ABSTRACT: A treatment system for the beneficiation of phosphate rock, wherein a first treatment section effects the beneficiation proper producing the coarse and the fine concentrates of phosphate rock separated from the impurities, while a second section handles the disposal of the separated waste material in the form of large volumes of the primary and secondary slimes. The invention minimizes or eliminates the need for large and objectionable lagoon areas to receive the slimes, in that it solves the disposal problem by the provision of a stagewise thickening operation for the slimes, conducted to produce a high-density mixed sludge that is readily disposable, while large volumes of process water are recovered instead of being lost by evaporation from the lagoons.
FIG. 5

SECONDARY SLIMES

PRIMARY SLIMES

OVERFLOW TO PROCESS

V-1

V-2

PRIMARY SLIMES

SAND

TO DISPOSAL

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This invention relates to the beneficiation treatment of phosphate rock mined from open pits, and arriving at the treatment plant in its naturally occurring form, that is mixed mainly with such impurities as clay and silica or sands, ranging from large lumps to fine particles, or even occluded or embedded in particles of heterogeneous rock.

More particularly, the invention relates to the problem of disposal of large volumes of slimes containing impurities separated from the phosphate rock as a result of the beneficiation treatment.

The wet beneficiation treatment yields concentrates of phosphate rock separated from the impurities, which concentrates in turn are chemically convertible, in a known manner, into phosphate fertilizers with phosphoric acid as a byproduct.

Conventional modes of such beneficiation treatment may differ from one another, but as a common criterion they will produce the so-called coarse and fine concentrates as separate fraction for stock piling.

The separated impurities or tailings comprise an initial coarse fraction in the form of large lumps of clay which are readily disposable, and subsequent large volumes of the so-called primary and secondary slimes presenting an increasingly difficult disposal problem. At present these slimes because of their high dilution and thick settling characteristics, have had to be transfomed to unsightly and potentially hazardous lagoons requiring large and potentially valuable land areas, whereas much of the operating water was lost in a slow and long drawn out process of settling and evaporation in these lagoons.

It is the object of this invention to provide a method and means for concentrating these slimes economically to produce a disposible sludge of relatively high solids concentration, while minimizing or eliminating the lagoons, and at the same time recovering large volumes of process water from the thickening operation.

A more specific aim is to carry the thickening operation to an extent where the resulting thickened sludge is readily convertible into a material directly usable as fill, that is by further dewatering of the sludge on filters or the like, or else by the addition of sand or clay, to produce fill material that may be dumped into the open pits of stripped phosphate mines for land reclamation.

For example, in a beneficiation treatment system embodying the invention, a first phase involving a series of combinations of washing operations, delivers the coarse concentrate of phosphate rock of slimes separated from coarse tailings in the form of lumps of clay. The balance of the material containing all the smaller mesh sizes, is treated in a second thickening phase involving a closed-circuit wet grinding operation which breaks up certain intermediate sizes thereby releasing embossed or locked-in particles of phosphate rock.

The resulting mixture, if subjected to centrifugal or cyclonic separation yields an overflow fraction representing the aforementioned so-called primary slimes whitish in color as a suspension mainly of fine clay particles down to micron size and even less. These are the naturally occurring fine clay particles as distinct from the type of fines that are created mechanically by grinding, scrubbing, and abrasion, in the course, or as part of the beneficiation treatment, and which subsequently mainly constitute the so-called secondary slimes having a much darker blackish color.

The underflow from the cyclone in this second treatment phase is a mixture containing the unlocked or released phosphate particles along with the impurities consisting mainly of those mechanically created slimes and sands. Consequently, this underflow from the cyclone is subjected to treatment yielding as separate fractions the fine concentrate for stock piling, the silica or sands, and the aforementioned secondary slimes usually obtainable at only about 0.5 percent solids concentration. These secondary slimes differing from the primary slimes not only in concentration and settling characteristics, but also in color such as black and white, are usually thickened in a single stage capable of producing a sludge in the order of a usual 5 percent to 6 percent solids concentration.

While it appears that this practical limit of 5 percent to 6 percent solids concentration of the secondary slimes could in fact be increased in a subsequent thickening stage even to about 22 percent, this still leaves unsolved the main problem of disposal of the much larger volumes and tonnages of the primary slimes produced at a solids concentration usually limited to about 4 percent. Therefore, as a matter of overall economy in the disposal of the slimes, present day practice calls for transferring to the lagoons the secondary slimes thickened to the aforementioned 5 percent to 6 percent concentration, together with the much larger volumes and tonnages of the primary slimes derived from the aforementioned cyclonic separation at their own limited solids concentration in the order of about 4 percent.

