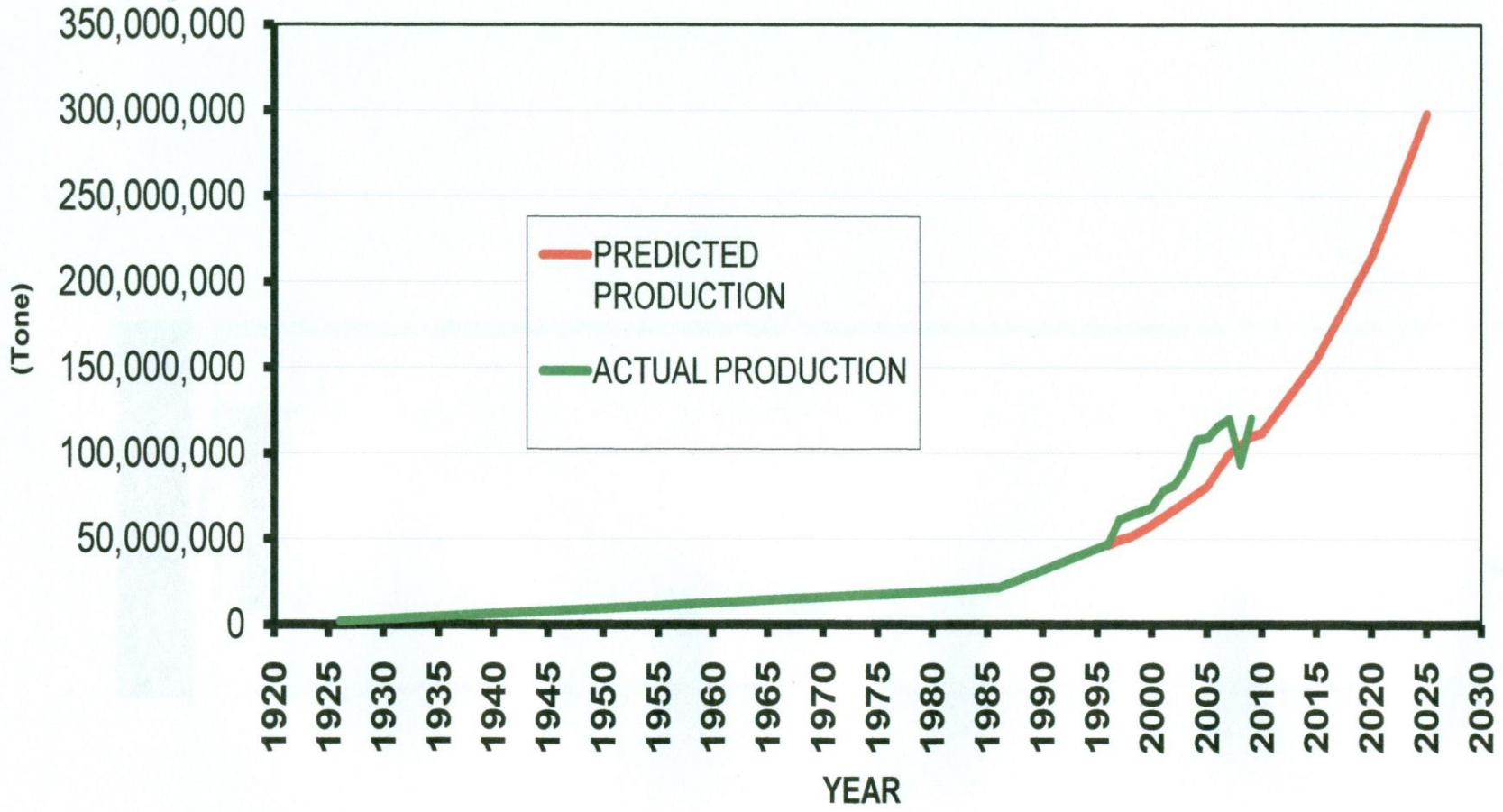
A NEW MODEL OF CHAIN SAW FOR UNDERGROUND MARBLE MINES

TOTAL WORLD PRODUCTION OF THE NATURAL STONE



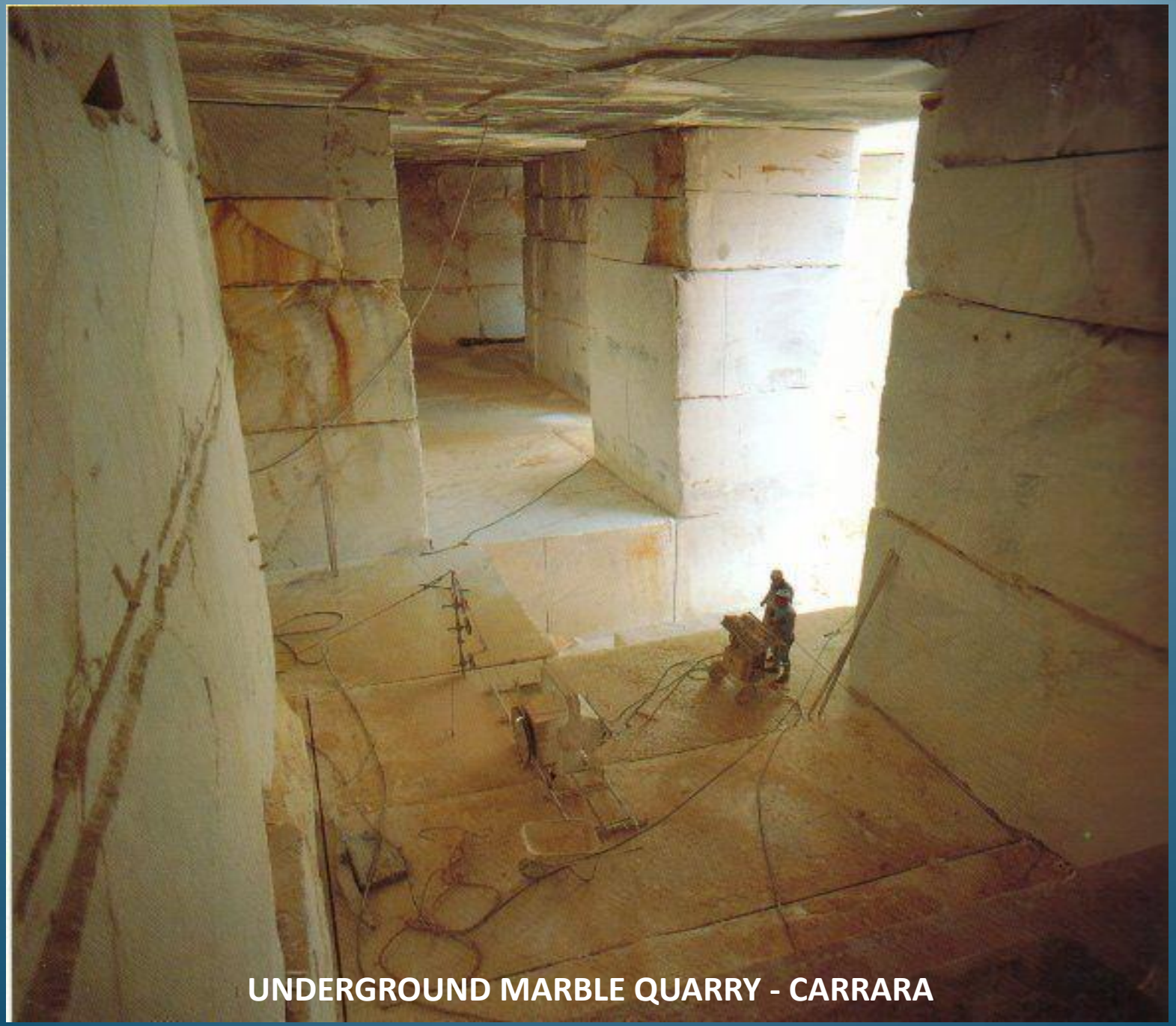
PRESENT DAY LANDSCAPE OF CARRARA MARBLE QUARRIES

MEDIUM-LARGE SCALE MARBLE QUARRY

IMPRESSIVE AMOUNT OF WASTE PRODUCED BY THE OPENING OF AN OPEN PIT MARBLE QUARRY

PIT MARBLE QUARRIES (PORTUGAL)

