PHYSICAL-CHEMICAL TREATMENT WITH GEOTUBE® FILTRATION APPLIED TO UNDERGROUND GOLD MINE DEWATERING IN WINTER

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ABSTRACT

Vezza Mine, a former gold mine includes a three-compartment shaft with four underground levels down to a depth of 741 metres, This mine was never put in production since its construction around 1997. In 2010, North American Palladium bought the mine and had to dewater the underground infrastructure to restart mine exploitation. Mine water was highly charged with Total Suspended Solids (TSS), Iron (Fe), Zinc (Zn) and Copper (Cu) and it was not possible to discharge that water into the natural environment. First step was to pump and treat water to dewater mine galleries and second step was to treat mine water on a regular basis. ASDR installed a chemical conditioning unit coupled with a Geotube® bag filtration unit. Treated water reached and exceeds the regulatory discharge criteria of the Quebec Government Directive 019. System has been running since January 2011 and still produces the same water quality.

Key Words: Water Treatment, Mine, Geotube Filtration, Dewatering.

INTRODUCTION

Vezza is an advanced-stage exploration project situated 80 kilometres by paved road from NAP's Sleeping Giant gold mine. The Vezza gold deposit historically underwent extensive exploration of 85,000 metres of drilling, and substantial underground development. The project, which has power at site, includes a three-compartment shaft with four underground levels down to a depth of 741 metres, a hoist, and surface and pollution control infrastructure. An internal feasibility study was prepared by AEM in 1997, but the project was never put into production due to the absence of nearby milling facilities and relatively low gold prices at the time.

In 2010, North American Palladium bought Vezza mine (picture 1). To re-start mine exploitation, first step of the project was to dewater the underground galleries and main shaft. Mine water didn't comply with the Quebec Government regulation for mine water discharge in the natural environment. A water treatment program was required and the second challenge was to start pumping and treating water during the winter period.

Picture 1. Vezza Mine – Head Frame

SITE CONDITION AND TREATMENT GENERAL DESCRIPTION

North American Palladium Ltd. asked for a water treatment program to control Total Suspended Solids (TSS) level as well as Iron (Fe), Zinc (Zn) and Copper (Cu) level to comply with the Directive 019 levels (Quebec Ministry of Environment and Parks 2012) required by Quebec environmental authorities in case of mine dewatering and exploitation (Table 1).

Table 1. Directive 019 - Discharge Criteria under Quebec Regulation

PARAMETER	Monthly Average Concentration	Maximum Concentration
Arsenic	0,2 mg/L	0,4 mg/L
Copper	0,3 mg/L	0,6 mg/L
Iron	3 mg/L	6 mg/L
Nickel	0,5 mg/L	1 mg/L
Lead	0,2 mg/L	0,4 mg/L
Zinc (extractable)	0,5 mg/L	1 mg/L
Cyanide	1 mg/L	2 mg/L
Hydrocarbons (C10-C50)	----------	2 mg/L
TSS	15 mg/L	30 mg/L

Pumping started in January 2011 and flow rate reached 100 m^3/h to 200 m^3/h for a 30 day period, 24 hours per day. Total pumped volume was about 72 000 m^3. As the objective was to maintain water level in the mine at a certain level, an average flow rate of 35 m^3/h was treated.

A physical-chemical treatment was used (picture 2), and is still in use, to comply with the level of contaminants authorized by Directive 019. This treatment is a process of coagulation-flocculation to capture dissolved ions and aggregate those ions into filterable flocs. Those flocs are filtered using geotextile filtration with a Geotube® bag. Once filtered, treated water is then stored in an existing lagoon and could be discharged or re-used in the mine exploitation process.

Picture 2. General view of treatment unit and Geotube® filtration

PHYSICAL-CHEMICAL TREATMENT

A 150 HP pump feeds a 4 inch underground pipe and above ground pipe to pump water from the galleries to the treatment unit. A 6 inch pipe is installed on the top of the treatment unit to feed the treatment unit.

As mine water contains TSS and heavy metals, in-line treatment is done in three chemical conditioning steps using three different additives, followed by a physical filtration (picture 3).

Step1: pH adjustment

pH is raised to 10,5 using sodium hydroxide addition. That step precipitates metals and unbalances electrical charges around the ions.