In contrast with the above outlined present-day mode of slimes disposal, this invention minimizes or avoids the need for the slow acting and otherwise objectionable lagoons or ponds, by establishing and substituting a thickening operation that is economically operable in such a manner as to produce a single mixed sludge containing the solids of both the primary and the secondary slimes at a relatively high concentration, that is in the order of about 14 percent, with large volumes of operating water recoverable in the overflow. With that concentration of a single mixed sludge economically achievable, several options for its final disposal present themselves, such as transfer to lagoons occupying only a fraction of the previously required area, or mixing with sand or clay to obtain a mixture directly usable as fill.

According to the invention, the above-indicated thickening results are attainable when both the primary and secondary slimes are thickened jointly to a practically attainable limit of about 5 percent to 6 percent solid concentration, and by having the resulting mixed and homogenized sludge thickened in a second stage to attain the aforementioned solids concentration of about 14 percent.

Beyond this, however, it was found that similar high solids concentrations are attainable at a substantial and economical reduction in total thickening area required, if, say, half of the primary slimes are fed to the first thickening stage, and the second half to the second thickening stage. A further significant saving in the required total thickening area is attainable by concentrating all of the secondary slimes in the first stage to the aforementioned limit of about 5 percent to 6 percent, for delivery into the second stage, while admixing all of the secondary slimes into the second thickening stage, which again results in the delivery of a mixed sludge having the aforementioned concentration of about 14 percent attainable with a relative minimum of thickening area.

It was also found that this mixed sludge of 14 percent concentration could be thickened even further in a third stage to a concentration in the order of about 22 percent, with further recovery of operating water in the overflow. Such high-density sludge may then be converted into fill for instance by admixing of other solids, or by filtration to produce a filter cake as fill and filtrate recoverable as operating water.

Other features and advantage will hereinafter appear.

FIG. 1 is a flowsheet according to this invention, comprising a phosphate beneficiation section and a slimes disposal section.

FIG. 2 is a contrasting flowsheet representative of prior art beneficiation treatment.

FIG. 3 and 4 show enlargements respectively of the beneficiation section and of the slimes disposal section of FIG. 1.

FIG. 5 is a sketch illustrating the manner of assembly of FIGS. 3 and 4, to constitute the complete flowsheet.

FIGS. 5 to 9 show various embodiments of the slimes disposal section.

In the flowsheet of FIG. 1 embodying this invention, a first treatment section "A" is generally representative of the beneficiation treatment proper delivering the coarse concen-
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3,622,087 3 trate 10 and the fine concentrate 11 of the phosphate rock stripped of the impurities. The waste products from this treatment section comprise a first fraction of coarse tailings 12 in the form of clay lumps or the like, a second fraction of tailings in the form of primary slimes 13, and a third fraction of tailings in the form of the secondary slimes 14, all as will be furthermore explained below.

The next section "B" of this flowsheet illustrates a manner of disposal of the large volumes of the primary and the secondary slimes, whereby the slimes disposal problem is solved through systematic thickening and concentrating operations in the plant, along with recovery of large volumes of operating water as overflow.

The invention is herein contrasted with earlier practice such as generally represented in the flowsheet of FIG. 2 wherein the phosphate beneficiation section "A-0" is identical to the section "A" of FIG. 1, whereas the waste disposal section "B-0" illustrates present-day typical practice of disposal of the primary and secondary slimes filling up lagoons which require large land areas and involve the loss of most of the process water mainly by evaporation.

The beneficiated treatment section "A-0" comprises a combination or sequences of separation treatment steps or unit operations whereby the phosphate rock is gradually stripped of its impurities. Each operation separates a mixture supplied thereto into an oversize fraction and an undersize fraction simply termed the oversize and the undersize, and designated in the drawings as plus (+) and minus (−) fractions respectively.

This treatment section "A-0" as herein exemplified is identical in both the flow sheets of FIG. 1 and FIG. 2, so that identical reference numerals may be applied to both. Accordingly, the impure raw phosphate material 15 from the mine is passed together with sufficient operating water through a first or coarse separating step as represented by a rotary screen or trommel 16. Thus, an initial coarse oversize fraction 17 delivered from the trommel contains coarse pieces of relatively pure straight phosphate rock along with the larger-sized impurities or lumps of clay and the like, as well as smaller interspersed or adhering particles of clay and sand.