OPEN PIT MARBLE QUARRY, MASSA CARRARA

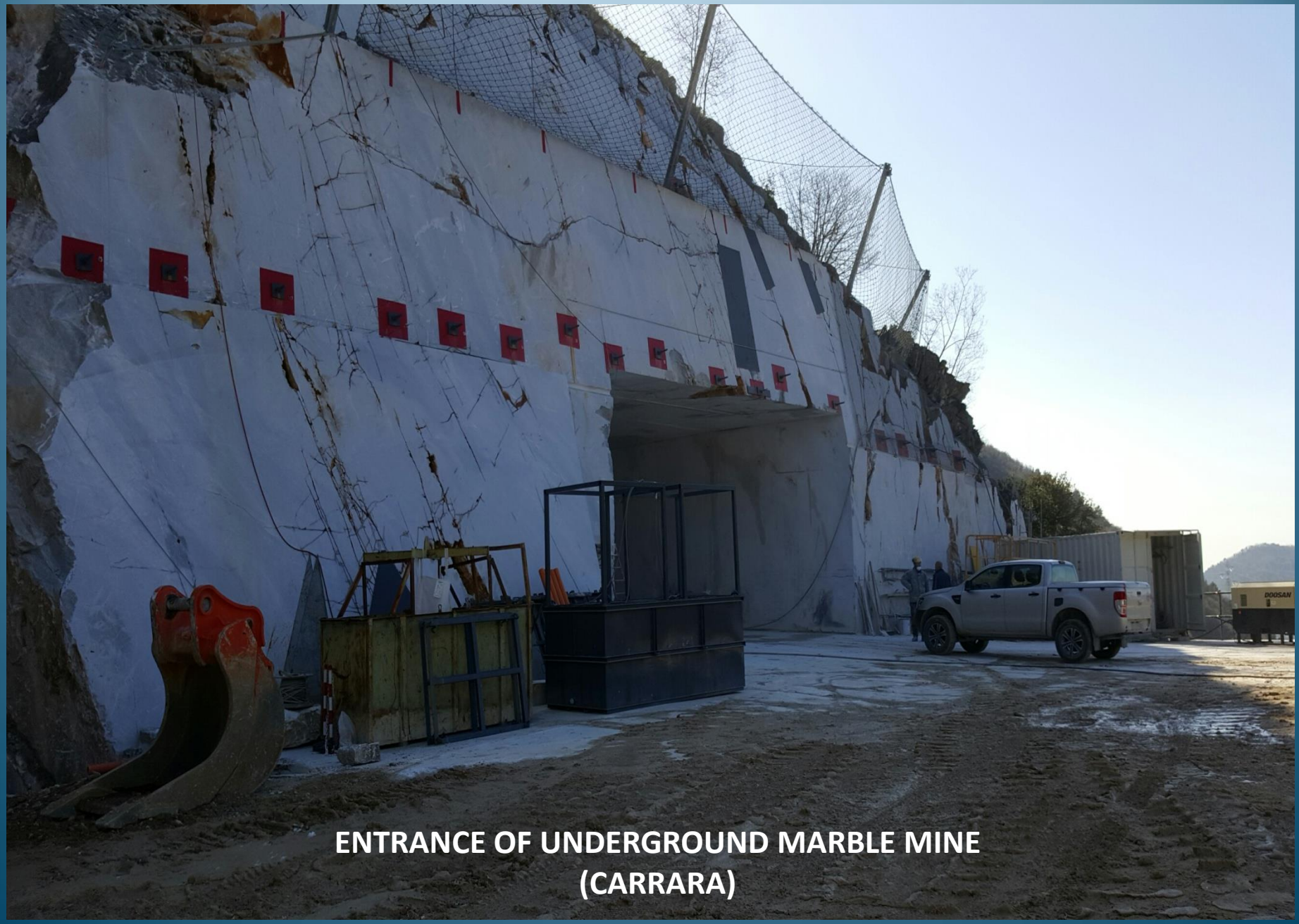


UNDERGROUND MARBLE QUARRY - CARRARA

ADVANTAGES OF UNDERGROUND MARBLE MINING OPERATIONS

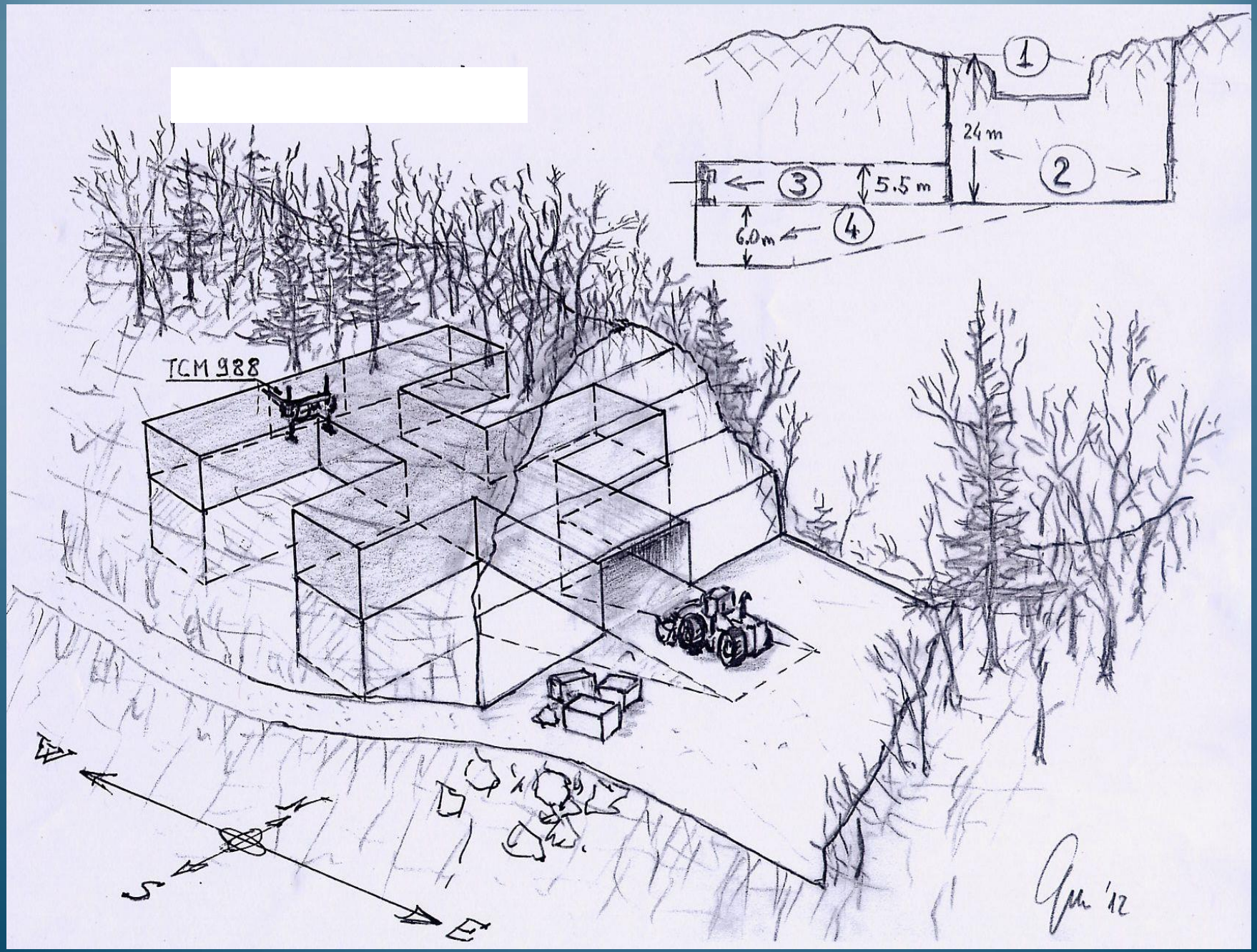
- Landscape-environment conservation
- Selective mining, marble resource optimization
- Increase in the yield of the blocks
- Wastage minimization
- Safety
- Application of innovative technologies
- involvement of skilled workers and professionals
- Possibility to work during all seasons

PREPARATORY WORKS FOR UNDERGROUND MARBLE MINE (CARRARA)



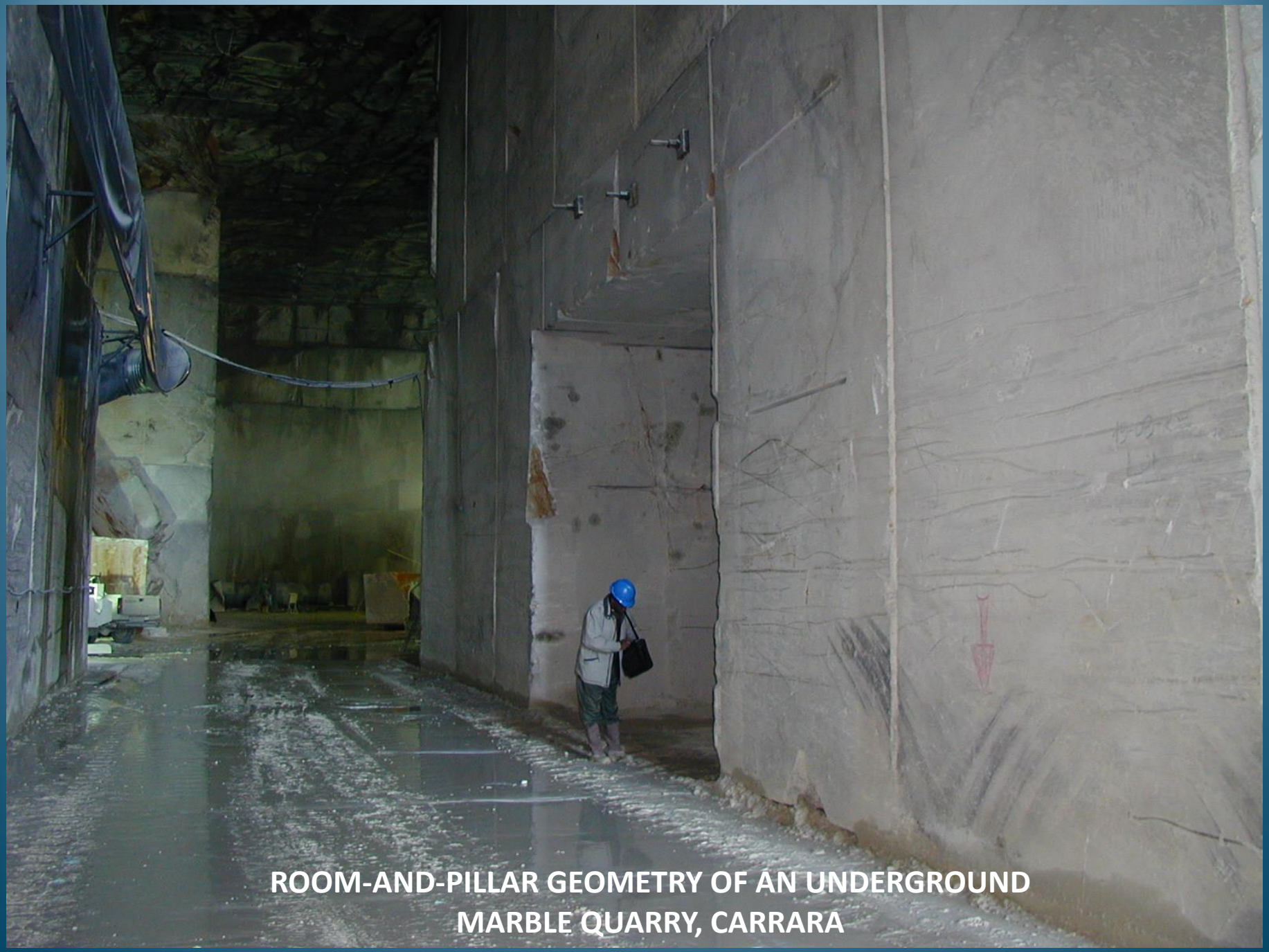
ENTRANCE OF UNDERGROUND MARBLE MINE (CARRARA)

ENTRANCE AND INITIAL DEVELOPMENT OF A MARBLE UNDERGROUND MINE (CARRARA)


