obtained data on down-dip extension
4. Locate continuation in the Nya Backadal area
5 Locate extensions in the western area including the SW area (Jönshyttan)
6. Compile data for mine planning, feasibility and commercial studies
7. Tie-up all the ground and obtain a mining licence

In this way by end 1987 the project can proceed to mine feasibility and planning.

Proposed Revised Budget

	SEK	£
Manpower inc. administration and support	1.32 M	120,000
Geochemistry, Mineralogy, Metallurgy	0.5 M	45,000
Land-legal	0.11 M	10,000
Drilling (3,000 m)	1.32 M	120,000
Geophysics	0.35 M	32,000
Total	3.60 MSEK	£327,000
-40% grant (?)	1.44	130,000
	2.16	196,000
50%? BP, 50% LKAB	1.08 MSEK	£98,000

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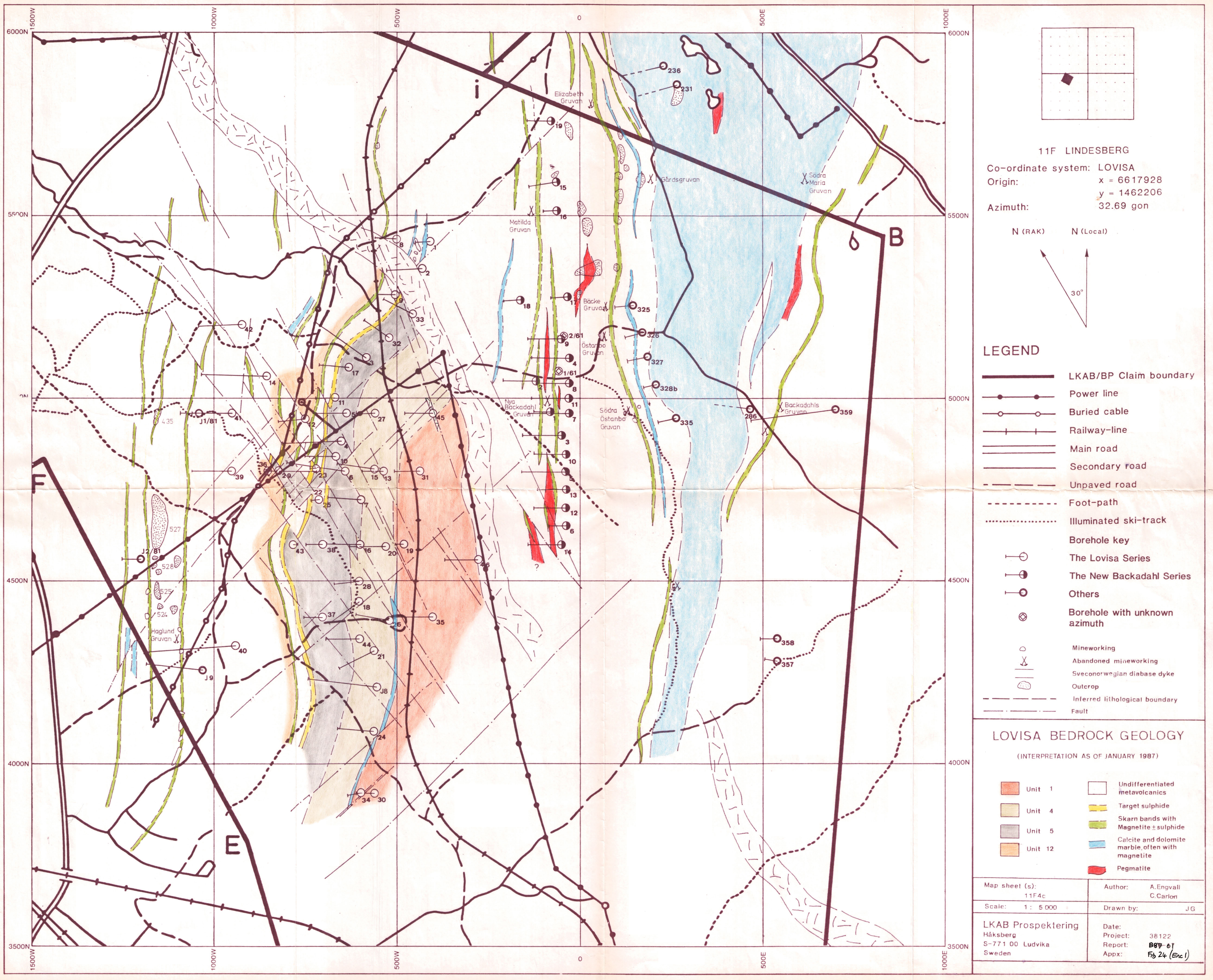

11F LINDESBERG
Co-ordinate system: LOVISA
Origin: x = 6617928
y = 1462206
Azimuth: 32.69 gon
N (RAK)
N (Local)
30°
LEGEND
LKAB/BP Claim boundary
Power line
Buried cable
Railway-line
Main road
Secondary road
Unpaved road
Foot-path
Illuminated ski-track
Borehole key
The Lovisa Series
The New Backadahl Series
Others
Borehole with unknown azimuth
Mineworking
Abandoned mineworking
Sveconorwegian diabase dyke
Outcrop
Inferred lithological boundary
Fault
LOVISA BEDROCK GEOLOGY
(INTERPRETATION AS OF JANUARY 1987)
Unit 1
Unit 4
Unit 5
Unit 12
Undifferentiated metavolcanics
Target sulphide
Skarn bands with Magnetite ± sulphide
Calcite and dolomite marble, often with magnetite
Pegmatite
Map sheet (s): 11F4c
Scale: 1 : 5 000
Author: A.Engvall C.Carlon
Drawn by: JG
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Report: B87-01
Appx: Fig 24 (Enc 1)
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6000N
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