The balance of the feed material or undersize fraction 18 passing through the screen openings of the trommel is a mixture of impurities such as clay and sand with smaller rock particles which in turn contain embedded or locked-in particles of phosphate rock.

The coarse or oversize fraction 17 from the trommel is delivered to a so-called log washer 19 for further separation treatment. The log washer has two functions, namely (a) to disintegrate clay and clay-bound sand matrices, and (b) to separate disintegrated fines from lumpy material. Both disintegration and transport of the coarse material are performed by blade-bearing inclined revolving "logs" which agitate and turn over the feed material in water in a box and at the same time push the settled lumpy material up an inclined bottom by reason of the spiral positioning of the blades. Discharge of the fines is effected by overflow, in suspension in water, at the lower end of the box.

Accordingly, the log washer 19 delivers an oversize fraction 20 which is a raked-up coarse mixture of phosphate rock and impurities separated from an overflow fraction 21 of undersize which in turn contain the locked-in phosphate rock particles in mixture with other suspended impurities. The oversize 20 from the log washer is further separated on a vibrating screen 22 delivering as an oversize fraction the aforementioned coarse tailings 12 such as lumps of clay and the like to waste. The undersize 23 from this screen represents a portion of the coarse concentrate 10 aforementioned for stock piling.

A second log washer 25 operating in parallel with log washer 19 receives the undersize fraction 23 from the trommel for further separation treatment which results in the delivery of an oversize fraction 26 containing what is potentially the coarse concentrate. The corresponding undersize fraction 27 consists mainly of particles containing locked-in phosphate rock, and herein termed the occluded rock. Yet all fractions have admixture of naturally occurring fine and superficial particles of clay as well as particles of sand.

The oversize fraction 26 from log washer 25 is further fractionated on a second vibrating screen 28 delivering an oversize fraction 29 which represents coarse concentrate of phosphate rock which as such may join the coarse concentrate contained in the undersize from vibrating screen 22. The undersize fraction 30 from screen 28 mainly contains occluded rock and is similar in size characteristics and composition to the overflow fractions 21 and 27 from log washers 19 and 25 respectively.

Occluded rock particles along with impurities are contained in the three fraction 30, 21, and 27, which fractions are therefore supplied jointly to a closed-circuit wet grinding system "S" well known of itself, in order to effect the liberation of the occluded phosphate particles. This grinding system may be of the type that comprises a rake classifier 31 operating in closed circuit with a mill 32. The rake product 33 from the classifier containing what are still unbroken particles of occluded phosphate rock is recirculated to the mill, while the overflow fraction 34 from the classifier containing the liberated particles along with impurities is subjected to centrifugal or decolionic action such as represented by a cyclone unit 35. This cyclone unit is operated in such a manner as to deliver an overflow fraction constituting the aforementioned primary slimes 13 obtainable for example at a solids concentration of about 4 percent of less, and mainly containing the fine and difficult-to-settle particles of naturally present clay down to micron size and submicron size.

The underflow 37 from the cyclone unit contains the bulk of the remaining fine impurities which, in distinction from the clay particles of the primary slimes, are those mainly created by previous comminution, grinding, and abrasion, together with naturally occurring particles of sand. These slimes also contain the bulk of the phosphate rock particles previously liberated in the grinding circuit, and potentially constituting the aforementioned fine concentrate 11 to be recovered by further separation treatment of this cyclone underflow.

Herein, the cyclone underflow 37 is subjected to treatment in a battery 38 of flotation cells operating to float the impurity particles exclusive of the silica or sand. This flotation product from the cells provides the aforementioned secondary slimes 14 highly diluted at a solids concentration for example in the order of 0.5 percent. The sink material or undersize fraction 39 delivered by the flotation cells 38 is a mixture 38% mainly of the liberated phosphate rock particles and sand. Receiving this mixture is a second battery 39 of flotation cells operated so as to deliver as flotation product 40 the silica or sand which as such is readily disposable due to drainage. The underflow from these cells constitutes the aforementioned fine concentrate 11 of phosphate rock stripped of impurities.

Heretofore, according to the flowsheet of FIG. 2, it has been customary to cope with the slimes disposal problem by pumping the bulk of the primary and secondary slimes over considerable distances as it were, to available terrain depressions or lagoons occupying large areas of land, thus relying on the slow process of settling and eventual compacting of the suspended solids, and on the natural evaporation of the water from these lagoons, to provide the fill. Hence, lagoon area has to be added continuously to accommodate the production of the plant, increasing the distance over which the slimes had to be pumped.

