the fact that we have no large stores of coal to invite the capitalist to invest his means in the trade.

The best coal seam we have is not over 4 feet thick, while often the average thickness of a vein does not exceed 3 feet. We have discovered only one practically useful coal seam as far as the series is explored. This, however, does not explain why our already opened mines, in profitably workable beds, do not produce more coal through the employment of a greater force of men, when our demand for coal is so great that millions of dollars are yearly sent abroad for the article. It is not the lack of coal; our now known beds would supply for a long time to come all we want for consumption. One of the reasons for so large an import of foreign coal is in the quality of the home production; its highly bituminous quality and rather large percentage of pyritous admixture unfit it for certain purposes, for iron smelting and for blacksmiths' use, for instance, while for family use a highly bituminous coal is rendered objectionable by the large quantity of fœtid smoke evolved through imperfect combustion. For gas production, the coal, otherwise very suitable, is little used on account of the inconvenience of purifying the gas from sulphur.

As fuel for steam production, the Michigan coal can compete with any coal imported for that purpose, and is superior to many of them. The production of our mines is far behind the consumption of coal for steam generation. Let us hope, however, that the coal-mining industry of the State, as long as it offers an article equally useful and fully as cheap or cheaper than the article imported, will receive the patronage of our manufacturers to a greater extent than it has heretofore done.

I have attempted, in the foregoing part of the report, to describe the geological structure of the Lower Peninsula of Michigan as accurately as the conditions allow.

From the statements made, we learn that the formations composing it are exclusively of sedimentary origin, and the deposits all superimposed on each other in undisturbed horizontal or nearly horizontal position. In some parts of the continent where the strata are disposed with similar regularity, they are found deeply eroded, and the valleys and ravines carved through them present opportunities for observing the rock beds, exposed in sections of large

vertical and horizontal extent, in which not only every stratum can be studied accurately in all its qualities and local peculiarities, but can also be clearly seen the relative positions which the superimposed strata hold to each other. The strata of Michigan are doubtless similarly eroded. The power and destructive action of these erosive forces are illustrated impressively by the ocean-like basins of the lakes surrounding us, which are their handiwork. Yet not only were all these wounds in the rocky skin of the earth healed in time through being filled up with débris carried from the destruction of other places, but a thick coating of the filling material was also spread over the levelled surface so as to hide from view even the scars. We are learning to comprehend what a great advantage this healing process was for man, who subsequently took possession of this portion of the globe, prepared for him and his welfare long, long years before the human race existed.

This loose, porous mass of débris, in proper comminution to make a soil, and being composed of every variety of mineral substance necessary for the sustenance of vegetable life, formed the destiny of this strip of land; it makes it an agricultural country. No great mineral wealth is hidden here under our feet which we could have reached through the gaps, so it were better they were closed and levelled, to enable us to harvest golden ears of wheat and corn from their surface, than that we should enter shadowy subterranean passages in search of gold, endangering our lives and without any certainty of success in the end. Still we are not entirely deprived of mineral wealth, which by many is thought an indispensable requisite for the household of a rich State. We have our modest share of coal, left as yet nearly untouched, but which, when exhumed, will be fully adequate for the supply of our demand for home consumption. We have tapped stores of salt brine, reserved for our benefit in the sponge-like sand-rock beneath us in inexhaustible quantities, drawing enough for all domestic wants, for curing thousands of barrels of delicious fish, caught in the cool, crystal waters of our lakes, and sent far abroad as an article of commerce, besides an immense surplus from which to provide our Western neighbors, in exchange for their coin. Then we have gypsum of snowy whiteness, laid open on the surface in quantities to last for generations to come for all the uses to which it is devoted. We have stone, lime, and sand enough to build our edifices; our grindstones have acquired fame over all the country adjoining us. Can we claim more for our peninsula, whose principal pride it is to produce the best wheat and the finest apples grown anywhere? If we had more, I fear it would demoralize us. But this is not all; we have our mining country set apart from this lower Arcadian land by a broad, intervening lake, where, to compensate for the scarcity of metal in the other part, nature has deposited its metallic treasures in an exuberance that challenges the competition of any other spot on the globe. Mountains of iron ore of the better kind are passed by unnoticed, because we find there plenty of it of a yet richer quality. Copper in malleable metallic condition lies there in blocks heavy enough to load down a three-master to a sinking condition, while, in finer granular condition, it is disseminated, in incredible quantities, through mighty sedimentary sand-rock masses and conglomerates forming a mountain range of over one hundred miles in length. Silver in pure metallic state is also found in no small quantity, and daily there are fresh discoveries of it.

Nature has well equalized the division of its gifts. The broken, hilly character of the mineral district, and its northern climate, although rendering it healthy and pleasant as a place of habitation, do not recompense the farmer as well for his labor as they do the miner, and, therefore, all industrial efforts in this region are directed to mining. The population of a district congenial for agriculture throws all its energy into the tillage of the land; another finds itself predestined for a manufacturing district by some natural advantages offered, such, for instance, as our lumbering districts. Each one of these will dispose of the surplus of its products to the other in exchange for its surplus; and only by such a division of occupation and interests, in accordance with external climatic and geological conditions, can the necessary life and circulation come into the social organism, and secure its healthy and durable existence. It would not add to our prosperity if all the natural advantages possessed by a single part of the State were to be equally distributed over the whole. The two peninsulas, united into a twin State, form the happiest union that could be made; both have their great advantages—one upholds the other; but if I were asked to say, which is the best, my choice would fall

upon the lower. As an agricultural district, it is absolutely self-sustaining, if we moderate our claims to the necessities of life. A mining district without agriculture, if yet full of gold, would let its inhabitants starve to death, if the agriculturist did not come to their relief.

When it became my duty to investigate the Lower Peninsula, I was already informed of the general facts concerning its structure, and I felt somewhat uneasy when I thought that I had no prospect of discovering any great mineral wealth within it, because I knew that there is a general feeling that the geologist should make numerous new discoveries, and report at length about the details of the rock formations, etc. I believe that I have done conscientiously all that could be done under given circumstances, but I have had to be more brief in the description of many things than was my wish, for the simple reason that I had not the opportunities to make more extended observations, on account of the very unfavorable and restricted exposures of the rock beds, which, as already explained, are in the greatest part of their extension covered by an unbroken mantle of drift masses. Perhaps I could have entertained the reader a little better by giving hypothetical speculations on things which could not be seen; but this would have been in opposition to my principle, which is to give facts only, as a guidance for the enterprises of explorers, and for the student of the earth's history.

The benefit to the commonwealth of a geological investigation consists not only in adding discoveries of new stores of minerals to those already known, but to a much greater extent, I think, in causing to be fairly understood the uselessness of explorations for certain minerals in places where they do not exist. Thousands and thousands of dollars have been spent in this way, which could have been saved to their owners, if they had had a clear comprehension of the structure of the earth's crust which they explored, or had asked advice of some one better informed than themselves, before they commenced their work; and in such sense, I know that the contributions to knowledge which I have made in this report will return to the State an ample equivalent for the expense of the investigation.

As an appendix to the foregoing report, exclusively devoted to the description of the Lower Peninsula, is added the report of Dr. Garrigues on salt production in Michigan. Two other special reports, on the roofing slates of Huron Bay, and on the silver-bearing rocks of the Ontonagon district, give the results of a short journey to the Upper Peninsula which I made by special order of the Geological Board.

APPENDIX A.

OBSERVATIONS ON THE ONTONAGON SILVER MINING DISTRICT AND THE SLATE QUARRIES OF HURON BAY.

BY

C. ROMINGER.

APPENDIX A.

OBSERVATIONS MADE ON A CURSORY TOUR THROUGH THE ONTONAGON SILVER MINING DISTRICT.

THE discovery of silver in the sedimentary rock beds of Iron River, in Ontonagon County, has recently attracted considerable attention on the part of miners and capitalists.

On my return from the examination of the Huron slate quarries, of which the report is given elsewhere, some gentlemen of Marquette, interested in the new mining district, asked me to go along with them and examine into the conditions under which the silver is found, which invitation I gladly accepted. In the first report on the Upper Peninsula, little has been said about the region in question, and at the time of its issue the discovery of silver had not yet been made, for which reason I think that the small contribution which I can add to our knowledge of this mining country will be welcome to those interested in its geology and in the development of its mineral resources. Ontonagon district has the same geological structure as the northeasterly part of Kewenaw peninsula, of which it is a direct continuation.

A ridge of copper trap, with a strike from northeast to southwest, and with a northern dip, divides it into an east and west part. The east part is a mountainous plateau with marshy flats, from which Ontonagon River collects its waters through branches, one of which is fed by a large inland lake, the Gogebic Lake.

After winding its way for a while along the foot of the ridge, and having united with its affluents from the south and north, the Ontonagon breaks transversely through the trap range and hastens in a direct northwestern course down the western slope to the lake.

The surface rock of this east side of the central trap range is the red Lake Superior sandstone inconformably abutting against or overlapping the trap rock, with horizontally disposed layers.

On the western slope of the ridge we find the trap rock overlaid by a heavy series of sand rock, conglomerate, and slate deposits, resting conformably on the trap, and participating in its upheavals. The age of these beds is intermediate between the trap and the horizontal sandstone deposits; but between all three of the indicated groups so great lithological affinities exist, that it is most natural to consider them as the consecutive products of one and the same epoch, in the commencement of which the just-formed strata were displaced by volcanic action, which subsided toward the end and left the last deposits undisturbed.

The trappean series is not clearly definable from the conformably incumbent higher beds which form the western slope of the range. The crystalline or amygdaloid trap seams are underlaid by conglomerates and by ripple-marked brown sandstones which are absolutely undistinguishable by lithological characters from similar rock beds found deposited above the trap, and the only way in which the two horizons can be distinguished is by observation of their relative positions to the underlying or incumbent strata of a certain well-marked lithological character.

The absence of all trappean rocks distinguishes the upper division from the lower, in which a constant alternation of trap with the sedimentary beds is observed.

The lately discovered silver-bearing rocks are sedimentary strata inclosed within the more recent non-trappiferous division, which conformably leans with its uplifted beds against the higher trappean hill range, forming a sloping belt of lower hills between the higher range and the lake.

In the north part of Kewenaw peninsula, this shore belt is formed by sandstones very little affected by the upheavals, and lithologically very similar to the horizontal sand-rock beds on the east side; they seem to be somewhat younger than those forming the belt at the foot of the Ontonagon range, and are, as far as known, not metalliferous.

In the interval between the mouth of Ontonagon River and the Porcupine Mountain spur, this rock series under consideration is of somewhat different lithological character; its beds are considerably dislocated by upheavals, and certain seams of the formation are rich in metallic silver, while others are so in metallic copper.

The thickness of this rock series in Ontonagon district is very great, amounting to at least 3000 or 4000 feet. The higher beds are prevalently of a dark grayish or greenish color, of argillaceous and arenaceous composition, and of rather fine-grained slaty or flaggy structure; the lower are prevalently brown-colored sand rocks and conglomerate. The metalliferous seams are above the brown sand-rock and below the gray slaty upper division, and have a much wider distribution than at first was supposed. The metal-bearing beds have actually been found by explorers, from Ontonagon River for 30 miles westward, in every locality where denudations of the rock beds could be seen; and beyond all doubt the existence of the metalliferous beds is not confined to this narrow district. On the other hand, it is not to be expected that the beds are everywhere charged with the metal in quantities which would pay for mining it: some spots may be found unusually rich, others where the same strata are barren of metal.

The silver and the copper are generally found in two separate seams which are only a few feet apart. The lowest seam is charged with scales and granules of metallic silver. In the upper seam the copper is found in similar fine scaly particles and granules, but in much greater quantities than the silver. The silver was first discovered in the rock beds exposed on Little Iron River, at the location of the Scranton mine; and, subsequently, in the valley of Big Iron River, the same strata were discovered either in natural outcrops or through test-pits, so that now a half dozen mining companies are located along Iron River valley, within the distance of a few miles.

The general direction in the dip and strike of the strata is conformable with the strike and dip of the copper range, from northeast to southwest, with northwestern dip; but this direction is only ideal, deducible from the geographical extension of the rock belts, while in actual field observation we find the strata dipping and striking in so many directions, that every locality is governed by its own rules. We find the rock bent in short curves, in synclinal or anticlinal position, or that abrupt breaks in the continuity of the strata cause considerable complications in the reciprocal position of the layers. In examining the bed of Iron River for two miles upward from its mouth, the strike and dip of the strata were found changing continually, so that for a while, in ascending the river bed, we actually descended into lower and lower strata, and then, in the further progress upward, began to rise from the lower beds to the higher, and this several times repeated.

