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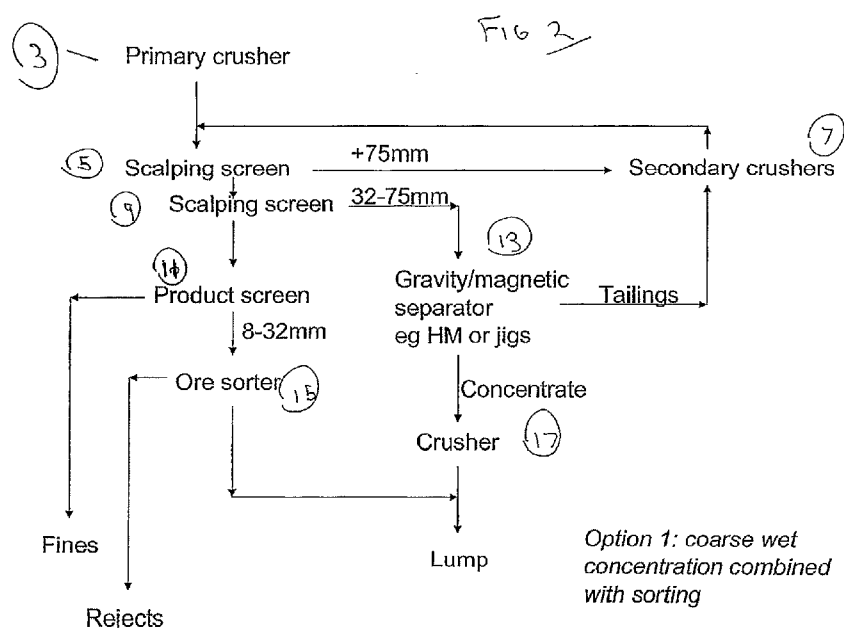
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(54) Title: A METHOD OF SORTING ORE



(57) Abstract: A method of sorting a mined material and/or a stockpiled material comprises processing the material in a plurality of steps that includes a dry sorting step and a wet concentration step and producing a fraction having a required particle size range and a required grade.

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A METHOD OF SORTING ORE

The present invention relates to sorting a mined material.

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The present invention relates particularly, although by no means exclusively, to a mined material in the form of iron ore (and stockpiled iron ore) and is described hereinafter in this context. However, the present invention also extends to other mined and stockpiled materials containing valuable components. The valuable components may be metals, such as nickel and copper. The valuable components may be non-metals materials such as coal.

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It is known to mine iron ore in large blocks of the ore from benches. In this conventional mining operation, typically, the blocks of ore are substantial, for example 40 m long by 20 m deep by 10 m high and contain 8000 tonnes of ore. Typically, a section of a bench is assayed by chemically analysing samples of ore taken from a series of drilled holes in the section to determine whether the ore is (a) high grade, (b) low grade or (c) waste material on a mass average basis. The cut-offs between high and low grades and between low grade and waste material are dependent on a range of factors and may vary from mine to mine and in different sections of mines. When the analysis is completed, a blackout plan of the section is prepared. The plan locates the drilled samples on a plan map of the section. Regions of (a) high grade, (b) low grade or (c) waste material are determined by sample analysis (such as chemical assay and/or mineral/material type abundances) and are marked on the plan, with marked boundaries separating different regions. The boundaries are also selected having regard to other factors, such as geological factors. The regions define blocks to be subsequently mined. The blocks of ore are

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5 blasted using explosives and are picked up from a mine pit
and transported from the mine pit. The ore is processed
inside and outside the mine pit depending on the grade
determination for each block. For example, waste ore is
10 used as mine fill, low grade ore is stockpiled or used to
blend with high grade ore, and high grade ore is processed
further as required to form a marketable product. The
further processing of high grade ore ranges from simple
crushing and screening to a standard size range through to
15 processes that beneficiate or upgrade the iron ore to
produce a product of a required customer specification.
The processing may be wet or dry.

20 A significant proportion of low grade ore is not
blended and remains as stockpiled ore. As a consequence,
there are large stockpiles of mined ore that have been
classified as low grade ore that have potentially
significant economic value notwithstanding the low grade
of the ore.

25 International application PCT/AU2009/001364
(International publication WO 2010/042994) in the name of
the applicant describes a method of sorting mined
material, such iron ore, including low grade iron ore,
comprising:

30 (a) determining whether a volume of a material
to be mined is upgradable and mining the volume of
material or determining whether a volume of a material in
a stockpile of mined material is upgradable; and

35 (b) after suitable size reduction (for example
by crushing and screening), dry sorting the mined or
stockpiled material that is determined to be upgradable
and producing an upgraded mined material.

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5 The upgraded mined material may be a product that meets a required customer specification or may be suitable to be processed further, for example by blending with other material, to produce a product of a required customer specification.

10 The International application also describes a dry sorting apparatus for sorting the mined or stockpiled material that is determined to be upgradable.

15 The disclosure in the specification of the International application is incorporated herein by cross-reference.

20 The approach of the method of the International application of determining whether material is upgradable is a quite different approach to conventional mining, as discussed above, which is based on making a mass average assessment of blocks of ore and categorising the ore as high grade, low grade, or waste material.

25 In the International application (and herein) the term "upgradable" is understood to mean that the mined or stockpiled material is a material that is capable of being dry sorted to improve the actual or potential economic value of the material.

30 The International application describes that the term "dry sorting" is understood to mean any sorting process that does not require added moisture for the purpose of effecting separation.

35 The term "dry sorting" is understood to have the same meaning in this specification, any sorting process that does not require added moisture for the purpose of effecting separation.

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The method and the apparatus described in the International application makes it possible to recover value from mined and stockpiled material such as iron ore that would otherwise be classified as low grade material or waste material as described above on a mass average basis. This is particularly the case where the particles in low grade material or waste material comprise one group of discrete particles that are above a threshold grade and another group of discrete particles that are below the threshold grade. The method and the apparatus also makes it possible to recover value from mined and stockpiled material such as coal that contains particles of shale and silica or other "impurities" by separating coal particles and these "impurity" particles. The end result is the production of products to required customer specifications.

