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Oficina de Patentes y Marcas de los Estados Unidos.

19 de marzo de 2020.

Por el presente se certifica que la adjunta es copia fiel de los registros de la Oficina de Patentes y Marcas de los Estados Unidos de los documentos pertenecientes a la solicitud de patente identificada a continuación que ha satisfecho los requisitos para la concesión de una fecha de presentación según el Código de los Estados Unidos 35, Art. 111.

Número de solicitud: 62/815.503.

Fecha de presentación: 8 de marzo de 2019.

El código del país y número de su solicitud que reivindica prioridad, para ser usado en el exterior de acuerdo con la Convención de París, es ***US62/815.503.***

Por autorización del Subsecretario de Comercio para la Propiedad Intelectual y Director de la Oficina de Patentes y Marcas de los Estados Unidos.

[Sigue una firma debajo de la cual se lee]: R. GLOVER. Funcionario de Certificaciones. *[Hay un sello aplicado que reza:]* Oficina de Patentes y Marcas Estadounidense. Departamento de Comercio.

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DEPOSICIÓN DE RELAVES POR DRENAJE EN CAPAS

ANTECEDENTES

El concepto de drenaje de mecha de suelos escasamente drenados con baja conductividad hidráulica ha sido ampliamente aplicado en las industrias de la agricultura y de la construcción y estabilización de suelos desde hace muchos años.

<https://trrjournalonline.trb.org/doi/pdf/10.3141/1757-07>

Un drenaje de mecha o por capas (ya sea vertical o lateral) se consigue insertando una capa continua de material de mayor conductividad hidráulica en el suelo con drenaje insuficiente, para dar lugar a que el agua se transfiera de las áreas de suelo de baja conductividad hidráulica a la capa de drenaje mucho más porosa, de la cual puede fluir por gravedad hasta un punto en el que se la pueda descargar.

La arena suele utilizarse como material de drenaje por mecha, puesto que tiene una elevada conductividad hidráulica (2-3 órdenes de magnitud mayor que el suelo de bajo drenaje).

Este canal de arena facilita el drenaje lento, pero continuo, desde el suelo de baja conductividad (por ej., arcilla) hacia el drenaje de arena, desde el cual puede ser extraído por gravedad a través de la arena hacia un punto de desagüe. El efecto de mecha de la arena insaturada parece “extraer el agua” del suelo saturado circundante.

Para relaves mineros, se pueden aplicar principios similares.

La distribución de tamaños de los relaves es tal que éstos tienen una baja conductividad hidráulica (por lo general de 10^{-4} a 10^{-6} cm/seg) y, por ende, cuando están presentes en un volumen grande, se mantienen “permanentemente” por encima del contenido de agua en el cual se puede producir la licuación de los relaves si se aplica un esfuerzo externo.

En efecto, en muchas jurisdicciones, las autoridades insisten en una cubierta impermeable en la base y los laterales del depósito de relaves (TSF, *por sus siglas en inglés*), para impedir la fuga de agua del TSF hacia el entorno circundante. Esta cubierta tiene muy baja conductividad hidráulica y asegura que el contenido de agua de los TSF cubiertos siga siendo afectado por la licuación casi a perpetuidad.

Debido al volumen de relaves retenidos detrás del muro del dique de contención, los fallos muy ocasionales de los muros de contención de los TSF utilizados para contener residuos de minería

son potencialmente catastróficos. Esos fallos han sido causa de pérdidas de vidas y daños ambientales a gran escala.

El concepto del uso de drenajes por capas verticales para eliminar el agua de los relaves ha sido sugerido y probado con éxito para la consolidación de relaves históricos. Por ejemplo, *Proceedings Tailings and Mine Waste 2015 Vancouver, BC, Octubre 26 a 28, 2015*.

Sin embargo, el costo de instalación de un número muy grande de drenajes por capas verticales, a una distancia de 1 a 3 metros a través de un almacenamiento de relaves de gran tamaño es prohibitivo. El costo de cada drenaje de mecha geotextil convencional es significativo.

Si se usa arena como material de drenaje de mecha, el volumen de arena requerido para formar los drenajes es grande y contribuye a la cantidad de material que se debe retener, los drenajes no son fáciles de adaptar y la eliminación del agua de la plétora de drenajes no es de mantenimiento simple.

Por ello, el drenaje de mecha vertical de una mina no ha progresado en la industria minera, debido a los costos considerables.

Las capas de arena suelen colocarse sobre cubiertas de TSF, para permitir el bombeo del agua desde la base de un TSF, donde puede ser transferida lateralmente hasta la ubicación de una bomba. Sin embargo, la tasa efectiva de desagüe del TSF está limitada a unos cuantos metros, por la baja conductividad hidráulica de los relaves superpuestos.

No se ha dado con métodos económicos de drenaje de mecha vertical o lateral para poder drenar la mayor parte del agua de un TSF.

En un campo no relacionado, la flotación de partículas gruesas (CPF, *por sus siglas en inglés*) ha sido señalada como método para aumentar el tamaño de trituración para la flotación. Ha sido promocionada como un medio de incrementar la recuperación, reducir el consumo de energía de molienda y separar el almacenamiento y el drenaje de los relaves áridos de libre drenaje de la CPF.

