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CHINA NUCLEAR SCIENCE AND TECHNOLOGY REPORT

低品位铀矿床留矿-原地浸出现场试验研究

A CASE STUDY OF SHRINKAGE-In PLACE LEACHING OF LOW GRADE URANIUM ORE DEPOSIT

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丁德馨：中南工学院资源开发工程系副教授。1982 年中南工业大学采矿工程专业毕业；1984 年获该校采矿工程专业硕士学位；1990～1992 年在澳大利亚新南威尔士大学做访问研究；1996～1997 年在英国诺丁汉大学做访问研究。

DING Dexin: Associate Professor in the Department of Resources Exploitation Engineering at Central South Institute of Technology. Received B.Eng. and M.Eng. in mining engineering at Central South University of Technology in 1982 and 1984 respectively. Worked as a Visiting Scholar at the University of New South Wales in Australia from 1990 to 1992 and at University of Nottingham in the United Kingdom from 1996 to 1997.

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丁德馨

（中南工学院，湖南衡阳）

周国和

（中国核工业总公司）

摘　　要

我国多数低品位铀矿床具有致密、坚硬、需先予以破碎而后才能应用浸出技术提取铀金属的特点。针对这些特点，进行了留矿法落矿的原地浸铀试验研究，对与此相关的采准系统、切割工艺、爆破参数、爆破工艺、喷淋系统、喷淋参数及集液系统等进行了试验。通过试验研究，获得了理想的工艺参数，提高了铀金属的回收率。

A Case Study of Shrinkage-In Place Leaching of Low Grade Uranium Ore Deposit

DING Dexin
(Central South Institute of Technology, Hengyang, Hunan)
ZHOU Guohe
(China's National Nuclear Corporation)

ABSTRACT

A case study of shrinkage-in place leaching of low grade uranium ore deposit is delt with. A test block was selected, and the shrinkage mining method was employed to construct the in place heap for leaching. Blast parameters and operations were carefully tried in order to make sure that the fragment size composition was adequate for leaching. A leaching system was planned and the corresponding leaching parameters were tried, too. The results show that the shrinkage method and the parameters for blasting and leaching are all adequate for the in-situ leaching of the blasted ore. This shrinkage-in place leaching system combines the mining and metallurgy processes into one and produces a lot of profits and could be applicable to many low grade uranium ore deposits which are so hard and compact that they have to be fragmented before being leached.

INTRODUCTION

In place leaching of fragmented uranium ore is a very efficient method which could be readily applicable to lower grade and submarginal uranium ore deposits. During 1970s many investigators worked on this method and great progress was made in the USA[1] and the former Soviet Union[2].

In China research on this mining method was not started until the early 1980s, and the efforts were mainly concentrated on the in-situ leaching of unfragmented low grade uranium ore deposits[3]. However, there are many low grade uranium ore deposits in China which are so hard and compact that they have to be fragmented before leaching could be applicable to them[4].

Therefore, in the early 1990s, the authors, together with other research scientists and engineers selected a test block and conducted a case study of shrinkage-in place leaching of uranium ore body in a uranium mine. This paper describes the research work and presents the relevant results.

1 GEOLOGICAL CONDITIONS

The uranium ore deposit, which is stratoid and gently dipping, is formed of volcanic lava under low to medium high temperature in the Mesozoic time. The fault structures and the second parallel feather fissures are well developed within the deposit. The ground water permeates at a speed of 0.0016 mm/d. It contains large amount of SO_4^{-2} ions and a bit of HCO_3^{-1} ions. The ore is mainly glassy rhyolite which is hard, compact and brittle. The predominant textures in the ore include impregnation texture and fine vein texture. The roof and floor of the ore body is of moderate hardness and their Protodyakonov factor of strength, f, is from 6 to 12.

