GCLS IN MINING REMEDIATION AND RECLAMATION

Mining has been beneficial to our society by providing the metals used in numerous industries and the government mint. The proper reclamation of sites after the useful life of a mining operation is a key to good environmental stewardship. Many of these mining sites are at high elevations and/or in remote locations. Geosynthetic clay liners (GCLs) have played an increasingly important role as one or more of the components of mining reclamation and remediation projects. The use of GCLs can be more cost effective and can reduce the construction time that would normally be required using conventional materials.

This paper studies two projects - the Apache Tailings Impoundments Remediation project and the Landusky Mine Surprise pit reclamation project. Both of these projects illustrate the fact that the tolerance of GCLs to freeze-thaw cycling allows construction seasons to be extended. In numerous projects throughout the world, GCLs have provided a cost-effective alternative to compacted clay liners where on-site clay has not been available.

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Geosynthetic Clay Liners in Mining Remediation and Reclamation Applications

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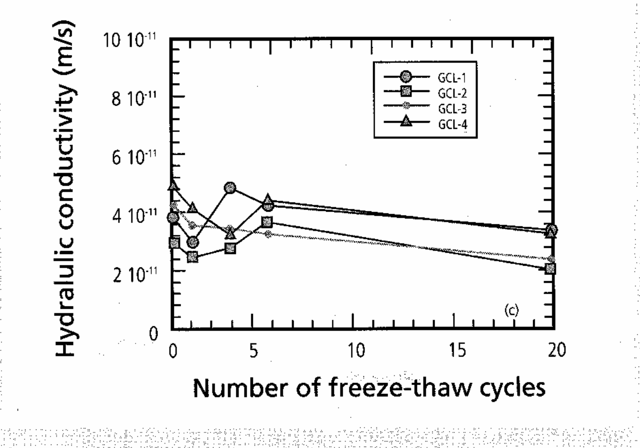
Introduction

Mining has been beneficial to our society, providing the metals used in numerous industries (e.g., automotive, construction, electronics and jewelry) and the government mint. The proper reclamation of sites after the useful life of the mining operation, is a key to good environmental stewardship. Many of these mining sites are at high elevations and/or in remote locations. Geosynthetics have played an increasingly important role as one or more of the components of mining reclamation and remediation projects. The use of geosynthetics can be more cost effective than natural materials, reduce the amount of time that would normally be required using conventional earthen materials and can extend the relatively short construction season at these sites.

For several years, it has been known that geosynthetic clay liners (GCLs) can extend the construction season beyond that previously attainable with compacted clay liners. A number of studies conducted during the 1990s showed that compacted clay liners can undergo increases of up to several orders of magnitude change in hydraulic conductivity when exposed to freeze-thaw cycling [(Zimmie and La Plante 1990); (Othman et al. 1994); (Chamberlain et al. 1995)]. During the freeze cycle, ice lenses formed in the compacted clay as water migrated toward the freezing front. Upon thawing the ice lenses in the compacted clay became cracks and were preferential pathways for flow.

To confirm that GCLs can be an attractive alternative to compacted clay liners, the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL), under its Construction Productivity Advancement Research (CPAR) program, and the U.S. Environmental Protection Agency (EPA) funded laboratory and field studies on the effect of freeze-thaw cycles on GCLs (Kraus et al. 1997). They found in laboratory studies that GCLs could withstand 20 freeze-thaw cycles with no deterioration in hydraulic conductivity (see Figure 1). The GCLs that were frozen and thawed for 20 cycles in the laboratory were examined to determine why their hydraulic conductivity did not increase. Randomly oriented ice lenses were present in the cross section of the frozen GCLs. However, the thawed GCL samples upon inspection were absent of cracks and appeared identical to samples that were hydrated but never frozen. Evidently, the bentonite clay in the GCLs is soft enough that the cracks formed by the ice lenses seal upon thawing.

Figure 1: **Hydraulic conductivity of a laboratory-tested GCL vs. number of freeze-thaw cycles (Kraus et al. 1997).**



In field pan tests a needlepunched GCL was subjected to a winter of freeze-thaw cycling in south central Wisconsin. Three needlepunched GCL specimens were tested, two with a seam and one without a seam. The leakage was measured prior to winter and in the spring. The hydraulic conductivity measurements showed no increase in hydraulic conductivity from the winter of freeze-thaw cycling. Overall, the results of the laboratory and field tests on the GCLs that were tested showed that freeze-thaw cycling did not adversely affect the hydraulic performance of GCLs.

Photo 1. Needlepunched GCL being installed over regraded tailings at Apache Tailings Impoundment of California Gulch Superfund site.

