Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
2414				

Kommer fra ..arkiv	Ekstern rapport nr	Oversendt fra	Fortrolig pga	Fortrolig fra dato:
Grong Gruber AS		Norsulfid AS		

Tittel

Mining of narrow orebodies at Grong Gruber

Forfatter	Dato	År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
Song Xiaotian	Feb	1989	Grong Gruber AS

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Røyrvik	Nord-Trøndelag		19241	Grong

Fagområde	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt)
Gruveteknisk		Jomafeltet Jomaforekomsten

Råstoffgruppe	Råstofftype
Malm/metall	Cu, Zn, S, Ag

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Kopi av en rapport med 12 vedleggmed flere kopier av ymse fagrapporter.

Hensikten med rapporten var å se på lønnsome alternativer i planleggeing av drift på smale malmer, studere gruvemetoder på slike malmer og å gjennomføre numerisk analyse av gruveprofilene for å øke gehalten fra de dreven områdene.

Det konkluderes med at 15 % av de totale malmreservene er knyttet til smale og små malmkropper. For flate malmer med mektigehet 2,5 meter benyttes R & P, mens sublevel stoping benyttes for malmer med bratt fall. Store variasjoner i gehalt gjør at det anbefales bruk av profilanalyser for å vurdere å utvelge områder som vil være ulønnsomme.

GRONG GRUBER A/S

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$                                                $
$                                                $
$    Mining of narrow orebodies at Grong Gruber  $
$                                                $
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
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By

Song Xiaotian

February 1990

Contents

According to agreement that this study is connected with Mine Planning of
narrow orebody at Grong Gruber, the main themes of the work were
-to seek profitable Alternative for mining of narrow and small orebodies.
-to study mining method adapted to conditions of narrow orebodies.
-to conduct numerical analysis of profile to improve ore grade mined.
A problem related to ore production was also discussed.

1. Ore reserves of narrow orebodies

The ore reserves of narrow or flat lying orebodies have been estimated by Tauno Manunen(An evaluation of the operation and development program, 1988).According to this report,the ore reserves and included reserves of narrow orebodies are as follows:

Area	Ore reserves of Cu.E.>2.11%(t)			Total reserves(t)	
	Total	Ore reserves of narrow orebodies	%	Total	Ore reserves of narrow orebodies
Y	294573	126808	30	638000	660000
B1	187872			1055000	
B2	780897	213217	50	2305000	1100000
X	1751520	107153	20	10668000	440000
Total	3014862	447178	100	14667000	2200000
%	100	15		100	15

It is noticed that the ore reserves of narrow and small orebodies are about 15% of total ore reserves of Cu.E.>2.11% and divided by area B2-50%,Y-30% and X-20%.With taking into account 15% proportion it has been estimated ore reserves of narrow orebodies for different areas.
This results:
Y-660000 t,B2-1100000 t,X-440000 t,Total-2200000 t.

2.Mining of narrow orebodies

2.1.Mining Alternatives

Mining of narrow orebodies were studied for area of Blocks 27,26 and 25 in every profile.Three Alternatives have been considered in this study. The first one is R&P with stoping size 5*6 m^2 and nonselective mining (Alt.1),the second is the same method with selective mining(Alt.1') and the third is R&P with stoping size 2.5*3 and nonselective mining(Alt.2). Rock dilution has been calculated by comparising thickness of orebody and stoping size in every profile(App.1,2,3.).The results of this calcu- lation are presented in tables 1,2,3.The dilution is closely connected with thickness of orebody and stoping size(see fig.1).

The results of analysis for B2 area Blocks 27,26,25 are summarised in 4,5,6,7,8 ,9Tables 4-!9 show that R&P with selective mining(Alt.1') is much better than with nonselective mining(Alt.1),rock dilution is decreased from 33% to 9%.For Alt.1' the main problem is the efficency of selectivity i.e. how much waste can be separately mined out during selective mining. The actual results of mining may be something between Alt.1 and 1' and real dilution level seems to be 9-33%.It is also noticed that by changing existing mining method with stoping size 5 m(Alt.1 or 1') to a method with stoping size 2.5 m(Alt.2),where rock dilution will be reduced from 9-33% to 5% and mining cost for Alt.2 will be 25% higher than Alt.1,the increment in profit is considerable.

Assuming 10% annual ore production from narrow orebodies,the annual increment in profit of Alt.2 is 0.95 MNOK/y,compared with Alt.1'.Calculation also shows that application of mining with stoping size 2.5 m for Blocks 27,26,25 gives total net present value(NPV) 4.19 MNOK during the rest of mine's lifetime. Taking into account the total area of narrow and small orebodies the economic result would be increased.

Fig.

Block: 27

Table 1

Alt. 1(5*6 m^2)

Profile	Ore in situ			Waste	Ore mined			Dilution
	t	Cu	Zn,%	t	t	Cu	Zn,%	%
B2 26	29488	2.11	.93	13018	42506	1.46	.65	31
27	61291	1.59	1.23	26943	88234	1.10	.85	31
28	21808	2.53	1.78	20458	42266	1.31	.92	48
29	29041	3.72	1.22	23568	52609	2.05	.67	45
30	51446	1.99	1.48	26259	77705	1.32	.98	34
31	45649	1.94	2.34	32043	77692	1.14	1.37	41
32	33955	3.10	1.13	25110	59065	1.78	.65	43
33	30181	2.42	.29	24141	54322	1.34	.16	44
34	29246	2.39	.31	20415	49655	1.41	.18	41
Sum	332105	2.30	1.25	211955	544054	1.40	.76	39

Alt. 2 (2.5*3 m^2)

Profile	Ore in situ			Waste	Ore mined			Dilution
	t	Cu	Zn,%	t	t	Cu	Zn,%	%
B2 26				234	29722	2.09	.92	1
27				1951	63242	1.54	1.19	3
28				3707	25515	2.16	1.52	15
29				7670	36711	2.94	.97	21
30				1587	53033	1.93	1.44	3
31				3046	48695	1.82	2.19	6
32				4966	38921	2.70	.99	13
33				0	30181	2.42	.29	0
34				0	29246	2.39	.31	0
Sum	332105	2.30	1.25	23161	355266	2.14	1.17	7

Block: 26   Table 2

Alt. 1(5*6 m^2)

| Profile | Ore in situ | | | Waste | Ore mined | | | Dilution |
	t	Cu	Zn,%	t	t	Cu	Zn,%	%
B2 20	38616	2.65	.91	29736	68352	1.50	.51	44
21	46085	2.81	1.75	25821	71906	1.80	1.12	36
22	50453	2.12	1.94	19995	70448	1.52	1.39	28
23	71284	2.17	1.95	28381	99665	1.55	1.39	28
24	70728	2.23	1.14	15372	86100	1.83	.94	18
25	30372	3.93	1.27	9682	40054	2.98	.96	24
Sum	307538	2.51	1.53	128987	436525	1.76	1.08	30

Alt. 2 (2.5*3 m^2)

| Profile | Ore in situ | | | Waste | Ore mined | | | Dilution |
	t	Cu	Zn,%	t	t	Cu	Zn,%	%
B2 20				5925	44541	2.30	.79	13
21				3778	44863	2.60	1.62	8
22				3268	53721	1.99	1.82	6
23				2975	74259	2.08	1.87	4
24				1229	71957	2.19	1.12	2
25				1383	31755	3.76	1.21	4
Sum	307538	2.51	1.53	18558	326096	2.36	1.45	6

Block: 25

Table 3

Alt. 1 (5*6 m²)

| Profile | Ore in situ | | | Waste | Ore mined | | | Dilution |
	t	Cu	Zn,%	t	t	Cu	Zn,%	%
B2 13	73527	2.11	.47	11958	85485	1.81	.40	14
14	52637	1.83	.65	21197	73834	1.30	.46	29
15	22100	2.91	.55	27818	49918	1.29	.24	56
16	25519	2.29	.50	7340	32859	1.78	.39	22
17	22948	2.04	.27	10986	33934	1.38	.18	32
18	49708	1.74	.71	20021	69729	1.24	.51	29
19	29327	1.49	.99	22356	51683	1.13	.56	43
Sum	275766	2.40	.60	121676	397442	1.42	.41	31

Alt. 2 (2.5*3 m²)

| Profile | Ore in situ | | | Waste | Ore mined | | | Dilution |
	t	Cu	Zn,%	t	t	Cu	Zn,%	%
B2 13				0	73527	2.11	.47	0
14				1690	54327	1.77	.63	3
15				5689	27789	2.31	.44	20
16				960	26479	2.21	.48	3
17				0	22948	2.04	.27	0
18				0	49708	1.74	.71	0
19				2139	31466	1.85	.92	7
Sum	275766	2.40	.60	10478	286244	1.98	.57	4

Table 4 (Block 27 Alt.1)

1990

PLAN ~~5~~   GRONG GRUBER A/S   TALLENE KNYTTET OPP MOT REGNEARK
                                         KONTRAKT BUDSJETT ~~~~ OG SIR

MALMVERDI/PRODUKSJONSKOST

		Kr/tonn	Kr/kg	%
CU	Metallinnhold i konsentrat		230	
	Bruttoverdi 1000 kg kons.	3451	15,00	100
	Fradrag smelteverk	1028	4,47	29,79
	Cif-verdi	2423	10,53	70,21
	Sir	308	1,34	8,92
	Verdi ab Joma Cu-innhold	2115	9,20	61,29
AG	Bruttoverdi	274	1,19	100
	Fradrag smelteverk	41	,18	15
	Cif-verdi	233	1,01	85
	Sir	0	0	0
	Verdi ab Joma Cu-innhold	233	1,01	85
CU + AG	Verdi ab Joma	2348	10,21	
ZN	Metallinnhold i konsentrat		450	
	Bruttoverdi 1000 kg kons.	4572	10,16	100
	Fradrag smelteverk	1596	3,55	34,90
	Cif-verdi	2976	6,61	65,10
	Sir	261	,58	5,71
	Verdi ab Joma Zn-innhold	2715	6,03	59,39

	RAMALM T	CU	ZN	AG gr.
PAGANG TONN	544054	1,40	,76	
UTVINNING %		86,00	66,00	(App 7)
MALM TONN		6550	2729	
KONSENTRAT %		24	53	
KONSENTRAT		27292	5149	
AG gram pr. 1 tonn konsentrat				200
ANTALL KG AG				5458

MALMVERDI:

CU:	D33*D11/C31*1000	110,77
AG:	F37*D18/C31*1000	10,13
ZN:	E33*D28/C31*1000	30,25
MALMVERDI		151,15
TOTAL PRODUKSJONSKOST JOMA (73630+9000-1800)/535=		151,18 (App 6)
FORTJENESTE PR. TONN RAMALM		-0,03

£NULL!

1990

PLAN ~~1989~~   GRONG GRUBER A/S   TALLENE KNYTTET OPP MOT REGNEARK
                                    KONTRAKT BUDSJETT ~~OG~~ OG SIR
                                              90
MALMVERDI/PRODUKSJONSKOST

		Kr/tonn	Kr/kg	%
CU	Metallinnhold i konsentrat		230	
	Bruttoverdi 1000 kg kons.	3451	15,00	100
	Fradrag smelteverk	1028	4,47	29,79
	Cif-verdi	2423	10,53	70,21
	Sir	308	1,34	8,92
	Verdi ab Joma Cu-innhold	2115	9,20	61,28
AG	Bruttoverdi	274	1,19	100
	Fradrag smelteverk	41	,18	15
	Cif-verdi	233	1,01	85
	Sir	0	0	0
	Verdi ab Joma Cu-innhold	233	1,01	85
CU + AG	Verdi ab Joma	2348	10,21	
ZN	Metallinnhold i konsentrat		450	
	Bruttoverdi 1000 kg kons.	4572	10,16	100
	Fradrag smelteverk	1596	3,55	34,90
	Cif-verdi	2976	6,61	65,10
	Sir	261	,58	5,71
	Verdi ab Joma Zn-innhold	2715	6,03	59,39

	RAMALM T	CU	ZN	AG gr.
PAGANG TONN	355286	2,14	1,17	
UTVINNING %		9,50	75,00	
MALM TONN		6880	3117	
KONSENTRAT %		24	53	
KONSENTRAT		28667	5881	
AG gram pr. 1 tonn konsentrat				200
ANTALL KG AG				5733

MALMVERDI:

CU: D33*D11/C31*1000   178.18

AG: F37*D18/C31*1000   16.30

ZN: E33*D29/C31*1000   52.91

MALMVERDI   247.39

TOTAL PRODUKSJONSKOST JOMA (73680+9000-1800)/535=   169.41

FORTJENESTE PR. TONN RAMALM   77.98

£NULL!

Table 5

Block: 27,26,25

Alt. 1(5*6 m^2)

Profile	Ore in situ			Waste	Ore mined			Dilution
	t	Cu	Zn,%	t	t	Cu	Zn,%	%
Block 27	332105	2.30	1.25	211955	544054	1.40	.76	39
26	307538	2.51	1.53	128987	436525	1.76	1.08	30
25	275766	2.40	.60	121676	397442	1.42	.41	31
Sum	915409	2.40	1.15	462618	1378021	1.59	.76	33

Alt. 2 (2.5*3 m^2)

Profile	Ore in situ			Waste	Ore mined			Dilution
Block 27				23161	355266	2.14	1.17	7
26				18558	326096	2.36	1.45	6
25				10478	286244	1.98	.57	4
Sum	915409	2.40	1.15	52197	967606	2.17	1.08	5

Table 6(B1.27,26,25 Alt.1)   11

1990

PLAN ~~5989~~   GRONG GRUBER A/S

MALMVERDI/PRODUKSJONSKOST

		Kr/tonn	Kr/kg	%
CU	Metallinnhold i konsentrat		230	
	Bruttoverdi 1000 kg kons.	3451	15,00	100
	Fradrag smelteverk	1028	4,47	29,79
	Cif-verdi	2423	10,53	70,21
	Sir	308	1,34	8,92
	Verdi ab Joma Cu-innhold	2115	9,20	51,28
AG	Bruttoverdi	274	1,19	100
	Fradrag smelteverk	41	,18	15
	Cif-verdi	233	1,01	85
	Sir	0	0	0
	Verdi ab Joma Cu-innhold	233	1,01	85
CU + AG	Verdi ab Joma	2348	10,21	
ZN	Metallinnhold i konsentrat		450	
	Bruttoverdi 1000 kg kons.	4572	10,16	100
	Fradrag smelteverk	1596	3,55	34,90
	Cif-verdi	2976	6,61	65,10
	Sir	261	,58	5,71
	Verdi ab Joma Zn-innhold	2715	6,03	59,39

	RAMALM T	CU	ZN	AG gr.
PAGANG TONN	1378027	1,59	,76	
UTVINNING %		86,50	69,35	
MALM TONN		18953	7263	
KONSENTRAT %		24	53	
KONSENTRAT		78971	13704	
AG gram gr. 1 tonn konsentrat				200
ANTALL KG AG				15794

MALMVERDI:

CU: D33*D11/C31*1000   126.53

AG: F37*D18/C31*1000   11.58

ZN: E33*D28/C31*1000   31.78

MALMVERDI   169.89

TOTAL PRODUKSJONSKOST JOMA (73680+9000-1800)/535=   151.18

FORTJENESTE PR. TONN RAMALM   18.71

£NULL!

