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(54) HEAP LEACH LINER

HAUFENLAUGUNGSAUSKLEIDUNG

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to the use of geosynthetic clay liners, and more particularly to bentonite barrier compositions for use in acidic / low pH environments.

BACKGROUND OF THE INVENTION

[0002] Various materials and procedures have been developed and utilized to form low permeability barriers in containment applications. For example, low permeability barriers are needed to separate waste fluids from contaminating the surrounding environment in industrial mineral and metal mining sites, and landfill sites. These barriers are also useful for aqueous containment applications such as leachate ponds, retention ponds, and water storage reservoirs. The term "containment" when used herein refers to both aqueous containments (e.g., ponds) as well as other containments that have components that are better separated from the surrounding environment. For example, "containment" may refer to the separation of ponds of liquid waste streams from industrial processes or leachates produced from these or other industrial processes from the surrounding environments.

[0003] For example, a copper mining site 10 is illustrated in Fig. 1 and includes crushed ore is piled in a heap 12 on top of a liner or layer 14, and a percolating chemical solution (typically dilute sulfuric acid) 16 is percolated through sprinklers 20 onto the heap 12, thereby leaching metals 24 down through the heap 12.

[0004] The liner 14 at the bottom of the heap 12 is sloped so that the leaching metals flow to a collection pool 28 which collects pregnant leach solution 32. The pregnant leach solution 32 is typically 60% to 70% pure copper in solution, which is taken from the collection pool 28 to a solvent extraction site 36 (where the sulfuric acid is separated and then recycled back to the sprinklers 20 and then onto the heap 12).

[0005] Of course, regulations (*e.g.,* local, international, state and federal standards) require that materials in the mining process do not contaminate the surrounding environment. It is thus crucial that the barriers, such as the liner 14 and the collection pool 28, have low permeability to block contaminants from escaping to the surrounding environment, particularly in application with highly acidic (low pH) materials such as sulfuric acid.

[0006] Barrier geomembranes such as geosynthetic clay liners (GCLs) have often been used in geotechnical sites for a variety of reasons, including to block contaminants from escaping to the environment around the site. See, for example, U.S. Patent No. 9,758,432 and U.S. Publication Nos. 2012/0216707 and 2012/0219366 regarding high pH environments. Further, geosynthetic clay liners (GCL) comprised of sodium (Na) bentonite have been used in many applications, including lining systems to collect leach solution from heap leaching of copper ore. However, the high concentration and low pH of the solutions in such systems can suppress swelling of such GCLs, resulting in high hydraulic conductivity through the barrier. As a result, maintaining the necessary barrier low permeability in low pH, high acidic applications has been difficult over time, particularly given the aggressiveness of the leachate in those applications. Document WO 2012/101410 A1, according to its abstract, provides a method comprising: providing a bentonite barrier composition comprising: bentonite; and a polyanionic low molecular weight polymer; and forming a containment using the bentonite barrier composition to provide at least partial separation for a containment from its environment. Document CN 114 149 203 B, according to its abstract, states a compound polymer modified bentonite anti-seepage barrier material as well as a preparation method and application thereof. The compound polymer modified bentonite anti-seepage barrier material is prepared from the following components in percentage by mass: 80 to 95 percent of sodium modified bentonite, 0.5 to 15 percent of polyanionic cellulose and 0.7 to 2.5 percent of hydroxypropyl methyl cellulose, the polyanionic cellulose and the hydroxypropyl methyl cellulose are a compound polymer.

SUMMARY OF THE INVENTION

[0007] In one aspect of the disclosure, a geosynthetic clay liner for containing low pH, acidic fluids such as leachate is provided, including a dry blended mix of bentonite and a high molecular weight cellulose ether polymer, wherein the mix is 1%-10% by weight of the polymer and 90%-99% by weight bentonite, wherein when hydrated the high molecular weight cellulose ether particles form a gel that clogs open pores between the hydrated bentonite particles, resulting in narrow and tortuous flow paths around said bentonite particles.

