(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 December 2007 (21.12.2007)

PCT

(10) International Publication Number
WO 2007/143779 A1

(51) International Patent Classification:
C22B 1/24 (2006.01) ***C22B 1/243*** (2006.01)
C22B 1/242 (2006.01)

(21) International Application Number:
PCT/AU2007/000817

(22) International Filing Date: 12 June 2007 (12.06.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2006903158 12 June 2006 (12.06.2006) AU

(71) Applicant *(for all designated States except US)*: **MURRIN MURRIN OPERATIONS PTY LTD** [AU/AU]; Level 4, 30 The Esplanade, Perth, Western Australia 6000 (AU).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **RODRIGUEZ, Michael** [AU/AU]; 4 Baloo Grove, Kingsley, Western Australia 6026 (AU).

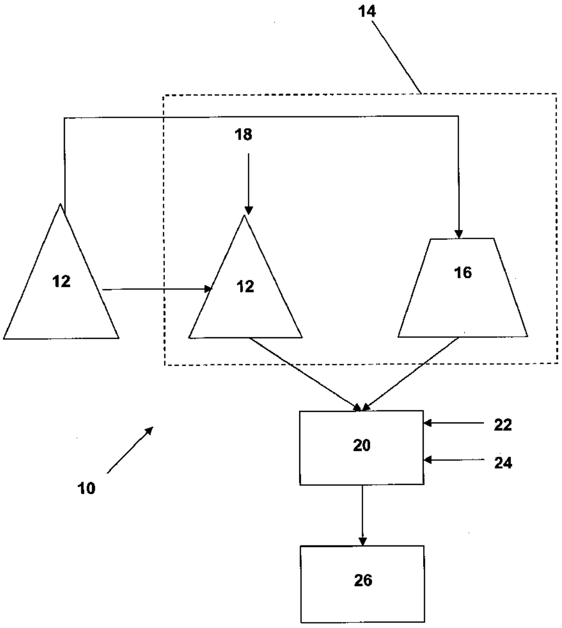
(74) Agent: WRAY & ASSOCIATES; Level 4, 1 William Street, Perth, Western Australia 6000 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(54) Title: METHOD FOR AGGLOMERATION



(57) Abstract: A method for agglomeration (10) characterised by the method steps of: i) adjusting the moisture content of an ore material to be agglomerated to a predetermined level, ii) passing the ore material to an agglomeration circuit (20); and iii) adding an acid containing agglomerating solution to the ore material in the agglomeration circuit to provide an agglomerated ore material, whereby the acid concentration of the agglomerating solution does not exceed about 100g/L.

WO 2007/143779 A1

“Method for Agglomeration”

Field of the Invention

The present invention relates to a method for agglomeration. More particularly, the present invention is intended to produce agglomerates of an ore to be leached using a dilute acid solution. The method of the present invention has particular application in the agglomeration of nickel laterite ores prior to heap leaching.

Background Art

Agglomeration is an ore treatment method that has been used extensively in the mining industry to improve the ore’s leaching characteristics. Agglomeration typically involves the binding of finer particles, including clays, to larger particles. This improves the percolation of leach solutions through the ore material and prevents migration of those finer particles. Additionally, this ensures that the target metal values contained in the fine materials are available to the leaching solution.

A variety of methods for agglomeration have been practised over the years, the simplest method involving the use of water to form the agglomerated particles. Water is popular from an economic viewpoint, but its use is highly dependent on the ore characteristics. Ores with particularly high clay and/or fines content may not necessarily respond as well to water agglomeration.

For this reason binding agents became very popular, and the use of such agents has been adopted quite extensively. However, binding agents, such as cement, are generally only used in alkaline leaching conditions as many of these binding agents are not stable in low pH conditions.

