

# Dome Mining: Floor vs. Roof Extraction

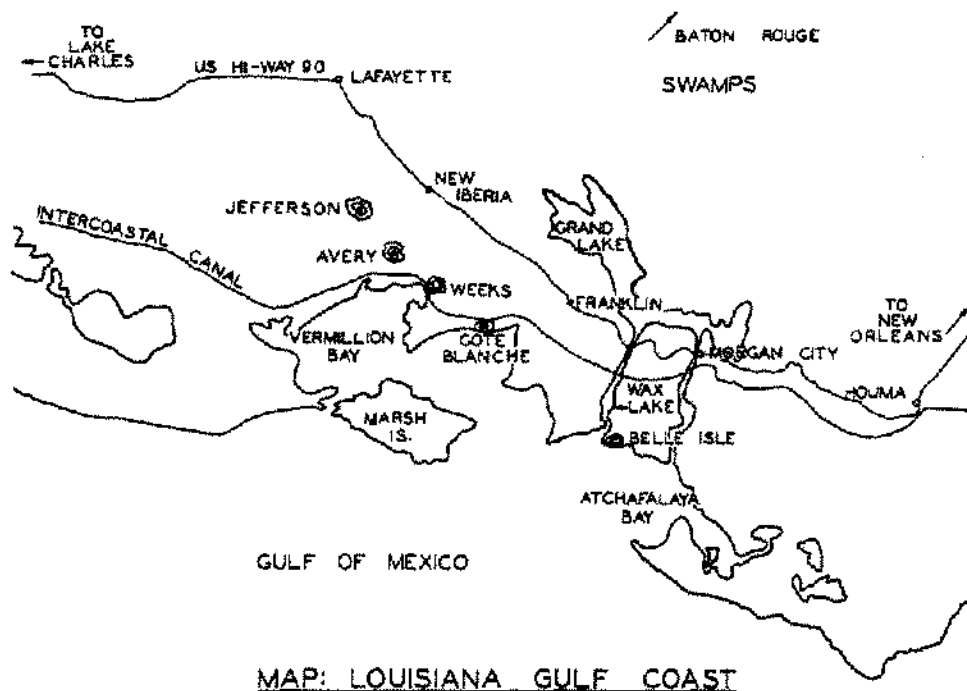
by  
Nicholas J. Nicola  
(Cargill, Inc.)

## ABSTRACT

The purpose of this paper is to present, in some detail, the two methods of mining salt in a dome formation and to include some of the important factors in both applications. Further, it is intended to present the reasons for the change to floor mining. In accomplishing this, a brief description of the Louisiana Gulf Coast domes will be made, along with some of the general mining conditions which exist in the producing mines.

## LOUISIANA GULF COAST DOMES

The five major domes (called islands) are Jefferson, Avery, Weeks, Cote Blanche and Belle Isle. These domes lie in an almost straight line running NW to SE, with the most northern being Jefferson. The northwestern four domes are spaced equidistant, about 8 or 9 miles apart and the distance between the two southeastern domes is about 18 to 20 miles. From their extremities the five domes are approximately 45 miles apart. (See map)



MAP: LOUISIANA GULF COAST

The close similarity of the physical characteristics suggest a common origin from a deep evaporite layer possibly 20,000 feet or more deep. It has been thought that the five domes pushed up through some weak structure in the overburden and formed these domes. At each of the domes, there is a definite rise at the surface. The surrounding area is very flat and low but these domes can be seen for miles and rise as much as 80 feet above sea level.

The salt is similar in the five domes, a massive micro-crystalline white to light gray Halite (NaCl) usually firm but at times inclined to crumble on impact. This has been reported from the existing mines and causes no apparent difficulty or danger. Impurities are minor, the most common being gypsum crystals with rare microscopic grams of pyrite, quartz, calcite and anhydrite. Dark bands in the salt usually indicate an increase in impurity. Hydrogen sulphide, water or various hydro-carbons are sometimes found in "pockets" but in small quantities which dissipate rapidly. Boulders or fragments of sedimentary rock are rarely present.