Table 7(Bl.27,26,25 Alt.1')   12

1990

PLAN ~~5869~~   GRONG GRUBER A/S

MALMVERDI/PRODUKSJONSKOST

TALLENE KNYTTET OPP MOT REGNEARK
KONTRAKT BUDSJETT ~~og~~ OG SIR

		Kr/tonn	Kr/kg	%
CU	Metallinnhold i konsentrat		230	
	Bruttoverdi 1000 kg kons.	3451	15,00	100
	Fradrag smelteverk	1028	4,47	29,79
	Cif-verdi	2423	10,53	70,21
	Sir	308	1,34	8,92
	Verdi ab Joma Cu-innhold	2115	9,20	61,29
AG	Bruttoverdi	274	1,19	100
	Fradrag smelteverk	41	,18	15
	Cif-verdi	233	1,01	85
	Sir	0	0	0
	Verdi ab Joma Cu-innhold	233	1,01	85
CU + AG	Verdi ab Joma	2348	10.21	
ZN	Metallinnhold i konsentrat		450	
	Bruttoverdi 1000 kg kons.	4572	10,16	100
	Fradrag smelteverk	1596	3.55	34,90
	Cif-verdi	2976	6,61	65,10
	Sir	261	,58	5,71
	Verdi ab Joma Zn-innhold	2715	6,03	59,39

	RAMALM T	CU	ZN	AG gr.
PÅGANG TONN	1007933	2,17	1,04	
UTVINNING %		90.63	72.20	
MALM TONN		19823	7568	
KONSENTRAT %		24	53	
KONSENTRAT		82595	14280	
AG gram pr. 1 tonn konsentrat				200
ANTALL KG AG				16519

MALMVERDI:

CU: D33*D11/C31*1000   180.93

AG: F37*D18/C31*1000   16.55

ZN: E33*D28/C31*1000   45.28

MALMVERDI   242.76

TOTAL PRODUKSJONSKOST JOMA (73680+9000-1800)/535=   ore: 151.18
                                                     waste: 86.55

FORTJENESTE PR. TONN RAMALM   59.55

£NULL!

Table 8(Bl.27,26,25 Alt.2)　　　　13

1990

PLAN ~~~~~~　　GRONG GRUBER A/S

MALMVERDI/PRODUKSJONSKOST

TALLENE KNYTTET OPP MOT REGNEARK
KONTRAKT BUDSJETT ~~~ OG SIR

		Kr/tonn	Kr/kg	%
CU	Metallinnhold i konsentrat		230	
	Bruttoverdi 1000 kg kons.	3451	15,00	100
	Fradrag smelteverk	1028	4,47	29,79
	Cif-verdi	2423	10,53	70,21
	Sir	308	1,34	8,92
	Verdi ab Joma Cu-innhold	2115	9,20	61,28
AG	Bruttoverdi	274	1,19	100
	Fradrag smelteverk	41	,19	15
	Cif-verdi	233	1,01	85
	Sir	0	0	0
	Verdi ab Joma Cu-innhold	233	1,01	85
CU + AG	Verdi ab Joma	2348	10.21	
ZN	Metallinnhold i konsentrat		450	
	Bruttoverdi 1000 kg kons.	4572	10,16	100
	Fradrag smelteverk	1596	3,55	34,90
	Cif-verdi	2976	6,61	65,10
	Sir	261	,58	5,71
	Verdi ab Joma Zn-innhold	2715	6,03	59,39

	RAMALM T	CU	ZN	AG gr.
PAGANG TONN	967606	2.27	1.09	
UTVINNING %		90.63	72.20	
MALM TONN		19907	7615	
KONSENTRAT %		24	53	
KONSENTRAT		82946	14368	
AG gram pr. 1 tonn konsentrat				200
ANTALL KG AG				16589

MALMVERDI:

CU:　　D33*D11/C31*1000　　　　　　　　　　　　　189.27

AG:　　F37*D18/C31*1000　　　　　　　　　　　　　17.32

ZN:　　E33*D29/C31*1000　　　　　　　　　　　　　47.46

MALMVERDI　　　　　　　　　　　　　　　　　　　254.05

TOTAL PRODUKSJONSKOST JOMA (73680+9000-1800)/535=　　169.41

FORTJENESTE PR. TONN RAMALM　　　　　　　　　　　84.64

£NULL!

Table 9 Mining Alternatives for Blocks 27,26 and 25

Ore in situ			
Tonnage,t	915409		
Ore grade,%			
Cu	2.40		
Zn	1.15		
Average thickness of orebody,m	2.6-3.7 (min.0.5, max. 10)		
Dip of orebody	Generally- flat and steep dipping in some places		

Alt.	1	1'	2
Mining method	R&P with nonselective mining	R&P with selective mining(degree of selectivity 80%)	R&P with nonselective mining
Drift size,m^2	5*6	5*6	2.5*3
Ore mined			
Tonnage,t	1378027	1007933	967606
ore grade,%			
Cu	1.59	2.17	2.27
Zn	0.76	1.04	1.09
Waste rock mining,t	0	370094	0
Rock dilution,%	33	9	5
Recovery,%			
Cu	86.50	90.63	90.63
Zn	69.35	72.20	72.20
Specific income,NOK/t	169.89	242.76	254.05
Annual ore production from narrow orebody -10%,t/y	53500	53500	53500
Total income from narrow orebody,MNOK/y	9.089	12.987	13.592
Specific cost,NOK/t	151.18(1)	Ore:151.18 Waste:86.55(2) Ore:waste=1:0.37	169.41(3)

Total cost,MNOK/y	8.088	9.801	9.063
Total profit,MNOK/y	1.001	3.185	4.529
Difference in profits of Alt.1' and 2,MNOK/y		1.344	
Investment of Alt.2,MNOK/y			0.397(4)
Increment in profit of Alt.2 compared with 1',MNOK/y		0.95	
Net present value(NPV) during the rest of min's lifetime- 5 years, MNOK	3.11(5)	9.90	14.09
Difference in NPV of Alt.1' and 2,MNOK		4.19	

----

(1) 72.94+45.02+33.22=151.18

(2) Cost of waste=Min. cost - Crushing cost+Indirect cost=72.94-3.0+0.5*33.22
=86.55

(3)Min. cost of Alt.2 is assumed25% more than 1.
1.25*72.94+45.02+33.22=169.41

(4) Cost of second-hand Toro 200D and Tamrock.Minimatic=0.222+0.175=0.397 MNOK/y

(5) $NPV = \sum_{0}^{5} \frac{1.001}{(1+0.1)^5}$ (App. 8)

2.2 Mining cost estimation

Mining cost of Alt.2 will be increased compared with Alt.1 due to increase in fragmentation cost and using small equipment.According to reaserch of optimization of rock fragmentation carried out by Dan Neilsen(International Mining Oct. 1986),the fragmentation degree is closely connected with costs of drilling and blasting.Supposing increment in costs of fragmentation by 50% and of loading -30%,the total mining cost is shown in table below:

	Costs,NOK/t	Increment in costs,NOK/t	%
Drilling	10.04	5.02	50
Blasting	8.78	4.39	50
Loading	7.78	2.33	30
Others	51.23	5.12	10
Total	77.83	16.86+77.83=94.69	121

This table shows that the mining cost of Alt.2 is 1.2 times of Alt.1.
A 20-25% increase in mining cost is a substantial increase for Alt.2,which can be accepted for cost estimation.It is,however,expected that ore crushing and grinding costs are directly affected by degree of fragmentation . The relationship between crushing/griding and ore fragmentation blasted was previously studied(Report:Problem concerned with fragmentation of rock,see App.9).According to this report the increasing power factor from 1.2 kg/m^3 to 2 kg/m^3 leads to decrease fragmentation size from 81 mm to 57 mm,and consenquently,to increase crushing effiency by 15-35% and griding by 5-10%. The above mentioned Swedish research project also indicates the equality of overall costs at power factors between 1.3 and 2.4 kg/m^3.

2.3.Applicability of mining Alt.

Both Alt.1' and 2 offer close profit,if Alt.1' has high selectivity and Alt.2-low costs.Alt.1' has advantage of application of existing equipment which can be adapted to less complicated conditions of orebody.Alt. 2 is method suitable for mining thinner orebody with complicated boundary. The applicability of these two Alt. is dependent on mining cost and efficency of selective mining.The increment in mining cost of Alt.2 is presented in table 10.

Table 10

Increment in Min.cost of Alt.2 compared with Alt.1',%	10	25	35	50	60
Spcific cost of Alt.2,NOK/t	158.47	169.41	176.71	187.65	194.94
Total cost,MNOK/y	8.478	9.063	9.454	10.039	10.430
Total profit,MNOK/y	5.114	4.529.	4.138	3.553	3.162

The efficency of Alt.1' is concerned with degree of selectivity as shown in table 11.

Table 11

Degree of selectivity,%	90	80	70	60	50
Ore mined					
Tonnage,t	961671	1007933	1054192	1100456	1146718
Ore grade,%					
Cu	2.28	2.17	2.08	2.00	1.92
Zn	1.10	1.04	1.00	0.96	0.92
Recovery,%					
Cu	90.63	90.63	90.63	90.63	90.15
Zn	72.20	72.20	72.20	69.35	69.35
Income,NOK/t	258.87	242.76	236.01	225.21	215.20
Total income,MNOK/y	13.85	12.99	12.62	12.05	11.51
Ore:waste	1:0.43	1:0,37	1:0.31	1:0.25	1:0.20
Total cost,MNOK/y	10.08	9.80	9.52	9.25	9.01
Total profit,MNOK/y	3.77	3.19	3.10	2.80	2.50

Tables 10 and 11 show that the profit of both Alt. appeared to be approximately equal for certain degree of selectivity of Alt.1' and mining cost of Alt.2. It also shows that when degree of selectivity of Alt.1' is about 70-80%,the Alt. 2 is more profitable on condition that the mining cost of Alt.2 is within 1.4 - 1.5 times of Alt.1.In other words the applicability of Alt.2 is limited by mining cost less than 1.5 times of Alt.1 for giving circumstances.(see fig.2).
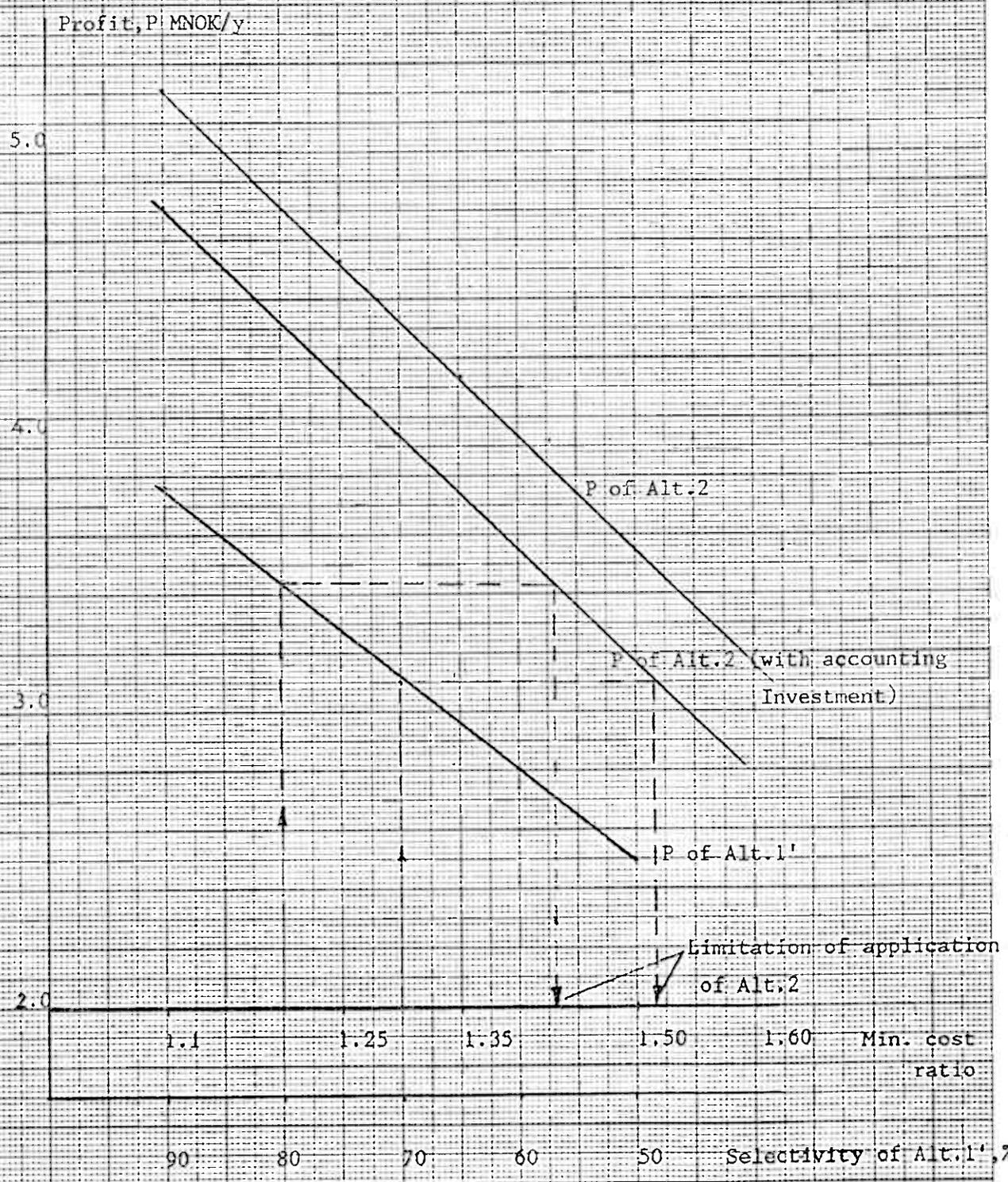
Fig.2

3. Economical influence of rock dilution during the rest of lifetime
   of the mine

Economical influence of rock dilution is of additional costs of mining
and dressing of the waste rock. The economical significance can be studied
by calculating net present value(NPV), that is the present value of all
the yearly cash flows during the rest of mine's lifetime.

