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Twenty-five Year Experience in Dewatering at Canadian Mining Complex

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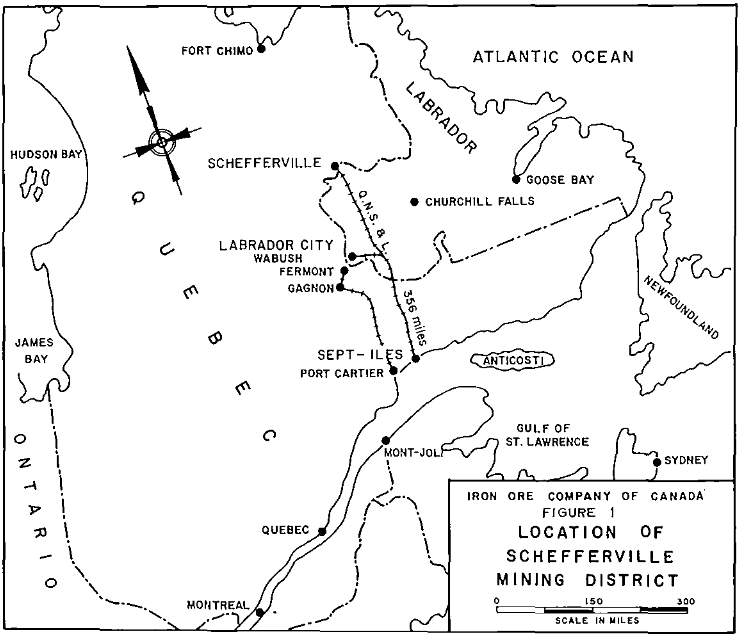
INTRODUCTION:

The Knob Lake complex of the Iron Ore Company is centered around the town of Schefferville (54° 49' North and 66° 50' West) located in Quebec, Canada. (Figure 1).

In addition to the Schefferville complex, the Iron Ore Company's other mining operation is located at Labrador City in Newfoundland. The terminal and port facilities are located at Sept-Iles in Quebec. The distance between mines in Schefferville and Sept-Iles is 365 rail miles.

For its subarctic location, the mean annual air temperature is -4.9 degrees Centigrade or 23.2 degrees Fahrenheit. The precipitation is high with 340 centimeters or 134 inches of snowfall, and 39.5 centimeters or 15.6 inches of rainfall.

In the Schefferville mining complex, six to seven open pit iron ore mines are operated each year. These mines are spread over a distance of approximately 26 miles from south to north and these deposits are located both in the province of Quebec, and Labrador, Newfoundland.



Location of Schefferville Mining District. Figure No. 1.

THE MINING SETUP:

The typical open pit mining setup consists of drilling a 9 7/8 inch diameter hole, blasting and loading the blasted ore by shovels into the trucks. The equipment presently in use at Schefferville consists of eight 50R drills, nine electric shovels with capacities varying from six to thirteen cubic yards, and twenty-nine 120 ton haulage trucks.

The ore is hauled from the pit to the primary crusher where it is reduced to -2 inch size in a two stage crushing operation.

PURPOSE OF DEWATERING:

Since the beginning of the mining operation in 1954, the regional and local water table had to be controlled in and around the open pit mines in order to mine efficiently. (1) & (2).

Drainage control is particularly important because of the following: (3) & (4).

1. To minimize the moisture content of the ore shipped.

2. To reduce pressure on the ultimate pit walls. (5) & (6).

3. To maintain dry operating conditions in the pit and along the haulage roads.

The first water problems were encountered in the spring of 1955. Dewatering shafts and drifts were tried. However, these were not successful because of caving problems and heavy water inflows. The problem at that time was solved using shallow wells and sumps.

Since that time, improvements in well drilling techniques such as casing of holes have permitted drilling of deeper wells. Although the run off water is still handled in open sumps, groundwater is pumped from deep wells by means of vertical turbine pumps.

TYPICAL MINE DEWATERING SETUP:

A typical mine dewatering setup is outlined taking Redmond Mine, located 10 miles south of Schefferville and presently in operation, as an example. The following dewatering facilities are required to allow mining efficiently in Redmond Mine which is approximately 3500 feet long, 2000 feet wide and 600 feet deep.

To divert the surface runoff water away from the deposit area;

1. The original creek had to be diverted through a ditch on the east side of the pit.

2. A small lake over the ore body had to be pumped out before the mining could commence in 1967.

3. The dyke road is used to divert the surface water away from the pit. The surface water which does get into the pit is handled through a series of ditches and sumps.

When the mining started at Redmond Mine in 1967, the water table was within 30 feet of the original ground surface.

In order for mining operations to proceed efficiently to deeper levels and for slope stability, sixteen wells up to

700 feet deep were drilled all along the perimeter of the mine between 1966 and 1976. In addition, twelve wells were drilled within the pit limits mainly to dewater the ore.