[0008] In one form of this aspect of the disclosure, the geosynthetic clay liner is adhered to a geotextile. In an alternate form, the geosynthetic clay liner is between two geotextiles wherein the geotextiles are connected together on opposite sides of the clay liner by needle punching.

[0009] In another form of this aspect of the disclosure, the polymer and the bentonite have a maximum particle size of 16 mesh. In a further form, when mixed the polymer has a maximum particle size of 200 mesh.

[0010] In another aspect of the disclosure, a method of protecting an environment around a site having low pH, acidic fluids is provided, including (a) providing a geosynthetic clay liner by mixing a bentonite barrier composition consisting of a dry mix of 90%-99% by weight bentonite particles and 1%-10% by weight high molecular weight cellulose ether particles, and (b) lining a containment with the geosynthetic clay liner, wherein the geosynthetic clay liner provides separation between

low pH acidic fluids in the containment and a surrounding environment, wherein when hydrated the high molecular weight cellulose ether particles form a gel that clogs open pores between the hydrated bentonite particles, resulting in narrow and tortuous flow paths around the bentonite particles.

[0011] In one form of this aspect of the disclosure, at least some of the fluids have a pH which is no more than about 2.

[0012] In another form of this aspect of the disclosure, the polymer and the bentonite have a maximum particle size of 16 mesh. In a further form, when mixed the polymer has a maximum particle size of 200 mesh.

[0013] In still another form of this aspect of the disclosure, the fluid is leachate from copper extracted from ore at the site.

[0014] In yet another aspect of the disclosure, a containment for low pH, acidic fluids is provided, including a geosynthetic clay liner consisting of a bentonite barrier composition consisting of a dry mix of 90%-99% by weight bentonite particles and 1%-10% by weight polymer particles of high molecular weight cellulose ether. A containment area for the fluids is lined with the geosynthetic clay liner so that the geosynthetic clay liner provides a barrier between the containment area and a surrounding environment. When hydrated the high molecular weight cellulose ether particles form a gel that clogs open pores in the hydrated bentonite, resulting in narrow and tortuous flow paths around the bentonite particles.

[0015] In one form of this aspect of the disclosure, the liner is adapted to result in the narrow and tortuous flow paths with fluids having a pH which is about 2 and lower.

[0016] In another form of this aspect of the disclosure, the liner is adapted to contain leachate from extraction of copper from copper ore.

[0017] In still another form of this aspect of the disclosure, the geosynthetic clay liner is adhered to a geotextile. In an alternate form, the geosynthetic clay liner is between two geotextiles wherein the geotextiles are connected together on opposite sides of the clay liner by needle punching.

[0018] In yet another form of this aspect of the disclosure, the polymer and the bentonite have a maximum particle size of 16 mesh. In a further form, when mixed the polymer has a maximum particle size of 200 mesh.

[0019] Other objects, features, and advantages of the invention will become apparent from a review of the entire specification, including the appended claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

Figure 1 illustrates a site for extracting copper from a crushed ore heap, and

Figure 2 illustrates a geosynthetic clay liner as disclosed herein for use in low pH, high acidic environments such as copper heap leaching.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0021] A geosynthetic clay liner 100 is disclosed herein having low permeability in applications encountering low pH, acidic (*i.e.,* pH less than 7) fluids such as leachate from a low pH, acidic copper heap. The liner consists of a dry blended mix of 90%-99% by weight bentonite and 1%-10% by weight polymer, with the polymer being high molecular weight cellulose ether. The bentonite and polymer are particles when dry mixed to form the liner, and have a maximum particle size of about 16 mesh. Advantageously, the polymer particles may have a maximum particle size less than the bentonite maximum particle size. That is, the polymer maximum sizes may be about 200 mesh so that polymer particles will fit into spaces between the bentonite particles.

[0022] In low pH, high acidic environments such as extraction sites with copper heap leaching of low grade ore, water is tied up in chemical reactions and thus not as readily available to result in swelling of bentonite particles necessary for the barrier liner permeability to be low enough to prevent leak of materials through the barrier and into the surrounding environment.

