



## Influence of Non-uranium Minerals on In-situ Leaching in Sandstone-type Uranium Deposits

ZHAO Zichao<sup>1</sup>, SONG Hao<sup>1,2,3\*</sup>, LI Qi<sup>1</sup>, YAN Wenquan<sup>1</sup>, SI Fei<sup>1</sup>, YAO Chang<sup>1</sup>, NIE Rui<sup>1</sup> and LI Wei<sup>1</sup>

<sup>1</sup> Chengdu University of Technology, Chengdu 610059, Sichuan, China

<sup>2</sup> Key Laboratory of Uranium Geology, China Geological Survey, Tianjin 300170, China

<sup>3</sup> Key Laboratory of Radioactive and Rare Scattered Minerals, Ministry of Land and Resources, Shaoguan 512026, Guangdong, China

Citation: Zhao et al., 2019. Influence of Non-uranium Minerals on In-situ Leaching in Sandstone-type Uranium Deposits. *Acta Geologica Sinica* (English Edition), 93(supp.2): 336–337.

**Abstract:** Sandstone-type uranium deposits represent uranium concentrations formed by low-temperature hydrothermal processes, usually of diagenetic to epigenetic origin (Abzalov M.Z., 2012). The main composition of sandstone-type uranium deposits are roughly similar, and uranium minerals in these deposits is dominated by uraninite, pitchblende or coffinite. Uranium can be extracted from host rocks by using acid or alkaline leach technologies. In-situ leach (ISL) technology is based on dissolving uranium minerals directly in their host rocks (in-situ) by reactive solutions that are injected through drill holes, and then pumping the dissolved solution to the surface through some drill holes (Marat Abzalov, 2016). However, non-uranium minerals have different influence on the acid and alkaline leaching process as the main composition in the host rock. In this paper, we research the influence of non-uranium minerals including carbonate, clay, iron minerals, organics in uranium deposits during ISL to improve the efficiency of uranium mining.

### 1 The role of carbonate

Calcite, dolomite and siderite are main carbonate in sandstone-type uranium deposits. The occurrence of those carbonate usually has a negative impact during ISL. They are the main acid-consuming minerals, because they are easy to react with acid. The product of that reaction such as  $\text{CaSO}_4$  can fill the blowhole via chemical jamming. Chemical jamming can be divided into two types: the former is caused by filling of  $\text{CaSO}_4$  in the pore; another is a layer of closed  $\text{CaSO}_4$  rim formed on the surface of ore-bearing rock, which can hinder interreaction between the uranium ore and leaching solution, so that it dramatically decreases the uranium concentration in leaching solution. In alkaline leaching, carbonate has different effects on ISL under different conditions. The dissolution of carbonate increase the concentration of carbanion ions ( $\text{CO}_3^{2-}$ ) and bicarbonate ions ( $\text{HCO}_3^-$ ) in leaching solution, and it forms stable complex such as  $[\text{UO}_2(\text{CO}_3)_2]^{2-}$  and  $[\text{UO}_2(\text{CO}_3)_3]^{4-}$  via cooperation between uranyl ion and carbanion, which plays a positive role in the leaching of uranium. When the pH of leaching solution exceeds 7.5, the carbonate precipitate again and block the pipelines, so the rate of

extraction and injection is decreased (Xing et al., 2017).

### 2 The role of clay

Clay minerals are common associated minerals in uranium deposits, the type, content and distribution of clay determine the pore structure and permeability of sandstone, thereby affecting uranium ore leaching. The main occurrence of clay minerals in sandstone-type uranium deposits are montmorillonite, illite, kaolinite, chlorite. These minerals have some special properties, such as the montmorillonite group clays have sensitivity to water, salt and alkaline. These properties can make the sand pore be plugged by swell. Additionally dependent on solution chemistry and uranium speciation, clay minerals may also adsorb uranyl species and thus there is a degree of “preg-robbing” by some clay minerals in uranium ores (R.J. Bowell et al., 2011). In acid leaching, clay minerals such as montmorillonite group clays in an ore can also chemically interfere with the leaching of uranium by consuming reactants acid (R.J. Bowell et al., 2011), such as a large amount of aluminum, iron, sodium, magnesium into the solution via react with acid, and it results precipitation of hydroxide during ISL.

