THE LATES MINING TECHNICAL SOLUTIONS IN THE VUONOS MINE PROMOTING BETTER ECONOMY OF OPERATION

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ABSTRACT

The orebodies we mine are small and usually also of low grade, and to improve their profitability we must apply new technology. Our contact with Finnish manufacturers of minin equipment has stood us in good stead. In Finland we are self sufficient m all the key mining machines, and many of the jointly developed machines have sold well abroad as well

We are currently developing sub-level stoping, which is the predominant stoping method we use, one of the main aims being to reduce dilution. The stopes are reinforced with cable bolting, and this is just about under control from planning right through to realization. We are using the first largely mechanized cable bolting equipment developed by Outokumpu Oy. We have favourable experience of big blasts in sublevel stoping. We are interested in large-diameter stoping holes. We have developed hardening back fill, which is imperative in many cases, by replacing concrete with milled furnace slag.

To intensify drifting we are increasing the length of the round. For the last few years we have not acquired pneumatic drilling units, all our machines being hydraulic. We have investigated the feasibility of fully electrical mining, which would not need pipelines of compressed air; we should have the final answer in the near future.

We follow with interest developments in electric loaders and trucks. Their use would enable us to reduce ventilation, which, in our cold climate, would reduce the costs of heating ventilation air during six months of the year.

We believe that in the next few years we shall be able to develop new mines. The mining plans proper will be done by applying computers.

Present-day technology offers interesting prospects for improving this respect, and we must develop technology in order to meet the challenge posed by mines being exhausted and the necessity of exploiting leaner ore deposits.

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1. GENERAL

Outokumpu Oy is the leading mining company in Finland, with activities covering the production of various metals and their processing. Turnover in **1984 was FIM 4.500** million and the number of employees was 8.700 at the end of the year. Exports, accounted for about 80% of Outokumpu Oy sales.

Ten mines are currently in production, but two of them will cease production during the current year because the ore will be exhausted. One new mine is being developed and will go into production in early 1986.

The total ore hoist in 1984 was 5 3 million t. One of the newest mines is Vuonos. The Vuonos deposit is located in the same geological zone as the old Outokumpu located in the same geological zone as the old Outokumpu ore deposit, which was discovered in 1910 and gave the name to the whole mining company. The shortest distance between these two ore deposits is a mere 4.2 km.

2. GENERAL ABOUT VUONOS

The discovery of the Vuonos ore deposit in 1963 as a result of systematic exploration was a remarkable achievement of scientific prospecting. Construction of the mine started in 1967 and production in 1972.

Diamond core drilling has verified 5.7 million t ore averaging 2.4 % Cu. The ore also contains some zinc, cobalt and precious metals. The orebody is subhorizontal and undulating. It is 3.5 km long, 50-200 m wide and 5-6 m thick on average.

The orebody is located fairly close to the surface of the ground, even its deepest portions being *no* more than c. 220 m from the surface. Hoisting has, therefore, been arranged by a conveyor belt 1.5 km long. Access to the mine, including maintenance, is via a ramp at an inclination of 1 : 8. In 1983, 402, 559 t ore were mined at Vuonos, but the ore will be exhausted by the end of the current year.

The ore is concentrated at Vuonos. Three concentrates are produced from the copper ore: copper, zinc and cobalt concentrate. The copper concentrate produced in 1983 contained 8.500 t copper. The concentrates are transported by rail to smelters and refineries of Outokumpu Oy.

The number of employees at Vuonos at the end of 1983 was 160, of whom about 70, including maintenance ar-d foremen, worked underground. When activities at Vuonos come to an end, Outokumpu Oy will provide jobs for all the employees at its other plants.

3. STOPING METHODS APPLIED AT VUONOS

The attitude of the orebody has imposed some constraints on stoping methods. The following three methods have been used:

	proportion of production
- inclined wall stoping	56 %
- room and pillar stoping	26 %
- longhole stoping	18%

Inclined wall stoping (Figure 1) is suitable when stoping subhorizontal orebodies without leaving pillars and when the thickness of the orebody is 3-8 m. In a longitudinal direction the orebody is divided by haulage drifts into areas 100-250 m long, whose width is the same as that of the orebody. The first stope is opened at the lowermost part of the orebody as a drift parallel to the strike between the haulage drifts. The inclination of the walls of the stope is 60 inwards. After being emptied, the stope is filled with classified tailings. The next stopes are opened against the tailings on both sides of the opening stope, and so on.