Una patente que utiliza la CPF para reducir los requerimientos de dique de relaves cubre la producción de una arena gruesa, con almacenamiento separado o un mezclado para incorporar la mayor cantidad posible de relaves en la arena, sin perder la estabilidad de la pila. (WO2016/170437 y WO2017/195008)

Excepto que la liberación de los minerales tenga lugar a un tamaño muy grueso, la distribución de los tamaños de partículas producida por la trituración y la clasificación significa que se debe

renunciar a la recuperación de los metales, o la eliminación conjunta de los relaves con el residuo de arena de la CPF. Por otra parte, después de mezclar la arena y los relaves espesados, es difícil apilar la mezcla.

LA PRESENTE INVENCION

Esta invención se relaciona con un método de disposición de relaves de minería que incluye las siguientes etapas:

obtener relaves de un proceso de enriquecimiento tal como la flotación de partículas gruesas (CPF) en forma de un residuo de arena por lo general en el intervalo de tamaños de 100-500 micrones y que es de libre drenaje;

depositar dicho relave en una ubicación de canal indicada, o diseminado en capas en un volumen de relaves;

para que así se forme un drenaje por capas lateral dentro del volumen de relaves.

El enriquecimiento de gruesos por medio de técnicas, tales como la CPF, aporta al potencial de producción de arena árida en grandes cantidades, en lugar de los relaves convencionales. La presente invención es un método de utilización de esta arena para mejorar la estabilidad de todos los relaves, reducir los costos de la eliminación permanente de los relaves y recuperar el agua adicional.

La liberación del mineral es tal que se pueden obtener altos niveles de recuperación a través del enriquecimiento de gruesos tal como la CPF, a un tamaño de partícula más gruesa que el que se emplea para el enriquecimiento convencional en la producción de un concentrado de alto grado. Cuando se aplica a mineral de cobre o hierro, se genera una relación de (arena/(arena más relaves)) de alrededor de 0,3-0,5. Esta proporción de residuo de arena benigno, que de todos modos debe ser eliminado, aporta el potencial para una forma muy diferente de eliminación de relaves.

El residuo de arena resultante suele estar por lo general en el intervalo de tamaños de 100-500 micrones y, a través del proceso de enriquecimiento de gruesos, ha eliminado la mayor parte de los finos formados durante la trituración y en este sentido es de libre drenaje.

La proporción de arena permeable generada por la flotación de gruesos permite su uso a gran escala en drenajes por capas, donde el volumen de drenaje es casi tan grande como el volumen de relaves que está drenando.

Y la arena es de un tamaño ideal como material de drenaje por mecha en un depósito de relaves.

- La arena de la CPF es de un grosor suficiente que le permite tener una alta conductividad hidráulica para transferir agua largas distancias, con una carga hidráulica moderada.
- La arena es lo suficientemente pequeña como para ser depositada sin inconvenientes por vía hidráulica y aun así decantar lo suficientemente rápido como para ser depositada en una ubicación de canal indicada, o simplemente diseminarse en capas dentro del volumen de relaves, sin necesidad de maquinaria pesada para operar en la superficie de los relaves.
- La densidad aparente de la arena y el tamaño son similares a los del relave, por ende, se restringe el mezclado de los sólidos entre las capas de arena y de relaves durante la deposición.
- El diámetro de la arena es apenas más grande que el de los relaves y por esto, la interfaz entre la arena y los relaves forma un “área de filtro” efectiva. Esta área de filtro permite drenar gradualmente el agua de los relaves hacia la arena, igual que ocurriría a través de una capa de arena en un dispositivo de filtro mecánico (Bentley).

Mediante la colocación dirigida de la alta proporción de arena, los canales de arena pueden ser colocados en forma tal que se puede reducir la trayectoria media del agua desde los relaves hasta un drenaje por capas a menos de unos cuantos metros.

La breve distancia entre los relaves y un drenaje por capas, permite el desagote eficiente de los relaves en un periodo de días y meses. Cuanto menor sea la distancia desde los relaves hasta el canal de arena desagado, más rápida será la eliminación del agua.

Considerando la literatura (referencia) y los cálculos, un periodo de alrededor de 6 meses daría una consolidación de los relaves de alrededor de 90 %, bastante más que los límites de la licuación potencial.

Los drenajes de arena por capas pueden estar interconectados para permitir el flujo del agua por gravedad, a un número administrable de puntos de desagüe convenientemente ubicados, para drenar la totalidad de los relaves.

En síntesis, la presente invención consiste en varias etapas

- Generar una gran cantidad de arena árida de tamaño conveniente a partir del mineral que está siendo procesado a través del enriquecimiento de gruesos,

- Depositar la arena y los relaves por separado en zonas interconectadas, en forma tal que se forme una serie de canales de arena continuos dentro del volumen total de relaves,
- Diseñar los canales de arena para promover el drenaje de agua por gravedad hacia los puntos de captación,
- Desaguar los puntos de captación, para sustentar el drenaje desde los relaves hasta los canales de arena.
- Construir progresivamente la matriz de canales de arena / relaves y utilizar el peso de la arena y los relaves superpuestos para acelerar el desagüe de los niveles inferiores.

La invención se puede utilizar dentro de una estructura de dique contenido, como la utilizada históricamente para el almacenamiento de relaves. Esto ofrece la ventaja de una elevada recuperación del agua y una muy modesta proporción de los relaves sujeta a licuación en cualquier momento. Ante el cierre final de la mina, los sólidos habrán sido desagüados y serán comparables al suelo normal retenido detrás de un muro de retención.

Como alternativa, la invención puede utilizarse para rellenar zonas agotadas por la minería, y luego, cuando ya se haya eliminado el agua, puede ser revegetada para rehabilitar la zona agotada por la minería. Esto resulta particularmente aplicable cuando un área está disponible para la deposición, sin inutilizar el recurso.

