Royal Oak Mines - Stakeholder Comment on the Draft Regulation under the NWT Environmental Protection Act - "Gold Roaster Discharge Control Regulation"

Royal Oak Mines, in cooperation with its employees, have worked very hard over the past years to hold the line or reduce wherever possible the cost of operating at the Giant mine. In 1995 this effort returned a margin of profit[2] of only $26.25 US per ounce of gold produced at the Giant mine. In 1995 the mine experienced a 10% drop in the number of ponces produced primarily as a result of lower mill feed grades and lower mill feed tonnages. It is within this context that the mine has to continue to struggle to maintain its future economic viability. If the cost of compliance with new legislation eats up this margin of profit then the corporation has no option but to consider the cessation of mining and milling activity at the Giant mine on the basis of economics.

Royal Oak Mines Inc. has a long standing record as a law abiding corporate citizen. The corporation has and will continue to act in compliance with all legislation and the associated regulations established by the representative governments in the jurisdictions in which the corporation operates. Royal Oak will continue to make its business decisions with due regard to all of the applicable legislation enacted by the duly elected governments in the jurisdictions in which it operates. In accordance with a duty to its shareholders Royal Oak will continue to make business decisions based on the economic reality at each of the mines the corporation operates. The corporation will not subsidize an unprofitable mine if the economic reality is such that this operation has no way of returning to profitablity in the forseeable future.

Background

The Giant mine first went into production in May of 1948. The ore body is a refractory gold deposit where the contained gold is locked within the matrix of an arsenic sulphide mineral called arsenopyrite. Direct leaching of this ore yields very low gold recoveries (approximately 25%). Consequently it was recognized from the mine's inception that the arsenopyrite mineral matrix would have to be broken down and the sulphur and arsenic contained within the ore removed to enable the contained gold to be economically extracted.

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[2]In 1995 the Giant mine produced 91,423 ounces of gold at an operating cost of $339 US per ounce (cash cost + amortization and depreciation). The average spot price for gold in 1995 was $384 US per ounce yielding an income of $4.1 Million US of which $1.7 Million was reinvested as capital in replacement equipment and development of the Supercrest ore reserves... source 1995 annual report for Royal Oak Mines Inc.

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To accomplish this, an Edwards Hearth type roaster was constructed at the Giant mine in 1948, however the complex nature of the ore yielded poor metallurgical results. In the early 1950's a refractory gold ore roasting technology called fluid bed roasting was tested at the Giant mine with encouraging results. A full scale fluid bed roaster was subsequently constructed however the initial equipment proved to be difficult to operate. Using the experience gained from this early fluid bed roasting equipment, the current two stage fluid bed roaster was designed and installed at Giant in the mid 1950's. This design has since become the standard for arsenopyrite gold roaster installations all over the world.

In the Giant milling process the gold bearing minerals, namely arsenopyrite and pyrite are recovered from the ore in a process called flotation. The resulting "flotation concentrate" is then roasted at an elevated temperature to break down the arsenopyrite and pyrite mineralization leaving behind a residue from which the gold can be economically extracted. This process employs a two stage fluid bed roaster operating at a temperature of 935^0 to 950^0 F.

In the first stage roaster pyrite and arsenopyrite are oxidized under slightly reducing conditions (ie a deficiency of oxygen in the roaster atmosphere to prevent over oxidation of the arsenic). The sulphur contained in the pyrite and arsenopyrite mineralization is oxidized to form sulphur dioxide in a gaseous state while yielding heat as a byproduct. This reaction fuels the roasting process. The arsenic contained in the arsenopyrite mineralization is oxidized to form arsenic trioxide also in a gaseous form. The solid residue from the first stage roaster is transferred into the second stage roaster while the gas stream exits the process to be cleaned in the downstream gas treatment plant.

In the second stage roaster the remaining pyrite and arsenopyrite mineralization is roasted under oxidizing conditions to remove as much as possible of the remaining sulphur to form sulphur dioxide in a gaseous form. The solid residue from the second stage roaster is primarily a mix of gold bearing iron oxide (hematite and magnetite) which is removed and sent to a gold recovery circuit. The gas stream exits the process and is combined with the gas stream from the first stage roaster to be cleaned in a downstream gas cleaning plant.

