The assessment of the fracture zone of Valias coal mine in Albania, using the single well point dilution method of a radioactive tracer

Romeo Eftimi[1] & Sokrat Amataj[2]

[1] ITA Consult, Rr. Rreshit Çollaku, pll. 10/3/18, Tirana, Albania, <eftimi@sanx.net>
[2]Institute of Nuclear Physics, Tirana, Albania, <amatajsokrat@hotmail.com>

Abstract: The vertical profile of groundwater flow velocity determined in four wells by the point dilution of a radioactive tracer was used for the identification of the thickness of the intensive fractured zone developed in Valias coal mine in Albania.

Key words: Point dilution method of a radioactive tracer, groundwater Darcy velocity, coal mining, rocks deformation zones, zone of intensive fracture.

Introduction

The mining under surface or under the groundwater bodies implies often the determination of the thickness of the intensive fractured zone of the rocks above the caving level. Knowing the thickness of this zone, the size of the protective pillar of the mine from the surface or groundwater bodies could be determined. In the present paper is described the application of radioactive tracer techniques and how the measured Darcy flow velocity is applied for dimensioning the protective pillar in Valias coal mine.

Geology and the problem of Valias coal mine

Valias coal mine is located about 15 km northwest to Tirana City. The coal layers belong to Upper Miocene, which are constituted of intercalations of clay, siltstone and less by sandstone and by coal layers and coal slates. The rock layers deep to the west by angles 10-12°, and to northwest by angles 3-4°. The Upper Miocene deposits are covered by Quaternary deposits represented of a gravel layer about 30 m thick and silt and clay sediments. The Upper Miocene deposits are characterized as a poor aquifer, while the gravel deposits are a very abundant one. In Valias coal mine is applied the longwall exploitation developed along the coal bed extension causing the total roof falling. The goafs created by the coal exploitation temporary were hold with metallic props. After removing of metallic props the roof starts to bend and later the roof rocks begin to failure. Zoto (1997) distinguishes three rock massive movement zones inside the deformation funnel; caved zone (Hc), zone of intensive fractures (Hf) and zone of plastic deformations with maximal subsidence Hs =2 m as shown

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in Figure 1. Should the zone of intensive fractures riches the gravel aquifer, the groundwater was expected to be drained in the mine, compromising the normal mining if not permanent loss of important coal resources.

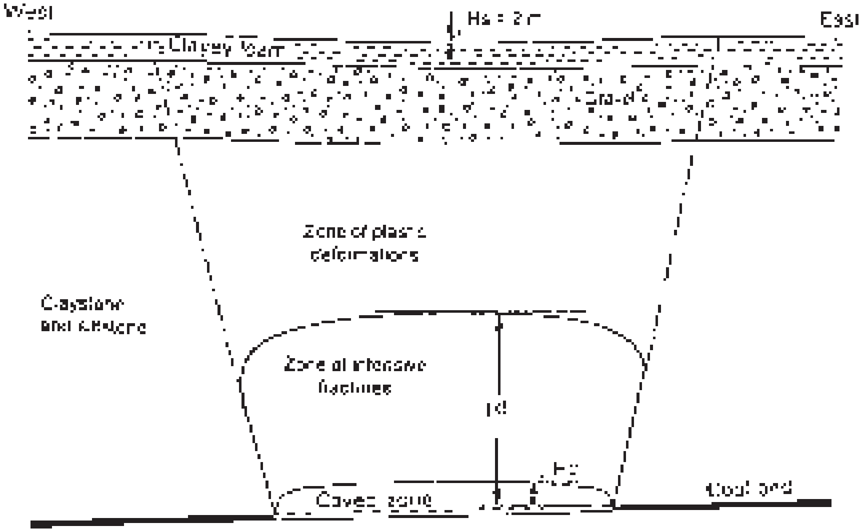

Figure 1. Schematic view of rock deformations zones in Valias coal mine

METHODOLOGICAL APPROACH

It was assumed that groundwater filtration velocity in the intensive fractures zone caused by the mining should be much higher than in the rocks not effected by intensive fracturing. The single well point dilution method of a radioactive tracer was applied for measuring the groundwater Darcy flow velocity. The experiments are organized according the following scheme: a) Estimation of the groundwater flow velocity, both, inside and outside the area of deformation funnel, expecting higher groundwater flow velocity inside then outside the area of deformation funnel; b) Estimation of groundwater flow velocity at different times in the same well, when it was outside the deformation funnel and after a certain time when it was included inside this funnel; in the second case the estimated groundwater flow velocity was expected to be higher; c) The groundwater flow velocity inside the deformation funnel was expected to be higher in the depth coinciding with the zone of intensive fractures than in the zone of plastic deformation of rocks. The experimental site is constituted of four boreholes drilled to the depth 117-138 m: Well 1 was located at the longwall axes area but outside the rock's movement zone; three wells were located inside the rock movement zone, one of them on the longwall axes area and two remaining wells were located on both sides of longwall periphery area.