Room and pillar stoping has been applied in the poorest portions of the orebody. The first stage consists of the driving of parallel drifts 6-10 m wide, which extend from footwall to roof. Longitudinal pillars 5 m wide are left between the drifts and then mined in the next stage. The loss of ore is, however, 15-20%. Special measures are taken to reduce the loss as will be described later under the heading "Remote-controlled loading".

Many applications of longhole stoping have been in use. One of them is concrete pillar stoping, which features parallel vertical drill holes and the filling of the stopes of the first stage with lean concrete. The sections between the concrete pillars are mined as stopes of the second stage in like manner but using tailings as filling. A method resembling top slicing, in which fan holes are drilled upwards, has also been used.

4. SHORTHOLE DRILLING AT VUONOS

The principal stoping methods at Vuonos are based on shorthole drilling. From the very beginning the drilling has been done with big pneumatic drilling jumbos. An essential feature of the drilling equipment has been sufficient coverage to enable even the thickest parts of the orebody to be drilled. As soon as hydraulic drifters were considered advanced and reliable enough, the first electro-hydraulic drilling jumbo was acquired at Vuonos and started drilling in 1977.

A Maximatic provided with two hydraulic drifters and manufactured by Tamrock, this jumbo can drill to a height of 7.2 m measured from the flood of the drift.

Encouraged by good results, Outokumpu Oy acquired A Tamrock Paramatic unit in 1981. It, too, is electro-hydraulic and has a range of 6.0 m.

Pneumatic drilling is done with detachable bits. The diameter of the drill rod is 1 1/8" and that of the bit 45 mm. The drill rod is 3.2 m long and its effective drilling length is 2.8 m. The equipment for hydraulic drilling is much the same except that the diameter of the bit is 51 mm and the rods are both thicker, 1 1/4", and longer, 4.0 m. The effective drilling length is 3.5 m.