La deposición de arena en canales puede hacerse por hidráulica. El agua portadora drenará libremente “hacia debajo del varamiento de arena” hasta el punto más bajo en el área de deposición. La baja conductividad hidráulica de los relaves subyacentes significa que el impacto de esta deposición de agua será mínimo y podrá ser recolectada y reciclada hasta una instalación de almacenamiento adecuada.

La colocación progresiva de espigas para la deposición de arena puede crear efectivamente “ríos de arena seca” en la superficie de los relaves en el ángulo de varamiento natural de arena. Cuando el río de arena tiene la profundidad deseada, se puede correr la espiga para generar la red interconectada de canales de arena.

Luego los relaves se depositan sobre un canal de arena o próximos a este.

El agua intersticial de los relaves es filtrada por gravedad con eficacia en la interfaz de los relaves y el lecho de arena. Una vez transferida hacia el lecho de arena hidráulicamente conductiva,

puede fluir por gravedad a través de la matriz de canales de arena hasta el punto de recolección del agua eliminada.

Al asegurar una profundidad de arena suficiente, se evita la potencial “colmatación” de los canales de arena.

Existen muchas posibles variaciones en cuanto a la colocación de la matriz de canales de arena. El diseño a seleccionar dependerá de las conductividades hidráulicas y de la geografía natural del área de deposición.

Por ejemplo, la deposición de estos canales de lecho de arena en los relaves puede ser un diseño de múltiples capas tipo sándwich que es continuo en todo el TSF (Figura 1); o una serie de canales de arena laterales creados por la mitad del TSF (Figura 2).

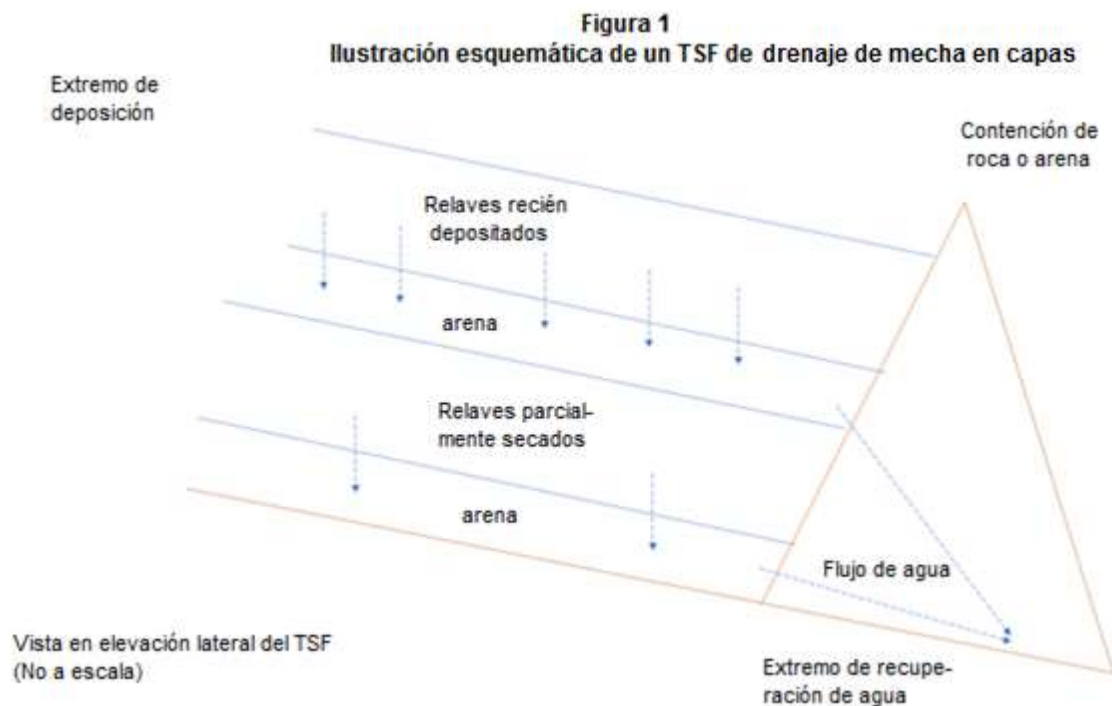
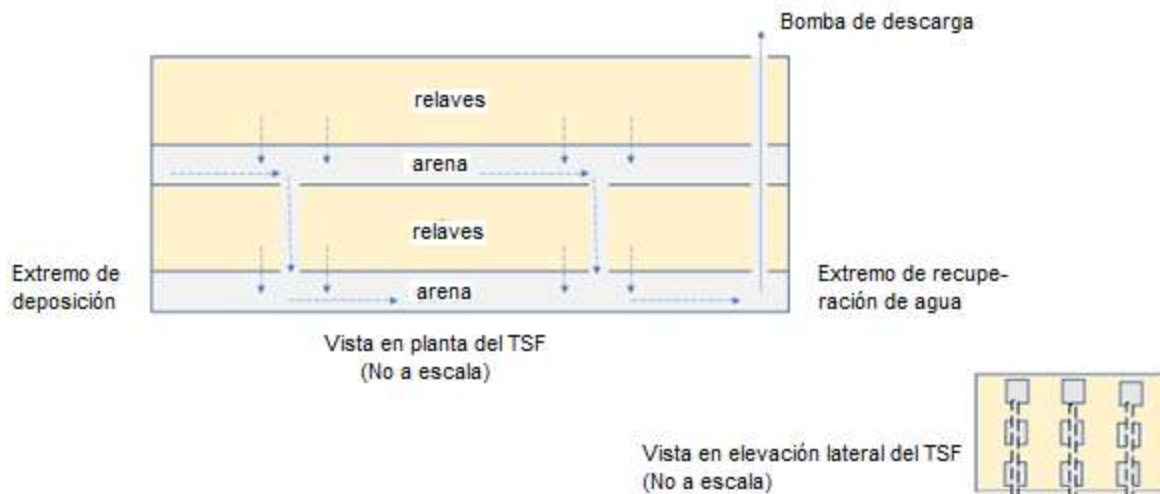