As illustrated in FIG. 2, this slimes disposal problem in the past was alleviated only partially due to the settling characteristics of the secondary slimes which, although of a segregating nature, made it possible to thicken them from the aforementioned 0.5 percent to a practically feasible limit in the range of about 5 percent to 6 percent. However, a relatively large settling area per unit weight of solids was required for this segregating type of suspensions, as represented by the thickener 41 equipped with rotary rake structure 42. Plant waste liquid 43 is shown to enter this thicken together with
the secondary slimes, the overflow from the thickeners providing a required addition to the underflow from the cyclone unit. Underflow from this thickener obtainable at about 5 percent to 6 percent solids concentration joins the much greater volume of the primary slimes obtainable for example at about 4 percent solids concentration from the cyclone unit. The combined bulk of the slimes with a water content of about 95 percent is transferred at 35% to the lagoons where this water is lost mainly by evaporation, and must be replaced as operating water at 40% from limited resources. Overflow from the thickener is applied to the underflow 37 of the cyclone.

By contrast, the slimes disposal section "B" of this invention comprises a system of thickening operations or stagewise thickening so conducted as to produce economically an homogenized mixture of both the primary and the secondary slimes, having a solids concentration of about 14 percent. Achieving a concentration of that order provides a suitable basis for disposal by the addition of sand or otherwise by further dewatering treatment, to attain the consistency of a material directly usable as fill, while recovering most of the process water as overflow from the thickening operations.

To attain a concentration of that order, the bulk of both the primary and the secondary slimes is delivered into a first stage thickener 46 where both slimes become thoroughly homogenized in a bed of sludge subject to the mixing action of the rotary rake structure 47 which moves the sludge to a central outlet 47. This thickener is dimensioned and operated so as to deliver an underflow 48 having what in this instance is a practically attainable limit of solids concentration in the aforementioned range of about 5 percent to about 6 percent, and to deliver an overflow available as process water.

A second stage thickener 50 receiving the underflow 48 from the first thickener, is dimensioned and operated so as to deliver an underflow 49 having been aforementioned solids concentration of about 14 percent as a basis for producing fill. A mixing container 51 is shown to receive the underflow 49 along with a supply of sand available from the flotation product 40 of the second stage flotation station 39 previously described. Overflows 48, 49, and 40 from the thickeners are thus available as operating water in the system indicated by a return conduit 40 having branch conduit 40 leading to the underflow 37 of the cyclone.

Operating data underlying this invention and pertaining to the economy and mode of operation of the slimes disposal section B, are presented directly below in reference to FIGS. 3 and 4 which taken together represent an enlarged rendition of the flowsheet of FIG. 1. Other embellishments of the slimes disposal section shown in FIGS. 5 to 9 along with operating data further below, provide additional support for this invention.

In the embodiment of FIGS. 3 and 4, the cyclone station 35 is shown to deliver the primary slimes 13 into the thickener 46, having a solids concentration of 4 percent, a volume of 17,000 g.p.m. (gallons per minute), and a solids content of 4,320 t.p.d. (tons per day) of clay. The bulk of the secondary slimes 14 derived from the first flotation station 38 also enters the first thickener 46, with a solids concentration of 0.5 percent, a volume of 25,000 g.p.m., and a solids content of 480 t.p.d., producing an underflow concentration of 5 to 6 percent.

A second thickener 50 receives the underflow from the first thickener, producing an underflow concentration of 10 percent.

Following are practical examples of the operation of the invention:

In view of the foregoing conditions, the operating data pertaining to the first thickener in FIG. 4 indicated on the drawing, is as follows:

First Thickeener Feed:
Secondary Slimes:
- Solids concentration: 0.5%
- Volume: 25,000 g.p.m. (24,970 g.p.m. water)

Operating data for the second thickener 50 in FIG. 4, receiving the underflow from the first thickener, are as follows:

Second Thickeener Feed:
- Solids concentration: 4.39%
- Volume: 16,985 g.p.m. (16,715 g.p.m. water)
- Solids content: 4,800 t.p.d.

Overflow 11,805 g.p.m. water
- Solids concentration: 15%
- Volume: 5,210 g.p.m. (4,910 g.p.m. water)
- Solids content: 4,800 t.p.d.
When operating the slimes disposal station in the manner shown in the embodiment of FIG. 6, a first thickener 54 receives the bulk of the secondary slimes 14 substantially without admixture of primary slimes, producing an underflow concentration of 5-6 percent. A second thickener 55 receives the underflow from the first thickener along with the bulk of the primary slimes 13, producing an underflow concentration of 14 percent.