At the mouth of Iron River, brownish, thin-bedded, sand-rock layers with intermediate shaly seams are seen in the banks, with an approximate strike northwest and a northwest dip. A short distance up the river runs in rapids over rocky bars, obliquely crossing its bed, which are lower strata than those at the entrance; their strike is about 15° north of west, with a dip east of north at an angle of about 20°. Ascending in the river channel, we pass over the edges of constantly lower and lower strata; these lower beds are dark bluish or blackish gray slaty layers of a fine-grained, sandy and argillaceous rock with fine micaceous scales; the surfaces of the thin slabs are ripple-marked. With the ascent the dip and strike of the strata constantly change. At a no greater distance than 150 steps above the former place where strike and dip were measured, the strike had changed to be south of west with a dip south of east. The strata here are still lower, thinly laminated flagstones containing some calcareous cement, but of the same dark, arenaceous, slate-like rock mass as the higher beds. The dark rock contains globules of calcareous concretions, and seams of softer shaly structure alternate with the ripple-marked harder slabs. Weathering slaty pieces are covered with a green efflorescence of carbonate of copper oxide. We have arrived now at the foot of low, stair-like falls, where, by a bend of the river, across the strike and with the dip of the strata, which latter is here south of east, instead of descending further in the series as we were doing, we ascend, step by step, into higher beds, similar in character to those seen before.

By another flexion of the river bed, it comes parallel with the strike of the strata, and without ascending or descending in the series, we move up its course, remaining on the same horizon; but soon, by another bend, a descent into lower beds, while still ascending the river, begins. The stamp works of the Ontonagon Mining Company are now in sight; the strike of the strata approaches gradually an almost due east and west direction, with a dip northward at a steep angle, and still, while ascending the river, we steadily descend upon lower beds. The rock below the stamp mill is in thicker, much more massive beds than seen before. Some seams approach also to the structure of ordinary sand rock, but the general character of the rock material has not changed much.

The sum of the thickness of the rock series passed over between the mouth of the river and the stamp mill, which is two miles up, can not be much less than 1500 or 2000 feet.

Under the more thick-bedded, argillaceo-arenaceous rocks mentioned, follow thinly laminated, blue, shaly layers, and then a bed, or several beds, of a rather coarse-grained, grayish sand rock, hardened by an abundant admixture of calcareous cement, and interlaminated by thin flexuose seams of a shining black shaly substance. This latter is the *silver-bearing rock*, varying from about 1 foot to 4 and 5 feet in thickness. Further up the river the strata retain the same direction, and in descending order, below the silver-bearing sand rock, we find at once a change in both the color and composition of the rock; we go through a series of brown sandstones and coarse conglomerate beds, of very great thickness, which seem to be directly followed by the trappean rock series. The miner has in this brown sand rock an infallible indication that he is below the silver-bearing beds; thus, when he sees in an outcrop the dark bluish slate-like beds and the brown sand rock coming in close contact, he knows that the silver-bearing rock band must be found between. The silver is contained in the sand rock in thin leaflets and granules, in pure metallic condition; the black shaly seams covering the surface of the ledges are generally richest in metal. Narrow fissures in the sandstone are also sometimes filled out with paper-thin sheets of silver, and the small druse cavities are lined with a film of it. Remarkable is the occurrence of rock oil in some of these druse cavities. In the sand rock containing the silver, thin seams and granular specks of vitreous copper ore are usually found interspersed; the miners consider them as sulphuret of silver, but I examined the ore and found it composed of copper alone with no silver.

By repeated synclinal or anticlinal curves in which the strata are bent, in various localities higher up the river, either higher or lower beds are brought to the surface. The silver-bearing bed is found again a mile south of the stamp mill, on the properties of the Cleveland and Collins Mining Companies, which join each other; also in Little Iron River. At the Scranton mine the ore is found under the same conditions, always resting on a foot wall of brown sand rock or conglomerate, and with a hanging wall of blue slaty rock.

A very interesting fault in the strata is observable in the river bed, about fifty steps up stream from the Collins mine.

At the mine the silver-bearing bed strikes diagonally across the river, 25° east of north, with a dip south of east. An abrupt break interrupts the strata then, and a belt of almost vertical ledges of brown conglomeratic sandstones crosses the river bed in a direction 25° south of west, with a dip northwestward, and on the other side of this belt similar conglomeratic sand-rock ledges come in contiguity to it, which strike in the direction of northwest and dip northeast with moderate inclination. In the bed of Mineral River, east of Iron River, entirely similar exposures are observed. A seam of sandy rock beds, which contain sometimes immense quantities of fine scaly or granular metallic copper, is found quite as uniformly distributed as the silver-bearing seam. It is found only 6 or 8 feet above the argentiferous beds.

The Nonesuch mine is opened in these cupriferous beds; its situation is in Town. 50, R. 43, Secs. 1 and 12. The strike of the formation is there 50° east of north, dip south of east, at an angle of 30°. The hanging wall of the mine is formed by blue arenaceous slates seen in a thickness of several hundred feet, exposed in the bed of the creek. The ore bed is an argillaceous and partly conglomeratic, greenish-gray sand rock, densely crowded with fine copper scales or coarser granules of that metal. Its thickness is about 8 feet. Some few feet below the ore bed, which is naturally exposed in the creek, another sand-rock seam is noticed which can be identified with the argentiferous sand-rock seams of the mines in Iron River.

The same superposition of the two ore beds I have noticed in the bed of Mineral River. At the base of the ore beds of the Nonesuch location, the brown sand rock and conglomerate beds are well denuded in the bed of the creek, in descending toward the stamp works of the mine.

The proportion of metallic copper mixed with this sand rock is very great, fully as great as in the best picked specimens of the Calumet and Heckla conglomerate, but the finely comminuted condition of the copper causes a great loss in the stamping and washing of the rock.

In Union River, a short distance west of Little Iron River, at the foot of the Porcupine Mountains, brown sand rock and conglomerate ledges of great thickness are uncovered in the bed of the creek, dipping at an angle of from 20° to 30° in a northeast direction.

The beds can be directly followed in descending series by going up stream toward Union mine, where they are seen in conformable superposition on the amygdaloid trap belt in which Union mine is opened. Under the amygdaloid belt other conglomerates and sand-rock strata are found, which can not be distinguished in lithological characters from the upper beds. A natural exposure of the two sand-rock belts with the amygdaloid rock between is seen in a ravine close to the side of the road leading from Union mine to the Nonesuch mine. The foot-wall sand rock of the Nonesuch mine seems to be the analogue to the hanging wall of the Union mine. On the west side of the Porcupine Mountains, the shore belt has the same geological structure as the Iron River district, and in all probability the silver-bearing rock seams can be found there also.

The silver is extracted from the rock by stamping all the rock as it comes from the ledge, without selection, and subjecting the stamped rock to the amalgamation process. The results of the experiments were quite variable, yielding, per ton of rock, from fifteen to fifty dollars' worth of metallic silver. The process of amalgamation was very imperfectly carried out, leaving in the sediments which settled from the wash-water a considerable proportion of amalgam globules. I am fully convinced, therefore, that, by proper management of the process, the average quantity of silver per ton would not be less than thirty dollars. The silver seems not to be confined to certain localities, but to have a wide horizontal distribution in this rock seam; still it would be unreasonable to expect that in every locality where these rock beds are found, they should contain silver in quantities to make mining remunerative.

REPORT ON THE SLATE QUARRIES OF HURON BAY.

By special order of the Board of Geological Survey, I left on August 23d, 1875, for Lake Superior district to examine the slate quarries on Huron Bay, with a view to reporting on the conditions under which the slate rock is found, and upon the quality of the rock as a roofing material. I spent in all two weeks on the excursion; therefore it can not be expected that I will give an exhaustive report on the complicated geological structure of this country, full as it is of upheavals. Yet I will endeavor to make a general statement covering all important facts connected with the distribution and qualities of this valuable rock species.

Let me here acknowledge the kind assistance received on this occasion from Mr. S. C. Smith, a gentleman favorably known for a great many years back as one of the most successful explorers of the Lake Superior country. He accompanied me on the excursion, and, aided by his minute acquaintance with the district, in which he had spent the whole previous season in explorations, I was enabled to see, during the short time at my disposal, nearly all the more important outcrops dispersed throughout its dense forests.

Glancing over the geological map of the Lake Superior district, issued with the report of 1873 on the Northern Peninsula, we see the area of the Huron mountains, which attain an elevation of about 1200 feet above the lake, represented as composed of the Laurentian rock series, mainly crystalline, granitic and dioritic, massive, or with obscurely stratified structure.

On its northern margin, at the foot of the mountains, which reach close up to the shore, this granitic rock series is surrounded by a narrow belt of horizontal strata of the Lake Superior sandstone, inconformably abutting against it. Southward, nearly reaching up to the highest crest of the mountain range, the Huronian rock series leans inconformably against it, with its uplifted beds, alternating between Slate rock, Quartzites, Diorites, and Jaspery strata, interstratified with heavy seams of iron ore in the form of magnetite, or as a red or brown iron oxide. These latter two are designated by the miners as red and brown hematite.

The western and northwestern slope of the granitic knot is surrounded by slates which belong likewise to the Huronian series, but differ from the slates of the Marquette district. It is not as yet clearly ascertained what position this slate occupies relative to the iron-bearing series.

The slate rock extends, at the head of the Bay of L'Anse, close to the shore, the outer edge of the shore line being formed by horizontal ledges of the Lake Superior sandstone, in plainly visible inconformable superposition on the uplifted edges of the slate rock. Mr. Hurley, of Marquette, during last summer, opened a quarry in this sand rock, and, as I am informed, found a very good marketable stone equal to the Marquette brown stones. In the slate exposures along the shore, we can see the strata frequently flexured in a series of synclinal and anticlinal axes. The slate is in shattered condition, with cleavage planes intersecting the lines of stratification at various angles; its color is a light green or bright red, or variegated. Hard and soft seams frequently alternate; it is not durable, nor does it split regularly, and can not therefore be used as a roofing slate. At intervals, belts of a metamorphic rock, intermediate in structure between a very compact glassy sandstone and a Diorite, are intercalated between the slate layers. Some of these belts are massive, like an intrusive volcanic rock, while others are distinctly bedded and alternate with thinner seams of slate rock. In places the tough, hard rock is rotten on the surface, and, when such is the case, lumps can be taken and crushed into sand by a mere pressure of the hand.

The thickness of the shale rock in the exposure can not well be estimated, as the strata repeat themselves several times on account of their synclinal and anticlinal position; but the rock is so much alike in its totality, that an identification of the corresponding strata on opposite sides of the axes of elevation can rarely be made. In one of the synclinal crevices, I noticed an interesting case of the filling up of the gap by horizontal layers of sandstone.

The bed of a creek which descends in a series of rapids, from the northern slope of the Huron mountains to the head of L'Anse Bay, presents a splendid section through at least 1000 feet of slate rock, with an approximate strike from northwest to southeast, and a southern dip. This slate is of darker color and more compact than the slate in the shore exposure, but is not at all suited for roofing purposes. Contact of the slates with the granitic rocks cropping out at the summit of this slope is not seen. Deep drift masses, mixed with slate and granitic blocks, occupy a large space between them.

The slate rock suitable for roofing is found on the northwest side of the Huron mountain range, in the vicinity of Huron Bay. A fine road 15 miles in length has been made from L'Anse to the slate quarries, which are about 3 miles south of Huron Bay, in Town. 51, R. 31, Sect. 28. From the Methodist Mission on the shore of L'Anse Bay, the road goes directly east, and for several miles along the surface rock is the horizontally stratified red sandstone which covers the entire land-spur between Huron and L'Anse Bays, with the exception of a knoll of so-called trap rock protruding on the west side of the head of the bay like an island.

Near the big bend of Silver Creek, where it changes its course from west to northeast, the road makes a steep descent and crosses the stream. The slate formation is here well uncovered; the strata are steeply inclined, dipping south, with a strike from northwest to southeast, showing, however, greater or less local variations in direction through tortuous plications on a large scale, or through minor zigzag corrugations, which frequently occur.

The slates exposed at this locality are of a blackish color, hard, silicious, and with irregular, uneven cleavage, unfitting them for roofing purposes; frequent seams of a compact, hard quartzose, hornblendic and feldspathic rock, in grain resembling a metamorphosed sandstone, alternate with the slates. Its color is either a greenish black or a light grayish shade. The road intersects the strike of the strata almost rectangularly, presenting, in its further progress, belts of slates several hundreds of feet in thickness, alternating with the hard quartzose rock generally designated by the name of trap, all retaining the same general strike and dipping direction.

We pitched our camp in the northeast corner of Sect. 25, of Town. 51, R. 32. The exposures of the slate rock at the bridge across Silver Creek are in Sect. 27, of the same town. Northeast from our camping-ground, in Sect. 19, of Town. 51, R. 31, after crossing over continued slate beds, with southern dip and the general northwest and southeast strike, we came to a high hill composed of a belt of hard, blackish-colored trap rock, about 500 feet in width, of obsoletely stratified structure, with rhomboidal cleavage cracks, and much resembling a basaltic igneous rock mass. On the other side of the crest of this hill the slate rock is met again with the same dip and strike as before. The slate is here more evenly laminated, but not of a quality that can be used for roofing.

The direct distance from our camping-place to the location of the slate quarries was three miles. In going there we had to intersect obliquely the strike of the strata, which is over all this space in the general northwest and southeast direction, with a southern dip, without a change of the direction which would cause a repetition. The thickness of the slate deposits must, consequently, be enormously great. In Section 30, after crossing two creeks running parallel with the strike of the strata, we came upon a belt of trap rock protruding as an abrupt hill range above the surrounding slate. This possibly may be the direct continuation of the trap range we found the day before, in Sect. 19, or, perhaps, a distinct belt, of which there seem to be many intercalated with the slate formation.

