Unit 8 Leaching

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School of Metallurgy and Environment

New words

- leach v. 浸出
- leaching in situ 就地浸出
- agitation [ˌædʒɪ'teɪʃn] n. 搅拌
- settling n. 沉降
- pulp density 矿浆密度
- digestion n. 溶出，浸煮
- acid leaching 酸性浸出
- leaching efficiency 浸出率
- pregnant solution 母液
- acid curing 酸熟化处理
- heap leaching 堆浸
- dump leaching 堆浸(without crushing)
- percolate ['pə:kəleit] v. 渗滤，使渗滤
- percolation leaching 渗滤浸出
- vat leaching 槽浸出
- countercurrent n. 逆流
- pulp leaching 矿浆浸出
- diffusion-controlled (受)扩散控制的
- chemically controlled 化学反应控制
- filtrate ['filtreit] n. 滤出液
- Filter cake 滤饼
- decantation[,dikæn'teiʃən]n.倾析，倾注

New words

- thiosulfate[ˌθaɪoʊ'sʌlfeɪt] 硫代硫酸盐
- chlorine ['klɔ:ri:n] n. 氯气
- spent acid 废酸
- sulfuric acid [sʌl'fjʊərik] 硫酸
- nitric acid 硝酸
- hydrofluoric acid [ˌhaɪdrəflu:'ɒrɪk] HF
- sulfurous acid ['sʌlfjʊərəs] 亚硫酸
- aqua regia ['ækwə] ['ri:dʒjə] 王水
- base n.碱
- ammonium hydroxide [ə'moʊniəm] n. 氨水
- ammine['æmi:n] n. 氨络合物
- ferric sulphate 硫酸铁
- polysulfide ['pɒli:sʌlfaɪd] 多硫化物
- cyanide ['saiənaid]n. 氰化物
- bauxite ['bɔ:ksait] 铝土矿
- monazite ['mɔnəzait] n. 独居石
- wolframite n. 黑钨，锰铁钨矿 ['wʊlfrəmait]
- anodic slime [æ'nɒdik] 阳极泥
- scheelite ['ʃi:laɪt] 白钨矿（CaWO4)
- feldspar ['feldspɑ:] n. 长石
- sericite ['serɪsaɪt] n. 云母（铝硅酸盐矿物）
- apatite ['æpətait] 磷灰石(磷酸盐矿物）

New words

- copper **pyrite** 黄铜矿
- zinc pyrite 锌黄铁矿
- pyrite cinder 硫铁矿烧渣
- selenide['selinaid] n. 硒化物
- telluride['teljuraid] n. 碲化物
- scrap alloy 废合金块
- psf (pounds per square foot) 磅/平方英尺
- tonnage['tʌnɪdʒ] n.吨位，吨数
- asphalt['æsfɔ:lt] n. 沥青，煤焦油
- compressed air压缩空气
- perforate ['pə:fəreit] v. 穿孔
- pad n. 垫片，基底
- sump n. 槽，池，坑
- false bottom 假底
- PVC polyvinyl chloride 聚氯乙烯 [ˌpɒlɪ'vaɪn(ə)l]
- perforated vertical pipes打孔的竖管
- worked-out copper mine采完的铜矿
- impervious[im'pə:viəs]adj. 不渗透的
- thickener ['θikənə] n. 浓缩机，沉降槽
- scraper ['skreipə] n. 刮板
- blade n. 叶片
- closed vessel 密闭容器
- autoclave n.压煮器，高压釜
- cladding n. 包层，覆层
- steam coil 蛇形管蒸汽加热
- hood ring 密封垫圈
- impeller n. 叶轮，轮

New words

- pachuca tank 帕秋卡空气搅拌浸出槽
- dorr agitator 道尔型混合式搅拌器
- turbomixer n. 叶轮式混合器
- Paddle ['pæd(ə)l] n.桨，叶片

discussion

- Leaching
- Leaching agent
- Leaching method

outline

- 1.Leaching principle
  - Definition
  - Influencing factor
    - Temperature,
    - particle size,
    - leaching agent concentration
- 2. Leaching agent
  - Water
  - Aqueous salt solution
  - Chlorine water
  - Acid
  - base

outline

- 3.Leaching method
  - leaching in place
  - Dump or heap leaching
  - Percolation or vat leaching
  - Pulp leaching
  - Hot digestion
  - Leaching under pressure

Language point

- Important sentence: Increase with increasing
- Describe advantage or disadvantage about leaching agent or sth
- Describe a step or a process

- Leaching is the process of extracting a soluble constituent from a solid by means of a solvent. In extractive metallurgy it is the process of dissolving a certain mineral (or minerals) from an ore or a concentrate, or dissolving certain constituents from metallurgical products such as calcines, mattes, scrap alloys, anodic slimes, etc. In this respect, either one or two purposes can be achieved:

Calcine焙砂, matte冰铜, scrap alloy废合金料, anodic slime阳极泥

Two purposes

- (1) Opening the ores, concentrates, or metallurgical products to recover the metal values.
- (2) Leaching easily soluble constituents (usually gangue minerals) in an ore or a concentrate in order to have it in a more concentrated form. e.g., the leaching of tungsten flotation concentrate with hydrochloric acid to dissolve away calcite and apatite.

Dissolve away:溶解掉
Open: 破坏,溶解

- It is necessary that the ore be finely ground in order to liberate the leachable mineral. Economic factors usually decide the particle size of ore before processing.
- The factors influencing the rate of a leaching process can be summarized in the following points:
  - (1) Rate of leaching increases with decreasing particle size of the ore since the smaller the particles, the larger is the surface area per unit weight.