The combined gas streams are passed through a series of cyclones to remove coarse calcine dust. The hot gas is then passed through an electrostatic precipitator where an electrical charge is imparted to the very fine particles of calcine dust remaining in the gas stream. The charged particles of dust are recovered on electrodes with the opposite charge, removed from the electrostatic precipitator and recycled to the milling process for extraction of the contained gold values.

The gas stream exiting the electrostatic precipitator is cooled to 260^0 F by mixing the hot gas with large volumes of ambient air in a contained mixing chamber. At the cooler temperatures the arsenic trioxide condenses from the gaseous phase into a solid (powder form). The cooled gas stream is passed through a series of baghouses where the arsenic is filtered from the gas stream. The effectiveness of the baghouse in recovering arsenic trioxide from the gas stream is greater than 99%. The recovered arsenic trioxide dust is pneumatically transferred from the baghouse to a rock storage vault located underground in the permafrost. The filtered gas exiting the baghouse is drawn through a fan and discharged to the atmosphere through a 49 meter high stack.

The Giant roaster off gas cleaning facilities were designed in the 1950's to comply with emission standards of the day. The facility was voluntarily upgraded in the 1970's to take advantage of technological advances and to reduce arsenic emissions to levels consistent with new emission guidelines set in Ontario.

The regulation proposed by the NWT Government will require that sulphur dioxide emissions be reduced by 90% and will most probably render the Giant roaster facility obsolete. The addition of gas scrubbing equipment or an acid plant are neither economically nor technically feasible. The requirement to remove both arsenic and sulphur dioxide from the roaster gas stream eliminates the viability of many of the standard gas cleaning processes currently employed in other industries.

The large volumes of ambient air used to cool the hot gas exiting the electrostatic precipitator enables arsenic trioxide to be recovered from the gas stream. This process results in a very dilute concentration of sulphur dioxide in the gas exiting the stack. The low concentration (typically 31 g/m^3 - less than 0.1% on a dry basis) technically precludes the production of sulphuric acid. Even if sulphuric acid could be recovered from the stack gas, the problem of transporting or disposing of the acid becomes insurmountable given the remote location of Yellowknife. Wet scrubbing of the gas to remove sulphur dioxide would require massive volumes of limestone to neutralize the sulphuric acid produced and would require treatment of the water to remove the entrained arsenic. An independent report commissioned by Environment Canada estimates the annual cost of wet scrubbing of the roaster gas and the subsequent treatment of the scrubber products at more than $18 million which is 3 to 4 times the amount of annual income generated by the Giant mine. Wet scrubbing is not an economically viable option. Wet scrubbing would produce large volumes of precipitated sulphate and ferric arsenate, the disposal of which presents a new environmental problem.

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Events Leading to the Regulation of Gold Roaster Discharges

An investigation of arsenic and sulphur dioxide emissions from the roaster stack at the Giant mine was undertaken by the N.W.T. Department of Renewable Resources after a request for such an investigation was filed with the Government of the Northwest Territories under the N.W.T. Environmental Rights Act on April 22,1991. The complaint was filed by two Yellowknife residents both of whom are well know local environmental activists who routinely oppose the presence of the Giant mine in Yellowknife. The complaint alleged that stack emissions were damaging vegetation to the northwest of the minesite.

In June of 1994 the NWT Government promulgated a guideline under the NWT Environmental Protection Act that established a standard for the maximum desirable level of sulphur dioxide in ambient air throughout all of the Northwest Territories. These standards were to be applied as a long term goal:

NWT Environmental Protection Act Guideline

Sulphur Dioxide micrograms per cubic metre		
Annual	**24 Hours**	**1 Hour**
30	150	450

The NWT Department of Renewable Resources has indicated that at their monitoring station in downtown Yellowknife the NWT standard for sulphur dioxide in ambient air is exceeded overall about 1% of the time. When only considering days when the wind is blowing into the monitor from the Giant mine the NWT standard is exceeded 10% of the time.