In Section 28 we enter the valley of another creek, along which the slate quarries are located. No change in the strike and dip of the strata is observed. The useful slate rock is a seam of the immense series already transgressed, differing from the rest only in possessing a more regularly laminated character. It is susceptible of being split into large, even slabs of any desired thickness, with a fine, silky, homogeneous grain, and combines durability and toughness with smoothness. Its color is an agreeable black, and very uniform. Several companies have located their quarries along the creek which runs parallel with the strike of the strata, and a tram-road about 3½ miles in length has been built down to the bay, where a dock is erected for the unloading of vessels and for convenient shipment of the slate.

I followed the exposures of the slate rock, which, however, are not all of the better quality, along the section lines of 28, 27, 26, and 25. Not far from there, in the next township, Range 30, Mr. Hurley has commenced to work a quarry, which so far furnishes a product fully equal in quality to that of the other quarries. On the town line between Secs. 24 and 25, I found another belt of trap protruding as an abrupt hill above the surrounding country. Its strike is nearly east and west, its dip south, and on both sides are slates of conformable strike and dip. The trap belt is about 60 feet wide, a dark hornblende rock, with quartz and chlorite veins, and divided into rhomboidal blocks by cleavage cracks, altogether resembling rather an intrusive mass than a sedimentary layer.

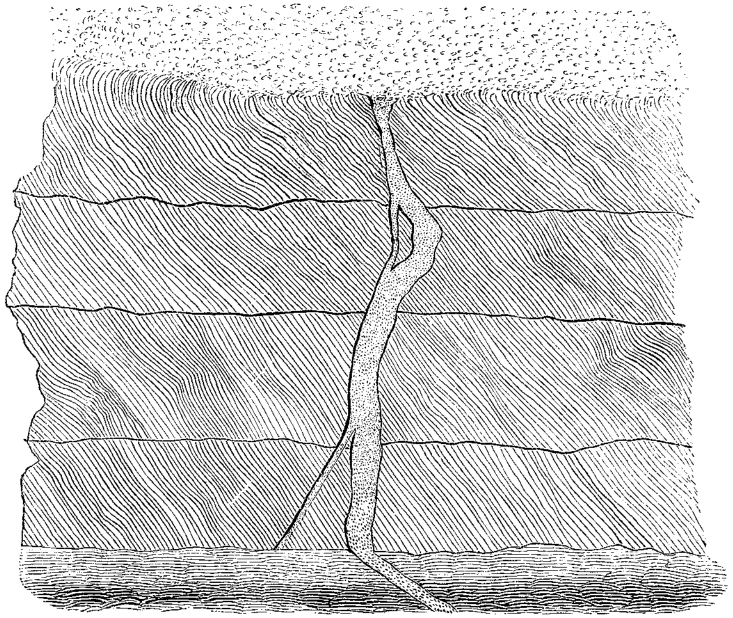
Along the tram-road, toward the bay, after intersecting a series of roofing slates, a dark belt of trap rock of about 100 feet thickness is crossed. Following this is a belt of white quartzite about

200 feet wide, succeeding to which are other slates of the inferior unmarketable quality. All these strata are conformable in strike and dip. Near the bay the horizontal sand-rock ledges are again encountered.

In the quarry of the Huron Bay Slate Company, the slate dips south, at an angle of from 45° to 60°. Three cleavage plains intersect the slate and divide it into rhombical blocks. The principal cleavage, with which alone it can be split into roofing slabs, is identical with the plane of stratification.

By another cleavage, intersecting the slates in horizontal direction, the walls of the quarry appear as if composed of a sequence of thick horizontal beds.

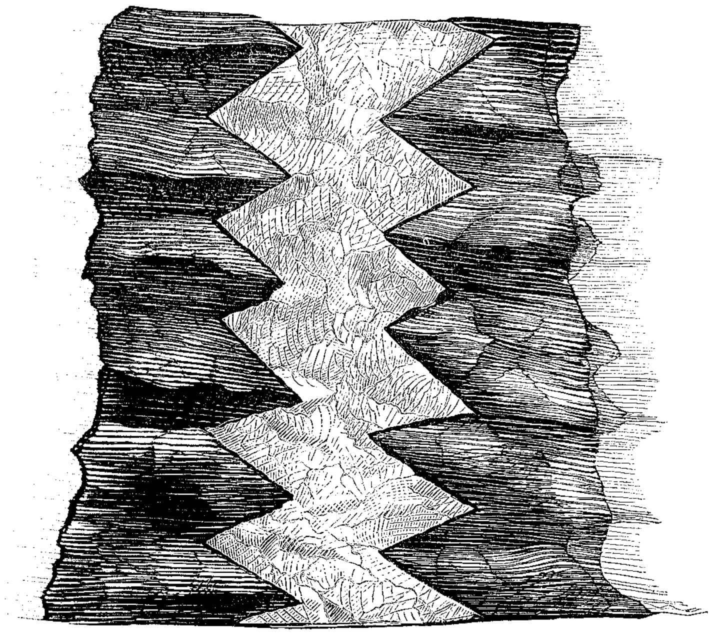
The rock mass here is frequently cleft by narrow, vertical fissures, which are filled out with different mineral substances essentially distinct in genetic character.



One of these fissures seen in the walls of the quarry, of irregular, somewhat tortuous form, in some places wide, in others narrow, and more than once divided into two branches, which subsequently unite, is filled with a compact, dark, greenish-colored rock mass, of amorphous or finely crystalline fracture, and interspersed with acicular sparry crystals, together with granular crys-

tals of pyrites and some leaflets of a shining brown mica. This mass is most intimately united with the slate wall on both sides, and has all the appearance of an injected igneous body. Near the surface the fissure is wider, and the inclosed rock substance spreads laterally over the immediately surrounding surface. The greatest width of the vein is perhaps a foot, but it shrinks in places to not more than half an inch.

Another class of fissures, which are of more frequent occurrence, are filled with milk-white quartz, mixed with calcspar and iron pyrites crystals. These are rarely over an inch wide, and the matter filling them is evidently deposited there from aqueous solutions percolating through the fissures. In some of them, the walls are straight and smooth; in others the slate has broken through in zigzag lines, with strongly indented, saw-like edges, often slightly dislocated so as to bring the teeth and indentations in opposition.



The process of quarrying the slate is attended with great waste, which is to some extent unavoidable. The slate is often unfavorably cleft, and the uplifted layers are sometimes curved or warped to such a degree as to make them unfit for roofing; but, besides this, a great waste occurs in getting out the rock, which is altogether done by blasting with powder. Necessarily, therefore, a great proportion of the loosened rock is shattered into worthless fragments.

I trust the managers and workmen of our quarries, most of whom have been at work in the slate quarries of the Eastern States, know how best to do the business; but I would take the liberty of suggesting that, by cutting narrow gangways into the walls, at intervals, the intermediate blocks or pillars could be taken out by a crowbar without the use of much powder. This would save a great part of the slate now destroyed, and in the end would be found to be a quicker process than the present.

At the time of my visit nearly 40 men were engaged in the quarry, turning out daily about 17 squares of roofing slate, which brings in the Chicago market from $7 to $8 per square.

The slate is of an excellent quality, and bears favorable comparison with the best slates of the Eastern States. In durability and in color, which is a uniform black with a grayish hue, it excels them all.

The opening of the quarries in this remote place, in the midst of a wilderness, was attended with great preliminary expense. The building of roads, the transportation of machinery, and the hire of men and constant transportation of supplies, had to be paid for at extra rates; then a long time was required in which to bring the quarry to a productive condition. I think, however, from all I can observe, that the worst difficulties have been encountered and overcome, and that nothing now stands in the way of the future prosperity of this highly commendable enterprise, undertaken at so great an expense and risk.

Several other quarries have been recently opened, in close proximity to that described above, some of which have produced already small quantities of slate for shipment, equal in quality to that of the first. The masses of good slate already discovered in the district promise an inexhaustible supply.

APPENDIX B.

REPORT ON THE SALT MANUFACTURE OF MICHIGAN.

BY

S. S. GARRIGUES, PH.D.,

STATE SALT INSPECTOR.

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APPENDIX B.

SALT IN MICHIGAN.—HISTORICAL.

IT was known from the earliest settlement of the country, that the Indians formerly supplied themselves with salt from springs existing in the peninsula, and numerous reservations of land supposed to contain the springs were made by the general government, and it is a matter of record that many years before Michigan was organized into a State government, attempts were made to manufacture the article.

By the act of admission of this State into the Union, in 1837, it will be recollected, the State authorities were permitted to select seventy-two sections of salt-spring lands.

A State geologist—the lamented Dr. Douglas Houghton—was appointed at the first meeting of the Legislature thereafter, who, in his report to the Legislature in January, 1838, says he regarded it important that the spring lands be selected for State purposes, at as early a day as possible, and most of his examinations the season previous were devoted to that end. Dr. Houghton's explorations resulted in finding many indications of saline springs, particularly on the Grand and Tittibawassee rivers, in Kent and Saginaw Counties, and also in St. Clair, Macomb, Wayne, and Jackson Counties. The Legislature passed an act for the improvement of the State springs in 1838, and by virtue of his appointment, Dr. Houghton was authorized to make examinations and to institute experiments, which he did on the Grand and Tittibawassee rivers with partial success.

Although public attention was at that time directed to our salt springs, and practical investigations relating to their development were for a time vigorously prosecuted, these experiments failed of complete success, and the subsequent death of Dr. Houghton, by depriving the State of one on whom it had relied to give intelligent direction to these enterprises, discouraged in a measure their further prosecution.

Guided, however, by the information thus furnished, other investigators took up the matter, and on a thorough examination of the subject became so fully satisfied of the existence of rich saline waters in our State, that they at once determined to extend their experimental researches still further, and soon demonstrated in the most satisfactory manner the entire correctness of the theory advanced.

Saginaw valley has the honor of having practically proved the wisdom of our first State geologist, in regard to the saline resources of the State, and demonstrated in a few short years, to an extent hardly to be credited, their unlimited supply, as well as their profitable and beneficial nature. Encouraged by the information furnished by the geological surveys, borings in several localities have been extended to other groups of rocks, much older and lower than the preceding, viz., Onondaga salt group—the representation in this State of the group so called in the State of New-York—and though their productiveness is not yet perhaps satisfactorily established, sufficient encouragement has been received to afford reasonable hopes that these rocks may yet yield a supply of salt sufficient to render them a source of profit, thus adding immensely to the saline wealth of the State.

WELL-BORING MACHINERY.

The proper location having been selected for the salt well, a drill house, 16 by 30 feet, with a tower, is erected. This is large enough for a boiler, small portable engine, and a forge for repairing tools and keeping the drill sharp.

The tower or derrick has a height of 50 feet, or is high enough to draw out the drilling poles. The tool with which the boring or drilling is done is a drill, 3 feet long, shaped at one end like a chisel, and made of the best quality of steel.

The drill is screwed into the sinker, which is a round iron bar 40 feet long and 3 inches in diameter, and weighing about 2000 pounds.

Attached to the sinkers by strong screws are the "jars;" these are about 7 feet long and made of good iron. The "jars" are two slotted links, moving up and down within each other, and are intended to increase the force of the blow of the drill upon the rock by allowing it to fall with a sudden jerk.

The jars are attached by a screw to the drill pole, which is, in turn, connected by a swivel to a chain. The chain is fastened to an ordinary "walking-beam" of wood, driven by an engine of small horsepower.

The beam rises and falls continually over the mouth of the well, the chain which suspends the tool passing over the end of the beam, being so arranged that it can be let out as the hole deepens, at the same time lifting the tool or drill and allowing it to drop with measured stroke on the rock, which is thus gradually drilled out. A workman sits at the mouth of the well, having the pole grasped by his hands, and after every stroke the poles are slightly turned so as to turn the drill which is working on the bottom, thus keeping the well true and circular in shape.

While the well is in process of boring, the tools are frequently removed and the sand pump introduced to remove the loose matter from the bottom of the well, which is done by means of a suction valve. The sand pump removes all the ground rock sand, and takes up at times stones an inch or more in size. In commencing the well, a strong wooden box 8 inches square, made from 2-inch plank, is driven down into the ground, say from 14 to 16 feet. Inside of this, an 8-inch iron tube or casing is put down as fast as the alluvial or drift material overlying the rock formation is broken up by the drill and taken out by the sand pump; this continues until the solid rock is reached.

At this point, considerable care should be taken that the opening into the rock is perfectly round and well finished by the drill; for the casing should be set so firmly in the rock as to prevent any sand or gravel from running in under the tube, and thus getting in on top of the drill and endangering its becoming fastened in the well.

The rock-drilling now commences and continues to the depth to which it is proposed to sink the well. After the drilling is done, the sides of the well are smoothed off with a tool called a reamer.

In most of the salt wells on the Saginaw River an offset is placed in the well at a short distance above the lower sand rock. Below the offset the size of the well is lessened half an inch in diameter.

