Detroit Salt Mine - Past & Future

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Work at the Detroit Salt Mine started in 1906 and it was mined with progressively more modern tools and techniques until it was closed in 1983. After a period of care and maintenance, the owners of the mine decided in 1997 to reopen it and produce salt again. Production of salt resumed in September 1998 - after an accelerated start-up program of less than nine months.

The paper will present the past and future of the mine. The effort involved to bring the mine back into production will be described in detail. The philosophy of maintaining full production with tightly controlled costs and a small labor force will be explained. The mine is in a well-developed urban area of the City of Detroit, so the unique nature of interactions with a local agencies and neighborhood groups will also be discussed.

The Detroit Salt Company has started with the "partnership" philosophy and continues to integrate that commitment with its employees, venders, transportation associates, contractors and consultants.

1. HISTORY

Detroit Salt and Manufacturing Co. (DSMC) first produced salt in Wayne County in Detroit with brine from wells in 1895. "In 1906 a radical departure in the salt industry of Michigan was made, when the [DSMC] started sinking a shaft at Oakwood [Detroit]."[(1)] Initial mining at the Detroit Salt Mine then commenced in "A" Bed through the No. 1 Shaft in 1910. The shaft was deepened in 1912, leading to the development of "B" Bed. This is the current mining level, approximately 1,200 ft (366 m) below the City of Detroit. International Salt acquired DSMC in 1913[(2)]. A second shaft was sunk in 1921.

No. 1 Shaft, a rectangular shaft, was initially unlined, with intermediate pumping stations in the shaft. There was a major inflow during a pump outage in the 1920's. To control future water inflows, two 42 inch (1.1 m) diameter steel pipes were placed in the shaft and the void behind them filled with concrete. The two pipes then formed two narrow circular conduits into the mine. No. 2 Shaft is a circular shaft. It was constructed by lowering a reinforced concrete caisson through the 83 ft (24.4 m) of glacial fill and forms the foundation of the original massive headframe and tipple building (demolished as part of the renovations) and remains as the foundation for the new headframe. The rest of the shaft through the bedrock to the mine level is lined with 18 to 42 inch (0.45 to 1.1 m) thick mass concrete. Most of the lining was faced with glazed brick. Both shafts were sunk using grouting to control the numerous and sometimes high volume water inflows. The exploits of the two shaft sinking exercises have been reported in EMJ [No. 1 Shaft][(3)] and in an internal Dravo Contracting Co. report [No. 2 Shaft][(4)]. A geological section is shown in Table 1, showing the 83 ft (25 m) of overburden, almost 800 ft (244 m) thickness of limestone, dolomite and sandstone sequences, to the start of the salt beds at almost 900 ft (274 m). The bottom of the 20 ft (6.1 m) thick "A" Bed is 1,040 ft (317 m) deep and the bottom of the 30 ft (9.1 m) thick "B" Bed is 1,140 ft (347 m) deep.

To control water pressure behind the linings in the two shafts, weeps from the numerous water bearing strata are collected in drain pipes and piped into wooden "pickle barrels" in the mine. This groundwater is subsequently pumped to the surface for disposal.

Initial mining was in the "A" Bed. Mining was switched to "B" Bed in 1912, to exploit the higher quality and thicker salt.

Table 1. Geological Section
(Thickness **T** & Depth **H** in ft [m])

	T	H
Blue clay	73[22]	73[22]
Clay & sand *	10[3]	83[25]
Dundee LS *	63[19]	146[45]
Lucas dolomite *	170[52]	316[96]
Amherstberg dolomite	19[6]	335[102]
Anderson LS	38[12]	373[113]
Flat rock dolomite	47[14]	420[128]
Sylvania sandstone *	113[34]	533[162]
Raison River series(dolomites)	124[38]	657[200]
Bass Island Series (dolomites)	220[67]	877[267]
Mixed salt & LS/dolomite	83[25]	960[293]
Rock salt	10[3]	970[296]
Mixed salt & LS/dolomite	50[15]	1,020[311]
Rock salt (**"A" Bed**)	20[6]	1,040[317]
Mixed salt & LS/dolomite	70[21]	1,110[338]
Rock salt (**"B" Bed**)	30[9]	1,140[347]
Mixed salt & LS/dolomite	199[61]	1,339[408]
Rock salt	25[8]	1,364[416]
LS/dolomite	73[22]	1,437[438]
Rock salt	369[112]	1,806[550]

LS - limestone

* Water bearing horizon within section

Adapted from A. H. Fay, Shaft of Detroit Salt Company, EMJ, March 18, 1911[3]

The limited cross section of the two "pipes" that formed No. 1 Shaft forced the mine to use No. 2 Shaft for both intake and return airflows, with divider walls. The two walls separated the rectangular central section of the shaft, with two square hoisting compartments, leaving the two outer segments for intake air. Air flowed into the workings on "A" Bed and into the rest of the mine via a raise to "B" Bed. After coursing through the workings, it was exhausted up the center of No. 2 shaft in the two hoisting compartments.