- (2) If a leaching process is diffusion-controlled then it will be greatly influenced by the speed of agitation. On the other hand if it is chemically controlled then it will not be influenced by agitation, provided that enough agitation is done to prevent the solid from settling.
- (3)Leaching rate increases with increasing temperature. However, this increase is much less remarkable for diffusion-controlled process than for a chemically controlled process.

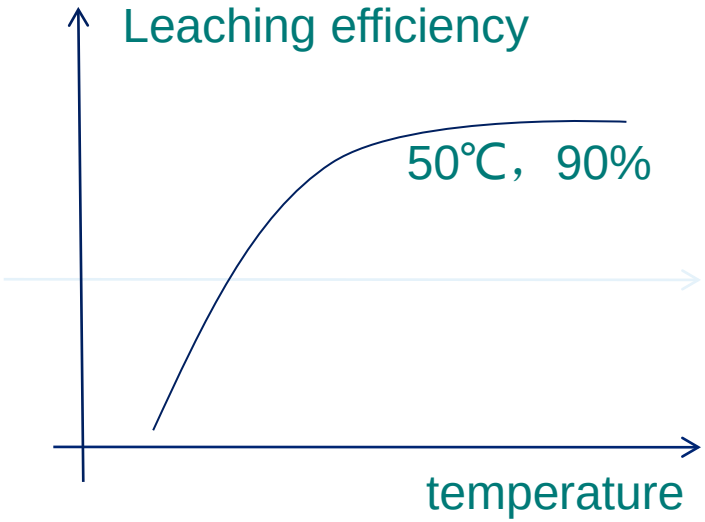
- (4) Rate of leaching increases with increasing concentration of the leaching agent.
- (5) Rate of leaching increases with decreasing pulp density, i.e. when a large volume of leaching agent is added to a small amount of solids.
- (6) If an insoluble reaction product is formed during leaching, then the rate will depend on the nature of this product. If it forms a nonporous layer, then the rate of leaching will greatly decrease. If, however, the solid product is porous, it will not affect the rate.

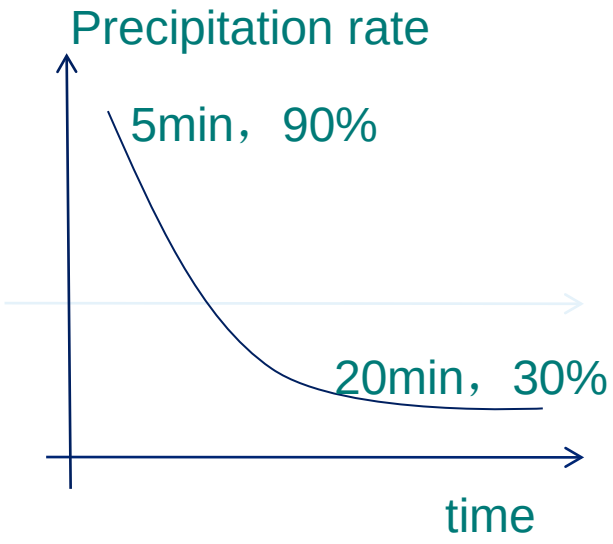
句型

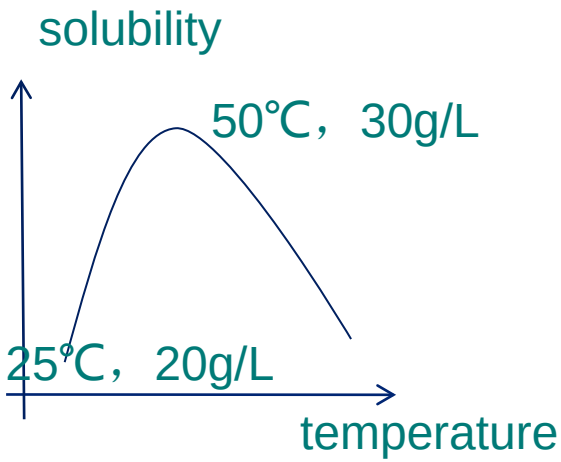
- Increase with increasing 随着
  -) Rate of leaching increases with decreasing particle size of the ore.
  - Leaching rate increases with increasing temperature