From these 28 inpit and peripheral wells an average of approximately 6400 U.S. Gallons per Minute are being pumped out of the pit throughout the year. This has resulted in successfully lowering the water table by 500 feet from the original water table during the 12 years of the operating life of the mine.

Similar types of the dewatering setup exist in other operating mines.

DEWATERING EQUIPMENT:

The total number of deep wells presently operating in the entire Schefferville area is 47. Approximately 25,000 U.S. Gallons per Minute are pumped from these 47 installations.

Most of the wells are equipped with vertical turbine type of pumps such as 10RM, 10EC and 8BS with varying number of stages. Most of these deep well pumps are equipped with 150 Horse Power vertical hollow shaft type motors.

During the last couple of years, down-the-hole pump and motor installations have been used in some of the deep wells. These include low volume (250 U.S. Gallons per Minute) high head capacity pumps such as the Pleuger 81 model, and low head and higher capacity (600 U.S. Gallons per Minute) model such as the Pleuger 101.

SELECTION OF WELL LOCATIONS:

Because of the highly variable nature of rocks in terms of geological structure, permeabilities and porosities, the location of dewatering wells requires careful consideration. (7) (8) (9) (10).

Table I shows variations in physical properties of three most common rock types which are encountered in mine dewatering and other geotechnical work in the area.

In general, a well location in the Schefferville mining district is determined by using the following criteria:

1. Location of regional recharge and discharge areas.

2. Location and extent of aquifer(s) in the area of the mine.

3. Geological structure and degree of leaching of various rock types.

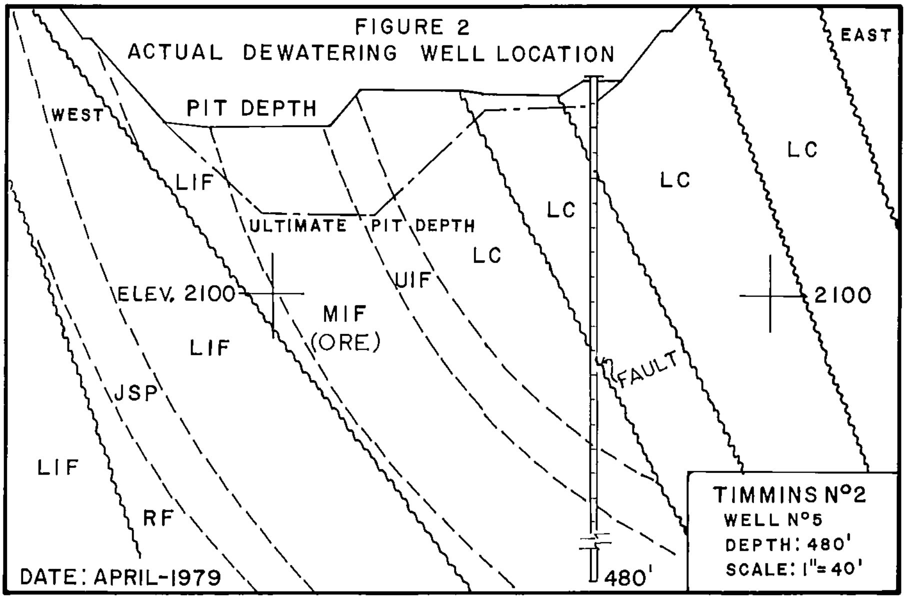
4. Engineering properties specially variations in permeabilities and porosities of wall rocks.

5. Pit layout and location of other mining facilities in the area.

Table No. I
Physical Properties of Some Typical Rock Types

Rock Type	Mean Bulk Density Pounds/Cubic Feet	Porosity Percent	Permeability Centimeters/ Second
Quartzite (Wishart Formation)	121	15 - 40	5.0×10^{-4} to 5.0×10^{-5}
Ferruginous Slate & Chert (Ruth Formation)	181	10 - 20	1.0×10^{-4}
Chert Breccia (Fleming Formation)	140	15 - 35	8.5×10^{-5}