The International application describes that dual energy x-ray analysis is one option for use in determining whether a mined material is upgradable. The International application also describes that dual energy x-ray analysis is one option for use in dry sorting particles of material that has been determined to be upgradeable material.

International application PCT/AU2009/001179 (International publication WO 2010/025528) in the name of the applicant describes a method and an apparatus for dual energy x-ray analysis of a mined material. The term "dual energy x-ray analysis" is understood herein to mean analysis that is based on processing data of detected transmitted x-rays through the full thickness of each particle obtained at different photon energies. Such processing makes it possible to minimise the effects of non-compositional factors on the detected data so that the data provides clearer information on the composition, type, or form of the material. The disclosure in the

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specification of the International application is incorporated herein by cross-reference.

5 The applicant has carried out further research
and development work on the method and the apparatus for
sorting mined or stockpiled material and the method and
the apparatus for dual energy x-ray analysis of a mined or
stockpiled material described in the above International
applications. In particular, the applicant has carried
10 out further research and development work on a dry sorter
for mined or stockpiled material that uses dual energy x-
ray analysis to assist in determining whether particles of
a mined or stockpiled material are above or below a
threshold grade and then dry sorting the particles of the
15 material on the basis of the grade determination.

 The above description is not to be taken as a
description of the common general knowledge in Australia
or elsewhere.

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 The applicant has realised that combinations of
dry sorting and wet concentration steps, optionally in
combination with size reduction steps and size separation
steps, can be effective combinations for upgrading mined
25 and stockpiled material and producing fractions having a
required particle size range and a required grade. In
particular, the applicant has realised that combinations
of dry sorting and wet concentration steps can provide
considerable flexibility to a mining operation in
30 situations where there are variations in grade across a
mine or mines and there is a need to blend ores from
different sources to obtain a product grade having a
required particle size distribution that meets a customer
specification. The applicant has also realised that
35 combinations of dry sorting and wet concentration steps
are beneficial, by way of example, for mined or stockpiled

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ore from conventional mining operations and for mined and stockpiled ore that is assessed as being "upgradable".

5 The term "wet concentration step" is understood herein to mean any concentration step that requires added moisture.

10 According to the present invention there is provided a method of sorting a mined material and/or a stockpiled material that comprises processing the material in a plurality of steps that includes a dry sorting step and a wet concentration step and producing a fraction having a required particle size range and a required grade.

15 The term "required particle size range" as used herein may be a required particle size range that meets a customer specification. The required particle size range may be a required particle size range for a downstream processing step or steps carried out by a customer. In any situation, the required particle size range for a customer specification depends on the mined material and the requirements for the downstream processing step or steps. In the case of steelmakers, the downstream processing step or steps include making sinter in a sinter plant and iron in a blast furnace or other type of smelter. Typically, steelmaking customers purchase iron ore in "lump" form for direct use in a blast furnace or in "fines" form for use in a sinter plant to produce a blast furnace feed material. Typically, lump iron ore is iron ore having a particle size range of 6-32 mm. Typically, fines iron ore is iron ore having a majority of particles having a size range of 1-6 mm. The 6 mm cut-off between lump and fines is an arbitrary cut-off. By way of further example, in the case of copper-containing and nickel-containing ores, the downstream processing step or steps may include flotation to produce a concentrate and

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subsequent smelting of the concentrate to produce a matte. In addition, in the case of copper-containing ores and nickel-containing ores, the downstream processing step may include heap (or other types of) leaching of the ore.

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It is noted that the reference to "required grade" in the preceding paragraph does not mean necessarily that the method described in the paragraph includes direct measurement of grade. The present invention extends to methods in which there is direct measurement of other parameters that are indicators of grade. These parameters include, by way of example, bulk density.

15

The above-described method of the present invention includes dry sorting steps and wet concentration steps that are used for processing different ore streams, more specifically ore streams having different particle size distributions. Hence, the method includes carrying out a dry sorting step on an ore stream having one particle size distribution and carrying out a wet concentration step on another ore stream having another particle size distribution. The present invention also extends to combinations of dry sorting steps and wet concentration steps on an ore stream of a given particle size distribution where a dry sorting step on the ore stream is followed by a wet concentration step on an output stream from the dry sorting step, and vice versa.

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The method may include multiple dry sorting steps.

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The method may include multiple wet concentration steps.

The method may comprise processing a feed material for the method in a size separation step that

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produces at least two fractions having different particle size ranges and separately processing the fractions in a plurality of processing steps, with the processing steps for at least one of the fractions including the dry
5 sorting step.

The method may comprise processing a feed material for the method in a size separation step that produces at least two fractions having different particle
10 size ranges and separately processing the fractions in a plurality of processing steps, with the processing steps including the dry sorting step and the wet concentration step.

The method may comprise processing a feed material for the method in a size separation step that produces at least two fractions having different particle size ranges and separately processing the fractions in a plurality of processing steps, with the processing steps
20 for at least one fraction including the dry sorting step, and with the processing steps for at least one of the fractions including the wet concentration step.

The method may comprise reducing the size of material in a fraction from the size separation step that is oversize in comparison to the required particle size range in a size reduction step and transferring the size-reduced material back to the size separation step.

One option for the method may comprise processing material in the size separation step and producing at least a fraction having the required particle size range and an oversize fraction.

The method may comprise processing the fraction having the required particle size range in the dry sorting step and producing the fraction having the required

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particle size range and the required grade.

The method may comprise processing the oversize fraction from the size separation step in a wet concentration step and producing a wet fraction having the required grade and another fraction.

The method may comprise processing the other fraction from the wet concentration step in the size reduction step and transferring the size-reduced material back to the size separation step.

The other fraction from the wet concentration step may contain particles that can be broken down into smaller particles, some of which may be of the required grade but were not able to be concentrated in the wet concentration step. With this in mind, a feature of the above-described option is that the size reduction step provides an opportunity for material that remains oversize to be returned to the wet concentration step and processed in this step again or for material that has the required particle size range due to the size reduction step to be processed in the dry sorting step.

