EVALUATION OF ACID PRODUCING SULPHIDIC MINE TAILINGS AS A PASTE BACKFILL

ASİT ÜRETEN SÜLFİDİK MADEN ATIKLARININ MACUN DOLGU OLARAK DEĞERLENDİRİLMESİ

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ABSTRACT: The level of environmental complaints with respect to mining has risen enormously in these days. The safe environmental disposal of sulphide bearing materials is fast becoming a major economic factor in determining the profitability of mining operations. Among sulphide minerals, especially, iron sulphides are the most common mining wastes. Surface disposal of pyrite and pyrrhotite tailings with high iron sulphide composition will lead to oxidation in the presence of air and water resulting in acid mine drainage. Therefore, for environmental and economic reasons, surface impoundment of pyrite and pyrrhotite tailings should be avoided. Disposal of sulphide bearing waste could be achieved by backfilling (underground disposal) instead of surface disposal. The underground placement of backfill falls into two categories -backfill required for ground support and underground disposal of tailings. There are new approaches and better technologies implemented in the last few years which enable mining operations to backfill total mill tailings. One of this approaches is the use of paste backfill technology. Paste technology has progressed from a research based backfill idea to a widely accepted, cost effective backfill method with the potential to radically change the way tailings are disposed of underground. Paste is simply dewatered tailings with little or no water bleed that are non-segregating in nature. The operating costs for preparation and transportation of paste may be higher but life of mine cost analysis shows comparable costs to conventional disposal with significant environmental benefits. The increased utilization of paste technology has improved the reliability and reduced the cost of preparation and transportation systems. This has led to the possibility of using paste for underground disposal. This paper explains the use of new technologies and ideas to improve the disposal of mine waste containing pyrite and pyrrhotite.

Key Words: Paste backfill, sulphide bearing tailings, acidic mine water, tailing disposal, underground spaces

ÖZ: Bu günlerde madencilik ile ilgili çevresel şikayetlerin seviyesi önemli ölçüde artmıştır. Sülfit içeren malzemelerin çevresel yönden güvenli bir şekilde depolanması, madencilik işlemlerinin karlılığını belirlemede büyük bir ekonomik faktör olmuştur. Sülfitli mineraller arasında özellikle demir sülfitler en yaygın madencilik atıklarıdır. Yüksek demir sülfit bileşimli pirit ve pirotit atıklarının yerüstünde depolanması, su ve hava varlığında oksitlenerek asidik maden suyu oluşumuna yol açmaktadır. Bu yüzden, çevresel ve ekonomik nedenler için, pirit ve pirotit atıklarının yerüstünde yığın yapılmasından sakınılması gerekmektedir. Sülfit içeren atıkların, yerüstünde depolanması yerine yeraltında dolgu olarak depolanması fayda sağlayacaktır. Dolgunun yeraltına yerleştirilmesi iki kategoride ele alınmaktadır; atıkların yeraltına depolaması ve zemin tahkimatı için gerekli dolgu. Tüm tesis atıklarını doldurmak için madencilik işlemlerine imkan sağlayan son bir kaç yıl içinde uygulanan yeni yaklaşımlar ve iyi teknolojiler vardır. Bu yaklaşımlardan birisi, macun dolgu teknolojisinin kullanılmasıdır. Macun teknolojisi, yeraltına depolanan atıklarda köklü olası değişiklere sahip, etkin (verimli) maliyetli dolgu yöntemi olarak geniş bir şekilde kabul gören dolgu esaslı bir araştırmadan geliştirilmiştir. Macun, basitçe doğada dağılmayan, az veya hiç su sızdırmayan susuzlandırılmış atıklardır. Macunun hazırlanması ve nakliyesi için operasyon maliyetleri yüksek olabilir. Fakat maden maliyet analiz ömrü önemli çevresel yararlı uygun depolama için karşılaştırmalı maliyetlerini gösterir. Macun teknolojisinin artan kullanımı, hazırlama ve nakliye sistemlerindeki maliyeti azaltmış ve güvenilirliğini artırmıştır. Bu ise yeraltı depolama için macun kullanma mevcudiyetine yol açmıştır. Bu makale, pirit ve pirotit içeren maden atıklarının depolanmasını geliştirme fikirlerini ve yeni teknolojilerin kullanılmasını açıklamaktadır.