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In 1975 the Federal Clean Air Act established the following air quality objectives for sulphur dioxide in ambient air throughout Canada:

Federal Clean Air Act Guideline

Average Concentration of SO_2 over a Continuous Period in ug/m^3		
1 Year	**24 Hours**	**1 Hour**
Maximum Desirable Level 30	150	450
Maximum Acceptable Level 60	300	900

Where:

The **Maximum Desirable Level** is the long term goal for air quality and provides a basis for an anti-degradation policy for unpolluted parts of the country, and for the continuing development of control technology.

The **Maximum Acceptable Level** is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, viability, personal comfort and well being.

It should be noted that these numbers remain objectives. They are intended as targets to guide Canadian industry and to spur the development of new emission control technologies. The Federal Government has chosen to not enact these levels into law.

Nine of the ten Canadian provinces have subsequently established their own ambient air quality objectives for sulphur dioxide. These objectives are presented in Table 1.

Table 1: Provincial Ambient Air Quality Objectives for Sulphur Dioxide	**Sulphur Dioxide ug/m³**		
	Annual	**24 Hour**	**1 Hour**
Canada			
Tolerable		800	
Acceptable	60	300	900
Desirable	30	150	450
British Columbia	49.2	255.6	884.9
Alberta	30	150	450
Saskatchewan	30	150	450
Manitoba	60	300	900
Ontario	55	275	690
Quebec	59.2	289.1	1315.2
New Brunswick	59.1	295.6	886.9
Nova Scotia	-	-	-
Prince Edward Island	60	300	900
Newfoundland	55	274.8	824.5
Northwest Territories	30	150	450
Yukon	-	-	-
Alaska	79	360.2	1283 (3 Hr)
U.S.A.	80	365	1300 (3 hr)

As can be seen the standard established by the Northwest Teritories is amongst the lowest of any set in Canada and is well below that applied in Alaska. It should also be noted that in the provinces which have a long history of significant mining and industrial development, ambient air quality objectives for sulphur dioxide were set at levels that are well above those imposed in the N.W.T.

Despite the establishment of these air quality objectives, most industrial sources of sulphur dioxide emissions in Canada are being regulated under site specific regulations or guidelines that establish industry specific standards that are higher than the provincial objectives listed in Table 1. This is primarily due to two factors:

i) The ability to achieve the provincial ambient air quality criteria for sulphur dioxide is limited by the availability and efficiency of state of the art technology to reduce sulphur dioxide emissions.

ii) The cost of installing and implementing sulphur dioxide emission control technology at plants that were constructed prior to the introduction of the current federal and provincial standards for ambient air quality is high. Implementation of a new standard often renders the emission control equipment at an industrial facility obsolete necessitating total replacement or major upgrading.

In most of these situations the provinces choose to apply the provincial standard to establish operating licenses for any new source of sulphur dioxide emissions. In these cases the standards are set prior to the facility being constructed. In nearly all cases across Canada, exemptions are granted to specific industrial sites that were in operation prior to these new standards being promulgated. There is general acknowledgement that the imposition of these new standards on existing plants without an extended period of adjustment would have significant negative impact on the future viability of these operations.

In the larger perspective it should be noted that the amount of sulphur dioxide emitted from the Giant roaster is relatively small when compared to other industrial development in Canada and throughout the world. For example the Hudson Bay Mining & Smelting operations in Flin Flon Manitoba have recently undergone a multi-million dollar upgrade to reduce total sulphur dioxide emissions by 25% to 23 KT daily or 220 KT annually. By comparison the Giant roaster emits 0.04 KT daily or 13 KT annually.

In Sudbury, the Ontario government negotiated a control order with both Falconbridge and INCO to control ground level concentrations of sulphur dioxide at 1,309 ug/m^3 on a 1 hour rolling average basis at the nearest populated area to the smelters. By comparison the Giant roaster stack is being asked to meet a 1 hour average of 450 ug/m^3 in Yellowknife. This ground level concentration of 1,309 ug/m^3 is the standard being met after the expenditure of large amounts of capital by both corporations to modernize smelting and pollution control equipment.

In these other jurisdictions the application of standards was based on achieving ground level concentrations of sulphur dioxide that protect the general public and surrounding environment. The levels were based on a review of the scientific evidence.

The regulation proposed by the NWT Government is more stringent than that applied in these cases and will have the impact of rendering the current ore roasting facilities at the Giant mine obsolete.