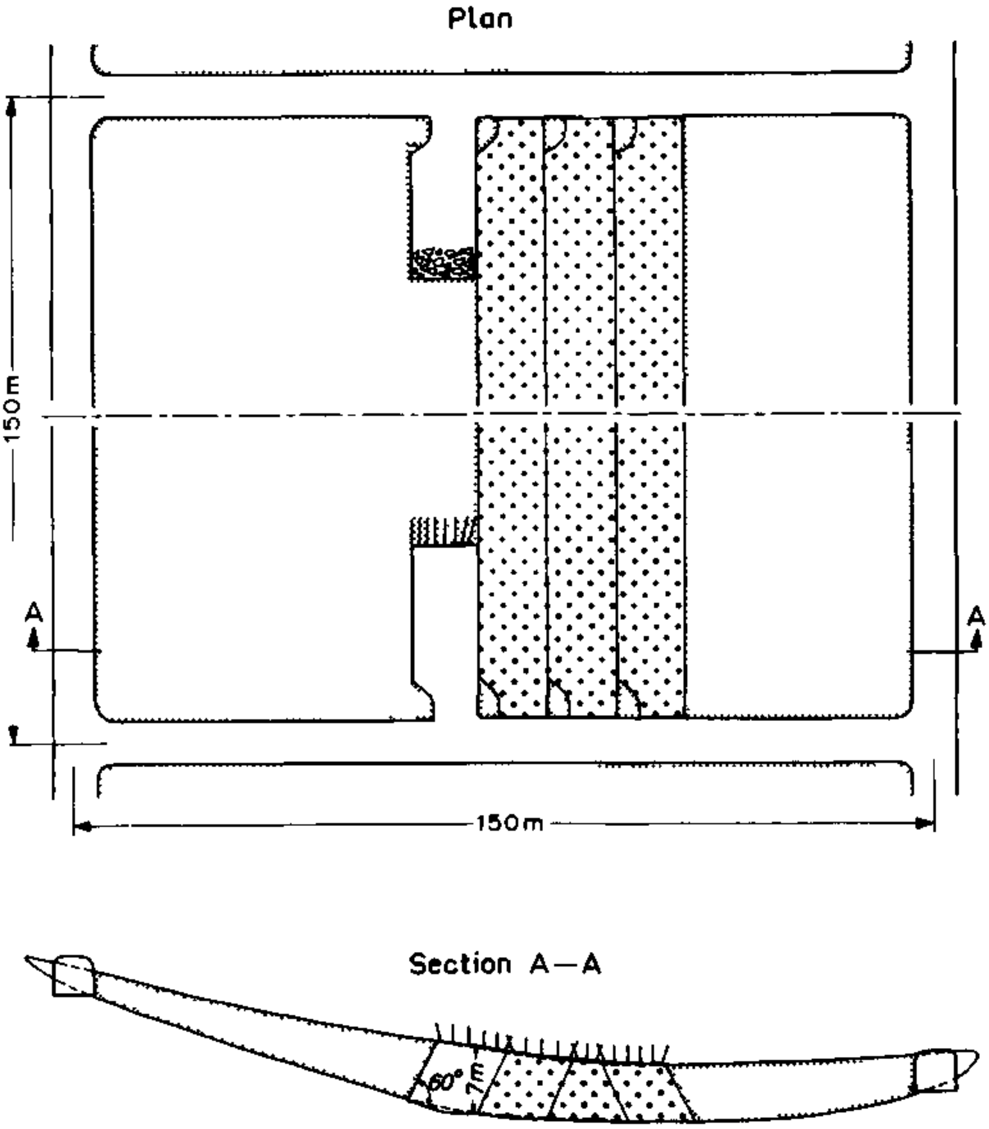


Figure 1— Inclined wall stoping at the Vuonos mine

The rate of pneumatic drilling in similar rocks is c. 55% that of hydraulic drilling. At Vuonos the rate of hydraulic drilling varies between 0.8 and 1.8 m/min. The average rate of pneumatic drilling has recently been 32 dr. m/h, that of the Maximatic 53 dr. m/h and that of the Paramatic 61 dr. m/h. The best shift rates with the Paramatic have been up to 550 dr. m. This, however, is feasible only if conditions are favourable and the driller is very experienced.

Figure 2 shows that the proportion of hydraulic drilling has increased continuously, already c. 91% of the shortholes at Vuonos being drilled with hydroulic drilling jumbos in 1983. The Maximatic drilled 77.000 m and the Paramatic 82.000 m.