Figura 2
Ilustración esquemática de un TSF de drenaje de mecha de canales laterales



Un tercer diseño posible incorpora el uso de drenajes de canalización vertical de arena, para interconectar los canales en tres dimensiones y promover una transferencia más rápida del agua a través de la arena, también se puede considerar. Esta estructura 3D es especialmente ventajosa para áreas extensas de deposición de relaves, donde el tiempo necesario para el flujo lateral del agua a través de los canales de arena hasta un punto de desagüe puede ser excesivo. Los drenajes verticales facilitan el drenaje hasta una capa de arena en la base de la pila, que luego puede ser desagotada.

Figura 3
Ilustración esquemática de un TSF de drenaje de mecha de canales tridimensional



En cuanto a cualquier diseño geométrico seleccionado, el área de filtrado efectiva para el desagüe de los relaves es muy grande, en comparación con cualquier proceso de filtración de relaves mecánico concebible.

Y en cuanto a los TSF históricos, existe el potencial de generar exceso de arena, luego colocar de manera selectiva los canales de desagüe a través del TSF histórico por excavación y relleno con arena. Inicialmente se puede recrear una cortina bidimensional de canales de drenaje de arena en capas en una proximidad razonable del muro del dique. Con la eliminación regular del agua de la arena, esto ayudará a solidificar los relaves en la zona del TSF que es más susceptible a la catastrófica fuga. Por otra parte, los flujos totales de agua hacia la cortina ayudarán a reducir la presión en los poros en todas las áreas del muro que no hayan quedado debidamente compactadas.

Si se desea un desagüe más rápido o más extensivo, la cortina se puede replicar en la tercera dimensión.

Ventajas de la presente Invención

La invención ofrece múltiples ventajas que contribuyen al éxito a largo plazo de aquellas operaciones mineras donde la eliminación de los relaves es un problema mayúsculo.

La ventaja principal es una reducción del consumo total de agua. Los relaves constituyen el ítem principal de consumo de agua en la mayoría de las operaciones mineras. A través de la provisión de drenajes por capas de arena y el tiempo extendido en que los relaves pueden drenar sin mayores pérdidas evaporativas, se calcula que el consumo de agua en los relaves disminuirá por lo menos a la mitad y más probablemente se recortará hasta alrededor del 20 % de la pérdida de agua convencional en los relaves.

Una segunda ventaja es la capacidad de incrementar la altura de la deposición de relaves, sin tener que preocuparse demasiado por una licuación accidental de la masa dispuesta. Esto implica que se afectará un área de tierra menor y, en el caso de algunas minas, la colocación de relaves mucho más cerca de la planta de procesamiento.

Una tercera ventaja es una instalación de relaves mineros permanentemente estable, que puede ser revegetada. Los relaves se habrán desaguado lo suficiente para comportarse de manera similar a otros suelos alrededor de la mina y se habrán eliminado los sulfuros del residuo de arena. Al final de la vida útil de la mina, se puede eliminar todo potencial de drenaje de ácido de la mina desde los relaves, sellando el acceso del aire a los canales de arena en los relaves.

Una cuarta ventaja es la oportunidad de rellenar las áreas agotadas por la mina, donde el suelo es adecuado para la revegetación. En el caso de la minería en franjas, esto habilita un proceso sucesivo de minería y colocación de las capas de arena y relaves en las áreas de minería agotadas histórica o recientemente. En el caso de la minería en pozo profundo, existe el potencial de reemplazar la arena y los relaves que han sido almacenados por separado. Esto permite la recolocación de los relaves y la recuperación de gran parte del agua contenida.

Y una quinta ventaja es la capacidad de depositar arena y relaves hidráulicamente sin filtración y transporte previos, y de todos modos obtener un almacenamiento de relaves “seco”. El capital y los costos operativos de tal deposición hidráulica son significativamente menores que la filtración y el apilamiento por medio de cintas transportadoras o equipos móviles para manipulación de sólidos.

[N. del T.: Del presente formulario sólo se traducen las partes pertinentes].

Información acerca del solicitante:

El proporcionar información acerca de la cesión en esta sección no sustituye el cumplimiento de cualquiera de los requisitos establecidos en la parte 3 del Título 37 del CFR que exige el registro de una cesión por parte de la Oficina.

Solicitante 1.

No deberá completarse esta sección si el solicitante es el inventor (o el/los inventor/es conjunto/s restante/s en virtud del art. 1.45 del Título 37 del CFR). La información que se ha de suministrar en esta sección es el nombre y el domicilio del representante legal que es el solicitante en virtud del art. 1.43 del Título 37 del CFR; o el nombre y el domicilio del cesionario, la persona a quien el inventor está obligado a efectuar una cesión de la invención, o la persona que demuestra derecho de propiedad suficiente en la materia que es la solicitante en virtud del art. 1.46 del Título 37 del CFR. Si el solicitante es un solicitante en virtud del art. 1.46 del Título 37 del CFR (cesionario, persona a quien el inventor está obligado a efectuar una cesión, o persona que demuestra derecho de propiedad suficiente) juntamente con uno o varios inventores conjuntos, entonces el/los inventor/es conjunto/s quienes también son el solicitante deberán identificarse en esta sección.