The mine was initially developed using a system of overhand breasting in panels with long pillars to isolate their ventilation circuits. Later developments included the introduction of undercutters and jumbo face drills, and more conventional drilling and blasting in regular room and pillar layouts. The relatively inflexible drills allowed the trim holes to be drilled straight and parallel, giving excellent roof control. Mucking, until fairly recently in the mine's history, was with modified shovels. An example of the steam shovels used when the mine opened is shown in Figure 1. The disadvantage of these shovels was that the room height could not be reduced when the seam thinned. The resulting reduction in roof beam thickness led to localized unstable conditions, with the potential for roof falls wherever the beam was less than 3 ft. Haulage was initially with trains of "Granby" cars and later with bottom dump trucks. International Salt developed its own trucks with trolley assist for the long hauls back to a massive crusher installation.

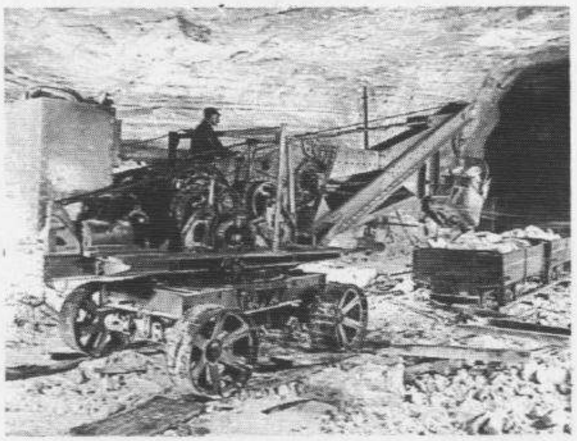

Figure 1. Steam shovel on wood rails. (c. 1912)

The mine became less productive as haulage distances increased. At the end of the mine's life it took almost one hour to get miners into the mine and out to the working faces. Ventilation losses through the hundreds of stoppings and brattices reduced air quality for the miners.

The layout is shown on Figure 2. The mine developed to the west along a "spine" of ore reserves beneath a railroad track system. Panels were developed off this "spine" as mineral rights were obtained, principally from industrial land owners, such as Ford Motor Company. The total area mined out is almost 1,100 acres.

International Salt stopped operations in 1983. The mine was then converted to a tourist attraction, until it was sold to Crystal Mines Inc. (CMI) in 1985. The underground mine tours continued for another year to obtain much needed revenue. Trailers, that had once run the miners to work, were then full of ever-inquisitive visitors. CMI's primary objective was to use the mine as a hazardous waste disposal facility. Due to changing legislation and the inability to permit the mine for this purpose, it went into a care and maintenance mode until 1997.

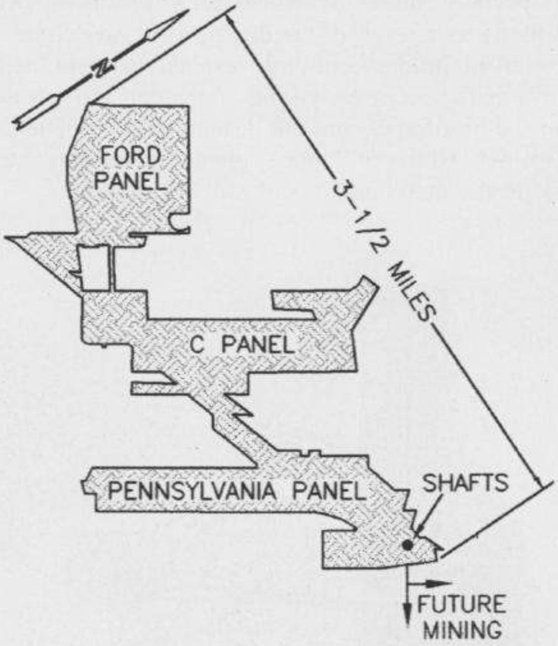

Figure 2. Mine layout.