1
24 m
2
3
5.5 m
4
6.0 m
TCM 988
W
N
S
E
'12

ENTRANCE AND WAY-OUT OF UNDERGROUND MARBLE QUARRIES

RAMP BUILT INSIDE A 3-LEVEL UNDERGROUND MARBLE MINE



ROOM-AND-PILLAR GEOMETRY OF AN UNDERGROUND MARBLE QUARRY, CARRARA

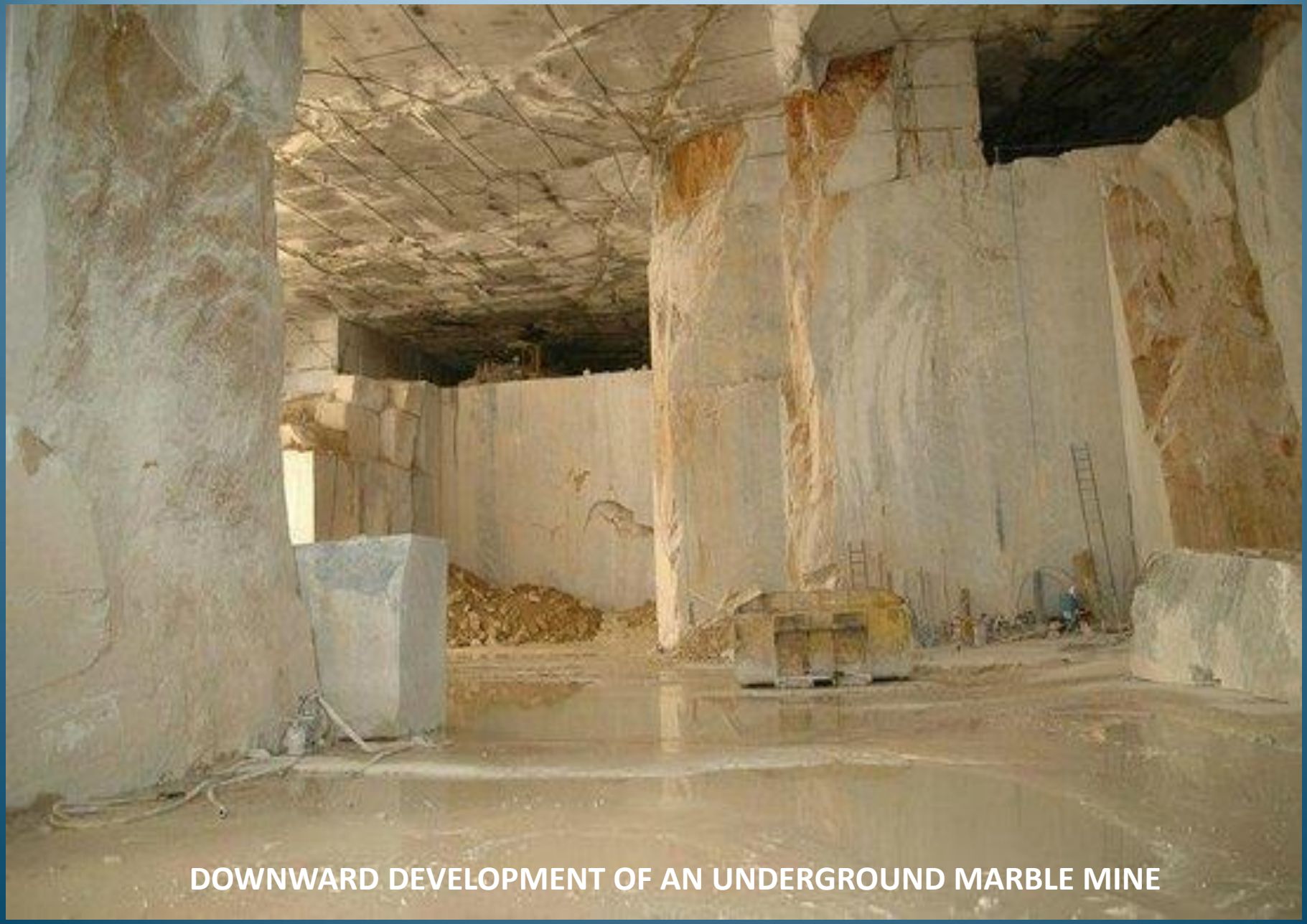
PILLAR OF LARGE SIZES WITH BOLTING

LARGE UNDERGROUND MARBLE MINE

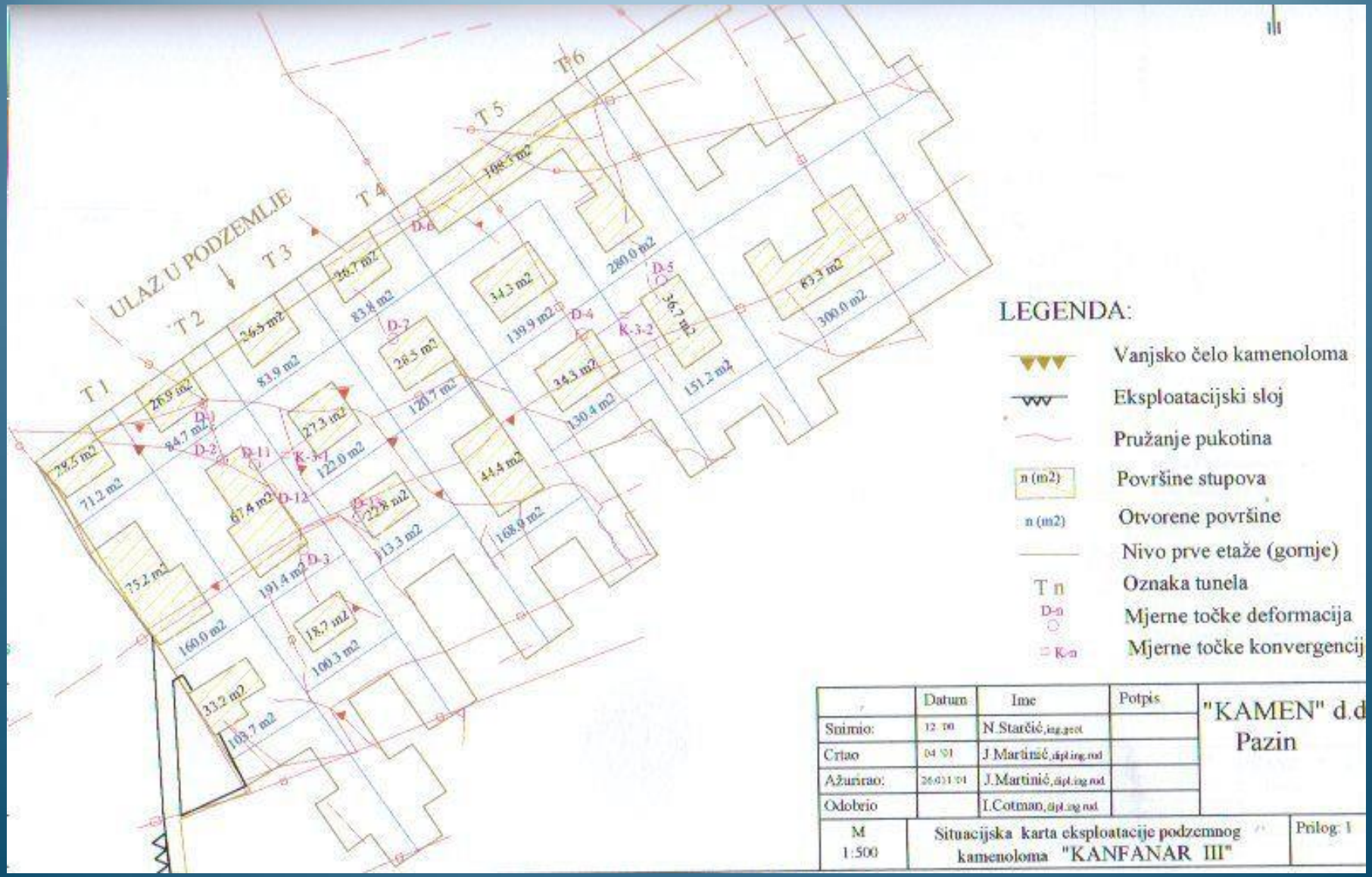
COLORADO YULE MARBLE MINE (U.S.A.)

TOP LEVEL OF AN UNDERGROUND MARBLE MINE

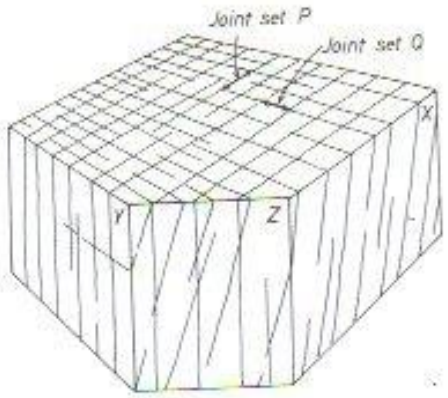
DOWNWARD DEVELOPMENT OF AN UNDERGROUND MARBLE MINE

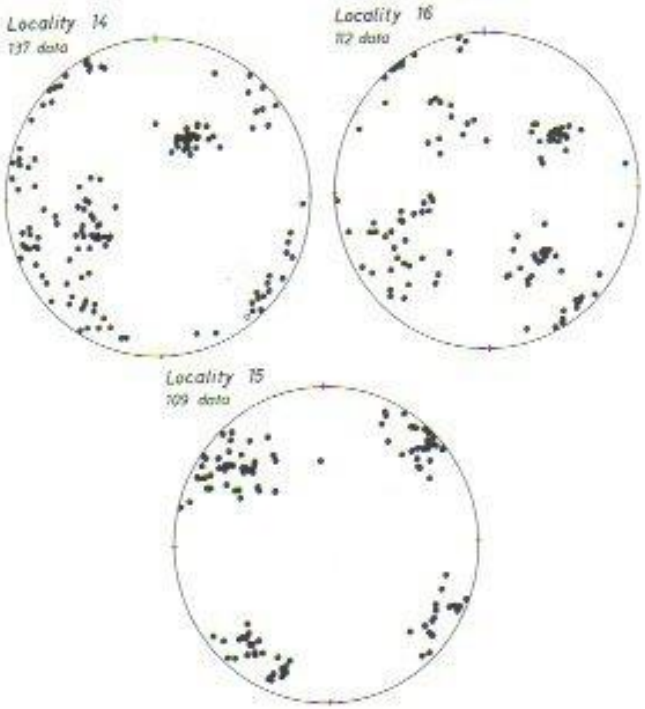


DOWNWARD DEVELOPMENT OF AN UNDERGROUND MARBLE MINE



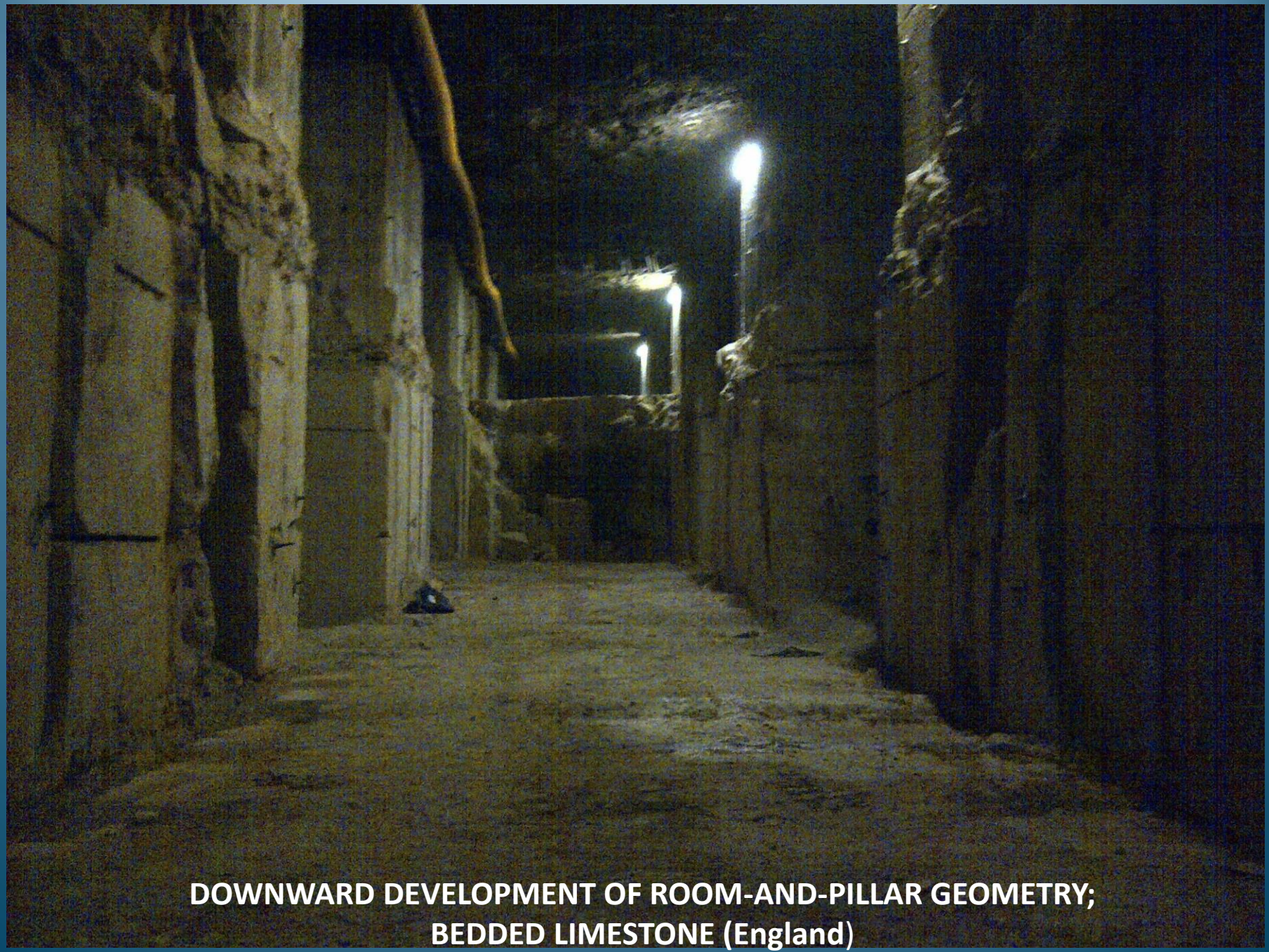
ROOM-AND-PILLAR DESIGN OF AN UNDERGROUND LIMESTONE MINE





FRACTURING ANALYSIS AND PROJECTIONS

MULTIPLE ENTRANCE-WAYOUT, THICK OVERBURDEN;
BEDDED LIMESTONE (England)