The method may comprise processing the wet fraction having the required grade in a further size reduction step and producing the fraction having the required particle size range and the required grade.

Another option for the method comprises processing material in the size separation step and producing a fines fraction and another fraction having larger particles.

The method may comprise processing the other larger particle size fraction in a further size separation step and producing a fraction having the required particle

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size range and an oversize fraction.

5 The method may comprise processing the fraction having the required particle size range in the dry sorting step and producing the fraction having the required particle size range and the required grade.

10 The further size separation step may also produce a fines fraction and the method may comprise processing the fines fraction in another size separation step and producing a larger size fines fraction and a smaller size fines fraction and adding the larger size fines fraction to the fraction having the required particle size range and the required grade from the dry sorting step.

15 The method may comprise processing the oversize fraction from the further size separation step in the size reduction step and transferring the size-reduced material back to the size separation step.

20 The method may comprise processing the fines fraction from the size separation step in a wet concentration step and producing a concentrated fines fraction having a higher grade than the average grade of the feed to the wet concentration step.

30 The method may comprise processing the fines fraction from the size separation step in a series of size separation steps and producing more than one fines fraction and processing each fines fraction in a separate wet or dry concentration step and producing a concentrated fines material having a higher grade than the average grade of the feed to the wet or dry concentration step.

35 A feature of the above-described other option for the method is that the oversize fraction is crushed and returned to the size separation step that produces the

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finest fraction and the oversize fraction. As a consequence, there is an opportunity for valuable material in this re-processed material to be captured either as a finest fraction that is processed in one or more wet
5 concentration steps or as a fraction having the required particle size range that is processed in the dry sorting step.

10 The mined material may include as-mined material.

The mined material may include mined material that has been stored in a stockpile.

15 By way of example, the dry sorting step may be used as an opportunity to recover value from stockpiles of material that have been classified as low grade or waste material on the conventional mass average basis of assessment of material.

20 The mined material supplied to the dry sorting step may include material that is determined to be upgradable, as described herein. In that event, a mining operation may include analysis of material to be mined or existing stockpiles of mined material to determine whether
25 the material is upgradable. The analysis may comprise taking a plurality of samples, such as drilled samples, from a volume of material to be mined, such as a block of ore of the type described above, prior to mining the material and analysing the samples, for example by
30 determining the grade of each of the samples, and making an assessment of whether the ore in the volume of ore is upgradable. The analysis may also comprise taking a plurality of samples from a stockpiled material and analysing the samples, for example by determining the
35 grade of each of the samples, and making an assessment of whether the material in the stockpiled material is upgradable. The number of samples required in any given

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situation will depend on factors relating to a particular mine or a section of the mine to be mined.

5 The dry sorting step may use any suitable analytical technique to determine the basis for sorting particles of material being processed in the sorting step.

10 One suitable analytical technique for the dry sorting step is dual energy x-ray analysis of particles, as described by way of example in the above-mentioned International application PCT/AU2009/001179. Other analytical techniques for the dry sorting step include, by way of example, x-ray fluorescence, radiometric, electromagnetic, optical, and photometric techniques. The applicability of any one or more of these (and other) techniques will depend on factors relating to a particular mine ore or a section of the mine to be mined.

20 The dry sorting step may dry sort on the basis of analysis of any parameter that is a direct measure of grade or is indicative of grade, of individual particles of the material.

25 The material may be mined by any suitable mining method and equipment. For example, the material may be mined by drilling and blasting blocks of ore from a pit and transporting the mined ore from the pit by trucks and/or conveyors. By way of further example, the material may be mined by surface miners moving over a pit floor and transported from the pit by trucks and/or conveyors.

35 The mined material may be a metalliferous or a non-metalliferous material. Iron-containing and copper-containing ores are examples of metalliferous materials. Coal is an example of a non-metalliferous material.

In the case of iron ore, the required particle

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size range may be a particle size range for "lump" iron ore or "fines" iron ore. Typically, lump iron ore is iron ore having a particle size range of 6-32 mm. Typically, fines iron ore is iron ore having a majority of particles
5 having a size range of 1-6 mm. The 6 mm cut-off between lump and fines is an arbitrary cut-off.

In the case of copper-containing or nickel-containing ores, the required particle size range may be a
10 particle size range for downstream processing including flotation to produce a concentrate and subsequent smelting of the concentrate to produce a matte. Alternatively, the required particle size range may be a particle size range for downstream processing including heap (or other types
15 of) leaching of the copper-containing ore or the nickel-containing ore.

According to the present invention there is also provided a method of sorting a mined material and/or a
20 stockpiled material that comprises a size separation step that produces at least two fractions having different particle size ranges and separately processing the fractions in a plurality of processing steps and producing fractions each having a required particle size range and a
25 required grade, with the processing steps for at least one of the fractions including a dry sorting step, and with the processing steps for at least one of the fractions including a wet concentration step.

30 According to the present invention there is also provided a method of sorting iron ore that comprises a size separation step that produces at least two fractions, with one fraction having a required particle size range for lump iron ore and another fraction having a required
35 particle size distribution for fines iron ore, and separately processing the fractions in a plurality of processing steps, with the processing steps for the lump

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iron ore fraction including a dry sorting step, and with the processing steps for the fines iron ore fraction including a wet concentration step.

5 According to the present invention there is also provided a method of sorting iron ore that comprises a size separation step that produces at least two fractions having different particle size ranges and separately processing the fractions in a plurality of processing
10 steps, with the processing steps for at least one of the fractions including a dry sorting step, and with the processing steps for at least one of the fractions including a wet concentration step and a size reduction step, and producing fractions having a required particle
15 size range and a required grade for lump iron ore.

 According to the present invention there is also provided a method of mining material, such as iron ore, comprising:
20

- (a) mining the material; and
- (b) sorting the mined material or stockpiled material in accordance with the above-described sorting
25 method.