On this offset is made the so-called rock-packing, the hole being drilled bevelling so as to receive a tightly-fitting iron collar or funnel-shaped piece of metal. A tube corresponding to the size of the upper part of the well is made to rest on this rock-packing as the offset, and runs to the top of the well; in this way, all the weak brine from the upper rock and any fresh water that may come into the well above the offset are shut off. Below the offset, the tube continues in reduced size to the locality of the lower sand rock, at which point the pumping chamber containing the pumping valves is placed.

In the early history of salt-well boring in Michigan, the pressure of the brine in the well tube forced it within 100 feet of the surface. More recently, owing no doubt to the great demand for brine, it does not rise so high. It only requires a small amount of power, after the pumping rods are properly balanced, to lift the brine out of the well into the settling tanks.

PUMPING BRINE.

Often, in starting up a new salt well, the brine is weak—that is, shows a small percentage of salt by the salinometer. This arises from the fact that a large quantity of fresh water or weak brine from the upper formations has passed down into the well during the time the well was opened or being tubed. To test this point, and to bring the brine up to the usual strength of salt brines, the pump is put in operation and run for some time. If the brine continues to show an increase of strength on being tested by the salinometer, the pumping is continued until the strength of brine remains permanent at such a percentage as wells of equal depth in the same locality have shown.

If, however, the brine does not increase in strength, there are strong probabilities that there is a leakage of fresh water or weak brine into the well at the offset. This should be remedied at once—the more so if the well is a deep one, such as most of those in the Saginaw Valley are; for in this case the offset in the well is below the so-called gypsum formation, and you are drawing in and mixing with your strong brine a weak brine from these formations which has a higher percentage of gypsum.

This mixing of the two brines in the well and tubing causes a precipitation or separation of the gypsum upon the pumping rods and in the pumping chamber. If this is not stopped, it will eventually close up the valves, and prevent them from being drawn out of the chamber. More than one instance has been known where

parties have suffered much extra expense in not attending to this kind of leakage.

A manufacturer, in starting up his well pump, may also find that he has a short supply of brine, and the brine in the well tube runs down as soon as the pump is stopped. In this case he may have strong suspicions that his well tube is defective, or that the joints are not put together tightly, causing a leakage. To ascertain where this is, the tubing should be lifted out, the lower valve being allowed to remain in. As the tubing is being drawn, the pressure of the column of brine in the tube on the joints or imperfections will show where the leakage is. If the tubing is imperfect, it should be taken out and replaced by perfect tubing. When the leakage is at the joint, a new thread should be cut upon it, or the joint should be screwed together more tightly.

It is very important that the salt manufacturer should ever be on the lookout for these leakages, as they may and do often arise from a jarring of the tubing in running the pump faster than the supply of brine comes to the pumping chamber, causing a vacuum and producing the so-called pounding of a well. The capacity of a well has been very materially affected by such a leakage, increasing the expense of pumping from 50 to 100 per cent.

The supply capacity of a well is also very materially increased by the position of the pumping chamber in the well. In the early history of salt wells in Michigan, the pumping chamber was generally placed a short distance below the offset. More recent tests go to prove that the best location for the pumping chamber is at or very near the point where the largest supply of brine comes into the well, and that point is the lower portion of the sand rock, or within a short distance of the bottom of the well.

In pumping a well, it is also important that the weight of the pumping rods should be evenly counterbalanced by a weight on the other end of the walking-beam; this relieves the engine, the only weight to be lifted being the brine.

The stroke of the piston in the pumping chamber should be made as long as possible, and the motion of the engine should not be over 32 revolutions to the minute. In this way, about the entire supply of brine in the well is obtained, without forming a vacuum, thus preventing the pounding of the well and the danger of parting the pumping rods or jarring the tubing loose at the joints, causing leakage.

The capacity of salt wells varies in different localities, from 12 to 20 gallons per minute—the size of the well and the quantity and porosity of the sand rock having much to do in increasing the amount. A good well will fill a cistern 20 x 30 x 6 feet in about 20 hours. A salt well in Saginaw City owned by Pierson, Wright & Co. produced enough brine during a manufacturing season of eight months to make over 26,000 barrels of salt. At East Tawas, the wells, 3½ inches in diameter, fill a cistern of the above size in about twelve hours. At Port Austin, the well fills a cistern in seventeen hours.

TESTING THE STRENGTH OF BRINES BY SALINOMETER, WITH COMPARATIVE TABLES.

The following table is extracted from Alexander Winchell's Report on the Geology of Michigan, published in 1861; it has been thought advisable to reprint it at length as a guide to our salt manufacturers.

"Pure water dissolves, at ordinary temperature, a little over one third its weight of salt, or from thirty-five to thirty-six hundredths. The amount varies somewhat with the temperature, and the results of different experiments are, moreover, not perfectly accordant; but from the most accurate observations, it appears that 100 parts by weight of pure saturated brine, at temperatures from 32° to 70° Fahr., contain from 26.3 to 26.7 parts of salt. Some earlier determination, however, gave but 25.7 parts, and upon this figure the table was calculated.

"The specific gravity of a saturated brine at 60° Fahr. is 1.205 pure water, being 1.000. The salinometer employed in many salt works for fixing the value of brine is an areometer with an arbitrary scale divided into 100 parts. The density of water on this scale is represented by 0° and that of saturated brine by 100°. Each degree of the salinometer, therefore, corresponds very nearly to one quarter of one per cent of salt. In the following table, the true specific gravity, with the corresponding degree of the salinometer, and of the hydrometer of Baumé, is given in the first three columns. The succeeding columns give the percentage of salt in a pure brine for each degree of the salinometer, the number of grains of salt to the wine pint of 36,625 cubic inches, and the number of gallons of such brine required to yield a bushel of salt weighing 56 pounds.

"From this table the properties and capabilities of any brine may be ascertained by knowing its strength as shown by the salinometer. Suppose, for instance, the salinometer shows 53°. The table shows at a glance that this corresponds to 13.78° of Baumé's hydrometer, a specific gravity of 1.100, and a percentage of 13.62; while a wine pint of the brine would furnish 1092 grains of a solid residue, and 44.7 gallons would produce a bushel.

"If the strength of a brine is expressed by giving its specific gravity, and we wish to compare the strength as thus stated with that of another brine given in degrees of the salinometer, or the number of grains in a pint, and we look in the column of 'specific gravity' in the foregoing table, and find the number which agrees nearest with the given one, then on the same horizontal we have all the synonymous expressions for the same strength, and it is seen at once whether the brine with which we wish to make the comparison is stronger or weaker.

"Or suppose, thirdly, that a land-owner desires to know the comparative strength of a brine spring on his premises, while he possesses no instrument for taking specific gravity. Let him evaporate a wine pint and weigh the residue, or take it to the apothecary to weigh; then the number of grains found in the fifth column of the table will show him all the equivalent expressions.

TABLE GIVING A COMPARISON OF DIFFERENT EXPRESSIONS FOR THE STRENGTH OF BRINE, FROM ZERO TO SATURATION.

Degrees Salinometer	Degrees Baumé.	Specific Gravity.	Per cent of Salt.	Grains of Salt in one Pint.	Gallons for a Bushel of Salt.
0	0	1.000	0	0	Infinite.
1	.26	1.002	0.26	19	2599
2	.52	1.003	0.51	38	1297
3	.78	1.005	0.77	56	863
4	1.04	1.007	1.03	75	647
5	1.30	1.009	1.28	94	516
6	1.56	1.010	1.54	114	430
7	1.82	1.012	1.80	133	368

Degrees Salinometer.	Degrees Baumé.	Specific Gravity.	Per cent of Salt.	Grains of Salt in one Pint.	Gallons for a Bushel of Salt.
8	2.08	1.014	2.06	152	321
9	2.34	1.016	2.31	171	285
10	2.60	1.017	2.57	191	256
11	2.86	1.019	2.83	210	232
12	3.12	1.021	3.08	229	213
13	3.38	1.023	3.34	249	196
14	3.64	1.025	3.60	269	182
15	3.90	1.026	3.85	288	169
16	4.16	1.028	4.11	308	158
17	4.42	1.030	4.37	328	149
18	4.68	1.032	4.63	348	140
19	4.94	1.034	4.88	368	133
20	5.20	1.035	5.14	388	126
21	5.46	1.037	5.40	408	120
22	5.72	1.039	5.65	428	114
23	5.98	1.041	5.91	448	109
24	6.24	1.043	6.17	469	104
25	6.50	1.045	6.42	489	99.7
26	6.76	1.046	6.68	510	95.7
27	7.02	1.048	6.94	530	92.0
28	7.28	1.050	7.20	551	89.5
29	7.54	1.052	7.45	572	85.3
30	7.80	1.054	7.71	592	82.3
31	8.06	1.056	7.97	613	79.5
32	8.32	1.058	8.22	634	76.9
33	8.58	1.059	8.48	655	74.5
34	8.84	1.061	8.74	676	72.1
35	9.10	1.063	8.99	697	69.9
36	9.36	1.065	9.25	719	67.9
37	9.62	1.067	9.51	740	65.9
38	9.88	1.069	9.77	761	64.1
39	10.14	1.071	10.02	783	62.3
40	10.40	1.073	10.28	804	60.6
41	10.66	1.075	10.54	826	59.1
42	10.92	1.077	10.79	848	57.6
43	11.18	1.079	11.05	869	56.1
44	11.44	1.081	11.31	891	54.7
45	11.70	1.083	11.56	913	53.4
46	11.96	1.085	11.82	935	52.2
47	12.22	1.087	11.08	957	50.9
48	12.48	1.089	12.34	979	49.8
49	12.74	1.091	12.59	1002	48.7
50	13.00	1.093	12.85	1024	47.6
51	13.26	1.095	13.11	1047	46.6
52	13.52	1.097	13.36	1070	45.6
53	13.78	1.100	13.62	1092	44.7
54	14.04	1.102	13.88	1115	43.8
55	14.30	1.104	14.13	1137	42.9

Degrees Salinometer.	Degrees Baumé.	Specific Gravity.	Per cent of Salt.	Grains of Salt in one Pint.	Gallons for a Bushel of Salt.
56	14.56	1.106	14.39	1160	42.0
57	14.82	1.108	14.65	1183	41.2
58	15.08	1.110	14.91	1206	40.4
59	15.34	1.112	15.16	1229	39.7
60	15.60	1.114	15.43	1252	38.9
61	15.86	1.116	15.68	1276	38.2
62	16.12	1.118	15.93	1299	37.5
63	16.38	1.121	16.19	1322	36.9
64	16.64	1.123	16.45	1346	36.2
65	16.90	1.125	16.70	1370	35.6
66	17.16	1.127	16.96	1393	35.0
67	17.42	1.129	17.22	1417	34.4
68	17.68	1.131	17.48	1441	33.9
69	17.94	1.133	17.73	1465	33.3
70	18.20	1.136	17.99	1489	32.7
71	18.46	1.138	18.25	1513	32.2
72	18.72	1.140	18.50	1538	31.7
73	18.98	1.142	18.76	1562	31.2
74	19.24	1.144	19.02	1587	30.7
75	19.50	1.147	19.27	1611	30.3
76	19.76	1.149	19.53	1636	29.8
77	20.02	1.151	19.79	1661	29.4
78	20.28	1.154	20.05	1686	28.9
79	20.54	1.156	20.30	1710	28.5
80	20.80	1.158	20.56	1736	28.1
81	21.06	1.160	20.82	1761	27.7
82	21.32	1.163	21.07	1786	27.3
83	21.58	1.165	21.33	1811	26.9
84	21.84	1.167	21.59	1837	26.5
85	22.10	1.170	21.84	1862	26.2
86	22.36	1.172	22.10	1888	25.8
87	22.62	1.175	22.36	1914	25.5
88	22.88	1.177	22.62	1940	25.1
89	23.14	1.179	22.87	1966	24.8
90	23.40	1.182	23.13	1992	24.5
91	23.66	1.184	23.39	2018	24.2
92	23.92	1.186	23.64	2045	23.8
93	24.18	1.189	23.90	2072	23.5
94	24.44	1.191	24.16	2098	23.2
95	24.70	1.194	24.41	2124	23.0
96	24.96	1.196	24.67	2151	22.7
97	25.22	1.198	24.93	2178	22.4
98	25.48	1.201	25.19	2205	22.1
99	25.74	1.203	25.44	2232	21.8
100	26.00	1.205	25.70	2259	21.6

"In making use of the table, it must be remembered that it will prove accurate only for *pure solutions of salt*. In this state, the chloride of calcium and magnesium which existed to some extent in our brines will cause the table to make a showing too favorable. As the percentage of impurities is a variable quantity, it was impossible to make allowance for them in the table. Though we can not therefore construct a table practically accurate, it is not thought best to discard all attempts at a table. As long as it is thought desirable to use the salinometer, it seems to be a matter of convenience to have at hand the ready means for converting its reading into the equivalent expressions.

"It must also be borne in mind that brines of the same strength possess different densities, depending upon the temperature, the density rapidly diminishing as the temperature rises. It is consequently necessary to experiment on brines at a uniform or standard temperature. The ordinary standard for hydrometrical operation is 60° Fahrenheit's thermometer, but the standard temperature at the Onondaga salines is 52°, that being the natural temperature of the brine as it issues from the well.