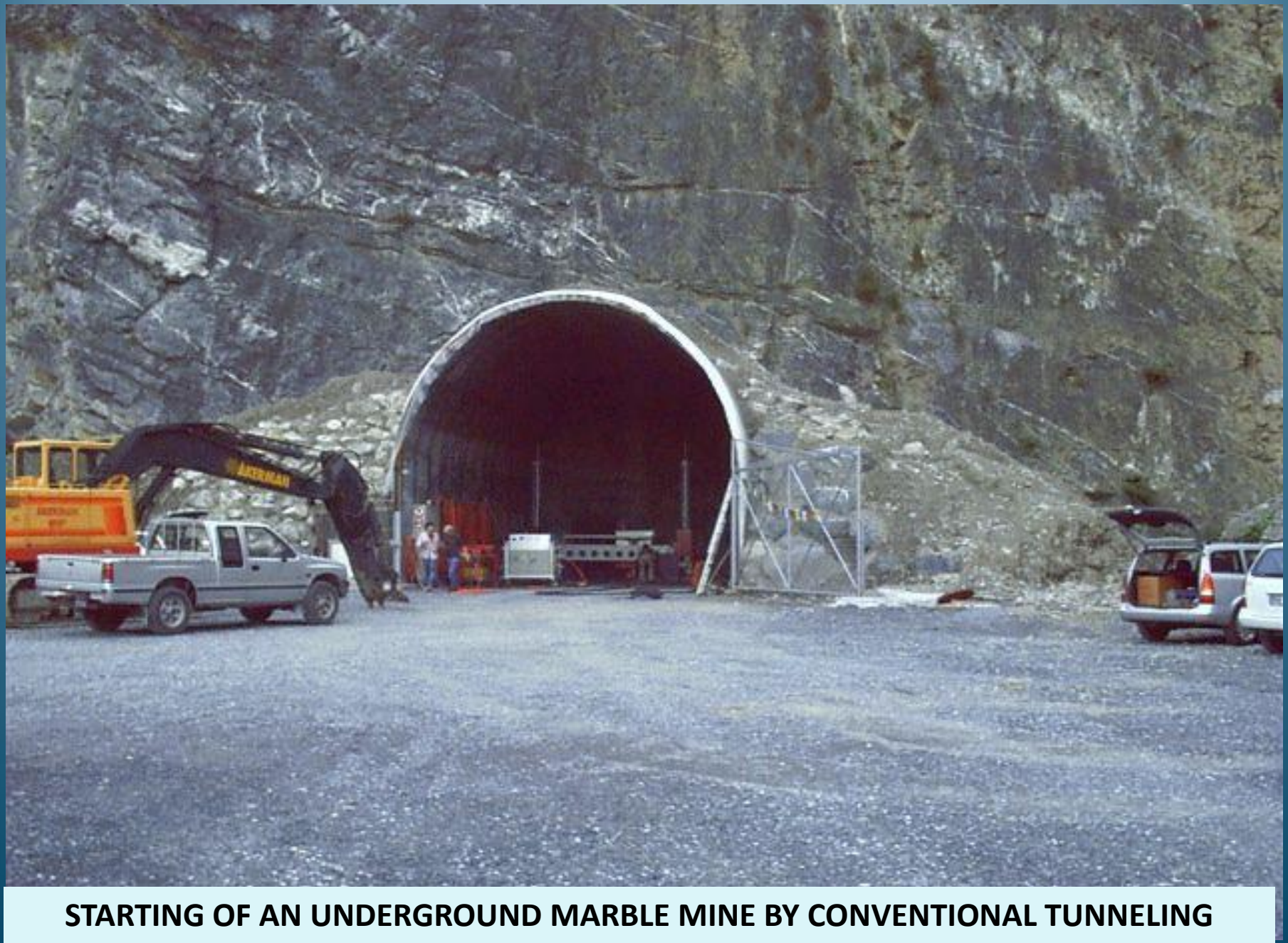


DOWNWARD DEVELOPMENT OF ROOM-AND-PILLAR GEOMETRY; BEDDED LIMESTONE (England)

POSSIBLE ENTRANCE LOCATION OF AN UNDEGROUND MARBLE MINE (China)

POSSIBLE ENTRANCE LOCATION OF AN UNDERGROUND LIMESTONE MINE (North Italy)

STARTING AN UNDERGROUND MARBLE MINE BY CONVENTIONAL TUNNELING (CHINA)



STARTING OF AN UNDERGROUND MARBLE MINE BY CONVENTIONAL TUNNELING (LIECHTENSTEIN)

STARTING OF AN UNDERGROUND MARBLE MINE BY CONVENTIONAL TUNNELING (CHINA)