[0023] Bentonite + high molecular weight cellulose ether polymer liners as disclosed herein are less chemically sensitive, whereby the polymer releases water which allows the bentonite of the liner to swell so as to close spaces between bentonite particles. As a result of such swelling, the liner 100 will have narrow and tortuous flow paths between the bentonite particles, and therefore low permeability through the liner.

[0024] It should be appreciated that the polymer-bentonite mixture 104 as disclosed herein may for convenience of handling and installing be adhered to a geotextile or, as illustrated in Fig. 2, may be a layer between two geotextiles 110, 112 wherein the geotextiles 110, 112 are connected together on opposite sides of the clay liner by needle punching.

[0025] It should then also be appreciated that the liner 100 can be used to form a containment area for low pH, acidic leachate, such as the collection pool 28 and/or liner/layer 14 of copper mining sites 10 such as shown in Fig. 1. That is, containment areas for such leachate may advantageously be lined with the polymer-bentonite geosynthetic clay liner 100 described herein so that the geosynthetic clay liner provides a barrier between leachate in the containment area and a surrounding environment. Moreover, when hydrated, the high molecular weight cellulose ether particles may also form a gel that clogs open pores within the hydrated bentonite, further narrowing the flow paths around the bentonite particles and resulting in low hydraulic conductivity through the liner 100.

[0026] It should be still further recognized that a liner 100 with the polymer-bentonite mixture 104 as described

herein (with or without geotextiles) may advantageously be used in a method of protecting an environment surrounding a site having low pH, acidic fluids, including but not limited to leachate. That is, a geosynthetic clay liner 100 consisting of a mixture of bentonite and a high molecular weight cellulose ether (in the described 1%-10% / 90%-99% by weight proportions) may be used to line a containment for the low pH, acidic fluid so that the geosynthetic clay liner provides a barrier between leachate in the containment and a surrounding environment. When hydrated, the high molecular weight cellulose ether not only releases water which allows the bentonite of the liner to swell but it also forms a gel that still further clogs open pores between the hydrated bentonite particles, resulting in narrow and tortuous flow paths around the bentonite granules and low hydraulic conductivity.

[0027] It should be appreciated that liners as disclosed herein may be used advantageously not only in copper mining but also in a variety of applications and environments requiring containment of acidic fluids (*i.e.,* with a pH less than 7), particularly those with a pH of about 2 or less.

[0028] Still other aspects, uses, objects and advantages of the geosynthetic clay liners disclosed herein will be recognizable by a full review of the specification and drawings herein.

Claims

1. A geosynthetic clay liner (100) for containing low pH, acidic fluids, comprising a dry blended mix of bentonite and a high molecular weight cellulose ether polymer (114), wherein said mix is 1%-10% by weight of said polymer and 90%-99% by weight bentonite, wherein when hydrated the high molecular weight cellulose ether particles form a gel that clogs open pores between the hydrated bentonite particles, resulting in narrow and tortuous flow paths around said bentonite particles.

2. The clay liner (100) of claim 1, wherein said geosynthetic clay liner (100) is adhered to a geotextile (110, 112).

3. The clay liner (100) of claim 1, wherein said geosynthetic clay liner (100) comprises a layer between two geotextiles (110, 112) wherein said geotextiles (110, 112) are connected together on opposite sides of said clay liner (100) by needle punching.

4. The clay liner (100) of claim 1, wherein when mixed said polymer and said bentonite have a maximum particle size of 16 mesh.

5. The clay liner (100) of claim 4, wherein when mixed said polymer has a maximum particle size of 200 mesh.

6. A method of protecting an environment around a site having low pH, acidic fluids, comprising:

   providing a geosynthetic clay liner (100) by mixing a bentonite barrier composition consisting of a dry mix of 90%-99% by weight bentonite particles, and 1%-10% by weight high molecular weight cellulose ether polymer particles; and
   lining a containment with the geosynthetic clay liner (100), wherein the geosynthetic clay liner (100) provides separation between low pH, acidic fluids in the containment and a surrounding environment, wherein when hydrated the high molecular weight cellulose ether particles form a gel that clogs open pores between the hydrated bentonite particles, resulting in narrow and tortuous flow paths around said bentonite particles.

