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ON THE USE OF A PENETRANT DYE TO STUDY ORE PERMEABILITY

S. KAIMAN

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ON THE USE OF A PENETRANT DYE TO STUDY ORE PERMEABILITY

by

S. Kaiman*

ABSTRACT

Tests showed that fractures and porous mineral constituents in rock specimens can be revealed by wetting the specimens with Zyglo, a surface-active oil. The fluorescence of Zyglo under ultraviolet light makes it possible to study the extent of its penetration and thus to assess the permeability of the ore. Application of the technique to a radioactive conglomerate confirmed the suspected co-incidence of permeable zones in the ore and uranium mineral concentrations. This could explain the amenability of the ore to leaching.

*Physical Scientist, Mineralogy Section, Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

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Direction des mines

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L'UTILISATION D'UN COLORANT PÉNÉTRANT POUR ÉTUDIER LA PERMÉABILITÉ DU MINERAI

par

S. Kaiman*

RÉSUMÉ

Les essais ont montré que les fractures et les minéraux poreux dans l'échantillon de roche peuvent être vus après avoir mouillé l'échantillon avec du "Zyglo" qui est une huile tensio-active. A cause de la fluorescence du "Zyglo" sous lumière ultra-violette, il est possible d'étudier la mesure de sa pénétration et d'évaluer la perméabilité du minerai. L'application de la technique à un conglomérat radioactif a confirmé la coincidence soupçonnée des zones perméables dans le minerai et les concentrations de minéral d'uranium. Cela pourrait expliquer la convenance du minerai au lessivage.

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*Scientifique en sciences physiques, Section de la minéralogie, Division de la métallurgie extractive, Direction des mines, ministère de l'Énergie, des Mines et des Ressources, Ottawa, Canada.

INTRODUCTION

Percolation leach testing of a radioactive conglomerate ore from Agnew Lake area, Ontario, was recently conducted in the Hydrometallurgy Section of the Extraction Metallurgy Division. Leaching of the ore with bacterially active sulphuric acid solution effected a uranium extraction of over 80 % in about 28 months[1]. The uranium-bearing minerals in this ore (mainly uranothorite and brannerite) are fine-grained and often occur concentrated in seams of pyritic matrix between the quartz pebbles of the conglomerate. The test sample consisted of coarse mine ore, essentially minus 8-inch in size, into which it was obvious from the extraction results that deep penetration of the ore pieces by the leachant had taken place. Fractures are visible in many pieces of the ore sample: some of these fractures may have been in the original rock and some may have been caused by either mining or milling. The desirability of confirming the permeability of the coarse ore to acid solution lead to a search for a technique for demonstrating the occurrence of fractures and/or porous mineral constituents.

Fluorescent dye has long been used in non-destructive testing laboratories to detect surface defects in metal castings. The use of a fluorescent dye, Zyglo, was recently reported by Rabb[2] who studied the penetration of leach solution, to which Zyglo had been added, and compared the depth of its penetration into rock that had been broken by different methods.

In this investigation, the use of Zyglo was studied as a means of determining the permeability of the radioactive conglomerate rock to acid solution.

PROCEDURE AND RESULTS

The indicator dye was Zyglo, type ZL-15*, a water-washable penetrant oil which fluoresces bright green under ultraviolet light. It was used undiluted in all the tests. For preliminary testing, block samples, approximately $\frac{3}{4}$ in. to 2 in. to the side, where sawn from the conglomerate, and the surfaces were smoothed on a grinding lap. The blocks were completely immersed in Zyglo for 30 minutes, washed with warm water to remove surface oil, and then were dried in air. When the surface was examined under ultraviolet light, fractures were seen to be clearly defined by the fluorescence of the oil left in them. After several hours, the fluorescent increased as oil exuded from the fractures and pores and spread over the surfaces of the test blocks.