Calculation

Discount	10%	
Alt.	2	1
Dilution,%	5	33
Ore production of narrow orebodies Kt/y	53	53
Production stage,y	5	5
Mining of waste rock,t/y	53*0.05=2650	53*0.33=17500
Total cost,NOK/t	187.65	151.18

NPV of additional costs
of mining waste rock,MNOK

$$\sum_0^5 \frac{2650*187.65}{(1+0.1)^5} \qquad \sum_0^5 \frac{17500*151.18}{(1+0.1)^5}$$

$$=1.55 \qquad\qquad =8.23$$

$$\sum_0^5 \frac{1}{(1+0.1)^5} = \frac{1}{(1+0.1)} + \frac{1}{(1+0.1)^1} + \frac{1}{(1+0.1)^2} + \frac{1}{(1+0.1)^3} + \frac{1}{(1+0.1)^4} + \frac{1}{(1+0.1)^5}$$

$$=3.11$$

Difference in NPV,MNOK	6.68

As shown in the calculation, the cost of mining waste rock for Alt. 1 is
clearly higher as compared with Alt. 2. The difference in NPV between Alt.
1 and 2 is 6.68 MNOK during 5 years. With no discount that means difference
in additional costs of 2.65-0.50=2.15 MNOK per year during the rest 5 years
lifetime. It is obvious that the most important factor influencing in economy
of mining narrow veins is to keep rock dilution low.

4. Mining methods

According to conditions of Grong Gruber, the R & P system is the most suitable method for mining narrow and flat lying orebodies, and sublevel stoping with accurate drilling can be successfully used for mining narrow and steep dipping orebodies. Both methods are more flexible and able to follow irregularities in the boundary of orebody. In every profile it should be studied the minimum stoping area to minimize waste rock mining.

Other mining methods as stoping with using monorails, Raise mining and Rill mining can also be considered for mining narrow orebodies(App.4).

The two mining methods and corresponding mining equipments adapted to narrow orebodies of Grong Gruber are listed below:

1).R & P system

Due to good mechanical conditions of rocks and stable hanging wall, the R&P systems with small equipments($2.5*3$ $m^{2)}$ are effective method for narrow flat orebodies. Removing parts of pillars and forming big room during 1981-82 years have indicated that in B2 area big spans can be allowed for mining narrow orebody with high recovery and minimum dilution. On basis of stress measurement the span may increased from 5 m to 10-12 m, the dimension of pillar remaints no changed i.e. $7.5*8$ m^{2} In this case the ore losses will be decreased from 23% to 15%.

2).Stoping of narrow orebodies with steep dipping

Combination of boundary drill holes for presplitting and central holes for fragmentation is proposed for mining of narrow and steep dipping orebodies. (see fig 3).This method with presplitting will provide the minimum stoping width and minimize overbreak of waste rock by careful blasting techniques.

Presplitting blasting involves drilling a row of closely spaced holes along the stoping boundary and drilling a row of normally spaced holes in the central of stopes. The presplit holes are fired before central holes for fragmentation to provide a fracture plane to which the central blast can break.

The specification for presplitting blasting design are shown in table below:

Hole diameter, mm	Spacing, m	Explosive charge, Kg/m
31-45	0.25-0.45	0.1-0.4

3/.Mining equipments

It is recommended to buid up some applications of second-hand small mining equipment from Outokumpu mines.They are:

-Toro 200D

Width 2 m

Height 2.25 m

Length 7.54 m.

_Tamrock.Minimatic

2 booms,3.2 m long

E 400 drillers

Width 2 m

Height 2.4 m

-Micromatic H 102

1 boom

HE 322 drifter

Width 1.2 m

Height 1.5 m

Drills 31-45 mm holes up to 3.3 m in length

The hole diameter for various mining methods are shown as follows:

Hole diameter,mm	Mining method
31-38	Drift and R&P for narrow orebodies
45	Drift and R&P for thick orebodies
57	LH stoping
76-89 *	Mass blasting of pillars

*-can be drilled with existing equipments.

Boundary of orebody

Drill hole for fragmentation

Drill hole for presplitting

Cross-section A-A

Horizontal plan

Fig.3

22
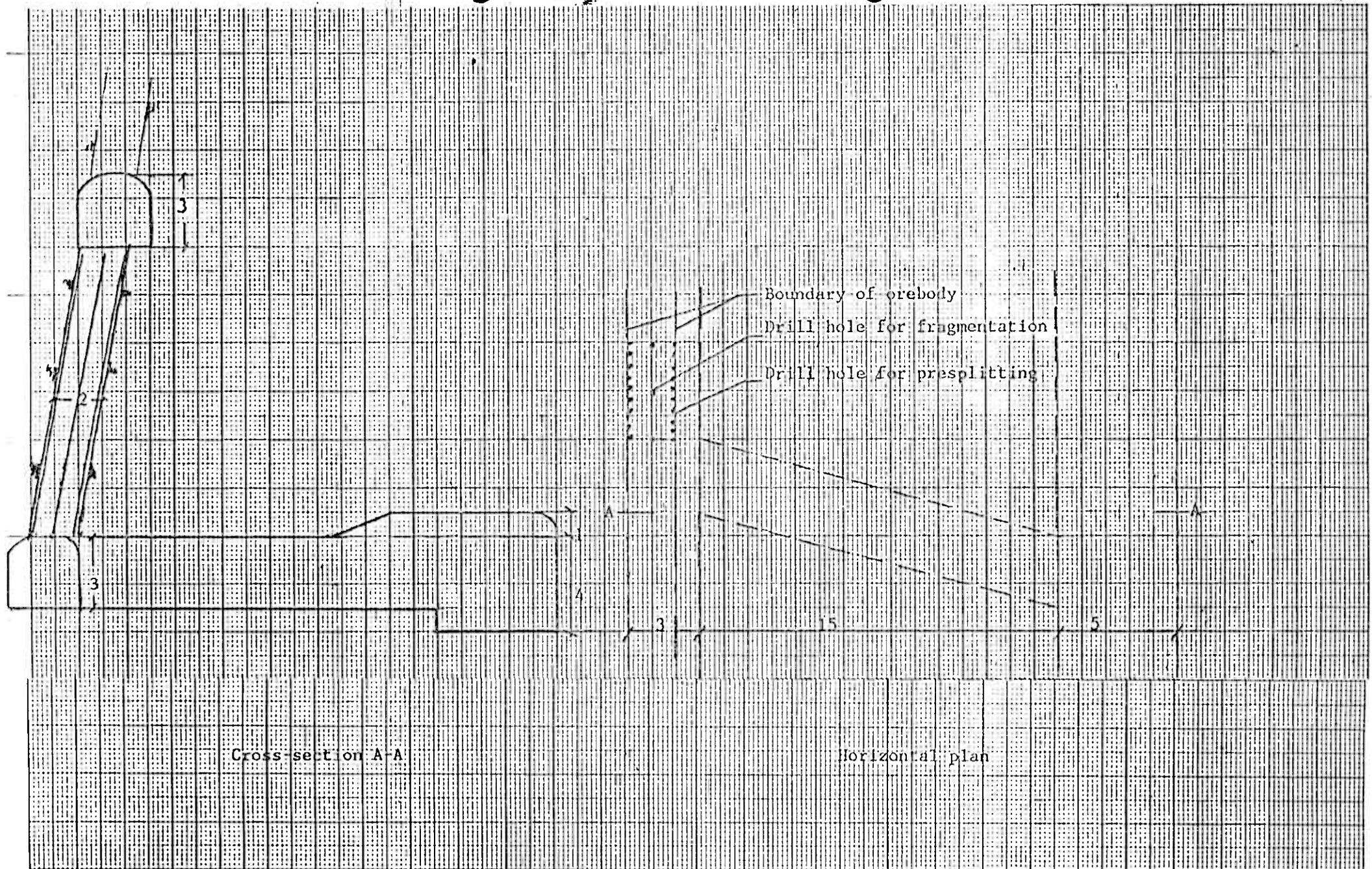
5.Analysis of profile

In order to control ore grade it is necessary to analyze every profile in every Block based on the following princeple:Every ton of ore mined shall normally have an ore value not lower than its total costs,and expect to return a profit. At times unprofitable rock is mined for other reasons,which are due to mining sequence and requirements of mining methods.

The analysis of every single profile of Block 27 is done by summarising the tonnage in both Cu and Zn categories.

Analysis of profile includes tonnage and grade distribution in situ,thickness and dip of orebodies,mining methods,dilution,recovery,tonnage and grade of ore mined and also costs,Income and profit.It is noticed that in the mineable reserves will be included only profitable areas,which give the best possible cash flow in dependence with current price and real costs of various mining methods.This analysis makes it possible to maxmize the profit by selecting unprofitable area.

Considering Profile 26 of Block 27.

The profit of 6 small blocks can be calculated,according to current price and real costs instead of using average cost,which depend on mining methods. If unprofitable block are not encluded,the ore grade mined will increase from 2.09-0.92 to 2.29-0.94 and corresponding increment in profit will reach to 17,08 NOK/t.The total increment in profit of this profile is 0.46 MNOK. From above analysis can be seen that the exclusion of unprofitable area will give considerable economic effect,if mining sequence and technical requirments are satisfied.

Block: 27

Profile: B2 26

1. Tonnage and grade

Zn,%

Cu,%	<1.0	1.01-2.0	2.01-3.0	>3.01	Total	Remark
<1.0	P=-					
	2712-.33-.88	4341-.72-1.26			7053-.57-1.11	
1.01-2.0		2573-1.92-1.25				
		5027-1.24-1.65				
	2409-1.58-.69	7550-1.47-1.52			9959-1.5-1.17	
2.01-3.0	7392-2.46-.66					
	3830-2.46-.66					
	Σ11222-2.46-.66				11222-2.46-.66	
>3.01						
	1254-12.5-.27				1254-12.5-.27	
Total						
	17597-2.73-.59	11891-1.20-1.43			29488-2.11-.93	
With no unprofit					26776-2.29-.94	

2. Thickness of orebody, Av., Min., Max., m   3.6 (2.1-5.5)

2. Dip of orebody (F-flat, S-steep)   F

4. Mining method and Equipment   R & P (2.5×30 m²)

	Total	With no unprofit
5. Ore mined (t-Cu-Zn)t,%	29722-2.09-.92	27010-2.27-.93
6. Rock dilution,%	1	
7. Recovery, (Cu-Zn),%	90.63 - 69.35	
8. Total cost, Kr/t	187.65 *	
9. Income, Kr./t	213.86	248.94
10. Profit, Kr/t	44.21	61.29

$$\star \quad 1.5 \cdot 72.94 + 45.02 + 33.22 = 187.65$$

Block: 27

Profile: B2 27

1.Tonnage and grade

Zn,%

Cu,%	<1.0	1.01-2.0	2.01-3.0	>3.01	Total	Remark
<1.0	P=- 19046-1-.3	10842-.51-1.93 4314-.87-1.77 15156-.61-1.88	1207-.88-2.16		35409-.83-1.04	
1.01-2.0	1213-1.76-.4 2290-1.34-.14 3503-1.49-.23			6006-1.52-3.2	9509-1.51-2.1	
2.01-3.0	2583-2.04-.09	6334-2.39-1.62	1877-2.31-2.15		10794-2.29-1.3	
>3.01	2945-6.94-.53 2634-3.19-.84 5579-5.17-.68				5579-5.17-.68	
Total	30711-2.07-.34	21490-1.13-1.8	3084-1.75-2.15	6006-1.52-3.2	61291-1.59-1.23	

With no unprofit

2.Thickness of orebody,Av.,Min.,Max.,m 3.7 (1.7-8.8)

2.Dip of orebody(F-flat,S-steep) .... F

4.Mining method and Equipment .... R & P (2.5×3.0 m²)

	Total	With no unprofit
5.Ore mined(t-Cu-Zn)t,%	63242-1.54-1.19	
6.Rock dilution,%	3	
7.Recovery,(Cu-Zn),%	86.50-72.20	
8.Total cost,Kr/t	187.65	
9.Income,Kr./t	187.82	
10.Profit,Kr/t	0.17	

Block: 27
Profile: B2 28

1. Tonnage and grade

Zn,%

Cu,%	<1.0	1.01-2.0	2.01-3.0	>3.01	Total	Remark
<1.0					3278-.63-.436 3278-.63-.436²	
1.01-2.0	2240-1.4-.07 1514-1.76-.73 Σ3759-1.55-.34		2471-1.19-2.21	1852-1.54-1.88	8082-1.45-1.95	
2.01-3.0						
>3.01	3096-2.91-.66 6034-4.4-.99 1318-4.59-.55 Σ7352-4.43-.91				3096-2.91-.66 7352-4.43-.91	
Total	14207-3.34-.70		2471-1.19-2.21	5130-.98-4.55	21808-2.53-1.78	