7. The method of claim 6, wherein at least some of said fluids have a pH which is no more than about 2.

8. The method of claim 6, wherein when mixed said polymer and said bentonite have a maximum particle size of 16 mesh.

9. The method of claim 8, wherein when mixed said polymer has a maximum particle size of 200 mesh.

10. The method of claim 6, wherein copper is extracted from ore at said site and said fluid is leachate.

11. A containment for low pH, acidic fluids, comprising:

    the geosynthetic clay liner (100) of claim 1;
    a containment area for the fluids, said area being lined with the geosynthetic clay liner (100), wherein the geosynthetic clay liner (100) provides a barrier between the containment area and a surrounding environment.

12. The containment of claim 11, wherein said liner is adapted to result in said narrow and tortuous flow paths with fluids having a pH which is about 2 and lower.

13. The containment of claim 11, wherein said liner is adapted to contain leachate from extraction of copper from copper ore.

14. The containment of claim 11, wherein said geosynthetic clay liner (100) is adhered to a geotextile.

15. The containment of claim 11, wherein said geosynthetic clay liner (100) comprises a layer between two geotextiles (110, 112) wherein said geotextiles (110, 112) are connected together on opposite sides of said clay liner (110) by needle punching.

16. The containment of claim 11, wherein when mixed said polymer and said bentonite have a maximum particle size of 16 mesh.

17. The containment of claim 16, wherein when mixed said polymer has a maximum particle size of 200 mesh.

Patentansprüche

1. Geosynthetische Tonauskleidung (100) zum Enthalten von sauren Flüssigkeiten mit niedrigem pH-Wert, umfassend eine trocken gemischte Mischung aus Bentonit und einem Celluloseetherpolymer (114) mit hohem Molekulargewicht, wobei die Mischung 1-10 Gew.**-** % des Polymers und 90-99 Gew.**-** % Bentonit ausmacht, wobei die Celluloseetherpartikel mit hohem Molekulargewicht, wenn sie hydratisiert werden, ein Gel bilden, das offene Poren zwischen den hydratisierten Bentonitpartikeln verstopft, was zu engen und gewundenen Strömungswegen um die Bentonitpartikel führt.

2. Tonauskleidung (100) nach Anspruch 1, wobei die geosynthetische Tonauskleidung (100) an einem Geotextil (110, 112) haftet.

3. Tonauskleidung (100) nach Anspruch 1, wobei die geosynthetische Tonauskleidung (100) eine Schicht zwischen zwei Geotextilien (110, 112) umfasst, wobei die Geotextilien (110, 112) auf gegenüberliegenden Seiten der Tonauskleidung (100) durch Vernadelung miteinander verbunden sind.

4. Tonauskleidung (100) nach Anspruch 1, wobei das Polymer und der Bentonit, wenn sie gemischt werden, eine maximale Partikelgröße von 16 Mesh aufweisen.

5. Tonauskleidung (100) nach Anspruch 4, wobei das Polymer, wenn es gemischt wird, eine maximale Partikelgröße von 200 Mesh aufweist.

6. Verfahren zum Schützen einer Umgebung um einen Standort mit sauren Flüssigkeiten mit niedrigem pH-Wert, umfassend:

Bereitstellen einer geosynthetischen Tonauskleidung (100) durch Mischen einer Bentonitbarrierezusammensetzung, die aus einer Trockenmischung aus 90-99 Gew.**-** % Bentonitpartikeln und 1-10 Gew.- % Celluloseetherpolymerpartikeln mit hohem Molekulargewicht besteht; und
Auskleiden einer Fassung mit der geosynthetischen Tonauskleidung (100), wobei die geosynthetische Tonauskleidung (100) eine Trennung zwischen sauren Flüssigkeiten mit niedrigem pH-Wert in der Fassung und einer Umgebung bereitstellt, wobei die Celluloseetherpartikel mit hohem Molekulargewicht, wenn sie hydratisiert werden, ein Gel bilden, das offene Poren zwischen den hydratisierten Bentonitpartikeln verstopft, was zu engen und gewundenen Strömungswegen um die Bentonitpartikel führt.

