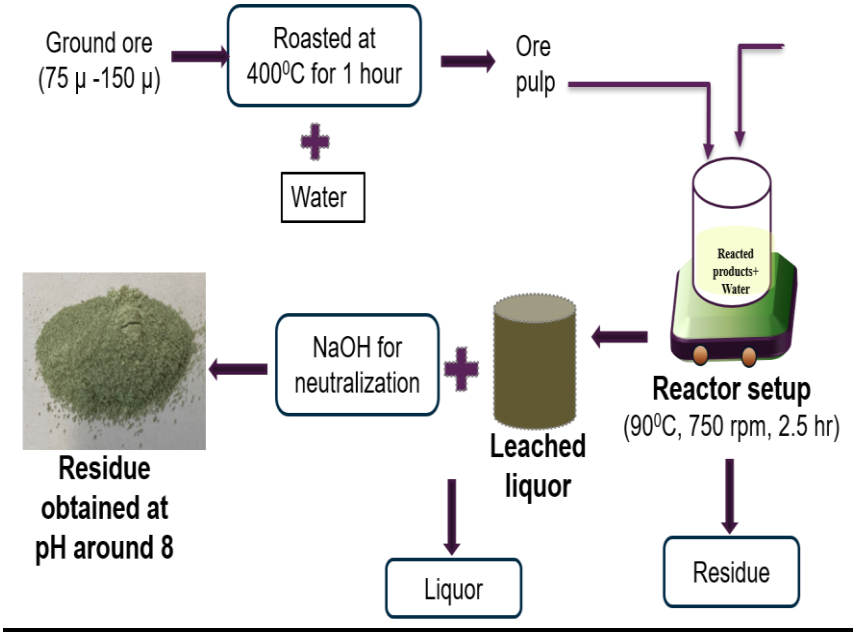

Figure 1

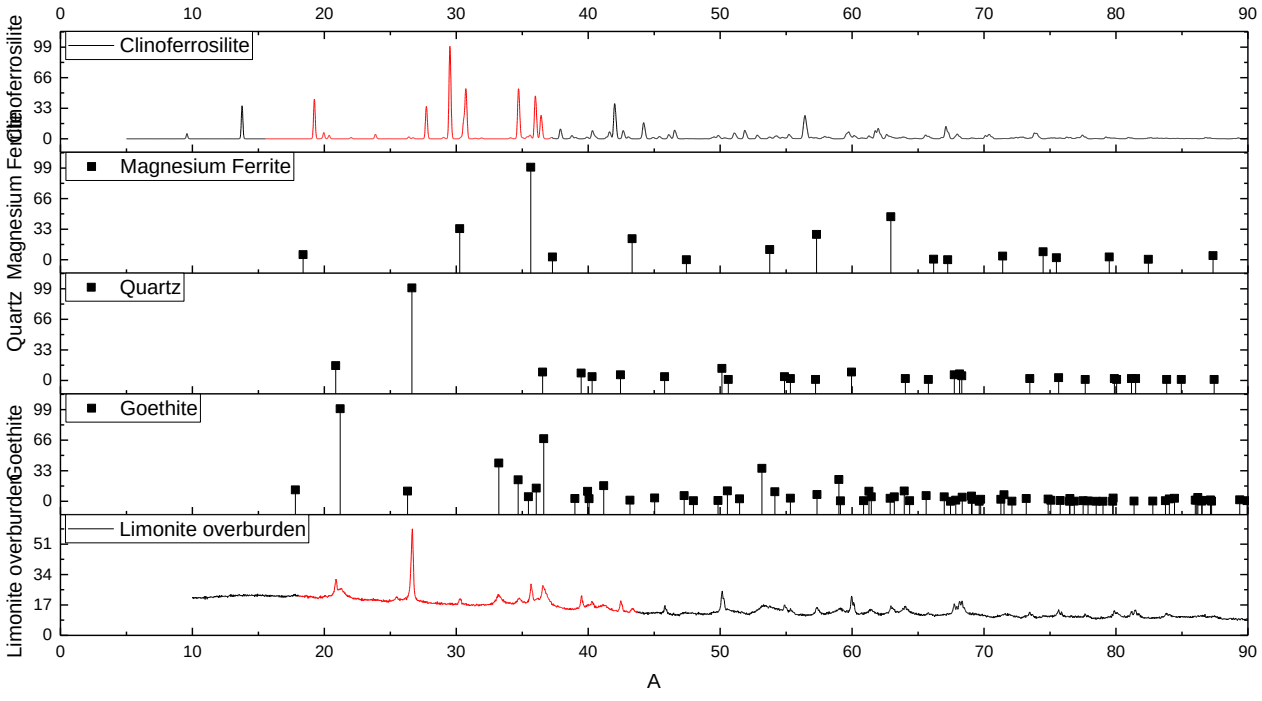

Figure 2

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Agent for the Applicant
09/03/2022

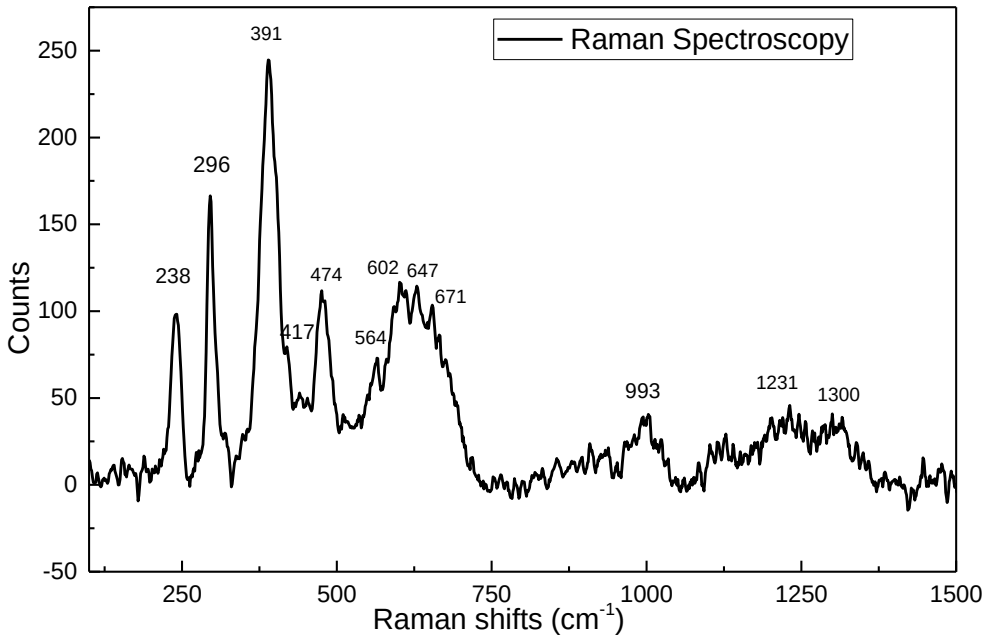

Figure 3

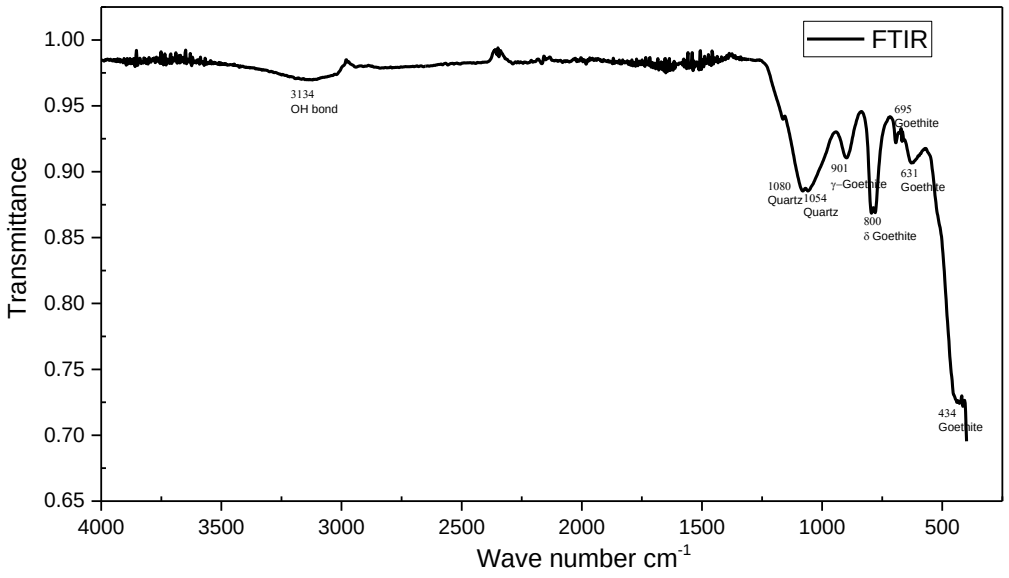

Figure 4

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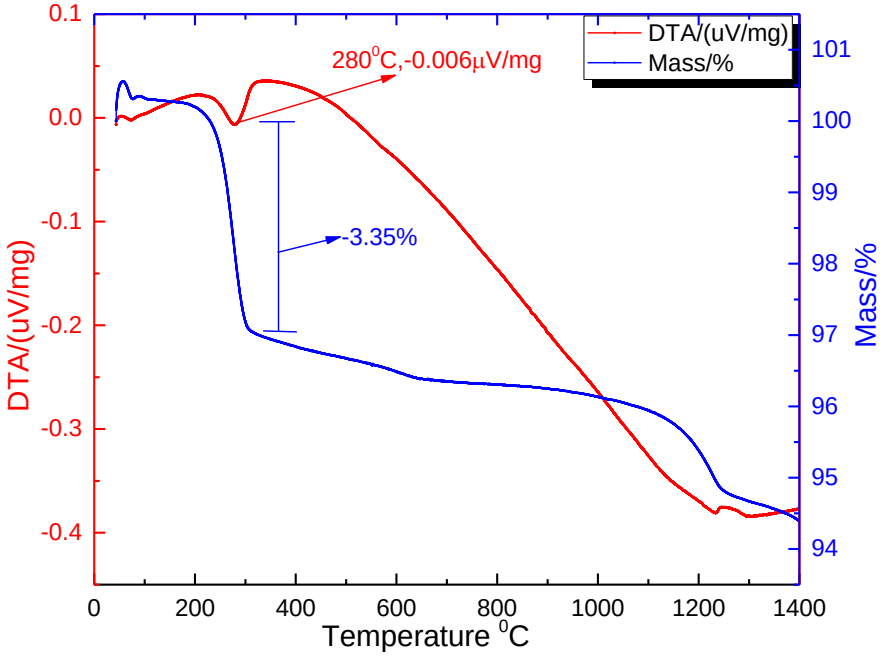