Case Study 1

The Apache Tailings Impoundments Remedial Action project is located in the City of Leadville, Colorado within Operable Unit (OU) 7 of the California Gulch Superfund site. The California Gulch site is located in Lake County, Colorado, in the upper Arkansas River basin, approximately 100 miles southwest of Denver. The Superfund site encompasses approximately 16 1/2 square miles and includes the towns of Leadville and Stringtown, a portion of the Leadville Historic Mining District, and the portion of the Arkansas River from its confluence with California Gulch downstream to the Lake Fork Creek confluence. The site has been organized into 12 OUs. The California Gulch site is located in the highly mineralized Colorado Mineral Belt of the Rocky Mountains. Mining, mineral processing, and smelting activities have produced gold, silver, lead, and zinc for more than 130 years in the Leadville area. The Leadville Historic Mining District includes an extensive network of underground mine workings in a mineralized area of approximately 2000 hectares (8 square miles) located around Breece Hill. The site was placed on the National Priorities List (NPL) in 1983 because of concerns about the impact of mine drainage on surface waters in the California Gulch and the impact of heavy metals loading in the Arkansas River. A feasibility study (MFG, 2000) was performed to assess the slope stability of existing tailing impoundments in California Gulch. The study also included development of remediation plans for the impoundments, surface water drainage, and runoff controls, and addressed erosion concerns related to the tailing impoundments.

The selected remedy is being implemented to fulfill the requirements of, and in accordance with, the Record of Decision (ROD) issued by the EPA on June 6, 2000. A Remedial Design Report (MFG, 2001), which included the Remedial Action Work Plan, was prepared by MFG, Inc. (MFG) of Boulder, Colorado on behalf of Asarco, Inc. The remedial design report presented and described the elements of work to be implemented to fulfill the requirements of the ROD and provided the supporting engineering evaluations. The alternative selected by the EPA consisted primarily of the following:

- installation and maintenance of temporary sediment, diversion and stormwater control structures;
- excavation of dispersed tailing and soil adjacent to the Main Impoundment to allow for the construction of sedimentation ponds;
- installation of a new section of sanitary sewer around the North Impoundment, connecting to an existing sewer line at the east and west ends including two new sewer lateral connections, and abandoning existing manholes and sewer line;
- regrading the tailing impoundments and placing excavated material in fill areas between the Main and North Impoundments and on top of the Main Impoundment;
- channelized California Gulch through the southern portion of the Main Impoundment;
- installed a 70,000 square meter (750,000 square foot) multi-layer cover system, consisting of a geosynthetic clay liner (GCL), geocomposite drainage layer, and an 18-inch soil cover, over the regraded tailing impoundments;
- constructed permanent diversion ditches, berms, and swale with erosion protection to provide surface water run-on and run-off control;
- extended or abandoned monitoring wells or piezometers, as necessary; and

- revegetation of the tailings impoundments and other disturbed areas with a native seed mixture covered it with an erosion control blanket.

The contractor for the project was Environmental Restoration LLC (ERLLC) of St. Louis, Missouri. ERLLC was provided technical geosynthetic installation assistance by Kaul Corporation, Lakewood, Colorado, a manufacturers' representative for several types of geosynthetics.

In the multi-layer cover system, a double-nonwoven needlepunched GCL was used on the slopes (which varied from 3H:1V to 5H:1V) and a woven-nonwoven needlepunched GCL was used on the top deck where the need for higher interface friction was not warranted. A triplanar drainage geocomposite was chosen for the drainage layer. The seeded soil cover is currently protected with a single-sided biodegradable-straw erosion control blanket. A GCL was also used to line the surface water run-off and run-on control structures.

Photo 2. Apache Tailings depositional area cap looking north with town of Leadville in background.

The project encountered various delays and did not start until September 2001. The site is located in mountainous terrain at an elevation of 10,500 feet above sea level. Thus, the project was under enormous time constraints to assure completion before significant snowfall accumulated in the area. Fortunately, a warm, dry fall and the use of GCLs as the liner allowed completion of the multi-layer cover system by early December. The GCL could be installed during temperatures of 20-40ºF with strong prevalent winds. A compacted clay liner would not have been able to be constructed as quickly because of freeze-thaw desiccation and earthwork time considerations.

<u>Case Study 2</u>
The Zortman Landusky Suprise Pit cap project in located in Landusky, Montana. From 1979 through 1998, Pegasus Gold Corporation and its wholly owned subsidiary company, Zortman Mining Inc. (ZMI) operated the Zortman and Landusky mines in the Little Rocky Mountains in northcentral Montana. While historic mining activity had occurred in the area since the mid-1860s, the advent of cyanide heap leach technology, combined with a sharp rise in gold prices, prompted the development of these two large-scale, open pit mining operations beginning in the late 1979. A 1992 review of water resources monitoring information by the Montana Department of Environmental Quality (MTDEQ) showed that acid rock drainage was a widespread occurrence at both the Zortman and Landusky Mines. The MTDEQ requested that ZMI propose corrective measures to their existing reclamation plans. In March 1998 ZMI and its parent company, Pegasus Gold Corporation, announced that were going to reclaim and close the mines.