Strong or concentrated acid has been a popular choice for agglomerating when binding agents are not suitable. In particular, the general trend is that the more concentrated the acid the more advantageous the results, although the use of concentrated acid is generally limited by economic factors. The advantages of concentrated acid are known to be that heat is generated by the exothermic reaction of the acid and the small amount of moisture present in the ore, resulting in better break-down of the ore minerals and exposing the target metal values. Concentrated acid also helps to form better agglomerates by breaking down bulk non-valuable minerals in the ore, for example silicates, particularly in laterites, such that upon re-precipitation and curing, a relatively strong agglomerate can be formed.

One of the main problems with using concentrated acid solutions in agglomeration, is that agglomerates can become friable, resulting in blockages in the heap once particles begin to break away. Further, the use of concentrated acid can also promote dissolution of unwanted impurities.

Further, agglomeration of ores prior to exposure to extractive metallurgical processes has most commonly been practised on a limited range of ore types. Most commonly these ore types include those bearing precious metals, such as gold and silver, and some limited base metals, particularly copper bearing ores. Nickel laterite or oxide ores have not been studied in particular detail with regard to heap leaching and present a number of particular difficulties, many of which are related directly to what is a generally high clay content.

The present invention disclosed herein relates to the use of a dilute acid solution for agglomeration with surprising results. The disadvantages of using water or strong or concentrated acid appear to be overcome, without sacrificing structural integrity of the agglomerates, whilst percolation rates and extraction levels are improved.

The preceding discussion of the background art is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was part of the common general knowledge in Australia as at the priority date of the application.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Throughout the specification, the term "atmospheric" when used with reference to leaching is to be understood to refer to any one of a heap, vat, dump, thin-layer or in-situ leach, unless the context requires otherwise.

Throughout the specification, the terms "ore" and "ore material" are understood to refer to any one of ore, ore reject material, concentrate, waste rock or mill scats material.

The term "agglomerate" is to be understood to refer to agglomerated ore material.

Throughout the specification, the term "curing" is understood to be the period of time occurring between agglomeration and subsequent application of leaching solution.

Disclosure of the Invention

In accordance with the present invention there is provided a method for agglomeration comprising the method steps of:

i) adjusting the moisture content of an ore material to be agglomerated to a predetermined level,

ii) passing the ore material to an agglomeration circuit; and

iii) adding an acid containing agglomerating solution to the ore material in the agglomeration circuit to provide an agglomerated ore material, whereby the acid concentration of the agglomerating solution does not exceed about 100g/L.

Preferably, the acid concentration of the agglomerating solution does not exceed about 50g/L.

Still preferably, the acid in the agglomerating solution is sulphuric acid.

The moisture content of the ore material prior to agglomeration preferably falls within the range of about 5% and 30%.

Still preferably, the moisture content of the ore material prior to agglomeration falls within the range of about 15% and 25%.

The agglomeration circuit may comprise one or more drum or rotary disc agglomerators.

The agglomerating solution of step iii) still preferably comprises a pregnant leach solution (PLS) from an existing atmospheric or pressure leach circuit.

Preferably, the agglomeration of step iii) is achieved by adding a maximum of about 100 kg of acid per tonne of ore material.

Still preferably, the agglomeration of step iii) is achieved by adding a total amount of acid which falls within the range of about 5 and 50 kg of acid per tonne of ore.

Preferably, a binding agent is applied to the ore material in the agglomeration circuit.

Still preferably, the binding agent may comprise any known binding agent, for example a polymeric binder.

Preferably, the agglomerated ore material is allowed to cure for a period not exceeding 21 days.

Still preferably, the curing time of the agglomerated ore material does not exceed 7 days.

Still more preferably, the curing time of the agglomerated ore material falls within the range of about 5 to 7 days.

The method for agglomeration of the present invention preferably provides for a percolation rate of leach solution through either a column or heap of greater than about 2,000 L/m^2/hr. Still preferably, the percolation rate is between about 2,000 and 45,000 L/m^2/hr.