Figure 5

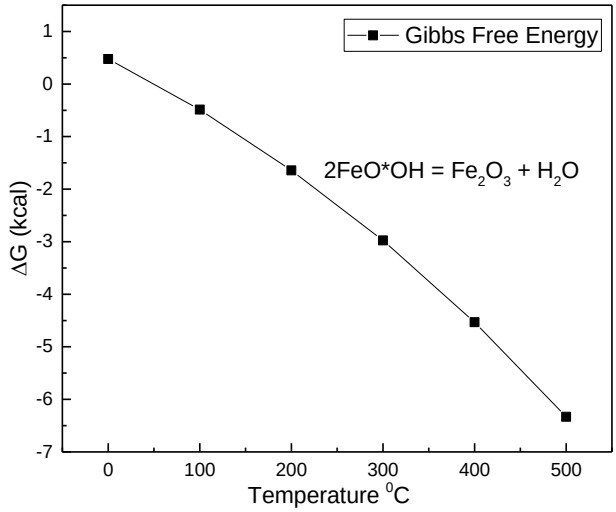

Figure 6

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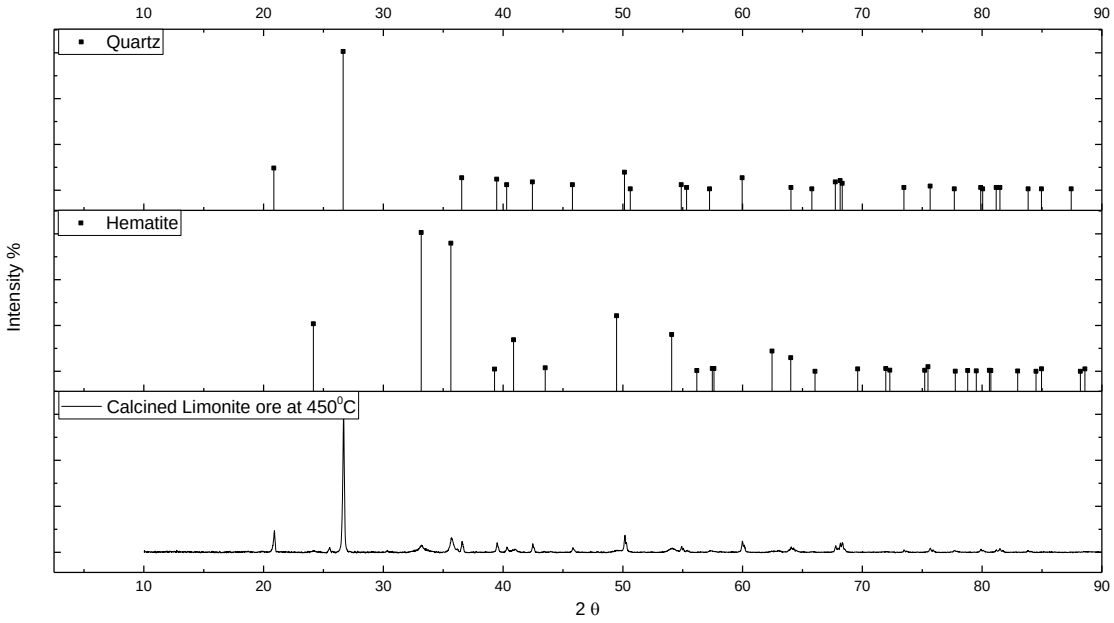

Figure 7

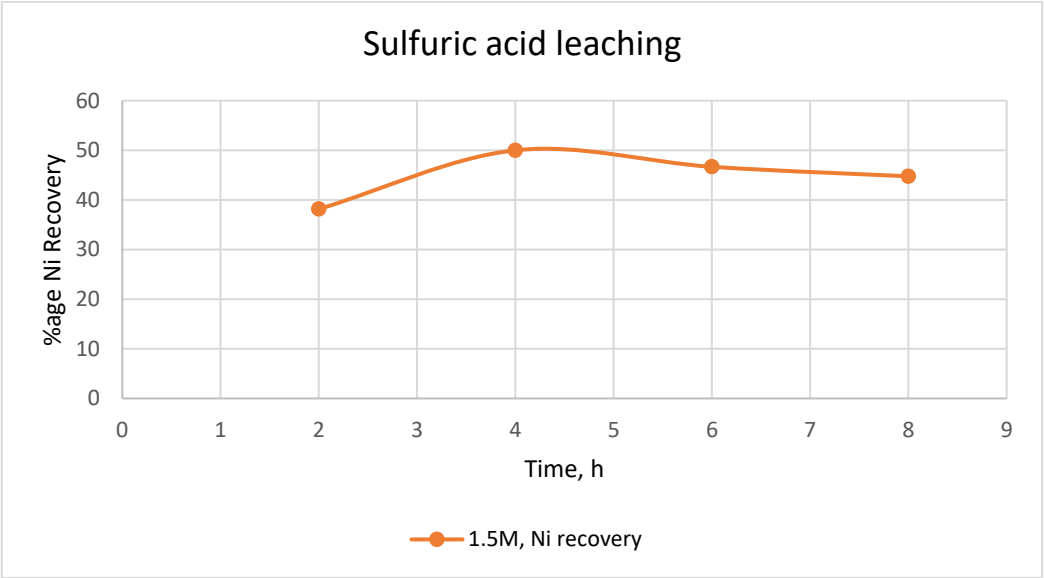

Figure 8

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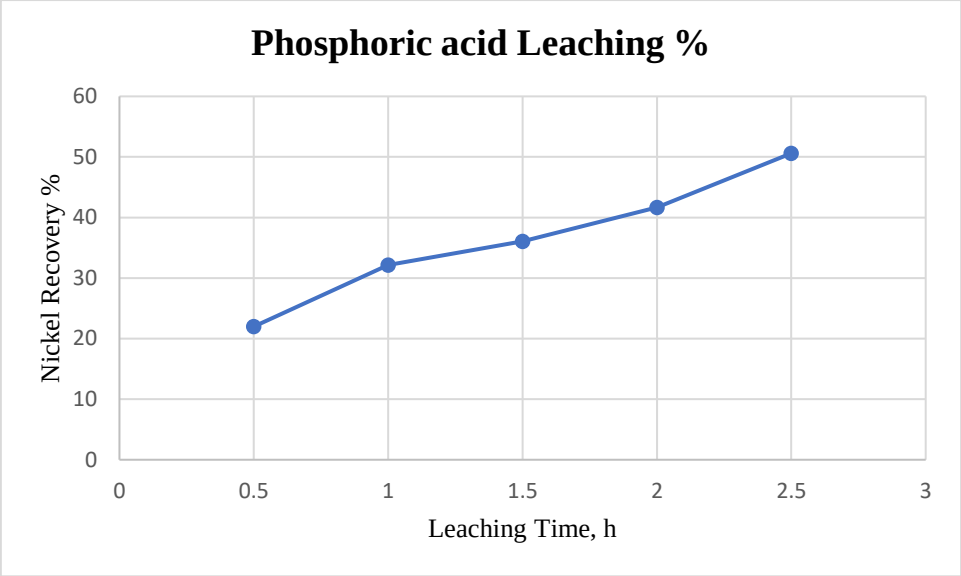