Anahtar Kelimeler: Macun dolgu, sülfit içeren atıklar, asidik maden suyu, atık depolama, yeraltı boşlukları

INTRODUCTION

The progress of economy has always been a key factor to the vitality of nations. The mining industry has always been a major contributor to the development and economic supremacy of progressive countries. Mining, as good as its potential impact is on economy, has been a target to environmental criticism. When there is no disposal of sulphide bearing materials, mine closure is a relatively straightforward process. Buildings must be removed and openings are sealed; waste dumps and tailing areas must be stabilized. Sulphide bearing mine wastes such as waste rock and tailings may continue to generate contaminated acid mine drainage for several years or even centuries after the closure of the operation.

The safe environmental disposal of sulphide bearing materials is fast becoming a major economic factor in determining the profitability of mining operations. Surface disposal of pyrite and pyrrhotite mine waste is the major cause of acid mine generation and the consequent environmental damages. The oxidation of sulphide materials (iron sulphides) generates sulphuric acid, which subsequently promotes the release of toxic heavy metals and run off to the surface streams and underground water. The disposal of sulphide bearing waste could be achieved by backfilling instead of surface disposal. Backfilling has been an integrated part of mine design for the last few decades and is accommodating to the requirements of deeper mining and bulk mining. There are new approaches and better technologies implemented in the last few years which enable mining operations to backfill total tailings. The new approach is the use of paste backfill technology (Ameri, 1999).

This paper explains the use of new technologies and ideas to improve disposal of high sulphide tailings. There are two ways to dispose of sulphide-bearing mine waste. These are the surface disposal (wetlands) and the underground disposal methods (backfilling).

ACID MINE DRAINAGE

Natural oxidation of sulphide mineral wastes during their disposal and storage at the mining sites may result in generation of acid mine drainage (AMD) that may contain high acidity and high concentrations of dissolved metals and sulphates. Acid generation occurs when sulphide minerals (most commonly pyrite and pyrrhotite) contained in the waste material are exposed to oxygen and water. The primary step is the oxidation of sulphide minerals and generation of acid, and subsequently, leaching of oxidized products occurs as rainwater and snowmelt enters the waste piles. If sufficient alkaline minerals are not present to neutralize the acid, the resulting leach water becomes acidic. This water is generally known as AMD (Kuyucak, 2002). The steps involved in the AMD generation process, using pyrite as the example, can be represented by the following reactions;

$$FeS_2\ (s) + 7/2O_2\ (g) + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-}\ (l) + 2H^+ \quad (1)$$

$$Fe^{2+} + 1/4O_2\ (g) + H^+ \rightarrow Fe^{3+} + 1/2\ H_2O \quad (2)$$

$$FeS_2\ (s) + 14\ Fe^{3+} + 8H_2O \rightarrow 15\ Fe^{2+} + 2SO_4^{2-}\ (l) + 16H^+ \quad (3)$$

$$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3\ (s) + 3H^+ \quad (4)$$

The overall sulphide to sulphate oxidation is summarized as follows:

$$FeS_2\ (s) + 15/4O_2\ (g) + 7/2\ H_2O \rightarrow Fe(OH)_3\ (s) + 2SO_4^{2-}\ (aq.) + 4H^+ \quad (5)$$

The principle components required for the formation of AMD are: (i) wastes containing reactive sulphides; (ii) molecular oxygen; (iii) water.

Factors Affecting AMD Generation

The type of sulphur minerals, the presence of oxygen and the quality and quantity of alkaline minerals found in the waste are the primary factors that affect AMD generation. The amount of acid produced by a given sample of iron disulphide over time is a function, in part, of the rate at which oxidation takes place. Several factors have been shown to have an effect on oxidation rate. These include (Michael, 1980); the crystal structure of the iron sulphide, the surface area per unit volume of iron sulphide, temperature, oxygen concentration, water partial pressure, pH, ferrous/ferric adsorption ratio and total iron concentration. The crystallography, the size of particles, and purity of the mineral have an effect on the stability of the mineral. The size of the particles is important in assigning relative oxidation rates. The finer the particles, the greater the surface area and, accordingly, the more reactive and acid producing the sample (Nicholson, 1994).

The oxidation of sulphide minerals is an exothermic process. Thus, a significant quantity of heat is released and an interior temperature encountered in mine waste piles can reach to 80°C. Microorganisms, mainly bacteria as mentioned above, are indigenous to the AMD environment. These microorganisms play a role in the direct and indirect oxidation of sulphur minerals (e.g., pyrite, pyrrhotite). The concepts of AMD generation and bacterial oxidation of pyrite via direct and indirect pathways are illustrated in Figure 1 (Kuyucak, 2002).