Brief Description of the Drawings

The present invention will now be described, by way of example only, with reference to an embodiment thereof and the accompanying drawing, in which;

Figure 1 is a diagrammatic representation of a method for agglomeration in accordance with the present invention;

Figure 2 is a graphical representation of size distribution date for whole ore and “scats” used in Example 1; and

Figure 3 is a graphical representation of Kappes test results showing acidity versus percolation or “drain down” rate.

Best Mode(s) for Carrying Out the Invention

In Figure 1 there is shown a method for agglomeration 10 in accordance with the present invention.

A nickel laterite ore 12 is subjected to a preparation step 14 during which the moisture content is adjusted to within about 5% and 30%, for example 15% and 25%. This moisture content may be achieved by air drying the ore in a heap 16, or by adding water 18 to the ore, as required.

The ore 12 is then passed to an agglomeration circuit 20 where an acid containing agglomerating solution 22 containing between about 5 and 100g/L of sulphuric acid, for example 45 g/L H_2SO_4, and a known binding agent 24, is added, and the ore 12 agglomerated to provide an agglomerated ore material 26.

The agglomerated ore material 26 may then be cured for a period of time. The curing time should not exceed 21 days as the stability of the agglomerated ore material 26 begins to deteriorate after this time. The balance between the stability of the agglomerated ore material 26 and permeability and extraction is maximised when the curing time falls within the range of 5 and 7 days.

The agglomeration circuit 20 may comprise one ore more drum or rotary disc agglomerators.

It is envisaged that the acid containing agglomerating solution 22 may comprise a dilute sulphuric acid solution, or a leach solution exiting an atmospheric or pressure leach circuit, or a mixture of both, such that the acid concentration falls within the range of about 5 to 100 kg acid per tonne of ore, for example between about 5 and 50 kg acid per tonne of ore.

It is further envisaged that the known binding agent may be provided in the form of a polymeric binder. For example, the non-ionic high molecular weight polyacrylamide copolymer Hi-Tex 82200™ and the cationic high molecular weight acrylamide copolymer OPTIMER AA182H™ are two that may be utilised.

It is still further envisaged that the acid in the agglomerating solution may also comprise any one of nitric acid and hydrochloric acid.

The present invention is further illustrated by way of the following non-limiting example:

EXAMPLE 1

Percolation testing, using a standard Kappes test procedure, was employed to measure the quality of the agglomerates produced using the method for agglomeration of the present invention.

Nickel laterite ore "scats" have been utilised in this example. The term "scats" is used to refer to the coarse fraction of the ore resulting from beneficiation of the nickel laterite ore. The scats contain both ore and gangue minerals that require additional processing to liberate the mineral. Mineralogical testing of the scats used indicate that the scats are 60% to 70% nontronite clay, 5% to 10% quartz, 5% to 10% goethite, 5% to 10% hematite, <5% kaolin, <5% opal, <5% chlorite, and less than 1% asbolane and bauxite.

Size distribution data for several sources of scats or whole ore are shown in Figure 2. Agglomerates were formed using the method of the present invention as described above, without binder and without curing. Specifically, agglomeration was carried out in a 20 L drum held securely in a portable cement mixer. 5 to 6 kg of 'as received' ore was loaded into the drum, mixed and a small amount of water or acid solution added to suppress dust generation. Some samples, noted below, were previously air dried. The required amount of concentrated acid (99% H_2SO_4) or dilute acid (45 g/L) was then added and the agglomerates formed continually assessed. All amounts of water and acid added were recorded. The agglomeration tests are summarised in Table 1 below:

Table 1

Ore Type	**Agglomeration solution**	**Dry Ore (kg)**	**% Moisture**	**Acid Added (g)**	**Water Added (g)**	**Liquid to Solid Ratio (vol/wt)**	**Acid Loading (kg/t)**	**% Moisture (calc)**
Low-grade Saprolitic Whole Ore	Dilute acid	29.87	9.5	371	11,186	0.38	12	27
	Concentrated acid	29.87	9.5	4,492	9,597	0.40	150	24