Figure 9

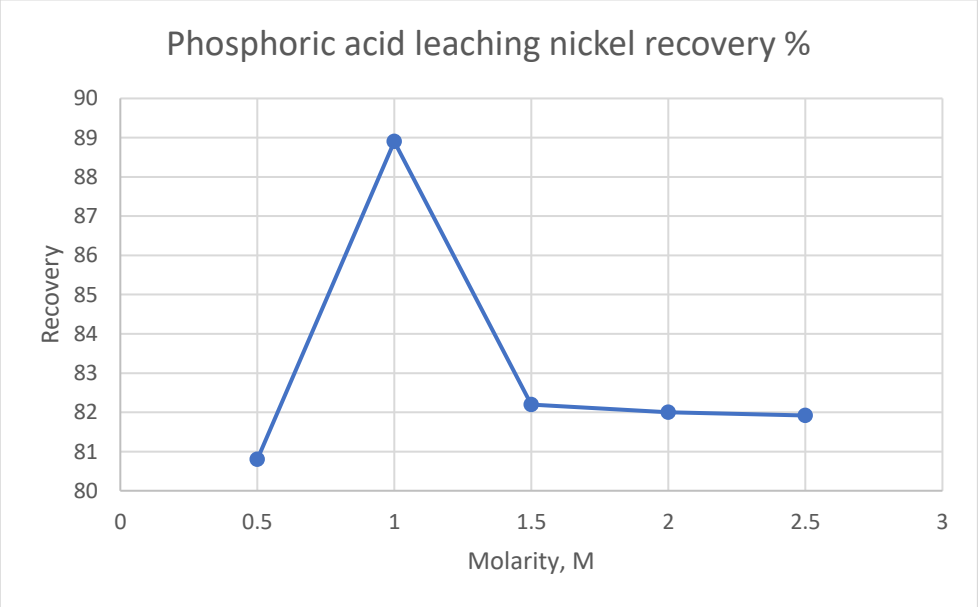

Figure 10

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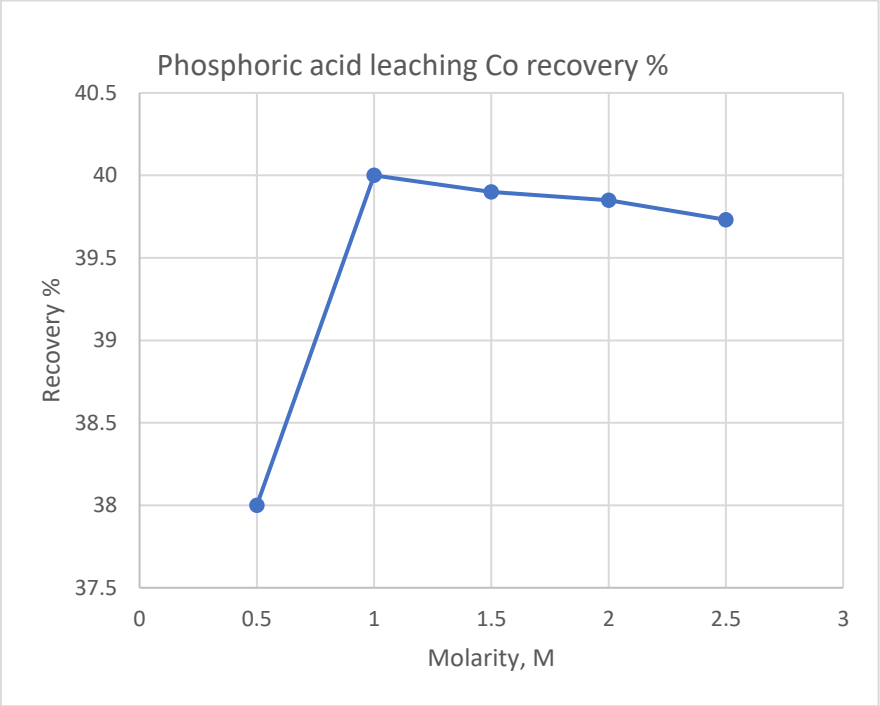

Figure 11

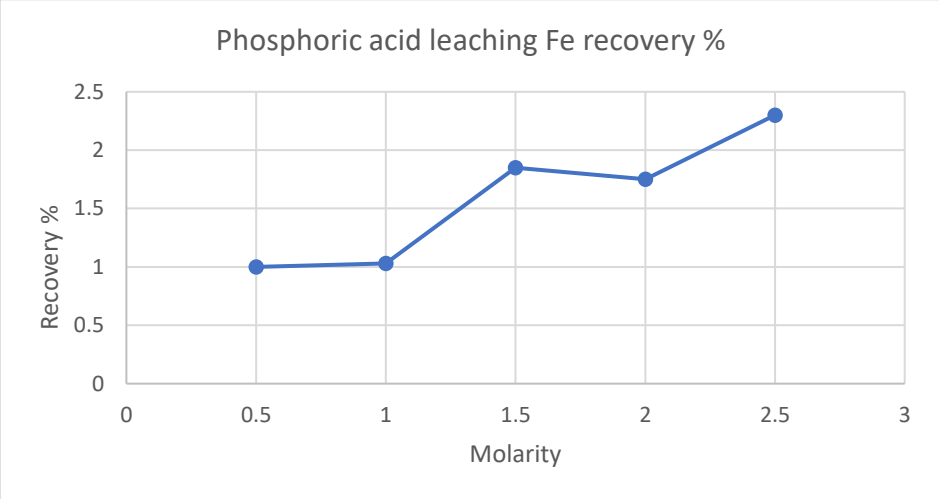

Figure 12

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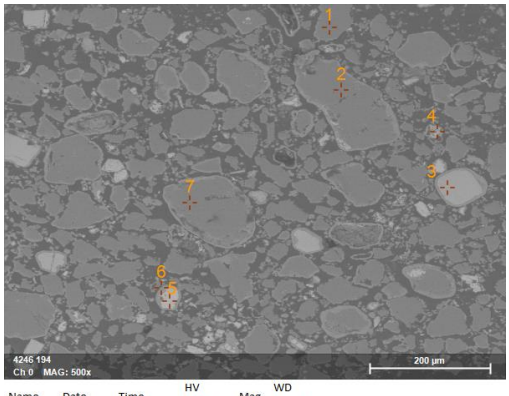


Normalized mass concentration [%]

Spectrum	Oxygen	Magnesium	Aluminium	Silicon	Phosphorus	Chromium	Manganese	Iron
1	50.24			48.92				0.84
2	51.11			48.12				0.77
3	16.50	5.63	7.99			52.61		17.26
4	15.36			2.25			1.26	81.13
5	28.62							71.38
6	48.70			2.45	20.91			27.93
7	50.49			49.51				
Mean	**37.29**	**5.63**	**7.99**	**30.25**	**20.91**	**52.61**	**1.26**	**33.22**
Sigma	**16.59**	**0.00**	**0.00**	**25.47**	**0.00**	**0.00**	**0.00**	**35.03**
SigmaMean	**6.27**	**0.00**	**0.00**	**9.63**	**0.00**	**0.00**	**0.00**	**13.24**

Name	Date	Time	HV [kV]	Mag	WD [mm]
4246 194	1/6/2022	3:24:34 PM	15.0 keV	500x	18.2 mm

Figure 13

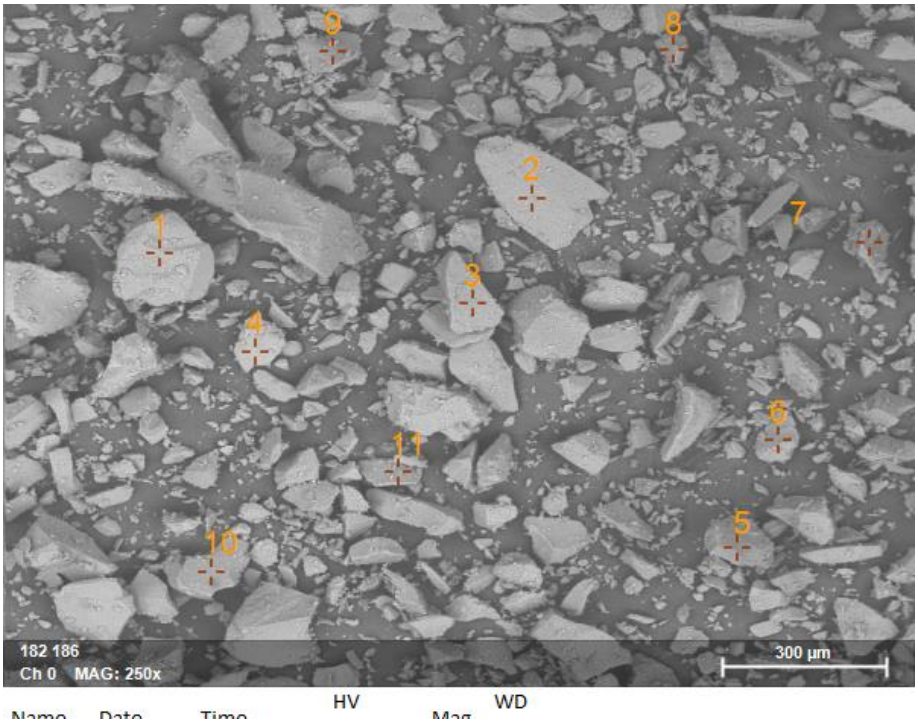
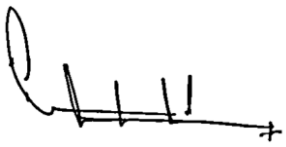


Figure 14



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09/03/2022

FORM 2

THE PATENTS ACT, 1970

[39 OF 1970]

&

THE PATENTS RULES, 2003

COMPLETE SPECIFICATION

[See section 10 and rule 13]

"A PROCESS OF RECOVERING NICKEL AND COBALT FROM AN ORE OR OVERBURDEN"

NAME AND ADDRESS OF THE APPLICANT:

TATA STEEL LIMITED

Jamshedpur, Jharkhand, India 831001

NATIONALITY: IN

The following specification particularly describes the invention and the manner in which it is to be performed.

TECHNICAL FIELD

The present disclosure generally relates to the field of metallurgy, and is particularly relevant to the process of recovering metals from an ore or overburden. More specifically, the present disclosure provides a process for recovering nickel and cobalt from an ore or overburden. The said process employs a step of calcination along with acid leaching for effective extraction and recovery of nickel and/or cobalt at atmospheric pressure.

BACKGROUND OF THE DISCLOSURE

Nickel (Ni) and Cobalt (Co) are period 4 d-block elements that find multiple uses in wide range of applications. While nickel finds wide applications in stainless steel industries, alloys, chemical industry and in batteries, cobalt is primarily used in lithium-ion batteries, and in the manufacture of magnetic, wear-resistant and high-strength alloys. Some high-speed steels also contain cobalt for increased heat and wear resistance.

Conventionally, nickel is obtained through extractive metallurgy, by extracting it from its ore by conventional roasting and reduction processes, whereas cobalt is obtained by reducing the cobalt by-products of nickel and copper mining and smelting. Cobalt and nickel are found together in nature in a large number of deposits. With constant innovation and growth in the steel and battery industries, both nickel and cobalt have seen high demand in the recent times.