7. Verfahren nach Anspruch 6, wobei mindestens einige der Flüssigkeiten einen pH-Wert aufweisen, der nicht mehr als etwa 2 beträgt.

8. Verfahren nach Anspruch 6, wobei das Polymer und der Bentonit, wenn sie gemischt werden, eine maximale Partikelgröße von 16 Mesh aufweisen.

9. Verfahren nach Anspruch 8, wobei das Polymer, wenn es gemischt wird, eine maximale Partikelgröße von 200 Mesh aufweist.

10. Verfahren nach Anspruch 6, wobei Kupfer aus Erz an dem Standort gewonnen wird und das Flüssigkeit Sickerwasser ist.

11. Fassung für saure Flüssigkeiten mit niedrigem pH-Wert, umfassend:

die geosynthetische Tonauskleidung (100) nach Anspruch 1;
einen Fassungsbereich für die Flüssigkeiten, wobei der Bereich mit der geosynthetischen Tonauskleidung (100) ausgekleidet ist, wobei die geosynthetische Tonauskleidung (100) eine Barriere zwischen dem Fassungsbereich und einer Umgebung bereitstellt.

12. Fassung nach Anspruch 11, wobei die Auskleidung so ausgelegt ist, dass sie zu den engen und gewundenen Strömungswegen mit Flüssigkeiten führt, die einen pH-Wert aufweisen, der etwa 2 und niedriger beträgt.

13. Fassung nach Anspruch 11, wobei die Auskleidung dazu ausgelegt ist, Sickerwasser aus der Gewinnung von Kupfer aus Kupfererz zu enthalten.

14. Fassung nach Anspruch 11, wobei die geosynthetische Tonauskleidung (100) an einem Geotextil haftet.

15. Fassung nach Anspruch 11, wobei die geosynthetische Tonauskleidung (100) eine Schicht zwischen zwei Geotextilien (110, 112) umfasst, wobei die Geotextilien (110, 112) auf gegenüberliegenden Seiten der Tonauskleidung (110) durch Vernadelung miteinander verbunden sind.

16. Fassung nach Anspruch 11, wobei das Polymer und der Bentonit, wenn sie gemischt werden, eine maximale Partikelgröße von 16 Mesh aufweisen.

17. Fassung nach Anspruch 16, wobei das Polymer, wenn es gemischt wird, eine maximale Partikelgröße von 200 Mesh aufweist.

Revendications

1. Revêtement géosynthétique en argile (100) destiné à contenir des fluides acides à faible pH, comprenant un mélange sec de bentonite et un polymère d'éther de cellulose (114) de poids moléculaire élevé, dans lequel ledit mélange est composé de 1-10 % en poids dudit polymère et de 90-99 % en poids de bentonite, dans lequel, lorsqu'elles sont hydratées, les particules d'éther de cellulose de poids moléculaire élevé forment un gel qui obstrue les pores ouverts entre les particules de bentonite hydratées, aboutissant à des trajectoires en écoulement étroites et tortueuses autour desdites particules de bentonite.

2. Revêtement en argile (100) selon la revendication 1, dans lequel ledit revêtement géosynthétique en argile (100) est collé à un géotextile (110, 112).

3. Revêtement en argile (100) selon la revendication 1, dans lequel ledit revêtement géosynthétique en argile (100) comprend une couche entre deux géotextiles (110, 112), dans lequel lesdits géotextiles (110, 112) sont reliés ensemble sur des côtés opposés dudit revêtement en argile (100) par aiguilletage.

4. Revêtement en argile (100) selon la revendication 1, dans lequel, lorsqu'ils sont mélangés, ledit polymère et ladite bentonite ont une taille de particule maximale de 16 mesh.

5. Revêtement en argile (100) selon la revendication 4, dans lequel, lorsqu'il est mélangé, ledit polymère a une taille de particule maximale de 200 mesh.