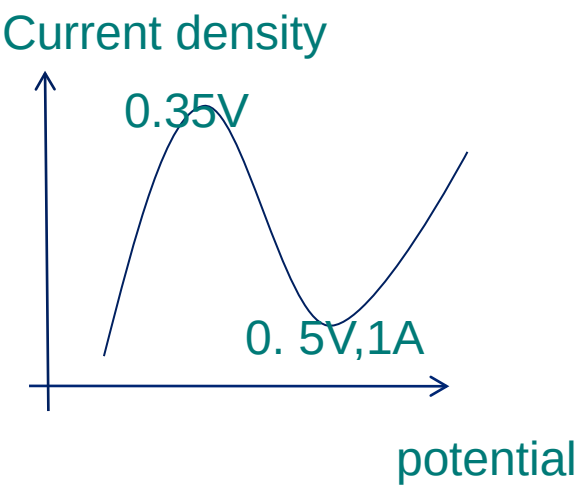
potential

practice

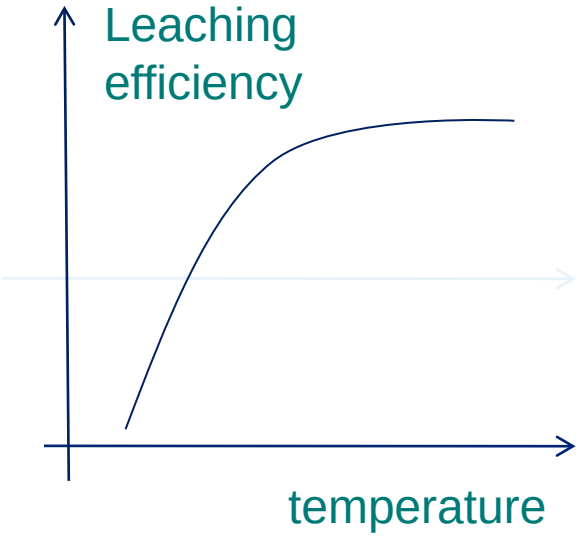

Leaching efficiency
50℃，90%
temperature

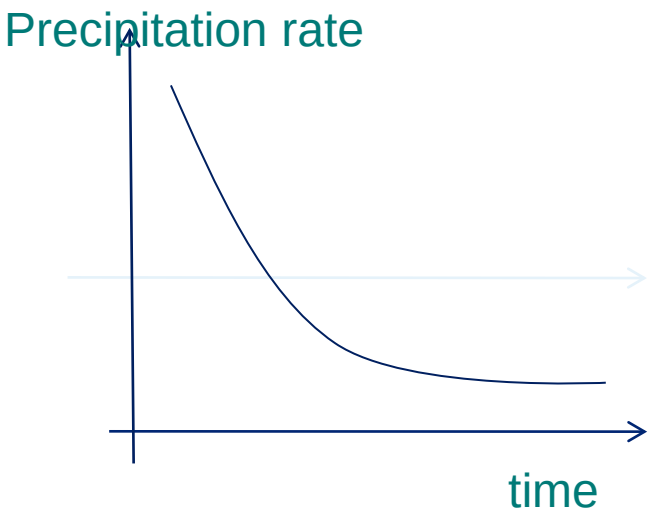

Precipitation rate
5min，90%
20min，30%
time


solubility
50℃，30g/L
25℃，20g/L
temperature

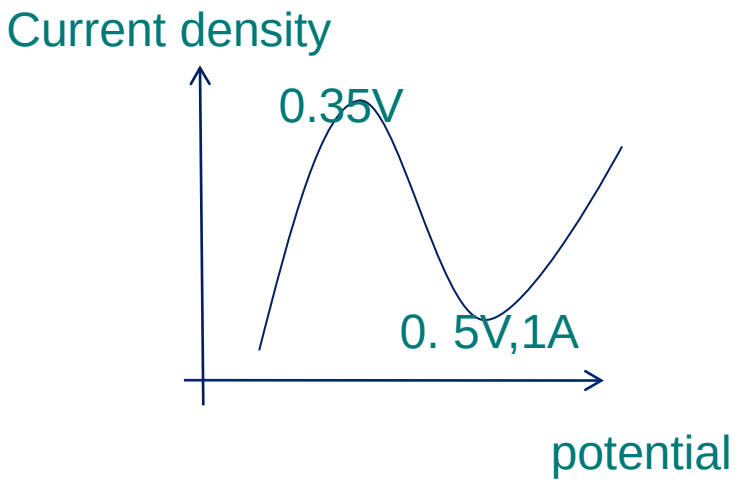

Current density
0.35V
0. 5V,1A
potential

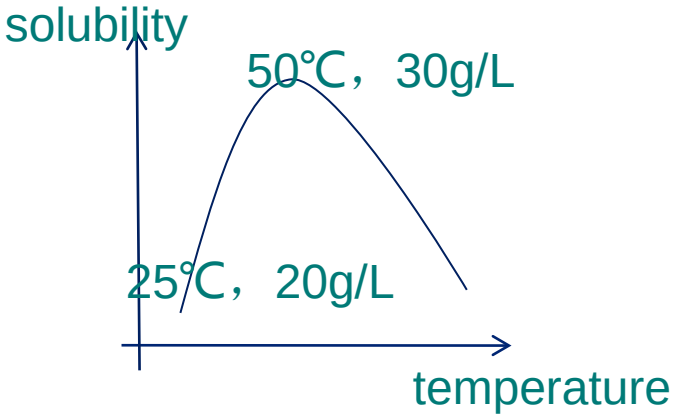
- The leaching efficiency increases with an increase of temperature and reaches a plateau of 90% above(at) 50℃.
- The precipitation rate decreases from 90% to 30% with time increasing from 5min to 20min. After that, it remains constant.





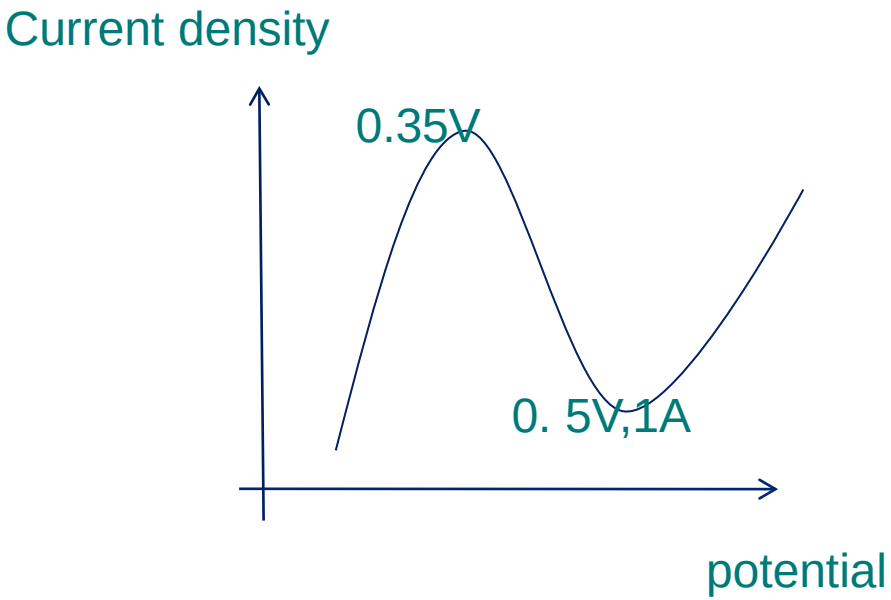
- The solubility increases from 20g/L at room temperature to 30g/L at 60℃, then it falls with the temperature increasing.