Scats$^{\#}$1	Dilute acid	2765	7.8	20.4	677	0.25	7.4	20
	Concentrated acid	2765	7.8	275.4	486	0.23	100	15
Scats$^{\#}$2	Dilute acid	2763	7.9	28.4	853	0.31	10.3	24
	Concentrated acid	2763	7.9	277.2	746	0.32	100	21
Scats$^{\#}$3	Dilute acid	2713	9.5*	18.9	694	0.26	7.0	20
	Concentrated acid	2713	9.5*	273.0	623	0.28	101	21

The Kappes percolation test involves filling a leaching column (0.1m diameter and 0.6m height) with agglomerates and measuring the initial ore height.

The column is tapped with a rubber mallet over its length so that the agglomerates are settled. The new height is then measured in order to determine the "slump" of the ore.

The column is then filled from the bottom with leaching solution containing sulphuric acid such that the solution covers all of the ore. The column then stands for 48 hours before the height of the agglomerates is measured again.

The percolation rate is then measured by opening the bottom drain valve, drained for an initial period of 5 seconds, then taking a timed sample of solution, measuring the quantity of solution discharged and calculating a flow rate in L/hr/m^2.

In order for the test to pass, a flow rate of at least 10,000 L/hr/m^2 and a slump of less than 10% must be achieved.

The Kappes percolation test results of the nickel laterite ore materials are shown in Table 2 below.

Table 2

Ore Material	**Agglomeration Solution**	**Loose Bulk Density (kg/m^3)**	**% Slump**	**Percolation Rate (L/hr/m^2)**
Low-grade Saprolitic Whole Ore	Dilute acid (12 kg/t)	0.74	8.6	15,144
	Concentrated acid (150kg/t)	0.93	14.9	351
Scats#1	Dilute acid (7.4 kg/t)	0.78	11.6	8,937
	Concentrated Acid (100 kg/t)	0.93	15.5	764
Scats#2	Dilute acid (10.3 kg/t)	0.74	11.2	2,673
	Concentrated acid (100 kg/t)	0.94	16.8	1,528
Scats#3	Dilute acid (50 kg/t)	0.74	10.6	2,903
	Concentrated acid (101 kg/t)	0.83	12.5	2,292

Agglomerates produced with both 100 kg/t and 150 kg/t concentrated sulphuric acid had a tendency to break down during the flooding stage, resulting in a layer of fines at the top of the agglomerated material, which in turn, affected percolation.

As can be seen from the results in Table 2, agglomerating with dilute acid in comparison to concentrated acid resulted in the samples passing the Kappes test. Further, the initial moisture content of the samples clearly alters the characteristics of the final agglomerates, affecting the percolation rates.

Shown in Figure 3 are the results of additional Kappes testing, conducted as noted above, showing percolation rates versus acidity for a number of tests on scats in various sized columns as noted in the legend. Agglomerates were produced using a dilute acid of 100 g/L H_2SO_4. As will be noted, most effective percolation rates are shown to be obtained at about 50 kg/t acid to ore. The percolation rates obtained at this level were between about 15,000 and 45,000 $L/m^2/hr$.

The ability to produce better agglomerates by controlling the moisture content of the ore material and the concentration of acid during agglomeration is shown to result in more stable agglomerates and better rates of percolation of leaching solution through the ore material. In turn, improved percolation rates lead to faster leaching kinetics and higher extractions.

Modifications and variations such as would be apparent to the skilled addressee are considered to fall within the scope of the present invention.

Claims

1. A method for agglomeration characterised in that the method comprises the steps of:

   (i) adjusting the moisture content of an ore material to be agglomerated to a predetermined level;

   (ii) passing the ore material to an agglomeration circuit; and

   (iii) adding an acid containing agglomerating solution to the ore material in the agglomeration circuit to provide an agglomerated ore material, whereby the acid concentration of the agglomerating solution does not exceed about 100g/L.