STARTING OF AN UNDERGROUND MARBLE MINE BY CONVENTIONAL TUNNELING

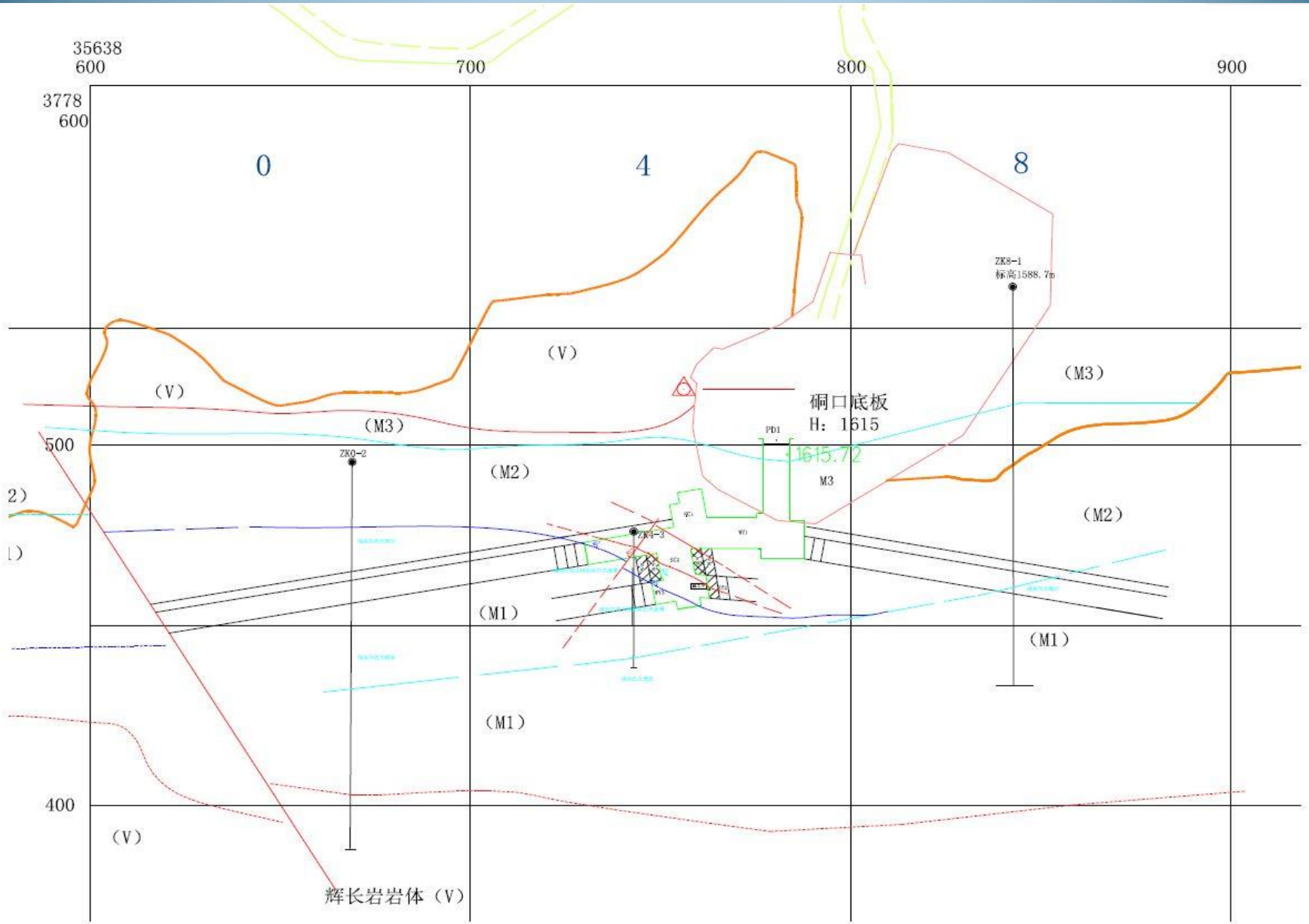
DEVELOPMENT OF AN UNDERGROUND MARBLE MINE STARTING FROM INSIDE

DEVELOPMENT OF AN UNDERGROUND MARBLE MINE STARTING FROM INSIDE

DEVELOPMENT OF AN UNDERGROUND MARBLE MINE STARTING FROM INSIDE

DEVELOPMENT OF AN UNDERGROUND MARBLE MINE STARTING FROM INSIDE

DEVELOPMENT OF AN UNDERGROUND MARBLE MINE STARTING FROM INSIDE



UNDERGROUND MARBLE MINE DESIGN STARTED BY CONVENTIONAL TUNNELING

CORES FROM RELATIVELY INTENSIVE EXPLORATION

DEVELOPMENT OF AN UNDERGROUND MARBLE MINE STARTING FROM INSIDE

UNDERGROUND MARBLE MINE STARTED FROM A RAILWAY TUNNEL
GALLERIA RAVACCIONE, CARRARA

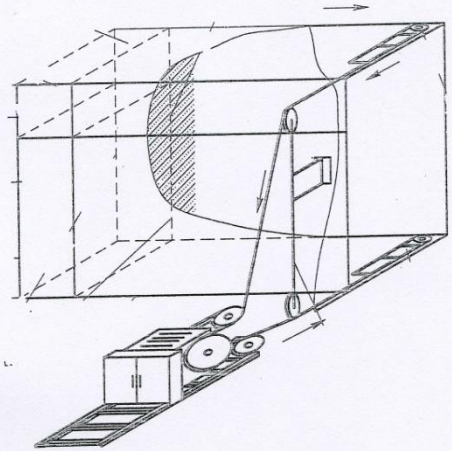
ENTRANCE OF UNDERGROUND MARBLE MINE, VERMONT, U.S.A

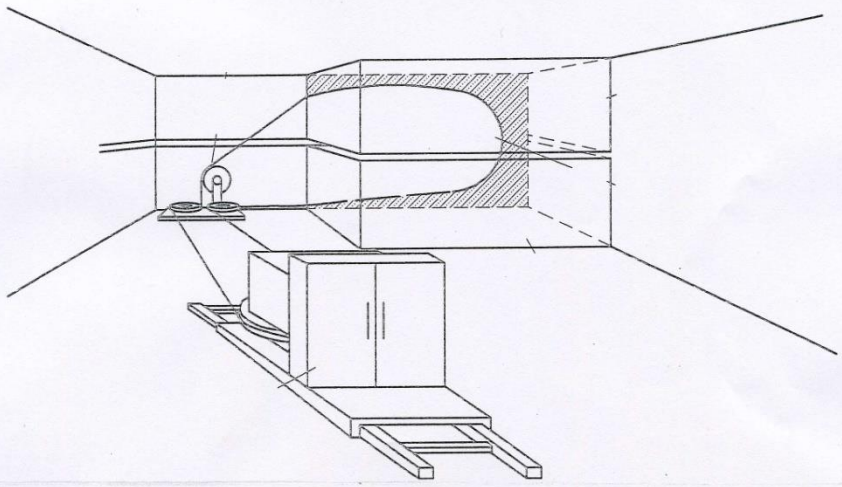
UNDERGROUND MARBLE MINE, VERMONT, U.S.A

METRIC SCALE FOLDS IN A MARBLE FORMATION

VERTICAL CUT BY CHAINSAW

HORIZONTAL CUT BY CHAIN SAW





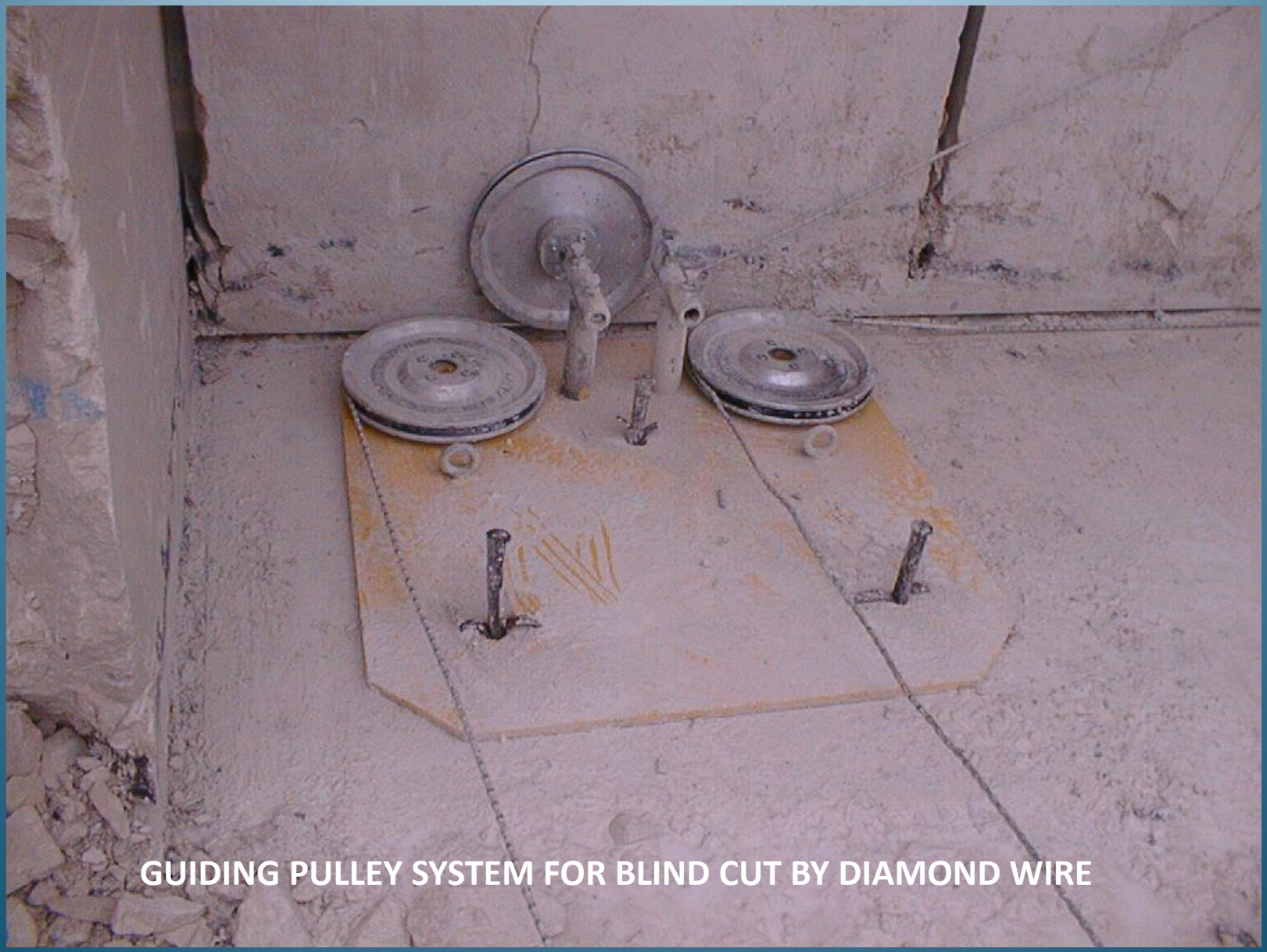
BLIND CUTS BY DIAMOND WIRE SAW


BLIND CUTS BY DIAMOND WIRE SAW

GUIDING PULLEY SYSTEM FOR BLIND CUT BY DIAMOND WIRE

GUIDING PULLEY SYSTEM FOR BLIND CUT BY DIAMOND WIRE SAW

PULL OUT AND REMOVAL OF BLOCKS BY MEANS OF FORK ON WHEEL LOADER



GUIDING PULLEY SYSTEM FOR BLIND CUT BY DIAMOND WIRE


BLIND CUTS BY DIAMOND WIRE SAW

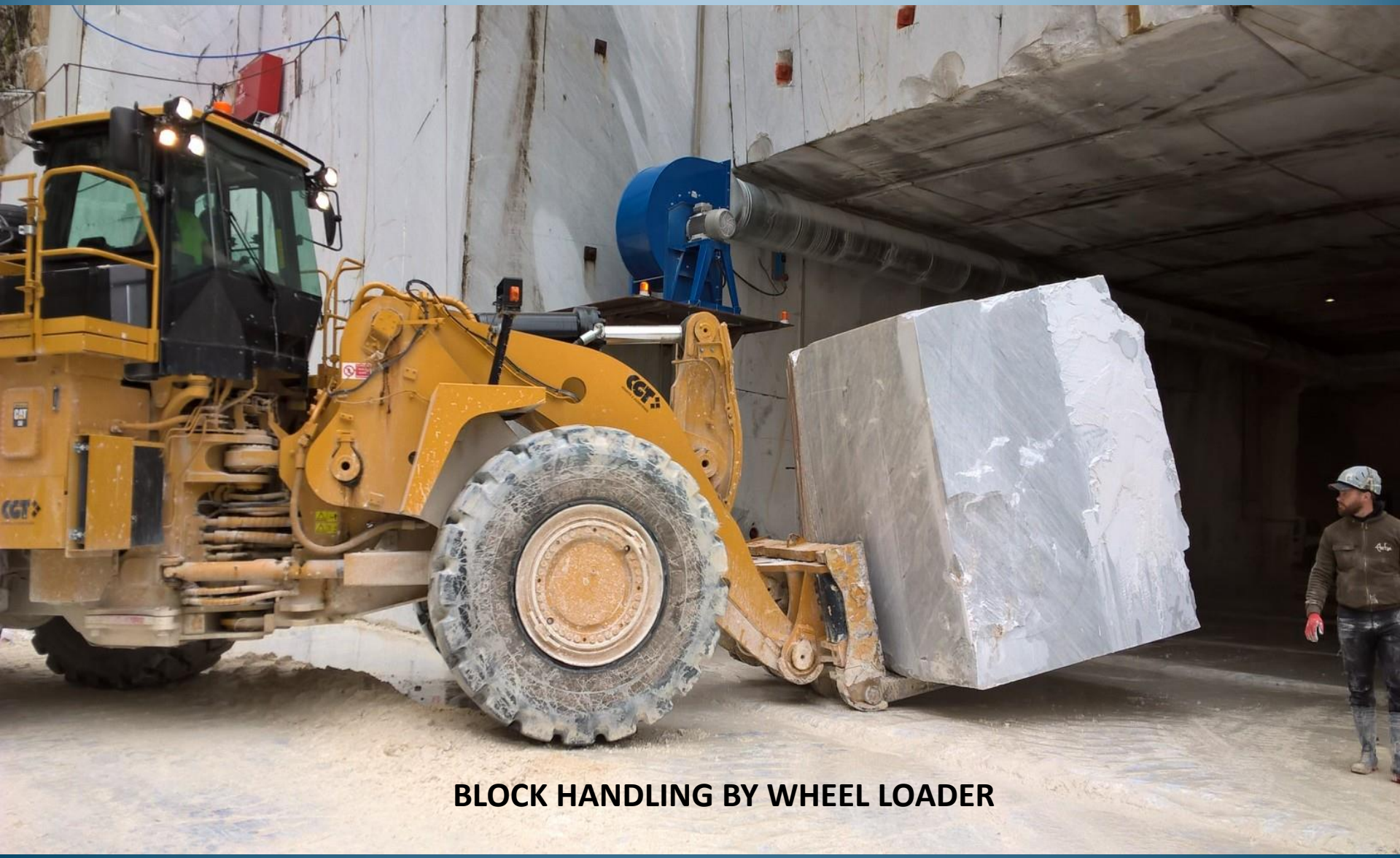
GUIDING PULLEY SYSTEM FOR BLIND CUT BY DIAMOND WIRE


BLIND CUT BY DIAMOND WIRE SAW

OPERATIONS BEFORE REMOVING THE BLOCKS

BLOCK PULL OUT BY MEANS OF BACK-HOE EXCAVATOR

HANDLING OF BLOCKS BY MEANS OF FORK ON WHEEL LOADER



BLOCK HANDLING BY WHEEL LOADER

BLOCKS OF LARGE SIZES

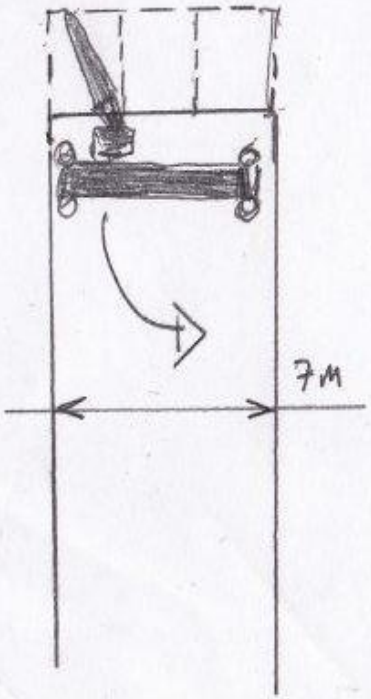
ALL THE BLOCKS OF EACH ADVANCEMENT CUT BY THE CHAIN SAW

TOP VIEW