While nickel has been conventionally supplied from the sulfide based nickel reserves, due to technical, economic and environmental reasons, attention in the recent times has shifted to more abundant lateritic type nickel resources. These account for majority of the world nickel reserves, and hence advanced processing techniques for recovering nickel from these reserves are steadily gaining more importance.

As a result of high nickel production costs associated with traditional pyrometallurgical techniques and the depletion of high-grade sulfide ores, a renewed interest has developed concerning the production of nickel and cobalt by hydrometalurgical processes, which primarily employ three different methods: tank leaching, heap leaching and high pressure acidic leaching (HPAL) of nickel laterites, amongst which HPAL is the most popular.

For a typical HPAL, slurried, crushed ore from the mine is conveyed to the processing plant to be pressure leached with sulphuric acid. The HPAL area receives the slurried feed, heats

it up to 225-270°C and mixes it with hot concentrated sulphuric acid inside special devices (autoclaves), which are typically titanium lined and very expensive. Nickel and cobalt are dissolved into the solution. The HPAL process thus utilizes elevated pressures of roughly 50 bar or 725 psi.

The literature also provides multiple methods for extraction of nickel and cobalt from different ores. These processes include steps of:

1) contacting ore of mesh size less than about one inch with a mineral acid solution of HCl, H2SO4 and HNO3, for dissolving substantial amounts of said nickel, and forming a pregnant nickel solution. The nickel is extracted from pregnant nickel solution by contacting said solution with an ion exchange resin selective to nickel absorption and thereby forming a nickel-loaded resin and extracting absorbed nickel from nickel loaded resin;

2) treating ore pulp and sulfuric acid solution in a cathode compartment of an electrolytic cell with an oxidation reduction potential of 200 to 300 mV, resulting in the reduction of Fe^{3+} from the Fe_2O_3 contained in the ore to Fe^{2+}, resulting in nickel, cobalt, and iron being dissolved in the sulfuric acid solution. The nickel, cobalt and iron contained in liquor is aerated with air in order to oxidize Fe^{2+} to Fe^{3+};

3) leaching the red soil nickel ore in a normal pressure pickling tank; and separating magnetic part from nonmagnetic part of the filter residue. The non-magnetic component can be utilized straight for silicon deep processing. The magnetic component may be leached at a pressure greater than atmospheric pressure, and the leached residue can be utilized as a raw material in the iron industry, and the leachate is recycled back into the normal pressure leaching tank to serve as the acid materials for high atmospheric pressure leaching;

4) separating ore into low magnesium limonite and high magnesium saprolite fraction and carrying out high pressure leaching in the presence of sulfuric acid, where the high pressure acid leaching is carried out in an autoclave at temperatures of 230° C to 270° and a pressure range of 40 to 50 Bar;

5) mixing red soil nickel with coal and roasting followed by leaching with vitriol oil. After filtration of leached slurry, ammonium sulfate and pyrolusite are added, and as a result Fe^{2+} is oxidized to Fe^{3+} and Mn^{4+} is reduced to Mn^{2+}. The technique can extract the valuable metal elements such as nickel, cobalt, iron, manganese from two ore deposits; or

6) slurrying an ore with water, and preheating to a leaching temperature between 230°C to 300°C., followed by adding sulfuric acid to leach the nickel values from the nickeliferous oxide ores. The obtained leached slurry was then neutralized and was subjected to liquid-solid separation.

However, most of these processes suffer from one or the other disadvantage, that include requirement of high amounts of acids and/or processing of the ore under high pressure. As a result, these processes are cost and energy intensive, and require significant capital and facilities to be performed. Further, these processes are also not necessarily selective in recovery of cobalt and nickel, and require large media for disposal of significant wastes that are generated.

Thus, there continues to exist a need for a more cost and energy efficient process, that allows selective recovery of nickel and cobalt at atmospheric pressure. The present invention aims to provide such a process.

SUMMARY OF THE DISCLOSURE

Addressing the aforesaid need in the art, the present disclosure provides a process of recovering nickel, cobalt or both, from an ore or overburden, at atmospheric pressure.

In some embodiments, the process comprises calcining and leaching of the ore or overburden for selectively recovering nickel, cobalt or both, at atmospheric pressure.

In some embodiments, the ore or overburden is an iron, limonite or chromite ore or overburden.

In some embodiments, the calcination converts the goethite phase of iron present in the ore or overburden to hematite phase.

In some embodiments, the calcination is carried out for a time period ranging from about 30 minutes to about 2 hours.

In some embodiments, the leaching is carried out by an acid selected from a group comprising sulphuric acid, phosphoric acid and hydrochloric acid, or any combination thereof.

In some embodiments, post the calcination and leaching, precipitation is carried out by filtering the leached liquor into residue and liquor, and contacting the filtered liquor with a neutralizing agent to recover the nickel, cobalt or both.

In some embodiments, the ore or overburden is siliceous and comprises at least 50 wt% of silica, less than about 1 wt% nickel and less than about 1 wt% cobalt.

In some embodiments, the process results in recovering at least about 50% of the nickel and at least about 30% of the cobalt present in the initial ore or overburden prior to the process.

BRIEF DESCRIPTION OF THE ACCOMPANYING FIGURES

Figure 1 shows an overview of the process employed.

Figure 2 shows XRD pattern of the limonitic overburden sample.

Figure 3 shows Raman spectroscopy of the limonitic overburden sample.

Figure 4 shows FTIR analysis of the limonitic overburden sample.

Figure 5 shows thermogravimetric analysis of the limonite overburden sample.

Figure 6 shows ΔG(kcal) vs Temperature (0C) Graph.

Figure 7 shows XRD pattern of the calcined limonite overburden.

Figure 8 shows the percentage of nickel recovered with 1.5M acid concentration of sulfuric acid, with varying leaching time.

Figure 9 shows the percentage of nickel recovered with 1.5M acid concentration of phosphoric acid, with varying leaching time.

Figure 10 shows the percentage of nickel recovered with varying acid concentration of phosphoric acid.

Figure 11 shows the percentage of cobalt recovered with varying acid concentration of phosphoric acid.

Figure 12 shows iron recovery in the leached liquor, after phosphoric acid leaching.

Figure 13 shows SEM-EDS analysis of filtered residue obtained upon filtration of the leached liquor.

Figure 14 shows SEM-EDS analysis of the end product.

DETAILED DESCRIPTION OF THE DISCLOSURE

In view of the limitations discussed above, and to remedy the need in the art for better processes, the present disclosure aims to provide a process of recovering nickel, cobalt or both, from an ore or overburden, at atmospheric pressure. The process combines a step of calcination with acid leaching for more cost and energy efficient selective recovery of nickel at atmospheric pressure.

However, before describing the invention in greater detail, it is important to take note of the common terms and phrases that are employed throughout the present disclosure for better understanding of the technology provided herein.

Throughout the present disclosure, the terms ‘calcination’ or ‘calcining’ or ‘calcined’ and the likes, are used interchangeably and are intended to convey the ordinary conventional meaning of the term known to a person skilled in the art and intends to cover a heating step or a thermal treatment that causes a chemical change, such as decomposition, phase transition, or removal of a volatile fraction from the entity or material exposed to calcination. Calcination is typically carried out to heat ores to high temperatures while staying below its melting point, in absence or limited supply of air or oxygen, generally for the purpose of removing impurities or volatile substances and/or to incur thermal decomposition. In the context of the present disclosure, calcination is referred to such a heating or thermal process through which an ore is heated to a temperature ranging from about 300°C to about 600°C, and is held at the said temperature for a predetermined period of time. For the purposes of the present disclosure, calcination is to be distinguished from roasting, in which more complex gas-solid reactions take place in presence of oxygen/air, and does not involve dehydration of ore.

Throughout the present disclosure, the term ‘ore’ is intended to convey the ordinary conventional meaning of the term known to a person skilled in the art and intends to cover a natural rock or sediment that contains one or more valuable minerals, typically containing metals, that can be extracted. Such an ore does not consist entirely of a single ore mineral and is mixed with other valuable minerals that can be extracted through further processing and extraction techniques.

Throughout the present disclosure, the term ‘overburden’ is intended to convey the ordinary conventional meaning of the term known to a person skilled in the art and intends to cover rock, soil or any natural material overlying a mineral deposit. In the broader sense, overburden is any material that lies above an area that lends itself to economical exploitation, such as the rock, soil, and ecosystem that lies above a coal seam or ore body. It typically refers to the rock, soil layer and other natural material that needs to be removed in order to access the ore being mined. In the context of the present disclosure, overburden are considered to be similar to ores in the sense that they can be treated and processed for extracting valuable minerals.

The ores (or the associated overburden) that are most typically employed for extracting of nickel and/or cobalt as per the process of the present disclosure are iron ores such as a limonite or chromite, nickel deposits such as a lateritic nickel ore, or limonite type laterites that are highly enriched in iron due to very strong leaching of magnesium and silica. However, as a person skilled in the art will readily understand from the present disclosure, the process described herein is not limited to a specific ore or the associated overburden of a specific kind, and any deposit having nickel and/or cobalt can be subjected to the process of the present disclosure for their extraction.

Throughout the present disclosure, the term ‘leach’ or ‘leaching’ is intended to convey the ordinary conventional meaning of the term known to a person skilled in the art and intends to cover a process of a solute becoming detached or extracted from its carrier substance by way of a solvent. In the context of the present disclosure, leaching is liberation of metals such as nickel and cobalt from a corresponding ore or overburden by chemical dissolution. Through leaching, the ore or overburden is concentrated by causing a chemical reaction with a reagent, such as an acid, which leads to the metal of interest being dissolved.