The salt core in forms of splines has in some domes pushed up close to the surface and in some instances as deep as 500 feet. The cores in the main domes are about 1 1/2-2 miles in diameter and tend to form a cylindrical section (Figure 1). At these diameters, the salt contours are steep to vertical, from 800 feet to 7,000 feet and at greater depths there is some overhang but well below any effective mining. Oil companies have drilled through these overhangs while drilling for oil to a lower sand. A typical test hole for salt is shown in Table I and gives the lithologic column. For the purposes of a slide some of the cores were not shown but it is evident of a continuous salt column from 510 feet to 1,600 feet.

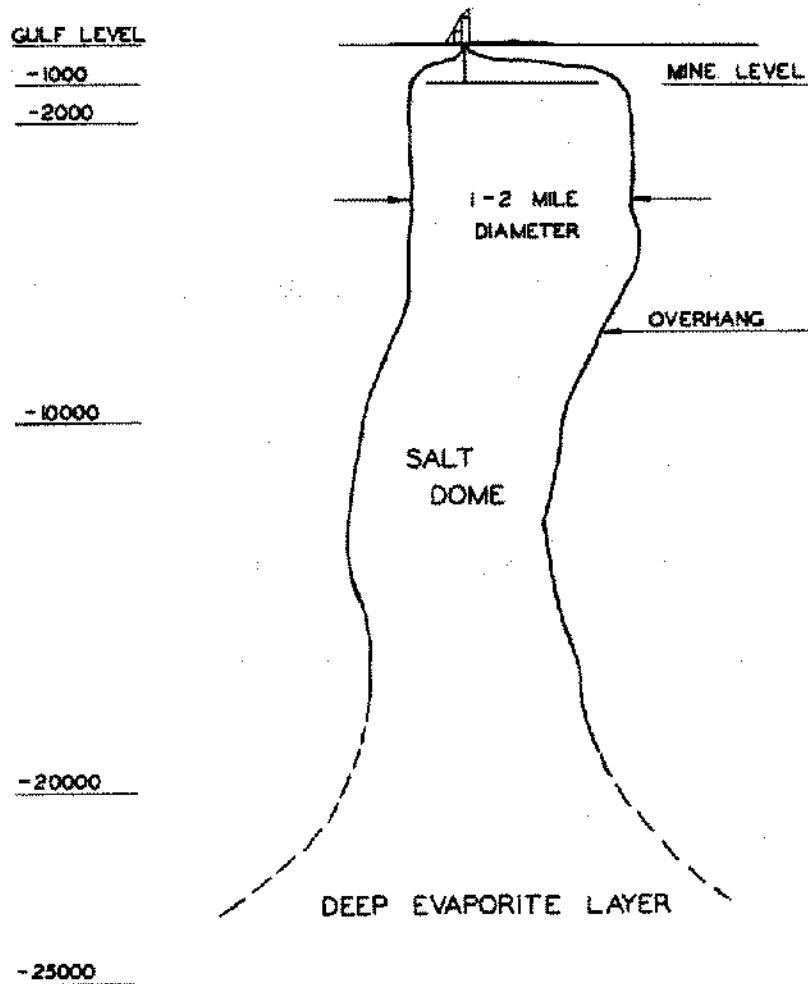


FIG. 1 TYPICAL SECTION

Table I  
 DRILLER'S LOG AND CORE SAMPLE OF TYPICAL TEST HOLE

Well

Cut casing flush with top of ground and welded plate over same. Recovered 85 ft. of 5 1/2 inch casing from well.

Depth	Formation
0 - 134	Clay
134 - 165	Sand and Strks of Clay
165 - 227	Sand
227 - 257	Mixture of Sand and Clay
257 - 319	Sand and Gravel
319 - 384	Sand
384 - 449	Hard Formation, Lime 7, Etc.
449 - 456	Sand and Gravel (Lost Circulation)
456 - 490	Limestone
490 - 510	Salt

Ran 13 jts. 26# 8 rd. and 1 cut piece 11 ft. of 7" casing total of 404 ft. Cemented with 50 ska POS mix, 2% calcium chloride and HA 5.

This well has open hole from 404 ft. to 490 ft., top oc salt, a rate hole from 490 ft. to 510 ft.

A core was cut from 490 ft. to 510 ft. to determine whether salt was reached. The core was cut with water base mud, and a 4' recovery of clean clear, hard salt was obtained with a 6 1/8 inch Reed hard formation core head.