To test the penetration of the Zyglo by capillary action, test blocks were immersed in Zyglo to a depth of 1/8 in. After 16 hours, the vertical surfaces had become wetted to a height of 1 to 2 inches above the level in the dish. Surface oil was washed off with hot water and cross sections, cut by wire saw, were examined to determine penetration. In one block with a vertical fracture, the Zyglo had penetrated the fracture to a height of 1.6 inches and completely across the section which at this level measured 7/8 x 7/8 inches.

*Manufactured by Magnaflux Corp., 7300 West Lawrence Ave., Chicago, Ill. 60656.

To investigate the movement of Zyglo downward in the ore, specimens were prepared by cementing either a bakelite or aluminum collar (20 x 12 mm) to a flat top of each of the 2-inch high blocks. Zyglo was poured into the collar to a depth of about 3/16 in. With each of the 3 blocks tested, oil became visible on the sides of the block within 2 hours and, after 8 hours, had penetrated to between 1 and 1¼ in. below the top of the block. The oil reached the bottom of one block in 24 hours and the bottom of another block after 48 hours.

To test the permeability of a dense specimen of the conglomerate ore, a block was cut and semi-polished to yield an irregular test specimen approximately 4¼ in. high (Figure 1). The specimen showed several transverse fractures and at right angles to the "base" of the block were subparallel bands or seams containing pyrite and radioactive minerals. The specimen was placed upright in a dish of Zyglo so that it was immersed to a depth of about 1/8 in. Wetting of the vertical surfaces proceeded slowly. The dye reached a maximum height of about 1½ in. after 22 hours, of 2 in. after 4 days, and of 3½ in. after 21 days. After 40 days, fluorescence just reached the top (4¼ in.) and after 49 days the oil had proceeded across the top of the test specimen. The specimen was washed thoroughly and then it was sectioned with a diamond saw at three levels (2, 3, and 4 in. above the base). Examination of the cut surfaces under ultraviolet light (see Figure 2) showed that the Zyglo rose in the specimen not only by wetting the outside surfaces but by capillary action through fine fractures and pores in the pyritic