Picture 3. Water quality at different steps of chemical conditioning

Step 2: Coagulation

A coagulant (aluminum sulfate) is added to change electrical interaction between Fe and Zn ions that now are able to agglomerate creating a spin floc. At the same time, aluminum sulfate is reducing pH to an acceptable level for the last step of the chemical conditioning.

Step 3: Flocculation

A polymer is added to produce flocs composed of spin-flocs agglomerated by the polymer long carbon chain. Those flocs reach a size larger than 400 microns so they can be filtered using a Geotube® bag.

The whole process takes place in a treatment unit designed and provided by ASDR (picture 4 and picture 5).

Picture 4. ASDR treatment units on site

Picture 5. Inside the ASDR treatment unit

Physical separation using a geotextile tube

A Geotube® is made of GT500 fabric which is composed of high-tenacity polypropylene yarns, which are woven into a stable network such that the yarns retain their relative position (Table 2). GT500 is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

Table 2. Specifications of Tencate GT500 fabric

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			Machine Direction	Cross Direction
Wide Width Tensile Strength (at ultimate)	ASTM D 4595	kN/m (lbs/in)	70 (400)	96.3 (550)
Wide Width Tensile Elongation	ASTM D 4595	%	20 (max.)	20 (max.)
Factory Seam Strength	ASTM D 4884	kN/m (lbs/in)	70.1 (400)	
Apparent Opening Size (AOS)	ASTM D 4751	mm (U.S. Sieve #)	0.425 (40)	
Water Flow Rate	ASTM D 4491	$L/m/m^2$ (gpm/ft^2)	813 (20)	
Mass/Unit Area	ASTM D 5261	g/m^2 (oz/yd^2)	585 (17.3) (Typical Value)	
UV Resistance (% strength retained after 500 hrs)	ASTM D 4355	%	80	

Clear effluent water simply drains from the Geotube® container through the small pores in the specially engineered textile. This results in effective dewatering and efficient volume reduction of the contained materials. This volume reduction also allows for the repeated filling of the TenCate Geotube® container. Over 99% of solids are captured, and clear filtrate can be collected and recirculated through the system.

After the final cycle of filling and dewatering, the solids remain in the bag and continue to densify due to desiccation as residual water vapor escapes through the fabric. During winter and spring, repeated freeze-thaw cycles would increase solid-liquid separation and the solid content inside the bag. Volume reduction can be as high as 90%. When full, the Geotube® container and contents can be deposited at a landfill, remain on-site, or the solids can be removed and land-applied when appropriate. In the case of the Vezza project, Geotube® bag dewatered content is safely removed and disposed in the mine tailings facility.

Two Geotube® bags 60 ft circumference x 100 ft long were installed to filter mine water after chemical conditioning into the treatment unit (Picture 6 and 7). Those tubes are installed on an impermeable lay-down area to collect exfiltration water prior to gravity drainage to the storage lagoon of treated water.

Picture 6. A Geotube® bag on an impermeable membrane.

Picture 7. Treated water flowing from the Geotube® bag

Even at very low temperature, Geotube® bags do not freeze. Snow and ice on the top of bag act as an insulation layer protecting the bag from low temperature. Also, continuous water flow helps to keep enough energy to avoid freezing under that insulation layer.

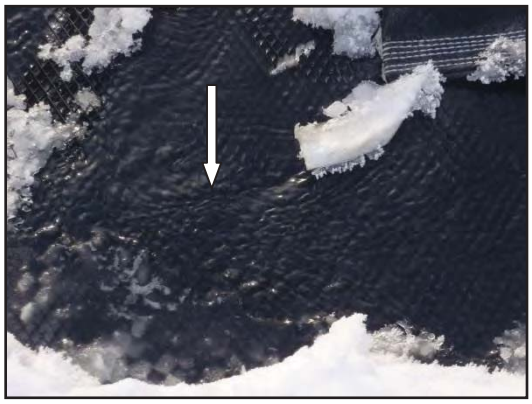
TREATMENT PERFORMANCES

Table 3 shows the results of mine water treatment using the ASDR treatment solution in 2010.