Well

Core No.	Depth		Amt. Cut	Amt. Rec.
	From	To		
1	510 ft.	537 ft.	27 ft.	27 ft.
5	607	637	30	30
10	757	787	30	30
15	874	893	19	14
20	1,013	1,040	27	16
25	1,160	1,190	30	27
30	1,310	1,340	30	29
35	1,460	1,490	30	2
39	1,580	1,600	20	20

Core bit and barrel used: Christenson Diamond core bit 4 1/2 inch, Christenson core barrel 3 1/2 inch.

Date started coring: 1/ 6/61

Date ended coring: 1/12/61

Plug and abandon well W/190 sacks of common neat cement salt saturated.

## GENERAL MINE CONDITIONS

Of the 3 existing mines the salt varies slightly in structure with the purities about the same. Room and pillar method of mining is used and the size openings depend on the compressive strength of the salt. Room widths vary from 50 feet to 100 feet and the pillars from 70 feet to 100 feet wide. All rooms are high and reach heights of 75 feet to 90 feet. In some instances as much as 110 feet have been mined but this practice was stopped because it was difficult to check the pillars at that height. Salt extraction varies from 57% to 75%, depending upon the salt strength. The Bureau of Mines' publication gives 5,000 psi bearing strength of Halite from one of the mines. The absence of sufficient published data on Halite strength to tell what variance of pressure there is leaves the door open for a more extensive survey of compressive strengths.

One of the biggest problems with high roof mining is the control of air. Because of the heights and the tremendous concussions from shots, it is very difficult to use conventional brattice to channel the air. Even if it were practical to hang a curtain at that height, it would be blown down after each shot. Consequently, it is important to move the air through long entries with fewer cross-cuts and to circulate the air in the large rooms with low-pressure, high-volume circulating fans. Return air from the shots should be dissipated as much as possible in the large rooms to prevent any on-rush of air against doors or air-locks. The tendency is to go to section mining even though the mining area is not extensive. Then these sections can be sealed off when completed and thereby eliminate circulation of air through the old works.

In the 3 mines, loading and hauling vary -- (1) one employs the use of all belt conveyors for haulage with portable crushers at the faces and extendable belt conveyors to the main belts. There shovels load and dump the salt directly into the crushers. (2) Another mine uses gathering-head crawler loaders and shuttle cars which haul to a primary crusher and then the use of belt conveyors haul salt to the shaft. (3) The third mine uses shovels and front-end loaders for loading into conventional rear-end dump trucks. Then these trucks dump into a hopper which feeds to a primary crusher. Here again belt conveyors haul the salt to the shaft.

All the mines do some screening below ground and storage is done below and above ground. The corrosive problem near the salt water and salt air presents a constant maintenance job. Corrosion is much less a problem underground and storage room is readily available. Future thinking is toward a more thorough screening and storage system underground.

## ROOF EXTRACTION

The early mining methods adopted many of the coal mining techniques and used similar equipment, such as, locomotives and mining cars on rails, electric drilling machines and short-wall cutters for low roof salt. Because of the larger volume of salt at a face, shovels, with short booms, were sometimes used as loaders. Later reverse bench mining was practiced for mining a high roof. (Figure 2)

All drill set-ups were made on the muck pile and it was always necessary to keep as much as 100,000 tons in reserve in order to prepare salt. In this method the muck pile was leveled and one of various lengths of 4 inch pipes was used as a drill column. A length of pipe closest to the opening was selected with a 5 foot telescoping extension pipe at the bottom. This provided a column within 6 inches of the required height. Then the column was set on a base plate and the pipe tightened to the roof by means of a screw jack at the bottom. Once the column was set an "A" frame (again there were various sizes) was raised vertically next to the column and supported by a ladder from the muck pile. The driller would then walk from the muck pile on the ladder to the face and drill column. A welded eye at the top of the column supported a rope block and the drill weighing about 125 lbs. was hoisted to the top of the column and clamped in position. Once the drill was clamped to the column, the driller swung his drill in an arc and drilled a fanned-out pattern. (Figure 3)

An old electric drill with a 4 foot thread bar was used to feed the auger and drill the face. Since there was no pressure against the face, a hole had to be picked, in order to keep the bit from walking away. Holes were drilled from 10 to 12 feet deep depending how close the columns were to the face and the nature of the face. When one fanned-out set-up was drilled, the drill was lowered on the column and another set-up was drilled. Usually two set-ups were drilled before