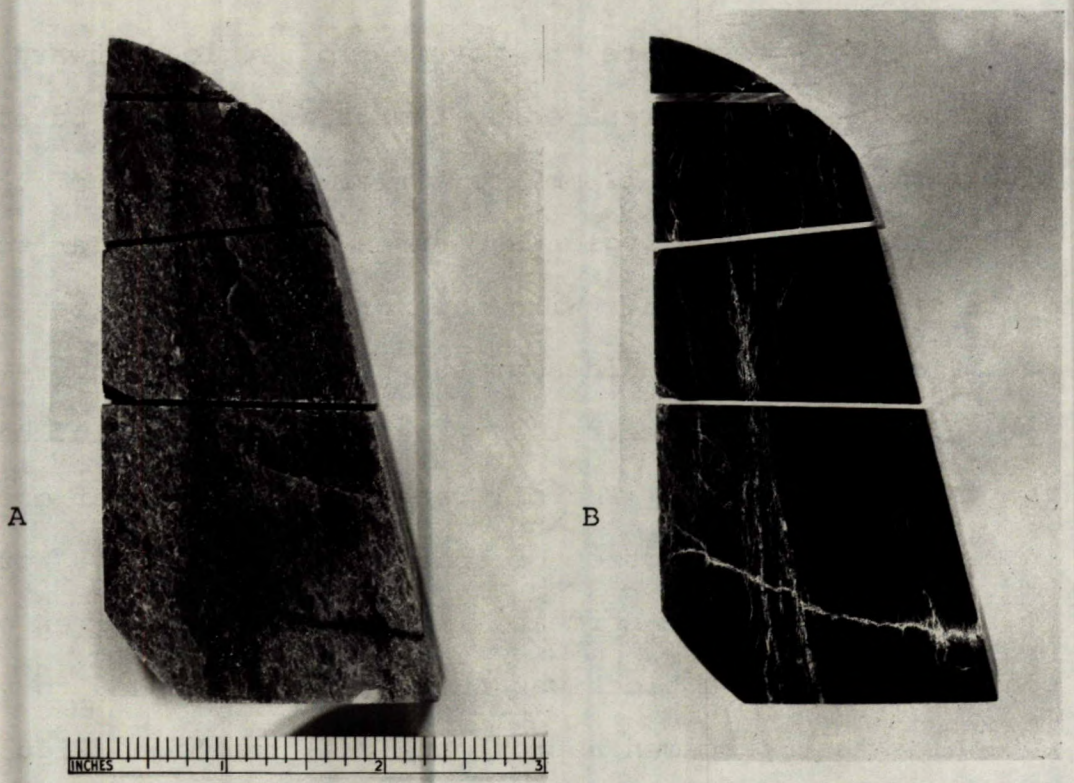

FIGURE 1: Test specimen of dense conglomerate ore, re-assembled. A - white light and B - ultraviolet light, to show penetration of Zyglo into micro-fractures. x 0.8

FIGURE 2: Cross sections of test specimen in Figure 1 to show distribution of Zyglo inside the specimen. Ultraviolet light. x 0.8

bands and in cross fractures in quartz pebbles. Although not all the pyritic seams are permeable, the main zones of penetration by the Zyglo correspond to these seams.

To study the extent of variation in the permeability of the conglomerate, six large specimens, selected at random, were investigated. Two of these specimens contained high proportions of sulphide mineralization, two showed little or no sulphides, and two contained moderate proportions. The lumps were not shaped except for one small flat surface which was ground on an end of each. A steel collar (1.6-in. ID) was cemented to the centre of the flat surface and the specimen was clamped so that this surface was horizontal. Zyglo was poured into the collar and more was added, as required, to maintain a reserve. Seepage of the oil through the specimens was monitored by observing the amount and level of fluorescence produced down the rough surfaces of the specimens. The rate varied considerably, as is shown in Table 1. The sides of Specimens 1 and 3 were wetted relatively quickly. Specimen 2 was but slightly penetrated by the oil, and Specimen 4 showed no fluorescence on its sides. Specimens 5 and 6 showed intermediate permeability.

TABLE 1

Permeability of Conglomerate

Specimen No.	Depth of Penetraction - inches			Distribution of Fluorescence
	66 hours	10 days	28 days	
1	3	4	4½	On all sides
2	1¾	1¾	1¾	One vertical seam
3	2	3	4	Broad zone
4	-	-	-	None visible
5	1¼	2	3	Vertical seam
6	3	3½	4	One side only

The indicated permeability in the six specimens appears to be proportional to the amount of pyrite and, because the radioactive minerals in conglomerates often occur closely associated with pyrite mineralization, a correlation between permeability and radioactivity was indicated. To confirm this possibility, the six specimens were divided into three groups of different degrees of permeability (see Table 2), Sample A being the most permeable type and Sample B the least permeable. The samples were pulverized for uranium analysis; the results are shown in Table 2. The analyses indeed show that the extent of permeability indicated by the Zyglo test is directly related to the uranium content, so that the most permeable specimens (Sample A) contain the most uranium, and the least permeable (Sample B) contain the least uranium.

TABLE 2

Uranium Content of Test Specimens

Sample	Permeability	Weight, grams	U%*
A (Specimens 1 and 3)	high	3,470	0.061
B (Specimens 2 and 4)	low	3,670	0.007
C (Specimens 5 and 6)	moderate	3,720	0.021

*Analyses by Chemical Analysis Section, Extraction Metallurgy Division, Lab. No. EMS 1797, 1798, 1799

DISCUSSION

Tests on a radioactive quartz pebble conglomerate with Zyglo penetrant dye showed that the oil rises or descends in the ore specimens by a combination of surface wetting and seeping through macro- and micro-fractures and porous mineral constituents. It was shown further that there is a high degree of correlation between the extent of fracturing and permeability of this ore and its uranium content: this probably accounts in large measure for the good extraction achieved by leaching.

CONCLUSION

The extent of penetration by Zyglo into an ore can be used to assess its permeability. This could be of particular interest when an assessment is being made of the possibility of leaching coarse ore by percolation methods.

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