The ore body in the test block is the front part of the deposit which is 270 m bellow the surface. It lies between level 185 m and level 197 m and occurs in the form of monoclonal structure. And its dip angle is 30° and the line of strike is located along NNW30°. There are many fissures and joints within the ore body, and a fault cuts through the ore body. The ore body is a pitchblende, which has an ore grade of 0.07% and is compact and brittle. It mainly consists of brown and red rhyolite porphyry which has porphyrilic crystal texture and massive texture. The country rock has a moderate hardness and its

Protodyakonov factor of strength, f, ranges from 8 to 10; its friability factor is 1.7; its volume weight, $2.37 \times 10^3 \ kg/m^3$. The ore is in the form of micro impregnation and contains bits of other minerals which are filled in the cracks within the ore.

2 MINING AND LEACHING SYSTEMS

The mining system for the test block was planned in accordance with principles for conventional shrinkage method. In the mean time consideration was also given to the transportation, flow and collection of the leach solution. The mining and leaching systems are illustrated in Fig. 1.

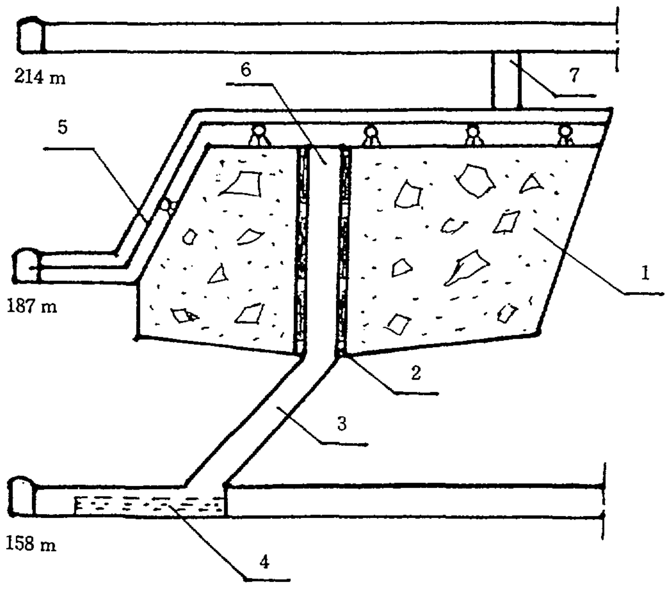

Fig. 1 Diagrammatic sketch of the mining and leaching systems

1. Blasted uranium ore for leaching; 2. Hole for collecting pregnant solution; 3. Raise for collecting the pregnant solution; 4. Pool for collecting the solution; 5. Pipe and spray nozzles; 6. Concrete raise for ventilation; 7. Raise for discharging the polluted air flow.

2.1 Development system for the block

Before the ore was blasted, there had already been a cross drift on level 187 m which run through the test block and connected the cross drift on level 214 m by a raise and the cross drift on level 158 m by another raise. The three drifts came from the three haulage ways on their own levels. All these drifts and raises comprised the development system for the test block. The raise connecting the test block and the cross drift on level 158 m was used for collecting the pregnant solution. A concrete pool capable of holding 40 m^3 of pregnant solution was constructed in the cross drift on level 158 m.

2.2 Making relief space

A 1.8 m high undercut was made throughout the entire block area to make relief space for the subsequent mining operation. The undercutting was started from the central bottom of the block and was pushed forward in the two opposite directions to the boundaries of the ore body so that the floor of the undercut was divided into two parts and both of them were sloped with a gradient of 5% to the central bottom. In this way, the pregnant solution could flow to the raise just bellow the block. Since the country host rocks had a very low permeability coefficient, no bottom structure was constructed for collecting the pregnant solution.

2.3 Breaking of the ore

An end cut was produced for each slice of ore to be blasted. The hole for the cutting was loaded with explosive which took up 70% of the volume of each hole and stemmed with mud. Caving of each slice was started by drilling holes 1.7 m deep in the back of the room so as to form an overhand stope and ensure ample face room for drillers. Each slice to be blasted was 1.5 m in thickness. The area for which each hole was blasted was 0.16 m^2. Each hole was loaded with explosive to 65% of its volume and the rest was filled with mud. All the holes were detonated simultaneously. Once the slice of the ore was blasted, one third of the broken ore was drawn out of the stope, and the rest was left in the stope for leaching.

