International Journal of Mine Water, 2 (1982). 15 - 18
Printed in Granada, Spain

TECHNICAL NOTES

FLOOD DETECTION IN MINES USING GAS CONCENTRATION ANOMALIES IN THE AIR VENTILATION SYSTEM

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ABSTRACT

Flooding in two mercury mines, both characterised by a continuous emanation of a CO_2-H_2S gas mixture, has been investigated and previously reported by the author. The investigations suggest a definite correlation between variations in the gas flow-rate and mixture concentration ratio and fluctuations in the piezometric level. This correlation is attributed to changes in the compressibility and solubility of the two gases. This technical note contains the pertinent results and conclusions of these investigations.

INTRODUCTION

Certain factors governed by the hydrodynamic environment around an underground mine are of crucial importance to predicting flooding phenomena.

Once the laws governing these hydrodynamic factors have been defined, variations in some of them will permit changes in the hydrogeologic conditions underground to be identified and advance warning of possible influxes of water to be given, thus reducing considerably the risks of flooding.

THE FLOOD DETECTION TECHNIQUE

Nearly all the extraction activities underground in Italy are conducted beneath the pre-existing hydrostatic level. In some cases the water in question have temperatures above 60°C. Consequently, precautionary and defensive measures are required, and these generally consist of the following traditional precautions :

- drainage from below, using tunnels underlying the excavations in course or submersible pumps;
- drilling radial holes (not always applicable in the presence of a fracture-derived permeability);
- abandoning protective diaphragms.

Unforeseen, and generally natural, incidents may nevertheless occur, against which the above precautions are inadequate. Studies must therefore be made of factors capable of giving advance warning of flooding, so as to abandon operations in good time.

During recent floodings it was noted that the hydrodynamic conditions around the underground excavations could be kept under observation by continuous monitoring of certain parameters such as the water-levels in nearby wells or old mines and the ventilation flow-rate in the tunnels, should the water have begun to flood the underground.

The mines characterised by continuous gas emanations exhibited important correlations between the hydrodynamic regime and the flow-rate of these gases.

Most of the results of these studies, which were based on data collected by the author during flooding in two mercury mines affected by continuous emanations of a CO_2-H_2S mixture, have already been presented in 2 earlier papers[1,2].

During these floodings the flow-rates of the CO_2 and H_2S in the tunnels were monitored continuously, along with the hydrodynamic conditions; the latter were obtained by measuring the water-level and water flow-rate in a well. The correlation between variations in flow-rate of the gas ceded by the rocks to the ventilation air and the variations in hydrodynamic conditions was mainly attributed to :

- gas compression or expansion as a result of the changing piezometric level;
- an increase or decrease in the solubility of these two gases with the variations in local mass and pressures of the water carrying them underground.

The most conspicuous effects were the increase in gas flow-rate and in the CO_2/H_2S concentration ratio with the rise in piezometric level and the decrease in these values with the lowering of this same level.

When fluctuations were observed in the piezometric level during flooding, the flow-rates of the two gases seemed to be controlled not only by the position and displacement rate of this level at the time of measurement, but also by the degree and frequency of these fluctuations: the latter affected the pressure gradients between gas-filled pits and tunnels and the amount of soluble gas, and greatly modified the permeability of the terrains.

CO_2 leakages during flooding were even noted in tunnels that had never before been affected by gas escapes; on such occasions the temporal behaviour of the flow-rates and of the CO_2 concentration took the form of two waves: the concentration wave was delayed with respect to the flow-rate wave, but appeared before the latter reached its peak, so that the appearance of CO_2 could be regarded as a warning signal.

After the first experimental results, an accurate interpretation of the flow-rate variations of these two gases permitted the prediction

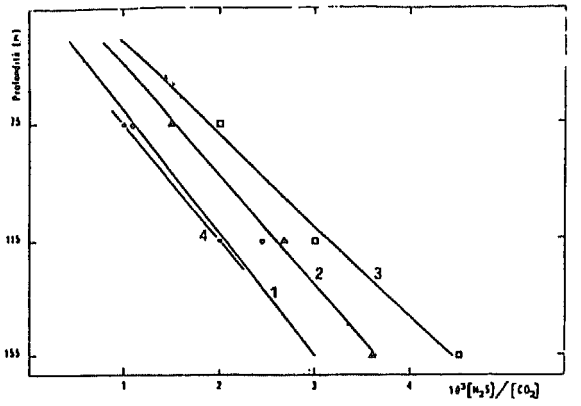

Figure 1: Bagni San Filippo mine. Depth versus H_2S/CO_2 concentration ratio. Straight lines 1,2 and 3 represent the gradually lowering piezometric level. Line 4 represents flooding in the deepest mining level.

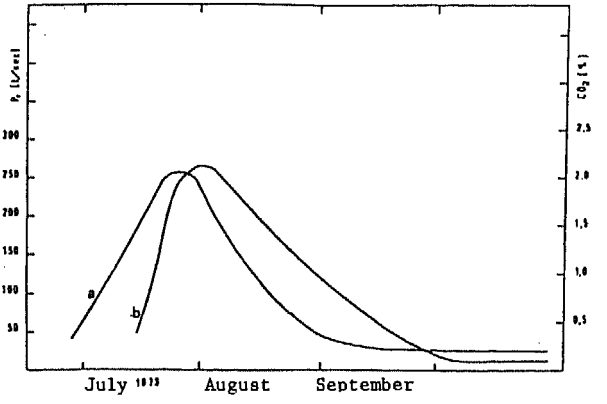

Figure 2: Selvena mine. a) Water flow-rate in the drop shaft, P_v; b) CO_2 concentration in the reflow current of some excavations on the -120 m level.

of the rise and fall of the piezometric level and imminent flooding.

The results can also be held valid in the case of flooding in mines affected by emanations of other types of gases; they are particularly applicable in mines affected by firedamp, in which the above experiments could not be conducted as the CH_4 would have created an explosive mixtur on reaching the same concentrations as the CO_2.

The influence of each parameter will undoubtedly vary depending on the type of gas involved. In the case of firedamp, for example, which is far less soluble than CO_2, compression and expansion would have a far stronger effect on solubility than they had for CO_2 Methane being much more sensitive to displacements of the piezometric level, will consequently provide an even earlier warning than CO_2, aside from the risks ensuing from large increases in CH_4 content during the rise of the water-table.

It is, however, impossible to define in absolute terms the gas flow-rate anomaly preceding flooding, because of the many forms this anomaly may take and because of the wide variety of gas emanations occurring in different mines.

For flood forecasting purposes, however, it is necessary only to define certain specific characteristics (that may occur during the rise of water-tables) that permit us to distinguish this from other possible anomalies.

REFERENCES

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