

MECHANISM OF BACTERIAL LEACHING OF ARSENOPYRITE

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Progress in the leaching of sulfide minerals by sulfur bacteria *Thiobacillus ferrooxidans* (Th. f.) has led in recent years to their industrial use in the hydrometallurgy of copper and uranium and to their more extensive use for sulfide products containing gold, tin, nickel, cobalt, molybdenum, and rare elements. The conversion of ferrous metallurgical plants to processing of raw material with a high content of arsenic, compounds of which contaminate water and air, makes it necessary to find ways of extracting this element from arsenic-containing material, eliminating or reducing to a minimum its toxic effect on the surroundings. A knowledge of the chemistry of bacterial leaching of arsenic from such material might accelerate the development of an economically efficient procedure for extracting metals by means of Th. f. [1] and its commercial application.

Arsenopyrite (FeAsS), the form in which arsenic is present in ore materials, is extensively broken down by sulfur bacteria [2-5]. However, the break-down mechanism is still far from clear. According to colleagues of VNI-1, during leaching of FeAsS part of the sulfur is incorporated in the solid phase in elementary form, and the other part goes into solution after oxidation to sulfate ions [5]. As regards iron and arsenic, during bacterial decomposition they are distributed between the liquid and solid phases in a specific ratio [6]. Arsenic is deposited as insoluble iron arsenates, formed by ions of arsenic and trivalent iron. The scheme of bacterial and chemical leaching of arsenopyrite may be represented as follows:

- 1) $2\text{FeAsS} + 6\frac{1}{2}\text{O}_2 + 3\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{AsO}_4 + 2\text{FeSO}_4$ (Th. f.);
- 2) $2\text{FeSO}_4 + \text{H}_2\text{SO}_4 + \frac{1}{2}\text{O}_2 \rightarrow \text{Fe}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$ (Th. f.);
- 3) $\text{Fe}_2(\text{SO}_4)_3 + \text{FeAsS} \rightarrow \text{FeAsO}_4 + 2\text{S}$ (chem);
- 4) $2\text{H}_3\text{AsO}_4 + \text{Fe}_2(\text{SO}_4)_3 \rightarrow 2\text{FeAsO}_4 + 3\text{H}_2\text{SO}_4$ (chem);
- 5) $2\text{H}_3\text{AsO}_4 + 3\text{FeSO}_4 \rightarrow \text{Fe}_3(\text{AsO}_4)_2 + 3\text{H}_2\text{SO}_4$ (chem);
- 6) $\text{Fe}_2(\text{SO}_4)_3 + 6\text{H}_2\text{O} \rightleftharpoons \text{Fe}(\text{OH})_3 + 3\text{H}_2\text{SO}_4$;
- 7) $\text{FeAsO}_4 + 3\text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{AsO}_4 + \text{Fe}(\text{OH})_3$.

It will be seen from these equations that the oxidation products of FeAsS (reaction 1) are arsenic acid H_3AsO_4 and ferrous sulfate FeSO_4 , which is oxidized by the bacteria (reaction 2) to ferric sulfate $\text{Fe}_2(\text{SO}_4)_3$. Oxidation takes place chemically - the $\text{Fe}_2(\text{SO}_4)_3$ regenerated by the bacteria reacts with FeAsS. Reaction in the solution between ferrous and ferric ions and H_3AsO_4 anions leads to formation of iron arsenates (reaction 4), deposited as a sediment; these undergo hydrolysis after treatment with 0.2 N hydrochloric acid (reaction 7). Thus Th. f. is involved both in direct oxidation of FeAsS and in the formation of $\text{Fe}_2(\text{SO}_4)_3$ by oxidation of the ferrous iron in arsenopyrite [6, 7].

Our aim was to study the pattern of change in the structure and composition of arsenopyrite during bacterial leaching. It was also of interest to establish the character of the crystalline system of elementary sulfur as one of the end products of bacterial decomposition of the mineral. Arsenopyrite belongs to the monoclinic system.

The sample investigated had an arsenopyrite content of 89%; the other components were sphalerite, pyrite, and oxidized minerals of iron and arsenic, and a few quartz grains were also present. The particle size was 0.074 mm.

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