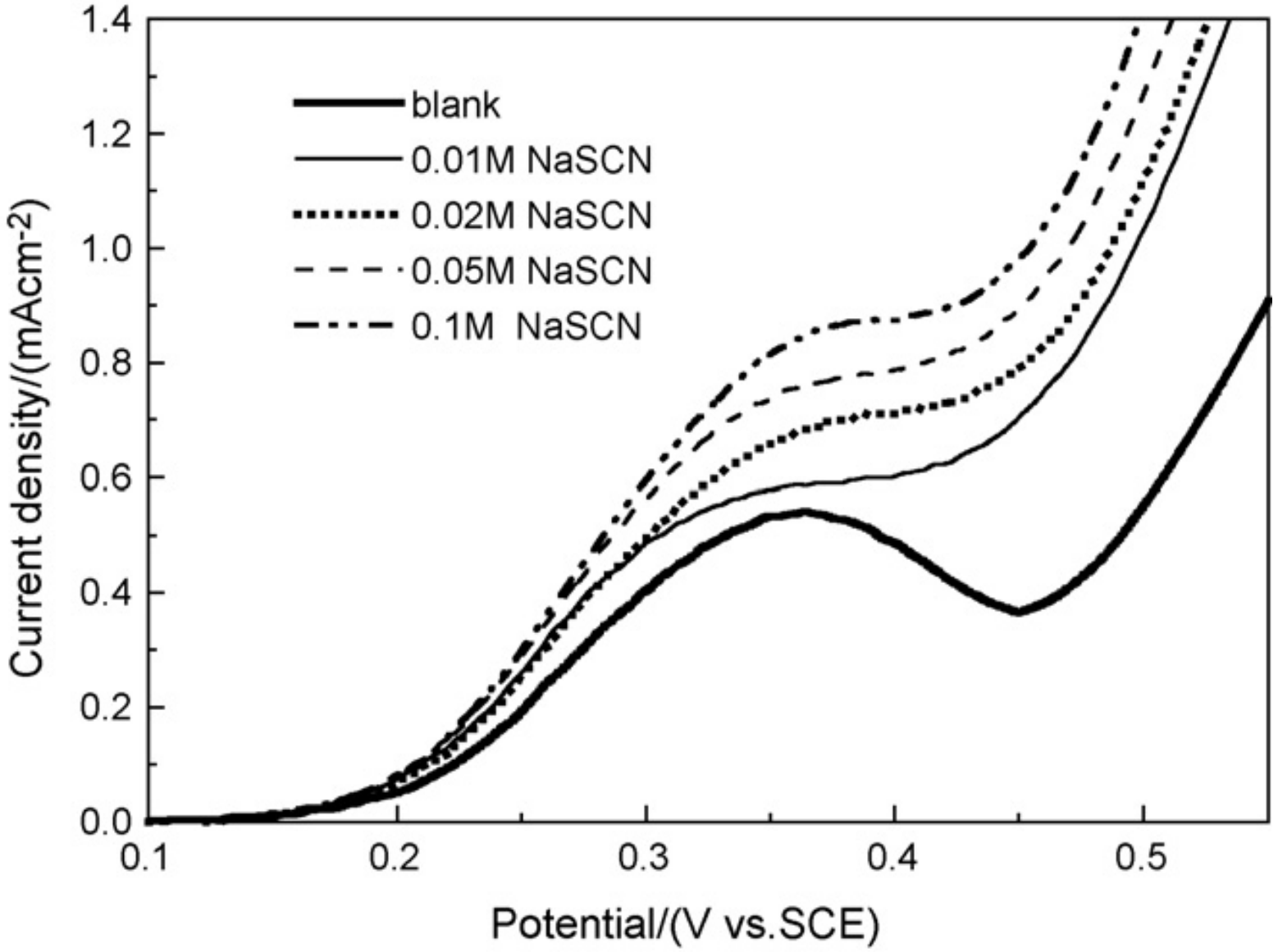




- The current increases with an increase of potential and peaks at 0.35V, then it falls to 1 A followed by increasing from 0.5 V upwards.

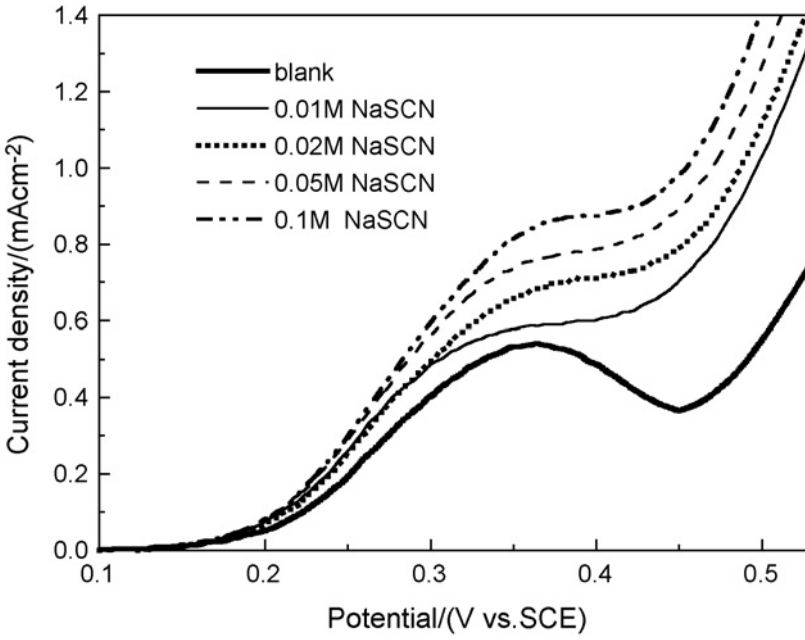
- The current increases when the potential increases from 0.2 V to 0.35V, then it falls to 1A at 0.5 V. After that, the current increases again.