BRINE ANALYSES.

The first practical attempt at salt-well boring in Grand Rapids was commenced August 12th, 1859, and finished October 14th, being 257 feet deep. A sample of brine taken at this time was analyzed by Prof. Fish, with the following results:

Specific gravity	1.01752
Fixed constituents	2.33385 per ct.
Carbonate of iron	0.00145
" lime	0.00473
" magnesia	0.00084
Free carbonic acid	0.00603
Silicic acid	0.00025
Sulphate of lime	0.13120
Chloride of calcium	0.27641
Chloride of magnesium	0.07196
Chloride of potassium	0.01561
Chloride of sodium (salt)	1.73696
Loss	0.08841
	2.33385

"Salt operations in Saginaw valley were first commenced in 1859. Through the influence of Dr. George A. Lathrop, the East Saginaw Salt Manufacturing Company was organized in April of that year, and commenced operations in May following. First well completed in March, 1860; first salt made in July, 1860."

Soon after passing into the first rock, indications of salt brine were found, and the following table shows the strength of brine obtained therefrom at various depths:

At 90 feet	1 degree.
" 102 "	2 degrees.
" 211 "	10 "
" 212 "	14 "
" 487 "	26 "
" 516 "	40 "
" 531 "	44 "
" 559 "	60 "
" 569 "	64 "
" 606 "	86 "
" 636 "	90 "

An analysis of brine from this well made by Prof. Douglass, on April 11th, 1860, is as follows:

Specific gravity	1.179
Saline matter	22.017 per ct.
Chloride of sodium (salt)	17.912
" calcium	2.142
" magnesium	1.522
Sulphate of lime	.116
Carbonate of iron	.105
Chloride of potassium	.220
Water	77.983
	100.000

Composition of brines taken from various salt wells on Saginaw River, in October, 1862, and analyzed by Dr. C. A. Goesmann—this investigation being directed to ascertain their commercial value:

Portsmouth, Bay County, Michigan. Depth of well, 664 feet. Brine, 54° by salinometer.

Sulphate of lime (gypsum)	0.4884
Chloride of calcium	0.3472
" magnesium	0.4333
" sodium (salt)	12.5315
Saline matter	13.8004
Water	86.1996
	100.0000

Gillmore Well, Bay City, Michigan. Depth of well, 505 feet. Brine, 65° by salinometer.

Sulphate of lime (gypsum)	0.3961
Chloride of calcium	0.5302
" magnesium	0.4115
" sodium (salt)	15.2674
Saline matter	16.6052
Water	83.3948
	100.0000

The two brines, as the depth of the wells will show, are from the upper salt-bearing sand rock, and are quite characteristic of this formation, as shown by the large percentage of gypsum and low percentage of chlorides.

Swift & Lockwood's Well, Saginaw City. Depth of well, 860 feet. Brine, 86° salinometer.

Sulphate of lime (gypsum)	0.0983
Chloride of calcium	2.6430
" magnesium	1.0685
" sodium (salt)	17.5103
Saline matter	21.3201
Water	78.6799
	100.0000

East Saginaw Salt Manufacturing Company, East Saginaw. Depth of well, 806 feet. Salinometer, 80°.

Sulphate of lime (gypsum)	0.1516
Chloride of calcium	2.2665
" magnesium	0.9629
" sodium (salt)	16.8636
Saline matter	20.2446
Water	79.7554
	100.0000

Bangor Salt Manufacturing Company, Banks, Bay Co., Michigan. Depth of well, 774 feet. Brine, 95° salinometer.

Sulphate of lime (gypsum)	0.0722
Chloride of calcium	2.9611
" magnesium	1.2612
" sodium (salt)	19.8595
Saline matter	24.1540
Water	75.8460
	100.0000

These three specimens of brine, as the depth of the wells will show, are from the lower salt-bearing sand rock, called the Napoleon sandstone by Winchell. The analysis shows a decrease in the percentage of gypsum, an increased percentage of the earth chlorides, and increased quantity of salt.

These are the representative brines of the Saginaw River, and are those which are mostly worked for their salt.

Composition of brines taken from wells outside of the Saginaw valley:

Ayres & Co.'s Salt Well, Port Austin, Huron Co., Michigan. Depth of well, 1198 feet. Brine, 88° salinometer.

Sulphate of lime	0.0129
Chloride of calcium	3.1274
" magnesium	1.5675
" sodium (salt)	17.6161
Saline matter	22.3239
Water	77.6761
	100.0000

Grant & Co.'s Salt Well, East Tawas, Iosco Co., Michigan. Depth of well, 905 feet. Salinometer, 85°.

Sulphate of lime (gypsum)	0.0350
Chloride of calcium	3.4843
" magnesium	1.2433
" sodium (salt)	15.6141
Saline matter	20.3767
Water	79.6233
	100.0000

The analyses of these brines show a marked increase in the earthy chlorides, and are without doubt from a lower saliferous horizon, located in the Devonian strata, and consequently intermediate between the Onondaga formation and the Michigan salt group—this same formation having been struck at Caseville, Huron County, at the depth of 1750 feet, and at Blackmar's Mills, 13 miles east of East Saginaw, at the depth of 1675 feet. The new wells going down at Oscoda, Mich., are without doubt in this formation also.

Composition of brines taken from wells on the Lake Shore of Huron County, and representing an excellent quality of brine for salt manufacturing—nearly approaching the Goderich brines in freedom from the earthy chlorides:

Sand Beach Well, Huron County. Depth of well, 702 feet. Brine, 84° salinometer. Analysis by Dr. S. P. Duffield.

Sulphate of lime (gypsum)	0.2539
Chloride of calcium	0.3000
" magnesium	0.1591
" sodium (salt)	22.5673
Saline matter	23.2803
Water	76.7197
	100.0000

White Rock Well, Huron County. Depth of well, 566 feet. Brine, 78.5° salinometer.

Sulphate of lime (gypsum)	0.2623
Chloride of calcium	0.5373

Chloride of magnesium	0.4106
" sodium (salt)	18.9134
Saline matter	20.1236
Water	79.8764
	100.0000

The following analyses of Michigan brines, made by H. C. Hahn, Ph.D., will show the chemical composition of other brines not included in the above list:

Oneida Salt Company, Crow Island, Zilwaukie. Specific gravity of brine, 1.1864.

Sodic chloride (salt)	19.304
Calcic chloride	2.623
Magnesic chloride	1.343
Calcic sulphate (gypsum)	0.080
" carbonate	trace
Magnesic carbonate	"
Ferrous carbonate	0.0054
" chloride	0.0032
Magnesic bromide	traces
Carbonic acid	"
Water	76.269
	99.6276

New-York Solar Salt Company, Zilwaukie. Specific gravity of brine, 1.1930.

Sodic chloride (salt)	19.914
Calcic chloride	3.040
Magnesic chloride	1.419
Calcic sulphate	0.073
" carbonate	0.0010
Magnesic carbonate	0.0006
Ferrous carbonate	0.0058
" chloride	0.0038
Water	75.042
	99.498

Michigan Solar Salt Company, Zilwaukie. Specific gravity of brine, 1.1900.

Sodic chloride	19.671
Calcic chloride	2.916
Magnesic chloride	1.381
Calcic sulphate	0.082
" carbonate	0.0010
Ferrous carbonate	0.0123
Magnesic carbonate	0.0015
Carbonic acid	trace
Water	75.715
	99.7800

Smith, Kelly & Dwight Well, at Oscoda, Iosco Co., Michigan. Specific gravity, 1.182. Depth of well, 1070 feet.

Sodic chloride (salt)	17.93
Calcic chloride	4.21
Magnesic chloride	1.93
Calcic sulphate	trace
" carbonate	"
Saline matter	24.19
Water	75.81
	100.000

RECEPTION AND SETTLING OF BRINE.

The salt manufacturer having satisfied himself in regard to the quantity and quality of the brine supply, must now be prepared with cisterns to store his brine during the process of settling.

These cisterns or outside settlers were formerly built in size 20 by 30 feet and 6 feet deep, having a capacity of 25,000 gallons. More recently the size of these has been increased to suit the wants of the manufacturer. They are built of sound 2 to 3 inch plank, well and properly keyed together by strong gripes, and are also calked to prevent leakage. These cisterns are elevated on piling or framed timbers, high enough to allow the settled brine to flow through pipes to the blocks.

The connections from the cisterns into the pipes are 6 inches

above the bottom, the flow of the brine being controlled by gates. The supply pipes from the cisterns are usually made of wooden pump logs having a 3-inch bore.

The brine, as shown by the analyses, contains a small percentage of carbonate of protoxide of iron, held in solution by an excess of carbonic acid.

If the brine was boiled down or evaporated with this iron in, it would give the salt a red color and very materially affect its commercial value.

As soon as the cistern is filled with brine, preparation should be made to settle it. A tight box large enough to hold a barrel or more of water is placed on the top of the cistern. In this a proper quantity of fresh burnt lime is slacked with fresh water, enough being afterward added to fill the box, so as to make a whitewash or milk of lime. This mixture being a caustic lime, is freely sprinkled over the brine. The brine is then thoroughly "plunged"—that is, it is stirred up until the lime is well mixed with the brine. The caustic mixture of lime having a strong affinity for the carbonic acid extracts the same from the brine, thus releasing the iron which is precipitated with the lime to the bottom of the cistern as an insoluble peroxide of iron. The brine is then allowed to rest for 48 hours, when it is quite clear and ready for the boiling house or block. This process is called "settling," and on the care with which it is conducted depends much of the success in making good salt.

EVAPORATION OF BRINE.

Having made a stock of settled brine, the next process in the manufacture of salt is the evaporation of the brine; and this is effected by three different methods:

1st. By the direct application of fire-heat to kettles and pans.

2d. By the use of steam, either exhaust steam from saw-mills, or steam generated by flue boilers built expressly for the purpose.

3d. By solar evaporation.

EVAPORATION OF BRINE IN KETTLE BLOCKS.

A kettle block for evaporation of brine consists of a wooden building, 140 feet long by 45 to 50 feet wide, with an elevation of 18 feet, so framed as to admit of the steam passing out at the ventilators. In this building are set from fifty to sixty kettles, having each a capacity of from 100 to 120 gallons. The kettles are set in two rows over arches running from the mouth or furnace to the chimney. These are called "arches." These arches run close together, with a dividing wall between them; the kettles are set close together in a row, resting on the dividing wall on the one side and on the inside wall on the other.

The fire arch or furnace at the front is 3 feet from the bottom of the kettles; from here the bottom of the arch gradually rises so that under the back kettles the space is only 10 or 12 inches. Here the flue passes into the chimney, which is about 40 to 50 feet high.

Between the arches and the salt bins, which are under the same building, is the sidewalk. On this sidewalk the salt boiler operates in drawing the salt from the kettles into the draining baskets, which, when it is sufficiently drained, are wheeled off to the salt bins on this sidewalk or platform. The bins, which run the entire length of the block, are divided off in sections, and are made with open floors for the proper drainage of the salt.

Through the centre of the block, just on top of the middle wall, two sets of pump logs or pipes are laid—one for fresh water, and one for the settled brine, each of them being supplied with faucets for each kettle.

The kettles, after being well cleansed, are filled with brine, and boiling soon commences after the fire is under good headway. A scum rises to the surface, which is taken off with a skimmer.

Of late years, owing to the dry and light material used for fuel (being the refuse slabs from saw-mills), the first ten or fifteen kettles in the arch are protected from the excessive heat by patent arches, which are built over the fire flue, and directly under the bottom of the kettle. By this arrangement and a narrowing of the flue, the heat is distributed more evenly through the entire arch, and the kettles boil more regularly.

Soon after the brine commences to boil, the crystals of salt commence to form on the top, and then fall to the bottom. When the brine is boiled down to about one third, the salt is dipped out with a ladle and thrown into a basket, which is placed over one side of the kettle. The salt is allowed to remain in the basket for two or three hours, the bitter water containing the earthy chlorides being thus drained off. Thorough drainage is considered an important point in this mode of manufacture. The balance of the brine or bitter water remaining in the kettle is now bailed out and thrown into the drainage trough. The kettle is then rinsed out with fresh water, and again filled up with brine.

The difference of the time in which the front and the back kettles boil down varies from four hours in the front to twelve hours in the back. The kettle blocks are generally run day and night by four men, two boilers and two firemen, taking tours of twelve hours each. The average product of a good kettle block is seventy-five barrels of salt per day of twenty-four hours.

EVAPORATION OF BRINE IN PAN BLOCKS.

Pan blocks are buildings of various dimensions, built to accommodate the size of the pan, settlers, and salt bins.

The pans are made of quarter-inch boiler-plate iron. They vary from 90 to 120 feet in length, being divided into sections of 30 or 40 feet, are 12 to15 feet wide, and from 10 to 12 inches deep. With some the sides are straight, the salt being raked to the side, lifted out with a shovel, and thrown on the draining boards. In others, the sides are flanged, and the salt is raked directly on to the draining boards.

Pans of the above size rest on three walls as in kettle blocks, the arches running directly under the pan to the chimney at the end. As the firing of these blocks is done mostly with slabs and light fuel, the first 30 or 40 feet are also protected by patent arches thrown across the flues, thus dividing the heat more generally throughout the block.