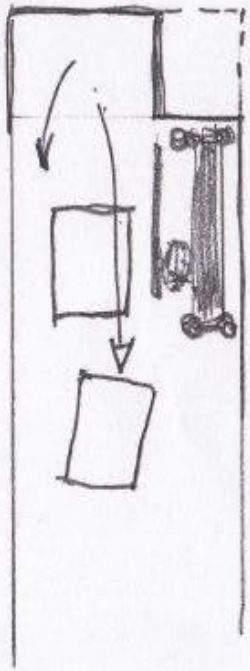
DEVELOPMENT STEPS FOR EACH ADVANCEMENT

4

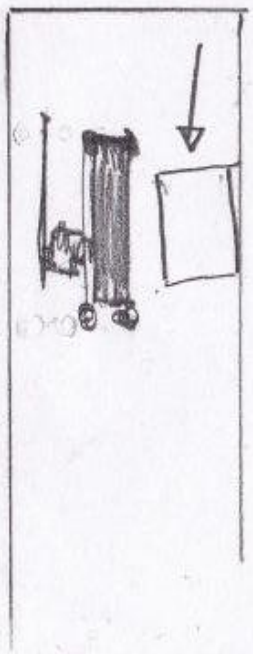
1

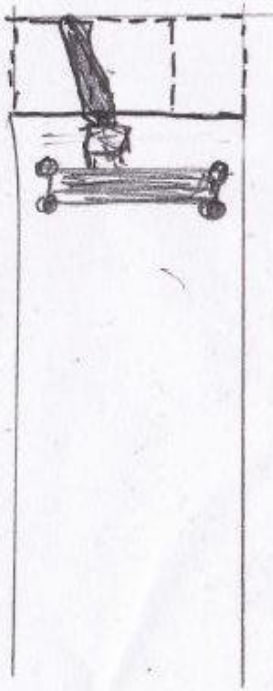


2



3

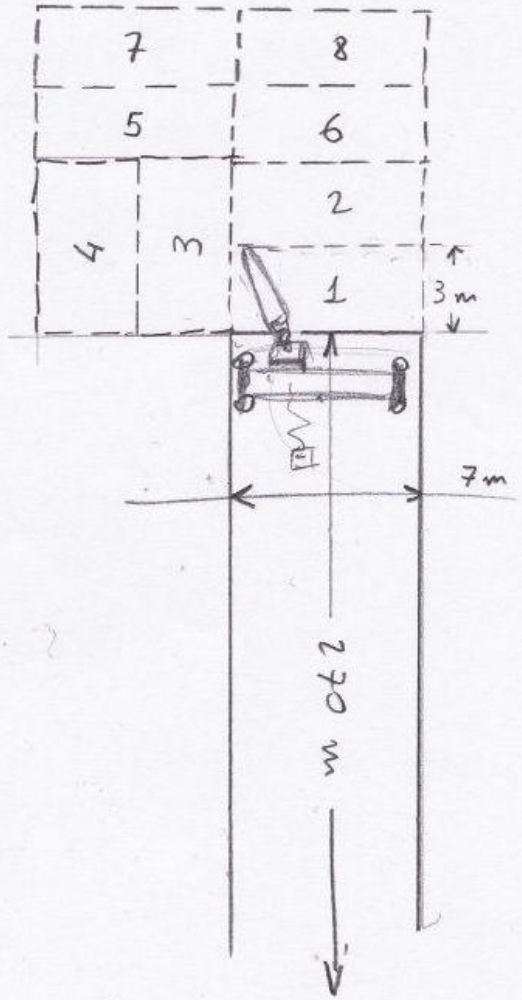


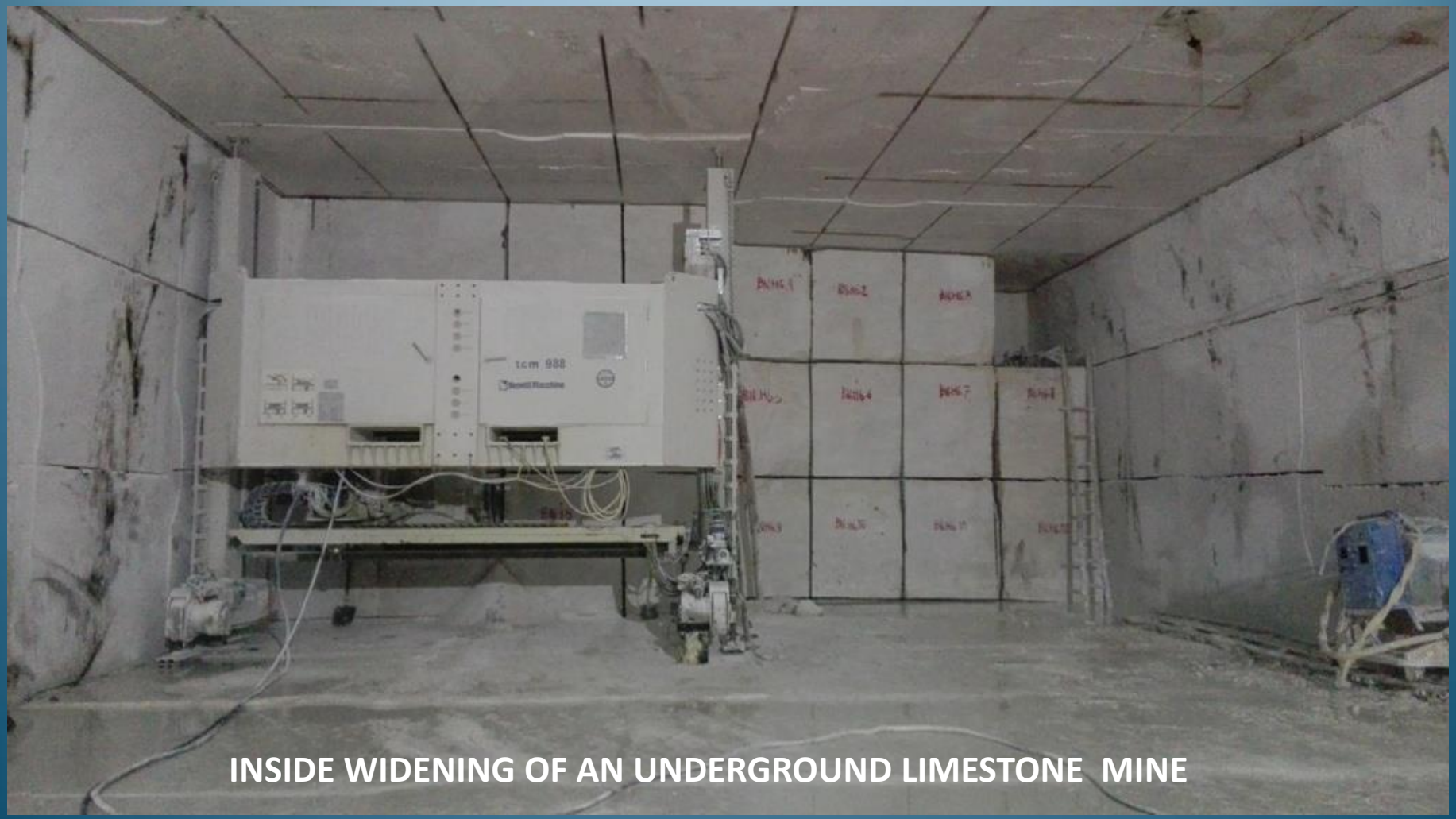


ENTRANCE WIDENING OF AN UNDERGROUND LIMESTONE MINE

TOP VIEW

DEVELOPMENT STEPS TO WIDEN THE TUNNEL





INSIDE WIDENING OF AN UNDERGROUND LIMESTONE MINE

INSIDE WIDENING OF AN UNDERGROUND LIMESTONE MINE

TROPICAL CARST TOPOGRAPHY, LIMESTONE QUARRY, INDONESIA

OPEN PIT AND UNDERGROUND LIMESTONE QUARRY, INDONESIA

ENTRANCE OF LIMESTONE UNDERGROUND MIINE, INDONESIA

UNDERGROUND LIMESTONE MINE, INDONESIA

UNDERGROUND LIMESTONE MINE, INDONESIA

BLOCKS CLASSIFIED AND SELECTED ACCORDING TO DIFFERENT COMMERCIAL VARIETIES; UNDERGROUND LIMESTONE MINE, INDONESIA

TRADITIONAL “H-FRAME” CHAIN SAW

TRADITIONAL H-FRAME CHIAN SAW

FANTINI “GU 70” CHAIN SAW

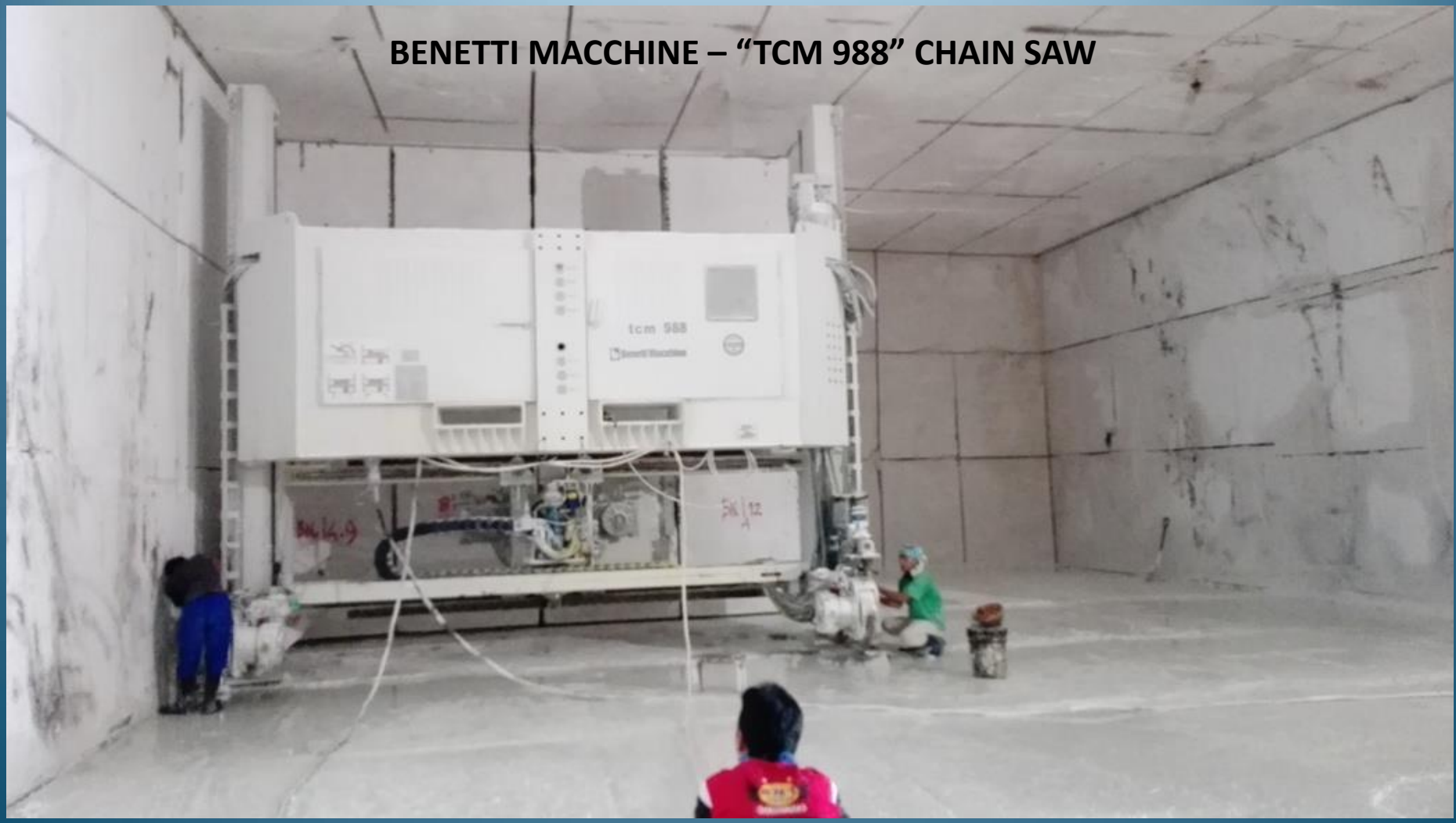
FANTINI “GU 70” CHAIN SAW

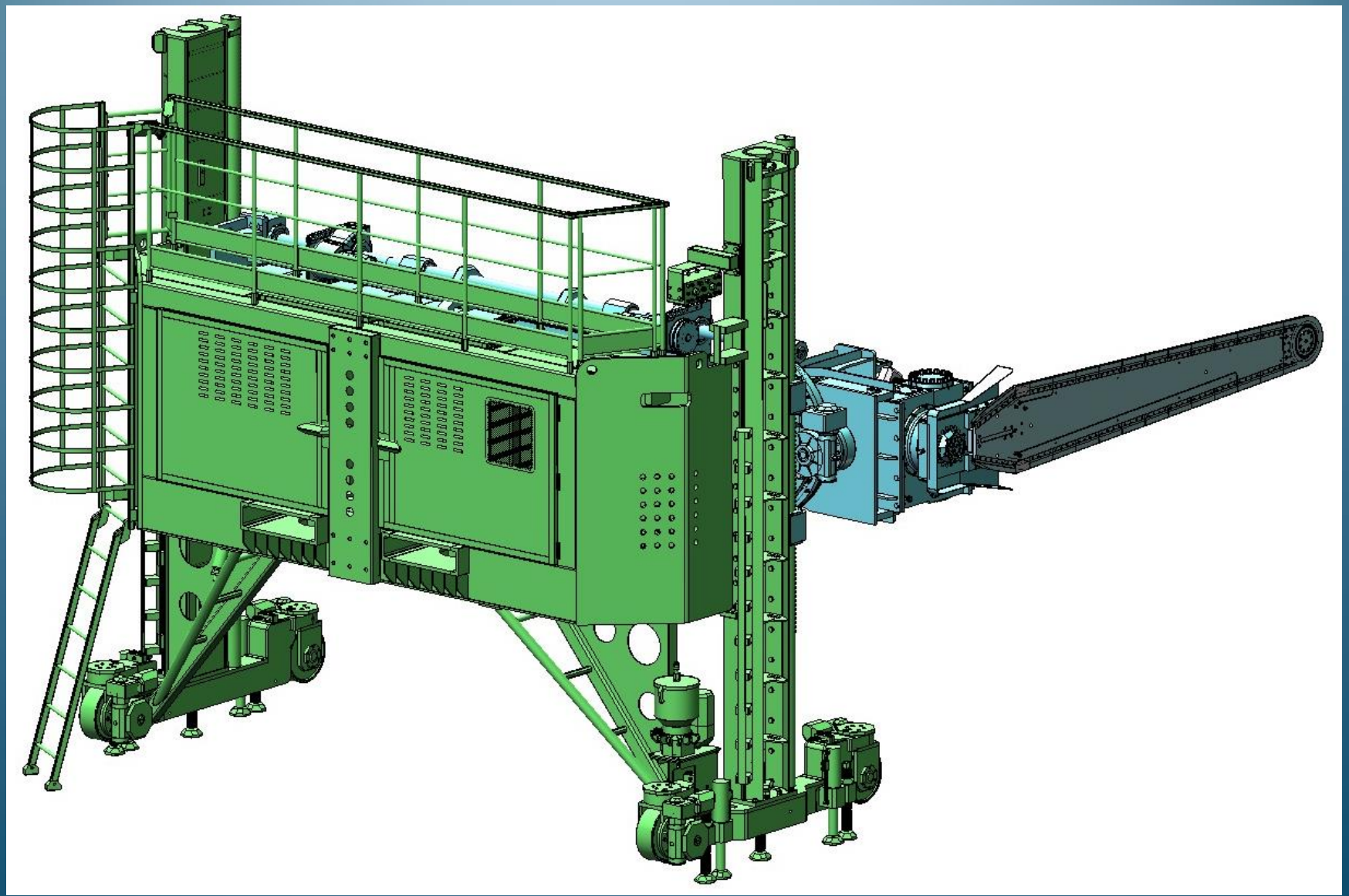
FANTINI “GU 70” CHAIN SAW

BENETTI MACCHINE – “TCM 988” CHAIN SAW

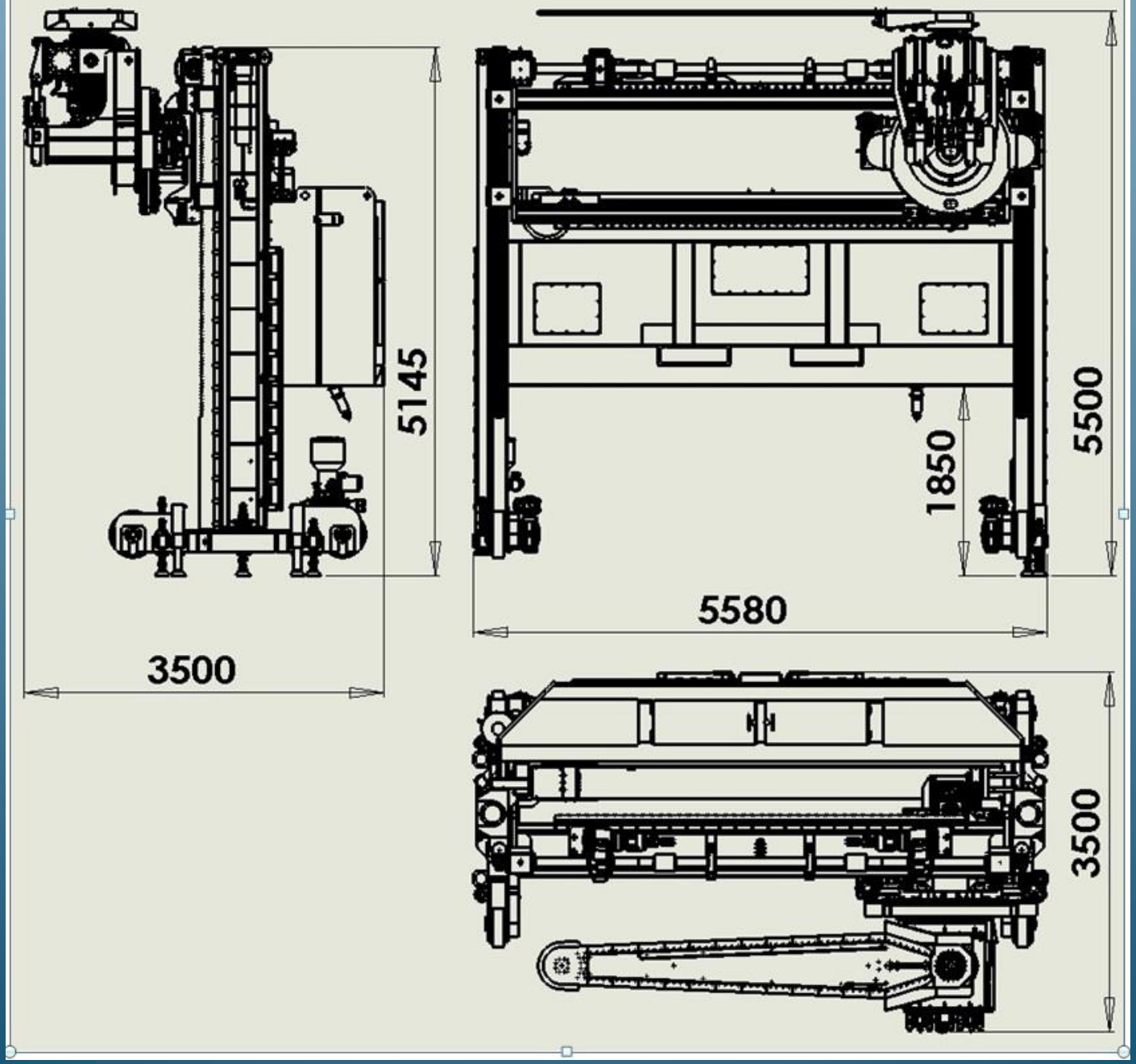
BENETTI MACCHINE – “TCM 988” CHAIN SAW

BENETTI MACCHINE – “TCM 988” CHAIN SAW





“TCM 988” CHAIN SAW

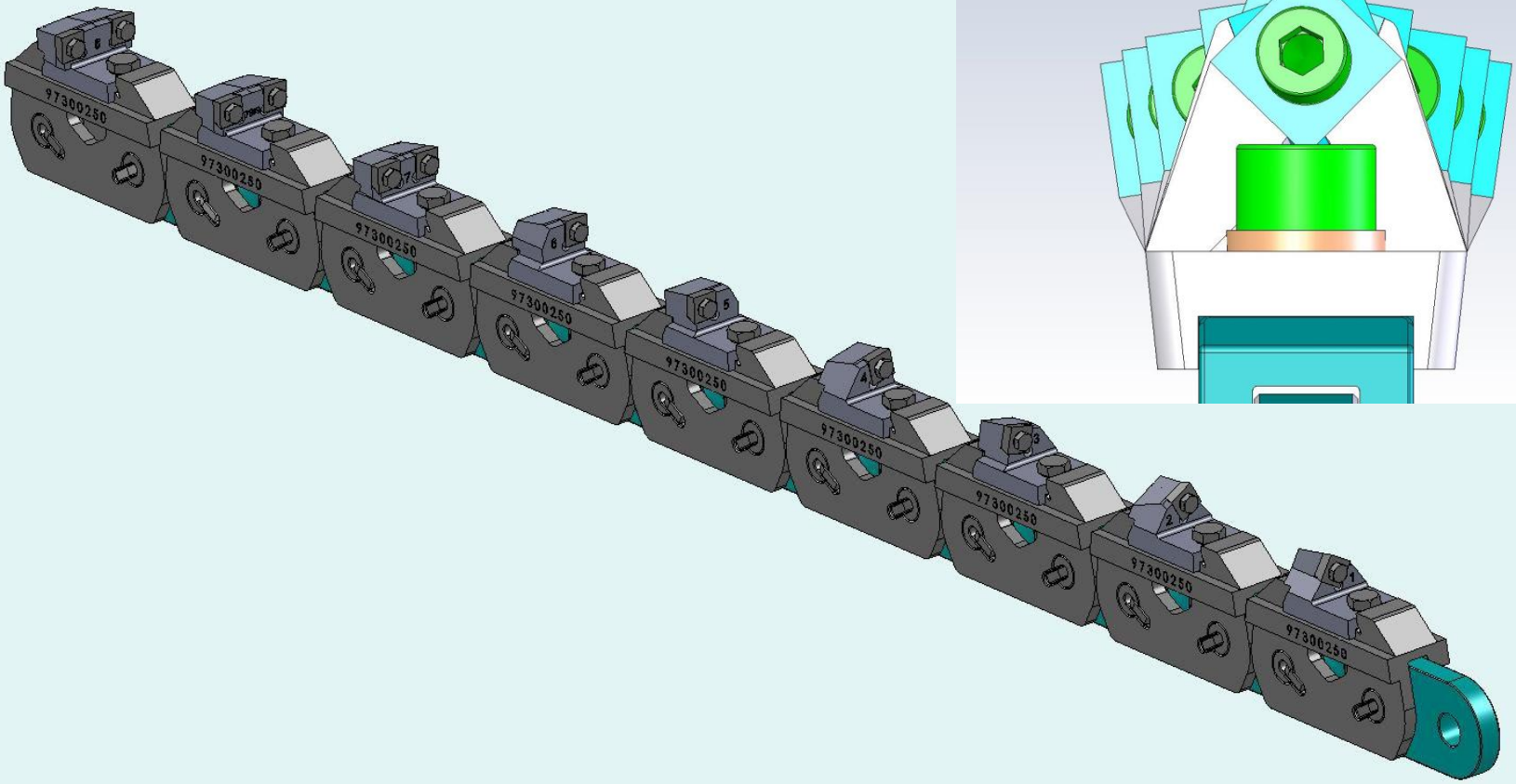

5145
3500
5500
1850
5580
3500

VERTICAL CUT

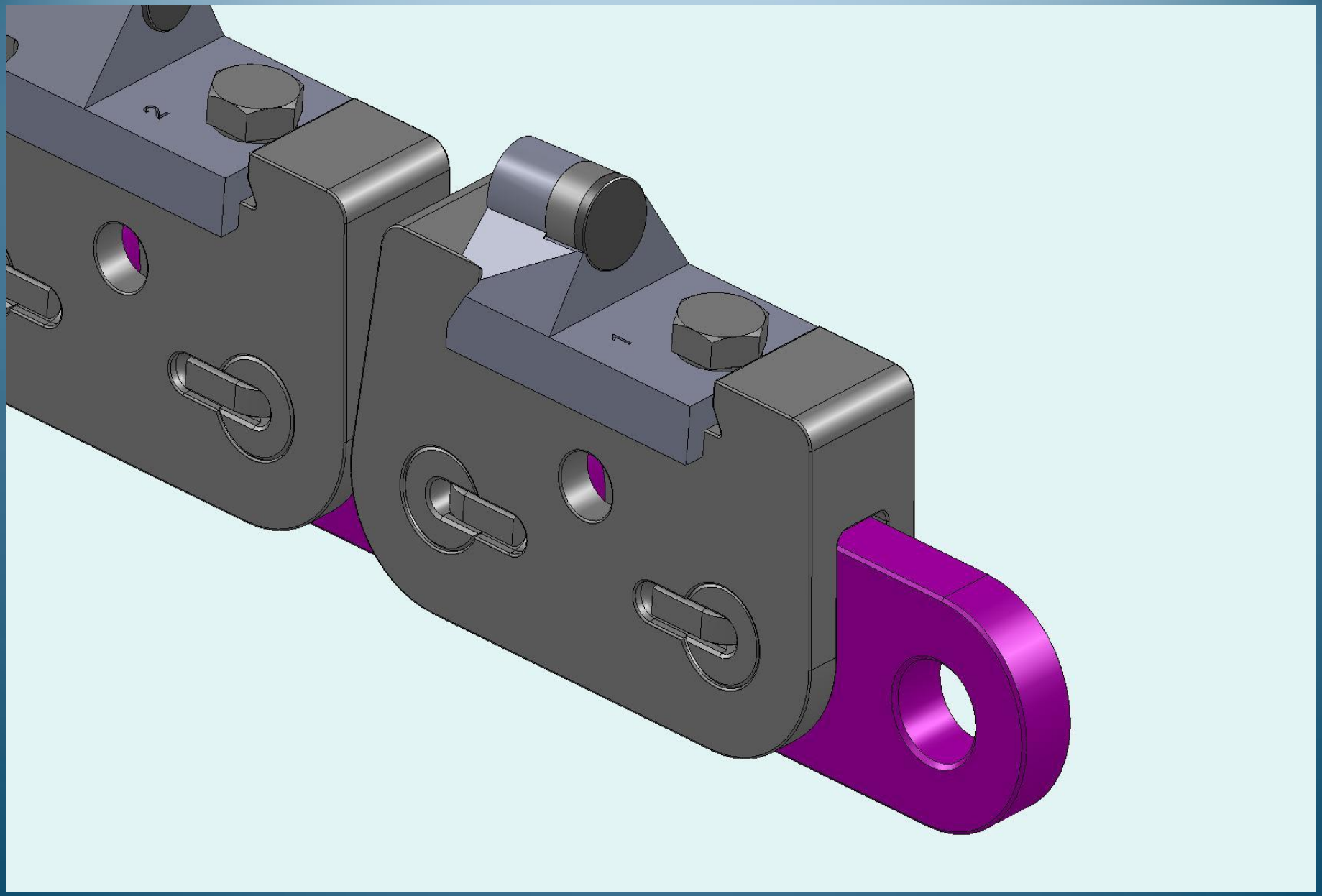
HORIZONTAL CUT

HEAD OF THE “TCM 988” CHAIN SAW

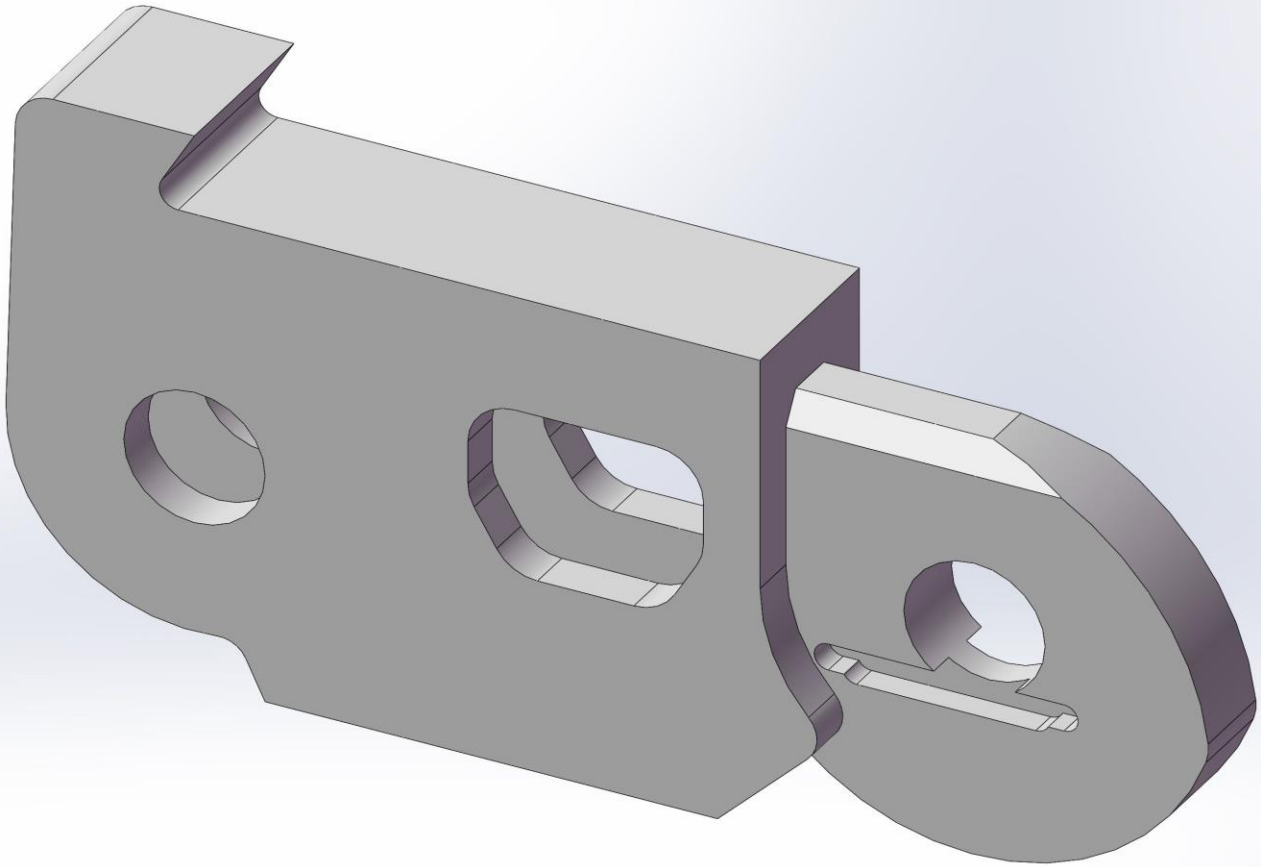
AUTOMATIC CONTROL OF THE MOVEMENTS OF THE ARM



CHAIN WITH TUNGSTEN CARBIDE TOOLS



CHAIN WITH PCD TOOLS



“MONO-LINK” SPECIAL CHAIN DESIGN

HANDLING OF THE “TCM 988” CHAIN SAW BY FORK ON WHEEL LOADER

CUTTING COST EVALUATION
TUNGSTEN CARBIDE TOOLS

		cm/min	cut depth (m)		m2/hour			
Cutting speed:		4,00	3,00		**7,20**			