6. Méthode de protection d'un environnement autour d'un site comportant des fluides acides à faible pH, comprenant :

   fournir un revêtement géosynthétique en argile (100) en mélangeant une composition barrière de bentonite consistant en un mélange sec de 90-99 % en poids de particules de bentonite, et de 1-10 % en poids de particules de polymère d'éther de cellulose de poids moléculaire élevé ; et
   revêtir un confinement avec le revêtement géosynthétique en argile (100), dans laquelle le revêtement géosynthétique en argile (100) assure la séparation entre les fluides acides à faible pH dans le confinement et un milieu environnant, dans laquelle, lorsqu'elles sont hydratées, les particules d'éther de cellulose de poids moléculaire élevé forment un gel qui obstrue les pores ouverts entre les particules de bentonite hydratées, aboutissant à des trajectoires en écoulement étroites et tortueuses autour desdites particules de bentonite.

7. Méthode selon la revendication 6, dans laquelle au moins certains desdits fluides ont un pH qui n'est pas supérieur à environ 2.

8. Méthode selon la revendication 6, dans laquelle, lorsqu'ils sont mélangés, ledit polymère et ladite bentonite ont une taille de particule maximale de 16 mesh.

9. Méthode selon la revendication 8, dans laquelle, lorsqu'il est mélangé, ledit polymère a une taille de particule maximale de 200 mesh.

10. Méthode selon la revendication 6, dans laquelle le cuivre est extrait du minerai audit site et ledit fluide est un lixiviat.

11. Confinement de fluides acides à faible pH, comprenant :

    le revêtement géosynthétique en argile (100) selon la revendication 1 ;
    une zone de confinement des fluides, ladite zone étant revêtue du revêtement géosynthétique en argile (100), dans lequel le revêtement géosynthétique en argile (100) constitue une barrière entre la zone de confinement et un milieu environnant.

12. Confinement selon la revendication 11, dans lequel ledit revêtement est adapté pour aboutir auxdites trajectoires en écoulement étroites et tortueuses avec des fluides dont le pH est inférieur ou égal à 2.

13. Confinement selon la revendication 11, dans lequel ledit revêtement est adapté pour contenir le lixiviat provenant de l'extraction du cuivre du minerai de cuivre.

14. Confinement selon la revendication 11, dans lequel ledit revêtement géosynthétique en argile (100) est collé à un géotextile.

15. Confinement selon la revendication 11, dans lequel ledit revêtement géosynthétique en argile (100) comprend une couche entre deux géotextiles (110, 112), dans lequel lesdits géotextiles (110, 112) sont reliés ensemble sur des côtés opposés dudit revê-

tement en argile (110) par aiguilletage.

16. Confinement selon la revendication 11, dans lequel, lorsqu'ils sont mélangés, ledit polymère et ladite bentonite ont une taille de particule maximale de 16 mesh.

17. Confinement selon la revendication 16, dans lequel, lorsqu'il est mélangé, ledit polymère a une taille de particule maximale de 200 mesh.