The brine boils very rapidly in these blocks, and as the salt makes fast, it requires much care and attention on the part of the workmen to keep the salt from baking on the bottom of the pan; this is prevented by raking out the salt almost as fast as it makes.

Improvements in heating pan blocks have been made of late years in those localities where the price of fuel is a consideration. A pan block of an improved plan for boiling the brine has been erected by Messrs. Ayres & Co., of Port Austin, Huron County.

The block is 120 feet long, 43 feet wide, outside post 10 feet high, and centre post 18 feet high—almost too high to carry off the steam in winter. The length was also calculated for four pans. Three pans only were put on, being each 30 feet long and 16 feet wide on bottom, sides flanging and bolted to the draining boards.

The pans rest on seven walls, which are so arranged that they make two fire flues in the centre and two return flues on the sides.

The centre and outside walls run the entire length and width of the pan. All the walls are a foot wide at the top. The two fire flues which are under the middle of the pan on both sides of the centre wall are 2½ feet wide. Height of grate to pan, 3½ feet. The return flues are next to the outside walls, under the sides of the pan, and are 2 feet wide. This gives a heating surface of 180 feet in length on both sides of the middle wall. The outside flues run into the chimney, which is placed at one side of the front of the block—the space under the pan being reduced to one foot.

The advantage of this arrangement of the flues is that, as the brine boils freely over the fire flues, the salt, as it makes, is thrown to the cool side of the pan, and therefore it is not so liable to bake to the bottom of the pan before it is raked out. Another advantage is in the economy of the heating surface, the entire amount being well used up before it gets to the chimney. This is shown in the amount of salt made—Ayres & Co. reporting the making of 140 barrels of salt with 13 cords of hemlock wood in a day of 24 hours.

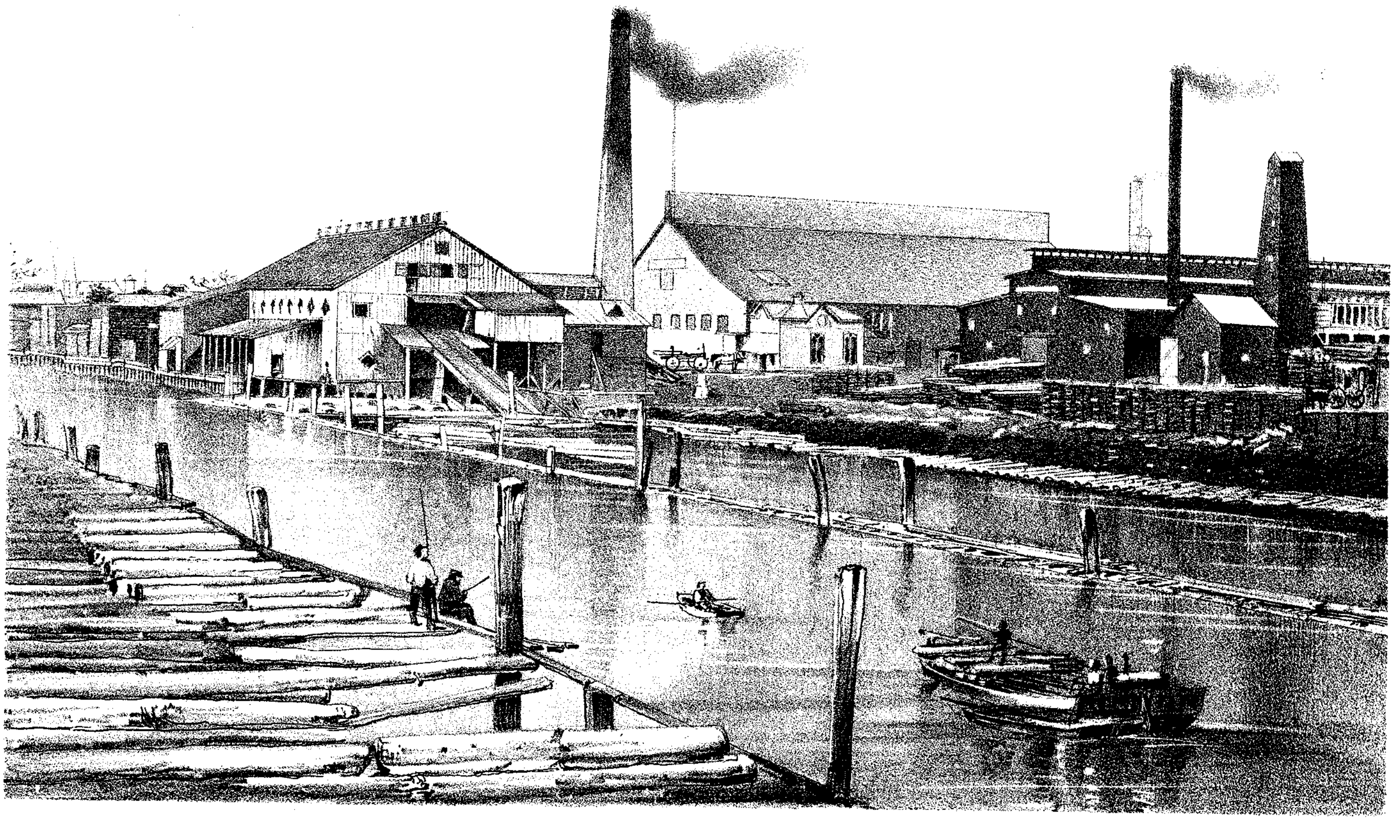
The brine for pan blocks is settled cold in the outside cisterns, and in most instances is brought to saturation by the inside steam settlers. The salt, as it makes in the pan, is drawn out by rakes upon the draining boards, where it remains for a time, when it is shovelled into barrows and taken to the store bins for further drainage.

It is very desirable that the draining boards should be so arranged in pan blocks that the workmen should not be compelled to walk over them in the operation of drawing or wheeling off the salt.

EVAPORATION OF BRINE BY STEAM.

The evaporation of salt brine by the steam process is now producing the largest portion of salt made in Michigan.

In describing the arrangements of a steam salt block and the accompanying process, we have selected the steam salt block, drill



J. Bien lith.

WORKS OF THE BUFFALO SALT CO.

house, cisterns, and saw mills of the Buffalo Salt Company, managed by Sears & Holland, of East Saginaw, and represented in the accompanying view.

This steam salt block is 140 feet long, 122 feet wide, and has an elevation of 52 feet to the top of the ventilator. Height of ventilator, 16 feet. Included therefore in the above space are the inside settlers, grainers, salt bins, and packing room.

The inside steam settlers are 136 feet long, 9 feet wide, and 6 feet deep, made of 4-inch plank, well keyed together and tightly calked.

This block is supplied with seven grainers, 136 feet long, 7½ feet wide, and 16 inches deep.

Over each grainer are the draining boards running the entire length. Passing through each settler and grainer, and near the bottom, are 4-inch galvanized tubing, four to five in number, depending on the size of the grainer, through which exhaust or live steam is forced.

In the steam as in the kettle process, the brine is first pumped into the outside settlers, where it is partially settled. It is then drawn into the inside steam settlers, where it is heated up by the steam pipes and brought to saturation—that is, a point just preceding the formation of salt crystals. It is allowed to remain until all sediment of iron has fallen to the bottom, by which time it becomes clear as crystal.

The brine is now ready to be drawn into the grainers, which are filled to about two thirds their capacity, or nearly full. As the settled brine comes into the grainers quite warm and fully saturated, it soon commences to make salt, which forms on the surface of the brine, and then falls to the bottom of the grainers, when a new lot of crystals are formed, to fall in the same way. The brine is also occasionally stirred so as to make the crystals fine. Thus the evaporation continues for twenty-four hours, the temperature being kept at from 170° to 175° of Fahrenheit. The brine being sufficiently evaporated by this time, the workmen commence the "lifting." This is done by first washing the salt in the brine that is left in the grainers, and then taking it out with shovels and throwing it on the draining boards, where it remains a number of hours for drainage.

A large "lift" or "draw" fills the boards with salt, and it is a beautiful sight to see the salt as it comes white and sparkling from the brine. The salt should remain on the draining boards to drain thoroughly, twenty-four hours if possible, before going to the bins. It lies in the bins two weeks to complete the drainage, when it is ready for inspection and barrelling for shipment.

SOLAR EVAPORATION OF BRINE.

The first preparation for solar evaporation is to have a series of covers or wooden vats. The covers are rectangular in shape, being 16 by 18 feet and from 6 to 8 inches deep. They are raised on wooden supports 2 to 3 feet from the ground, and are arranged in sets or strings. Each cover has a movable roof, which can be run on or off to protect or expose the brine, according to the weather. At the end of the string of graining covers, somewhat higher and deeper, are the "strings" of settling covers into which the brine is led from the store reservoirs or cisterns. No lime is used in settling the brine in this process; for in these deep rooms, the brine absorbs a portion of oxygen from the air, by which means the carbonate of iron, which is dissolved in the recent brine, is converted into an insoluble peroxide of iron. In Syracuse, a second series of covers are used to get rid of the gypsum, which separates or is deposited in the form of a crystal. As the quantity of gypsum is very small in the Saginaw brines these rooms are now dispensed with.

As soon as there is a show of salt crystals, the first stage of the process is accomplished, and the saturated brine known as salt pickle is ready for the last stage. It is then drawn into the salt room or graining vats, in which the salt soon commences to crystallize on the bottom of the covers.

"One of the conditions required for the production of a good, large-grained solar salt, which is most esteemed in the market, is that the bottom of the covers in the salt room should be as smooth as possible, rough surfaces favoring the deposition of numerous small crystals. It is also necessary to have the salt covers supplied with a sufficient supply of good pickle, so that the salt already deposited may always be covered. An exposure of the salt uncovered to the air favors the formation of new small crystals, and the addition of an unfinished or not sufficiently concentrated pickle produces the same effect. It is also important that the waste or exhausted pickle from which the greater part of the salt has crystallized should be

discharged from time to time, as its presence not only impairs the quality, but diminishes the quantity of the salt deposited."

The time required for the evaporation of sufficient pickle to make a crop of salt depends largely upon the weather, dry and clear weather being, of course, most favorable; six weeks to two months is the usual time. Three crops of salt a season are gathered—the first about the middle of July, the second in the early part of September, and the third at the end of October. The second crop is generally the best, as it is coarser than the others.

The crop of solar salt is gathered by first loosening it from the bottom of the "covers" with a rake or spud. It is then washed in the pickle that is still left in the cover, and "gathered" to the street gunwale. Here it is shovelled into draining tubs, to remain a short time before being emptied into the salt carts for removal to the salt bins for further drainage.

TREATMENT OF CRUDE PRODUCT.

The legal time, fourteen days, required for drainage having passed, the bins are opened and the salt is packed in barrels holding five bushels, or 280 lbs.—each barrel being branded with the name of the firm or person manufacturing the same.

GRADES AND QUALITY OF MICHIGAN SALT.

The salt product has been divided by the State Inspector into the following grades:

Fine.—In barrels, 280 lbs., suitable for general use for all family purposes.

Packers.—In barrels, 280 lbs., suitable for packing and bulking meat and fish. One of the best and purest grades of salt, and branded when coarse, C Packers C.

Solar.—In barrels, 280 lbs.; when screened, branded C Solar C for coarse and F Solar F for finer grades. Solar salt suitable for bulking meats.

Second Quality.—All salt intended for No. 1 of any of the above grades, when for any cause it is condemned by the inspector, is branded Second Quality and sold as such. This salt is good for salting stock, hay, hides, etc.

ANALYSIS OF SALT.

Experience proves that the best quality of salt can be made from Michigan brines, and that a great preponderance of the salt sold in the market has been found as pure and as efficient an antiseptic as any mined or manufactured elsewhere, either in our own or foreign countries.

The following are the analyses of the various grades of Michigan salt:

Kettle Salt made by the East Saginaw Salt Company, East Saginaw, Michigan. Analyzed by Dr. C. A. Goesmann:

Sulphate of lime	0.3165
" calcium	0.3564
Chloride of magnesium	0.1408
Moisture	3.3441
Chloride of sodium (salt)	95.8422
	100.0000

Carrollton Salt Company, Carrollton, Michigan. Kettle Salt, analyzed by Dr. H. C. Hahn:

Sulphate of lime	0.405
Chloride of calcium	1.127
" magnesium	0.517
Moisture	3.292
Chloride of sodium (salt)	94.669
	100.000

Pan Salt made by Bay City Salt Company, Bay City, Michigan. Analyzed by S. S. Garrigues, Ph.D.:

Sulphate of lime,	0.697
Chloride of calcium	0.329
" magnesium	0.340
Moisture	1.346
Chloride of sodium (salt)	97.288
	100.000

Pan Salt made by Taylor & Co., Zilwaukie. Analyzed by Dr. H. C. Hahn:

Sulphate of lime	0.088
Chloride of calcium	0.737
" magnesium	0.445
" sodium (salt)	98.730
	100.000

Steam Salt made by Buffalo Salt Company, East Saginaw, Michigan. Analyzed by Dr. H. C. Hahn:

Sulphate of lime	0.478
Chloride of calcium	1.365
" magnesium	0.694
Moisture	3.478
Chloride of sodium (salt)	94.366
	100.000

Steam Salt made by New York and Michigan Salt Company, at Zilwaukie. Analyzed by Dr. H. C. Hahn:

Sulphate of lime	0.363
Chloride of calcium	0.699
" magnesium	0.313
Moisture	3.308
Chloride of sodium (salt)	95.327
	100.000

SOLAR SALT.