 The ore may be mined by any suitable mining method and equipment. For example, the ore may be mined by drilling and blasting blocks of ore from a pit and
30 transporting the mined ore from the pit by trucks and/or conveyors. By way of further example, the ore may be mined by surface miners moving over a pit floor and transported from the pit by trucks and/or conveyors.

35 The present invention is described further by way of example only with reference to the accompanying drawings, of which:

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Figure 1 is an example of a blockout plan for a section of a mine bench in a conventional mining operation, with the Figure being Figure 1 of the specification of International application PCT/AU2009/001364; and

Figures 2 and 3 are a series of flowsheets illustrating a number of, although not the only, embodiments of the method of sorting ore in accordance with the present invention.

The description of the invention is in the context of a mined material in the form of iron ore. It is noted that the invention is not confined to iron ore and extends to other mined materials containing valuable components. The valuable components may be metals. Coal is another valuable component.

Figure 1 is a blockout plan for a section 51 of a bench in an open pit iron ore mine operating as a conventional mine. The plan shows the locations of a series of drilled holes 53 (indicated by crosses) that have been drilled to obtain samples. The samples are analysed to determine the grade of ore in the samples. The plan also shows assayed and is marked with a series of boundaries 55 that divide the section into a series of blocks 57 on the basis of whether the ore in the blocks is determined by the sample analysis to be (a) high grade, (b) low grade or (c) waste material based on ore grade. There are six blocks 57 shown in the Figure. High grade blocks 57 are referred to as "HG", low grade blocks are referred to as "LG", and waste blocks are referred to as "W" in the Figure. The cut-offs between high and low grades and between low grade and waste material are dependent on a range of factors and may vary from mine to mine and in different sections of mines. Each block 57 of

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ore is blasted using explosives and is picked up from a mine pit and transported from the mine pit. The ore is processed inside and outside the mine pit depending on the grade determination for each block. For example, waste
5 ore is used as mine fill, low grade ore is stockpiled or used to blend with high grade ore, and high grade ore is processed further as required to form a marketable product. The processing may be wet or dry.

10 In a conventional mining operation, the low grade ore blocks are not usually blended with other ore and are stockpiled and not sold and hence represent significant lost economic value. However, some or all of these blocks and existing stockpiles of previously mined ore that has
15 been classified as low grade material, may be suitable for upgrading in accordance with the present invention and are processed, including dry sorted, by way of example with reference to the flowsheets of Figures 2 to 4.

20 As is described above, International application PCT/AU2009/001364 describes an alternative approach to mining material which, in the context of iron ore, is based on assessing whether an ore to be mined or a stockpiled ore is "upgradable", with an assessment of
25 whether an ore is upgradable being based on a number of factors. The factors include whether the ore particles can be sorted into particle streams that are above or below a threshold grade. Upgradable ore includes ore that has discrete particles that are above the threshold grade
30 and discrete particles that are below the threshold grade. The assessment may include assessing the extent to which size reduction of ore can separate ore into such discrete particles. Ore that has finely disseminated iron through all the particles is generally not upgradeable.

35

The present invention includes the use of dry sorters, particularly (although by no means exclusively)

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dry sorters that can process ore to be mined or stockpiled ore that is "upgradable" and would otherwise be classified as low grade ore on the basis of conventional mining methodology. The present invention also includes the use
5 of wet concentrators, such as wet gravity concentrators and wet magnetic concentrators. The applicant has found that combinations of dry sorting and wet concentration steps, together with size reduction steps and size separation steps, can provide a mining operation with
10 considerable flexibility to produce a range of products having required customer specifications, particularly particle size and grade.

The Figures 2 and 3 flowsheets are described in
15 the context of ore that has been transported from the mine pit to a primary crusher 3 and is crushed in the crusher. It is noted that the invention also extends to situations in which the ore is crushed and sorted in the mine pit. It is also noted that the invention also extends to
20 situations in which the ore is stockpiled ore. The ore may be ore that has been assessed as being "upgradable" or ore that is conventionally mined ore.

The embodiments shown in Figures 2 and 3 are
25 examples of two of a larger number of possible combinations of dry sorting and wet concentration steps for processing mined ore. In each embodiment shown in Figures 2 and 3 dry sorting steps and wet concentration steps are respectively used for processing different ore
30 streams, more specifically ore streams having different particle size distributions. The present invention also extends to combinations of dry sorting and wet concentration steps on an ore stream of a given particle size distribution where a dry sorting step on the ore
35 stream is followed by a wet concentration step on an output stream from the dry sorting step, and vice versa.

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With reference to Figure 2, the crushed ore from the primary crusher 3 is supplied to a scalping screen 5, for example in the form of a vibrating screen, that separates the ore on the basis of particle size into an oversize fraction of +75 mm and an undersize fraction of -75 mm.

The oversize fraction from the scalping screen 5 is transferred to a secondary crusher 7 and, after size reduction in the crusher, is transferred back to the stream from the primary crusher 3.

The undersize fraction from the scalping screen 5 is transferred to a downstream scalping screen 9, for example in the form of a vibrating screen, that separates the ore on the basis of particle size into an oversize fraction of 32-75 mm and another size fraction of -32 mm.

The -32 mm size fraction from the scalping screen 9 is transferred to a downstream product screen 11, for example in the form of a vibrating screen, that separates the ore on the basis of particle size into a fines fraction of -8 mm and a product fraction of 8-32 mm.

The product fraction from the product screen 11 is a product fraction at least in terms of particle size distribution. It is understood that the reference to "product fraction" in this context is not of itself an indication that the fraction is suitable in that form for a customer specification.