☒ Cesionario.

☐ [Sin marcar]. Representante legal en virtud del Art. 117, Título 35 del USC.

☐ [Sin marcar]. Inventor conjunto.

☐ [Sin marcar]. Persona a la cual el inventor está obligado a efectuar una cesión.

☐ [Sin marcar]. Persona que demuestra el derecho de propiedad suficiente.

Si el solicitante es el representante legal, indicar con qué facultad efectúa la presentación de la solicitud de patente, el inventor es: [En blanco.]

Nombre del inventor fallecido o legalmente incapacitado: [En blanco.]

Si el solicitante es una Organización, marcar este casillero: ☒

Nombre de la Organización: ANGLO AMERICAN SERVICES (UK) LTD

Información acerca del domicilio postal del solicitante:

Domicilio 1: 20 Carlton House Terrace

Domicilio 2: *[En blanco.]*

Ciudad: Londres

Estado/Provincia: *[En blanco.]*

País: Reino Unido

Código postal: SW1Y 5AN

Número de teléfono: *[En blanco.]*

Número de fax: *[En blanco.]*

Dirección de correo electrónico: *[En blanco.]*

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March 19, 2020

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APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A
FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: 62/815,503

FILING DATE: March 08, 2019

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY
APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS
CONVENTION, IS US62/815,503

By Authority of the
Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office




R GLOVER
Certifying Officer

Electronic Acknowledgement Receipt

EFS ID:	35363514
Application Number:	62815503
International Application Number:	
Confirmation Number:	1798
Title of Invention:	TAILINGS DEPOSITION
First Named Inventor/Applicant Name:	Anthony Owen FILMER
Customer Number:	22204
Filer:	Anthony Michael Duncan Jr./Donald Sias
Filer Authorized By:	Anthony Michael Duncan Jr.
Attorney Docket Number:	742439-000115
Receipt Date:	08-MAR-2019
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Time Stamp:	13:14:15
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$280
RAM confirmation Number	030819INTEFSW00011139192380
Deposit Account	
Authorized User	

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Specification	742439_000115_Specification.pdf	719410	no	6
			04024629a6b968ad848c27714ae60e9a677285f3		

Warnings:**Information:**

2	Application Data Sheet	742439_000115_Application_Data_Sheet.pdf	1256023	no	8
			3cb7316630019568d3724dbb62a0973c996a001d		

Warnings:**Information:**

3	Fee Worksheet (SB06)	fee-info.pdf	29863	no	2
			e249dc66b4e78e9d624a3185bb1598e4af5c73b0		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Wicked Tailings Deposition

Background

The concept for wicking of poorly drained soils with low hydraulic conductivity, has been widely applied in the agricultural, and construction and land stabilisation industries for many years.

<https://trjournalonline.trb.org/doi/pdf/10.3141/1757-07>

A wicking (either vertical and lateral) drain is achieved by inserting a continuous layer of higher hydraulic conductivity material into the poorly drained soil, to allow water to transfer from the areas of low hydraulic conductivity soil to the much more porous drain, from which it can flow by gravity to a point where it is removed.

Sand is often used as the wicking material, because it has a high hydraulic conductivity (2-3 orders of magnitude greater than the poorly drained soil)

This sand channel enables slow but steady drainage from the low conductivity soil (e.g. clay) into the sand drain, from where it can be removed by gravity through the sand to a dewatering point. The wicking effect of the unsaturated sand appears to 'draw water out' from the surrounding saturated soil.

For mine tailings, similar principles can apply.

The size distribution of the tailings is such that they have a low hydraulic conductivity (typically 10^{-4} to 10^{-6} cm/sec) and hence when present in any large volume, remain 'permanently' above the water content at which liquefaction of the tailings can occur if an external stress is applied.

Indeed, in many jurisdictions, authorities insist on an impermeable liner to the base and sides of the tailings storage facility (TSF) to prevent water leakage from the TSF to the surrounding environment. This lining has a very low hydraulic conductivity and ensures that the water content of lined TSFs will remain subject to liquefaction almost in perpetuity.

Very occasional failures of containment walls of the TSFs used for containing mining residues, are potentially catastrophic, due to the volume of tailings retained behind the restraining dam wall. Such failures have caused loss of life and large scale environmental damage.

The concept of utilising vertical wick drains to dewater tailings has been suggested and successfully trialled for the consolidation of historical tailings. E.g.

Proceedings Tailings and Mine Waste 2015 Vancouver, BC, October 26 to 28, 2015,

However, the cost of installing a very large number of vertical wick drains, at a spacing of 1-3 metres, across a large tailings facility is prohibitive. The cost of each conventional geotextile wick drain is significant.

If sand were used as the wicking material, volume of sand required to form the drains is large and contributes to the quantity of material to be retained, the drains are not easy to retrofit, and the dewatering of the plethora of drains is not readily maintained.

So vertical wicking of mine has not progressed across the industry due to excessive costs.

Layers of sand are routinely placed on TSF liners, to enable pumping of water from the base of a TSF, where it can transfer laterally to a pump location. However, the effective rate of dewatering of the TSF is limited to several metres, by the low hydraulic conductivity of the overlying tailings.

No economic methods of either vertical or lateral wicking have been found for wicking of most of the water from a TSF.