FIG. 2 ROOF  
EXTRACTION  
REVERSE BENCH  
METHOD

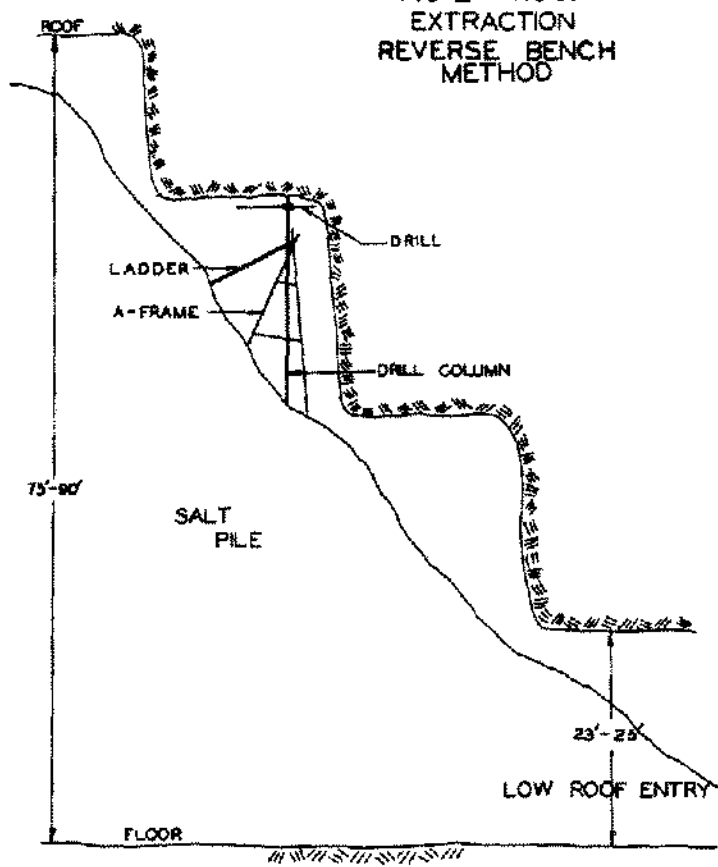
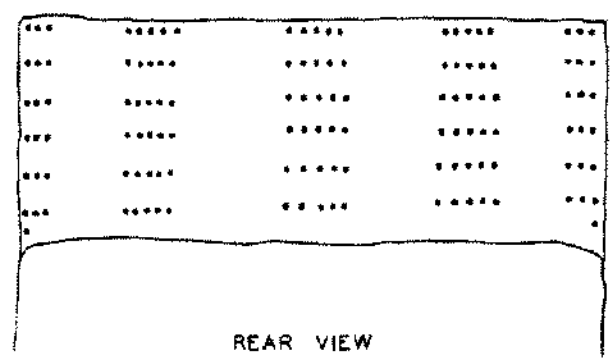
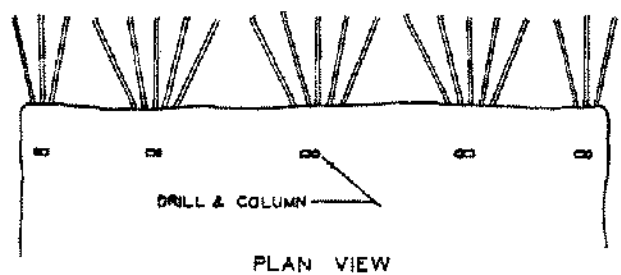


FIG. 3 DRILL PATTERN



a smaller "A" frame was set up to lower the drill. This was continued until the bottom row was drilled. In the meantime, a crew was setting up another drill column for the driller. A crew was constantly setting up and tearing down columns or hauling powder or equipment prior to a shot. A good day's work was considered 30-32 holes per driller and an entire face took about 32 man-hours to drill. Another 100 man-hours to set up, prime holes, and move equipment so a total of 132 man-hours was used to shoot 1200 tons or a 24 foot face. Because of the wedge section between the drill patterns, quite a bit of blocking resulted and necessitated secondary shooting. As you can see from the sketches, this was a hazardous method because men were working on what you might call scaffolding and they were handling heavy equipment by brute strength, which resulted in many back injuries. Powder had to be handled by hand and carried up the slope for loading. Equipment and supplies had to be moved before each shot and brought back after a shot. In addition to this hazard, a quality problem presented itself because of the wood chips and frayed electric cables getting into the salt. Tendency to choke at the corners after a shot involved cleaning by hand. There was always the danger of rolling boulders, skinned legs and hands. The roof of the top bench was scaled ahead of the loading and hauling crew behind the pile but the scaling of the lower two benches was very difficult, because it could not be reached readily.