Idle time								
for P.I.				20%				
Actual cutting								
speed					**5,76**			
Tool life:		*tool rotation (m)*	*blade length (m)*	*m2*	*# corners*	*m2/1 set of tips*	*# Tips/chain*	*m2/tip*
		20,00	**3,00**	**60,00**	8,00	**480,00**	120,00	**4,00**
Tool cost:		*Unit price €*	*m2/tip*		*€/m2*	*cost fraction*		
		2,80	**4,00**		**0,70**	**4%**		
Grease:		*Price €/kg*	*kg/hour*	*m2/hour*				
		5,00	1,00	**7,20**	**0,69**	**4%**		
Chain & arm		*Price €*	*Life (hours)*	*m2/hour*				
consumables		7.000,00	2.000,00	**7,20**	**0,49**	**3%**		
Electric Power		*€/kWh*		*m2/hour*				
		15,00		**7,20**	**2,08**	**11%**		
Labour:		*€/hour*	*% actual work/hour*	*m2/hour*				
		30,00	100%	**5,76**	**5,21**	**29%**		
Depreciation and		*Value/10 years €*	*working hours/year*	*m2/year*				
Maintenance:								
		35.000,00	1.500,00	**8.640,00**	**4,05**	**22%**		
Miscellaneous:								
Handling of blocks and machines,								
waste removal, water supply,								
securing, lighting, ventilation, etc.					**5,00**	**27%**		
Total cost				€/m2	**18,22**	**100%**		

CUTTING COST EVALUATION PCD TOOLS

		cm/min	*cut depth (m)*		*m2/hour*			
Cutting speed:		6,00	3,00		**10,80**			
Idle time								
for P.I.				20%				
Actual cutting								
speed					**8,64**			
Tool life:						*m2/1 set of tips*	*# Tips/chain*	*m2/tip*
						12.000,00	120,00	**100,00**
Tool cost:		*Unit price €*	*m2/tip*		*€/m2*	*cost fraction*		
		40,00	**100,00**		**0,40**	**3%**		
Grease:		*Price €/kg*	*kg/hour*	*m2/hour*				
		5,00	1,00	**10,80**	**0,46**	**3%**		
Chain & arm		*Price €*	*Life (hours)*	*m2/hour*				
consumables		7.000,00	2.000,00	**10,80**	**0,32**	**2%**		
Electric Power		*€/kWh*		*m2/hour*				
		15,00		**10,80**	**1,39**	**10%**		
Labour:		*€/hour*	*% actual work/hour*	*m2/hour*				