The product fraction from the product screen 11 is transferred to a dry ore sorter 15 and the particles are sorted on the basis of ore grade, i.e. average composition, of the particles into two streams. The sorter 15 (and the other ore sorters described hereinafter) may be a sorter that uses dual x-ray analysis

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or any other suitable analytical technique to determine ore grade. The present invention extends to the use of other types of dry sorters. One fraction, referred to as "lump" in the Figure, from the ore sorter 15 comprises ore that has an iron concentration above a threshold ore grade, for example 63 wt.% Fe. This fraction is a required product fraction, in terms of particle size distribution and composition, and forms a marketable product or a product that can be blended with other ore streams to produce a marketable product. The other fraction, referred to as "rejects" in the Figure, from the ore sorter 15 comprises ore that has an iron concentration below a threshold ore grade, for example 63 wt.% Fe. This fraction is transferred to a stockpile to be used, for example, as land fill. It is noted that the threshold ore grade may be any suitable grade and that the present invention is not confined to 63 wt.% Fe.

The oversize fraction from the scalping screen 9, i.e. the 32-75 mm fraction, is transferred to a wet concentrator 13 that produces a concentrate fraction having the required product grade and a tailings fraction. The required product grade may be any suitable grade.

The tailings fraction from the wet concentrator 13 is transferred to the secondary crusher 7 and, after size reduction in the crusher, is transferred back to the stream from the primary crusher 3.

The concentrate fraction from the wet concentrator 13 is de-watered and then transferred to a secondary crusher 17 and crushed to a product particle size distribution of 8-32 mm. The output from the crusher 17 is a product fraction with the required particle size distribution and grade.

- 20 -

With reference to Figure 3, there are significant similarities between this flowsheet and the Figure 2 flowsheet and, hence, the same reference numerals are used to describe the same features.

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Crushed ore from the primary crusher 3 is supplied to a scalping screen 5, for example in the form of a vibrating screen, that separates the ore on the basis of particle size into an oversize fraction of +75 mm and an undersize fraction of -75 mm.

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The oversize fraction from the scalping screen 5 is transferred to a secondary crusher 7 and, after size reduction in the crusher, is transferred back to the stream from the primary crusher 3.

15

The undersize fraction from the scalping screen 5 is transferred to a downstream scalping screen 9, for example in the form of a vibrating screen, that separates the ore on the basis of particle size into an oversize fraction of 8-75 mm and an undersize fraction of -8 mm.

20

The undersize fraction from the scalping screen 9 is a fines stream that is transferred for further size separation and for wet processing of separate size fractions.

25

More particularly, the fines stream from the scalping screen 9 is transferred to a fines screen 19 and separated into a -1 mm fraction and a 1-8 mm fraction.

30

The -1 mm fraction is transferred to a particle classifier 21, such as a hydrocyclone, and classified into an ultrafines stream and a 0.1-1 mm stream.

35

The 1-8 mm fraction and the 0.1-1 mm fraction are transferred as separate streams to respective wet

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concentrators 23 and 25 and are upgraded in the concentrators. The upgraded concentrates from the wet concentrators 23 and 25 form a fines product having a required particle size distribution and grade for a customer specification.

The oversize fraction from the scalping screen 9 is transferred to a product screen 19, for example in the form of a vibrating screen. The product screen 19 separates the ore on the basis of particle size into an oversize fraction of 32-75 mm and a product fraction of 8-32 mm.

The oversize fraction from the product screen 19 is transferred to the secondary crusher 7 and, after size reduction in the crusher, is transferred back to the stream from the primary crusher 3.

The product fraction from the product screen 19 is transferred to a product screen 21, for example in the form of a vibrating screen. The product screen 21 separates the ore on the basis of particle size into a product fraction of 8-32 mm and a fines fraction of -8 mm.

The fines fraction from the product screen 21 is transferred to the fines screen 19.

The product fraction from the product screen 21 is transferred to a dry ore sorter 15 and the particles are sorted on the basis of ore grade, i.e. average composition, of the particles into two fractions. The sorter 15 (and the other ore sorters described hereinafter) may be a sorter that uses dual x-ray analysis or any other suitable analytical technique to determine ore grade by direct measurement or by measuring parameters that are indicative of grade. As indicated above in relation to the Figure 2 embodiment, the present invention

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extends to the use of other types of dry sorters. One fraction, referred to as "lump" in the Figure, from the ore sorter 15 comprises ore that has an iron concentration above a threshold ore grade, for example 63 wt. % Fe.

5 This fraction is a required product stream, in terms of particle size distribution and composition, and forms a marketable product or a product that can be blended with other ore streams to produce a marketable product. The other fraction, referred to as "rejects" in the Figure,
10 from the ore sorter 15 comprises ore that has an iron concentration below a threshold ore grade, for example 63 wt. % Fe. This fraction is transferred to a stockpile to be used, for example, as land fill.

15 The above-described embodiments are examples of a number of possible embodiments for sorting ore in accordance with the present invention. Each embodiment has particular features that may be appropriate depending on the requirements of a particular mining operation. The
20 present invention extends to a significant range of other combinations of size reduction and dry sorting and wet concentration steps.

Many modifications may be made to the embodiments
25 of the present invention described above in relation to Figures 2 and 3 without departing from the spirit and scope of the invention.

By way of example, whilst the embodiments
30 comprise the use of scalping screens and product screens in the flowsheets, the screens may be any suitable screens and, moreover, the required size separation may be achieved by any suitable means and is not confined to the use of screens.

35 In addition, whilst the embodiments refer to particular size fractions, the present invention is not so

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limited and extends to separating ore into any suitable size fractions for a particular mine and mining operation and downstream market requirements. Specifically, it is noted that the present invention is not confined to a
5 product size fraction of 8-32 mm described in relation to the embodiments.

In addition, whilst the embodiments refer to a particular threshold grade of 63 wt.% Fe, the threshold
10 ore grade may be any suitable grade and the present invention is not confined to 63 wt.% Fe.

In addition, whilst the embodiments refer to the use of crushers, the present invention is not so limited
15 and extends to any suitable equipment for reducing the particle size of material.