blank
0.01M NaSCN
0.02M NaSCN
0.05M NaSCN
0.1M NaSCN
Current density/(mAcm-2)
Potential/(V vs.SCE)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0.1
0.2
0.3
0.4
0.5

- In the absence of thiocyanate, an obvious peak appears at 0.35V and has been interpreted as gold passivation due to Tu adsorption. With the presence of thiocyanate, a positive effect on gold dissolution is observed as denoted by the increase in current density at all potentials above which gold oxidizes.

- The maximum rate of gold dissolution increases with increasing thiocyanate concentration. Thiocyanate also appears to retard the passivation of gold surface as a current density plateau around 0.35V is observed rather than a peak. A current density plateau with increasing potential is typical of an electrochemical reaction under mass transport control.



- The choice of a leaching agent depends on many factors.
  - (1) Chemical and physical character of the material to be leached.
  - (2) Cost of the reagent.
  - (3) Corroding action of the reagent and consequently the materials of construction.
  - (4) Selectivity for the desired constituent to be leached.
  - (5) Ability to be regenerated, e.g., in the leaching of ZnO by H_2SO_4 the acid is regenerated during electrolysis.

- The following leaching agents are in common use. Water alone, is used to leach calcines produced by sulfating or chloridizing roasting, such as the leaching of zinc sulfate or treated pyrite cinder, and also in the leaching of Re_2O_7 from flue dusts in MoS_2 roasting.
- Water in the presence of air or oxygen, and at about 150°C dissolved sulfides, converting sulfates.
  - In common use:常用
  - pyrite cinder黄铁矿烧渣

Aqueous salt solutions

- (1) Ferric sulfate:---used for leaching sulfide minerals.
- (2) Sodium carbonate:---used for leaching uranium ores.
- (3) Sodium chloride:---used for leaching $PbSO_4$.
- (4) Sodium cyanide:---used for leaching gold and silver from their ores.
- (5) Sodium sulfide :---used for leaching sulfide minerals forming soluble polysulfides.
- (6) Sodium thiosulfate:---used for leaching silver chloride produced by salt roasting of ores.

❖ Chlorine water

- Chlorine water was once used in leaching gold ores, but was abandoned when the cyanidation process was discovered. It has been suggested for leaching sulfide ores.

Acids

- Sulfuric acid is the most important leaching agent. It is the cheapest acid, has only minor corrosion problems encountered with its use, and is effective in opening most ores.
- It is used either dilute, concentrated, or sometimes mixed with hydrofluoric acid. In many cases, spent acid from electrolytic processes is adjusted to the required concentration and used.
- Other acids such as hydrochloric and nitric, are used only to a limited extent. Sulfurous acid is finding new applications for leaching some ores, such as low grade manganese types. Aqua regia is used for leaching native platinum ores, and in the refining of gold and silver by parting.
  - Minor无关紧要的，较小的，small, little
  - Sulfurous acid 亚硫酸
  - Aqua regia王水