The fresh air was directed to the stope through the cross drift on level 158 m. And the polluted air was discharged into the air through drift on level 214 m.

To make sure that the ore near the hanging wall could be made use of, part of the hanging wall and foot wall was blasted. In this way, heap was constructed which had the angle required for leaching.

2.4 Fragment size

The leaching requires that the propotion of fragments with a size of smaller than 50 mm should be as high as possible, so that, before a new slice of ore was worked on, many samples were taken at different points so as to determine the fragment size composition of the blasted ore for leaching through screening. The meassured fragment size composition was listed in Table 1.

Table 1 Fragment size composition of the blasted ore

Fragment size/mm	−50	+50～−100	+100～−200	+200 and above
Percentage/%	60.62	18.57	17.18	3.63

2.5 Leaching system

After the final slice of ore was blasted, the broken ore was kept being drawn out of the stope until the height of the space between the back of the room and the top of the blasted ore heap came to about 1.8 m. Since the back was in a fracture zone, concrete supports were constructed to control its stability and ensure the safety for the lasting leaching operation.

The leaching system included main and branch leach solution supply pipes and spray nozzles. The main pipe started form the fixed bed for ion exchange on the surface and went all the way to the top of the test block where 13 branch pipes were connected to the main pipe. To the end of each branch pipe was attached a spray nozzle which could adjust the volume of leach solution flowed through itself and could be repositioned easily. All the spray nozzles were divided into two sets and these two sets of spray nozzles worked interchangeably.

The pregnant leach solution flowed into the pool constructed in the drift on level 158 m for collecting the solution. Then the solution was pumped into the fixed bed for ion exchange on the surface.

2.6 Production process for uranium product

The production process is illustrated in Fig. 2.

Table 2 The designed parameters for leaching

Items	Parameters	Remarks
Acidity of leach solution/$g \cdot L^{-1}$	5～10	
Velocity of leaching/$L \cdot m^{-3} \cdot h^{-1}$	6	
Regulation for leaching	Intermittent	Help to separate out the metal
Means of leaching	Spray nozzle & spray irrigation	Achieve uniform leaching
Acidity of pregnant leach solution/$g \cdot L^{-1}$	1～4	

Continue table 2

Items	Parameters	Remarks
Liquid-to-solid ratio for leaching	2.5 : 1	
Duration of leaching/d	250	
Precipitant/%	30～40	Use NaOH as precipitant
pH value for precipitation	7.0	
Length of time for agitation/min	<15	
Grade of residue/%	0.015	Metal recovered 70%
Acid consumption/%	2.0	
Rate of flow for drip wash/$m^3 \cdot h^{-1}$	0.75	
Concentration of leachant	0.25 $mol \cdot L^{-1}$ NaCl +0.025 $mol \cdot L^{-1}$ H_2SO_4	

