Proceedings of the 17th Annual British Columbia Mine Reclamation Symposium in Port Hardy, BC, 1993.
The Technical and Research Committee on Reclamation

MINE ROCK GUIDELINES - AN OVERVIEW

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ABSTRACT

The identification of low pH waters seeping from a uranium mine waste rock dump in northern Saskatchewan initiated the investigation into the potential for acid mine drainage conditions to exist at the mines in northern Saskatchewan.

Studies conducted by the companies operating in the province and the Saskatchewan Environment and Public Safety Mineral Industry Environmental Protection Branch (MIEPB) identified acidic seeps at each of the mining operations. Once identified the question asked was, "how do we assess the problem?".

To be consistent in the approach to assessing the problem the MIEPB decided to publish a guideline that would be a reference manual for the mining companies, government agencies and other interest groups. To ensure that the manual was current the MIEPB contracted a consulting firm to, under the direction of the MIEPB, write the document.

The most important criteria that the consultant had to meet was that of producing a document that was not a text book but rather a "hands-on" users manual.

If success can be measured in numbers then the over two hundred and fifty requests that we have had for the Guidelines would indicate to us that the Guidelines are a success.

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MINE ROCK GUIDELINES -- An Overview

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INTRODUCTION

The identification of acid mine drainage at uranium mines in northern Saskatchewan alerted the Department of the Environment and Public Saftey, Mineral Industry Environmental Protection Branch and the mining industry to the fact that Saskatchewan was not exempt from the problems widely known in other areas of the country and the world that are associated with acid mine drainage.

The magnitude of the problem and its short and long term environmental impacts on northern Saskatchewan have yet to be determined.

The identification of acid mine drainage in Saskatchewan alerted the regulators and industry to the possibility that there may be problems with, not only the existing mines, but also the mines that were being proposed for development. Therefore, not only were we asking the existing mines to evaluate their waste rock, we were also asking the potential operators to evaluate their waste rock prior to mining. As soon as we entered into discussions with the existing and potential operators questions arose, such as:

1. Why look at the waste rock? We don't: have or we don't anticipate a problem?

2. What rock types do we analyze?

3. Size of sample to be collected?

4. Number of samples required?

5. What parameters should be looked at?

6. What laboratory tests will be acceptable?

7. What do the test results mean?

8. How do we utilize the information in planning for decommissioning?

DEVELOPMENT OF THE GUIDELINES

In order to assist operators and potential operators in addressing the preceding questions in a consistent manner the Mineral Industry Environmental Protection Branch decided to develop a set of Guidelines for the industry.

By utilizing the advice and comments from the various stakeholders during the initial stages of development of the Guidelines a product specific to the Saskatchewan mining industry was developed rather than utilizing previously produced texts such as the British Columbia Acid Mine Drainage Task Force and California Mining Association texts on acid mine drainage.

We found when we reviewed the British Columbia and California products that they were written like a text book rather than something that could be actually used as a hands on manual. So, with that in mind, we said that our first criteria for the Saskatchewan guide would be for the final product to be a "hands on, how to manual."

It was at this stage in the development that Mr. Andy Robertson of Steffen Robertson and Kirsten (B.C.),(S.R.K.), was contacted to discuss the compilation of the manual.

During our initial discussions with S.R.K. we indicated that we wanted the final product to be:

1. The Guide must not be a text book but a hands on "user friendly" guide.

2. We did not want a rewrite of the British Columbia guide.

3. We wanted the guide to be representative of the Saskatchewan mining industry.

4. The guide had to be written in such a way so that all stakeholders (ie the mining industry, the regulators, the scientific community, consultants and the general public) in the Saskatchewan mining industry could first of all understand what they were reading and then be able to apply what they had learned.

5. The guide could not be voluminous; that is to say that we didn't want something that was so thick and intimidating that those that received the guide would end up using it for book ends.

6. The guide had to be written so that each section in the guide is a stand alone chapter. The reason for this was to have a document that could be changed on a section by section basis instead of having to rewrite the complete document each time new information was received or technology changed.

WASTE ROCK STEERING COMMITTEE

Coinciding with the initiation of the development of the guide the Mineral Industry Environmental Protection Branch initiated the formation of a Waste Rock Steering committee. The committee was formed to provide a forum for information exchange on the subject of Acid Mine Drainage and Waste Rock Management. The committee is comprised of a representative from each of the active and potentially active; uranium mining companies and a representative from each of the three regulatory agencies.