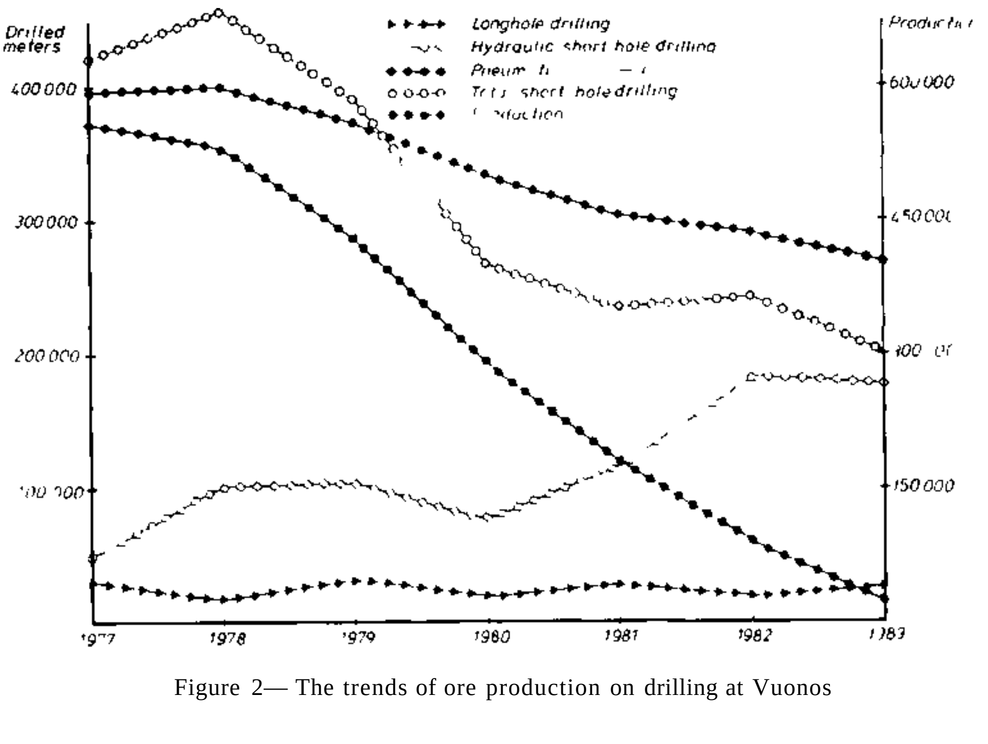


Figure 2— The trends of ore production on drilling at Vuonos

Figure 3 illustrates the trend in drilling costs without capital expenditure. The differences aie conspicuous and favour hydraulic drilling. The same data are shown in Table 1, but classified. The table is supplemented with the following information:

- Hydraulic drilling lengthens the life of drill steels by up to 50%. The small difference in 1981 is attributable to initial difficulties, e.g. the training of new drillers, with the new Paramatic drilling jumbo.

— Cost due to salaries are inversely proportional to drilling rates.

- The energy costs of hydraulic drilling are negligible. At Vuonos, costs due to compressed air increase out of all proportion when pneumatic drilling is reduced. Hence, e.g. the number of leaks in the large system of pneumatic pipelines remains constant but their proportion increases.

— In 1980, the hydraulic Maximatic was submitted to an expensive basic repair that included changing the a> les to meet new requirements for brakes. The basic repair markedly increased maintenance costs. The effect of ageing equipment on costs is exemplified by the fact that in 1982 the maintenance costs of the Maximatic per drilled metre were twice as high as those of the newer Paramatic.

The maintenance interval, the drifter exchange interval and the life of the hydraulic drifters are 2-3 times higher than those of the pneumatic drifters. The three original drifters in the Maximatic drilling jumbo at Vuonos are still in use, even though they have drilled a total of c. 600.000 m.

Preparations of drilling and the tramming of an electro-hydraulic drilling jumbo can be done much more rapidly and easily than on a pneumatic drilling jumbo.

There are some other aspects that also favour hydraulic drilling. Exhaust air is not discharged into the work site atmosphere, and thus there is no oil and water mist and visibility is better. Moreover, there are no damp drafts at the site as a result of exhaust air, and the site remains warm. Hydraulics offer better opportunities for developing drilling automation and remote control.