With no unprofit ____

2. Thickness of orebody,Av.,Min.,Max.,m _____ 2.6 (1.5-8.0)

2. Dip of orebody(F-flat,S-steep) _____ F u S

4. Mining method and Equipment R&P Sublevel stoping (2.5×3 cm²)

	Total	With no unprofit
5. Ore mined(t-Cu-Zn)t,%	25515-2.16-1.52	
6. Rock dilution,%	15	
7. Recovery, (Cu-Zn),%	90.63 - 77.35	
8. Total cost,Kr/t	187.65	
9. Income,Kr./t	270.77	
10. Profit,Kr/t	83.12	

Block: 27
Profile: B2 29

1. Tonnage and grade

Zn,%

Cu,%	<1.0	1.01-2.0	2.01-3.0	>3.01	Total	Remark
<1.0						
1.01-2.0	2192-1.52-.35 1956-1.27-.20 54098-1.4-.28		678-1.66-2.59		4776-1.44-.61	
2.01-3.0		4631-2.82-1.95		2295-2.79-304	6926-2.81-2.31	
>3.01	7484-4.23-.89 4260-C.65-.61 5?1?44-4.75-.7?	5-595-4.61-1.26			17339-4.71-.94	
Total	15842-3.88-.66	10226-3.8-1.57	678-1.66-2.59	2295-2.74-306	29041-3.72-1.??	
With no unprofit						

		Total	With no unprofit
2. Thickness of orebody,Av.,Min.,Max.,m		3.1 (0.5-10.0)	
2. Dip of orebody(F-flat,S-steep)		F	
4. Mining method and Equipment		R & P (2.5×3.0 m²)	
5. Ore mined(t-Cu-Zn)t,%	36711-2.94-.97		
6. Rock dilution,%		2L	
7. Recovery,(Cu-Zn),%		90.63-69.35	
8. Total cost,Kr/t		187.65	
9. Income,Kr./t	312.61		
10. Profit,Kr/t	124.96		

Block: 27
Profile: B2 30

1. Tonnage and grade

Zn,%

Cu,%	<1.0	1.01-2.0	2.01-3.0	>3.01	Total	Remark
<1.0				5440-.47-3.23 3003-.76-3.24 1325-.62-3.09 4090-.55-2.69 5768-.58-3.21	13858-.57-3.06	
1.01-2.0	P=- 10710-1.05-.19	3990-1.37-1.93		1404-1.38-3.61	16104-1.16-.92	
2.01-3.0	1516-2.3-.25 3542-2.37-.17 5058-2.35-.15				5058-2.35-.15	
>3.01	4514-4.54-.74 908-3.81-.18 1510-6.93-.31 6482-5.05-.60	1663-3.37-1.09 8281-3.11-1.52 9944-3.15-1.45			16426-3.9-1.11	
Total	22250-2.51-.3:	13934-2.64-1.59	4090-.55-2.69	11172-.68-3.26	51446-1.99-1.48	

With no unprofit

---

2. Thickness of orebody,Av.,Min.,Max.,m   3.3 (1.7-5.0)
2. Dip of orebody(F-flat,S-steep)   F
4. Mining method and Equipment   R.&.P. (2.5×3,0m²)

	Total	With no unprofit
5. Ore mined(t-Cu-Zn)t,%	53033-1.93-1.44	
6. Rock dilution,%	3	
7. Recovery,(Cu-Zn),%	90.15-77.35	
8. Total cost,Kr/t	187.65	
9. Income,Kr./t	244.81	
10. Profit,Kr/t	57.19	

Block: 27
Profile: B2 31

1. Tonnage and grade

Zn,%

Cu,%	<1.0	1.01-2.0	2.01-3.0	>3.01	Total	Remark
<1.0	P=- 1330-.72-.27	4324-.79-1.43		11154-.66-3.2	16808-.7-2.51	
1.01-2.0		6442-1.51-1.47		7750-1.26-4.92	14192-1.37-3.35	
2.01-3.0	1383-2.37-.38		6213-2.88-2.06		7596-2.79-1.75	
>3.01	7053-5.12-.52				7053-5.12-.52	
Total	9766-4.13-.47	10766-1.22-1.45	6213-2.88-2.06	18904-.91-3.91	45649-1.94-2.36	
With no unprofit					44319-1.98-2.4	

2. Thickness of orebody, Av., Min., Max., m 3.0 (1.7-5.8)

2. Dip of orebody (F-flat, S-steep) .... F, S

4. Mining method and Equipment .... R&P, Sublevel stoping (2.5×3.0m

	Total	With no unprofit

5. Ore mined(t-Cu-Zn)t,% 48695-1.82-2.19

6. Rock dilution,% 6

7. Recovery, (Cu-Zn),% 90.15-82.49

8. Total cost, Kr/t 187.65

9. Income, Kr./t 276.45

10. Profit, Kr/t 88.80

Block: 27

Profile: B2 32

1. Tonnage and grade

Zn,%

Cu,%	<1.0	1.01-2.0	2.01-3.0	>3.01	Total	Remark
<1.0			5879-.83-284		5879-.83-284	
1.01-2.0	8036-153-.72				8036-1.53-.72	
2.01-3.0						
>3.01	6006-7.19-.22	14034-3.21-1.04			20040-4.4-.79	
Total	14042-3.95-.51	14034-3.21-1.04	5879-.83-2.84	—	33955-3.1-1.13	
With no unprofit						

2. Thickness of orebody, Av., Min., Max., m   2.9 (1.2-4.9)

2. Dip of orebody (F-flat, S-steep)   F

4. Mining method and Equipment   R&P (2.5×3.0m²)

	Total	With no unprofit
5. Ore mined(t-Cu-Zn)t,%	35921-2.70-.99	
6. Rock dilution,%	13	
7. Recovery,(Cu-Zn),%	90.63-69.35	
8. Total cost,Kr/t	187.65	
9. Income,Kr./t	291.24	
10. Profit,Kr/t	103.59	

Block: 27

Profile: βZ 33

1.Tonnage and grade

Zn,%

Cu,%	<1.0	1.01-2.0	2.01-3.0	>3.01	Total	Remark
<1.0						
1.01-2.0	6952-1.59-.29				6952-1.59-.29	
2.01-3.0	19678-2.61-.11	3551-2.96-1.26			23229-2.66-.29	
>3.01						
Total	26630-2.34-.16	3551-2.96-1.26			30181-2.42-.29	

With no unprofit

2.Thickness of orebody,Av.,Min.,Max.,m   2.9 (2.5-5.9)

2.Dip of orebody(F-flat,S-steep)   F,S

4.Mining method and Equipment   R&P, Sublevel stoping (2.5×3.0m²)

	Total	With no unprofit
5.Ore mined(t-Cu-Zn)t,%	30181-2.42-.29	
6.Rock dilution,%	0	
7.Recovery,(Cu-Zn),%	90.63-69.35	
8.Total cost,Kr/t	187.65	
9.Income,Kr./t	236.06	
10.Profit,Kr/t	48.41	

Block: 27

Profile: B2 34

1.Tonnage and grade

Zn,%

Cu,%	<1.0	1.01-2.0	2.01-3.0	>3.01	Total	Remark
<1.0						
1.01-2.0	7394-1.59-.29				7394-1.59-.29	
2.01-3.0	17765-2.6-.11	4087-2.96-1.26			21852-2.67-.35	
>3.01						
Total	25159-2.3-.16	4087-2.96-1.26	--		29246-2.39-.31	
With no unprofit						

2.Thickness of orebody,Av.,Min.,Max.,m   3.0 (2.8-3.1)

2.Dip of orebody(F-flat,S-steep)   E.S

4.Mining method and Equipment   R&P. Sublevel stoping (2.5×3.0 m²)

	Total	With no unprofit
5.Ore mined(t-Cu-Zn)t,%	29246-2.39-.31	
6.Rock dilution,%	0	
7.Recovery,(Cu-Zn),%	90.63 - 69.35	
8.Total cost,Kr/t	187.65	
9.Income,Kr./t	234.12	
10.Profit,Kr/t	46.47	

6.Ore production

As above mentioned grade control is important factor influencing on economy of the mine.There is another possibility to improve profit by inceasing ore production. According to production plan 1990-1992 (App.10),the increasing ore production has been planned.When considering ore production it should be studied the change of costs with increasing ore production by Break.even analysis(App.11). The ore production plan and results of calculation are shown in table 12.

Table 12

Year	1989	1990	1991	1992	prognosis
Ore production,t/y	497397	535000	545000	550000	575000
Ore grade,%					
Cu	1.45	1.35	1.35	1.35	1.35
Zn	1.86	1.87	1.87	1.87	1.87
Recovery,%					
Cu	86.50	85.78	85.78	85.78	85.78
Zn	79.44	79.44	79.44	79.44	79.44
Income,NOK/t	217.16	207.81	207.81	207.81	207.81

Cost,NOK/t

Variable(c')=91.65 *(App.12)*

Fixed(c_0)=69.57

C_0 =69.57*497000=34.57 MNOK/y

	1989	1990	1991	1992	prognosis
Sum cost,NOK/t	161.22	156.28	155.09	154.52	151.78
Profit,NOK/t	55.94	51.53	52.72	53.29	56.03
Total income,MNOK/y	107.93	111.18	113.26	114.30	119.49
Total cost	80.13	83.61	84.52	85.00	87.27
Total profit,MNOK/y	27.80	27.57	28.74	29.31	32.22
Increment in production,%		100	102	103	108
Change in costs,%		100	99	98	97
Increment in profit,%		100	104	106	116

Table 12 shows that in terms of production plan 1990-1992 increasing ore production of 1% leads to increase in profit 2% by lowering fixed costs. Comparising the influence of ore quantity and ore quality on profit,it can be found that ore grade increases 1%,the increment in profit will be changed by 5%(table 13).This means the ore grade has more influence on profit than ore production.

Table 13

Ore production,t/y	535000	535000
Ore grade,%		
Cu	1.35	1.364
Zn	1.87	1.90
Income,NOK/t	207.81	210.47
Profit,NOK/t	51.53	54.19
%	100	105

The Break-even point of ore production at Grong Gruber is
34576000/207.81-91.65=0.3 Mt/y(see fig.4).It is noticed that reduction of Break-even point leads to increase profit as result of combination of income affected by ore grade mined and costs estimated by ore production.

F,MNOK/y

P,I,C MNOK/y

0

20

40

60

80

100

Fig.4

0.2 0.4 0.6 0.8

A,Mt/y

P

C

I

F,MNOK/y

O'

A

B

F

P

A'

V

I
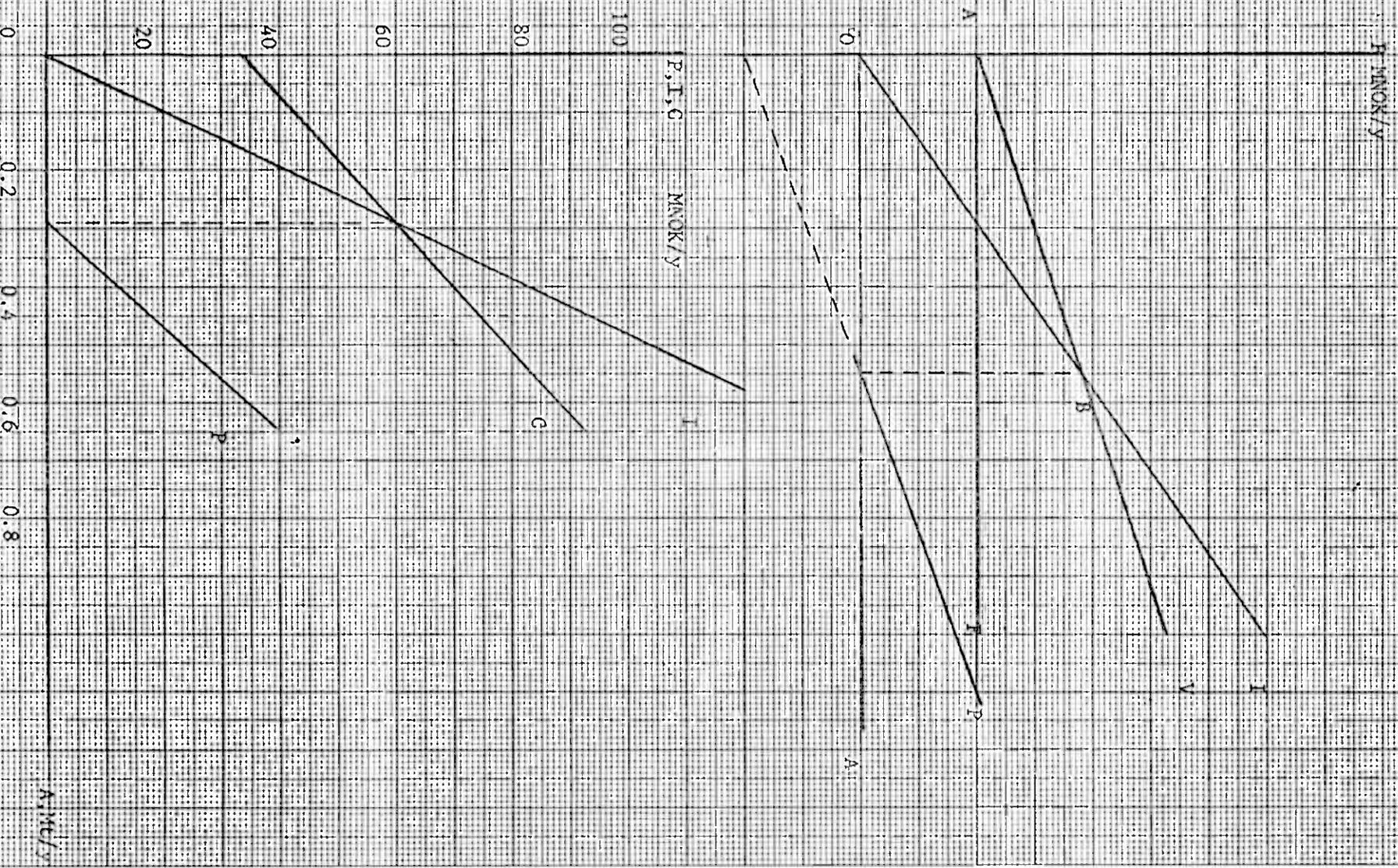
The ore reserves of narrow and small orebodies have been estimated about 15% of total reserves. The ore production from these areas should be considered in accordance with mine plan.