In an unrelated field, coarse particle flotation (CPF) has been identified as a method of increasing the grind size for flotation. It has been promoted as a means of increasing recovery, reducing grinding energy consumption, and separate storage and draining of the barren, free draining CPF tails.

A patent to utilise CPF to reduce tailings dam requirements covers the production of a coarse sand, with either separate storage or mixing to incorporate as much of the tailings in the sand, whilst still maintaining stack stability. (WO2016/170437 and WO2017/195008)

Unless the liberation of minerals occurs at a very coarse size, the distribution of particle sizes resulting from grinding and classification means that either metal recovery, or complete tailings co-disposal with the CPF sand residue, must be sacrificed. In addition, after mixing of the sand and thickened tailings, the mix is difficult to stack.

Current Invention

This invention relates to a method of disposing of mining tailings including the steps of:

- obtaining tailings from a beneficiation process such as coarse particle flotation (CPF) in the form of a sand residue typically in the size range of 100-500 microns and that is free-draining;
- depositing said tailing at a targeted channel location, or spread in layers within a tailings volume;
- thereby to form a lateral wicking drain within the tailings volume.

Coarse beneficiation using techniques, such as CPF, opens the potential for production of barren sand in large quantities, in lieu of conventional tailings. The current invention is a method to utilise this sand to enhance the stability of all the tailings, reduce the costs of tailings disposal, and recover additional water.

Mineral liberation is such that high recoveries can be achieved through coarse beneficiation such as CPF, at a coarser particle size than used for conventional beneficiation to produce a high-grade concentrate. When applied to copper or iron ore, generates a ratio of (sand/(sand plus tailings)) of around 0.3-0.5. This proportion of benign sand residue, which must be disposed of anyway, provides the potential for a very different form of tailings disposal.

The resultant sand residue is typically in the size range of 100-500 microns, and has had most fines formed during grinding, removed by the coarse beneficiation process, and as such is free draining.

The proportion of the permeable sand generated through coarse flotation enable its large-scale use in wicking drains, where the volume of drain is almost as large as the volume of tailings it is draining.

And, the sand is ideally sized as a wicking material in a tailings storage facility.

- CPF sand is sufficiently coarse that it has a high hydraulic conductivity to enable transfer water for long distances, with a modest head.
- The sand is small enough to be easily deposited hydraulically and yet settles rapidly enough to be laid down in a targeted channel location, or simply spread in layers within the tailings volume, without the need for heavy equipment operating on the surface of the tailings
- Sand's apparent density and size similar to tailings, hence solids mixing between sand and tailings layers during deposition is limited.
- The diameter of the sand is only slightly larger than that of tailings, and hence the interface between sand and tailings forms an effective 'filter area'. This filter area allows water to gradually drain from tailings to sand, just as it would through a sand layer on a mechanical filter device (Bentley)

By targeted placement of the high proportion of sand, channels of sand can be placed such that the mean path length of water from the tailings to a wicking drain can be reduced to less than a few metres.

The short distance from tailings to a wicking drain, enables efficient dewatering of the tailings, over a period of days and months. The lower the distance from tailings to dewatered sand channel, the faster the dewatering.

Based on literature (reference) and calculations, a period of around 6 months should result in around 90% tailings consolidation, well beyond the limits for potential liquefaction.

The sand wicking drains can be interconnected to allow gravity flow of water, to a manageable number of conveniently located dewatering points, to drain the overall tailings.

In summary, the current invention consists of multiple steps

- Generate a high of suitably sized barren sand from the ore being processed by coarse beneficiation,
- Deposit the sand and tailings separately in interconnected zones, such that a series of continuous sand channels are formed within the overall volume of tailings
- Design the sand channels to promote gravity drainage of water to catchment points.
- Dewater the catchment points, to sustain the drainage from tailings to the sand channels.
- Progressively build the sand channel / tailings matrix and utilise the weight of overlying sand and tailings to accelerate the dewatering of the lower levels.

The invention can be utilised within a contained dam structure such as historically used for tailings storage. This offers the benefit of high water recovery, and a very modest proportion of the tailings being subject to liquefaction at any time. On ultimate mine closure, the solids will be dewatered, and be comparable to normal soil retained behind a retaining wall.

Alternatively, the invention can be used to backfill mined out areas, and then when dewatered can be revegetated to rehabilitate the mined-out area of land. This is particularly applicable if a area is available for deposition, without sterilising the resource,

The deposition of sand into channels can occur through hydraulic. The carrier water will freely drain 'down the beach' to the lowest point in the deposition area. The low hydraulic conductivity of the underlying tailings means that the impact of this deposition water will be minimal, and it can be collected and recycled to a suitable storage facility.

The progressive placement of sand deposition spigots can effectively create 'dry sand 'rivers' on the surface of the tailings at the natural beaching angle of sand. When the sand river has the desired depth, the spigot can be moved to create the interconnected network of sand channels.

Tailings are then deposited over or next to a sand channel.

The interstitial water from the tailings is effectively filtered by gravity at the interface of the tailings and sand bed. Once transferred into the hydraulically conductive sand bed, it can flow by gravity through the matrix of sand channels to the dewatering collection point.

By ensuring sufficient depth of sand, the potential for 'silting up' of the sand channels is avoided.

There are many possible variations on the placement of the matrix of sand channels. The selected design will be a function of the hydraulic conductivities, and natural geography of the deposition area.

For example, the deposition of these sand bed channels in the tailings can be in a multilayer sandwich design which is continuous across the full TSF (figure 1); or a series of lateral sand channels created through the middle of the TSF (figure 2).