### 3 The role of iron minerals

There are three types of iron minerals, including ferrous minerals (pyrite and siderite, etc), ferric minerals (hematite and limonite, etc) and zero-valent iron mineral (meteorite iron), in sandstone-type uranium deposits (Peng et al., 2003). In acid leaching, the reaction between iron minerals and acid produce  $\text{Fe}^{3+}$ . When the pH of solution exceeds 1.5, the precipitation of  $\text{Fe}(\text{OH})_3$  formation rate will increase rapidly, and if the pH reaches 4.1,  $\text{Fe}(\text{OH})_3$  will precipitate nearly completely. In alkaline leaching, the main related iron minerals are pyrite and siderite, and both of them can consume massive oxidants and produce acid to neutralize the solution to reduce the pH level, so that it increases the consumption of alkaline. Meanwhile, the precipitation of  $\text{Fe}(\text{OH})_3$  can adsorb uranyl ions as well.

### 4 The role of organics

The organics usually show negative effects to ISL. During the

\* Corresponding author. E-mail: songhao2014@cdut.edu.cn

acid leaching, organics can be oxidized by acid and consume more acids. Analogously, in the alkaline leaching, oxidation of organics consume a large amount of oxygen in the oxidation stage, and the product of organic acid will reduce the pH level.

## 5 Conclusion

Based on the analysis of the influence of different minerals to uranium leaching during ISL process, we considered that carbonate, clay, iron minerals and organics play a major role in ISL of uranium. Among them, carbonate has the greatest influence on acid leaching, and the acid leaching is not applicable when their content exceeds 2% in ore body. Nevertheless, pyrite has the greatest influence on alkaline leaching, and the alkaline leaching is not applicable when their content exceeds 2% in ore body. However, many other factors can affect ISL of uranium deposits, so it is difficult to determine ISL methods by a single or several measurement factors. The accurate ISL methods can be selected according to the specific conditions of deposits.

**Key words:** sandstone-type uranium deposit, in-situ leaching, carbonate, clay, iron minerals, organics

**Acknowledgements:** This research was sponsored financially by the National Key R&D Program of China (Nos. 2018YFC0604202 and 2018YFC0604200), and China Geological Survey (DD20190119), the National Natural Science Foundation Program of China (No. 41503037), and a grant (No. RRSM-KF2018-03) from KLRRSM, Ministry of Land and Resources.

## Reference

Abzalov M.Z., 2012. Sandstone hosted uranium deposits amenable for exploitation by in-situ leaching technologies.

*Appl Earth Sci*, 121(2): 55–64.

Marat Abzalov, 2016. Applied Mining Geology, Modern Approaches in Solid Earth Sciences. *Springer International Publishing Switzerland*: 391–403.

Peng Xinjian, Min Maozhong, Wang Jinping, Jia Heng, Wei Guanhui, and Wang Jianfeng, 2003. Characteristics and geochemical significance of the ferrum phases in the Shihongtan interlayered-oxidation zone sandstone type uranium deposit. *Acta Geologica Sinica*, 77(1): 120–125.

R.J.Bowell, J.Grogan, M.Hutton-Ashkenny, C.Brough, K.Penman, and D.J. Sapsford, 2011. Geometallurgy of uranium deposits. *Minerals Engineering*, 24 (2011): 1305–1313.

Xing Yongguo, Jiang Xiaohui, Huo Jiandang, and Liu Jinhui, 2017. Alkaline in-situ leaching of uranium in high-acid-consumption sandstone-type uranium deposit. *Hydrometallurgy of China*, 36(6): 467–472.

## About the first author



ZHAO Zichao, male, born in 1996 in Handan City, Hebei Province; Postgraduate student of Chengdu University of Technology; He is now interested in the study on the process mineralogy of sandstone-type uranium deposit. Email: 877171585@qq.com; phone: 15930206516.

## About the corresponding author



SONG Hao, male, born in 1986 in Sanmenxia City, Henan Province; Doctor; graduated from Chengdu University of Technology; associate professor of Chengdu University of Technology. He is now interested in the study on economic geology and geochemistry. Email: songhao2014@cdut.edu.cn; phone: 13679090240.