Accordingly, to reiterate, the present disclosure relates to a process of recovering nickel, cobalt or both, from an ore or overburden. The process is carried out at atmospheric pressure and is applicable to any ore or overburden suitable for such a recovery. The significance of the process of the present disclosure lies in combination of calcination with leaching, that helps in cost and energy efficient selective recovery of nickel and/or cobalt from the respective ore or overburden.

In some embodiments, the calcination precedes the step of leaching, and allows for better recovery of nickel and/or cobalt from the ore or overburden by increasing the surface area of the ore or overburden, thereby aiding in leaching that follows.

As mentioned previously, while some of conventional processes employ leaching for such recovery of metals, use of calcination along with leaching in the present disclosure is unique and advantageous compared to known processes. The present process allows the extraction at atmospheric pressure, thereby not requiring cost and energy intensive set-ups, such as industrial autoclaves etc. Without the use of calcination, use of high pressure becomes inevitable, thereby leading to a more complex and expensive process. Further, the process of the present disclosure also leads to selective recovery of nickel and cobalt over iron and other components of the ore or overburden.

In some embodiments, the calcination is carried out at a temperature ranging from about 300°C to about 600°C. The calcined ore or overburden is thereafter contacted with an acid for further step of leaching.

In some embodiments, post calcination, the calcined ore or overburden is contacted with an acid to allow leaching of the ore or overburden and obtain leached liquor. Subsequently, the leached liquor is then filtered and precipitated for recovery of nickel and/or cobalt.

Thus, the present disclosure provides a process of recovering nickel, cobalt or both, from an ore or overburden, said process comprising:

(a) calcining the ore or overburden at a temperature ranging from about 300°C to about 600°C;
(b) contacting the calcined ore or overburden with an acid, and allowing leaching of the ore or overburden to obtain leached liquor; and
(c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.

As mentioned above, the calcination is carried out at a temperature ranging from about 300°C to about 600°C. Accordingly, in a non-limiting embodiment, the calcination is carried out at a temperature of about 300°C, 305°C, 310°C, 315°C, 320°C, 325°C, 330°C, 335°C, 340°C, 345°C, 350°C, 355°C, 360°C, 365°C, 370°C, 375°C, 380°C, 385°C, 390°C, 395°C, 400°C, 405°C, 410°C, 415°C, 420°C, 425°C, 430°C, 435°C, 440°C, 445°C, 450°C, 455°C,

460°C, 465°C, 470°C, 475°C, 480°C, 485°C, 490°C, 495°C, 500°C, 505°C, 510°C, 515°C, 520°C, 525°C, 530°C, 535°C, 540°C, 545°C, 550°C, 555°C, 560°C, 565°C, 570°C, 575°C, 580°C, 585°C, 590°C, 595°C or about 600°C, including at any temperature value in between.

In some embodiments, the ore or overburden subjected to the process of the present disclosure is an iron ore or overburden.

In some embodiments, the ore or overburden subjected to the process of the present disclosure is a limonite, laterite or chromite ore or overburden.

Thus, in some embodiments, the present disclosure provides a process of recovering nickel, cobalt or both, from an iron ore or overburden, said process comprising:

(a) calcining the iron ore or overburden at a temperature ranging from about 300°C to about 600°C;
(b) contacting the calcined ore or overburden with an acid, and allowing leaching of the ore or overburden to obtain leached liquor; and
(c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.

Similarly, in some embodiments, the present disclosure provides a process of recovering nickel, cobalt or both, from a limonite ore or overburden, said process comprising:

(a) calcining the limonite ore or overburden at a temperature ranging from about 300°C to about 600°C;
(b) contacting the calcined ore or overburden with an acid, and allowing leaching of the ore or overburden to obtain leached liquor; and
(c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.

In some embodiments, the present disclosure provides a process of recovering nickel, cobalt or both, from a lateritic nickel ore or overburden, said process comprising:

(a) calcining the lateritic nickel ore or overburden at a temperature ranging from about 300°C to about 600°C;
(b) contacting the calcined ore or overburden with an acid, and allowing leaching of the ore or overburden to obtain leached liquor; and

(c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.

Similarly, in some embodiments, the present disclosure provides a process of recovering nickel, cobalt or both, from a chromite ore or overburden, said process comprising:

(a) calcining the chromite ore or overburden at a temperature ranging from about 300°C to about 600°C;
(b) contacting the calcined ore or overburden with an acid, and allowing leaching of the ore or overburden to obtain leached liquor; and
(c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.

In some embodiments, any of the ores or overburdens subjected to the process of the present disclosure are siliceous and comprises at least 50 wt% of silica.

Thus, in some embodiments, the ore or overburden subjected to the process of the present disclosure is an iron ore or overburden, and comprises at least 50 wt% of silica.

In some embodiments, the ore or overburden subjected to the process of the present disclosure is a limonite, laterite or chromite ore or overburden, and comprises at least 50 wt% of silica.

Further, in some embodiments, any of the ores or overburdens subjected to the process of the present disclosure comprise less than about 1 wt% nickel and/or less than about 1 wt% cobalt.

Thus, in some embodiments, the ore or overburden subjected to the process of the present disclosure is an iron ore or overburden, and comprise less than about 1 wt% nickel and/or less than about 1 wt% cobalt.

In some embodiments, the ore or overburden subjected to the process of the present disclosure is a limonite, laterite or chromite ore or overburden, and comprise less than about 1 wt% nickel and/or less than about 1 wt% cobalt.

In some embodiments, the overburden subjected to the process of the present disclosure is a limonitic overburden comprising about 0.4 wt% Ni and about 0.079 wt% Co.

In some embodiments, the overburden subjected to the process of the present disclosure is a limonitic overburden comprising about 0.4 wt% Ni.

In some embodiments, the ore or overburden is a chromite ore or overburden obtained from Sukinda mines in Odisha, India.

Through the step of calcination in the process of the present disclosure, not only does the overall recovery of nickel and cobalt becomes better, the calcination also converts the goethite phase of iron present in the ore or overburden to hematite phase. This allows leaching of nickel under mild conditions feasible, and results in low acid consumption and low iron dissolution from the ore or overburden. As a result, there is selective recovery of nickel and cobalt over iron and other components of the ore or overburden. Calcination also ensures that leaching reaction can be effectively and efficiently completed at atmospheric pressure, and hence the overall process requiring less operating cost as compared to high pressure leaching.

This calcination as part of the process of the present disclosure is carried out for a time period ranging from about 30 minutes to about 2 hours.

Thus, in some embodiments, the ore or overburden is calcined at a temperature ranging from about 300°C to about 600°C for a time period ranging from about 30 minutes to about 2 hours. Accordingly, in a non-limiting embodiment, the calcination is carried out for a time period of about 30 minutes, 35 minutes, 40 minutes, 45 minutes, 50 minutes, 55 minutes, 60 minutes, 65 minutes, 70 minutes, 75 minutes, 80 minutes, 85 minutes, 90 minutes, 95 minutes, 100 minutes, 105 minutes, 110 minutes, 115 minutes, or about 120 minutes, including for any time period value in between.

Thus, in some embodiments, the present disclosure provides a process of recovering nickel, cobalt or both, from an ore or overburden, said process comprising:

(a) calcining the ore or overburden at a temperature ranging from about 300°C to about 600°C for a time period ranging from about 30 minutes to about 2 hours;

(b) contacting the calcined ore or overburden with an acid, and allowing leaching of the ore or overburden to obtain leached liquor; and

(c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.

However, prior to the calcination, the ore or overburden is subjected to grinding to bring the ore or overburden size in a range of about 30 microns to about 250 microns. This allows for better processing of the ore and overburden, as higher surface area enhances the rate of leaching reaction carried out post the calcination.

Accordingly, in a non-limiting embodiment, the grinding is carried out to bring the ore or overburden size to about 30 microns, 40 microns, 50 microns, 60 microns, 70 microns, 80 microns, 90 microns, 100 microns, 110 microns, 120 microns, 130 microns, 140 microns, 150 microns, 160 microns, 170 microns, 180 microns, 190 microns, 200 microns, 210 microns, 220 microns, 230 microns, 240 microns or about 250 microns, including any size value in between.

Once calcination is over, the calcined ore or overburden is contacted with an acid, to allow leaching of the ore or overburden and to in-turn obtain leached liquor.

In some embodiments, the acid is selected from a group comprising sulphuric acid (H_2SO_4), phosphoric acid (H_3PO_4) and hydrochloric acid (HCl), or any combination thereof.

Thus, in some embodiments, the present disclosure provides a process of recovering nickel, cobalt or both, from an ore or overburden, said process comprising:

(a) calcining the ore or overburden at a temperature ranging from about 300°C to about 600°C;
(b) contacting the calcined ore or overburden with sulphuric acid (H_2SO_4), and allowing leaching of the ore or overburden to obtain leached liquor; and
(c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.

Similarly, in some embodiments, the present disclosure provides a process of recovering nickel, cobalt or both, from an ore or overburden, said process comprising:

(a) calcining the ore or overburden at a temperature ranging from about 300°C to about 600°C;

(b) contacting the calcined ore or overburden with phosphoric acid (H_3PO_4), and allowing leaching of the ore or overburden to obtain leached liquor; and

(c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.

Similarly, in some embodiments, the present disclosure provides a process of recovering nickel, cobalt or both, from an ore or overburden, said process comprising:

(a) calcining the ore or overburden at a temperature ranging from about 300°C to about 600°C;

(b) contacting the calcined ore or overburden with hydrochloric acid (HCl), and allowing leaching of the ore or overburden to obtain leached liquor; and

(c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.