Mining Alternative with stoping size 2.5 m for narrow orebodies of B2 area gives annual economical result 0.95 MNOK,compared with existing mining method. The main mining methods are R&P for mining narrow and flat lying orebody and sublevel stoping for mining narrow and steep dipping orebody.Both methods with using smaller equipments are more flexible and able to grade control.

Due to considerable variation in grade,analysis of profile is recommended.This provides effective approch of evaluating mining narrow orebody to maximize the profit by selecting unprofitable areas.

Malmberegning 24/11/89

Profil: 22 26

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L,m	t,m
1	49	31	55	4541	0.72	1.26	4.43	16.5	2.9
2	40	9	24	2712	0.33	0.83	3.39	13.0	3.1
3	31	48	32	2523	1.92	1.25	4.07	8.0	3.8
4	57	62	83	5087	1.24	1.65	4.41	17.5	3.3
5	15	157	5	1254	12.50	0.27	4.13	7.0	2.1
6	38	38	2	2409	1.58	0.09	3.17	11.0	3.4
7	110	182	49	7392	2.46	0.66	3.36	20.0	5.5
8	57	94	25	3830	2.46	0.66	3.36	17.0	3.3

****
| TOT: | 397 | 621 | 273 | 29408 | | | | 110 | |
| GJ.SN: | | | | | 2.11 | 0.93 | 3.71 | | 3.6 |

	Waste rock	Alt.1	t'	
1	35		2.1	3101
2	25		1.9	1695
3	10		1.2	814
4	30		1.7	2646
5	20		2.9	1672
6	18		1.6	1141
8	29		1.7	1949
				13018

42506   1.46   .65

Alt.2

| 5 | 2.8 | | .4 | 234 |

234

29722   2.09   .92

L-Length of orebody
t-Thickness of orebody
t'-Thickness of waste rock

Malmberegning 24/11/89

Profil: B2 27

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Sov	L	t
1	214	190	57	19046	1.00	0.30	4.45	54	4.0
2	130	55	209	10842	0.51	1.93	4.17	46	2.8
3	70	91	192	6006	1.52	3.20	4.29	13	5.4
4	81	151	103	6334	2.39	1.62	3.91	10	8.1
5	53	38	76	4314	0.87	1.77	4.07	6	8.8
6	16	21	5	1213	1.76	0.40	3.79	7	2.3
7	23	43	40	1877	2.31	2.15	4.08	10	2.3
8	17	11	26	1207	0.88	2.16	3.55	10	1.7
9	37	204	16	2945	6.94	0.53	3.98	20	1.8
10	41	53	2	2583	2.04	0.09	3.15	6.8	6.0
11	35	31	3	2290	1.34	0.14	3.18	7	5.0
12	37	84	22	2634	3.19	0.84	3.36	15	2.5

++

| TOT: | 755 | 972 | 751 | 61291 | | | | 205 | |
| GJ.SN: | | | | | 1.59 | 1.23 | 4.06 | | 3.7 |

Waste rock   Alt. 1

		t'	
1	54	1.0	4806
2	101	2.2	8423
6	13	2.7	1440
7	27	2.7	2203
8	33	3.3	2343
9	-64	3.2	5094
12	37	2.5	2634

26943

88234   1.10   .85

Alt. 2

6	1.4	.2	106
7	2.0	.2	163
8	8.0	.8	568
9	14.	.7	1114

1951

63242   .1,54   1.19

Malmberegning 27/11/89

Profil: B2 28

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Sov	L	t
1	28	31	2	2240	1.40	0.07	4.00	12	2.3
2	37	21	143	3273	0.63	4.36	4.43	11	3.4
3	18	27	11	1519	1.76	0.73	4.22	12	1.5
4	40	90	20	3096	2.91	0.66	3.87	5	8.0
5	21	29	90	1852	1.59	4.86	4.41	4	6.3
6	70	265	60	6034	4.40	0.99	4.31	23	3.0
7	18	60	7	1318	4.59	0.55	3.66	12	1.5
8	35	29	59	2471	1.19	2.31	3.53	23	1.5

****

TOT:	267	552	388	21808				102	
GJ.SN:					2.53	1.73	4.08		2.6

Waste rock

Alt. 1

			t'	
1	32		2.7	2560
2	18		1.6	1595
3	42		3.5	3545
6	46		2.0	3765
7	42		3.5	3274
8	81		3.5	5719
				20458

42266	1.31	.92

Alt. 2

1	9.4		.2	192
3	12		1.0	1013
7	12		1.0	878
8	23		1.0	1624
				3707

25515	2.16	1.52

Malmberegning 27/11/89

Profil: B2 29

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	27	33	8	2192	1.92	0.35	4.06	20	1.3
2	27	24	4	1906	1.27	0.20	3.53	28	.9
3	8	11	18	678	1.66	2.59	4.24	15	.5
4	99	317	67	7484	4.23	0.89	3.78	20	5.0
5	60	241	26	4260	5.65	0.61	3.55		
6	55	131	90	4631	2.82	1.95	4.21	14	10
7	27	64	70	2295	2.79	3.04	4.25		
8	75	258	70	5595	4.61	1.26	3.73	25	3.0

****

| TOT: | 378 | 1079 | 353 | 29041 | | | | 122 | |
| GJ.SN: | | | | | 3.72 | 1.22 | 3.84 | | 3.1 |

Waste rock

Alt. 1

t'

1	74	3.7	6009
2	115	4.1	8105
3	68	4.5	5724
8	50	2.0	3730
			23568

| | 52609 | 2.05 | .67 |

1	24	1.2	1949
2	45	1.6	3177
3	30.	2.0	2544
			7670

| | 36711 | 2.94 | .97 |

Malmberegning 20/11/85

Profil: Be 30

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Sov	L	t
1	126	112	20	10710	1.05	0.19	4.25		
2	64	26	176	5440	0.47	3.23	4.25	41	.3
3	48	22	110	4090	0.55	2.69	4.26	14	4.5
4	20	35	4	1516	2.30	0.25	3.79	12	4
5	17	19	51	1404	1.38	3.61	4.13	7	3
6	39	23	97	3003	0.76	3.22	3.85	18	1.7
7	16	8	41	1325	0.62	3.09	4.14	16	2.4
8	22	56	18	1663	3.37	1.09	3.78	4	4
9	56	205	33	4514	4.54	0.74	4.03	12	1.8
10	7	17	1	458	3.81	0.18	3.27	13	4.3
11	17	105	5	1510	6.93	0.31	4.44	7	3.4
12	111	253	125	8281	3.11	1.52	3.73	23	5
13	55	84	4	3548	2.37	0.11	3.22	15	3.6
14	57	55	77	3990	1.37	1.93	3.50	24	2.4

****

| TOT: | 655 | 1085 | 753 | 51446 | | | | 196 | |
| GJ.SN: | | | | | 1.99 | 1.48 | 3.93 | | 3.3 |

Waste rock

Alt.1

t'

1	31	2	6970
2	7	.5	595
3	12	1	1022
4	14	2	1061
5	33	3.3	2726
6	42	2.6	3203
7	4	1	331
8	38	3.2	2903
9	9	.7	733
10	11	1.6	995
13	21	1.4	1352
14	62	2.6	4368

26259

77705 1.32 .98

Alt. 2

5	8	.8	661
6	1.6	.1	123
8	8.4	.7	635
14	2.4	.1	168

1587

53033 1.93 1.44

Profil: 82 31

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	47	34	62	4324	0.79	1.43	4.60	26	1.8
2	98	54	256	8389	0.64	3.05	4.28	17	5.8
3	36	39	167	3190	1.20	5.23	4.43	14	2.5
4	19	33	5	1383	2.37	0.38	3.64	7	2.7
5	19	10	4	1330	0.72	0.27	3.50	7	2.7
6	60	59	214	4560	1.30	4.70	3.80	15	4
7	35	20	101	2765	0.72	3.64	3.95	20	1.7
8	17	67	3	1282	5.26	0.21	3.77	7	2.4
9	24	24	32	1752	1.35	1.85	3.65	10	2.4
10	88	179	129	6213	2.88	2.06	3.53	24	3.6
11	32	165	16	2223	7.12	0.71	3.63	11	2.9
12	51	129	17	3448	3.75	0.50	3.36	15	3.4
13	70	74	62	4890	1.57	1.33	3.36	25	2.8

****

| TOT: | 596 | 886 | 1067 | 45649 | | | | 198 | |
| GJ.SN: | | | | | 1.94 | 2.34 | 3.83 | | 3.0 |

waste rock

Alt. 1

t'

1	83	3.2	7654
3	35	2.5	3101
4	16	2.3	1172
5	16	2.3	1127
6	15	1	1140
7	66	3.3	5214
8	18	2.6	1372
9	26	2.6	1893
10	33	1.4	2372
11	23	2.1	1686
12	24	1.6	1622
13	55	2.2	3685
			32043

| | | | 77692 | 1.14 | 1.37 |

1	18	.7	1656
7	16	.8	1264
8	.7	.1	53
9	1	.1	73
			3046

| | | | 48695 | 1.82 | 2.19 |

Malmberegning 21/11/89

Profil: B2 32

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	59	70	32	5098	1.37	0.63	4.32	25	2.4
2	37	25	88	2945	0.84	2.98	3.98	15	2.5
3	32	53	26	2938	1.80	0.87	4.59	10	3.2
4	38	24	79	2934	0.81	2.69	3.86	32	1.2
5	18	108	2	1357	7.90	0.17	3.77	15	1.2
6	63	330	11	4649	7.10	0.24	3.69	15	4.2
7	196	450	146	14034	3.21	1.04	3.58	40	4.9

****

| TOT: | 443 | 1054 | 384 | 33955 | | | | 152 | |
| GJ.SN: | | | | | 3.10 | 1.13 | 3.83 | | 2.9 |

Waste rock

Alt. 1

t'

1	65	2.6	5616
2	38	2.5	2985
3	18	1.8	1652
4	121	3.8	9387
5	57	3.8	4298
6	12	.8	886
7	4	.1	286

25110

59065   1.78   .65

Alt. 2.

1	2.5	.1	216
4	42	1.3	3242
5	20	1.3	1508

4966

38921   2.70   .99

Malmberegning 21/11/89

Profil: B2 33

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	153	319	13	11903	2.68	0.11	3.89	55	2.8
2	125	194	9	7775	2.50	0.12	3.11	5c	2.5
3	53	105	45	3551	2.96	1.26	3.35	9	5.9
4	110	111	20	6952	1.59	0.29	3.16	38	2.9

****

| TOT: | 441 | 729 | 87 | 30181 | | | | 152 | |
| GJ.SN: | | | | | 2.42 | 0.29 | 3.42 | | 2.9 |

Waste reck

Alt. 1

t'

1	121		2.2	9414
2	125		2.5	7775
4	110		2.1	6952
				24141

54322   1.34   .16

Alt. 2

1-4	0	0	0

30181   2.42   .29

Malmberegning 21/11/89

Profil: B2 34

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Sov	L	t
1	122	254	10	9492	2.68	0.11	3.89	40	3
2	133	207	10	8273	2.50	0.12	3.11	48	2.8
3	61	121	51	4087	2.96	1.26	3.35	20	3
4	117	118	21	7394	1.59	0.29	3.16	38	3.1

****

| TOT: | 433 | 700 | 92 | 29246 | | | | 146 | |
| GJ.SN: | | | | | 2.39 | 0.31 | 3.38 | | 3.0 |

Waste rock

Alt. 1

t'

1	80	2
2	106	2.2
3	40	2
4	76	2
	302	

20415

49655   1.41   .18

Alt. 2

| 1-4 | 0 | 0 |

29246   2.39   .31

App. 2   Block 20.

Malmberegning 22/11/89

Profil: B2 20

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	ℓ	t
1	116	315	34	8398	3.75	0.41	3.62	11	11
2	23	51	4	2019	2.51	0.19	4.39	10	2.3
5	12	40	1	1054	3.78	0.11	4.39	5	2.4
6	52	156	6	3817	4.09	0.15	3.67	11	4.7
7	47	77	6	3769	2.05	0.15	4.01	11	4.3
8	41	64	3	3559	1.81	0.08	4.34	8	5.1
9	16	36	49	1264	2.84	3.88	3.95	10	1.6
10	21	36	22	1739	2.07	1.25	4.14	13	1.6
11	33	26	40	2284	1.15	1.76	3.46	15	2.2
12	51	106	94	3519	3.02	2.67	3.45	17	3.0
13	39	37	66	2753	1.36	2.39	3.53	20	2.0
14	24	21	19	1925	1.08	1.01	4.01	19	1.2
15	34	59	8	2516	2.35	0.33	3.70	17	2.0

****

| TOT: | 509 | 1024 | 352 | 38616 | | | | 167 | |
| GJ.SN: | | | | | 2.65 | 0.91 | 3.79 | | 3.0 |

Waste rock   Alt. 1

		t'	
2	27	2.7	2370
5	13	2.6	1141
6	3	.3	242
7	7.7	.7	618
9	34	3.4	2686
10	44	3.4	3643
11	42	2.8	2906
12	34	2.0	2346
13	60	3.0	4236
14	72	3.8	5774
15	51	3.0	3774
			29736
			68352	1.50	.51

Alt. 2

2	2	.2	176
5	.5	.1	44
9	9	.9	711
10	12	.9	994
11	5	.3	623
13	10	.5	706
14	25	1.3	2005
15	9	.5	666
			5925
			44541	2.30	.79

Malmberegning 30/ 3/88

Profil: B2 21

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	$\angle$	t
1	13	2	33	972	0.23	3.40	3.74	8	1.6
2	33	6	41	2251	0.28	1.83	3.41	10	3.3
3	24	2	46	1685	0.14	2.75	3.51	6	4
4	32	183	4	2522	7.24	0.15	3.94	8	4
5	51	130	3	3570	3.65	0.09	3.50	16	3.2
6	16	48	13	1187	4.05	1.11	3.71	15	1
7	17	47	11	1187	3.97	0.92	3.49	8	2
8	46	211	21	3422	6.17	0.60	3.72	8	5.7
9	105	384	30	8715	4.41	0.34	4.15	18	5.8
10	43	34	29	2812	1.22	1.03	3.27	21	2
11	11	23	1	706	3.27	0.09	3.21	5	2.2
12	36	32	105	2628	1.23	3.99	3.65	11	3.3
13	60	85	129	4524	1.88	2.86	3.77	12	5
14	56	43	153	4603	0.93	3.33	4.11	17	3.3
15	42	35	104	2982	1.19	3.50	3.55	12	3.5
16	31	31	82	2319	1.33	3.53	3.74	15	2

****

| TOT: | 616 | 1296 | 805 | 46085 | | | | 190 | |
| GJ.SN: | | | | | 2.81 | 1.75 | 3.74 | | 3.2 |

waste rock

Alt. 1

		t'	
1	27	3.4	2020
2	17	1.7	1159
3	6	1	421
4	8	1	630
5	29	1.8	2030
6	60	4	4452
7	24	3	1675
9	63	3	4120
10	14	2.8	899
11	19	1.7	1387
14	29	1.7	2384
15	18	1.5	1278
16	45	3	3366
			25821

| | 71906 | 1.80 | 1.12 |

Alt 2

1	7	.9	524
6	22	1.5	1632
7	4	.5	279
10	10	.5	654
11	2	.3	128
16	7.5	.5	561
			3778

| | 49863 | 2.60 | 1.62 |

Malmberegning 5/ 4/88

Profil: B2 22

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	34	39	27	2638	1.46	1.04	3.88	5	6.8
2	30	86	3	2358	3.64	0.11	3.93	5	6
3	162	331	186	12474	2.65	1.49	3.85	10	16.2
4	122	88	324	10736	0.82	3.02	4.40	15	8
5	38	56	165	3116	1.80	5.29	4.10	12	3.1
6	32	59	116	2797	2.10	4.13	4.37	16	2
7	23	108	5	1748	6.16	0.27	3.80	15	1.5
8	20	29	8	1340	2.20	0.62	3.35	10	2
9	42	55	2	3032	1.80	0.06	3.61	10	4.2
10	69	140	23	4651	3.00	0.49	3.37	14	5
11	14	27	8	902	2.98	0.88	3.22	5	2.8
12	26	20	29	1960	1.01	1.50	3.77	9	2.8
13	37	33	85	2701	1.23	3.14	3.65	20	1.8

****

| TOT: | 649 | 1071 | 981 | 50453 | | | | 146 | |
| GJ.SN: | | | | | 2.12 | 1.94 | 3.89 | | 4.4 |

Waste rock

Alt. 1

		t'
5	23	1.9
6	48	3
7	-53	3.5
8	30	3
9	8	.8
11	11	2.2
12	20	2.2
13	64	3.2
	254	19995

| | 70448 | 1.52 | 1.39 |

Alt. 2

6	8	.5
7	15	1
8	5	.5
13	14	.7
	42	3268

| | 53721 | 1.99 | 1.82 |

Malmberegning 22/11/89

Profil: 32 23

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	85	53	291	7038	0.75	4.13	4.14		
2	213	320	439	19255	1.66	2.28	4.52		
3	33	117	2	2653	4.42	0.06	4.02	60	7.5
4	40	63	10	3008	2.11	0.34	3.76		
5	78	156	63	6209	2.51	1.01	3.98		
6	16	11	33	1379	0.81	2.36	4.31	5	3.2
7	28	38	59	2122	1.79	2.78	3.79	10	2.8
8	32	67	35	2285	2.94	1.53	3.57	11	2.9
9	49	102	43	3763	2.70	1.13	3.84	17	2.9
10	40	231	33	2912	7.94	1.15	3.64	10	4
11	16	38	2	1046	3.59	0.21	3.27	8	2
12	11	29	1	693	4.19	0.13	3.15	8	1.4
13	26	24	86	2044	1.19	4.22	3.93	10	2.6
14	31	42	59	2505	1.69	2.34	4.04	10	3.1
15	54	96	66	4720	2.04	1.39	4.37	12	4.5
16	28	50	19	1949	2.55	0.97	3.48	14	2
17	31	67	41	2418	2.78	1.71	3.90	10	3.1
18	40	23	47	2800	0.82	1.67	3.50	12	3.3
19	23	12	31	1541	0.76	2.02	3.35	11	2
20	13	7	33	944	0.73	3.50	3.63	10	1.3

****

TOT: 887   1546   1393   71284   218

GJ.SN: 2.17 1.95 4.02   4.0

Waste rock

Alt. 1

		t'
6	9	1.8
7	22	2.2
8	23	2.1
9	36	2.1
10	10	1
11	24	3
12	29	3.6
13	24	2.4
14	19	1.9
15	6	.5
16	42	3
17	19	1.9
18	20	1.7
19	33	3
20	37	3.7
	353	28381

99665   1.55   1.39

Alt. 2

11	4	.5
12	9	1.1
16	6	.5
19	6	.5
20	12	1.2
	37	2975

74259   2.08   1.87

Malmberegning 22/11/89

Profil: 82 24

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Sov	L	t
1	43	28	60	3354	0.84	1.79	3.30	10	4.3
2	30	24	13	2328	1.04	0.55	3.88		
3	46	52	21	3643	1.42	0.59	3.96	18	5.9
4	31	25	166	2635	0.96	6.30	4.25		
5	25	40	1	1595	2.50	0.07	3.19	10	2.5
6	99	69	7	6514	1.06	0.11	3.29		
7	45	73	20	3465	2.11	0.59	3.85	20	7.2
8	20	21	12	1488	1.43	0.84	3.72	7	2.9
9	142	372	25	10622	3.50	0.24	3.74	20	7.1
10	16	21	1	1123	1.88	0.07	3.51	8	2
11	34	132	5	2509	5.37	0.18	3.69	15	2.2
12	107	71	252	8860	0.80	2.84	4.14		
13	31	36	111	2716	1.32	4.10	4.38	15	9.2
14	22	69	3	1720	4.00	0.17	3.91	7	3.1
15	66	95	40	4422	2.14	0.91	3.35		
16	40	83	42	2672	3.12	1.57	3.34	17	6.2
17	14	131	5	1112	11.75	0.41	3.97	7	2
18	73	123	4	4599	2.67	0.09	3.15	10	1.3
19	29	59	11	1960	3.03	0.54	3.38	10	2.9
20	38	32	1	2386	1.34	0.03	3.14	11	3.5
21	15	22	9	1005	2.15	0.85	3.35	8	1.9

****

| TOT: | 966 | 1578 | 809 | 70728 | | | | 193 | |
| GJ.SN: | | | | | 2.23 | 1.14 | 3.66 | | 5.0 |

Waste rock   Alt. 1

		t'
1	7	.7
5	25	.5
8	15	2.1
10	24	3
11	42	2.8
14	13	1.9
17	21	3
19	21	2.1
20	17	1.5
21	25	3.1
	210	

15372

86100 1.83 .94

Alt. 2

10	4	.5
11	4.5	.3
17	3.5	.5
21	4.8	.6
	16.8	

1229

71957   2.19   1.12

Malmberegning 23/11/89

Profil: B2 25

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Sov	L	t
1	39	15	40	3042	0.49	1.30	3.90	20	2
2	21	53	3	1764	2.99	0.19	4.20	7	3
3	56	102	2	3539	2.89	0.06	3.16	25	5
4	67	432	63	5239	8.24	1.20	3.91		
5	30	90	4	2184	4.13	0.18	3.64	10	3
6	12	78	2	893	8.69	0.17	3.72	6	2
7	35	72	3	2317	3.10	0.12	3.31	7	5
8	4	10	0	262	3.82	0.07	3.27	4	1
9	20	44	1	1296	3.43	0.07	3.24	12	5.9
10	51	174	6	3560	4.90	0.16	3.49	5	4
11	21	59	2	1420	4.17	0.12	3.38	12	5
12	61	66	259	4856	1.35	5.33	3.98		
**********	**********	**********	**********	**********	**********	**********	**********	108	
TOT:	417	1195	385	30372					
GJ.SN:					3.93	1.27	3.64		3.8

Waste rock

Alt. 1

		t'
1	60	3
2	14	2
5	20	2
6	18	3
8	16	4
11	5	1
	133	9682
		40054 2.98 ,96

1	10	.5
6	3	.5
8	6	1.5
	19	1383

31755 3.76 1.21

Malmberegning 28/11/89

Profil: B2 13

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	92	112	14	6532	1.71	0.22	3.55		>5
2	46	47	4	3128	1.51	0.12	3.40		>5
3	41	69	49	3592	1.92	1.37	4.38	10	4.1
4	71	72	70	5439	1.33	1.29	3.83		>5
5	185	335	93	13912	2.41	0.67	3.76		>5
6	50	27	2	3000	0.89	0.05	3.00	11	4.5
7	43	25	2	2563	0.97	0.08	2.93	10	4.3
8	105	88	11	6594	1.34	0.17	3.14		
9	27	48	10	1782	2.67	0.56	3.39		>5
10	54	40	40	4493	0.88	0.89	4.16	10	2.7
11	72	123	2	5990	2.05	0.04	4.16	16	3.4
12	28	38	4	2290	1.53	0.16	4.09	8	>5
13	54	89	12	4039	2.20	0.29	3.74	16	3.5
14	71	241	15	5410	4.45	0.28	3.81	23	3.4
15	54	193	17	4765	4.06	0.36	4.41		3
	993			73527	2.11	0.47	3.87		>5

Waste rock

Alt. 1

		t'
3	9	.9
6	5.5	.5
7	7	.7
9	23	2.3
10	26	1.6
12	12	1.5
13	26	1.6
14	46	2
	155	11958

85485   1.81   .40

Alt. 2

1-15	0	0

73527   2.11   0.47

Profil: 82 14

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Sov	L	t
1	89	191	21	6550	2.91	0.32	3.68		>5
2	80	74	102	5856	1.26	1.74	3.66		>5
3	44	39	57	3265	1.18	1.73	3.71	13	3.4
4	15	6	21	1197	0.49	1.79	3.59	7	2.1
5	93	89	71	8407	1.06	0.85	4.52	36	2.6
6	33	63	18	2574	2.43	0.70	-3.90	18	1.8
7	23	51	5	1707	2.97	0.29	3.71	6	3.8
8	24	29	9	1843	1.59	0.48	3.84		>5
9	59	66	8	4177	1.57	0.19	3.54		>5
10	58	73	7	4338	1.75	0.17	3.74	17	3.4
11	85	121	12	6120	1.37	0.19	3.60		>5
12	12	20	4	845	2.42	0.43	3.52	5	2.4
13	13	24	1	879	2.72	0.16	3.38	7	2
14	39	66	5	2941	2.26	0.16	3.77		>5
15	18	36	2	1296	2.81	0.17	3.60	7	2.5
16	8	14	3	642	2.16	0.53	4.01	4	2
18	30	95	4	2262	4.18	0.18	3.77		
19	10	28	1	678	4.10	0.15	3.39		
20	17	70	2	1261	5.59	0.17	3.71		
21	43	66	8	3474	1.90	0.24	4.04		
22	78	93	6	6521	1.43	0.09	4.18		

$\longrightarrow$ lake Hjernet

****

TOT: 871 1217 367 66533

GJ.SN: 693 52637 ~~1.97 0.86 3.8~~

1.83 0.65 3.84

Waste rock

Alt. 1

		t'
3	21	1.6
4	20	2.9
5	86	2.4
6	58	3.2
10	27	1.6
12	13	2.6
13	21	3.
15	18	2.5
16	12	3
	276	21197

73834 1.30 .46

Alt. 2

4	3	.4
6	13	.7
12	.5	.1
13	3.5	.5
16	2	.5
	22	1690

54327 1.77 .63

Malmberegning 28/11/89

Profil: B2 15

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Sov	L	t
1	32	91	14	2662	3.41	0.52	4.16	15	2
2	29	74	15	2378	3.12	0.64	4.10	10	2.9
3	38	117	7	2850	4.10	0.23	3.75	11	3.4
4	58	58	35	3689	1.53	0.94	3.18		>5
5	27	68	22	1836	3.72	1.20	3.40	11	2.5
6	31	38	6	1922	1.99	0.29	3.10	15	2
7	29	58	4	2065	2.79	0.21	3.56	17	1.7
8	33	24	10	2099	1.14	0.48	3.18	15	2.2
9	19	33	7	1239	2.64	0.59	3.86	15	1.3
10	17	82	1	1360	6.00	0.10	4.00	17	1
11	41	54	59	3460	1.56	1.71	4.02		
12	46	64	7	3827	1.67	0.17	4.15		

****

TOT:	400	761	187	29387			
GJ.SN:	313			22100	2.89	0.64	3.67
					2.91	0.55	3.67

Waste rock

Alt. 1

		t'
1	45	3
2	21	2.1
3	18	1.6
5	28	2.5
6	45	3
7	56	3.3
8	42	2.8
9	56	3.7
10	68	4
	379	27818

49918   1.29   .24

Alt. 2

1	7.5	.5
6	7.5	.5
7	14	.8
8	4.5	.3
9	18	1.2
10	26	1.5
	78	5689

27789   2.31   .44

Malmberegning 21/ 3/88

Profil: B2 16

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	24	63	17	1954	3.20	0.87	4.07	15	1.6
2	99	85	4	5960	1.43	0.07	3.01		>5
3	101	204	23	6464	3.16	0.35	3.20		>5
4	33	89	7	2924	3.05	0.23	4.43	11	3
5	21	29	1	1705	1.68	0.07	4.06	6	3.5
6	50	82	5	3230	2.53	0.14	3.23		>5
7	24	13	27	1714	0.76	1.58	3.57	7	3.4
8	20	19	44	1568	1.21	2.81	3.92	7	3

****

TOT:	372	584	128	25519					
GJ.SN:					2.29	0.50	3.43		

Waste rock

Alt. 1

		t'
1	51	3.4
4	22	2
5	9	1.5
7	11	1.6
8	14	2
	107	7340

32859	1.78	.39

Alt. 2

1	14	.9
	14	960

26479	2.21	.48

Malmberegning 24/ 3/88

Profil: B2 17

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	.31	23	4	1972	1.18	0.19	3.18	8	4
2	47	73	8	2942	2.48	0.26	3.13	15	3
3	19	73	4	1638	4.48	0.22	4.31	7	2.7
4	76	152	8	5305	2.86	0.16	3.49	22	3.5
5	29	32	3	1891	1.67	0.17	3.26	7	4
6	38	42	13	2660	1.58	0.47	3.50	12	3.1
7	100	73	22	6540	1.12	0.33	3.27	29	3.4

****
TOT: 340   468   62   22948
GJ.SN: 2.04   0.27   3.37

Waste rock

Alt. 1

		t'
1	8	1
2	30	2
3	16	2.3
4	33	1.5
5	7	1
6	23	1.9
7	46	1.6
	163	

10986

33934   1.38   .18

Alt. 2

1-7   0   0

22948   2.04   .27

Malmberegning 24/ 3/88

Profil: B2 18

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	37	49	17	2553	1.90	0.67	3.45	13	2.8
2	33	80	67	2482	3.24	2.70	3.76	8	4.1
3	44	46	27	3115	1.49	0.86	3.54	15	2.9
4	26	22	29	2288	0.94	1.27	4.40	11	2.3
5	67	65	25	5668	1.15	0.44	4.23	14	4.8
6	41	19	89	3337	0.56	2.67	4.07	11	3.7
7	87	83	49	7169	1.16	0.69	4.12	20	4.3
8	65	82	20	5447	1.51	0.37	4.19	20	3.2
9	50	274	13	4320	6.34	0.31	4.32		>5
10	29	37	6	2424	1.53	0.25	4.18		>5
11	33	31	4	2488	1.23	0.18	3.77	13	2.5
12	37	50	2	2775	1.79	0.07	3.75	15	2.5
13	91	28	6	5642	0.49	0.10	3.10	23	4

****

TOT:	640	866	354	49708					
GJ.SN:					1.74	0.71	3.88		

Waste rock

Alt.1

t'

1	29	2.2
2	7	.9
3	32	2.1
4	30	2.7
5	3	.2
6	14	1.3
7	14	.7
8	36	1.8
11	32	2.5
12	38	2.5
13	23	1
	258	20021

69729 1.24 .51

Alt. 2

0   0

1-13

49708 1.74 .71

Malmberegning 28/ 3/88

Profil: B2 19

Blokk	Areal	Cu	Zn	Tonn Tot	Cu	Zn	Spv	L	t
1	21	65	16	1634	3.95	0.97	3.89	8	2.5
2	-30	38	88	2172	1.75	4.05	3.62	15	2
3	12	47	5	874	5.33	0.60	3.64	9	1.3
4	54	41	71	3650	1.13	1.94	3.38		>5
5	41	13	63	2640	0.50	2.39	3.22	15	2.7
6	73	138	34	5548	2.49	0.62	3.80	30	2.4
7	113	120	8	7413	1.62	0.11	3.28	25	4.5
8	17	17	1	1129	1.53	0.11	3.32	8	2
9	31	39	2	2003	1.93	0.09	3.23	13	2.4
10	33	66	2	2264	2.90	0.10	3.43	15	2.2

****

TOT:	425	584	290	29327					
GJ.SN:					1.99	0.99	3.45		

Waste rock

Alt. 1

t'

1	20	2.5
2	45	3
3	33	3.7
5	35	2.3
6	78	2.6
7	13	.5
8	24	3
9	34	2.6
10	42	2.8

22356

324	

51683   1.13   .56

Alt. 2

2	7	.5
3	11	1.2
6	3	.1
8	4	.5
9	1	.1
10	5	.3

2139

31

31466   1.85   .92
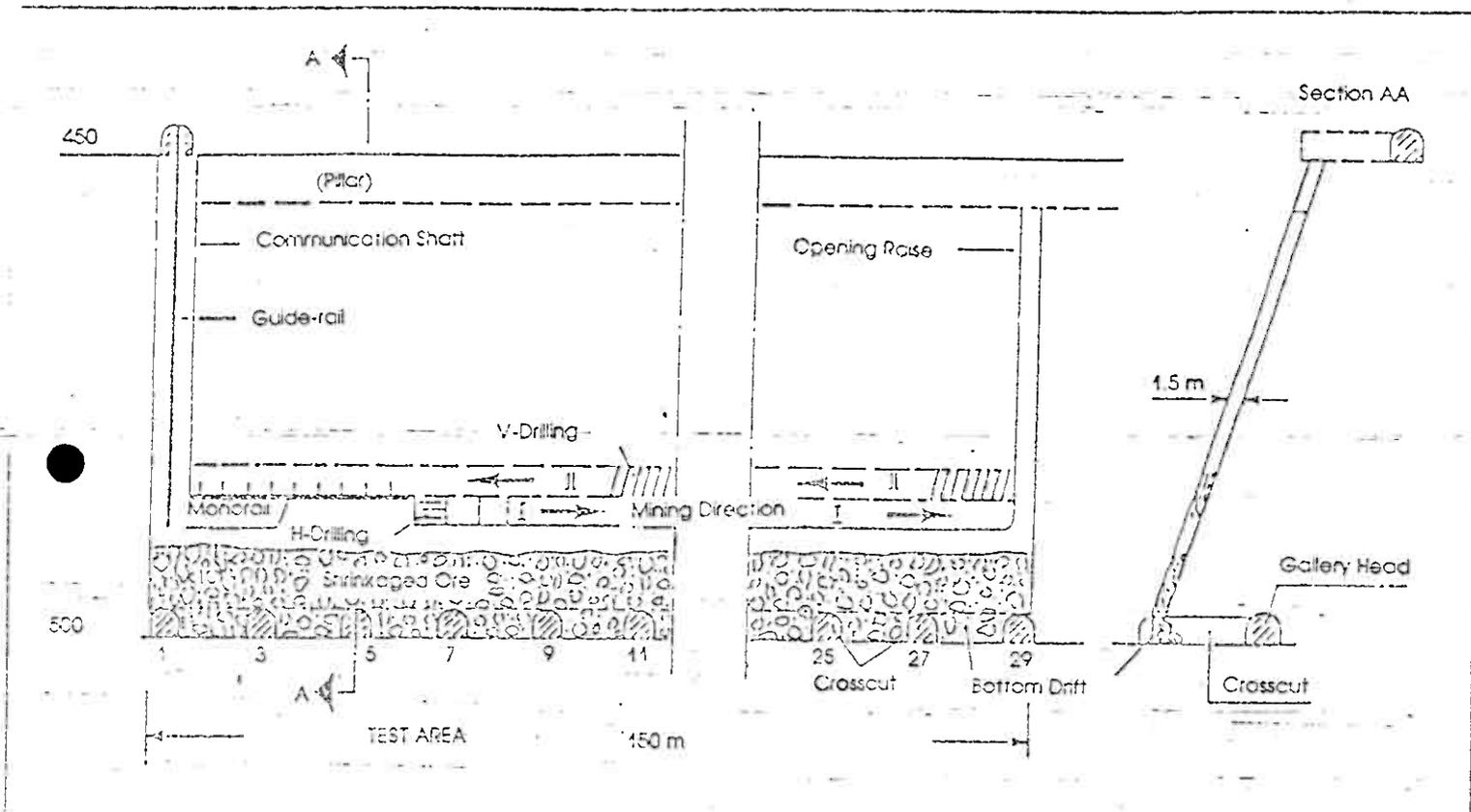
Fig. 1— Proposals for mechanized shrinkage-stoping using monorails.
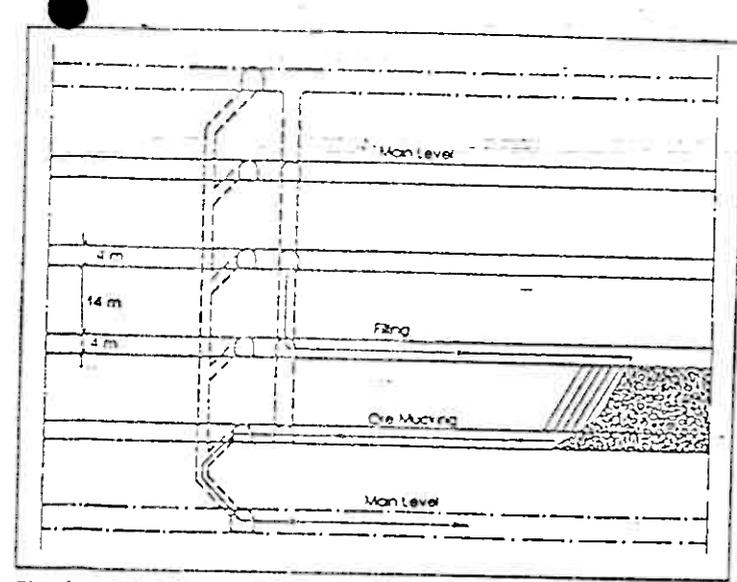
Fig. 3— Rill mining as practiced at Kristineberg.
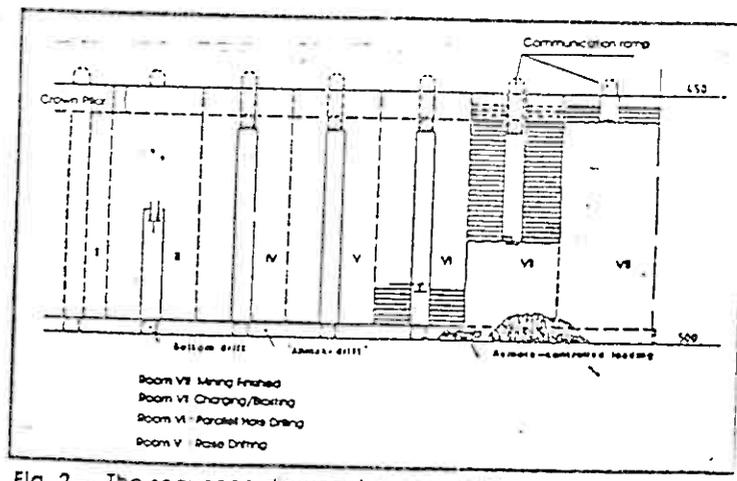
Fig. 2— The sequence diagram for raise mining.

MINING METHOD	Productivity in ton per manshift				
	30	60	90	120	150
Open pit					
Block caving					
Room and pillar					
Sub-level caving					
Cut-and-fill stabilized					
Drift-and-fill stabilized					
Undercut and fill stabilized					

Figure 5 – Productivity for different mining methods

MINING METHOD	Operating cost $ per ton crude ore					
	3	6	9	12	15	18
Open pit						
Block caving						
Room and pillar						
Sub-level caving						
Cut-and-fill stabilized						
Drift-and-fill stabilized						
Undercut and fill stabilized						

Figure 6 – Operating costs for different mining methods

MINING METHOD	Waste rock dilution into crude ore & ore losses					
	10%	20%	30%	40%	50%	60%
Open pit						
Block caving						
Room and pillar						
Sub-level caving						
Cut-and-fill stabilized						
Drift-and-fill stabilized						
Undercut and fill stabilized						

▭ Waste rock dilution into crude ore
▭ Ore losses

Figure 7 – Waste rock dilution and ore losses for different mining methods.

than Bolliden's are used when planning mine, this can then result in other mini methods being referred to for instan the CFM technique. Such criteria cou be:

- optimum economic profit when min a mineral deposit

- winning of all mineralized mater in the deposit, whether it's ore or r

CFM methods do normally have hig cost per ton ore mined compared w other underground bulk-mining metho Anyway, these higher costs are well comps sated by the two big advantages of CFM methods.

2.1 High ore recovery - low waste dilut

The economic consequences of these t factors have been well stressed in a pap by Professor G. Almgren, compiled the Näsliden symposium here in Luleå 1980.

In that paper, the technique for calculat the "net-present-value" (NPV) of an deposit, is presented. By varying the ope ting costs, the waste dilution factor the ore recovery etc, of different min methods, the effect on the NPV of deposits can be studied.

The impact of waste dilution and of loss in an actual case, are calculated a given scenario. Figure 8.

Assuming in this case that by chang the existing mining method to a new met where both the dilution and the ore percentages will be reduced from 20 to 10 %, the operating costs for the mining method can then be as much 25 % higher than for the old method still result in a higher NPV for the depo

It should be noted that:

- a 25 % increase in operating costs a substantial increase for a new met

- a 10 % decrease in waste dilution a small decrease when changing from bulk-mining method to CFM. Possibly % seems more realistic.

Beside the above mentioned two main adv tages, some other advantages character the CFM method.

- The use of waste rock from developm

110

1990

PLAN 5559   GRONG GRUBER A/S

TALLENE KNYTTET OPP MOT REGNEARK
KONTRAKT BUDSJETT OG SIR

MALMVERDI/PRODUKSJONSKOST

		Kr/tonn	Kr/kg	%
CU	Metallinnhold i konsentrat		230	
	Bruttoverdi 1000 kg kons.	3451	15,00	100
	Fradrag smelteverk	1028	4,47	29,79
	Cif-verdi	2423	10,53	70,21
	Sir	308	1,34	8,92
	Verdi ab Joma Cu-innhold	2115	9,20	61,28
AG	Bruttoverdi	274	1,19	100
	Fradrag smelteverk	41	,18	15
	Cif-verdi	233	1,01	85
	Sir	0	0	0
	Verdi ab Joma Cu-innhold	233	1,01	85
CU + AG	Verdi ab Joma	2348	10,21	
ZN	Metallinnhold i konsentrat		450	
	Bruttoverdi 1000 kg kons.	4572	10,16	100
	Fradrag smelteverk	1596	3,55	34,90
	Cif-verdi	2976	6,61	65,10
	Sir	261	,58	5,71
	Verdi ab Joma Zn-innhold	2715	6,03	59,39

	RAMALM T	CU	ZN	AG gr.
PÅGANG TONN	535000	1,35	1,87	
UTVINNING %		86,19	82,39	
MALM TONN		6225	8243	
KONSENTRAT %		24	53	
KONSENTRAT		25938	15552	
AG gram pr. 1 tonn konsentrat				200
ANTALL KG AG				5188

MALMVERDI:

CU:	D33*D11/C31*1000	107,00
AG:	F37*D18/C31*1000	9,81
ZN:	E33*D26/C31*1000	92,96
MALMVERDI		209,77
TOTAL PRODUKSJONSKOST JOMA (73680+9000-1800)/535=		151,18 ✓
FORTJENESTE PR. TONN RAMALM		58,59

ENULL!

gruve (35438+3583)/535=39021/535:
=72.94
opredn: (20345+3742)/535=24087
evrige   /535=45.02

17772/535=33.22

App. 7.

pr20   tab. 1

antall prover	gehalts område	Cu utv	ant pr.	Zn utv
27	0.8-1.0	81.25	5	69.35
74	1.0-1.2	83.93	25	72.20
77	1.2-1.4	85.78	50	75.04
75	1.4-1.6	86.50	72	77.35
30	1.6-1.8	87.05	55	77.80
11	1.8-2.0	90.15	51	79.44
12	2.0 -	90.63	32	82.49
sum 306			290	

Denne tabellen tar hensyn til bare pågangsgehalt for Cu
eller Zn alene.

Eneste begrensning er at utvinninger under 65 % er tatt bort.

Grunnlaget er driftsanalyser 1988

4

EVALUATION OF MINING NARROW AND NARROW FLAT LYING OREBODIES

These orebodies have been evaluated to be totally
about 450 000 tons. One basic assumption for the
mining method could be to use in steeper parts some
application of cut and fill method. The selectivity
of the mining is very important for the best
possible economical result. To control mining the
sludge drilling is recommended. If all the stopes
will be filled with waste rock from development
works, it can be seen that with the capacity of
50 000 tpa (waste rock) it can be filled 28 000 m3
which gives ore 110 000 t and with the capacity of
70 000 tpa it can be filled 39 000 m3 giving
150 000 t of ore. Without having no detail planning
from these areas, however, it can be considered
that the capacity of 100 000 tpa (ore) is
realistic.

It should be noticed that this capacity is also
necessary to achieve all the ore mined out, if the
life-time of the mine is only 4 to 5 years !

Some mining ideas are presented in app. 10, 11, 12.

It has been collected some information about small
mining equipment from Outokumpu mines. However, it
is no possibility to do any bigger investments. So
it is recommended to build up some applications
from old machines for instance for scaling. At the
mine there is one Wagner ST2. At Keretti mine there
is unused equipment as follows :

- Toro 200D   price about 222 000 NOK
          used   3 000 h
          width   2 000 mm
          height   2 250 mm
          length   7 540 mm
          with safety canoby (no cabin)

- Tamrock-Minimatic   price about 175 000 NOK
          pneumatic
          2 booms, 3.2 m long
          E 400 drillers
          width about 2 000 mm
          height   2 400 mm
          with safety canoby

These equipment can operate in a drift sized about
2.5 m x 3.0 m.

App. 9

PROBLEMS CONCERNED WITH FRAGMENTATION OF ROCK

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ABSTRACT

In this paper, the problems concerned fragmentation of rock blasted by explosive charge are described. Mainly the influence of geological weakness during blasting and the grinding index affected by blasting have been analysed and discussed, also mathematical model of fragmentation is given.

1. Problem of Weakness Influence and Computer Simulation

Measurement at site shows that, there are three forms of the dimension distribution for common weak-surface space:

1) Negative index distribution —— the position of weak-surface is random, that is to say, the formations of weak-surfaces are independent mutually;

2) Uniform distribution —— in certain range, the distribution densities of space size of weak-surfaces are equal;

3) Normal distribution —— the average values of weak-surface space are the most space sizes present. This distribution shows that, the formation of one weak-surface is related to the adjacent weak-surface.

The actual distribution of any sites is described based on the above-mentioned distribution forms similar to the combined distribution form. Fig. 1 is the negative index distribution of weak-surface space in a limestone mine. This distribution form is popular.

Here taking the negative index distribution for example, introducing three dimension distribution of the weak-surface is derived with Monte-Carlo computer

2. Relationship between Grinding Index and Fragmentation Degree

Usually, it is considered that, mining is only to supply desired ore to mineral processing, no much attention is paid to the problem of improving the crushing property of mineral processing through increasing the fragmentation degree of ore and reducing the ore strength in mining process.

In recent years, USSR has got research results on the influence of blasting intensity on the fragmentation property of magnetite-quartzite. The ore block is fragmented by blasting. The grinding efficiency of crude ore is increased by 9-12% due to the development of weak fractures making the mechanical strength of ore reduced. In addition, the cost and energy consumption of the complete fragmentation process of mining, crushing and grinding are analysed, providing the basis for the complete fragmentation process and the reasonable mining of the mines.

In order to find out the relationship between blasting intensity and crushing property, we have done an experiment in a tantalum-niobium mine.

The test results show that, there is a change in the inner fracture of rock sample before and after blasting with 45 g, 60 g and 75 g explosive charges. There is no clear fracture blasted with 45 g charge, clearer fracture with 60 g charge, the numbers of fractures increase from 0.8 pieces/cm^2 before blasting to 1.9 pieces/cm^2; blasting with 75 g charge, fracture numbers per centimeter or per square centimeter considerably increase, 8 times and 2.7 times respectively more than before blasting (See Table 5). The main difference for test between blasting before and after, is the distribution state of fractures changed from branching to network, that is to say, the density and length of fracture increase; simultaneously, the width of the fracture also enlarged, increasing from 0.005-0.01 mm before blasting to 0.04-0.1 mm. The microscope observation result of the above polished section of rock sample shows that, increase of explosive amount can enlarge density and tensile of fracture, therefore increasing explosive consumption per unit ; higher blasting intensity can reduce rock strength; it is favourable for secondary blasting at the working

face, natural fragmentation during haulage, as well as crushing and grinding at concentrators.

In order to analyse the influence of blasting intensity on fragmentation, the measurement of impact-crushing work index was done for fragmental rock blasted by three different amounts of explosives. See Table 6. It can be seen from Table 6, if we want to reduce crushing work index considerably, blasting intensity must be increased. Increasing blasting intensity can reduce rock strength blasted, impact-crushing work index and energy consumption of crushing, and improving crushing efficiency.

The relationship between different blasting intensity and grinding efficiency was studied. The research result shows that, explosive consumption per unit is increased from 0.8 kg/m³ to 1.6 kg/m³; grinding efficiency is increased by 30% (Table 7). By calculation, blasting cost increases 0.384 yuan RMB/t, grinding material and power consumption costs reduce 0.434 yuan RMB/t, 0.05 yuan RMB/t saved for treating 1 ton of crude ore.

Research on particle size of primary fragmentation of hematite-magnetite-quartzite is carried out under the conditions of different explosive consumption per unit. See Table 8. Seeing from Table 8, -60 mm particle size is the most proportion in all the amount of fragmental ore, when explosive consumption per unit increases to 2 kg/m³, -60 mm size increases from 56% to 69.3%. The amount of coarse size decreases from 11.6% to 4.1%; the average size decreases from 81 mm to 57 mm, therefore, leading to accurance of large amount of weak fractures. This micro-defect can play its role sufficiently in secondary and tertiary crushing and grinding. It ensures that, primary crushing efficiency increases by 15-35%, secondary and tertiary crushing by 10-18%, grinding by 5-10%.

The presence of micro-fracture is helpful to rock fissuring. That can not only increase shovel efficiency, but improve crushing, grinding and metallurgical results. See Table 9. (1)

The economic benefit for treating 1 million tons of ore can increase 72900 Rbs by increasing explosive consumption per unit.

4

App. 10   ALT I

NORSULFID GRUPPEN   BUDSJETT OG PLANER 1990 - 1992

SELSKAP :   GRONG GRUBER A/S

PRODUKSJONSPLAN

		Anslag	Budsjett	Prognose	Prognose
		1989	1990	1991	1992
RÅMALM tørrvekt	tonn	497397	535000	545000	550000
KOBBERKONSENTRAT					
Gehalt i råmalm	%	1,45	1,35	1,35	1,35
Utvinning	%	85,69	86,19	86,19	86,19
Kobberinnhold	tonn	6199	6223	6341	6400
Gehalt i konsentrat	%	23,74	24,00	24,00	24,00
Kobberkonsentrat	tonn	26115	25929	26421	26667
SINKKONSENTRAT					
Gehalt i råmalm	%	1,86	1,87	1,87	1,87
Utvinning	%	78,82	82,39	82,39	82,39
Sinkinnhold	tonn	7282	8243	8397	8474
Gehalt i konsentrat	%	52,62	53,00	53,00	53,00
Sinkkonsentrat	tonn	13837	15553	15843	15989
SVOVELKISKONSEN-TRAT					
Gehalt i råmalm	%	0,00	0,00	0,00	0,00
Utvinning	%	0,00	0,00	0,00	0,00
Svovelkisinnhold	tonn	0	0	0	0
Gehalt i konsentrat	%	0,00	0,00	0,00	0,00
Svovelkiskonsentrat	tonn	0	0	0	0

Break-Even Analysis-

The economic efficiency of mine depends upon the net difference between income and costs of production. As above-mentioned income and costs are assumed to be linear function of the quntity of ore production. In this case Break-Even analysis is greatly simplified and mathematical and graphic Break-Even models can be presented for the analysis of profit.

Under assumption of linearity, the pattersn of income and costs will appear as in fig.8. The costs consist of fixed and variable costs. Fixed costs are represented by line AF. The sum of variable cost and fixed cost is represented by line AV. Income is represented by line OI.

Legend

	Unit designation	
Annual ore production	t/y	A
Income per ton of ore production	v/t	I_0
Annual income per year	v/y	I
Fixed cost per year	v/y	c_0
Variable cost per ton	v/t	c'
Sum of fixed and variable costs	v/y	c
Annual profit	v/y	p

Thus

$$P = I - C,$$

or $P = I_0 A - (c_0 + c'A),$

$$P = (I_0 - c')A - c_0$$

The Break-Even point (point B) occurs when lines oI and AV intesect.

At point B, I=C and $I_0 A = c_0 + c'A$, solving for A:

$$A = c_0 / I_0 - c'$$

If $c_0 / (I_0 - c')$ is substituted for A in $I = I_0 A$, the income at the Break-Even point may be found, it is

$$I = I_0 (c_0 / I_0 - c')$$

Likewise, if $c_0 / (I_0 - c')$ is substituted for A in $C = c_0 + c'A$, the cost at the Break-Even point may be found, it is

$$C = c_0 + c'c_0 / I_0 - c'$$

Suppose that a mine is operating with costs of 10 v/t, 50% variable specific cost is 5 v/t, and 50% fixed cost of 5.100000=500000 v/y.

$$I_0 = 245.0.9.0.02 / 0.22 (1 - 0.25) = 15 \ v/t$$

The Break-Eben point under these conditions is

$$A = c_0 / I_0 - c' = 500000 / 15 - 5 = 50000 t/y$$

If 60000 t/y are being produced,the annual profit is

$$P=(I_0-C')A-C_0=(15-5)60000-500000=100000 \text{ v/y}$$

Any change in the income or the cost will affect the Break-Even point.
If the variable cost is reduced to 4.5 v/t by using more effective mining method,the Break-Even point will be:

$$A= 500000/15-4.5=47600 \text{ t/y}$$

At 60000 t/y,the annual profit will now be
$$P=(15-4.5)60000-500000=130000 \text{ v/y}$$
Thus up to 130000-100000=30000 v/y.
If the fixed cost is reduced to 450000 v/y,the Break-Even point will be

$$A=450000/15-5=45000 \text{ t/y}$$
At 60000 t/y,the annual profit $P=(15-5)60000-450000=$ 150000 v/y
As a effective approch for reducing the Break-Even point, consider a improving ore quality that will make it possible to increase the income to 17 v/t,the Break-Even point would be
$$A=500000/17-5=41700 \text{ t/y, and}$$
$$P=(17-5)60000-500000=220000 \text{ v/y}$$
Often it is possible to reduce the Break-Even point and increase profit as a result of combination of income and costs(5).There are three possibilities to increase the profit to be considered.The situations which will bring positive profit are characterized in following manners, see fig.9.

$$P=+ \begin{cases} I_2 > I_1 & C_2 \gtreqqless C_1 \\ I_2 = I_1 & C_2 < C_1 \\ I_2 < I_1 & C_2 << C_1 \end{cases}$$

Present situation is giving index 1 and the changed situation index 2 .

App. 12.

	c	c_f	c_v

HITTIL IAR		
RES.	PLAN	AVVIK %
356672	386400	-7.69
28423	36960	-23.10
354874	382756	-7.28
1.53	1.40	
.22	.19	
23.65	24.00	
4669	4646	.50
85.86	86.71	
1.76	1.73	
.35	.25	
52.42	53.00	
4690	5468	-14.23
75.26	82.58	

18065
8498

	HITTIL IAR	ARSPLAN				
	1000KR	KR/T	KR/T			
mine	27066	76.27	62.29	_40% 24.72	60% 37.37
Conc.	14787	41.67	40.16	_35% 14.06	65% 26.10
mine + conc.	41853	117.94	102.45		
Hjelpeavd.	5479	15.44	13.90	65% 9.04	35% 4.86
insteerten	1642	4.63	3.91	100% 3.91	
Prosperdering	347	.98	1.33	100% 1.33	
Genralia	4953	13.96	15.82	85% 13.45	15% 2.37
Kontenadm	1104	3.11	2.86	100% 2.86	
	0				
others sum	13525	38.11	37.82		
Total Jonna	55378	156.05	140.27	69.57	70.70

	BUDSJETT	ANSLAG			
	HITTIL	ARET			
	78855	146904		
	-73	-19441		
SIR	8194	20,95 10925	0	100% 20.95
	70588	116538		
	900	1200		
	55521	76000		
	-	5506		
	15967	47244		
	-1500	-1500		
	11925	15900		
	4125	5500		
	6667	35344		

Total	161.22	69.57	91.65