Upon the completion of a rough draft of the Mine Rock Guideline members of the Waste Rock Steering Committee were asked to review the document and provide comments to MIEPB. The comments were reviewed by the Mineral Industry Environmental Protection Branch and SRK and changes were made to the guide as necessary.

CONTENTS OF THE GUIDELINES

On June 25, 1992 the:

Saskatchewan Environment and Public Safety
Mines Pollution Control Branch
Mine Rock Guidelines Design and Control of
Drainage Water Quality

were released to the mining industry, other regulatory agencies and the general public.

Note: The Mines Pollution Control Branch was renamed Mineral Industry Environmental Protection Branch effective January 1, 1993.

The Guidelines which have been produced are contained in a manual that consists of 127 pages of text, 11 pages of table of contents and references and 38 pages of figures. There are ten sections to the Guidelines which discuss the following topics:

1. Introduction

Introduces the reader to the Guide, provides some background information and discusses the structure of the Guide. Section one also presents a brief history of Acid Rock Drainage.

2. Saskatchewan Uranium Mines

The second section provides some of the background information on the uranium industry in the Province, as well as introduces the regulatory role in the industry. It also provides some information on the water quality, acid generation potential and general geology of northern Saskatchewan.

3. Acid Generation And Metal Leaching

As the title indicates this section of the Guide discusses the process involved in the development of acid conditions and metals leaching

4. Site Assessment

Section four is the first section of what are allied the "how to chapters". This section covers the topics that would be critical to performing a credible assessment of a mine site. Topics discussed under the heading of Field Investigations include: initial investigation, seep surveys, detailed laboratory studies, detailed field investigations, rock pile instrumentation, sediment sampling and biological monitoring.

5. Prediction

The section on Prediction is the second largest section of the Guide. This section's objective is to introduce the user to the various factors involved in predicting the potential the waste rock may have for having adverse effects on the environment. The section covers the topics of sampling, laboratory testing, interpretation and many more.

6. Control Technology

This section discusses the various options that are currently available to the operator for the control of an existing situation or for the mine that is in the planning stages.

7. Modelling

The section on modelling introduces the reader to the models that may be applicable to their situation. The section also discusses the topics of infiltration, dump characterization, acid generation, flow path and surface and subsurface flow.

8. Closure and Long Term Control

The closure and control section discusses the various topics that are related to the discussion of how to close out a site. Topics covered include; physical stability, chemical stability, land use and aesthetics, long term performance of control options, risk of failure, and methodology for evaluation of options.

9. Monitoring

This section discusses the various approaches to monitoring a site.

TABLE 1.1

Summary Guide to Site Assessment and Management Plan Development

SUBJECT STAGES IN PLAN DEVELOPMENT	APPLICABLE TO:			APPROPRIATE SECTION OF GUIDE
	NEW MINE	EXISTING MINE	CLOSED MINE	
Understanding of Acid Generation	●	●	●	1,2,3
Understanding of Metal Leaching	●	●	●	1,2,3
Definition of Pre-development Environment	●	●	○	7.1
Definition of Development	●	●	●	
Site Assessment - Field Investigations	•	●	●	4
Contaminant Release Prediction				
- ARD	●	○	•	5
- Contaminant Leaching	●	○	•	5
Control Measures Selection and Design				
- Subaqueous deposition	●	○	•	6.2.4
- Covers	●	●	●	6.2.3
- Others	○	○	•	6
Modelling	●	●	○	7
Closure Plan Preparation	●	●	●	8
Monitoring				
- Surface water	●	●	●	9
- Groundwater	○	●	●	
- Mine rock/tailings	-	●	●	
- Sediments	•	●	●	4.3.6
- Biological	●	●	●	4.3.7
- Seeps	-	●	●	4.3.2
- Control Structures	-	●	●	
- Climate	●	●	●	

Key: ● Required at comprehensive level.
○ Generally required at intermediate level.
• May be required; usually at low or intermediate level.

Steffen Robertson and Kirsten

10. References

The references in this section have been written to coincide with the section in which they are referenced.