Determination of the filtration velocity by single well point dilution method of a radioactive tracer

The solution existing between the dilution velocity of a radioactive tracer injected in a well and the groundwater filtration velocity is (Halevy et al., 1967):

$$V_f = \frac{V}{\alpha F t} \ln \frac{C}{C_o}$$

Where: V_f = groundwater filtration velocity; V = volume of labeled water column; α = coefficient of distortion of the flow lines by the presence of the filter tub; F = area of the section perpendicular to the groundwater flow direction; C = concentration of the labeled water column at time t = t; C_o = concentration of the labeled water column at t = t_o.
Using the procedure described by Drost et al. (1968), Drost & Neumaier (1974) and Klotz et al. (1979) the estimated coefficient α resulted 2.04 to 2.10. As the vertical flows in Valias boreholes were negligible the measurements were done without packers (Boanza et al., 1970). As a tracer is used iodine-131 as NaI solution and the used activity of each injection was 13-150 μCi. A mechanical syringe (Tazioli, 1973) was used to inject the tracer. For radioactivity measurement digital analog scintillation detector is used.

Elaboration of data and results

The measurements corrected for the natural radioactivity of the rocks and for the radioactivity decay during the time interval from the injection to the measurement enable to evaluate

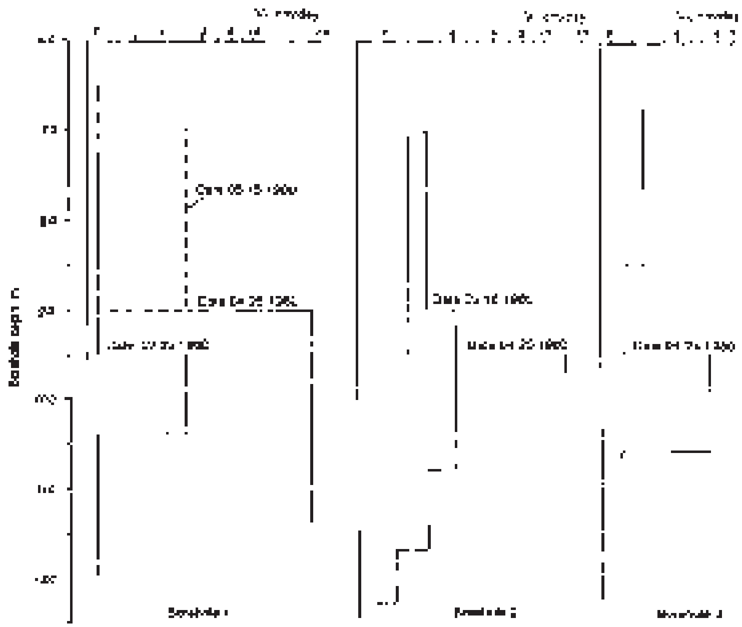

Figure 2. The profiles of estimated groundwater flow velocity of boreholes 1, 2 and 3

the intervals of different groundwater velocity. Figure 2 shows the results of all experiments conducted at borehole 1, 2 and 3.

The groundwater filtration velocity at borehole 1 prior that the rock massive suffers the deformations resulted from 0.2 to 0.6 cm/day. When this borehole was included inside the area of deformations the filtration velocity measured at three experiments shown in Figure 2 resulted from 5 to 17.5 cm/day. Similar results are gained at borehole 2, but somewhat less indicative result the measurements at boreholes 3 and 4. As shown in Figure 2 the groundwater filtration velocity is increased below the depth 90 m at borehole 1 and below the depth 95 m at boreholes 2 and 3. The top of the zone of intensive fractures is identified at the depth about 90 m. The results obtained by the radioactive method are in a very good harmony with the results obtained by the water injection method (PANO & ZOTO, 1985).

CONCLUSIONS

The point dilution method of a radioactive tracer may provide an independent approach for solving the problem of the identification the thickness of the zone of intensive fractures developed above the mines applying the total roof falling method of caving. The application of this method in conjunction with other methods, as for example water injection method, is likely to be most productive. In Valias coal mine the thickness of the zone of intensive fractures resulted to be about 50 m and the thickness of the protection pillar, being in safe side, was accepted to be 60 m.

REFERENCES

BOANZA, E., PLATA, A., & PILES, E. (1970): Application de la tecnica del pozo único mediante el marcade de todo la columna piesométrica. *Isotope Hydrology*, IAEA, pp. 695-711, Vienna.

DROST, W., & NEUMAIER, F. (1974): Application of single borehole methods in groundwater research. *Isotope Techniques in Groundwater Hydrology*, (Proc. Symp. Vienna, IAEA, 1974); IAEA, pp. 241-254, Vienna.

DROST, W., & KLOTZ, D. (1983): Aquifer characteristics. *Guidebook on Nuclear Techniques in Hydrology*, IAEA, Vienna, pp. 223-256, Vienna.

HALEVY, E., MOSER, M., ZELLHOFER, D., & ZUBER, A. (1967): Borehole Dilution Techniq1ues: A Critical Review, *Isotope in Hydrology*, Proc. Symp. Vienna, IAEA, 1966, pp. 531, Vienna.

KLOTZ, D., MOSER, H., & TRIMBONI, P. (1979): Single borehole techniques: Present statues and examples of recent application. *Isotope Hydrology*, Proc. Symp. Neuherberg, 1978, Vol 1. IAEA, pp. 159, Vienna.

PANO, T., & ZOTO, V. (1985): The protection of the Valias coal mine from the groundwater. *Bul. Shk. Minerare*, No. 1, (in Albanian), pp. 23-34. Tirana.

TAZIOLI, G. (1973): Metodologie e technice radioisotopiche in idrogeologia, Geologia Applicata e Idrogeologia, Vol. VIII, Parte II, pp. 209, Bari.

ZOTO, V., & ALIKO, E. (1984): The ground surface movement and their observation. *Bul. Shk. Minerare*, No. 1-2, (in Albanian), Tirana.