Under these conditions, the operating data for the first thickener 54, as indicated in the drawing, are as follows:

**First Thickener**

**Feed:**
- Primary Slimes: None

**Secondary Slimes:**
- Solids concentration: 0.5%
- Volume: 9,150 g.p.m. (24,970 g.p.m. water)
- Solids content: 480 t.p.d.

**Overflow:** 15,850 g.p.m. water

**Underflow:**
- Solids concentration: 5-6%
- Volume: 9,150 g.p.m. (9,120 g.p.m. water)
- Solids content: 480 t.p.d.

**Required Unit Area:** 250 sq. ft./ton of solids/24 hours

Thickener Area: 480 sq. ft./200,000 sq. ft.

Operating data for the second thickener in FIG. 6 are as follows:

**Second Thickener**

**Feed:**
- Primary: None

**Secondary Slimes:**
- Solids concentration: 1%
- Volume: 9,150 g.p.m. (24,970 g.p.m. water)
- Solids content: 480 t.p.d.

**Overflow:** 20,940 g.p.m. water

**Underflow:**
- Solids concentration: 14%
- Volume: 5,210 g.p.m. (4,910 g.p.m. water)
- Solids content: 4,800 t.p.d.

**Required Unit Area:** 50 sq. ft./ton of solids/24 hours

Thickener Area: 4,800 sq. ft./240,000 sq. ft.

Operating data for the third thickener in FIG. 7 are as follows:

**Third Thickener**

**Feed:**
- Overflow from Second Thickener

**Secondary Slimes:**
- Solids concentration: 1%
- Volume: 5,210 g.p.m. (4,910 g.p.m. water)
- Solids content: 4,800 t.p.d.

**Overflow:** 2,080 g.p.m. water

**Underflow:**
- Solids concentration: 225%
- Volume: 3,120 g.p.m. (2,820 g.p.m. water)
- Solids content: 4,800 t.p.d.

**Required Unit Area:** 50 sq. ft./ton of solids/24 hours

Thickener Area: 4,800 sq. ft./240,000 sq. ft.

Comparison of Thickener Areas A-1, A-2, A-3, A-4 of FIGS. 4, 5, 6, and 7 respectively:

A-1 = 1,100,000 sq. ft. (two thickeners)
A-2 = 771,280 sq. ft. (two thickeners)
A-3 = 370,000 sq. ft. (two thickeners)
A-4 = 730,000 sq. ft. (three thickeners)

In summary, this invention provides a system and method for treating phosphate rock material, wherein the beneficia-\n
tion operation is combined with an improved operation for effecting the disposal of the primary and the secondary slimes resulting from the beneficia-

tion operation. The invention disposes of these slimes economically through a systematic procedure of thickening steps which provide the basis for the delivery of the mixed slimes solids in a form usable as fill material, while recovering the thickener overflows as process water, and minimizing or eliminating lagoon area.

This is accomplished by supplying the secondary slimes blackish in color and largely containing the matrix material, to the first thickener which delivers its underflow or sludge into the second thickener. The primary slimes being of light greyish color and mainly containing clay particles is supplied to at least one of said thickeners, and in a manner whereby the primary slimes are thickened in the presence of secondary slimes.
solids. Thus, all of the primary slimes may be supplied to the first thickener, or partly to the first thickener and partly to the second thickener, or all of the primary slimes may be sent to the second thickener. In this way, the underflow sludge from the first thickener is producible at a solids concentration ranging from about 5 percent to about 6 percent or better, while the underflow sludge from the second thickener is producible at a solids concentration ranging from about 12 percent to about 14 percent.

With that solids concentration as a basis, the consistency of the sludges may be increased further so as to render them applicable as fill material. This increase may be achieved in several ways, as by the addition of sand preferably derived from the beneficiation operation itself, or by way of further thickening of the sludge in a third thichner for instance to a solids concentration of about 22 percent, again producing overflow water reusable as process water in the operation of the system. This may be followed by the addition of sand to the underflow sludge from the third thickener, or by subjecting this sludge to centrifugal separation for example in a solid bowl type centrifuge.

Depending upon the amount of sand added to the pumplable sludge from the second thickener or the third thickener, the consistency may be increased to a semifluid or to a substantially nonfluid state of a desired fill material. If the sludge from the third thickener be further dewatered as in a solid bowl type centrifuge, this will produce a moist cake material, the degree of moisture and consistency depending upon the manner of operation of the centrifuge. Depending upon its moisture, the cake material in turn may be mixed with sand.