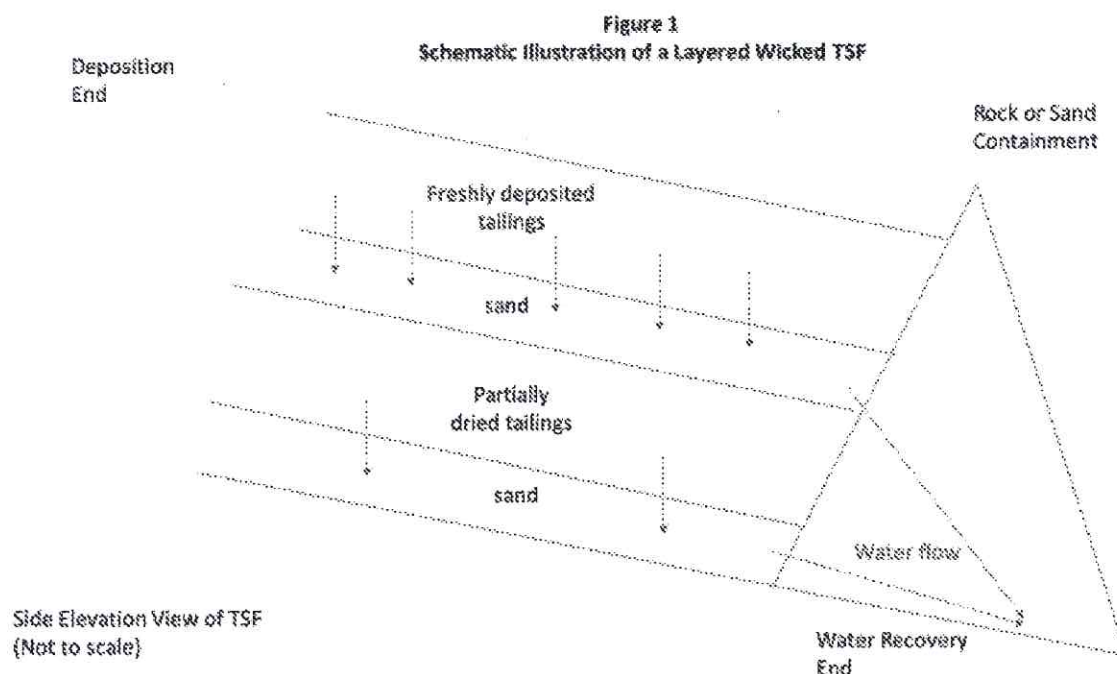
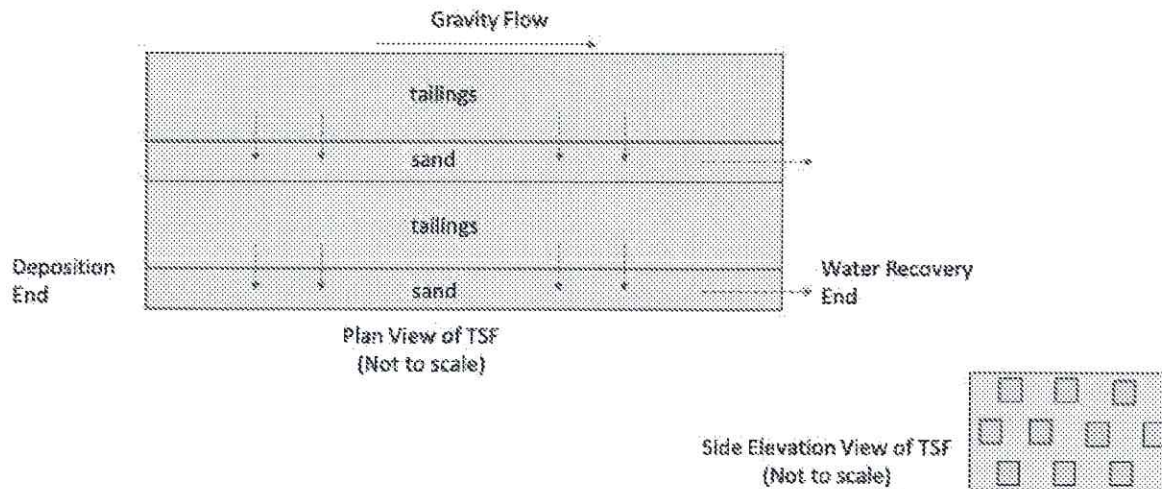
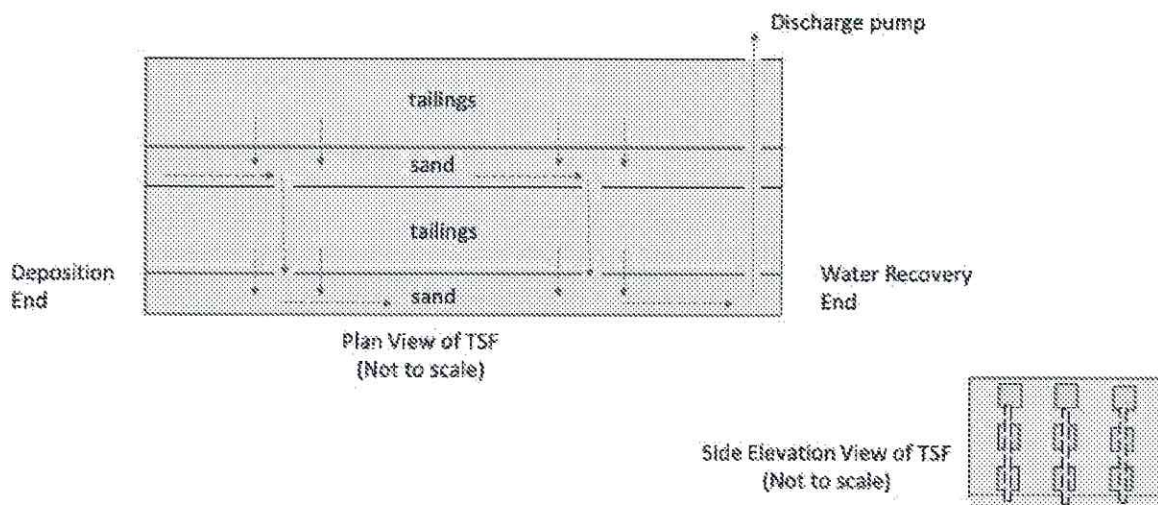