The acid so employed as part of the process of the present disclosure, is present at a molar concentration ranging from about 0.25M to 2.5M.

Thus, in some embodiments, the sulphuric acid (H_2SO_4), phosphoric acid (H_3PO_4) or hydrochloric acid (HCl), or any combination thereof is contacted with the calcined ore or overburden at a molar concentration of about 0.25 molar, 0.3 molar, 0.4 molar, 0.5 molar, 0.6 molar, 0.7 molar, 0.8 molar, 0.9 molar, 1 molar, 1.1 molar, 1.2 molar, 1.3 molar, 1.4 molar, 1.5 molar, 1.6 molar, 1.7 molar, 1.8 molar, 1.9 molar, 2 molar, 2.1 molar, 2.2 molar, 2.3 molar, 2.4 molar, or about 2.5 molar, including at any concentration value in between.

This acid is contacted with the calcined ore or overburden for a time period ranging from about 30 minutes to about 8 hours. Accordingly, in a non-limiting embodiment, the leaching is carried out for a time period of about 30 minutes, 60 minutes, 90 minutes, 120 minutes, 150 minutes, 180 minutes, 210 minutes, 240 minutes, 270 minutes, 300 minutes, 330 minutes, 360 minutes, 390 minutes, 420 minutes, 450 minutes, or about 480 minutes, including for any time period value in between.

The said leaching is carried out at a temperature ranging from about 50°C to about 100°C. Accordingly, in a non-limiting embodiment, the leaching is carried out at a temperature of about 50°C, 55°C, 60°C, 65°C, 70°C, 75°C, 80°C, 85°C, 90°C, 95°C, or about 100°C, including at any temperature value in between.

In some embodiments, once the leaching is completed, the leached liquor is cooled to bring the temperature down to room temperature.

Thus, in some embodiments, the present disclosure provides a process of recovering nickel, cobalt or both, from an ore or overburden, said process comprising:

(a) calcining the ore or overburden at a temperature ranging from about 300°C to about 600°C for a time period ranging from about 30 minutes to about 2 hours;

(b) contacting the calcined ore or overburden with sulphuric acid (H_2SO_4), phosphoric acid (H_3PO_4) or hydrochloric acid (HCl), or any combination thereof, at a molar concentration ranging from about 0.25M to 2.5M, for a time period ranging from about 30 minutes to about 8 hours, and at a temperature ranging from about 50°C to about 100°C, to allow leaching of the ore or overburden to obtain leached liquor; and

(c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.

In some embodiments, prior to contacting with the acid, the calcined ore or overburden is mixed with water at a pulp density ranging from about 10% (w/v) to about 50% (w/v). Accordingly, in a non-limiting embodiment, the leaching is carried out by first contacting the calcined ore or overburden with water prior to the contact with acid, at a pulp density of about 10%, 11%, 12%, 13%, 14%, 15%, 16%, 17%, 18%, 19%, 20%, 21%, 22%, 23%, 24%, 25%, 26%, 27%, 28%, 29%, 30%, 31%, 32%, 33%, 34%, 35%, 36%, 37%, 38%, 39%, 40%, 41%, 42%, 43%, 44%, 45%, 46%, 47%, 48%, 49%, or about 50% (w/v), including at any pulp density value in between.

As mentioned above, leaching of the calcined ore or overburden results in production of leached liquor. This leached liquor is thereafter subjected to filtration for obtaining two components - a filtered liquor and a filtered residue.

In some embodiments, the filtration is carried out by any technique known to a person skilled in the art and includes decantation, pressure filtration and vacuum filtration, or any combination thereof.

In some embodiments, the filtration is carried out by Whatman filter paper no. 40, 41 and/or 42.

Upon filtration, the filtered liquor is contacted with a neutralizing agent for neutralizing the acid employed during the leaching and to precipitate out the desired nickel and/or cobalt.

In some embodiments, the neutralizing agent is selected from a group comprising sodium hydroxide (NaOH), ammonia (NH_3) and magnesium oxide (MgO), or any combination thereof.

The neutralizing agent is added to the said filtered liquor at a concentration ranging from about 1M to about 4M. Thus, in a non-limiting embodiment, the sodium hydroxide (NaOH), ammonia (NH_3) and magnesium oxide (MgO), or any combination thereof is added to the filtered liquor at a molar concentration of about 1 molar, 1.1 molar, 1.2 molar, 1.3 molar, 1.4 molar, 1.5 molar, 1.6 molar, 1.7 molar, 1.8 molar, 1.9 molar, 2 molar, 2.1 molar, 2.2 molar, 2.3 molar, 2.4 molar, 2.5 molar, 2.6 molar, 2.7 molar, 2.8 molar, 2.9 molar, 3 molar, 3.1 molar, 3.2 molar, 3.3 molar, 3.4 molar, 3.5 molar, 3.6 molar, 3.7 molar, 3.8 molar, 3.9 molar, or about 4 molar, including at any molar concentration value in between.

In some embodiments, the percentage recovery of nickel and/or cobalt is calculated using the formula: $\frac{W_1}{W_o} * 100$,

where w_0 is the weight of the nickel in feed and w_1 is the weight of nickel in the leached liquor. The w_1 is further calculated as:

w_1 (nickel weight in leached liquor) = (volume of leached liquor in ml) * (concentration of nickel in g/ml).

Accordingly, the process of the present disclosure results in recovering at least about 50% of the nickel and at least about 30% of the cobalt present in the initial ore or overburden prior to the process.

In some embodiments, the process of the present disclosure allows for selective extraction of nickel and/or cobalt, while preventing extracting of silica and iron, which are effectively captured and retained as part of the filtered residue. Thus, the process of the present

disclosure provides for selective recovery of nickel and cobalt over iron and other components of the ore or overburden.

Thus, to summarize, the present disclosure provides a process of recovering nickel, cobalt or both, from an ore or overburden at atmospheric pressure, said process comprising:

(a) calcining the ore or overburden at a temperature ranging from about 300°C to about 600°C for a time period ranging from about 30 minutes to about 2 hours;

(b) contacting the calcined ore or overburden with water at a predetermined pulp density, followed by sulphuric acid (H_2SO_4), phosphoric acid (H_3PO_4) or hydrochloric acid (HCl), or any combination thereof, at a molar concentration ranging from about 0.25M to 2.5M, for a time period ranging from about 30 minutes to about 8 hours, and at a temperature ranging from about 50°C to about 100°C, to allow leaching of the ore or overburden to obtain leached liquor; and

(c) filtering the leached liquor into filtered residue and liquor, followed by contacting the filtered liquor with NaOH, NH_3 or MgO, or any combination thereof for precipitating and recovering the nickel, cobalt or both.

As mentioned previously, in some embodiments, any of the ores or overburdens subjected to the process of the present disclosure are siliceous and comprises at least 50 wt% of silica.

Thus, in some embodiments, the ore or overburden subjected to the process of the present disclosure is an iron ore or overburden, and comprises at least 50 wt% of silica.

In some embodiments, the ore or overburden subjected to the process of the present disclosure is a limonite, laterite or chromite ore or overburden, and comprises at least 50 wt% of silica.

The step of calcination increases the surface area of an ore or overburden through development of cracks along with crystal boundaries as well as porosity and permeability. Hence the pre-treatment process by calcination enhances reactivity through solid-liquid interactions as well as the efficiency of the subsequent leaching step.

Further, calcination also transforms the goethite into hematite phases through de-hydroxylation process. In the overburden ore, nickel and cobalt are present in goethite phase. So, through calcination pre-processing, there is liberation of the goethite phase in a manner which indirectly helps improve the efficiency of the subsequent leaching step.

Thus, to solve the need of the art for more efficient processes, the present disclosure provides the aforementioned process of recovering nickel and/or cobalt from an ore or overburden. Advantages of the process of the present disclosure include but are not limited to -

- recovery of nickel and/or cobalt at atmospheric pressure;

- recovery of nickel and/or cobalt at lower acid concentrations;

- higher recovery of nickel and/or cobalt at atmospheric pressure, from an ore or overburden comprising very small/minute quantities of nickel and cobalt;

- recovery of nickel and/or cobalt at lower costs and energy;

- recovery of nickel and/or cobalt with lower waste generation and in an environmentally effective manner; and

- recovery of nickel and/or cobalt at lesser capital and need for elaborate infrastructure.

EXAMPLES

The present disclosure is further described with reference to the following examples, which are only illustrative in nature and should not be construed to limit the scope of the present disclosure in any manner.

Materials

The materials used in the examples are:

Acids: Sulfuric acid (85%) and Phosphoric acid (85%), available as commercial grade.

Ore/Overburden: Chromite/Limonite overburden was obtained from Sukinda, Odisha.

Ore size: Size range of 38 micron to 75 microns was chosen for all the experiments.

The equipment used was hot plate and stirring machine to keep constant stirring rate for all the laboratory experiments.

Example 1: Recovery of Nickel and Cobalt by using Sulphuric Acid

The 150 grams of ore was removed from its natural environment, dried and grinded to a size range 38 micron to 75 microns. The ore was then subjected to calcination at 400°C to increase the surface area of the ore material and to transform the goethite phase of iron to hematite phase present in the ore.

After 1 hour of calcination, water was added to the calcined ore in a beaker to achieve a pulp density of 30% (w/v). The calcined ore along with the water, was thereafter subjected to leaching by adding sulfuric acid at a molar concentration of 1.5M. Leaching was allowed to be carried out for about 2 to 8 hours (figure 8). The beaker was kept on the hot plate and temperature of 90°C was maintained throughout the experiment. The beaker containing leached sample was then cooled to bring the temperature down to room temperature. The leached liquor was then filtered by using Whatman filter paper no. 41 to obtain residue and liquor. The liquor was then contacted with NaOH at a molar concentration of 1M to 4M to precipitate out nickel and cobalt. Figure 1 provides an overview of the process employed.