		30,00	100%	**8,64**	**3,47**	**25%**		
Depreciation and		*Value/10 years €*	*working hours/year*	*m2/year*				
Maintenance:								
		35.000,00	1.500,00	**12.960,00**	**2,70**	**20%**		
Miscellaneous:								
Handling of blocks and machines,								
waste removal, water supply,								
securing, lighting, ventilation, etc.					**5,00**	**36%**		
Total cost				€/m2	**13,75**	**100%**		
			AVERAGE	€/m2	**15,99**			

Production and cost estimate of TCM 988

(numbers in bold = formula)

useful sizes of TCM988 for each advancement (m)	6,5 * 5,5 * 3,0				**Cost in €**
sizes of each block (m)	3,0 * 1,6 * 1,8				
number of blocks for each advancement	12				
vertical cuts (m2)	5 * (3 * 5,5)	**82,50**			
horizontal cuts (m2)	4 * (3 * 6,5)	**78,00**			
				unit cost (€/m2)	
total cut surface	m2	**160,50**		6,00	**963,00**
average cut speed including entry and exit	m2/h	10,00			
time needed to make all cuts of one advancement operation	total h	**16,05**			
	working h/day	8,00			
time needed to make all cuts of one advancement operation	days	**2,01**			
idle time for: installation, blind cuts, "LP", "CR", removal of blocks, securing	perc.	50%			
net time needed to make one advancement operation	days	**3,01**			
				production cost	
total volume removed (m3)	6,5 * 5,5 * 3	**107,25**		€/m3	**8,98**
cutting waste	m3	**6,74**			
	total m3/day	**28,90**		miscellaneous extra cost	
production yield	block recovery	50%		blind cuts, etc.	0,50
actual production rate	m3/day	**14,45**		actual €/m3	**13,47**
	# days/year	250,00			
production capacity per year	m3/year	**3.612,20**		one-year prod. cost €	**48.651,08**
				average sale price €/m3	150,00
				one-year turnover €	**493.179,47**

"LP" = Levelling - Positioning

"CR" = Chain Rotation