Solar Salt made by East Saginaw Salt Company, East Saginaw. Analyzed by Dr. C. A. Goesmann:

Sulphate of lime	0.3165
Chloride of calcium	0.3564
" magnesium	0.1408
Moisture	3.3560
Chloride of sodium (salt)	95.8333
	100.0000

Solar Salt made by New York and Michigan Salt Company, at Zilwaukie. Analyzed by Dr. H. C. Hahn:

Sulphate of lime	0.173
Chloride of calcium	0.743
" magnesium	0.417
Moisture	2.197
Chloride of sodium (salt)	96.470
	100.000

Average analysis of common salt, made by Dr. C. A. Goesmann, of Syracuse salt:

Sulphate of lime	1.2550
Chloride of calcium	0.1550
" magnesium	0.1369
Moisture	3.0000
Chloride of sodium (salt)	95.4531
	100.0000

Amount of salt made in Michigan by the different processes for the last seven years:

	1869.	1870.
Kettle salt	335,663 bbls.	301,900 bbls.
Pan "	42,000 "	56,430 "
Steam "	176,761 "	255,142 "
Solar "	15,264 "	15,507 "
Total	569,688 bbls.	628,979 bbls.

	1871.	1872.
Kettle salt	290,550 bbls.	202,300 bbls.
Pan "	68.080 "	65,800 "
Steam "	336,162 "	435,920 "
Solar "	37,645 "	20,461 "
Total	732,437 bbls.	724,481 bbls.

	1873.	1874.	1875.
Kettle salt	192,250 bbls.	181,200 bbls.	117,000 bbls.
Pan "	127,700 "	130,500 "	199,100 "
Steam "	471,129 "	685,888 "	741,429 "
Solar "	32,267 "	29,391 "	24,336 "
Total	823,346 bbls.	1,026,979 bbls.	1,081,865 bbls.

	Kettle Salt.	Pan Salt.	Steam Salt.	Solar Salt.
1869	335,663 bbls.	42,000 bbls.	176,761 bbls.	15,264 bbls.
1870	301,900 "	56,430 "	255,142 "	15,507 "
1871	290,550 "	68,080 "	336,162 "	37,645 "
1872	202,300 "	65,800 "	435,920 "	20,461 "
1873	192,250 "	127,700 "	471,128 "	32,267 "
1874	181,200 "	130,500 "	685,888 "	29,391 "
1875	117,000 "	199,100 "	741,429 "	24,336 "

FUEL.

The fuel used in kettle blocks is cord wood, mixed soft and hard, refuse slabs, and sawdust from saw-mills. Mixed wood now costs $1.25 per cord, delivered at block. Slabs cost 45 to 50 cents per cord at the mills.

A kettle block will consume 10 cords of mixed wood in 24 hours, or 16 cords of slabs in the same time.

Pan blocks on the Saginaw River are run almost entirely with slabs and sawdust from the saw-mills. On the lake shore, mixed cord wood is the fuel used. A pan block 90 feet long, and 16 feet wide, as above described, will use 13 cords of mixed wood in 24 hours, making 140 barrels of fine salt.

Steam blocks are mostly heated during the day with the exhaust from the saw-mills. This is the steam that has been made in the mill boilers. Having performed the work of running the mill engines, it is then exhausted into the pipes connected with the salt block, which carry it through the settlers and graining vats, and causes the evaporation of the brine. If the mill does not run at night, the boilers are connected directly with the steam pipes in the salt block, and live steam is used, the fuel being the sawdust left from running the mill in the day-time.

BARRELS, MATERIAL, AND COST.

The salt barrels of Michigan are now mostly made of pine staves and heading. In some localities, elm staves and ash heading are used. Most of the pine staves are made of the refuse lumber from the saw-mills. The elm stave is mostly made from stave bolts cut for that purpose.

There were manufactured into salt barrels, on the Saginaw River, last year, staves, heading, and hoops as follows:

Staves	16,195,480
Heading	6,138,000
Hoops	9,872,000

The barrels are mostly made by hand in cooper-shops connected with the salt blocks. The average cost of salt barrels is from 28 to 30 cents each. The Rules and Regulations on Cooperage are as follows:

COOPERAGE.

(Regulations in regard to Barrels.)

All staves must be of such length that when the barrel is finished it shall not be less than 30½ inches, or more than 31½ inches long. Soft-wood staves, whether rove or cut, to be ½ an inch thick. Hard-wood staves 7/16 of an inch thick after seasoning. Staves not more than 4 inches wide, of sound timber, and properly jointed.

Heading must be ⅝ of an inch thick, of good, sound lumber, free from holes or unsound knots, smooth for branding. No basswood will be allowed for either staves or heading.

Hoops to be 1 inch wide and ¼ of an inch thick, 10 to each barrel, shaved and well set.

Barrels for fine salt must have heads 17½ inches in diameter. Chime to be 1 inch from point of croze. Bilge from 21 to 21½ inches in diameter outside.

Solar salt may be packed in barrels not less than 30 inches in length with a head 16½ inches. Barrels charred on the inside must be rejected.

LABOR.

The work connected with a kettle block can be accomplished by 7 men and 1 two-horse team, divided as follows: 2 boilers, 2 firemen, 1 engineer, 1 salt-packer and 1 teamster.

The capacity of pan blocks being greater than that of kettle blocks, more labor is required, and is divided as follows: 4 boilers, 3 firemen, 2 engineers, 2 salt-packers, and 2 or 3 teamsters.

Steam blocks being run with exhaust steam, the same firemen who run the mill during the day are employed. At night an extra man is put on. The number of boilers varies with the capacity of the block, being from 4 to 6 men, engineers 2. In many of the steam salt blocks the boilers also pack the salt, after they have finished lifting the same.

In the early history of the salt manufacture, the supply of good labor hands was not equal to the demand. Of late years, the supply has been largely in excess.

The average price of labor in 1864 was $2 a day. In the present year, the average pay per day for salt laborers is $1.25.

FIXED OUTLAY IN DETAIL.

The following figures give the fixed outlay of E. F. Gould's steam salt block at Carrollton, Saginaw County, Mich.:

Size of block, 177 feet long, 84 feet wide, with an elevation of 26 feet. It has 2 inside settlers and 5 graining vats.

Size of settlers, 126 feet long, 7½ feet wide, and 6 feet deep.

Size of grainers, 126 feet long, 7 feet 9 inches wide, and 15 inches deep.

Outside settlers, 20 x 30 feet, 6 feet deep, 4 in number.

Bin room for storing 3000 barrels of salt unpacked. Shed room for 3500 barrels of packed salt.

Capacity of block, 125 barrels a day, and has 2 salt wells.

Engine and boilers for two wells	$2,800.00
Drilling salt wells	2,200.00
Poles for wells	250.00
Tubing "	1,400.00
Pump chamber and valves	250.00
Salt block, cisterns, settlers and grainers	9,600.00
Tubing and connection to salt block	3,500.00
Total	$20,000.00

The cost of the Buffalo Salt Company's block, as described in this article, was $4000 for tubing and $6000 for block, cisterns, settlers and grainers.

COMPANIES, CAPITAL, AMOUNT OF SALT MADE, NUMBER OF KETTLES, GRAINERS, PANS AND COVERS, DEPTH OF WELLS, ETC.

Salt Works and Location.	Salt made in 1875.	Capital Invested.	No. of Blocks.	No. of Grainers.	No. of Kettles.	No. of Pans.	No. of Covers.	No. of Wells.	Depth of Wells.	Mode of Manufacture.
Bay County.	bbls.								feet.	
John McGraw & Co., Portsmouth...	43,837	$25,000	1	10				3	1000	Steam.
M. Watrous & Son, " ...	8,471	20,000	1	4				1	1000	"
A. Miller, " ...	48,812	60,000	2	9				4	1050	"
S. McLean & Son, Bay City.......	25,135	50,000	3	8				3	1050	"
S. H. Webster, "	15,981	20,000	1	5				1	1040	"
A. Rust & Co., "	27,134	20,000	1			3		2	1000	Steam and Pan.
Hay, Butman & Co., "	New	20,000	1	5				1	1036	Steam.
N. B. Bradley & Co., "	29,264	30,000	2	7				2	1000	"
William Peter, "	17,081	20,000	1	6				1	1047	"
Eddy, Avery & Co., Bay City.......	35,292	35,000	2	3		3		3	1050	Steam and Pan.
H. M. Bradley & Co., "	21,243	20,000	1	5				1	1000	Steam.
Pitts & Cranage, "	23,292	25,000	1	5				2	960	"
N. W. Gas and Water Pipe Co., Bay City..........	11,660	20,000	1			2		1	740	Steam and Pan.
Folsom & Arnold, Bay City.........	10,135	25,000	1	5				2	954	Steam.
Chapin & Barber, "	31,096	20,000	2	5	60			2	938	Steam & Kettles.
Dolson, Chapin & Co., "	26,796	25,000	2	6	60			2	950	" "
John McEwan, "	14,529	20,000	1	4				1	935	Steam.
Atlantic Salt Co., "	2,563	58,000	1		60		404	2	800	Kettles and Solar.
J. P. Hall, "	New	20,000	1	4				1	823	Steam.
Carrier & Co., "	15,329	20,000	1	4				2	735	"
Moore & Smith, Banks...........	3,791	20,000	1	3				2	830	"
Leng & Bradfield, "	5,351	23,000	1			3		1	800	Pan.
Taylor & Moulthop, "	4,781	25,000	1			2		2	840	Steam and Pan.
Keystone L. & Salt Co., Banks......	6,196	20,000	1	3				1	980	Steam.
H. W. Sage & Co., Winona.........	51,989	40,000	1	10				4	1020	"
W. H. Malone, Salzburg...........	New	20,000	1	4				1	1023	"
Ladrach Bros., "	5,060	10,000	1					1	1000	Kettles.
L. L. Hotchkiss & Co., Salzburg....	8,728	20,000	1	5	50			1	1013	Steam.
Saginaw Co.										
East Sag. Salt Mf. Co., E. Saginaw...	30,208	110,000	3		120		493	3	806	Kettles and Solar.
A. P. Brewer, " ...	18,960	25,000	1	5				2		Steam.
C. & E. Ten Eyck, " ...	5,705	15,000	1	3				1		"
Warner & Eastman, " ...	New	20,000	1	6				1		"
Sears & Holland, " ...	22,956	75,000	2	7		3		2	750	Steam and Pan.
Thompson & Camp, " ...	15,240	20,000	1	4				1	750	Steam.
Burnham & Still, " ...	3,329	15,000	1	3				1	762	"
Gebhart & Estabrook, " ...	New	20,000	1	5				1	820	"
George Rust & Co., " ...	21,941	20,000	1	6				2	820	"
Eaton, Potter & Co. " ...	4,515	10,000	1		60			1	825	Kettles.
Bundy & Youmans, " ...	12,575	15,000	1		60			1	820	"
H. Beschke, " ...	New	10,000	1			2		1	828	Pans.
Sturtevant & Green, Saginaw City..	21,907	30,000	2	5	60			2	830	Steam & Kettles,
Swift & Lockwood, " ...	15,848	20,000	2	4	60			2		" "
Barnard & Binder, " ...	26,367	50,000	2	4		2		3	830	Steam and Pan.
Conrad Kull, " ...	14,931	10,000	1		60			1	802	Kettles.
Geo. F. Williams & Bro., " ...	16,168	20,000	1			3		1	800	Pans.
C. T. Brenner, " ...	5,319	10,000	1	3				1	770	Steam.
Pierson, Wright & Co., " ...	24,752	25,000	1	5				2	741	"
Chicago Salt Co., Florence........	3,300	50,000	2		120			2	800	Kettles.
Shaw & Williams, "	25,609	25,000	1			3		1		Pans.
H. B. Allen, Carrollton...........	5,621	10,000	1			1		1	800	"
E. F. Gould, "	11,350	20,000	1	5				2	800	Steam.
T. Jerome & Co., "	19,350	25,000	1			2		1	746	Pans.
E. Litchfield, "	Not run	75,000	3		180			1	743	Kettles.
H. Ballentine & Co., Carrollton.....	"	30,000	1		60			1	763	"
Saginaw Valley Salt Co., "	5,000	20,000	2		120			1	780	"
H. P. Lyon & Co., "	11,941	20,000	2		60		500	1		Kettles and Solar.
A. J. Bliss & Bro., Zilwaukie.......	17,431	20,000	2	5		2		2	835	Steam and Pans.
John F. Driggs & Co., "	5,153	25,000	2		60	2		1	840	Kettles and Pans.