AMD Predicting and Controlling Techniques

Mining industries face the challenge of preventing AMD occurrences in a cost-effective manner. The most feasible method would be to control and prevent AMD at the source. As the mining industry faces more restricted regulations and massive expenses to treat AMD, a variety of serious research programs are initiated to solve the long-term problem.

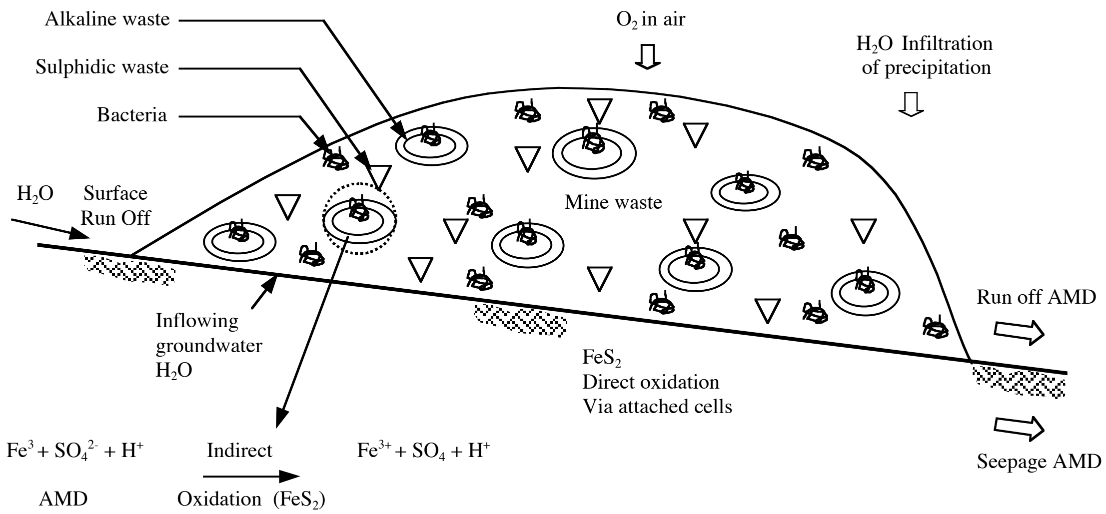

Figure 1. The Concepts of AMD Generation and Bacterial Oxidation of Pyrite Via Direct and Indirect Pathways (Kuyucak, 2002).
Şekil 1. Direkt ve Endirekt Yollar Vasıtasıyla Piritin Bakteriyal Oksidasyonu veAMS Oluşumu (Kuyucak, 2002)

The following are the examples of such different approaches to the design of passive systems, to effectively ameliorate AMD on a permanent basis. However it should be reminded that most of these techniques are still under study and in research stage. So far there has been no one system capable of producing a perfect result. Some of these systems could be summarized by the following; the disposal of the waste in wetlands, subaqueous disposal and underground disposal (Ameri, 1999).

PASTE TECHOLOGY

In recent years, use of paste backfill has evolved from an experimental backfill method with limited application to a technically viable and economically attractive alternative. This is primarily due to the development of dewatering and transportation systems that allow for controlled and consistent production and delivery of paste in a cost-effective manner. In addition, it has been recognized that underground backfill provides for a mechanism to safely dispose of mine wastes such as tailings, which results in cost savings and reduced immediate and long-term liability. Minimising this liability through a reduction in surface disposal will have a beneficial effect on the feasibility of any mining venture. The benefits of paste technology are many, and cover a wide range of issues, including design, operation, reclamation, environmental protection, and public perception. Several publications discuss the geotechnical advantages of using paste (Cincilla et al., 1997; Landriault et al., 1997; Robinsky, 1999; Kesimal et al., 2002a; Yılmaz et al., 2003a).

Paste technology has been used relatively widely in underground backfilling applications because of its economic and practicable advantages over hydraulic fill and rock fill. A similar technology has now been developed (and continues to be refined) for treatment and disposal of tailings both underground and at surface (Brackebush and Shillabeer, 1998).

A comparison of mine operating costs for typical slurry, paste and rock fill systems are summarized in Table 1. From this production data, it can be seen that paste backfill use may realize considerable cost savings relative to slurry fill, due in large part to reduced binder consumption needs, decreased costs for barricade development and pumping charges for decanted water from placed backfill.