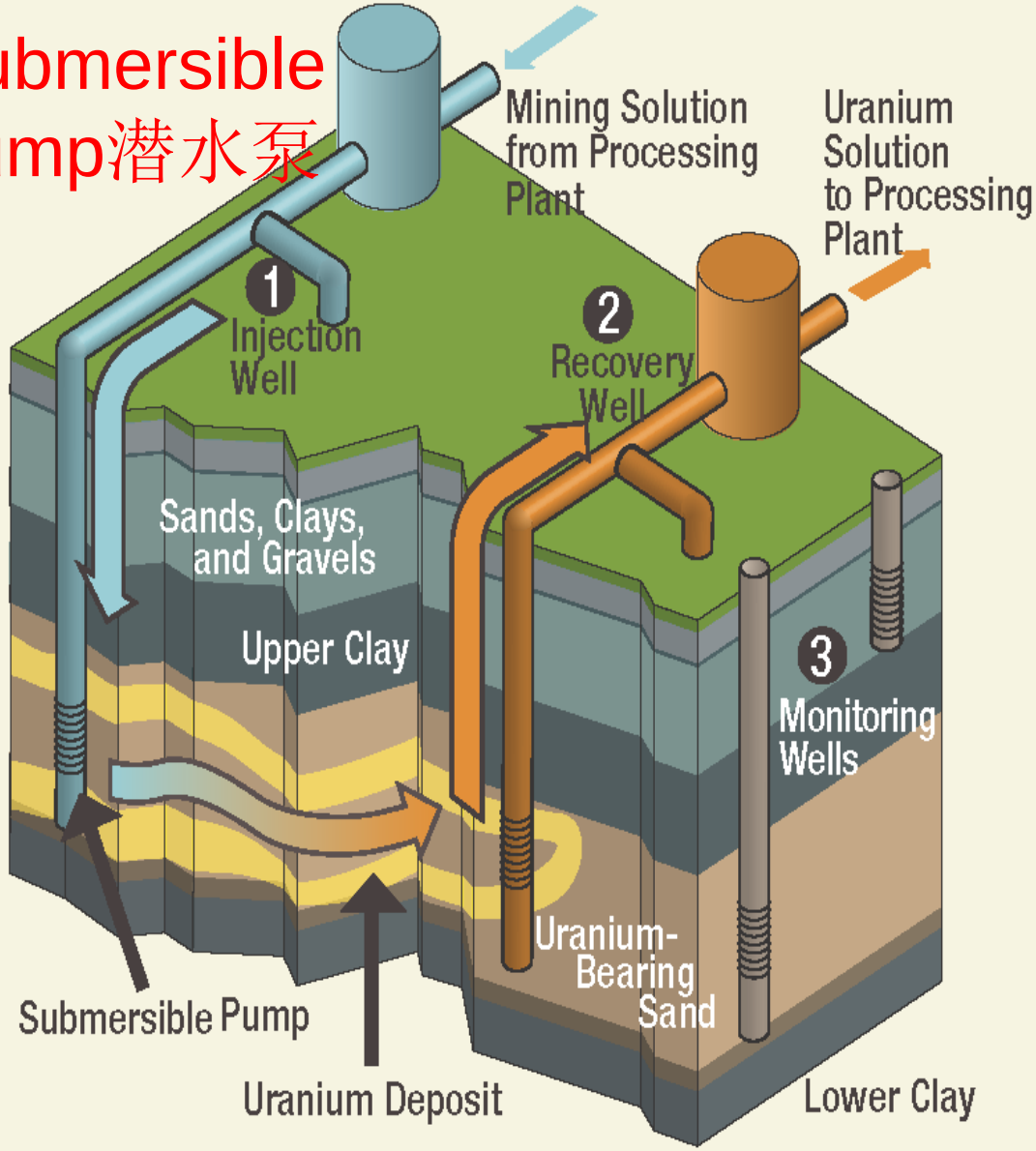
Bases

- Sodium hydroxide is used chiefly for dissolving aluminum from bauxite, for opening monazite sand, and for leaching wolframite and scheelite ores. Ammonium hydroxide is used for extracting those metals (such as copper and nickel) that form soluble ammines from their ores.
- Leaching by bases has the following advantages:
  - (1) negligible corrosion problems;
  - (2) most suitability for ores containing much carbonate gangue;
  - (3) more-selectivity, since iron oxides will not be leached.

- The grade of the ore and the ease with which the mineral values are dissolved in a particular reagent are the controlling factors in determining the choice of the leaching method. The most common methods of leaching are discussed in the following sections.
  - Factor in doing sth
  - Ease容易

Figure 37. The In Situ Uranium Recovery Process

Submersible pump潜水泵



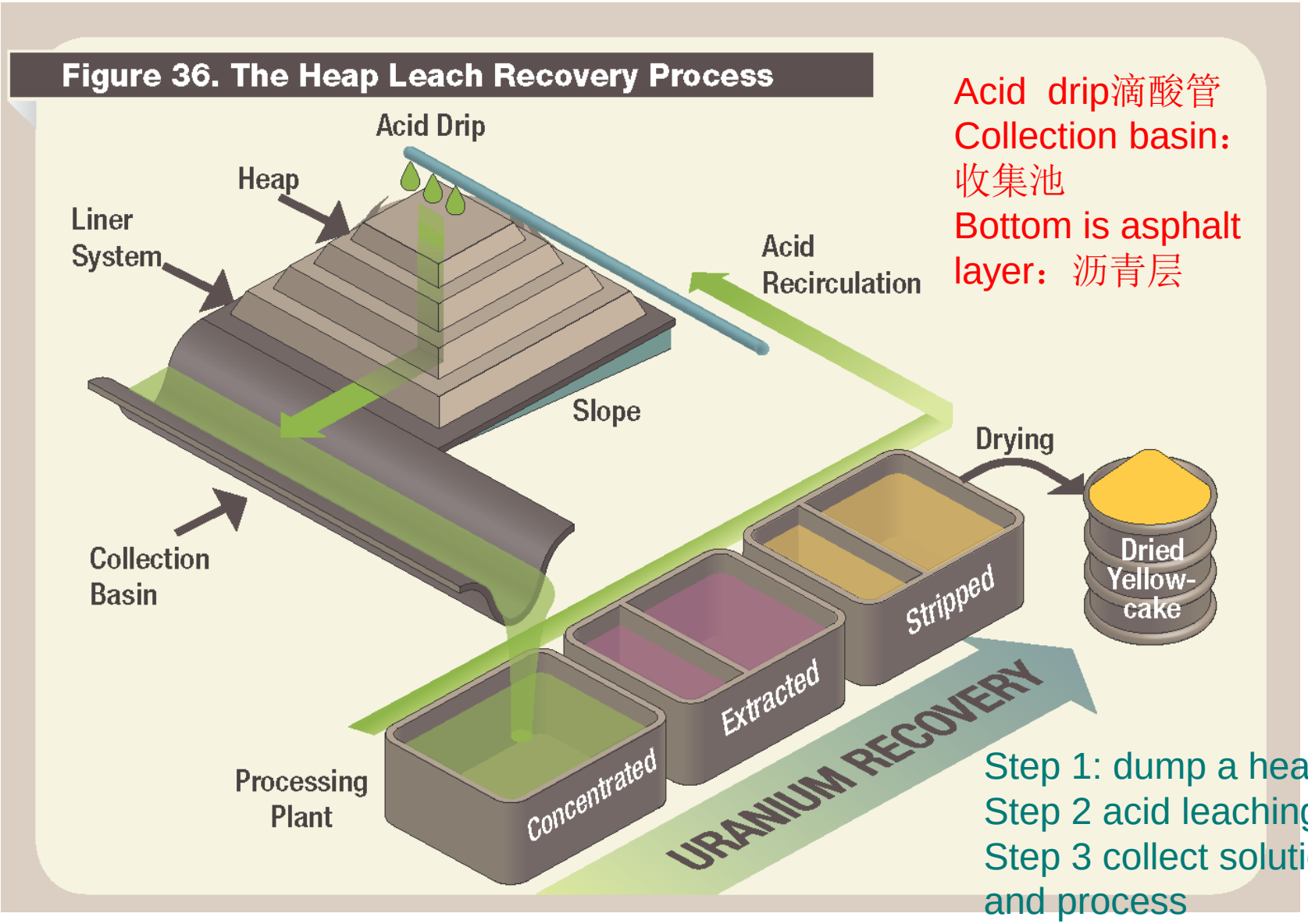
Injection wells (1) pump a chemical solution—typically groundwater mixed with sodium bicarbonate, hydrogen peroxide, and oxygen—into the layer of earth containing uranium ore. The solution dissolves the uranium from the deposit in the ground and is then pumped back to the surface through recovery wells (2) and sent to the processing plant to be processed into uranium yellowcake. Monitoring wells (3) are checked regularly to ensure that uranium and chemicals are not escaping from the drilling area.