USING THE: GUIDELINES

Various sections of the Guidelines can be used to answer questions which arise pertaining to the evaluation of waste rock. The following is a list of the previously referenced questions and the answers arrived at by using the information contained in the Guidelines. The following table (Table 1.1) is an excerpt from the Guideline. It can be seen that it is relatively simple to access the section of the Guideline that contains the information that one may be interested in.

1. Why look at the waste rock? We don't have or we don't anticipate a problem?

This was, and in some instances, still is the response that we will get from an operator. However it is becoming more accepted that as ore bodies are being investigated in some cases there is a potential problem.

2. What rock types do we analyze?

"Sampling is perhaps the most critical aspect of the prediction program. Samples must be representative of all geologic and lithologic units related to the mine development plan, and representative of the relative amounts of each type of material, "(page 5-6 Mine Rock Guideline). Having said this, the uranium ore bodies of today are complex. This may be a bit of an understatement. For example, the following is an excerpt from a paper written by Mr. P. Bruneton of Cogema Canada on the Geology of the Cigar Lake Uranium Deposit.

"The deposit is enveloped by extensively altered rocks. In the basement, hydrothermal alteration (illitization, chloritization, development of dravite-phosphates-calcite) is superimposed upon previous retrograde and regolithic alterations. In the sandstones, alteration processes display concentric zones generally extending up to about 300 meters above the orebody. They consist, from top to bottom, of bleaching, grey alteration (sulphide impregnations), euhedral quartz crystals growths, and argillization (illite) with massive quartz dissolution and intense fracturing. The orebody is commonly capped by a zone of hematized clay (illite, Fe-rich illite and Mg-rich illite) containing siderite and hydrocarbons."

Therefore the question remains what rock types do we analyze? For the underground mine operator the job of selecting an appropriate zone of mineralization is made easier because you are not dealing with the large volumes of waste rock that are associated with open pit operations.

One method of evaluation that we feel holds some promise for evaluating orebodies prior to or post mining is discussed in the New Initiatives section of this paper.

3. Size of sample to be collected?

For a static test this could mean a sample size of a 1 kg minimum. For kinetic test the sample size may vary widely depending on the type of test to be performed, eg. a flow through column test may require 2-5 kgs of sample where a modified humidity cell test may require many kilograms depending on the size of the column being used.

4. Number of samples required?

The number of samples to be collected for each rock unit will be dependent on the stage of the testing program, the mass of the rock, the level of concern and the heterogeneity of the unit. A curve has been developed from a number of sites in British Columbia (See Figure 1).

5. Which parameters should be looked at?

The basic analysis that is required is the determination of the whole rock chemistry of the samples. The following Figure 2 lists the parameters of interest. Tests to determine the total sulphur content are used to determine the acid generation potential of the samples.

6. What laboratory tests will be acceptable?

Generally static and kinetic tests are completed on each of the samples or a combination of samples. The static tests are performed to provide qualitative data. Where as the kinetic tests are performed to provide information on time and rate dependent reactions.

7. What do the test results mean?

As stated previously the static test will provide qualitative data. Various percentages or concentrations of elements will be determined from this analysis. The kinetic test results will assist in the determination of how fast the chemical constituents will be released or how fast and to what degree the acid generating potential of the waste rock comes into affect.

8. How do we utilize the information in planning for decommissioning?

The information provided from the test work will help to determine how the mining company should manage the waste rock associated with the mining of the ore body. For example if the waste is acid generating then disposal options other than above ground disposal should be considered. If the waste rock is not acid generating but has significant amounts of secondary mineralization then it may be necessary to develop management strategies that inhibit or retard the leaching process.

