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INRUSH PREVENTION IN AN UNDERGROUND MINE

by

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ABSTRACT

The paper presents the first experimental results of a study for locating both, the water circulation network and possible isolated water bodies around an underground mine. The main purpose of the study is to define the geometry and the possible connections of water bodies and other cavities intersected with by the mining excavations, and evaluating the parameters which characterize the inflow from the bodies of water.

INTRODUCTION

In order to prevent inrushes of water in an underground mine or to reduce their effects once inflows have occurred, it is important to be familiar with the hydro-geological and hydrodynamic conditions around the existing and future mine workings. In particular, it is important to establish the geometry of the permeable formations, of the karst cavities, of the abandoned mine workings, whether waterlogged or potentially liable to floodings and to know the characteristics of surface and underground water courses which might flood into the mine.

RESULTS OBTAINED FROM A PRELIMINARY INVESTIGATION

The subject matter dealt with here is a part of a research programme being carried out in the Campino mine (Southern Tuscany) , the results of which can be extended to underground mines in similar hydro-geological conditions. The purpose of the research is to recognize the geometry and other characteristics of the ground water regime and of any back water cavity around the mine workings. For this purpose the following parameters are evaluated:-

- o Elevations at which the exploratory boreholes intersect the water bodies are accurately identified .
- o Initial static water pressure and flow rate from each source of water is accurately logged.
- o Trends of pressure and flow rates are recorded as the cavity is de-watered.

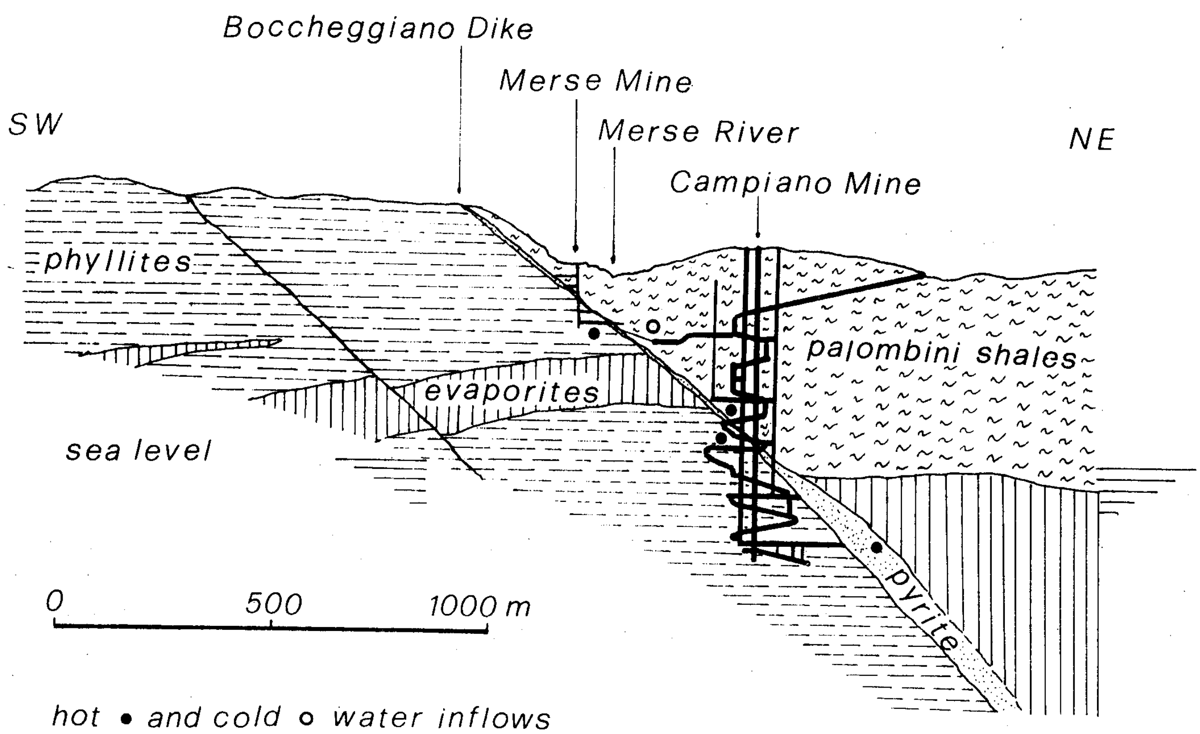

Figure 1 Geological Cross-section of the Boccheggiano Orebody in the Merse and Campiano Mines