With the high piles of salt, a shovel with a dip stick was the only equipment used to load because a slide could cover up any low loading equipment. The salt could actually be undermined without falling and at times it was necessary to shoot the pile down before a shovel could load again. Haulage units included trucks and belts. With the boulders which were buried at times the loading cycle was increased in order to move these to one side.

Another method used later was the high-roof jumbo rig where the entire face from the low roof ceiling to the high roof ceiling was drilled and shot as one face (Figure 4). As you can see from the sketch, two platforms worked separately. One rides on the outside frame from

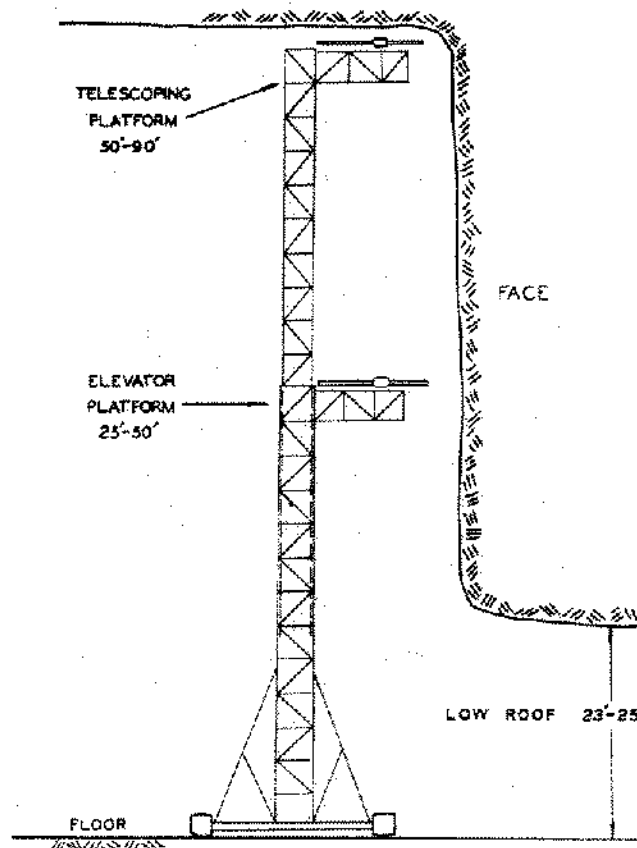


FIG. 4 HIGH-ROOF JUMBO RIG

25-50 feet high; the other rides on a telescoping frame and travels from 50-90 feet or whatever height was being drilled. On each platform there were 4 drills; the same as used in the reverse bench mining method. These drills, however, were mounted on a horizontal pipe and could be loosened and slid horizontally. Two drillers operated the 4 drills and one man worked on the floor to move the jumbo and the platforms when needed. It took 5 man-shifts or 120 man-hours to drill and shoot a face of approximately 2,400 tons. There were close to 200 holes in a face of this size. Here again you had the problem of slabbing at the bottom which involved some secondary shooting. However, the slabbing from this method was much less than from the reverse bench mining method. Both platforms could be used but the danger of a scale falling from the drilling platform above prevented the use of both platforms simultaneously. The face was drilled from the top down and loaded in the same manner. This was a much better and safer method of high roof mining and cut the costs almost in half. Maintenance on the jumbo was high because of the constant check and replacement of worn-out cables and pulleys used to move the platforms. In addition switches, brakes and the tracks had to be maintained so the jumbo would operate efficiently. Occasionally a scale would hit the rig which necessitated some welding or repair work on the main frame. Variations of the above methods of mining the high roof have been tried but none has proven economical.