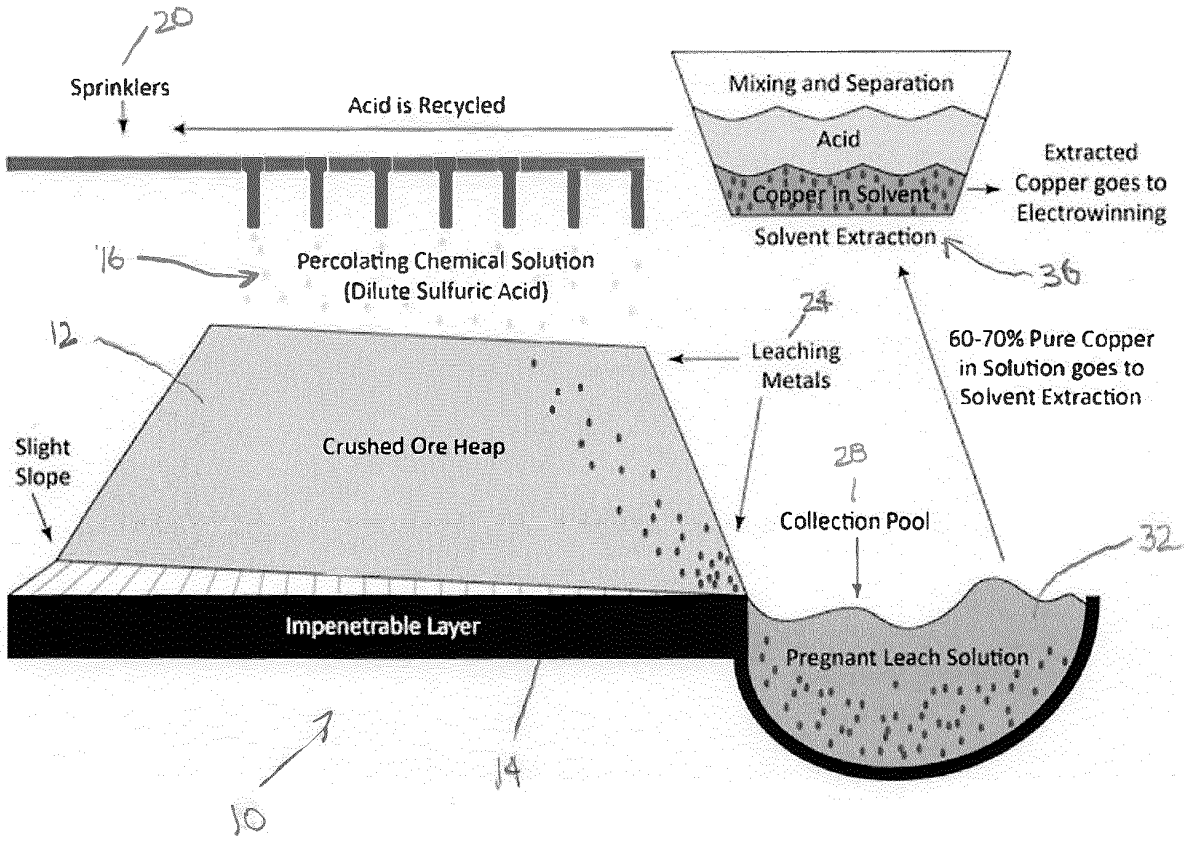
20
Sprinklers
Acid is Recycled
Mixing and Separation
Acid
Copper in Solvent
Extracted Copper goes to Electrowinning
Solvent Extraction
36
16
Percolating Chemical Solution (Dilute Sulfuric Acid)
24
12
Leaching Metals
60-70% Pure Copper in Solution goes to Solvent Extraction
Slight Slope
Crushed Ore Heap
28
Collection Pool
32
Impenetrable Layer
Pregnant Leach Solution
14
10

Fig. 1

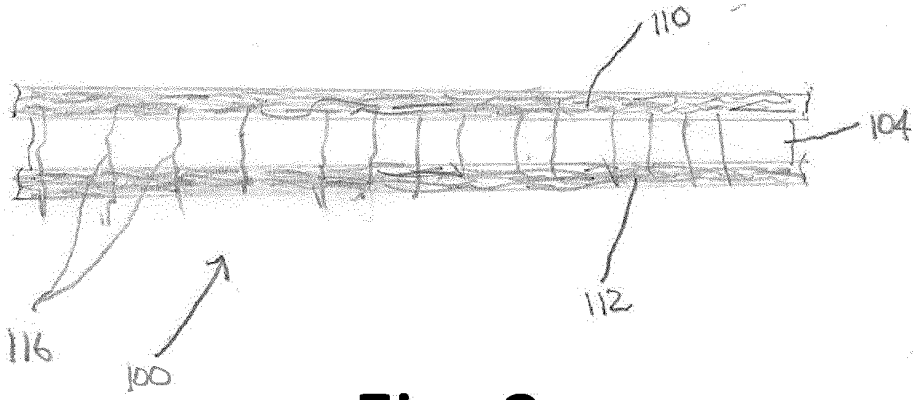
110
104
116
100
112

Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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