2. A method according to claim 1, wherein the acid concentration of the agglomerating solution does not exceed about 50g/L.

3. A method according to claim 1 or 2, wherein the acid in the agglomerating solution is sulphuric acid.

4. A method according to any one of the preceding claims, wherein the moisture content of the ore material prior to agglomeration falls within the range of about 5% and 30%.

5. A method according to any one of the preceding claims, wherein the moisture content of the ore material prior to agglomeration falls within the range of about 15% and 25%.

6. A method according to any one of the preceding claims, wherein the agglomeration circuit may comprise one or more drum or rotary disc agglomerators.

7. A method according to any one of the preceding claims, wherein the agglomerating solution of step iii) comprises a pregnant leach solution (PLS) from an existing atmospheric or pressure leach circuit.

8. A method according to any one of the preceding claims, wherein the agglomeration of step iii) is achieved by adding a maximum of about 100 kg of acid per tonne of ore material.

9. A method according to any one of the preceding claims, wherein the agglomeration of step iii) is achieved by adding a total amount of acid which falls within the range of about 5 and 50 kg of acid per tonne of ore.

10. A method according to any one of the preceding claims, wherein the binding agent is applied to the ore material in the agglomeration circuit.

11. A method according to any one of the preceding claims, wherein the binding agent comprises a polymeric binder.

12. A method according to any one of the preceding claims, wherein a curing step is provided after the agglomeration circuit.

13. A method according to claim 12, wherein the curing time of the agglomerated ore material does not exceed 21 days.

14. A method according to claim 12 or 13, wherein the curing time of the agglomerated ore material does not exceed 7 days.

15. A method according to any one of claims 12 to 14, wherein, the curing time of the agglomerated ore material falls within the range of about 5 to 7 days.

16. A method according to any one of the preceding claims, wherein a percolation rate of leach solution through either a column or heap of greater than about 2,000 L/m^2/hr is achieved.

17. A method according to any one of the preceding claims, wherein a percolation rate of between about 2,000 and 45,000 L/m^2/hr is achieved.