Photo 3. Landusky Mine with the L87/91 leach pads in the foreground and the Surprise Pit and other pits in the background.

The MTDEQ and Bureau of Land Management (BLM) are overseeing implementation of a mine reclamation plan using reclamation bonds from ZMI and other available funding. A technical grouping group consisting of representatives of MTDEQ, BLM, EPA and Native American tribes was formed to develop reclamation alternatives. The development of remediation alternatives centered on addressing six general reclamation issues;

- final amounts of mine pit backfill- There was a lot of discussion about the appropriate amount of mine pit backfill. Both the benefits of mine pit backfill and the drawbacks were raised. Pit backfilling can be used to address surface drainage concerns, prevent exposure of acid generating highwalls, reduce visual impacts, and lessen the overall disturbance footprint.

- relocation of mine waste facilities - Connected with the pit backfill issue is the issue of impacts associated with the removal of mine waste facilities, such as waste rock dumps or spent ore from leach pads, and placing them as backfill. Removal of some of these waste facilities from problematic locations (such as near drainage bottom) could eliminate a source of contamination. Relocation could be used to consolidate mine waste in a single location, thus reducing infrastructure costs for monitoring, capture and treatment of impacted waters. Concern was about where relocated mine would be placed, and the increased environmental risk of moving mine waste from a watershed where capture of contaminated seepage has been implemented to another drainage area that does not have significant water quality contamination.
- drainage of mine pits – Achieving free draining conditions of the mine pits was a priority reclamation objective due to the potential adverse impacts associated with the infiltration of runoff through the mine pit floor or the creation of a pit lake.
- protection/restoration of water quality and quantity – Existing and historic mining operations have impacted water quality and aquatic habitat. The mines were discharging under interim effluent guidelines that may not be protective of the environment. Establishment of final effluent limits and points of compliance under an MPDES permit were included in the analysis.
- reclamation grading, cover design and revegetation – Achieving a stable reclamation slope that will minimize infiltration and support revegetation is important to reclamation success. Impacts associated with performance of the reclamation cover included, impacts from infiltration of precipitation, slope erosion, and ability to support vegetation.
- restoration of area aesthetics and land use – Areas within the Little Rocky Mountains and specific sites near Zortman and Landusky mines are culturally and historically important to various North America Indian peoples. The mine disturbances have created impacts that affect the use of the mountains for traditional cultural purposes. Development of reclamation measures that would make the mountains more conducive to traditional cultural practices were identified.

In the Fall of 1999 the technical working group identified interim reclamation activities that could be conducted using available funds. Interim reclamation work at the Landusky Mine includes: regrading, placement of soil and planting on the L80-82, L83 and L84 leach pads; cutting a drainage notch around the L85/86 leach pad; regrading the Gold Bug pit complex; regrading the east side of the L91 leach pad ; building out the L84 dike and contouring the slope southeast of the L84 dike; reducing the highwall at the north end of the Gold Bug pit by blasting; backfilling the Suprise (it's not a misspelling-there really is only one 'R' in the name) and Queen Rose pits to establish positive drainage; installing a GCL liner over the backfill on the Suprise pit floor; and regrading the August #1 waste rock dump to cover adjacent pit benches.

Recently, interim reclamation work on the Landusky Mine Suprise pit began. The engineer/contractor for the Suprise pit reclamation project was Spectrum Engineering of

Billings, Montana. Additional clean waste material was imported into the pit and the bottom was graded to a relatively flat 3% slope and a two-inch layer of bentonite was spread over the waste and compacted. The bentonite layer was then overlaid with a membrane-laminated unreinforced GCL (Photo 3). The GCL, laminated with a thin polyethylene membrane, was used because infiltration needed to be minimized, even if the pit pooled with several feet of water during snowmelt. Small piles of cover soil were placed intermittently on the GCL panels to prevent movement from high winds until placement of the full final cover. The use of a GCL allowed for quick installation and approximately 20,000 square meters (220,000 square feet) of material were installed in three days in November 2001.

Photo 4. Installation of laminated GCL at the Landusky mine Suprise Pit.

Summary

GCLs have become a useful tool in mining reclamation and remediation. As illustrated by the Apache Tailings Impoundments Remediation project and the Landusky Mine Suprise pit reclamation project, the tolerance of GCLs to freeze-thaw cycling allows for an extended construction season. Also, GCLs provide a cost-effective alternative to compacted clay liners where on site clay is not available.

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Biography

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