Example 2: Recovery of Nickel and Cobalt by using Phosphoric Acid

The 150 grams of ore was removed from its natural environment, dried and grinded to a size range 38 micron to 75 microns. The ore was then subjected to calcination at 400°C to increase the surface area of the ore material and to transform the goethite phase of iron to hematite phase present in the ore.

After 1 hour of calcination, water was added to the calcined ore in a beaker to achieve a pulp density of 10% (w/v). The calcined ore along with the water, was thereafter subjected to leaching by adding phosphoric acid at a molar concentration of 0.25M. Leaching was allowed to be carried out for about 0.5 to 2.5 hours (figure 9). The beaker was kept on the hot plate and temperature of 90°C was maintained throughout the experiment. The beaker containing leached sample was then allowed to cool down to room temperature. The leached liquor was then filtered by decantation and vacuum filtration by using Whatman filter paper no. 41, 42 and 43 to obtain residue and liquor. The liquor was then contacted with NaOH at a molar concentration of 1M to 4M to precipitate out nickel and cobalt.

The experiment was repeated by varying the molar concentration of phosphoric acid between 0.5M and 2.5M, as shown in example 5 below.

Example 3: Analysis of initial ore – Limonite overburden employed in the examples 1 and 2 above

Chemical Analysis:

The chemical analysis of the limonite overburden was done using ICP OES for the elements. The weight percentage of all the elements are given in the table 1 below. As can be seen, the nickel is present in the form of NiO at about 0.52 wt%, whereas the cobalt is present in the form of CoO at about 0.079 wt%. The major component of the overburden is silica (SiO_2), present at about 59.55 wt%.

Elements/Components	Weight %
Fe_2O_3	30.08
SiO_2	59.55
Al_2O_3	1.26
CaO	0.04
MgO	0.46
Co	0.079
NiO	0.52
Cr_2O_3	2.25
LOI	4.39
P_2O_5	0.05
S	0.07
Na_2O	0.32
K_2O	0.15
MnO	NA
Total	**99.219**

Table 1

XRD of Limonite overburden:

XRD patterns of the overburden sample shows presence of mainly goethite and quartz phases. The highest peak at 2 thetas of 27° is matching with highest intensity of quartz. Highest intensity of goethite (JCPDS=98-007-1810) is at 21° with limonite overburden obtained from Sukinda, Orissa. The other mineral present in the ore is mainly magnesium ferrite (JCPDS= 98-007-6176). Figure 2 shows the XRD pattern of Limonitic overburden sample. This result is also in accordance with FTIR and Raman spectroscopy.

Raman Spectroscopy:

The results from Raman spectroscopy are provided in the table 2 below:

Mineral	**Raman Shift (cm^{-1})**
α-Goethite	296, 391, 417, 474, 564
Quartz (Si-O-Si)	450-550 cm^{-1} (474)
Magnetite	296, 564, 671
Pyroxene Mg^{2+}	993
Magnetite Fe^{2+}	671

Table 2

In general, these pyroxenes are characterized by (1) the Si-O stretching modes above 800 cm^{-1}; (2) the Si-O bending modes between 500 and 760 cm^{-1}; and (3) SiO_4 rotation and metal-oxygen translation modes below 500 cm^{-1}. From the Raman peaks, peak at (~993 cm^{-1}) and peak at (~671 cm^{-1}) correlate well enough with the proportions of Mg^{2+} and Fe^{2+}. Figure 3 shows the Raman spectroscopy of the limonitic overburden sample.

FTIR Analysis:

The FTIR spectroscopy of limonite overburden shows the presence of goethite and quartz phases at 1080 and 1054 cm^{-1} corresponding to Si-O-Si bonds. The FTIR spectroscopy also shows bonds of OH present in goethite phase. The results from FTIR spectroscopy are provided in the table 3 below along with figure 4:

Wave number (cm^{-1})	Bond	Minerals
434	Si-O, FeO_6 hexagon	Quartz, Goethite
631	FeO_6 Hexagon	Goethite
695	Si-O	Quartz
800	H-O bonds, AlO, SiO or MgO bands	Quartz, δ- Goethite
901	H-O bonds	γ- Goethite

1054	Stretching vibrations of Si-O-Si bonds	Quartz
1080	Stretching vibrations of Si-O-Si bonds	Quartz
3134	OH bond	

Table 3

Thermogravimetric Analysis:

Thermogravimetric analysis was done for the ore sample and it shows the weight loss at 280˚C which can be due to transformation of goethite to hematite. The endothermic peak at 280˚C shows weight loss of approximately 3.35% due to phase transformation of goethite to hematite (figure 5).

Similarly, the ΔG(kcal) or Gibbs free energy vs Temperature (°C) graph is shown in figure 6. Delta G is negative in the temperature range of approximately room temperature to 500˚C. This shows that the dihydroxy of goethite to hematite is feasible at 450˚C.

Example 4: Analysis of calcined ore from examples 1 and 2 above

The calcined ore was further characterized by XRD to see the phase change in the calcined ore. XRD results (figure 7) show the presence of hematite and quartz as the major phase whereas goethite and quartz formed the major phases in the initial ore material, along with some presence of magnetite phase.

The calcined ore was then leached in the presence of sulfuric acid with varying time while keeping the temperature and pulp density constant as in example 1. The effect of reaction time and molarity were investigated. XRD of calcined sample was done to see the transformation of phases from goethite to hematite. Figure 7 mainly shows presence of hematite and quartz phases, thereby confirming formation of hematite at 450˚C.

Example 5: Analysis of recovery of nickel from the leached liquor

The leached liquor was obtained by precipitating the undissolved particles from leached solution by employing neutralizing agent. The effect of percentage of recovery was studied concisely to understand the extent of leaching reaction at varying time and at 1.5M sulphuric

acid concentration. Figure 8 shows the percentage of nickel recovery with 1.5M sulfuric acid with varying leaching time.

Similar, experiments were done using phosphoric acid as leaching agent. Figure 9 shows the percentage of nickel recovery at 0.25M of phosphoric acid concentration. The nickel recovery is about 51 wt% after 2.5 hours of leaching time.

As can be seen, the recovery of nickel is about 50% with both sulphuric as well as phosphoric acid. However, in case of phosphoric acid leaching, the leaching time required to achieve 50% nickel recovery is less as compared to leaching reaction with sulfuric acid.

Percentage of Recovery is calculated by the following formula:

Percentage recovery of Nickel = $\frac{W_1}{W_o} * 100$,

where w_0 is the weight of the nickel in feed and w_1 is the weight of nickel in the leached liquor. w_1 is further depicted as below:

w_1 (nickel weight in leached liquor) = (Volume of leached liquor in ml) * (Concentration of nickel in g/ml)

W_0 (nickel weight in feed) = 0.4*150/100 gm = 0.6 gm

[Ni wt% present in the feed NiO provided in table 1 above is calculated using conversion factor 1.2725, i.e., 0.52/1.2725 = 0.4086 wt% in 100 gm of feed. Hence for 150 gm of feed, the Ni wt% is 0.6 gm];

The table 4 below provides data for calculating recovery based on leaching by phosphoric acid (figure 10):

Molarity	Time in hrs.	Vol of leached liquor (ml)	Ni conc. in g /ml	Ni amount in gm	**Ni recovery**
0.5	2.5	1240	0.000391	0.48484	**80.80666667**
1	2.5	1411	0.000378	0.533358	**88.893**
1.5	2.5	1298	0.00038	0.49324	**82.20666667**

Table 4

Similar to recovery of nickel through phosphoric acid leaching, figure 11 shows cobalt recovery with phosphoric acid leaching.

Percentage recovery of Cobalt = $\frac{W_1}{W_o} * 100$,

W_0 (cobalt weight in feed) = 0.079*150/100 gm = 0.1185 gm

[Co wt% present in the feed provided in table 1 above = 0.079 wt% in 100 gm of feed. Hence for 150 gm of feed, the Co wt% is 0.1185 gm];

The table 5 below provides data for calculating recovery based on leaching by phosphoric acid (figure 11):

Molarity	Time in hrs.	Vol of leached liquor (ml)	Co conc. in mg/l	Co amount in gm	**Co recovery**
0.5	2.5	1240	36.4	0.045136	**38.08945148**
1.5	2.5	1298	36.44	0.04729912	**39.9148692**

Table 5

As mentioned above, figures 10 and 11 show recovery percentage of nickel and cobalt from leached liquor obtained by leaching through phosphoric acid. This is further compared with recovery percentage of iron as provided in figure 12, which confirms the selective leaching of nickel and cobalt by the instant process, when compared with iron.

Chemical Analysis of the Residue:

This was further confirmed through SEM-EDS of filtered residue which showed the distribution of elements in residue. Iron formed precipitate with phosphoric acid and was filtered along with residue part. As a result, the SEM-EDS showed the presence of Fe and Si as major phase.

This residue obtained after the filtration of the leached liquor was further characterized with ICP, XRD and SEM-EDS to evaluate its properties. Chemical analysis of residue showed Fe at 17.57 wt% and SiO_2 at 43.3 wt% (table 6 below), further confirming that Fe formed residue with phosphoric acid as mentioned above.