In 1997 the owners of the mine decided to reopen it and produce salt again as Detroit Salt Company (DSC). Two factors influenced this decision: the shortfall in production caused by the flooding of a large underground salt mine in upstate New York and the potential costs associated with closing the mine.

2. A NEW LIFE

A business plan for the new mine was produced by Coopers Lybrand, with assistance from Harding Lawson Associates, and presented to the bank for possible financing. Comerica Bank of Detroit enthusiastically endorsed the project late in 1997. The business plan was refined to include a detailed equipment list, and a comprehensive project schedule of costs and sequencing of activities.

From the start, the philosophy of the owners was to hire the best people and give them the freedom to do their best work. This has allowed the mine to be developed with speed and economy. Each individual involved in the project - whether as a supplier, contractor, consultant or member of the DSC staff - has taken pride in his or her role in the venture and is directly responsible for the subsequent success of the company. In particular, the close relationship between the owners of the mine and the project management team allowed decisions to be finalized quickly on all major elements of the start-up project. The absence of formal engineering procedures compelled vendors and contractors to become involved in the detailed specification of the material and services. This approach brought competent, highly qualified people to the work and allowed them to take a partnership role in it.

The primarily items of mining equipment needed for the underground mine included:

- undercutter - Joy 15RU
- two-boom jumbo drill - Tamrock HS-206T
- powder rig - Dynatec rebuild
- scaler - Gradall G3W
- front end loaders - Cat 980G (two)
- feeder breaker - Stamler BF14
- conveyors - various used units
- various service vehicles

These units were all purchased as used equipment and then refurbished after being lowered into the mine. The jumbo drill, which was designed to run on a mine compressed air and water supply system, was fitted with a diesel compressor and an air/water mist flushing system. The jumbo's rotary/pneumatic hydraulic drifters make short work of the drillholes, even when the occasional rocky inclusion is encountered in the salt seam.

The only exception to the policy of buying good used equipment was the purchase of the two new Cat front end loaders which are used in a hard working load-and-carry mode. The buckets have been modified to hold about 12 tons.

The primary projects in the rebuilding project are discussed in the following sections.

2.1 Manpower

Skilled miners were hired from across the United States and Canada for the development of the new mine. Skilled and unskilled local personnel were also recruited. After the required safety training, their job duties included everything from jackleg drilling, to rigging and lowering heavy equipment down the shaft, to mucking out and rehabilitating areas of the old mine that had been worked in the early part of the century.

2.2 Shafts

Both shafts were in need of serious repairs, including demolition and clean-up of the deteriorated fittings and divider walls, refurbishing guides, rehanging and installing utility lines, and installing a ventilation divider wall in No. 2 Shaft. This work was done by an outside contractor - American Mine Services of Denver, Colorado. An aggressive schedule was accomplished on time and on budget under the direction of an experienced shaft boss - Ray Klenda. AMS personnel also assisted Minesteel Fabricators Inc. in the erection of the headframe.

2.3 Hoists

The production hoist is a 1925 bi-cylindrical (11 ft (3.4 m) major diameter, 7 ft (2.1 m) minor diameter), conical drum Ottumwa Iron Works hoist, with two 500 hp (373 kW) ac motors. The service hoist is a 1910 double drum (78 inch (2 m) diameter) Vulcan hoist with a 60 hp (45 kW) ac motor. Both hoists had been used throughout the period since the mine had stopped production. However, there were numerous issues that needed to be addressed to insure that they would operate safely and productively when used for full production. G. L. Tiley and Associates of Hamilton, Ontario, Canada were chosen by the project management team to take on this essential work. Tiley's engineers, including Murray Martin and George Haufek, worked tirelessly to upgrade the control, power and safety systems of the hoists, and the related mechanical and hydraulic systems.

2.4 Headframe

The old No. 2 Shaft headframe and tipple building were in poor condition, with exposed and corroded reinforcing bar, and slabbing and flaking concrete. The exposed steel structural elements were severely corroded. Initial consideration had been given to repairing the concrete and replacing the worst of the steel beams. However, safety concerns and the unpredictability of the extent of the work led to the decision to replace the headframe with a new all steel structure. Minesteel Fabricators Inc. of North Bay, Ontario, Canada was selected to prepare the design of the new headframe and skip dumping system to match the dimensions of the existing structure. Tubular structural steel was used for the main members to reduce potential corrosion. Figure 3 shows the new No. 2 Shaft headframe. DSC's increasing confidence in its abilities (especially those of Minesteel's President, Ron Elliott), as a result of the design work, to deliver an excellent product on time resulted in them being awarded - successively - the fabrication and erection of the headframe, and the design and fabrication of two new 10 ton (9.7 tonne) aluminum/stainless steel skips, the shaft divider wall, and collar doors.