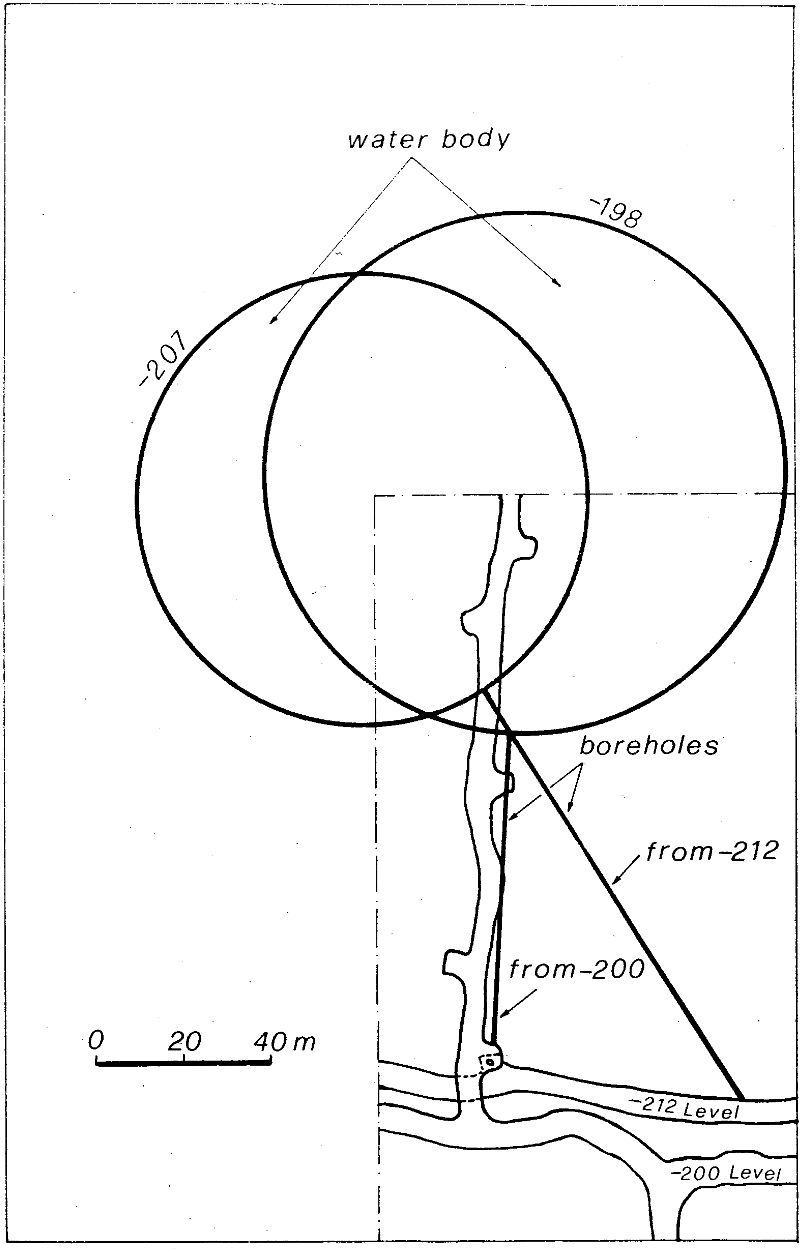

Figure 2 Comparison between the maximum horizontal Dimensions of the water body detected by means of two boreholes and size of the tunnels.