Paste Definition

Table 1. Operating Cost Comparison for Backfill Types (Henderson et al., 1997)
Table 1. Dolgu Tiplerinin Operasyon Maliyetlerinin Karşılaştırılması (Henderson vd., 1997)

Operating Costs (US$/tonne ore)	Slurry Fill	Rock Fill	Paste Fill
Binder	2.30	2.00	1.50
Fill Preparation	1.31	1.20	2.20
Distribution	0.92	3.50	0.90
Barricades	1.28	----	0.60
Ditches/Clean-up	0.98	----	----
Pumping	0.91	----	----
Miscellaneous	0.21	0.21	0.21
Total Cost	13.19	5.91	5.41

Tailings paste is defined as a dense, viscous mixture of tailings and water that, unlike slurries, does not segregate when not being transported. Paste has a working consistency similar to wet concrete, and several of the geotechnical characterization techniques have their origin in the concrete industry. Widely used measure of consistency is the slump cone, and the photograph by Grabinsky et al. (2002) in Fig. 2 shows the difference between high-density slurry, high slump (250 mm) and medium slump (175 mm). It is not practicable to prepare a stiffer slump than 175 mm due to pumping constraints, and most surface paste disposal operations operate at approximately 250 mm consistency.

One of the most distinguishing properties of paste is the grain size distribution of the solids. Based on a large volume of empirical data and operational experience, it has been determined that a paste must contain at least 15 % by weight passing 20 μm to exhibit the typical paste flow properties and retain sufficient colloidal water to create a non-segregating mixture.

Figure 2. Slumps; Slurry (a), 250 mm Slump Paste (b), 175 mm Slump Paste (c) (Grabinsky et al., 2002).
Şekil 2. Slamplar; Slari (a), 250 mm Slamplı Macun (b), 175 mm Slamplı Macun (c) (Grabinsky et al., 2002).

According to Robinsky (1999), one of the pioneers of paste technology, virtually all mineral processing methodologies generate tailings amenable to paste production. When being transported either by gravity or through pumping, paste produces a plug flow, with the fine particles creating an outer annulus, thereby reducing friction. The coarse particles are forced into the center of the conduit with the finer fraction acting as the carrier. This allows for conveyance of very coarse fragments, the size of which is only limited by the pipe diameter. Cincilla et al. (1997) provide a general overview of paste properties and characterization.

Paste Backfill Laboratory Tests

Additives such as Portland cement are commonly added to the tailings paste as this significantly increases strength and durability. Published data for pastes with various percentages of cement addition (Kesimal et al., 2002b) indicate that uniaxial compressive strengths range from 0.18 MPa to more than 1.5 MPa for Portland cement percentages of 3 to 7 %, with curing times between 7 and 28 days. Cement additions as low as 1 % can produce a product with a significant increase in strength (over that produced with no cement addition).

The uniaxial compressive strength (UCS) is regarded as the most useful measure for comparing the relative strengths of cemented backfills. There are several factors which affect UCS including cement content, water/solids ratio (W/S), size distribution, and cement type. Figure 3 to 6 show the results of test work by Lamos and Clark (1989) to determine the effect of each of these factors on UCS.

Figure 3 and 4 show the benefit of increased cement content and decreased water/solids ratio on UCS. The latter graph clearly demonstrates the advantage of maximizing fill solids density.

Figure 5 illustrates the advantage of using well-

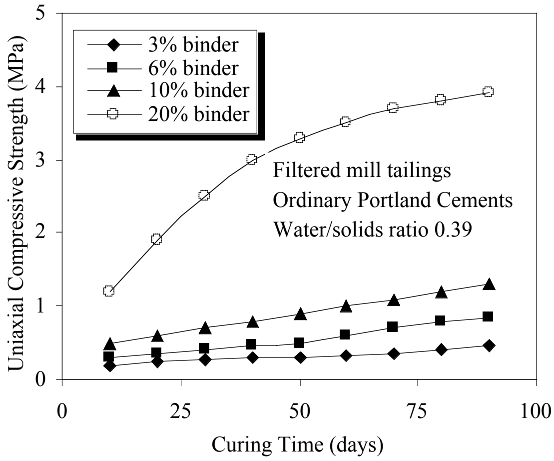

Figure 3. The Effect of Cement Content on UCS of Filtered Mill Tailings (Lamos and Clark, 1989)
Şekil 3. Filtrelenmiş Tesis Atıklarında Çimento İçeriğinin Dayanıma Etkisi (Lamos and Clark, 1989)