Figure 1

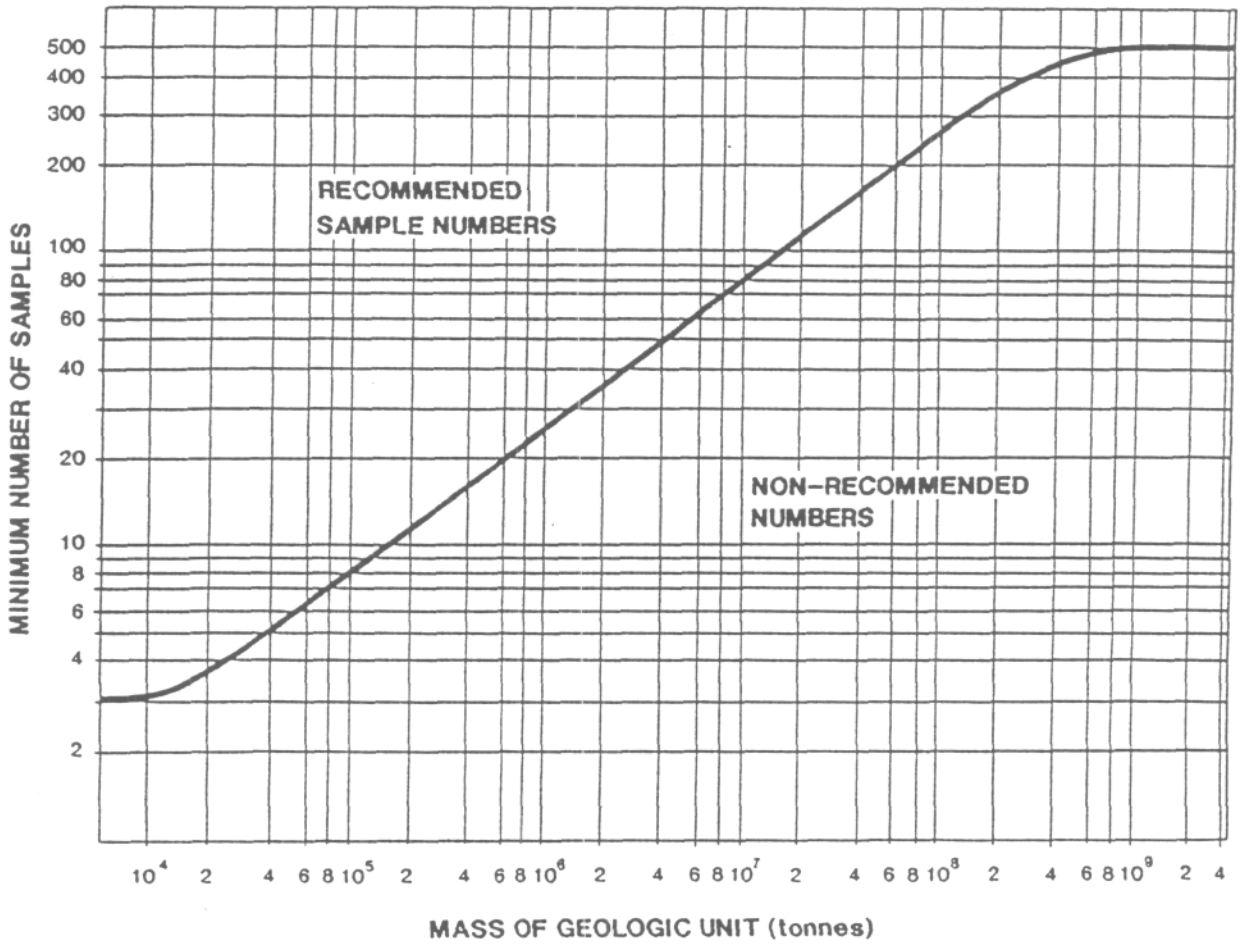

Figure 5.2 Recommended Minimum Number of Samples as a Function of Mass of Each Lithologic/Classification Unit (after SRK et al., 1989)

Figure 2

TABLE 5.2
Proposed Whole Rock Chemistry Analyses for Mine Rock
(after MPCB, 1990)