Figure 2
Schematic Illustration of a Lateral Channel Wicked TSF



A third possible design incorporates the use of vertical sand wicking drains, to interconnect the channels in three dimensions, and promote a more rapid water transfer through the sand, may also be considered. This 3D structure is particularly useful for large areas of tailings deposition, where the time required for lateral water flow through the sand channels to a dewatering point can be excessive. The vertical drains facilitate drainage to a sand layer at the base of the heap, which can then be dewatered.

Figure 3
Schematic Illustration of a 3 Dimensional Channel Wicked TSF



For any selected geometric design, the effective filter area for the tailings dewatering is very large compared to any conceivable mechanical tailings filtration process.

And for historic TSFs, the potential exists to create excess sand, then selectively place dewatering channels through the historic TSF by drilling and backfilling with sand. Initially a two-dimensional curtain of sand wicking channels can be created in reasonable proximity to the dam wall. With regular dewatering of the sand, this will assist to solidify the tailings in the zone of the TSF most susceptible to catastrophic breakout. In addition, the overall flows of water to the curtain will assist in reducing pore pressure in any areas of the wall that have not been suitably compacted.

If more rapid or more extensive dewatering is desired, the curtain can be replicated in the third dimension.

Benefits of the Current Invention

The invention delivers multiple benefits, all of which contribute to the long-term success of those mining operations where tailings disposal is a significant issue.

The first benefit is a reduction in total water consumption. Tailings forms the major form of water consumption at most mining operations. Through provision of sand wicking drains, and the extended time in which tailings can drain without major evaporative losses, it is estimated that the water consumption in tailings will be at least halved, and more likely cut to around 20% of the conventional water loss in tailings.

a second benefit is the ability to increase the height of tailings deposition, without undue concern about catastrophic liquefaction of the disposed mass. This implies lower land area which will be disturbed, and for some mines placement of tailings much closer to the processing facility.

A third benefit is a permanently stable mine tailings facility, that can be revegetated. The tailings will have drained sufficiently to behave similarly to any other soil around the mine, and sulphides will have been removed from the sand residue. At the end of mine life, any potential for acid mine drainage from the tailings, can be eliminated by sealing the access of air to the sand layers in the tailings.

A fourth benefit, is the opportunity to backfill mined-out areas, with soil that is suitable for revegetation. For strip mining, this will be a sequential process of mining and placement of the sand and tailings layers in the historically or recently mined out areas. For deep open pit mining, the potential exists to replace sand and tailings which have been separately stored. This enables replacement of the tailings and recovery of much of the contained water.

And a fifth benefit is the ability to deposit both sand and tailings hydraulically without and prior filtration and conveying, and still achieve a 'dry' tailings storage. The capital and operating costs of such hydraulic deposition is significantly lower than filtration and stacking using conveyors or mobile solids handling equipment.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	742439-000115
		Application Number	
Title of Invention	TAILINGS DEPOSITION		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor	1				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Anthony	Owen	FILMER			
Residence Information (Select One) US Residency ● Non US Residency Active US Military Service						
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Address 2						
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Postal Code	4169		Country ⁱ	AU		
Inventor	2				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	742439-000115
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Title of Invention	TAILINGS DEPOSITION		

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ An Address is being provided for the correspondence Information of this application.

Customer Number	22204		
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Application Information:

Title of the Invention	TAILINGS DEPOSITION		
Attorney Docket Number	742439-000115	Small Entity Status Claimed	☐
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)		Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	742439-000115
		Application Number	
Title of Invention	TAILINGS DEPOSITION		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
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This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

			Remove
Application Number	Country ^j	Filing Date (YYYY-MM-DD)	Access Code ^j (if applicable)
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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

☐ NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	742439-000115
		Application Number	
Title of Invention	TAILINGS DEPOSITION		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

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B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	742439-000115
		Application Number	
Title of Invention	TAILINGS DEPOSITION		

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Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant	1	Remove
------------------	---	------------------------

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

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☒ Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest

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Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name

Mailing Address Information For Applicant:

Address 1	20 Carlton House Terrace		
Address 2			
City	London	State/Province	
Country	UK	Postal Code	SW1Y 5AN
Phone Number		Fax Number	
Email Address			

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	742439-000115
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Title of Invention	TAILINGS DEPOSITION		

Assignee	1
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.	

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See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Anthony M. Duncan Jr., Reg. No. 71,904/		Date (YYYY-MM-DD)	2019-03-08	
First Name	Anthony M.	Last Name	Duncan Jr.	Registration Number	71,904

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		Application Number	
Title of Invention	TAILINGS DEPOSITION		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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