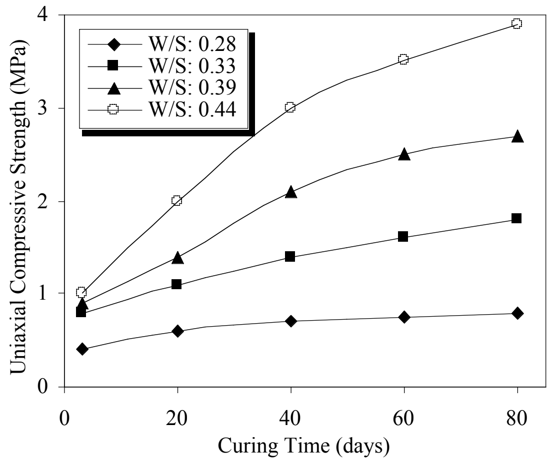

Figure 4. The Effect of Water/Solids Ratio on the UCS of Filtered Mill Tailings (Lamos & Clark, 1989)

Şekil 4. Filtrelenmiş Tesis Atıklarında Su/Katı Oranının Da yanıma Etkisi (Lamos and Clark, 1989).

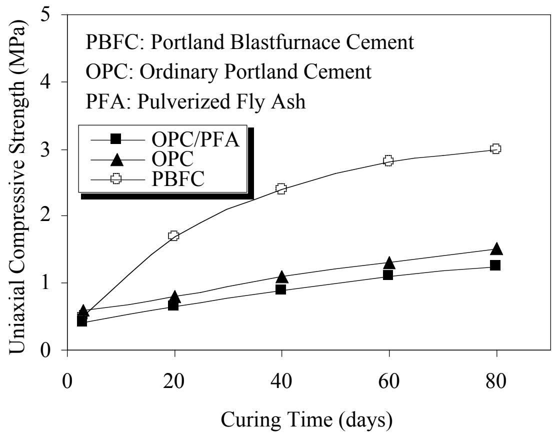

Figure 6. The Effect of Binder Type on the UCS of Filtered Mill Tailings (Lamos and Clark, 1989)

Şekil 6. Filtrelenmiş Tesis Atıklarında BağlayıcıTipinin Dayanıma Etkisi (Lamos and Clark, 1989)

graded, lower porosity filtered tailings over classified tailings to produce a stronger fill.

Figure 6 shows the results of UCS tests on fill samples with different types of binder. Using pulverized fly ash in place of Portland cement lowers the strength

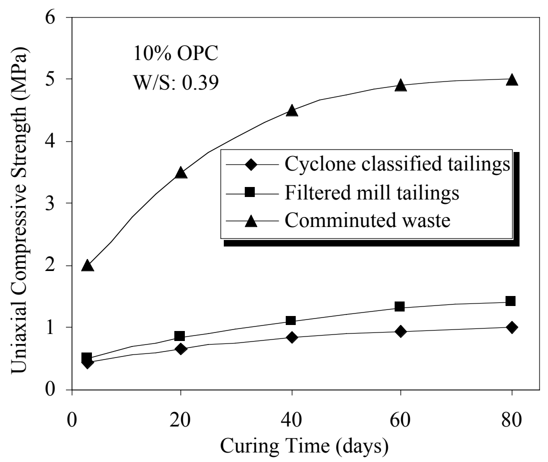

Figure 5. The Effect of Tailings Type on Backfill UCS (Lamos and Clark, 1989)

Şekil 5. Atık Tipinin Dolgu Dayanımı Üzerine Etkisi (Lamos and Clark, 1989)

at cure times of up to 90 days but may provide higher long term strength.

Most of the research to date on the cured properties of paste backfill has focused on measuring UCS as a function of solids density, particle size and grading, binder content, and cure time. Figure 7 shows the 28 days UCS of paste fill prepared from coarse, medium and fine full plant tailings compared to hydraulic fill (Thomas et al., 1979). The solids density and strength of