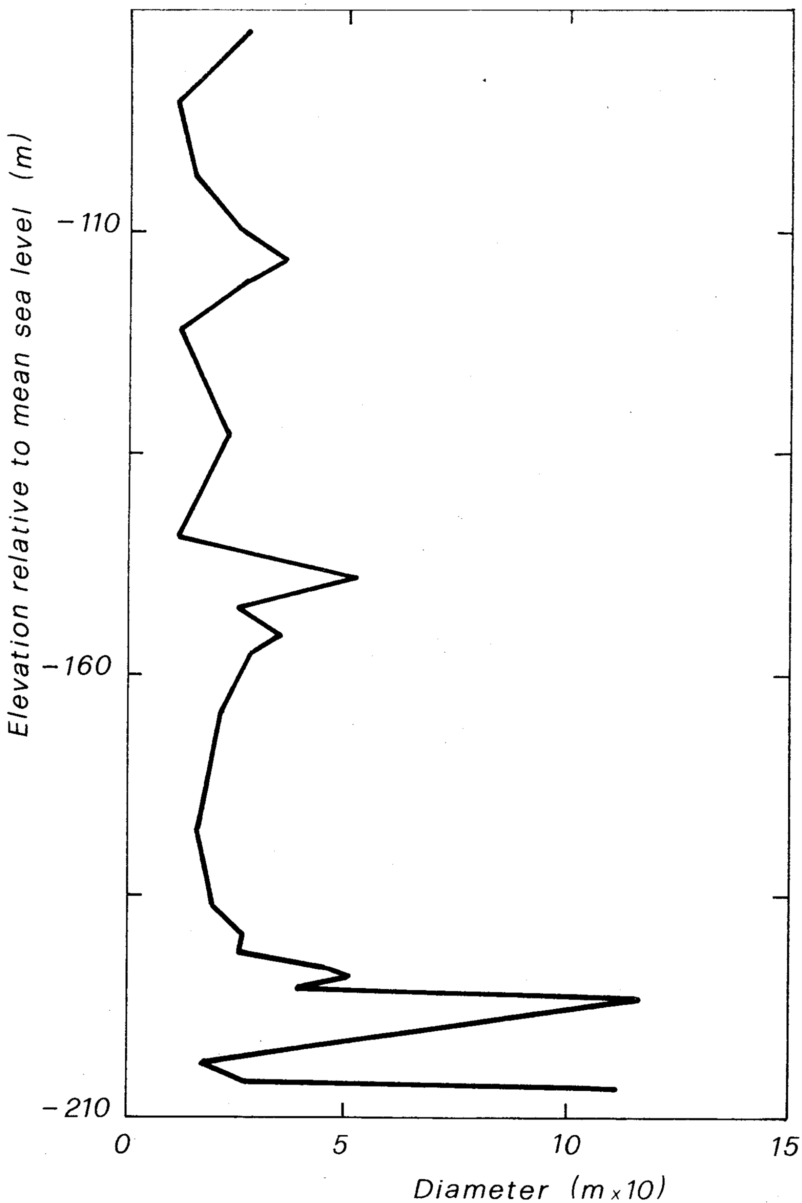

Figure 3 Equivalent diameter of the horizontal section of fracture in relation to elevation above sea level.

Table 1

Day	Flow Rate 0.001 m^3/s	Stable Pressure at zero flow MPa	Water Head above Floor m	Volume inflow m^3	Head Drop m	Area of Water m^2	Equivalent Radius m	Intermediate Elevation m
0	16							
1	16							
2	15	1.094	111.60					
				1257.98	2.07	607.72	27.82	110.56
3	14.12	1.074	109.53					
				1205.28	12.40	97.20	11.12	103.03
4	13.78	0.925	97.13					
				1149.98	6.20	185.48	15.37	94.03
5	12.84	0.892	90.93					
				3290.55	6.20	530.73	26.00	87.83
8	12.55	0.831	84.73					
				1084.32	1.03	1052.74	36.62	84.21
9	12.55	0.821	83.70					
				1965.60	3.10	634.06	28.42	82.15
11	10.20	0.790	80.62					
				853.63	8.27	103.22	11.47	76.46
12	9.56	0.709	72.33					
				6448.90	15.50	416.06	23.02	64.58
16	9.10	0.577	56.83					
				770.69	7.23	106.60	11.65	53.21
17	8.74	0.486	49.60					
				4468.61	2.07	2158.75	52.44	48.56
23	8.50	0.466	47.53					

Table 1 (Continued)

Day	Flow Rate 0.001 m^3/s	Stable Pressure at zero flow MPa	Water Head above Floor m	Volume inflow m^3	Head Drop m	Area of Water m^2	Equivalent Radius m	Intermediate Elevation m
				2133.22	4.13	516.52	25.65	45.46
26	7.96	0.426	43.40					
				2042.50	2.07	986.71	35.45	42.36
29	7.80	0.405	41.33					
				1302.91	2.06	632.48	28.39	40.30
31	7.28	0.385	39.27					
				4127.76	11.37	353.04	21.53	33.58
38	6.37	0.274	27.90					
				3066.34	14.47	211.91	16.43	20.66
44	5.46	0.132	13.43					
				1327.10	4.13	321.33	20.23	11.36
47	4.78	0.091	9.30					
				1185.84	2.07	572.87	27.01	8.26
50	4.37	0.071	7.23					
				1084.75	2.06	526.58	25.90	6.20
53	4.00	0.051	5.17					
				1650.24	1.04	1586.77	44.96	4.65
58	3.64	0.041	4.13					
				2083.54	1.03	2022.85	50.76	3.61
65	3.25	0.030	3.10					
				1856.74	1.55	1197.90	39.06	2.32
72	2.89	0.015	1.55					
				5554.22	0.52	10681.19	116.65	1.29
95	2.70	0.010	1.03					
				2471.04				
108	2.50	0.010	1.03					
111	0.34							
112	0.09							
115	0.00							