### FLOOR MINING

A definite transition came about 4 or 5 years ago when the need for increased volumes of salt made it necessary to go to a more economical method of preparation. Some floor mining had been practiced for a number of years but very limited because the old mines were committed to high roof mining and to the equipment already on hand. Floor mining on a larger and more organized scale was the answer and the advent of ammonium nitrate as an explosive brought about a lower cost of salt preparation. In addition, it was a much safer way of drilling and loading and eliminated as much as 50% of the scaling caused by irregular drilling on the ribs. A rib that was heretofore controlled by 28-30 holes was now controlled by 3 or 4 (Figure 5). It is essential that the rib holes are drilled as near to vertical as possible. Even if it takes a little more time to accomplish this, it will eliminate a scaling problem later on.

Floor mining can be started one of two ways. Either slope up to the high roof ceiling and start a low roof face operation and then floor mine to the floor level; or keep the low roof ceiling as the roof and bench mine to a new floor level. The latter would be the cheaper of the two methods; since the low roof has already been scaled, it would eliminate one phase of the preparation cycle. However, if mining commitments prevented lowering the floor level or if most of the low roof area has been depleted, it might be necessary to develop a low roof at the high roof level in order to maintain two separate methods. The advantage of this operation is the storage of prepared salt. There is no limit to the amount which can be shot and kept in reserve. (Figure 6) With this method it was also necessary to drill the holes as near to the bottom as possible and to remove sufficient cuttings so that priming and shooting would be more effective and result in better fragmentation. An auger type steel will leave about 3 feet of salt in the hole. An air drill, using "A" rods, with air cleaning does a better job but also presents a dust problem.

The ideal situation with a new mine operation or level and present, improved equipment and techniques is to start a low roof development with a height which will enable a floor drill to operate along with low roof mining equipment. Then to floor drill to whatever depth has been found practical. Here, however, an auger type drill steel will work because the hole can be drilled below the floor level and the column of cuttings will be under any effective floor level. With this method it is necessary to clean out each floor shot before another is shot because it is necessary to undercut each shot (Figure 7). Salt being very homogeneous does not have any seams or strata to which it can be shot. If it is not undercut, the floor becomes very rough and presents a problem with loading and haulage equipment. Also with this method loading equipment used in the faces can also be used in the floor, as you do not have a high pile which would necessitate using a shovel. Each floor shot even though it may contain 2,000 or 3,000 tons will be shot as far as 300 feet from the face, and consequently will not reach a height of possibly over 15 feet.