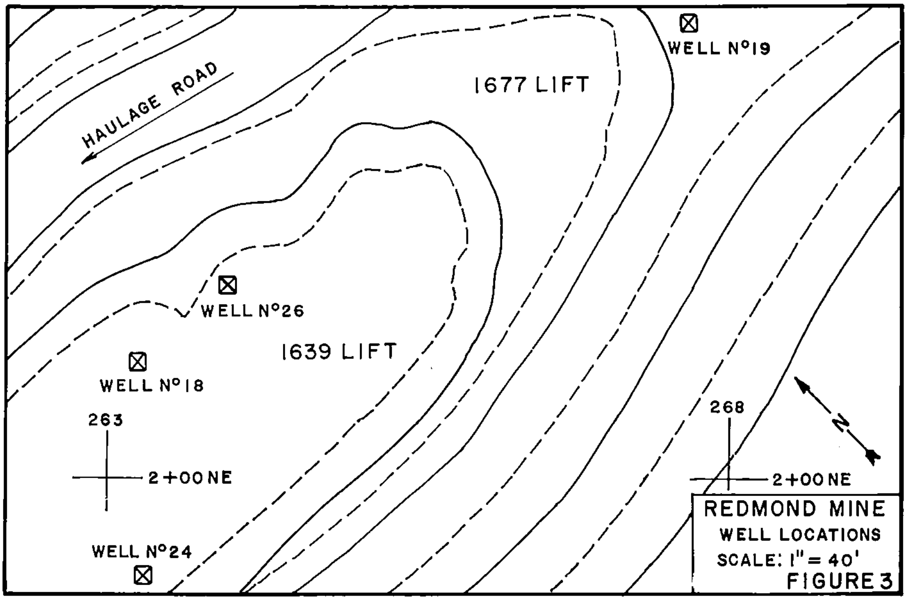
An example of the complex nature of the geological structure with a series of parallel faults in Timmins 2 mine is shown in Figure 2. The meaning of the abbreviations used in Figure 2 are as follows: - LC = Lean Chert, UIF = Upper Iron Formation, MIF = Middle Iron Formation, LIF = Lower Iron Formation, JSP = Jaspillite, RF = Ruth Formation. This particular well location was chosen to dewater the ore at at depth and to lower the water table in the wall rocks on the east side of the pit. In order to achieve these two purposes, only an inpit well could be drilled.



Actual Dewatering Well Location at Timmins 2 Mine. Figure No. 2.

Another example, in terms of having a rather limited choice for a well location, is shown in Figure 3. This part of the Redmond mine is relatively narrow. The water table was only 40 feet from the mining elevation in 1978 in spite of the fact that wells no. 18 and no. 19 were operating in the area.

In order for mining to proceed to deeper levels during 1978 and 1979, additional wells were required. The location of well no. 24 was chosen in 1978 to minimize interference with the operation. However, it could not completely dewater the ore because of the relatively impermeable characteristic of the Ruth Formation. Therefore another well (no. 26) was required in early 1979 to complete the mining of ore from the last two lifts or approximately for 75 feet. The mining in this part of the pit was successfully completed in July, 1979.



Redmond Mine Well Locations. Figure No. 3.

WELL DRILLING SEQUENCE:

Having selected the location(s) of dewatering wells, the next step is to drill and develop these wells.

The following is the sequence of drilling and developing a typical dewatering well in the mining area.

1. Installation of starting casing 18 inches in diameter drilled by a rotary production drill.

2. Cementing of well casing using portable cement machine.

3. Drilling of 15 inch diameter hole to required depths of up to 700 feet using the Frank Comet Rig.

4. The installation of pre-slotted casing in the well. In the past, the casing was perforated using a knife after its installation in the hole. It should be mentioned that screen casings were not successful because of their failure due to blast vibrations.

5. Development of well.

6. Installation of pump, motor and pipeline suitable for the well location.

SOME OPERATING PROBLEMS:

Some of the operating problems which are commonly encountered in the mine dewatering work are outlined as follows:

1. Culvert shacks are required to protect pump installations from adverse weather conditions.

2. In case of leaking pipeline during the winter, both ice and snow must be removed to repair the pipeline. However, snow cover over the pipeline is desired to prevent freezing.

3. Draining points must be installed in pre-determined locations to allow line drainage in case of pump or power failure.

4. Build up of snow and ice on the power line causing at times, power failure.

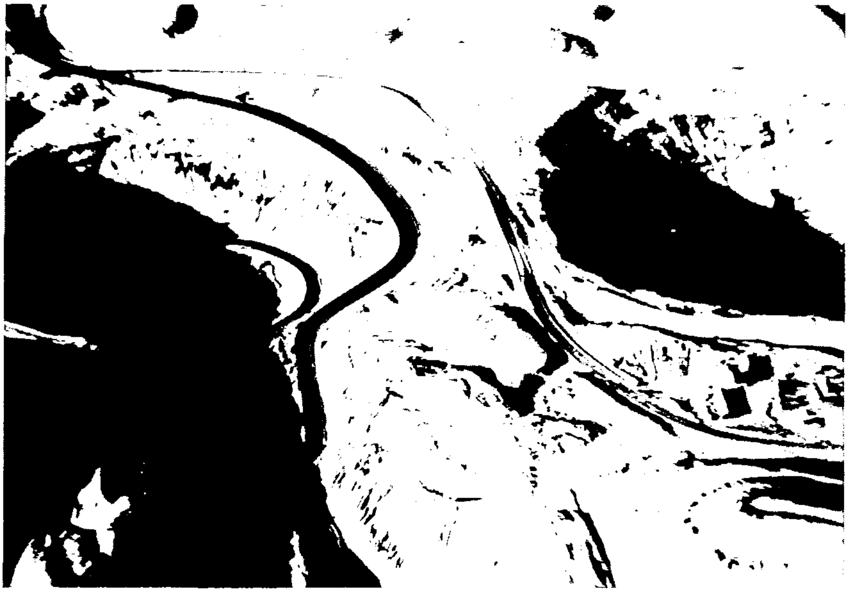
SPECIAL PROBLEMS:

Because of its location and the highly variable rock properties, mining in the Schefferville area presents some special problems. Three of these problems are briefly outlined below.

1. Pumping Due to Regional Water Table Conditions

The necessity to keep the water table lowered by pumping water out from a pit which is depleted during the period when an adjacent mine is in operation. This was the case in Ruth Lake/French/Burnt Creek Mining Complex located 3.5 miles west of Schefferville. During the seven year period between 1970 and 1976 while ore was being mined from Burnt Creek Mine, pumping installations had to be kept operational in two adjacent mines, Ruth Lake and French, which were closed for mining in 1966 and 1970 respectively. In its final stages, French Mine alone had 27 deep well installations and pumped over 19,000 U.S. Gallons per Minute on a continuous basis.

Figure 4 shows the location of Burnt Creek Mine (on the left) and French Mine (on the right).



Location of Burnt Creek (on the left) and French (on the right) Mines. Figure No. 4.

A Floating pipeline and pumping setup at Hematite Lake. Figure No. 5.

In order to maintain the water level at a required elevation in the operating pit such as Burnt Creek, a floating platform equipped with vertical turbine pumps had to be installed in the depleted mines. Because of the volume of water required to be pumped out, this type of installation had to be maintained during the winter months. This was achieved by installing heated culvert pipe around the pump intake to prevent freezing.

Another interesting aspect of dewatering work in the area is the necessity of frequently pumping water from a mine into a booster tank using the high capacity, low head submersible pump and then pumping the water out of the tank using high head, high capacity vertical turbine pumps. Such a setup was used at Ruth Lake and French Mines. This type of setup facilitates better access to the vertical turbine pumps at all times for maintenance purposes.

Figure 5 shows a floating platform equipped with two vertical turbine pumps and a floating pipeline setup in Hematite Lake. Water had to be pumped out of this lake in order to deplete mining of ore from Fleming 3 pit which extended underneath the lake bed.

2. <u>Presence of Permafrost</u>

Another unique aspect of our dewatering work is related to the presence of permafrost up to depths of 375 feet in more northern areas of the operation (11). The runoff water flowing over the impervious frozen ground creates additional handling problems. The common solution used is to install a sump below the depth of thaw and pump the water out of these sumps. Horizontal, low head, high capacity pumps are used to pump water from areas of surface accumulation to the main sump installation.

Two other interesting points related to dewatering in permafrost are:

a) Water due to melting of ice, must be pumped from production blast holes before loading of explosives.

b) While mining to the bottom of permafrost, deep wells are not required. However, the groundwater below the bottom of permafrost is handled by the similar type of deep well pumping installations as described above.

3. Elross Creek Diversion

An unusual dewatering project which has been successfully completed in the area involved the diversion of a major natural stream called Elross Creek flowing through the center of the Timmins ore body. This diversion was required in order to mine the ore underneath. For the diversion channel to be completed at a reasonable cost, available mining equipment had to be used for excavation. The final preparation of the open channel was completed by using tractors and scrapers.

In the area where backfilling was required, special precautions had to be taken to avoid seepage of water through fill. This involved installation of wooden supports on which conveyor belting was laid to allow for differential settling. Impervious rubber liner was installed over the conveyor belting.

Peak flow of up to 110,000 gallons per minute is handled successfully during the spring runoff through the diverted channel.

REMAINING UNSOLVED PROBLEMS:

Although considerable progress has been made in controlling the mine dewatering situation in the area over the last 25 years, several problems remain to be solved. Some of these are:

a) How to model complex geological and hydrological conditions existing in the Schefferville area on computer for the purpose of proposing new well locations. (12)

b) Problems of drilling 15 inch diameter deep wells in the area at a more reasonable cost.

c) Selection of pumps and related equipment suitable for highly variable pumping conditions such as varying head and flow capacity for each installation.

d) How to improve the overall pumping capacity from each mine in spite of operating delays caused by blasting, relocation of pipelines, inspection and change of pumps, etc., in relatively small size pits.

e) How to train and retain the manpower required to keep the entire dewatering operations going 24 hours a day, 365 days a year.

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