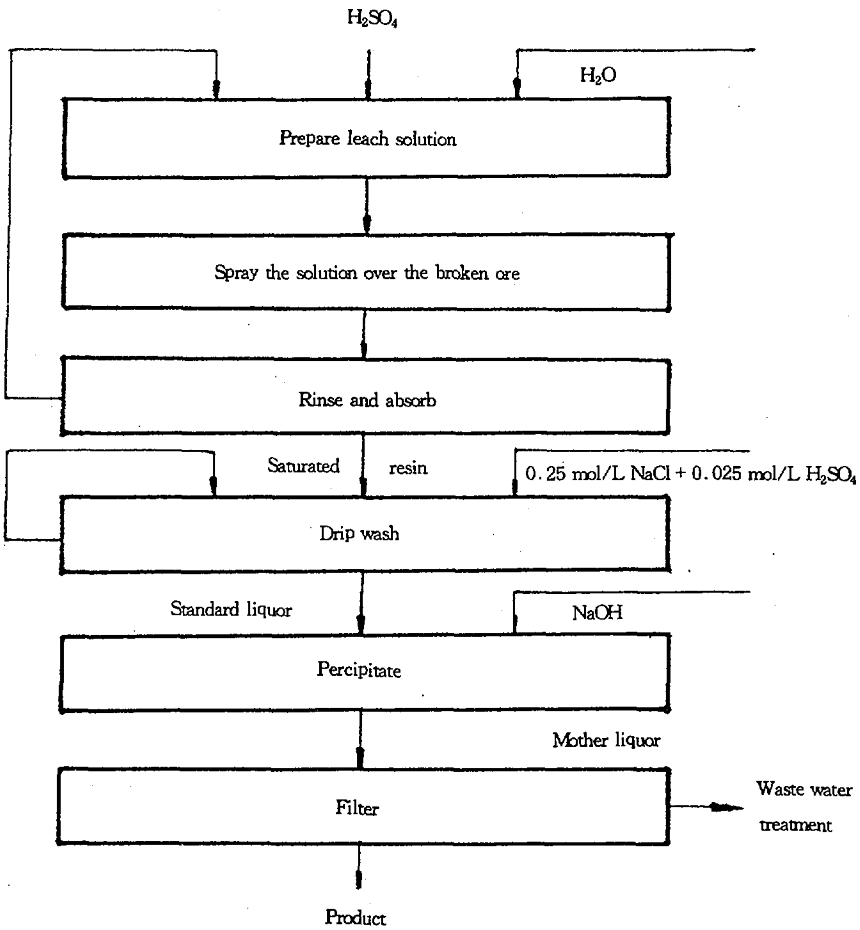

Fig. 2 Diagrammatic sketch of the production process for the uranium product

2.7 Parameters for leaching

The designed parameters for spraying and leaching are listed in Table 2.

3 RESULTS AND DISCUSSION

Table 3 Test results

Items	Test results
Duration of leaching/d	357
Total amount of leach solution consumed/m^3	5493.2
Total amount of pregnant leach solution recovered/m^3	5007
Spray-to-pause ratio	0.41 : 1
Total amount of acid consumed/kg	3300
Acid consumption ratio/%	1.55
The amount of metal extracted/kg	916.789
Metal recovery proportion/%	82.1

After 357 days of leaching, satisfactory results were obtained. The results are listed in Table 3.

As can be seen from Table 3, some results are better than the designed parameters. By comparing the test results with the conventional mining method and metallurgical process, the shrinkage-in place leaching method has the following advantages.

(1) The cost for hoisting and transporting the broken ore was greatly reduced since much of the broken ore was left in the stope for leaching.

(2) The cost for post treatment of the leached ore was also greatly reduced since, for the shrinkage-in place leaching, the leached ore did not need any post treatment.

(3) The acid consumption for the shrinkage-in place leaching was much lower than that for metallurgical treatment.

(4) The power consumption for the shrinkage-in place leaching was also much lower than that for metallurgical treatment.

REFERENCES

1 United Nations' Center for Natural Resources, Energy and Transport. Recent Ad-

vances in Mining and Processing of Low Grade and Submarginal Mineral Deposits. New York: Pergamon Press Inc. , 1976

2 ZHU Zhixiang, et al. The Construction, Development and Mining in Leaching Mines (in Chinese) . Translated from Russian, Edit Board of Uranium and Gold, 1992

3 Research Group of In-situ Leaching. New Advances in In-situ Mining in China (in Chinese) . The Sixth Research Institute, China's National Nuclear Corperation, 1991

4 WANG Changhan. Prospect for In-situ Leaching of Fragmented Ore (in Chinese) . Proceedings of the Second National Conference on In-situ Mining, The Organizing Committee, 1992

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