18. A method according to any one of the preceding claims, wherein the ore material is a nickel laterite ore material.

19. A method for agglomeration substantially as hereinbefore described with reference to Figure 1.

20. A method for agglomeration substantially as hereinbefore described with reference to Example 1.

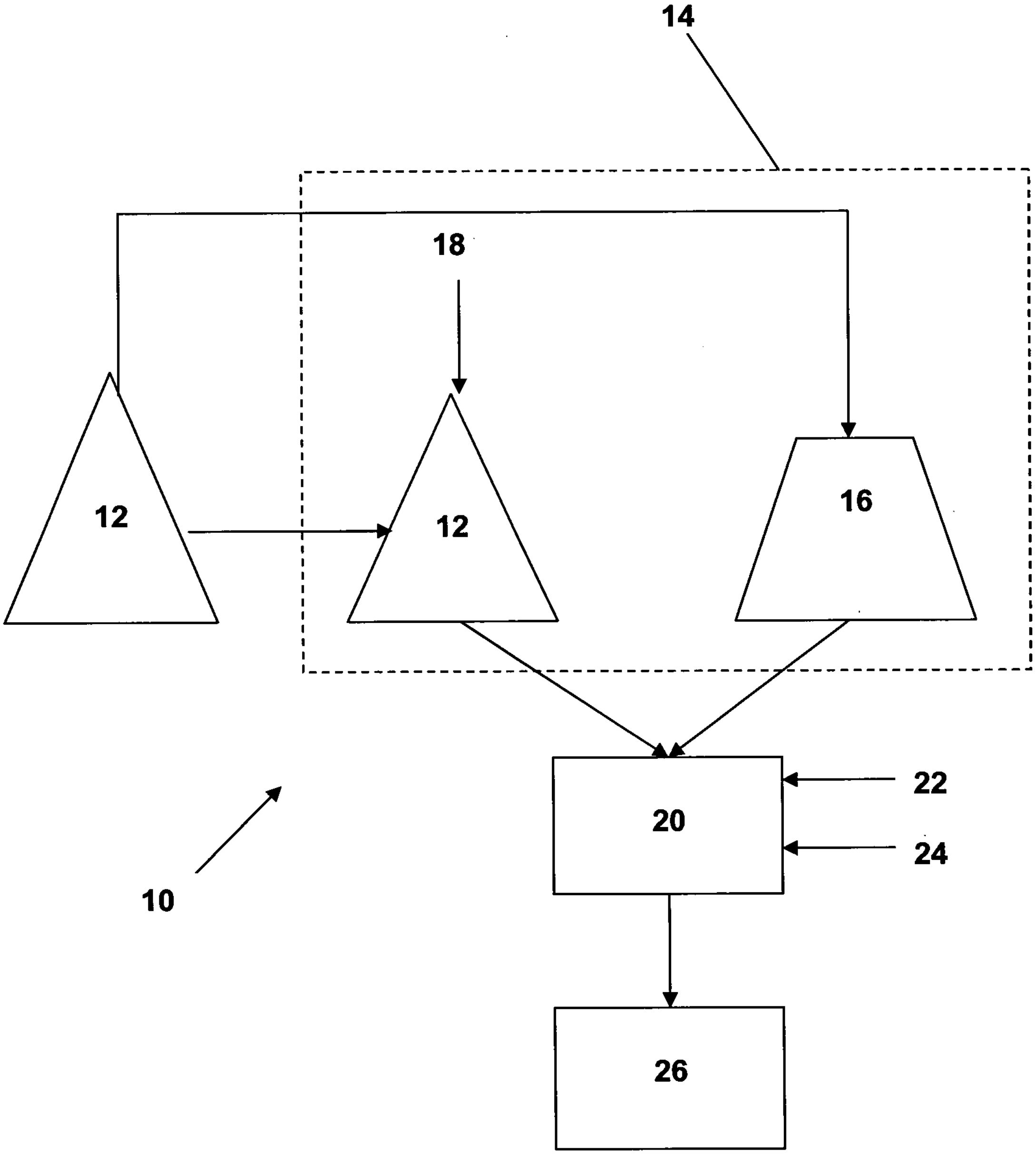


FIGURE 1

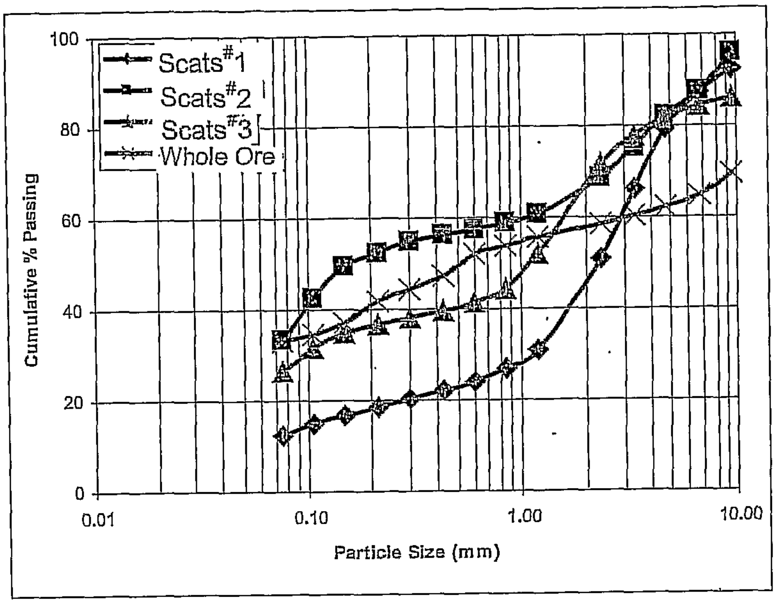


FIGURE 2

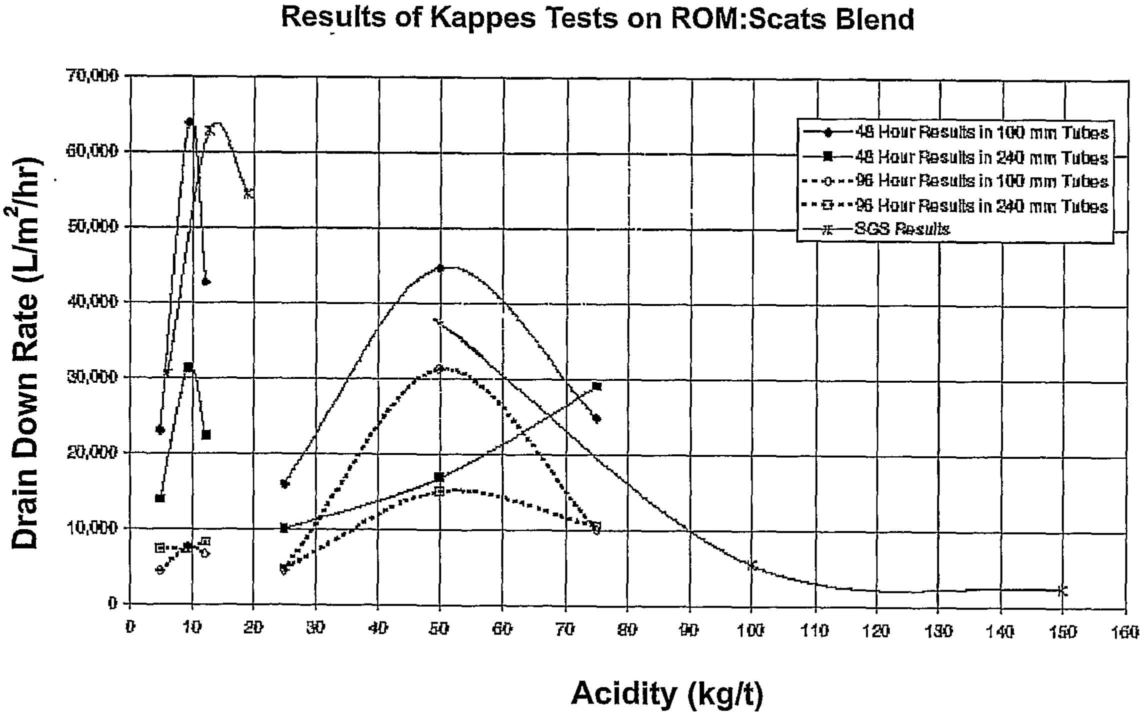


FIGURE 3

INTERNATIONAL SEARCH REPORT	International application No. **PCT**/AU2007/000817

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

C22B 1/24 (2006.01) ***C22B 1/242*** (2006.01) ***C22B 1/243*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC^8 as above

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Derwent WPI: IPC^8 as above and (acid+)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2001/075184 A2 (BHP Minerals International Inc) 11 October 2001 Whole Document	1 to 20
X	US 4308055 A (Serbent et al) 29 December 1981 Whole Document	1 to 20
X	EP 014255 B1 (Th. Goldschmidt AG) 18 November 1981 Whole Document	1

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

"A"	document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 19 July 2007	Date of mailing of the international search report 25 JUL 2007
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **DAVID K. BELL** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : (02) 6283 2309

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	0175184	AU	55204/01	AU	2006100869	BR	0109795
		CA	2404003	EP	1272680	US	6312500
		ZA	200207784				
US	4308055	AU	58321/80	CA	1141164	DE	2919272
		EP	0021465	JP	55161032		
EP	0014255	DE	2903971				

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX