

Study on Leaching of High-Magnesium Laterite

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Abstract. The leaching of laterite containing high-magnesium content was investigated in this study. The results show that the acidity of the leach liquors from high pressure leaching of laterite containing high iron content is high enough for the leaching of high-magnesium laterite. After leaching at 70°C, 60min and solid/liquor ratio of 10g ore/L leaching agent, the mineral containing high magnesium content was completely dissolved, and the iron minerals were essentially undissolved. The solution pH increased to 2.5 or above, which was suitable for the subsequent iron removal process.

Introduction

The leaching of laterite containing high magnesium content is always conducted at atmospheric pressure, which needs large amounts of acid, such as sulfuric acid, hydrochloric acid or nitric acid [1, 2]. The leaching of laterite containing high iron content is always conducted at high pressure, which produces leach liquors with a certain amount of residual acid [3-5]. Additionally, the iron in the leach liquors from pressure leaching process has a relatively low concentration, usually within 1-2g/L. Thus, the goethite process is utilized to remove iron from leach liquors of pressure leaching of laterite. The goethite process usually requires that not only the Fe³⁺ concentration in the solutions is below 1-2g/L, but also the solution pH is greater than 2[6-8]. However, the pH of leach liquors from pressure leaching of laterite is about 1 or so. This restricts the goethite process to be used for iron removal from leach liquors of pressure leaching of laterite.

In this study, the leaching of laterite containing high magnesium content was investigated, using the leach liquors of pressure leaching of laterite containing high iron content as the leaching agent. This can reduce the acid consumption of high-magnesium laterite and increase the pH of leaching agent to meet the requirement of goethite process. The leaching conditions were studied. The dissolution of minerals with high-magnesium content and the variation of solution pH were discussed.

Experimental

Materials. The Ore samples containing high magnesium content were grey rock shivers. Ore samples were ground in a discal crusher for a few minutes to mill the rock shivers, followed by being screened to below 165µm. Then the ore samples were dried overnight in an oven at 100°C. The chemical analysis of the ore samples is shown in Table 1. The magnesium content was about 24wt.% while the iron content was only 4wt.%, corresponding to the characteristics of high-magnesium laterite. Mineralogical investigation results are shown in Table 2, which shows that the ore samples consist mainly of serpentine, with minor hematite and traces of magnetite and chromite.

Table 1 Elemental analysis of the ore samples (wt.%)

Ni	Co	Mg	Fe	Al	Cr	Mn	Si
0.9	0.09	23.5	4.05	0.57	0.13	0.05	16.8

Table 2 Mineral composition of the ore samples(wt.%)

serpentine	magnetite	hematite	chromite
86	trace	5	trace

The leaching agent was prepared by dissolving cobalt sulfate, nickel sulfate, magnesium sulfate, ferric sulfate, ferrous sulfate and aluminum sulfate (analytical grade) with distilled water, with Ni^{2+} , Co^{2+} , Mg^{2+} , Al^{3+} concentrations of 1.21g/L, 0.11g/L, 0.95g/L, 0.14g/L and Fe^{2+} 和 Fe^{3+} concentration of 0.93g/L and 1.91g/L. The concentrations of metal ions were similar to those in the leach liquors of pressure leaching of laterite. The solution pH was adjusted to 1.1 using the dilute sulfuric acid.

Methods. Leaching experiments were carried out in a 500ml Erlenmeyer flask. A mixture of the ore sample and the leaching agent were placed in the Erlenmeyer flask. The Erlenmeyer flask was placed in a magnetic stirrer, heated to the desired temperature, and then leached for a set time at 450rpm. The slurry was filtered and the leach residues were washed with distilled water and dried for 4h at 100°C.

The filtrate was analyzed for nickel, cobalt, magnesium, aluminum by a iCAP 6300 inductively coupled plasma-atomic emission spectrometer. The Fe^{2+} and Fe^{3+} concentrations in the filtrate were determined by standard potassium dichromate titration. The solution pH was measured using a pH meter (PHS-3E, Shanghai INESA Scientific Instrument Co., Ltd., China).

Some leach residues were analyzed using a D/max 2550 X-ray diffractometer (XRD) with Cu K α radiation between 10° to 80° (2 θ).

Results and discussion. It can be seen from Table 3 that the solution acidity decreases and solution pH increases with the increase of leaching temperature. Increasing leaching temperature to 70°C, the solution pH was 2.4, which was within the pH range of goethite process. Further increasing leaching temperature to 80°C, the solution pH changed little. Additionally, the serpentine was gradually dissolved with the increase of leaching temperature. Serpentine was not present at 70°C, indicating the complete dissolution. There might be minor serpentine at 60°C and its amount might be too low to be detected by XRD, as the solution pH increased obviously when increasing temperature from 60°C to 70°C. Hematite was present in the leach residues within the temperature range of 60-80°C, indicating hematite could not be dissolved at temperatures below 80°C. The undissolved magnetite and chromite might be present in the leach residues, but their amounts were too low to be detected by XRD. There should be silicon oxide in the leach residues. They are not detected by XRD, probably because of their amorphous state.

Table 3 Solution pH and phases of leach residues under different temperatures
(solid/liquor ratio: 10g ore/L leaching agent, 60min)

Temperature(°C)	30	40	50	60	70	80
Solution pH after leaching	1.21	1.32	1.85	1.98	2.43	2.51
Phases of leach residues	serpentine, hematite	serpentine, hematite	serpentine, hematite	hematite	hematite	hematite

Table 4 shows that the solution pH increases rapidly with the increase of solid/liquor ratio, indicating that the dissolution of serpentine consume large amounts of acid. The solution pH increased slowly when solid/liquor ratio was 10g ore/L leaching agent or above. When solid/liquor ratio was 14g ore/L leaching agent, there was undissolved serpentine in the leach residues, indicating the too high solid/liquor ratio would result in the incomplete dissolution of serpentine.

Table 4 Solution pH and phases of leach residues under different solid/liquor ratios (60min, 70°C)

Solid/liquor ratio (g ore/L leaching agent)	4	6	8	10	12	14
Solution pH after leaching	1.34	1.95	2.18	2.43	2.78	2.79
Phases of leach residues	serpentine, hematite	serpentine, hematite	hematite	hematite	hematite	serpentine, hematite

Table 5 Solution pH and phases of leach residues under different leaching times
(solid/liquor ratio: 10g ore/L leaching agent, 70°C)

Leaching time(min)	30	45	60	75	90
Solution pH after leaching	1.41	1.79	2.43	2.58	2.57
Phases of leach residues	serpentine, hematite	serpentine, hematite	hematite	hematite	hematite

Table 6 Solution pH and phases of leach residues under different leaching times
(solid/liquor ratio: 14g ore/L leaching agent, 70°C)

Leaching time(min)	30	45	60	75	90
Solution pH after leaching	1.29	1.65	2.49	2.54	2.61
Phases of leach residues	serpentine, hematite	serpentine, hematite	serpentine, hematite	serpentine, hematite	serpentine, hematite

The solution pH also increased with the increase of leaching time, and changed little when increasing leaching time to 60min or above, as seen in Tables 5 and 6. Serpentine was not present in the leach residues at 60min and solid/liquor ratio of 10g ore/L leaching agent, indicating 60min was long enough to completely dissolve serpentine. However, when solid/liquor ratio was 14g ore/L leaching agent, even if increasing leaching time to greater than 60min, serpentine was still present. This further proves that the too high amount of ore sample is not beneficial to the leaching of high-magnesium minerals. This is probably because that the high amount of ore sample requires the high amount of acid in the leaching agent, while the acid amount is adequate when increasing solid/liquor to >10g ore/L leaching agent. Apparently, the acidity should be an important effect on the leaching of high-magnesium laterite.

Table 7 Concentrations (g/L) of metal ions in the liquors after leaching of high-magnesium laterite (70°C, 60min)

Solid/liquor ratio (g ore/L leaching agent)	Ni ²⁺	Co ²⁺	Mg ²⁺	Fe ²⁺	Fe ³⁺	Al ³⁺
10	1.30	0.14	2.95	3.41	1.08	0.17
14	1.33	0.16	4.44	3.61	1.93	0.19

By comparing the concentration data in Table 7 and those in the leaching agent, it can be found that the concentrations of nickel, cobalt, magnesium and aluminum ions increase. This is because of the dissolution of the high-magnesium minerals. The values of concentrations of metal ions did not increase obviously, simply because that the volume of filtrate increased. However, the Fe³⁺ concentration increased little, probably because that the iron minerals such as hematite, magnetite and chromite were hardly dissolved.

Conclusions

The high-magnesium laterite can be leached using the leach liquors from pressure leaching of laterite containing high-iron content as the leaching agent. The process can adjust the acidity of the leaching agent and decrease the acid consumption of high-magnesium laterite. When the solid/liquor ratio was 10g ore/L leaching agent, leaching time was 60min and leaching temperature was 70°C, the high-magnesium minerals can be dissolved completely, and the solution with pH of 2.5 or above and Fe³⁺ concentration of 1-2g/L can be obtained, which is suitable for the further goethite process. The iron minerals were undissolved and can be introduced into the pressure leaching process.

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