Leaching in place

- This method is mainly used for copper ores which are too low in grade to justify mining and transportation expenses. The ore is simply shattered and leached in place over long periods of time.
- The method makes use of the presence of iron sulfides in the ore, which under the combined action of air and water, undergo oxidation over periods of weeks or even years to form ferric sulfate.
- The end product, essentially copper sulfate, is collected in tunnels.

插入语

- The oxidation reactions are exothermic and the heat generated facilitates continued oxidation.



Acid drip滴酸管
Collection basin：收集池
Bottom is asphalt layer：沥青层

Step 1: dump a heap
Step 2 acid leaching
Step 3 collect solution and process
Step 4 acid regeneration

堆浸操作的描述

- The low grade uranium ore to be leached is dumped on a liner system(防渗系统） with an asphalt layer at the bottom to form a heap. The heap is about 2 to 3 m high with a slight slope. The collection basin is laid at the lower bottom of the heap. One perforated pipe is placed on the top of the heap. Acid is slowly dripped from the pipe and allowed to percolate through the heap. The leaching solution is collected in the basin and then sent to the processing plant to be processed into uranium yellowcake after concentration, extraction and stripping. Then the acid solution is recirculated to the leaching system.

pay attention to the operation description. 5 sentences.

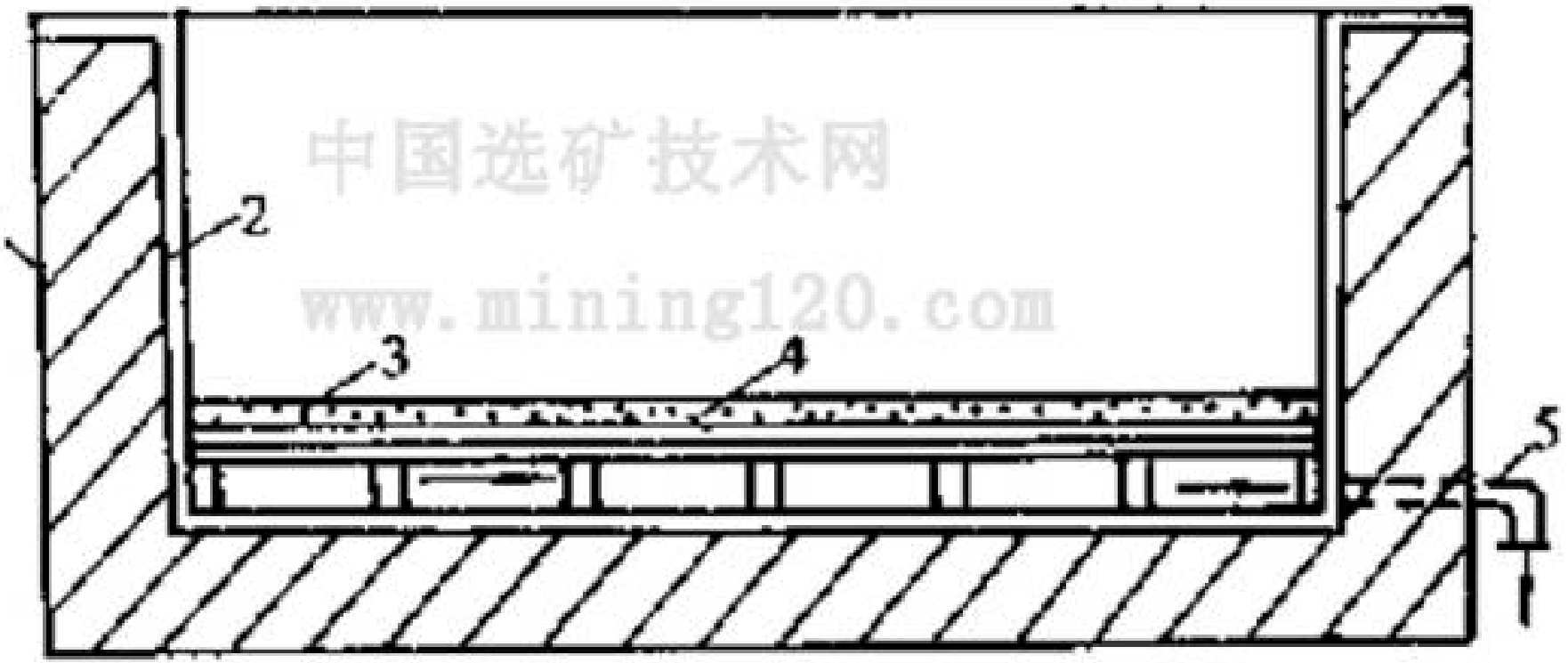
Heap or dump leaching

- Depending upon the tonnage processed, an area of about 300 by 400 ft is leveled and then covered with an asphalt layer. 夷平
- Low grade ore is then dumped onto the site by dump trucks to a level of 20-30 ft high. Either water or dilute sulfuric acid is then sprayed at the top of the dump, and leach solution is collected in streams at the bottom of the heap.
- Sometimes, perforated vertical pipes are introduced at regular intervals inside the heap to facilitate the flow of water and at the same time allow air circulation to facilitate the leaching process.

- In other cases, ditches running the entire width of the pad at regular intervals are made. A perforated pipe of 4-inch diameter is laid in every ditch and is then covered with gravel. The ore about 1 inch in size is then dumped into the site and leveled by a tractor 20-30 *ft* high. Two parallel 6-inch diameter PVC pipes are installed perpendicular to the buried pipes and are connected to their discharge ends. The PVC pipes discharge into a 100,000 gallon sump.

Percolation or vat leaching渗滤浸出或槽浸

- The material to be leached is placed in a tank equipped with a false bottom covered with a filtering medium. The solvent is added at the top of the tank and is allowed to percolate through the material.
- These tanks are usually arranged so that a countercurrent system is employed; the new solids being added to the last tank and weak liquid to the first and pumped successively from one tank to another till it reaches the last tank, almost saturated. Tanks having a capacity of 12,000 tons of ore are in common use.



1—槽体；2—水泥衬里；3—矿砂层；4—假底；5—出液管

- This process is well suited to cases where the material is porous and sandy, and is inapplicable to material which tends to pack into impervious masses.
- Regularity in the size of particles rather than their actual size is the chief factor governing good percolation.
- When the particles are of unequal size, the small ones pack in the openings between the larger ones, thereby clogging the channels.
- Then extraction will become slow and channeling of solutions through the bed may take place.

- The method is therefore unsatisfactory if much slime is present. Its advantages are minimum solvent consumption, the production of high grade pregnant solution, and elimination of the use of expensive thickeners or filters.
- When leaching is finished, the tanks are emptied manually, and a new batch is introduced. The method is used for leaching gold, copper, and uranium ores.

pay attention "how to describe advantages"

Pulp Leaching

ores or concentrates
（solid）

leaching agent
（liquid）

Plup
（densities vary from 40 to 70% solids）

Agitation

Pulp leaching

- Pulp leaching with agitation pulp of ores, concentrates, etc. is usually prepared for leaching by grinding the material in water (to minimize dusting) to produce the optimum particle size.
- Pulp densities vary from 40 to 70% solids. The leaching agent is added and the pulp is agitated continuously.

Pulp leaching

Pulp leaching may be carried out in a single stage or two stages:

- (1) Single stage. This may be batch or continuous process. In the continuous process a fixed proportion of the pregnant solution is removed from the circuit as filter-cake moisture; the remainder is returned as filtrate to the leaching tank. The method has the advantage of high economy as to reagent consumption and is applied particularly for ores that require high reagent concentration for efficient extraction.

the remainder剩余， filtrate 滤液

Pulp leaching

Pulp leaching may be carried out in a single stage or two stages:

- (2) Two-stage. In this method the leaching solution from the second stage containing the dissolved values and unused reagent is advanced to the first stage. This method has the advantage of recovering the unused reagent.

Advanced返回

Hot digestion溶出

- This method of leaching in heated vessels is used when extremely rigorous treatment of material is necessary. Highly concentrated solutions (either acidic or basic) and high temperatures (at or near the boiling point of the solution) combined with efficient stirring are required.
- The digester is an open vessel, heated externally, and is operated batchwise. Examples of this process are the leaching of ilmenite 钛铁矿or monazite sand独居石in sulfuric acid.
- In some cases hot digestion is carried out in ball mills to achieve thorough grinding during the treatment, as for example in the acid leaching of wolframite 钨锰铁矿concentrate.

多个条件的描述 Highly concentrated solutions and high temperatures combined with efficient stirring； Batchwise分批次，间歇； ball mills 球磨

Leaching under pressure

- Two types of pressure leaching are to be distinguished:
  - (1) In absence of oxygen. In this case the ore is heated with the leaching agent at a temperature above the boiling point of the solution to achieve a high reaction rate.
  - Therefore, the process must be carried out in a closed vessel that withstands the vapor pressure of solution at that temperature. An example is leaching bauxite with caustic soda solution.
  - (2) In presence of oxygen. Here the pressure in the autoclave is due to the solution pressure plus the oxygen pressure (or air pressure if air is used instead of oxygen). In this case the rate of leaching depends on the oxygen partial pressure and not the total pressure. This method is used mainly for leaching sulfide ores or uranium oxide ores.

Withstand经受

Part	Content
principle	Definition and purpose, influencing factors
Leaching agent	Water, aqueous salt solution, acid, base,chlorine
Leaching methods	Leaching in-situ,Heap leaching, vat leaching, pulp leaching, leaching under pressure, hot digestion

Homework

1.Recite the words and phrases; Exercises Part II

2.Write a summary of this unit

end


lecturer: Xiyun Yang


School of Metallurgy and Environment