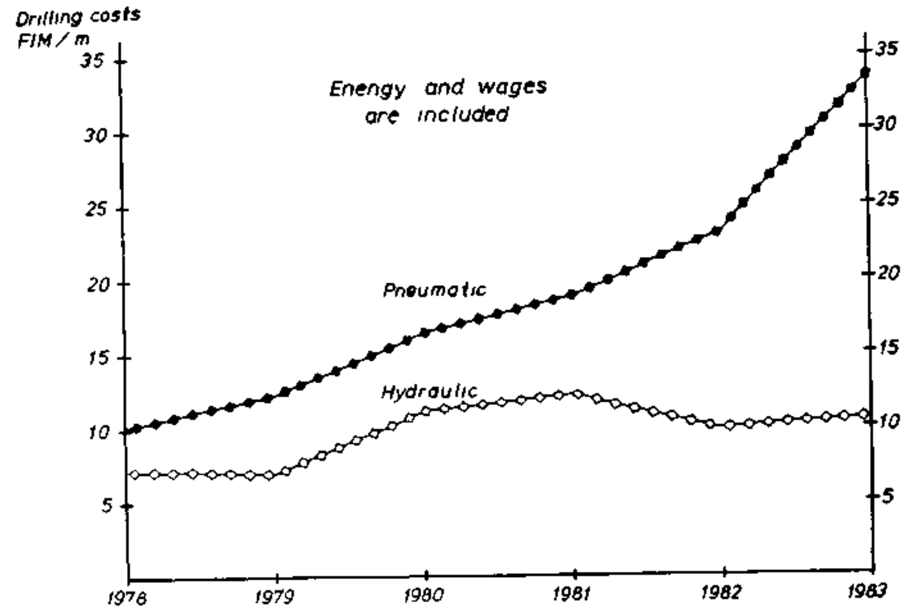


Figure 3— The trend of drilling costs

Table 1- Drilling Costs FIM/Drifled Meter

	1978		1979		1980		1981		1982		1983	
	P	h	P	h	P	h	P	h	P	h	P	h
Drill Steel	3 34	169	326	161	3 87	2 20	319	2 97	3 32	244	3 48	251
Wages	1:08	084	119	097	1 28	108	163	1 19	2 22	123	234	1 32
Energy	1 72	009	209	0J09	2 95	0.09	5 68	011	8 89	013	11 68	0 20
Sharpening	086	086	097	0 97	1 23	1 23	1 10	1 10	1J06	106	0 97	0 97
Maintenance	317	3 59	4 42	3 08	700	6 51	719	6 75	7 59	4 99	1511	5 52
TOTAL	1017	7J07	1193	6 72	16 33	1111	18 79	1212	2308	9 85	33 58	10 52

p — pneumatic h hydraulic

It is generally known that the noise level of the hydraulic drifter is markedly lower than that of the pneumatic drifter. According to our measurements the noise level of a pneumatic drifter is c. 112 dB (A), that of the same drifter provided with an exhaust air cyclone c. 105 dB (A) and that of the hydraulic drifter c. 104 dB (A).

5. REMOTE-CONTROLLED LOADING

At the end of 1983 Outokumpu Oy had seven diesel-operated loaders provided with remote control. All of them are either Toro 500 or Toro 350 loaders. In 1983 they loaded some 214.000 t by remote control. This small tonnage reveals that remote control is applied only in special cases. The loading rate while using remote control is about 70% of the conventional loading rate.

The following examines some applications of longhole stoping to a case in the Vuonos mine, Fig. 4 and Table 2.

Table 2- Comparison of different alternatives in longhole stoping

		ALTERNATIVE		
		A	B	C
HAULAGE DRIFT	m	240	-	-
DRILLING DRIFT	m	140	140	140
ORE RECOVERY				
- Normal Loading	t	53 000	32 000	32 000
- With R.C. Loading	t"	-	-	18000
ORE LOSSES	t	1000	22 000	4 000
ORE LOSSES	%	2	40	8
PROFIT	FİM	- 143 700	+ 215 800	+ 643 500
PROFIT	FIM/t	-2,71	+6,74	+12,87

In case A a haulage drift is driven outside the ore and from it loading drifts to the ore. A total of 240 m of drift is needed in the country rock. The ore is loaded safely in the normal way from the loading drifts.

In case B no developing work is done outside the ore, which is loaded at the same drift in which the production drilling and blasting took place. Since it is not possible to go outside the stoping face into the area already blasted, the loss of ore is considerable, about 40%.

Alternative C differs from case B only in that a remote-controlled loader is used. It allows the ore to be loaded much more accurately without endangering safety because it can go outside the stoping face.