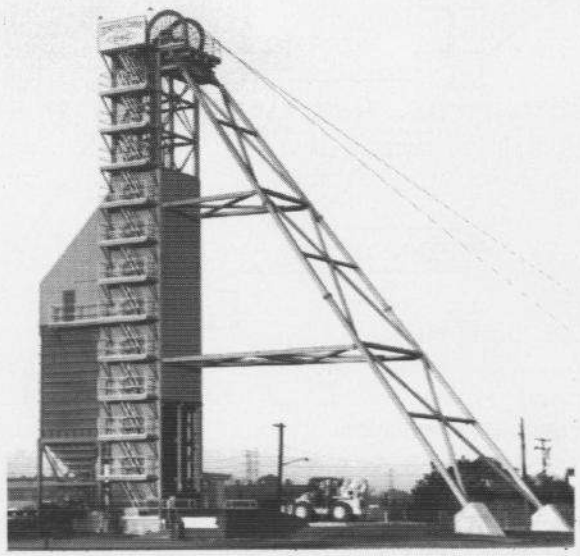

Figure 3. The new headframe.

2.5 Building Demolition/Site Preparation

A local company - Bierlien Demolition Contractors of Midland, Michigan demolished all the old run-down buildings that could not be safely rehabilitated. These included both the No. 2 headframe and the tipple buildings associated with both shafts, surface crushing and screening systems, the conveyor gantry to the storage silos, the storage silo/load-out facility, and several other smaller structures. Bierlien also assisted in regrading the old stockpile area to enable it to be used again in an environmentally acceptable manner. The general site clean up associated with this work turned the mine site from something that resembled a moonscape to a modern industrial facility.

All the demolition and any subsequent erection work was coordinated to minimize the downtime in the mine's development schedule. The most crucial period was the demolition of the old No. 2 Headframe and erection of the new one. As soon as the mining equipment had been lowered into the mine, the No. 2 headframe and tipple building were demolished. However, underground work continued by maintaining access through the twin tubes of No. 1 Shaft, with air blown into No. 2 Shaft through an old access tunnel beneath the massive collar seal. To assist in mating the new headframe steel to the existing - and unknown - foundations on the shaft caisson, a foundation "mat" of structural steel was incorporated into the new headframe design. As soon as the caisson was exposed, the new foundation "mat" was bolted into place and the headframe legs in turn bolted to it.

In the experience of the authors the unusual multiple functions of No. 2 Shaft are worth noting: the shaft is used for production skipping, personnel and materials hoisting, and intake and exhaust ventilation, as well as serving as the conduit for all utilities and services.

2.6 Electrical

The electrical system in the old mine was simply not up to code, with substandard wiring and grounding and control systems. Fred Kelly of Kelly Power Services of Cincinnati, Ohio, with capable assistance from several Canadian mine electrical services companies, completely redesigned the power distribution system and installed a modern, safe and reliable system. 4,800 volt power is taken into the mine via two parallel feeder cables in No. 2 Shaft. Two primary distribution centers in the mine supply 480 volt power to the shaft bottom area (main fans, pumps, workshop), the crushing and screening plant, the feeder breaker, and the working faces.

2.7 Screen Plant

The crushing and screening plant was designed and built with simplicity in mind. The salt is crushed in a face line feeder breaker and passed over scalping screens; undersize goes to the product belt and oversize goes to roll crushers; crusher throughput is passed over finishing screens, with oversize recycling to the crushers (see Figure 4).

The relatively few processes in the plant, coupled with efficient blasting, produces minimal fines.