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CLAIMS

1. A method of sorting a mined material and/or a stockpiled material that comprises processing the material in a plurality of steps that includes a dry sorting step and a wet concentration step and producing a fraction having a required particle size range and a required grade.
2. The method defined in claim 1 comprises processing a feed material in a size separation step that produces at least two fractions having different particle size ranges and separately processing the fractions in a plurality of processing steps, with the processing steps including the dry sorting step and the wet concentration step.
3. The method defined in claim 1 comprises processing a feed material in a size separation step that produces at least two fractions having different particle size ranges and separately processing the fractions in a plurality of processing steps, with the processing steps for at least one of the fractions including the dry sorting step, and with the processing steps for at least one of the fractions including the wet concentration step.
4. The method defined in claim 2 or claim 3 comprises processing the feed material in the size separation step and producing at least a fraction having the required particle size range and an oversize fraction in comparison to the required product particle size range.
- 5 The method defined in claim 4 comprises reducing the size of material in the oversize fraction in a size reduction step and transferring the size-reduced material back to the size separation step.

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6. The method defined in claim 4 or claim 5 comprises processing the fraction having the required particle size range in the dry sorting step and producing the fraction having the required particle size range and the required grade.

7. The method defined in any one of claims 4 to 6 comprises processing the oversize fraction from the size separation step in a wet concentration step and producing a wet fraction having the required grade and another fraction.

8. The method defined in claim 7 comprises processing the other fraction from the wet concentration step in the size reduction step and transferring the size-reduced material back to the size separation step.

9. The method defined in claim 7 or claim 8 comprises processing the wet fraction having the required grade in a further size reduction step and producing the fraction having the required particle size range and the required grade.

10. The method defined in claim 2 or claim 3 comprises processing material in the size separation step and producing a fines fraction and another fraction having larger particles.

11. The method defined in claim 10 comprises processing the other larger particle size fraction in a further size separation step and producing a fraction having the required particle size range and an oversize fraction.

12. The method defined in claim 11 comprises processing the fraction having the required particle size range in the dry sorting step and producing the fraction

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having the required particle size range and the required grade.

13. The method defined in claim 11 or claim 12
5 wherein the further size separation step produces a fines fraction and the method comprises processing the fines fraction in another size separation step and producing a larger size fines fraction and a smaller size fines fraction and adding the larger size fines fraction to the
10 fraction having the required particle size range and the required grade from the dry sorting step.

14. The method defined in any one of claims 11 to 13
15 comprises processing the oversize fraction from the further size separation step in the size reduction step and transferring the size-reduced material back to the size separation step.

15. The method defined in any one of claims 10 to 14
20 comprises processing the fines fraction from the size separation step in a wet concentration step and producing a concentrated fines fraction having a higher grade than the average grade of the feed to the wet concentration step.

25 16. The method defined in any one of claims 10 to 15
comprises processing the fines fraction from the size separation step in a series of size separation steps and producing more than one fines fraction and processing each
30 fines fraction in a separate wet or dry concentration step and producing a concentrated fines material having a higher grade than the average grade of the feed to the wet or dry concentration step.

35 17. The method defined in any one of the preceding claims wherein the mined material includes as-mined material.

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18. The method defined in any one of the preceding claims wherein the mined material includes mined material that has been stored in a stockpile.

5

19. The method defined in any one of the preceding claims wherein the mined material supplied to the dry sorting step includes material that is determined to be upgradable, as defined herein.

10

20. The method defined in any one of the preceding claims wherein the dry sorting step includes any one or more than one of dual energy x-ray analysis, x-ray fluorescence, radiometric, electromagnetic, optical, and photometric techniques.

15

21. The method defined in any one of the preceding claims wherein the mined material is iron ore and the required particle size range is a particle size range for "lump" iron ore.

20

22. The method defined in claim 21 wherein the lump iron ore is iron ore having a particle size range of 6-32 mm.

25

23. The method defined in any one of claims 1 to 20 wherein the mined material is iron ore and the required particle size range is a particle size range for "fines" iron ore.

30

24. The method defined in claim 23 wherein the fines iron ore is iron ore having a majority of particles having a size range of 1-6 mm.

35

25. The method defined in any one of claims 1 to 20 wherein the mined material is copper-containing ore or nickel-containing ore and the required particle size range

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is a particle size range for downstream processing including flotation to produce a concentrate and subsequent smelting of the concentrate to produce a matte.

5 26. The method defined in any one of claims 1 to 20 wherein the mined material is copper-containing ore or nickel-containing ore and the required particle size range is a particle size range for downstream processing including heap (or other types of) leaching of the copper-
10 containing ore or the nickel-containing ore.

27. A method of sorting a mined material and/or a stockpiled material that comprises a size separation step that produces at least two fractions having different
15 particle size ranges and separately processing the fractions in a plurality of processing steps and producing fractions each having a required particle size range and a required grade, with the processing steps for at least one of the fractions including a dry sorting step, and with
20 the processing steps for at least one of the fractions including a wet concentration step.

28. A method of sorting iron ore that comprises a size separation step that produces at least two fractions,
25 with one fraction having a required particle size range for lump iron ore and another fraction having a required particle size distribution for fines iron ore, and separately processing the fractions in a plurality of processing steps, with the processing steps for the lump
30 iron ore fraction including a dry sorting step, and with the processing steps for the fines iron ore fraction including a wet concentration step.

29. A method of sorting iron ore that comprises a
35 size separation step that produces at least two fractions having different particle size ranges and separately processing the fractions in a plurality of processing