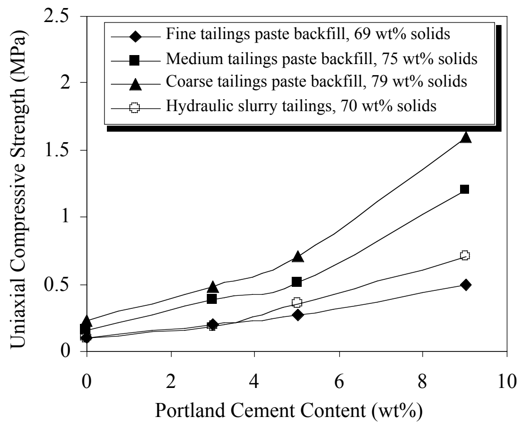

Figure 7. 28 Days UCS of Paste Backfills Prepared from Tailings of Varying Particle Size Compared to Hydraulic Fill (Thomas et al., 1979)

Şekil 7. Hidrolik Dolguya Kıyasla Çeşitli Boyuta Sahip Atıklardan Hazırlanan Macun Dolguların 28 Günlük Dayanımları (Thomas et al., 1979)

the paste backfill decreases as the tailings become finer because the fill is able to retain more water and the water to cement ratio increases. The fine tailings paste backfill has a low solids density of 70% and produces strengths which are similar to a typical hydraulic fill. While classification of a specific tailings product will generally results in lower fill strengths than if full plant tailings are used, these results show that it is unjustified to assume that all paste backfills are stronger than hydraulic fill.

Paste Preparation – Tailings Dewatering

The dewatering method for paste backfill made from run of mine tailings is normally a two-stage process. The tailings are conventionally thickened and then filtered to form a wet cake. This material is then re-pulped under closely controlled conditions to accurately prepare the correct consistency paste. Recent equipment development has allowed paste to be prepared in a one-stage process. These systems are called "deep tank dewatering systems" (Figure 8) and there are manufacturers that have succeeded in constructing such units (Naylor et al., 1997).

The thickeners retain the tailings for longer and are higher, which allows for the added dewatering associated with compression of the tailings. The consistent

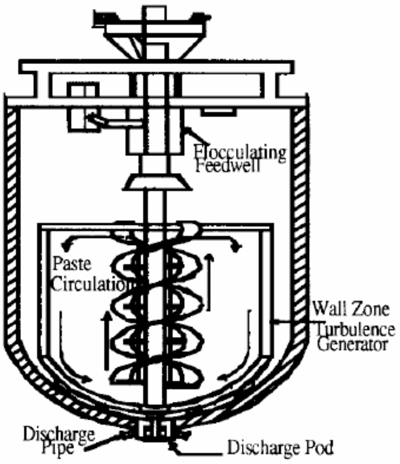

Figure 8. Deep Tank Dewatering Systems (Naylor et al., 1997).

Şekil 8. Derin Tank Susuzlandırma Sistemleri (Naylor et al., 1997).

preparation of paste from such equipment is tailings dependent and testing is required.

Tailings Transportation

For paste backfill transportation design is required to ensure a full line which reduces hammer and wear, in turn reducing the risk of plugging the line. For surface disposal, the transportation issues are more straightforward, normally related to finding a pump that can provide the necessary driving force with the required availability to operate 24 hours a day. Positive displacement pumps can provide the necessary pressure and capacity.

The pressure gradient for pipeline transportation of paste is much higher than the gradient for dilute slurries. Much more pumping energy is therefore required to deliver the paste from the mineral processing plant to the tailings deposit. Practical pumping distances range up to three kilometers (Brackebusch and Shillabeer, 1998).

As discussed above, additives have the potential to reduce friction losses. Experience gained to date has been inconclusive but this may be because commercially available plasticisers were developed for concrete pumping and act on the cement fines. For paste backfill, cement content is minimal and for the surface disposal of paste, there is unlikely to be any cement.

Environmental Benefits

Of all potential advantages, associated with disposal of acid-generating tailings in paste form, the environmental benefits are amongst the most promising. As regulatory and societal demands on the mining industry continue to increase, use of paste technology may provide an avenue for minimizing or even eliminating various environmental issues.

The environmental benefits of disposal of acid-generating tailings in paste form are several. First, very little free water is available for generation of a leachate, thereby reducing potential impacts on receiving waters and biological receptors. In addition, the permeability of a poorly-sorted, run-of-mill paste is significantly lower than that of classified, well-sorted tailings. This limits infiltration of rainfall and snowmelt, which also results in a reduction of the seepage volume. When placed underground, the paste may represent a hydraulic barrier to groundwater flow, thereby limiting interaction between paste and groundwater. Second, the higher degree of saturation within the paste retards the ingress of oxygen, which reduces the potential for generation of AMD. Third, the paste production technology allows for production of an engineered material by modifying the paste geochemistry in such a manner that environmental benefits result. Fourth, co-disposal of other waste materials with paste is made feasible by the paste production technology. In particular, encapsulation of acid generating tailings in appropriately-designed paste may provide significant benefits in terms of environmental control and waste management. These environmental benefits are described in more detail in following sections (Newman et al., 2001).