	Fe	SiO_2	MgO	MnO	Al_2O_3	Cr_2O_3	LOI	Ni	P_2O_5
Residue (wt%)	17.57	43.3	0.379	0.19	0.54	2.094	5.7	0.033	26.6

Table 6

Chemical Analysis of the end product:

SEM-EDS analysis was carried out for the end-product. Figure 14 shows the distribution of elements throughout the area, wherein nickel distribution was found to be around 12%. Further, there were impurities present in the sample such as sodium, iron, magnesium and silicon in the sample, as observed by table 7 below:

Normalized mass concentration [%]

Spectrum	Oxygen	Sodium	Magnesium	Aluminium	Silicon	Phosphorus	Calcium	Chromium	Manganese	Iron	Nickel
1	41.49	9.61	8.44		3.67	20.60	2.14		1.51	2.37	10.17
2	33.92	5.57	8.19		5.14	23.14	2.40		2.21	1.51	17.92
3	48.76	7.82	8.68		3.17	16.39	1.77		1.54	2.84	9.04
4	16.50	2.94	6.56		2.45	35.18	5.31		3.77	5.04	22.26
5	49.84	8.96	7.98		2.96	15.09	1.86		1.60	3.32	8.38
6	37.53	8.05	9.02		5.11	22.84	2.37		1.82	2.83	10.43
7	50.83	8.22	8.53		3.23	15.50	2.76		1.19	2.16	7.58
8	12.83	5.49	4.88		1.63	34.90	3.99	1.53	4.36	11.89	18.51
9	47.27	10.30	7.55		3.58	18.48	1.81		1.70	2.29	7.02
10	47.77	7.63	8.20	2.47	3.36	16.60	1.83		1.63	2.08	8.43
11	31.23	7.56	7.67		4.65	26.13	3.02		2.51	3.65	13.57
Mean	**38.00**	**7.47**	**7.79**	**2.47**	**3.54**	**22.26**	**2.66**	**1.53**	**2.17**	**3.63**	**12.12**
Sigma	**13.32**	**2.10**	**1.17**	**0.00**	**1.08**	**7.23**	**1.10**	**0.00**	**1.01**	**2.90**	**5.19**
SigmaMean	**4.01**	**0.63**	**0.35**	**0.00**	**0.33**	**2.18**	**0.33**	**0.00**	**0.31**	**0.87**	**1.57**

Table 7

Example 6: Comparative analysis for Recovery of Nickel by using Phosphoric Acid, in a process devoid of calcination

The process employed in this example was identical to example 2 above, except for the fact that no step of calcination was performed in this example. The initial ore and nickel concentration remained identical as described above in examples 2 and 3. The results as provided in table 8 below confirmed that the recovery of nickel was reduced considerably to only about 40% when calcination was not performed as part of the process for recovering nickel from the overburden.

Vol of leached liquor (ml)	Ni conc. in g /ml	Ni amount in gm	**Ni recovery**

942	0.000258	0.243036	**40.506**

Table 8

Additional embodiments and features of the present disclosure will be apparent to one of ordinary skill in art based on the description provided herein. The embodiments herein provide various features and advantageous details thereof in the description. Descriptions of well-known/conventional methods and techniques are omitted so as to not unnecessarily obscure the embodiments herein.

The foregoing description of the specific embodiments fully reveals the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments in this disclosure have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the embodiments as described herein.

Throughout this specification, the word “comprise”, or variations such as “comprises” or “comprising” wherever used, will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps. Similarly, terms such as “include” or “have” or “contain” and all their variations are inclusive and will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

The terms "about" or “approximately” are used herein to mean approximately, in the region of, roughly, or around. When the term "about" is used in conjunction with a numerical value/range, it modifies that value/range by extending the boundaries above and below the numerical value(s) set forth. In general, the term "about" is used herein to modify a numerical

value(s) or a measurable value(s) such as a parameter, an amount, a temporal duration, and the like, above and below the stated value(s) by a variance of +/-20% or less, +/-10% or less, +/-5% or less, +/-1% or less, and +/-0.1% or less of and from the specified value, insofar such variations are appropriate to perform in the disclosed invention, and achieves the desired results and/or advantages as disclosed in the present disclosure. It is to be understood that the value to which the modifier "about" or "approximately" refers is itself also specifically, and preferably, disclosed.

With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity. As used in this specification and the appended claims, the singular forms "a," "an" and "the" includes both singular and plural references unless the content clearly dictates otherwise. The use of the expression 'at least' or 'at least one' suggests the use of one or more elements or ingredients or quantities, as the use may be in the embodiment of the disclosure to achieve one or more of the desired objects or results. As such, the terms "a" (or "an"), "one or more", and "at least one" can be used interchangeably herein.

Numerical ranges stated in the form 'from x to y' include the values mentioned and those values that lie within the range of the respective measurement accuracy as known to the skilled person. If several preferred numerical ranges are stated in this form, of course, all the ranges formed by a combination of the different end points are also included.

As regards the embodiments characterized in this specification, it is intended that each embodiment be read independently as well as in combination with another embodiment. For example, in case of an embodiment 1 reciting 3 alternatives A, B and C, an embodiment 2 reciting 3 alternatives D, E and F and an embodiment 3 reciting 3 alternatives G, H and I, it is to be understood that the specification unambiguously discloses embodiments corresponding to combinations A, D, G; A, D, H; A, D, I; A, E, G; A, E, H; A, E, I; A, F, G; A, F, H; A, F, I; B, D, G; B, D, H; B, D, I; B, E, G; B, E, H; B, E, I; B, F, G; B, F, H; B, F, I; C, D, G; C, D, H; C, D, I; C, E, G; C, E, H; C, E, I; C, F, G; C, F, H; C, F, I, unless specifically mentioned otherwise.

Any discussion of documents, acts, materials, devices, articles and the like that has been included in this specification is solely for the purpose of providing a context for the disclosure. It is not to be taken as an admission that any or all of these matters form a part of the prior art base or were common general knowledge in the field relevant to the disclosure as it existed anywhere before the priority date of this application.

While considerable emphasis has been placed herein on the particular features of this disclosure, it will be appreciated that various modifications can be made, and that many changes can be made in the preferred embodiments without departing from the principles of the disclosure. These and other modifications in the nature of the disclosure or the preferred embodiments will be apparent to those skilled in the art from the disclosure herein, whereby it is to be distinctly understood that the foregoing descriptive matter is to be interpreted merely as illustrative of the disclosure and not as a limitation.

All references, articles, publications, general disclosures etc. cited herein are incorporated by reference in their entireties for all purposes. However, mention of any reference, article, publication etc. cited herein is not, and should not be taken as, an acknowledgment or any form of suggestion that they constitute valid prior art or form part of the common general knowledge in any country in the world.

We claim:

1) A process of recovering nickel, cobalt or both, from an ore or overburden, said process comprising:
    (a) calcining the ore or overburden at a temperature ranging from about 300°C to about 600°C;
    (b) contacting the calcined ore or overburden with an acid, and allowing leaching of the ore or overburden to obtain leached liquor; and
    (c) filtering the leached liquor followed by precipitation to recover the nickel, cobalt or both.
2) The process as claimed in claim 1, wherein the ore or overburden is an iron ore or overburden.
3) The process as claimed in claim 1, wherein the ore or overburden is a limonite, laterite or chromite ore or overburden.
4) The process as claimed in claim 1, wherein the ore or overburden is subjected to grinding prior to the calcination to bring the ore or overburden size in a range of about 30 microns to about 250 microns.
5) The process as claimed in claim 1, wherein the calcination converts the goethite phase of iron present in the ore or overburden to hematite phase.
6) The process as claimed in claim 1, wherein the calcination is carried out for a time period ranging from about 30 minutes to about 2 hours.
7) The process as claimed in claim 1, wherein the acid is selected from a group comprising sulphuric acid, phosphoric acid and hydrochloric acid, or any combination thereof.
8) The process as claimed in claim 7, wherein the acid is employed at a molar concentration ranging from about 0.25M to 2.5M.
9) The process as claimed in claim 1, wherein prior to contacting with the acid, the ore or overburden is mixed with water at a pulp density ranging from about 10% (w/v) to about 50% (w/v).
10) The process as claimed in claim 1, wherein the leaching is carried out for a time period ranging from about 30 minutes to about 8 hours, at a temperature ranging from about 50°C to about 100°C.

11) The process as claimed in claim 1, wherein the precipitation is carried out by filtering the leached liquor into residue and liquor, and contacting the filtered liquor with a neutralizing agent selected from a group comprising NaOH, NH_3 and MgO, or any combination thereof.

12) The process as claimed in claim 11, wherein the neutralizing agent is added to the liquor at a concentration ranging from about 1M to about 4M.

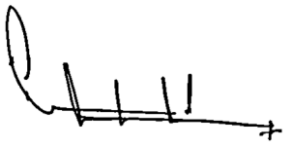
13) The process as claimed in claim 1, wherein the ore or overburden is siliceous and comprises at least 50 wt% of silica.

14) The process as claimed in claim 1, wherein the ore or overburden comprises less than about 1 wt% nickel and less than about 1 wt% cobalt.

15) The process as claimed in claim 1, wherein the process results in recovering at least about 50% of the nickel and at least about 30% of the cobalt present in the initial ore or overburden prior to the process.

16) The process as claimed in claim 1, wherein the process is carried out at atmospheric pressure.

Dated this 09th day of March 2022

Signature: 

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To:

The Controller of Patents

The Patent Office, at Kolkata

“A PROCESS OF RECOVERING NICKEL AND COBALT FROM AN ORE OR OVERBURDEN”

ABSTRACT

The present disclosure relates to a process of recovering nickel and cobalt from an ore or overburden. Particularly, the present disclosure provides a process for recovering nickel and cobalt from an ore or overburden, that employs a step of calcination along with acid leaching for effective extraction and recovery of nickel and/or cobalt at atmospheric pressure. The process of the present disclosure can be used for any ore or overburden comprising nickel and/or cobalt, and avoids the use of high pressure, cost and energy intensive processes.