Future of the Giant Mine Under The Regulation

Over the past five years the majority of the ore extracted from the Giant mine has come from the mining of remnant pockets of ore left behind from previous mining activities. Without a major new discovery it will become more and more difficult to replace the reserves mined each year.

At the end of 1995 the Giant mine had a mineable ore reserve of 826,000 ounces of gold. Mine staff have identified an additional 1,317,000 ounces of gold in mineralized material that may some day be upgraded to the mineable reserve category.

The reported mineable reserve for the Giant mine includes 149,000 ounces of gold in mineable ore located at the Nicholas Lake property north of Yellowknife. This later reserve is not refractory in nature and will not require roasting to recover the contained gold consequently the true reserve at the Giant mine is only 677,000 ounces of gold.

At current mining rates and economic conditions, the Giant mine has an identified ore reserve of 6.7 years. If all of the mineralized material can be successfully converted to ore this life would be extended by an additional 13 years. The ability to convert this mineralized material into mineable ore is very much a function of the ability of the mine to keep its operating costs down. This mineralized material is generally lower in grade and is thus much more sensitive to any change in operating costs.

The N.W.T. Government has identified a $30 to $50 million capital cost to replace the existing roaster at Giant with a pressure oxidation system utilizing an autoclave. In Royal Oak's estimation the capital cost of this conversion will be in the order of $50 to $60 million. Without taking any financing costs into account this upgrade would equate to a cost of between $74 and $89 Cdn per ounce of gold produced when amortized over the remaining mineable reserve. In 1995 operating costs at the Giant mine were $458 Cdn per ounce which includes depreciation and amortization. The investment in a new $50 million plant would raise operating costs to $532 Cdn per ounce produced.

The current market value of gold is only $524 Cdn ($385 US at an exchange rate of 1.36). It can quickly be seen that an investment of between $50 and $60 million Cdn at this late date in the mine life would wipe out any possible return on investment and render the mine uneconomic. The cost of financing such a $60 million investment at 8% interest would be $4.8 Million per year or $53.30 Cdn per ounce of gold produced. As can be seen the interest cost alone on such an investment would wipe out any margin of profit and render the mine an uneconmic proposition.

Adding additional reserves into the mineable category would spread the capital cost out but this proposed regulation significantly raises the economic threshold for moving reserves from the lower mineralized material category into the mineable category. Consequently an investment of this magnitude does not make economic sense at this late date in the mine life.

It should be noted that while a pressure oxidation circuit eliminates any gaseous emissions of sulphur dioxide and arsenic into the atmosphere, the pressure oxidation process still produces a waste stream from which both arsenic and sulphur must subsequently be precipitated and discharged into the mine's tailings impoundment. Operating costs associated with the treatment of concentrate through a pressure oxidation plant are typically much higher than the cost of treating a ton of concentrate through the fluid bed roaster. This would worsen the poor economics associated with converting from the roaster to a pressure oxidation circuit at the Giant mine.

Recommendations

In finalizing the Gold Roaster Discharge Control Regulation, Royal Oak would ask the NWT Government to consider the following:

1) What are the socio-economic benefits that will be derived by the citizens of the Northwest Territories as a result of the promulgation of this regulation?

2) The probable outcome of the promulgation of this regulation will be the premature cessation of mining and processing activities at the Giant mine. The high cost involved in complying with this regulation will significantly impair the future ability of the corporation to continue the development and upgrading of marginal mineralized material into mineable ore effectively shortening the mine life. Do the employment benefits that will be lost to the citizens of the N.W.T. outweigh the benefits attained from reducing sulphur dioxide emissions? What would be the harm in "grandfathering" the existing roaster facility at the Giant

Mine and allowing the mine to run out its ore reserve? The current regulation sets June 30, 2006 as the target date for closure of the Giant Mine without some major change in economic outlook.

3) Is this action being taken to placate the interests of a minority group who have been effective at lobbying Government? Does this action represent the interests of the majority of citizens in the N.W.T.?

These are questions that Government must answer honestly for itself.

It should be pointed out that the proposed regulation as worded does not have timelines for implementation of the required measures over the next 12 to 18 month period that are workable given the realities of engineering and the limited construction season in the N.W.T.