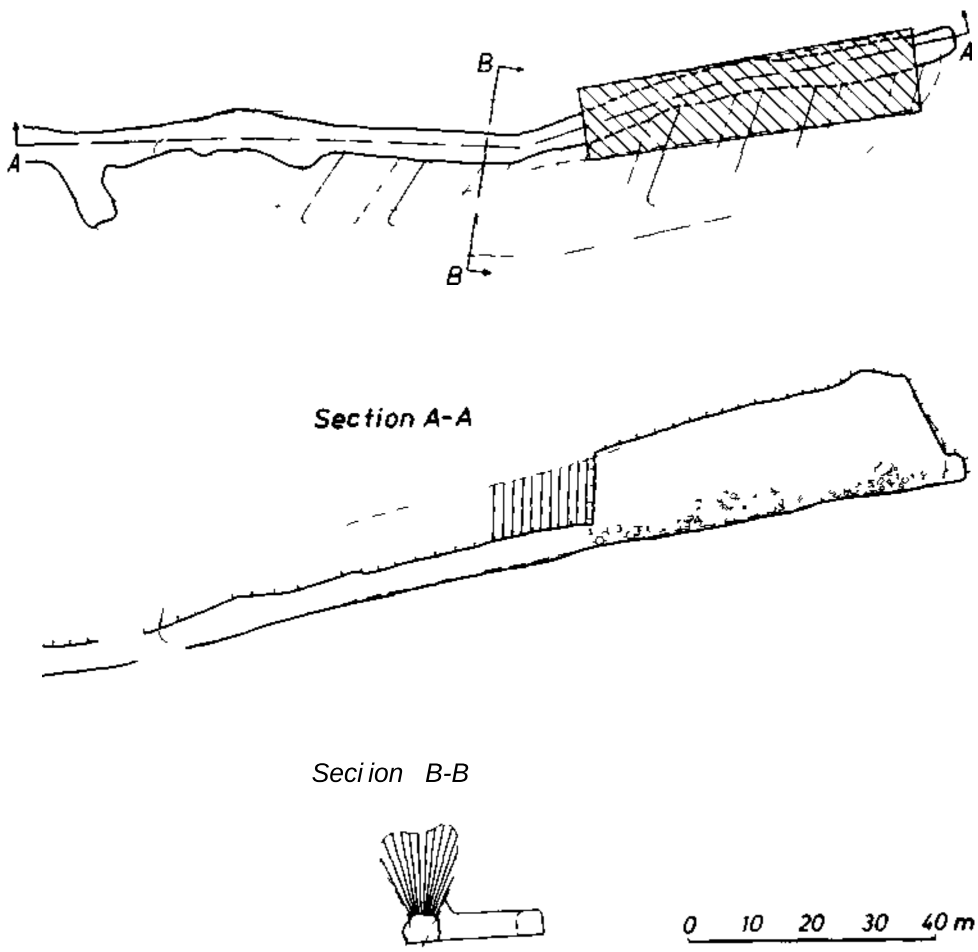


Figure 4— An example of longhole stoping

Compiled in Table 2 are the data on alternatives A, B and C. The bottom two lines in the table show that remote control is needed to make the stoping of ore economically viable in the case stated and it also permits stoping with a moderate loss of ore. An additional advantage is that the ore can be brought into production faster when it is not necessary to drive a separate haulage drift and make the loading drifts in the country rock.

Figure 5 shows another example associated with room and pillar stoping. Without remote control 21% of the ore would remain in the pillars. Some of the pillars, however, can be mined and the ore loaded safely by remote control. This procedure reduces the loss of ore to 12%.

6. MECHANIZED ROCK BOLTING

Rock bolting is needed at Vuonos to strengthen the drifts and stopes. The bolts are usually reinforcing rods 2.4 m long and 16 or 20 mm in diameter.

Until spring 1982 the bolting was done with the old method in which the holes were drilled by drilling jumbos and the bolts were inserted into the holes by grouting. The work was done with a scissor platform provided with all the necessary implements, such as a small concrete mixer and an injection container. The drilling was done by one man but the grouting of the bolts by two men. In one shift about 70 holes were drilled for bolts and about 90 bolts were grouted. The rate was reduced by the fact that often only a small number of bolts was needed at a target.