In any instance, if sludge from the thickeners be pumped to a disposal area or lagoon, such area will be correspondingly reduced, while also gaining by the recovery of process water in the thickener overflows. Further increase of the consistency as above set forth will minimize the disposal area, even converting the same into land capable of supporting vegetation and/or structures.

1. A system for the treatment of phosphate rock material, which comprises a beneficiation section constructed and arranged for producing a coarse concentrate separated from the balance of the material which in turn contains phosphate rock occluded in a matrix material, and also producing a fine concentrate of particles liberated from said matrix material as by comminution, and producing separated from said fine concentrate primary waste slimes mainly containing fine clay particles, and having a solids concentration of about 4 percent or less, as well as secondary waste slimes mainly containing the comminuted matrix material, and having a solids concentration of about 0.5 percent;

and a slimes disposal section which comprises a first thickener equipped with rotary rake structure, a second thickener similarly equipped, both thickeners operating in series with the second thickener receiving the underflow from the first thickener and both thickeners delivering overflows of water, means for supplying said secondary slimes to said first thickener, and means for supplying said secondary slimes to at least one of said thickeners, said first thickener being adapted and capable to deliver an underflow having a solids concentration ranging from about 5 percent to about 6 percent, said second thickener being capable to deliver an underflow providing an homogenized mixture of solids of both slimes having a solids concentration ranging from about 12 percent to about 14 percent.

2. The system according to claim 1, with the addition of means for increasing the consistency of said underflow from the second thickener, whereby said underflow is rendered applicable as fill material.

3. The system according to claim 1, with the addition of means operable for re-using the overflows from said thickeners as process water in the system.
fractionating apparatus comprises a first flotation station receiving the underflow from said cyclone apparatus, and delivering said secondary slimes as flotation product, a second flotation station receiving the underflow from said first station, containing said liberated phosphate particles, and effective to deliver silica and sand as flotation product and said fine concentrate as underflow.

17. The system according to claim 16, wherein said classifying devices comprise a trommel receiving the phosphate rock, and producing an oversize and an undersize, a first log washer receiving said undersize and in turn producing an emerging oversize and an overflowing undersize, containing occluded phosphate rock, a first vibrating screen apparatus receiving said from the first log washer and delivering a portion of said nonphosphate rock as undersize, and a first portion of coarse concentrate as oversize, a second log washer receiving the oversize from said trommel, and delivering an emerging oversize representing coarse waste, and an overflowing undersize containing occluded phosphate rock, a second vibrating screen apparatus receiving the oversize from the second log washer, and delivering coarse waste as oversize, and coarse concentrate as undersize, and means for collecting the undersize from said log washers and from said first screen apparatus, all containing occluded phosphate rock, for feeding to said grinding circuit.

18. A system for treating phosphate rock material which comprises a beneficiation section constructed and arranged for producing a coarse concentrate separated from the balance of the material which in turn contains phosphate rock occluded in a matrix material, and also producing a fine concentrate of particles liberated from said matrix material as by comminution, and producing separated from said fine concentrate primary waste slimes mainly containing fine particles, as well as secondary waste slimes containing the comminuted matrix material, and a slimes disposal section which in turn comprises a first thickener equipped with rotary rake structure, a second thickener similarly equipped, both thickeners operating in series with the second thickener receiving the underflow from the first thickener, both said thickeners delivering overflows of water, means for supplying the secondary slimes to the first thickener, and means for supplying said primary slimes to at least one of said thickeners, so that substantially all primary slimes are subjected to thickening in the presence of the solids of the secondary slimes.

19. The system according to claim 18, with the addition of means operable for reusing the overflows of both said thickeners as process water in the system.

20. The system according to claim 18, with the addition of means for increasing the consistency of said underflow from the second thickener, whereby said underflow is rendered applicable as fill material.

21. The system according to claim 18, with the addition of means for supplying sand added to the underflow from the second thickener, thereby increasing the consistency of said underflow for rendering it applicable as fill material.

22. The system according to claim 18, wherein said primary slimes are supplied mainly to said second thickener.

23. The system according to claim 18, with the addition of a third thickener receiving the underflow from the second thickener, and a supply of sand added to said underflow, thereby increasing its consistency for rendering it applicable as fill material.

24. The system according to claim 18, with the addition of a third thickener receiving the underflow from the second thickener, and a centrifugal machine operable to concentrate the underflow from said third thickener to the consistency of fill material.