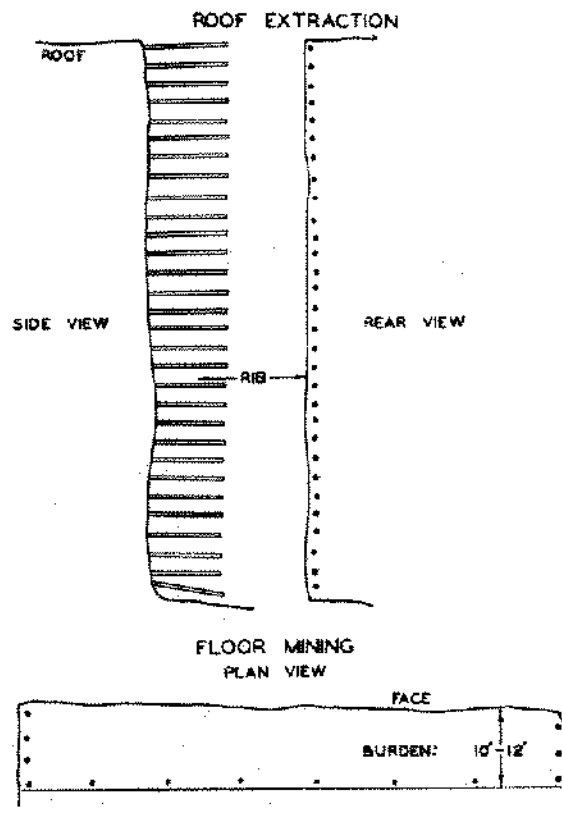


FIG. 5 RIB-CONTROL

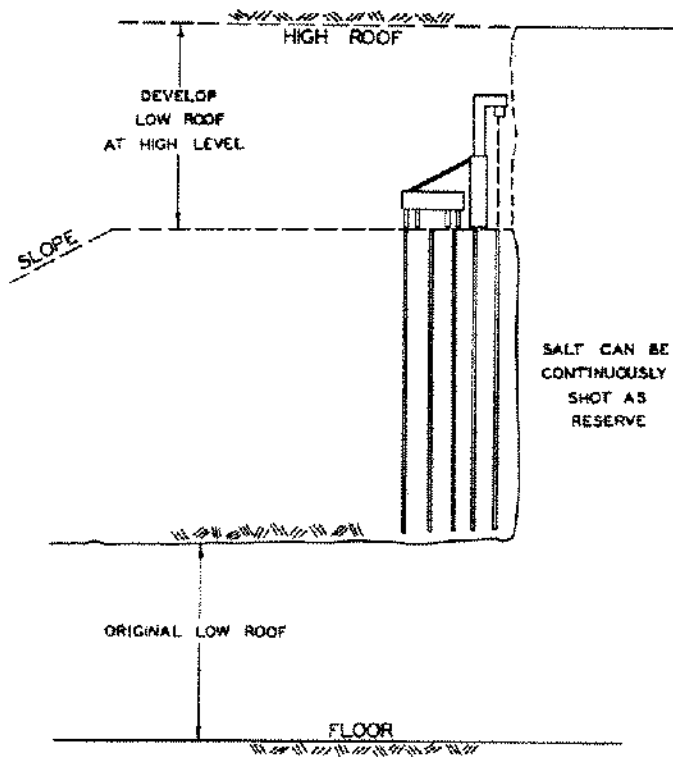


FIG. 6 FLOOR MINING

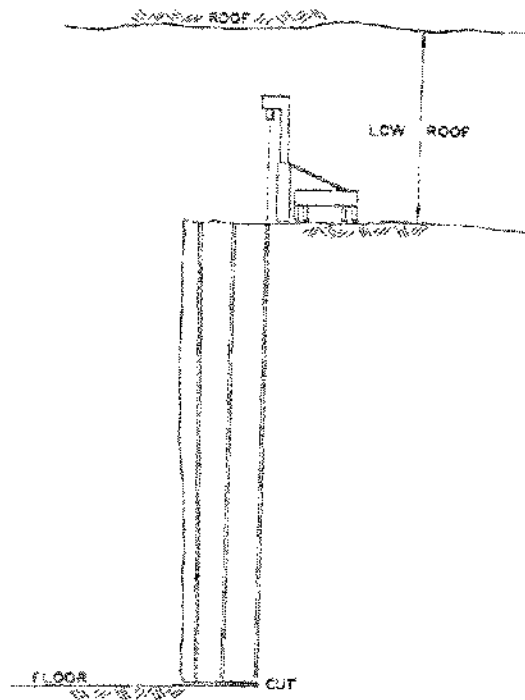


FIG. 7 FLOOR DRILLING

### CONCLUSIONS

A comparison of the two methods of dome mining is as follows:

1. Safety: Floor mining presents a much safer operation because of smoother rib controls, eliminating some scaling problems; a safer operation because of simpler equipment and less high climbing hazards.
2. Quality Control: Foreign materials in the salt are very easily controlled with floor mining because of the simplicity of the drilling equipment and because the preparation crew is narrowed down to 2 or 3 persons. They alone are responsible for the quality of the salt shot.
3. Costs: Floor mining lowers cost per ton and utilizes less man-power. An efficient operation can cut costs as much as 40%.
4. Equipment: Floor mining uses more standardized equipment for low roof and floor operations, such as, loading and hauling units, and eliminates the use of special jumbos. Maintenance cost and replacement of parts are minimized with simplified machinery.
5. Secondary shooting: With floor mining secondary shooting is kept to a bare minimum because of controlled blasting and much better fragmentation.
6. Explosives: With floor mining ammonium nitrate is a simple and safe method of shooting. The powder-factor also gives more tons per pound of explosive.
7. Cleanup: Roof extraction requires less cleanup time since each shot does not have to be cleaned thoroughly. In addition, less push-up time is required because the salt is not shot as far from the face.
8. Undercutting: Roof extraction eliminates one cutting operation, but with improvement in the design of present-day cutting machines, this is a very small phase of salt preparation.

Floor mining at heights as high as 100 feet is certainly an ideal situation. You have all the benefits of open pit mining with none of nature's elements with which to cope.