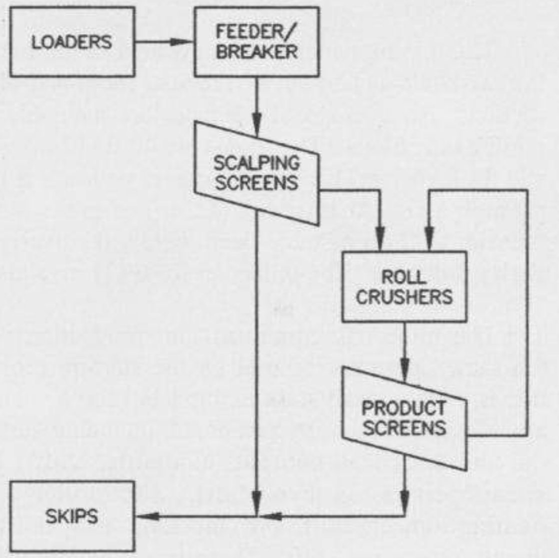

Figure 4. Salt flow diagram.

2.8 Surface Stockpile/Material Handling

New stockpiling and rail loading facilities were established. These facilities allow salt to go from the 200 ton tipple bin in the production headframe to either stockpiles or direct to a rail load out system. The rail load out system consists of almost a mile of new track. Pads are in place to build a total of 300,000 tons in stockpiles.

2.9 Underground Development

Underground work included getting all the production and support equipment operational, establishing new working areas, travelways, ventilation controls, and ensuring that all necessary safety and health regulations were met. Incredibly, the 85 year-old mine workings that formed the start of the new mine panels were in excellent shape. This was undoubtedly due to careful blasting by the old timers and the arch that they left in the roof.

The conservative new mine panel layout was approved by Jack Parker of Jack Parker and Associates of Toivola, Michigan, after extensive reviews of the ground conditions throughout the old workings by him and the project management team.

The mine was producing salt again in September 1998 - after an accelerated start up of less than nine months.

3. FUTURE

The mining panel in the new area to the east of the two shafts is laid out as a regular room-and-pillar section. An average of 15 faces are available for mining operations. The rooms are 40 ft (12 m) wide and 22 ft (6.7 m) high in the center with a 2 ft (0.6 m) high arch. At least 4 ft (1.2 m) of salt is left in the roof to form a stable beam below the overlying shaley dolomite. The pillars are 70 ft (21 m) square.

The mine has continued into production with the same approach, as used in the start-up project; that is, with a small and flexible labor force. There are a total of 33 hourly personnel, including surface rail and truck load out, plus nine office staff. The mine operates on two shifts, with drilling and blasting on dayshift and mucking and hoisting mainly on second shift. There is a 6 hr interval to allow the blasting fumes to clear before the second shift.

The blasting is done with 47 hole pattern of 2 in (51 mm) diameter, 14-1/2 ft (4.4 m) deep drill holes, as shown in Figure 5. ANFO is blown into the holes and initiated with 8 gram boosters and half-second, salt mine delay caps. The 850 short tons (770 tonnes) per face is produced with a powder factor of 0.6 lb/ton (0.3 kg/tonne).

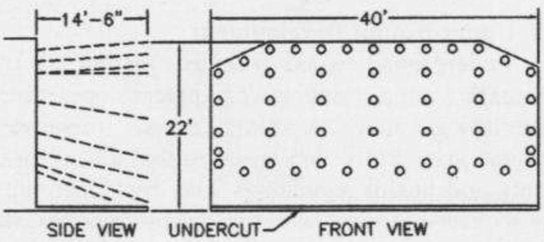

Figure 5. Drill pattern.

The mine is in a developed urban area of the City of Detroit, so there are unique issues in dealing with local agencies and neighborhood groups. A local public relations firm has been hired to assist the mine management in dealing proactively with the concerns of nearby homeowners.

The work force doesn't know its limitations. Productivity norms are well in excess of industry practice. For example, the under-cutter operator has cut as many as eleven faces in a single shift, and even exclaimed "I would have had more but I had to move my trailing cable by myself!"

This approach of a relatively few, multiple function personnel and working foremen has resulted in high tons per manshift.

4. ACKNOWLEDGEMENTS

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REFERENCES

1. C. W. Cook, The Brine and Salt Deposits of Michigan - Their Origin, Distribution and Exploitation, Michigan Geological and Biological Survey, Publication 15, Geological Series 12 (1914)

2. Detroit News, Jan. 9, 1913, p 4, col 3

3. A. H. Fay, Shaft of Detroit Salt Company, EMJ, March 18, 1911

4. Shafts, Slopes and Tunnels, The Dravo Contracting Company, Pittsburgh PA, Bulletin No. 302: 1169 Ft Salt Shaft, p 8-9