PARAMETER	TEST PROCEDURE	REPORTING UNITS
Radionuclides		
(Uranium Orebodies)	Require SRC type methods	
Lead 210 (Pb^{210})	and detection limits, as per	bq/g
Polomium 210 (Po^{210})	analyses done for Eagle	bq/g
Radium226 (Ra^{226})	Point Mine Rock	bq/g
Thorium 230 (Th^{230})		bq/g
OTHERS	DETECTION LIMIT	
Al_2O_3	0.1%	%
Fe_2O_3	0.01%	%
CAO	0.01%	%
MGO	0.01%	%
K_2O	0.01%	%
Na_2O	0.01%	%
SiO_2	0.1%	%
TiO_2	0.01%	%
P_2O_5	0.01%	%
Ag	0.1 ug/gm	ug/gm
As	0.2 ug/gm	ug/gm
B	10 ug/gm	ug/gm
Ba	1 ug/gm	ug/gm
Be	1 ug/gm	ug/gm
Bi	0.2 ug/gm	ug/gm
Cd	0.1 ug/gm	ug/gm
Cl	?	ug/gm
Co	1 ug/gm	ug/gm
Cr	1 ug/gm	ug/gm
Cu	1 ug/gm	ug/gm
Fe	1 ug/gm	ug/gm
K	?	ug/gm
Mo	2 ug/gm	ug/gm
Ni	1 ug/gm	ug/gm
pb	2 ug/gm	ug/gm
S	0.002%	ug/gm
Sb	0.2 ug/gm	ug/gm
Se	0.2 ug/gm	ug/gm
Ti	?	ug/gm
U	0.1 ug/gm	ug/gm
V	1 ug/gm	ug/gm
W	?	ug/gm
Zn	1 ug/gm	ug/gm
Zr	1 ug/gm	ug/gm
% LOI	0.1%	ug/gm
Ag	0.001 ug/gm	ug/gm
Other rare earths?	1 ug/gm	ug/gm

NEW INITIATIVES

Presently we are working on rewriting chapters five and six of the guide. Chapter five which discusses methods of prediction will be rewritten to include a method of evaluating the quality and quantity of waste rock prior to mining, during mining and post mining.

Chapter six will be rewritten in order to expand the section on the utilization of wetlands in the treatment of waste rock seepage.

A revised version of the guide should be available in early to mid 1993.

Preview of Changes to Section Five

In order to answer the questions related to determining what the waste rock quality and quantity would be we decided, along with the help of Larry Richardson who was then working for Denison Mines Midwest Joint Venture, to investigate a method of evaluating waste rock quality and quantity prior to mining or post mining.

We felt that if mining companies could calculate what the ore grade was for a particular orebody and the amount of tonnes of ore; could not the same approach be taken to evaluate the grade of selected secondary mineralization and the tonnes of the particular mineral or minerals present. What Larry Richardson did was take this idea and use it to determine the potential problems with the waste rock associated with the Midwest Joint Venture project.

Briefly the methodology that is being used is as follows:

1. The waste rock located above and below the orebody was sampled by acquiring samples of drill core from predrilled holes surrounding the orebody. In addition two additional holes were sampled throughout their lengths to represent background or reference material located in the vicinity of the orebody. The drill holes were also utilized to identify the material in which shaft sinking would take place.

2. There were four areas of the proposed mine development that were sampled. Three of these were the drill level, the haulage level, and the drainage level. Samples of the drill core were collected every forty centimetres over a four meter section for each level being examined. Samples from the fourth area, the bench over cut were taken four meters above the intersection with the ore zone.

   Therefore there were approximately ten samples taken over four meters for each of the development levels sampled.

3. Thirty three individual parameters were assayed on each of the one hundred and five samples collected. It was found that there was a very noticeable difference in the mineralogy from one level to another. In order to evaluate further the information from the metals analysis the data was entered into a computer software program called Borsurv. The program is usually used to calculate ore reserves. In this case the program was used to compute the percentages of each mineral that was of interest. A colour plot in plan view or cross section is produced of the blocks that contain the various concentrations of the particular mineral of interest on that particular development level.

4. The information from the computer analysis should make it possible to estimate the approximate quantity of barren waste or special waste rock material that will be encountered during mine development.

5. Leach tests were conducted using column leach and humidity cell tests on seven separate composites of the core samples. The leach tests were run for ten weeks to determine the teachability of the waste rock. Acid base accounting was also carried out on the samples.

Although this is a new approach to waste rock evaluation we feel that this method has great potential in assisting with waste rock management in the future.

CONCLUSION

It is our belief that through consultation with the various stakeholders involved in the Saskatchewan mining industry and in this particular case the uranium industry that a better understanding of the issues will result. We have used the consultative process to produce and publish Mine Rock Guidelines which are specific to our Province.

To date approximately two hundred and fifty copies of the Guidelines have been distributed around the world in countries such as: Africa, Argentina, USA, etc. The interest shown and the comments received can only suggest that as stakeholders we have all done our job.

References

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