Table 3. Water analysis

Parameters	Raw water mg/L	Treated water mg/L	Directive 019 level mg/L
Copper (Cu)	0.061	0.02	0.300
Iron (Fe)	4.700	0.480	3.000
Zinc (Zn)	0.453	0.015	0.500
TSS	98	9	15
pH	8.05	8.11	6 to 9.5

Presently the treatment unit is operated by a team of Vezza Mine staff trained by ASDR. The treatment performance is still achieved after more than 3 years of operation (Picture 8).



Picture 8. Clean effluent from the geotextile filtration tube Geotube®

CONCLUSION

ASDR mine water physical-chemical treatment combined with Geotube® filtration is an efficient solution to reach environmental discharge objective even in Nordic conditions.

Vezza Mine utilized that solution for gallery mine water treatment and has now been applied daily for more than 3 years.

REFERENCES

Quebec Ministry of Environment and Parks. 2012. Directive 019 about Mining Industry. Quebec Government. 95 p.

Overcoming Northern Challenges

Proceedings of the 2013 Northern Latitudes Mining Reclamation Workshop and

38th Annual Meeting of the Canadian Land Reclamation Association

Whitehorse, Yukon September 9 – 12, 2013

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Wednesday:	**Back To Tuesday**
Eary, Russell, Johnson, Davidson and Harrington	Water Quality Modelling and Development of Receiving Environment Water Quality Objectives for the Closure Planning in the Keno Hill Silver District (paper not attached)
Knight	Galena Hill, Yukon, Ecosystem Mapping Project
Polster	Natural Processes: An Effective Model For Mine Reclamation
Dustin	Implementation of contaminated water management system upgrades to allow for dewatering of two open pits at the Vangorda Plateau, Faro Mine Complex, Yukon
Kempenaar, Marques and McClure	Tools for Arctic Revegetation: What's in Your Toolbox?
Smreciu, Gould, and Wood	Establishment of Native Boearl Plant Species On Reclaimed Oil Sands Mining Disturbances
Keefer	Twin Sisters Native Plant Nursery
Pedlar-Hobbs, Ludgate and Luchinski	Key Factors in Developing and Implementing a Successful Reclamation Plan
Chang, et.al	Effects of Soil Aggregates Sizes (paper not attached)
Heck	Phytoremediation of petroleum hydrocarbon impacted soils at a remote abandoned exploration wellsite in the Sahtu Region, Northwest Territories
Janin	Passive treatment of drainage waters: Promoting metals sorption to enhance metal removal efficiency
Stewart and Siciliano	Biological Soil Crusts and Native Species for Northern Mine Site Restoration
Nadeau and Huggard	Restoration Planning and Application of Ecological Succession Principals
Simpson	Defining Disturbance and Recovery - the influence of landscape specific ecological responses to oil and gas linear disturbances in Yukon

NORTHERN LATITUDES MINING RECLAMATION WORKSHOP

The Northern Latitudes Mining Reclamation Workshop is an international workshop on mining, land and urban reclamation and restoration methods. The objective of the workshop is to share information and experiences among governments, industry, consultants, Alaska Natives, northern First Nations and Inuit groups which undertake reclamation and restoration projects, or are involved in land management in the north or in comparable environments.

The first Workshop was held in Whitehorse, Yukon Territory, Canada in 2001 and it has been held every two years since, alternating between Canada and Alaska. The primary sponsors of the Workshop include the Yukon Geological Survey, Indian and Northern Affairs Canada, Natural Resources Canada, US Department of the Interior Bureau of Land Management, and the State of Alaska Department of Natural Resources.

CANADIAN LAND RECLAMATION ASSOCIATION

The CLRA/ACRSD is a non-profit organization incorporated in Canada with corresponding members throughout North America and other countries. The main objectives of CLRA/ACRSD are:

- To further knowledge and encourage investigation of problems and solutions in land reclamation.
- To provide opportunities for those interested in and concerned with land reclamation to meet and exchange information, ideas and experience.
- To incorporate the advances from research and practical experience into land reclamation planning and practice.
- To collect information relating to land reclamation and publish periodicals, books and leaflets which the Association may think desirable.
- To encourage education in the field of land reclamation.
- To provide awards for noteworthy achievements in the field of land reclamation.

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