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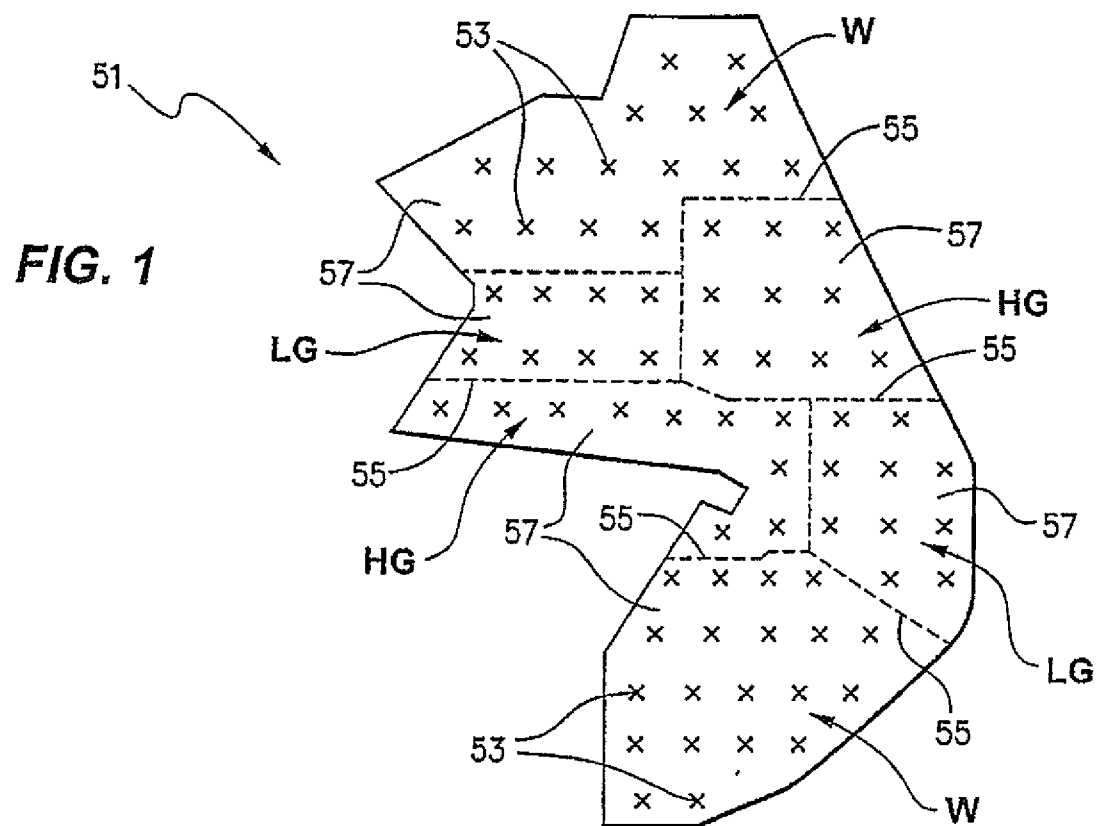
steps, with the processing steps for at least one of the fractions including a dry sorting step, and with the processing steps for at least one of the fractions including a wet concentration step and a size reduction
5 step, and producing fractions having a required particle size range and a required grade for lump iron ore.

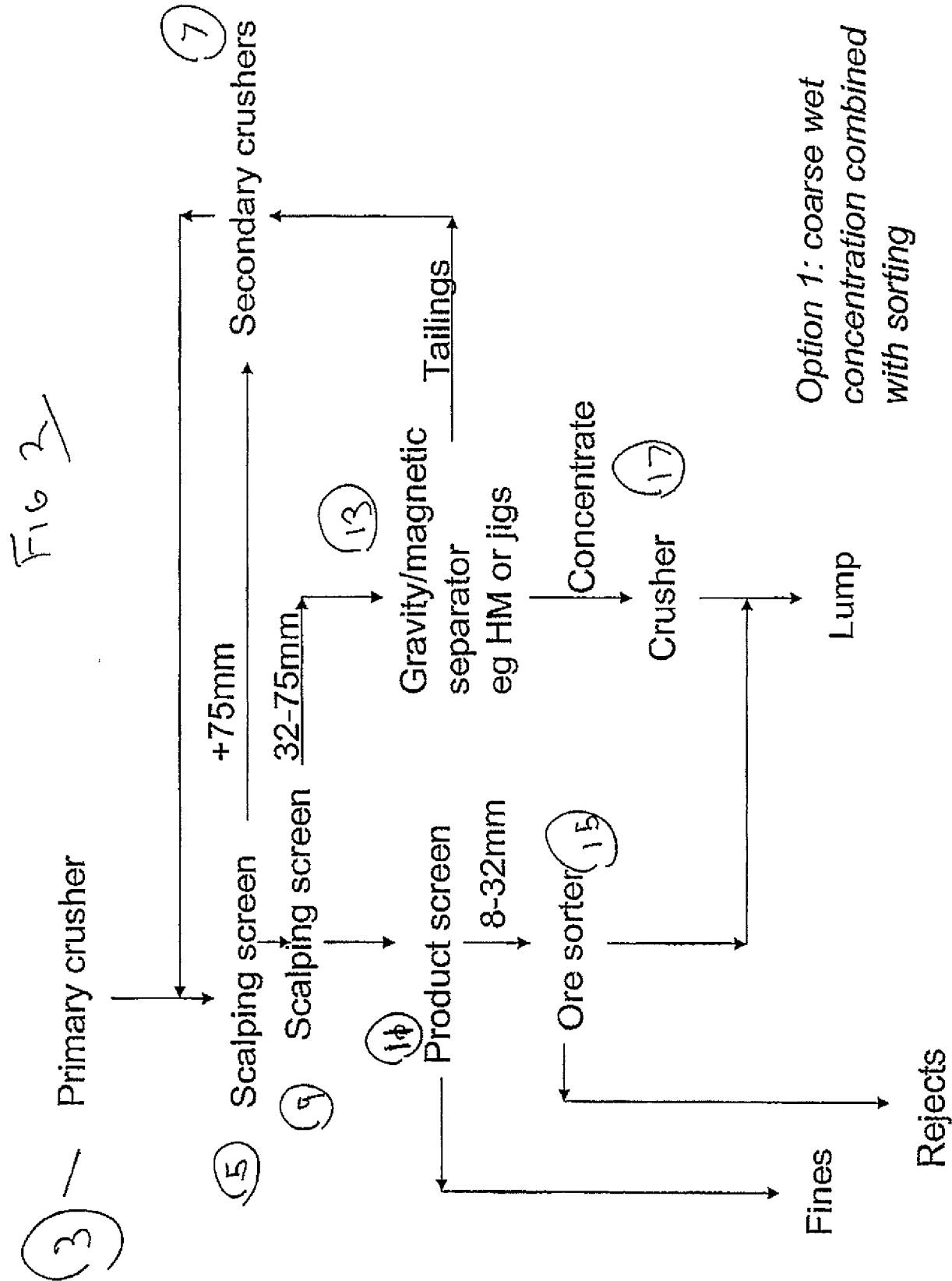
30. A method of mining material, such as iron ore, comprising:

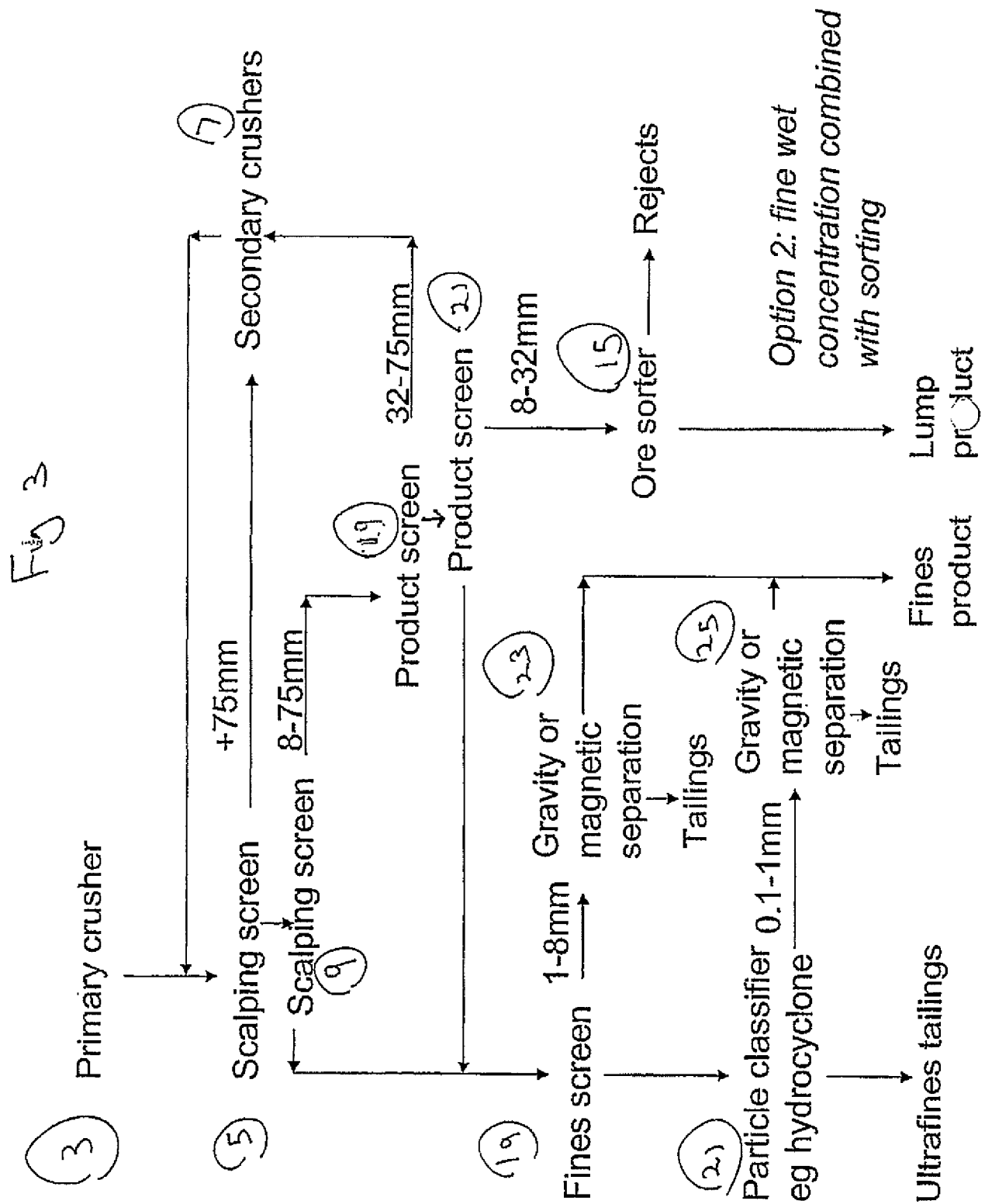
10

(a) mining the material; and

(b) sorting the mined material or stockpiled material in accordance with the sorting method defined in
15 any one of the preceding claims.







INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

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B07B 13/00 (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)

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)

WPI, EPODOC: IC/EC (G01N 1/00/LOW, G01N 9/00/LOW, G01N 21/00/LOW, G01N 23/02/LOW, G01N 27/00/LOW, G01N 33/24, B07C, B07B 1/0 0/LOW, B07B 13/00/LOW, B03B, B03D, E21C 41/00/LOW) & Keywords (MINING, MATERIAL, STOCKPILE, ORE, UPGRADE, DRY, WET, SORT, X-RAY, FLUORESCENCE, POLYENERGETIC, RADIOMETRY, ELECTROMAGNETIC, OPTICAL, PHOTOMETRY, CONCENTRATION, GRAVITY, REDUCTION, CRUSHING, GRINDING, SEPARATION, SCREENING, PARTICLE) and like terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/042994 A1 (TECHNOLOGICAL RESOURCES PTY. LIMITED [AU]) 22 April 2010 Abstract; page 1, 4 th paragraph; page 7, 4 th paragraph – page 10, 1 st paragraph; claims 1 – 22; figures 1 – 10	1 – 30
A	WO 2010/025528 A1 (TECHNOLOGICAL RESOURCES PTY. LIMITED [AU]) 11 March 2010 Abstract; claims 1 – 25; figures 1 – 6	
A	SU 397826 A1 ((KRIV-I) KRIVOROG OREMINING INST) 17 September 1973. English abstract retrieved from EPODOC database	
A	Abstract	



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
08 November 2011

Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2011/001253

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	2010042994	AU	2009304592	CA	2740630	CN	102187059
WO	2010025528	AU	2009290155	CA	2736608	CN	102187206
		EP	2335057				
SU	397826	NONE					
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.							
END OF ANNEX							