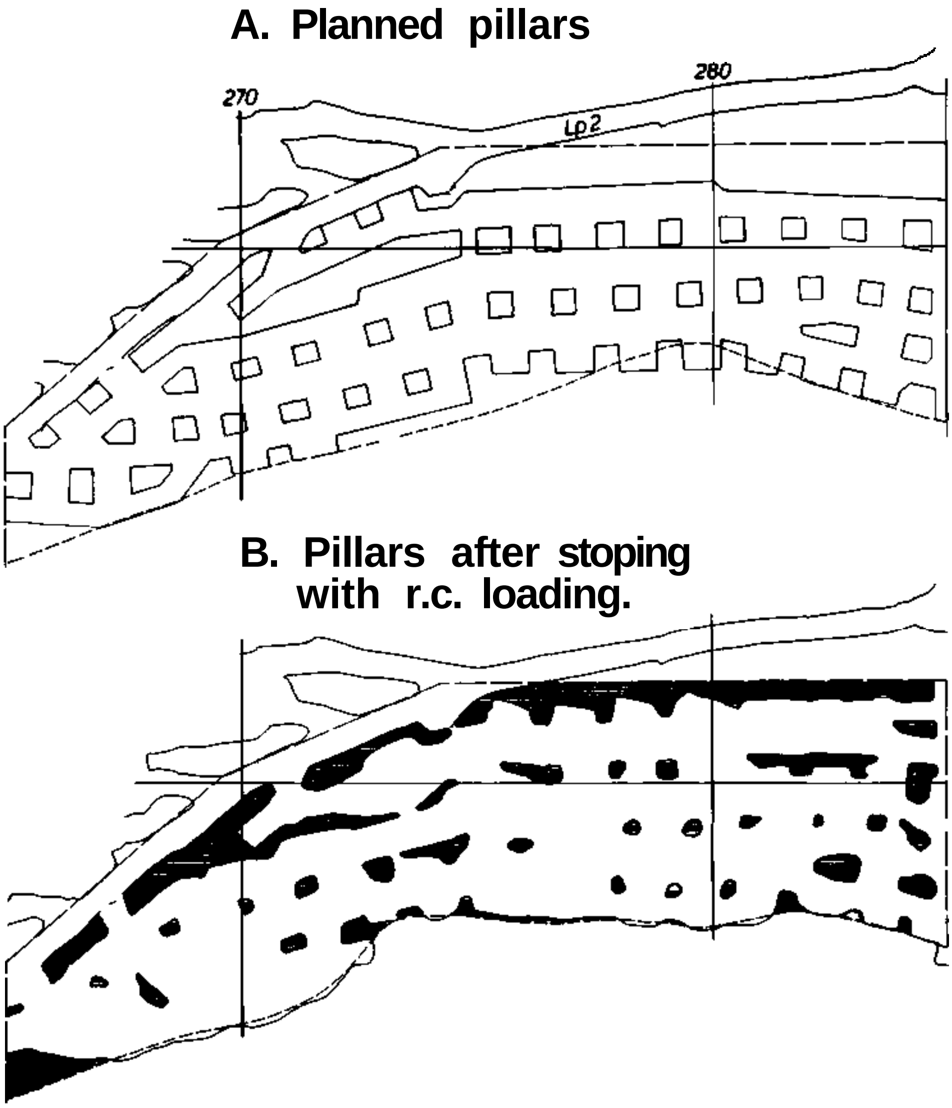
In May 1982 Robolt bolting equipment, manufactured by Tamrock, was introduced. It undertakes all the necessary operations: drills the hole, injects resin into it, insserts the bolt into the hole, mixing the resin at the same time, and prestresses the bolt after a stand-up period of about 1.5 minutes. All this is done by one man and the average rate so far has been about 40 bolts per shift.

The costs of the old and new methods, capital costs included, are compared with each other in Table 3. Measured directly in money, the new Robolt method is slightly more expensive than the old one, mainly because of the high price of the resin. A bolt that can be prestressed is more expensive than a grouting bolt. There is grouting equpment on the market that can be attached to the bolting unit. Inspite of its high cost resin bolting offers the following advantages:

— Direct reinforcment. Even large areas can be bolted systematically all the way through.

— Higher occupational safety. The bolter is always working in an area that has already been reinforced and is sufficiently far away from the dangerous boulting target.

— Work turnover is accelerated. The time needed to complete the work is reduced. The work can be continued immediately because there is no need to wait until the bolts are ready to carry the load as is the case with grouted bolts.



Original ore reserves	115100 t	
Ore Losses case A	24 370 t	21%
Ore Losses case B	13 420 t	12%

Figure 5— Room and pillar stoping

Table 3- Rockbolting costs

	TOTAL COST FIM/BOLT	
	Old Method	Robolt
CAPITAL COST	24	33
WAGES	29	13
MAINTENANCE	35	24
BOLT STEEL	11	26
CONCRETE/RESIN	4	20
T O T A L	103	116

The above items are difficult to convert into money. However, it has been estimated that, owing to the increase in work turnover, several hundreds of thousands of marks can be saved annually at Vuonos.

A number of serious accidents have occurred in Outokumpu Oy mines during rock bolting. We believe that they can be avoided by using the Robolt method. Two other mines of ours are applying the same mechanized rock bolting. At present, however, it is not feasible to assess the savings due to the reduction in accidents.