Table 2

Day	Flow Rate 0.001 m^3/s	Stable Pressure at zero flow MPa	Water Head above Floor m	Volume inflow m^3	Head Drop m	Area of Water m^2	Equivalent Radius m	Intermediate Elevation m
0	3.40	0.071	7.23					
				673.92	3.10	217.39	16.64	5.68
21	1.80	0.041	4.13					
				584.06	1.03	567.05	26.88	3.61
25	1.58	0.030	3.10					
				1095.55	-2.07			4.13
33	1.59	0.051	5.17					
				1718.50	1.04	1652.40	45.88	4.65
46	1.47	0.041	4.13					
				2398.46	0.51	4702.86	77.40	3.87
62	2.00	0.035	3.62					
				2177.28				
97	1.60							
				5261.76				
139	1.30							
				2052.00				
158	1.20							
				2756.16				
188	1.00							
				2954.88				
214	0.90							
				1321.92				
231	0.90							
				1982.00				
258	0.80							
				3672.00				

Table 2 (Continued)

Day	Flow Rate $0.001\ m^3/s$	Stable Pressure at zero flow MPa	Water Head above Floor m	Volume inflow m^3	Head Drop m	Area of Water m^2	Equivalent Radius m	Intermediate Elevation m
308	0.90	0.020	2.07					
				1710.72	0.00			
329	0.90	0.020	2.07					
				2496.96	0.00			
354	080	0.020	2.07					
				2494.80	0.00			
389	0.85	0.020	2.07					
				1028.16	0.00			
402	0.85	0.020	2.07					
				2523.31	0.00			
435	0.92	0.020	2.07					

With the aid of all known geological, hydrodynamic and physio-chemical data, the described methodology should enable to identify the geometry of the waterlogged bodies encountered and of any existing connections with increasingly refined approximations if the loggings are done more frequently.

In the companio mine the development of the mine is carried out in the lower part of the orebody dyke, mainly consisting of pyrite, which in the past was exploited from the surface to a depth of 150 m in the Merse Mine. It is situated along a large normal fault which in the hanging wall has practically impermeable schisto-clayey flysches (Palombini Shales) and cavernous limestone (Upper Trias), characterized by high porosity and transmissivity and in the footwall Phyllite with high fracture permeability. Figure 1 shows the geological cross section of the fault in correspondence to the Merse and Campanio Mines. This ore body is located about 8 km South of geotherma fields which encountered stream at approximately 100 and 700 m in the Triassic formation and at a depth of over 2000 m in the phyllites.

In the Champino mine the water could infiltrate from above, from the permeable structures and the stopes of the old mine workings, and or from underneath, from deep natural steam- bearing or water bearing reservoirs. So far it has been observed that in proximity to both the footwall and the hangingwall of the deposit, water bearing bodies are present which are sometimes recharged by weak inflows and which are dangerous because of the large masses of hot water content and on account of their piezometric heads which exert high pressures on the diaphragms.

In order to reconstruct the geometry of these water bearing bodies, during the drainage, the approximate values of the surfaces of the horizontal cross sections of the cavities were determined at various elevations. The values of mean pieziometric head is given by :-

$$(q_1+q_2)(t_2 - t_1) / 2 (h_1 - h_2)$$

Where

q_1= the flow rate of water leaving the cavity
h_1= elevation of the original water level in the cavity
$t1$ = time at zero flow rate
q_2= Flow rate at time t_2
h_2= the elevation of water level at time t_2.

Tables 1 and 2 show the calculation procedure adopted for Campino mine to obtain these surfcaes and the equivalent diameters of the cavities filled with thermal water at 72 ^{o} C intersected by two boreholes. Figure 2 shows the maximum horizontal dimensions of the water body. In figure 3 , where diameter versus elevations are plotted, the shape of the cavity is roughly determined. These results are slihghtly overestimated due to a weak continous inflow of water in the cavity.

In order to obtain correct representations of cavities it is advisable to carry out very frequent surveys determining flow rates and pressure regimes; the smaller the time intervals at which the water surface elevation is calculated, the closer the reconstructed cavities will be to the real ones.

CONCLUSIONS

The presented here allows us to define at several levels the elevation of the water surfaces. The shape of these sections and the position of the water body can be determined by establishing the parameter of each horizontal section by means of their meeting points with boreholes and (or) with mining stopes. For the programming of future work, in order to avoid dangerous situations, and for the evaluation of possible risks for the existing stopes, it is important know the geometry and position of cavities, because they could also after draining, fill up again with water e.g. the occlusion of the holes, which made the draining possible., or by landslides which could obstruct the water crossing through these boreholes. The experimental method also allows to record possible change in the geometry of a cavity, allowing it to fill up again after draining, and retesting the inflow characteristics during its draining.

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