SURFACE DISPOSAL

Surface disposal of sulphide bearing mine waste is the major cause of acid mine generation. Sulphide minerals are unstable when exposed to oxygen and water, and begin to react almost immediately. This reaction yields sulphuric acid and causes the leaching of heavy metals, in concentrations which may be toxic to aquatic life (Yılmaz et al., 2003b).

The key to prevent acid mine drainage appears to be the prevention of oxygen from coming into contact with sulphide-bearing waste materials. Acid generation is often regarded as the most difficult problem that a mining company has to face during the reclamation phase. Today, the submerged tailings method is considered to be the best for preventing acid production in tailings (Figure 9). Implementation of this method requires that some provisions be taken at the pre-operational phase of mining activity (Norman and Raforth, 1998).

UNDERGROUND DISPOSAL

The implementation of paste backfill technology in modern metal mining operations must take into account the physical and chemical stability of the paste mixture sent underground, which may vary with time (Bernier and Li, 2003). There are great advantages associated with the correct and successful use of sulphide bearing materials in backfill operations. In recent years, mining has been hit hard economically by environmental regulations and concerns. It is the common belief that finding solutions for environmental problems associated with mine waste disposal is highly cost intensive. Backfilling with sulphide bearing tailings not only satisfies some environmental requirements but also offers economical incentives. Taking advantage of self-cementing properties of pyrrhotite economizes the use of expensive Portland cement. So far CANMET (Canadian Centre for Mineral and Energy Technology) has sponsored a few studies to investigate the possible stabilization of impoundment containing pyrrhotite and pyrite bearing tailings. In these studies, the formation of a hardpan on a tailing impoundment is examined as a means to isolate the AMD generating tailings. Utilization of the cementitious properties of pyrrhotite in underground operations and consolidation of acid producing pyrite and pyrrhotite, not only furnishes a more attractive environmental solution to disposal of these sulphide materials, but also provides structural support for mining operations.

Pastes have been used extensively as backfill for underground mines (Figure 10). There is now interest in the potential of paste as an alternative to more traditional slurry tailings disposal methods (Cincilla et al., 1997). Most rock types are amenable to paste production for surface disposal may not be suitable for underground

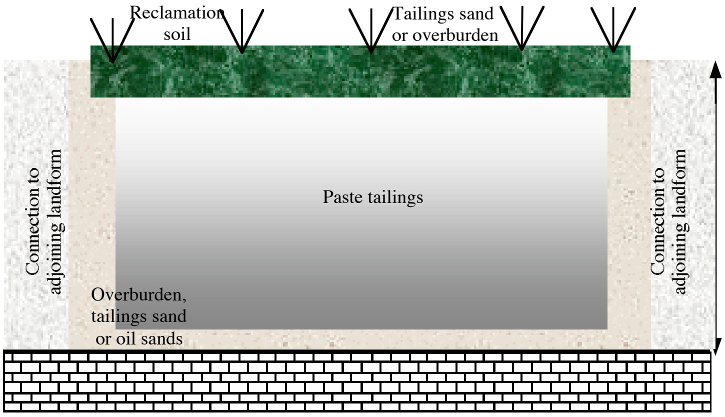

Figure 9. Surface Paste Disposal at Pit Form
Şekil 9. Çukur Şeklinde Yerüstü Macun Depolama

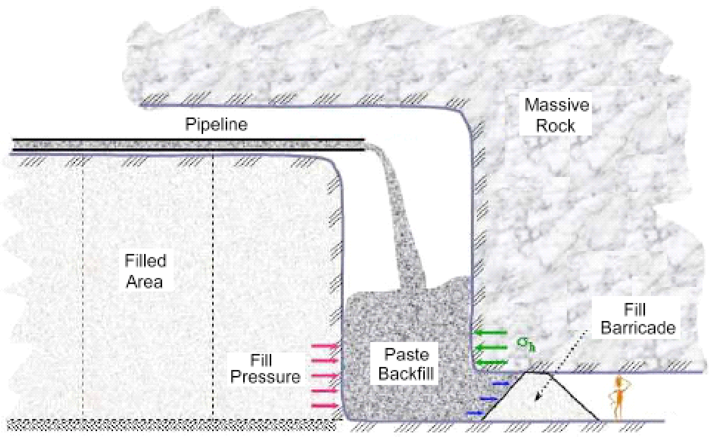

Figure 10. Paste Backfill Placement to Underground Mines
Şekil 10. Yeraltı Madenlerine Macun Dolgunun Yerleştirilmesi

backfill. For example, high-sulphide content tailings with Portland cement added have been used for underground backfill to reduce the volume of surface tailings, strengthen underground workings, and minimize subsidence. But reaction between pyrite and free calcium ions produced by the dissolutionof unstable portlandite hydrate ($Ca(OH)_2$) can result in the precipitation of swelling secondary gypsum and very expansive ettringite, i.e. $Ca_6Al_2[(OH_{12})](SO_4)_3(OH)_{12}{\cdot}26H_2O$, which produces a weak mortar not suitable for backfill (Ouellet et al., 1998). However, acid generation is probably less likely to occur in paste tailings because permeability is decreased and less oxygen can reach the minerals.

CONCLUSIONS

The use of paste for surface and underground disposal of acid-generating tailings as an alternative to traditional methods is opening the way for a new era in mineral waste management practice. Paste disposal has many benefits related to the operational, environmental, and regulatory aspects of mineral extraction and processing facilities. For acid generating tailings, the principal benefits of use of paste technology are the following:

- ❖ Reduced leachate generation due to water retention and decreased permeability
- ❖ Reduced sulphide oxidation due to increased moisture content and decreased permeability
- ❖ Ease of modification of paste characteristics
- ❖ Co-disposal of other waste materials.

In addition, paste technology holds promise in altering the public perception of mining wastes and the mining industry in general. Comprehensive geochemical characterization of paste is crucial to evaluation of paste designs and disposal alternatives. Especially, the use of large-scale field cells is proving to be of great value in determining and predicting the long-term environmental stability of paste.

ÖZET

Çevre konusunda tüm dünyada gelişen hareket, madencilik sektörünü de etkilemiştir. Özellikle, cevher zenginleştirme sonucu açığa çıkan sülfitli atıkların yerüstünde depolanarak çevreyi kirletmesi nedeniyle atıkların yeniden değerlendirmesi ve alternatif atık depolama yöntemlerini zorunlu kılmıştır.

Alternatif atık depolama yöntemlerinden birisi, yeraltı ve yerüstünde uygulanan dolgu yöntemleridir. Yeraltı madenciliğinde uygulanan dolgu işlemi; yeraltı faaliyetlerinin güvenli bir şekilde yapılması, yüzeyde meydana gelen çökmeleri engelleme ve atıkları depolama açısından büyük bir önem taşımaktadır.

Yeraltı maden sahalarında yaygın olarak kaya dolgu, hidrolik dolgu ve macun dolgu yöntemleri kullanılmaktadır. Kaya dolgusu, madeni alınmış boşlukları doldurmak için pasa olarak adlandırılan yan kayaç ve çeşitli boyutta agregalardan oluşan bir dolgu tipidir. Hidrolik dolgu, malzemenin su ile nakli, üretilen yerin doldurulması, fazla suyun katı dolgu malzemesinden ayrışması ve sertleşmesi esasına dayanır. Macun dolgu ise kuru olarak ağırlıkça % 75-85 maden atıkları, % 15-25 su ve % 2-9 arasında bağlayıcı karışımından oluşan yüksek yoğunluklu bir malzemedir. Karışımın macun oluşturması için 20 μm altı malzeme miktarının % 25 olması gerekmektedir.

Madencilik endüstrisinde macun dolgu yöntemi oldukça yeni bir teknolojidir. İlk olarak 1980 yılında Almanya'da Grund Madeninde kullanılmıştır. Macun dolgu teknolojisinin gelişmesi ve dolgu işlemi olarak madencilik işlemlerine önemli katkısı sonucu son yirmi senedir dünyanın bir çok yerinde özellikle de Kanada'da başarıyla uygulanmaktadır.

Hidrolik ve kaya dolgusuna göre düşük işletme maliyeti ve yüksek dayanımı macun dolgu yönteminin yaygınlaşmasında büyük rol oynamıştır. Cevher zenginleştirme atıklarının tamamının yeraltında depolanabilir olması ve böylece atık depolama ve iyileştirme maliyetlerinin önemli ölçüde azalması macun dolgu yönteminin en önemli avantajlarındandır.

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