Salt Works and Location.	Salt made in 1875.	Capital Invested.	No. of Blocks.	No. of Grainers.	No. of Kettles.	No. of Pans.	No. of Covers.	No. of Wells.	Depth of Wells.	Mode of Manufacture.
Rust, Eaton & Co., Zilwaukee....	23,432	25,000	2	4	60			1	800	Steam.
New York and Mich. Solar Salt Co., Zilwaukie..........	13,877	270,000	1	4			2695	3	860	Steam and Solar.
W. R. Burt & Co., Melbourne.......	49,117	75,000	2	8				4	950	Steam and Pan.
Lake Shore.										
Frank Crawford, Caseville, Huron Co.	29,065	30,000	2	3		3		3	1760	" "
Pigeon River Furnace Co., Caseville.	5,206	30,000	1	6				1	1760	Steam.
Ayres & Co., Port Austin..........	13,994	20,000	1			3		1	1198	Pans.
New River Salt Co., New River...	6,964	15,000	1			3		1		"
Port Hope Salt Co., Port Hope.....	14,883	20,000	1			3		1	785	"
Jenks & Co., Sand Beach..........	New	20,000	1			3		1	702	"
Thomson & Bro., White Rock......	32,414	20,000	1			6		3	565	"
Grant & Son, East Tawas, Iosco Co.	Not run.	20,000	1	4				1	905	Steam.
Weekes Bros., " "	8,895	25,000	1	4		1		1	835	"
Loud, Gay & Co., Oscoda.........	New	50,000	1	8				3	1103	"
Smith, Kelly & Dwight, Oscoda ...	New	25,000	1	4				1	1070	"
Totals..............	1,081	2,216,000	95	240	1310	55	4092	119		

SYSTEM OF INSPECTION.

The irregularities that crept into the manufacture of salt, deteriorating its quality and value, soon made it evident that some system of inspection should have to be adopted to protect the careful manufacturer against the ignorance and carelessness of others.

As early as the year 1865, a system of local inspection was adopted by a number of the salt manufacturers, which had a tendency to improve a portion of the salt product. The inspection, however, not being a general one, and there being no State law by which offenders could be punished, the effectiveness of the inspection was greatly diminished, and it soon became evident that some more stringent system, backed by a State law, would be the only way to secure uniformity of manufacture.

To meet this point, a committee of the then existing Saginaw and Bay Salt Association was appointed in 1868 to draft a law meeting the wants of the salt manufacturers. The law as perfected by the Association was presented at the next session of the State Legislature and passed by them—approved March 6th, 1869, and amended by an Act approved April 16th, 1875.

AN ACT TO REGULATE THE MANUFACTURE AND PROVIDE FOR THE INSPECTION OF SALT.

SECTION 1. *The People of the State of Michigan enact*, That no salt manufactured in this State after this act takes effect shall be sold within the State, nor exported therefrom, until the same shall first be duly inspected, as provided in this act. Any person who shall violate the provisions of this section shall pay, for the use of the people of this State, as a fine, the sum of twenty cents for each bushel of salt sold or exported, contrary to the provisions of this act. In case any manufacturer of salt shall knowingly sell, or export, or permit to be sold or exported, salt, contrary to the provisions of this act, he shall, on conviction thereof, be liable to a fine not exceeding one thousand dollars, or imprisonment in the county jail not exceeding ninety days; *Provided*, That nothing in this act shall apply to any salt packed and in the hands of dealers when this act takes effect.

SEC. 2. Immediately after the passage of this act, and every six years thereafter, there shall be appointed by the Governor of this State, by and with the advice and consent of the Senate, an Inspector of Salt, who shall be a person of competent skill and ability, and who shall hold his office for six years and until his successor shall be appointed and qualified, unless sooner removed for cause. He shall at all times be subject to removal by the Governor, for cause; and in addition to other causes which may arise, incompetency, or inefficiency in the performance of the duties devolved on him by this act, shall be deemed good cause for removal. In case of vacancy in the office, it shall be the duty of the Governor to fill the same, by appointment, immediately upon receiving notice thereof, and such appointment shall hold until the close of the next session of the Senate, and in the mean time the Governor shall, with the consent of the Senate, appoint to fill the vacancy, for the unexpired portion of the term.

SEC. 3. Immediately after his appointment and qualification, the inspector shall divide the salt-making territory of this State into so many inspection districts as he may judge necessary, and shall appoint for each district one or more competent and efficient deputy inspectors, who shall hold office at the pleasure of the inspector, and for whose acts he shall be responsible. Such districts may be changed from time to time, as may be necessary. The inspector shall give his entire time, skill, and attention to the duties of his office, and shall not be engaged in any other business or occupation.

SEC. 4. The inspector shall be entitled to receive an annual salary of twenty hundred dollars. He shall also be allowed the further sum of five hundred dollars annually for the expenses of providing and furnishing his office, and for clerk hire, stationery, books, printing, and travelling expenses. His deputies shall be entitled to such sums, in each case, as he may approve, not exceeding in any case the sum of one hundred dollars per month for the time actually employed. All salaries and expenses provided for by this act shall be retained by the inspector out of the money received under Section 5 of this act, and accounted for, and paid out by him as provided in this act: salaries to be paid monthly.

SEC. 5. Each person, firm, company, and corporation, engaged in the manufacture of salt, or for whom any salt shall be inspected, shall from time to time, as salt is inspected or offered for inspection, pay, on demand, to the inspector, or the deputy of the district where the salt is inspected, three mills for each bushel of salt inspected or offered for inspection; *Provided*, That the same may be required to be paid in advance; *And provided further*, That but one inspection fee shall be paid upon the same salt. In case any person, firm, company, or corporation shall neglect or refuse to pay such inspection fees, on demand, at his, their, or its office or manufactory, the party so refusing shall be liable to an action therefor, in the name of the inspector, and the certificate of inspection, with proof of the signature of the inspector, or deputy giving the same, shall be *prima facie* proof of the liability and the extent of the liability of the party so in default; and it shall be lawful for the inspector and his deputies to refuse to inspect salt manufactured at the works so in default until the amount due is paid. All money received by or paid to any deputy inspector under this section shall be forthwith paid to the inspector. The inspector shall keep just and true accounts of all money received under this section, and an account of the amounts received from or paid by each person, firm, company, and corporation engaged in the manufacture of salt, and all other things appertaining to the duties of the office, and the said books and accounts shall always, during office hours, be subject to the inspection and examination of any person who may wish to examine them, shall be deemed the books of the office, and shall be handed over to his successor in office, together with all the money and effects appertaining to the office.

SEC. 6. The inspector shall, before entering upon the duties of his office, take the oath prescribed by the constitution of this State, which oath shall be filed in the office of the Secretary of State. He shall also execute a bond to the people of this State, in the penal sum of ten thousand dollars, conditioned for the faithful performance of the duties of his office, which bond shall have at least two sureties, and shall be subject to the approval of the State Treasurer, and when approved shall be by such Treasurer filed and deposited in his office; and the inspector shall renew his bond every year. Any person or corporation injured by the neglect or default of such inspector, or by his misfeasance in office, or by the neglect, default, or misfeasance of any of his deputies, may maintain an action on such bond, in the name of the people, for the use of the party prosecuting, and shall be entitled to recover the full amount of damages sustained.

SEC. 7. Each of the deputies appointed by the inspector shall take the oath of office prescribed by the constitution, and shall give bond to the inspector in such sum, and with such sureties as he may approve, conditioned for the faithful performance of his duties as such deputy; and in case said inspector shall be obliged to pay any sum for the neglect or default or misfeasance of any deputy, he may recover of such deputy and his sureties on such bond the amount he was obliged to pay, with accruing costs.

SEC. 8. The inspector shall keep his principal office in either Saginaw or Bay County, and the deputy for the district in which such office is located may occupy the same office. This office shall be kept open at all times during business hours. All the books, records, and accounts shall be kept at this office, and each deputy shall, at least once in each week, make written report, by mail or otherwise, to the inspector, of the salt inspected by him during the week, stating for whom, and the quality and quantity thereof. Abstracts of these reports shall be entered in books provided for that purpose. Said inspector shall, in proper books, keep a full record and account of all his transactions; and such books shall also be open for the examination of all persons wishing to examine the same during office hours.

SEC. 9. The inspector shall not be in any way concerned in the manufacturing or selling of salt, or have any interest whatever, directly or indirectly, in any salt manufactory or erection for manufacturing salt in the State of Michigan, or in the profits of any such manufactory.

SEC. 10. It shall be the duty of the deputy, in each district, to visit, once in each day, Sundays excepted, each salt manufactory in his district, when in operation, and to ascertain if there be therein any salt of bad quality, and such as ought not to pass inspection.

SEC. 11. It shall be the duty of the inspector in person to visit the manufactories in which salt is made, that may be in operation, in the different districts, as often as practicable.

SEC. 12. The inspector or deputy, at each visit, as provided in this act, shall carefully examine the salt in the bins, and the brine in kettles, or pans, or vats, in which the salt is manufactured. If the salt in the bins or any part thereof is of bad quality and such as ought not to pass inspection, or if the brine in the kettles, or pans, or graining vats has not been cleansed, he will direct and see that the owner, or occupant, or boiler, or other person having charge of the manufactory, remove the bad salt from the bin and place it with second-quality salt, or throw it among the bitterns, as the inspector or deputy may direct, and that the impure brine in the kettles, or pans, or graining vats be thrown out, and new brine substituted.

SEC. 13. No lime nor lime-water shall be used by any person in the manufacture of salt, in the kettles or pans, or graining vats, used for manufacturing, under a penalty of twenty-five dollars and costs for each offence, to be sued for in the name of the people of this State; *Provided*, That iron vessels used in the manufacture of salt may be whitewashed, when cool, to prevent the accumulation of rust.

SEC. 14. Every person desiring to have salt inspected shall apply to the inspector or deputy inspector of the district where the same shall be, which inspector or deputy inspector shall thereupon actually examine the salt so offered for inspection, in the package in which the same may then be.

SEC. 15. To facilitate such examination, it shall be the duty of the person or company offering the salt for inspection, to unhead or bore the barrel, or to open the bag or other package in which the salt is contained, as may be directed by the inspector or deputy inspector, so as to expose the salt to his touch, view, and examination.

SEC. 16. The inspector or deputy inspector shall not pass any salt as good unless he shall find it to be well made, free from dirt, filth and stones, and from admixture of lime, or ashes of wood, and of any other substance which is injurious to salt, fully drained from pickle, the bitterns properly extracted therefrom, and manufactured as directed by this act and by the rules and regulations of the inspector.

SEC. 17. The person or company offering the same for inspection shall in all cases provide the necessary force to lift the salt while the inspector or deputy weighs or measures it, and shall also furnish the necessary help and material to brand the salt for and under the direction of the inspector or deputy inspector.

SEC. 18. Each manufacturer shall provide a scale or balance at his works, to be examined from time to time, and approved by the inspector, in which all the salt offered for inspection at his works may be weighed.

SEC. 19. Each inspector or deputy shall deliver to the party for whom he shall inspect salt, a certificate of the quantity and quality inspected, and shall thereupon direct the employés of the manufacturer to brand or mark, under his personal supervision, with durable paint the package containing the salt so inspected, with the surname of the inspector at length and the initials of his Christian name, with addition of the word inspector, in letters at least one inch in length, and shall also cause to be marked or branded by the employés of the manufacturer, upon the head of the barrel, cask, or package, the weight prescribed for such barrel, cask, or package by the inspector, when such weights are in conformity to the rules and regulations prescribed by the inspector in that regard; and if such weights do not correspond to the rules and regulations, he shall cause the same to be repacked so as to conform thereto.

SEC. 20. If the said salt shall be put up in barrels, it shall not be marked unless the barrels are thoroughly seasoned, stout, and well made, with such number of hoops as shall be prescribed by the inspector, to be well nailed and secured.

SEC. 21. Every person who shall falsely or fraudulently make or counterfeit, or cause to be made or counterfeited, or knowingly aid and assist the false or fraudulent making or counterfeiting the mark or brand of any inspector or deputy inspector, on any package containing salt, shall be deemed guilty of felony, and on conviction thereof shall be subject to a fine of not less than one hundred nor more than one thousand dollars, or be imprisoned in the State prison for a term not less than one nor more than six years, or both, in the discretion of the court.

SEC. 22. No manufacturer or other person shall pack, or cause to be packed, in barrels, casks, boxes, or sacks, any salt, until an inspector shall have determined, upon actual examination, that the same is sufficiently drained of pickle, and otherwise fit to pack.

SEC. 23. The inspector and his deputies, in their daily examination of the several salt manufactories, shall examine all bins of salt, for the purpose of ascertaining whether any salt is packed contrary to the provisions of the last foregoing section.

SEC. 24. If any manufacturer or other person shall pack any salt before the inspector or one of his deputies shall have determined that it is fit for packing, he shall forfeit the sum of twenty-five cents for every bushel of salt so packed.

SEC. 25. Barrels, casks, or sacks in which salt shall have been packed and inspected, shall not again be used for the packing of salt therein, until the marks or brands made by the inspector shall be first cut out or removed; and if any person shall pack, or cause to be packed, or shall aid or assist in packing any uninspected salt in any such barrels, casks, or sacks, without first cutting out or removing such marks or brands, he shall forfeit, for every bushel of salt so packed, the sum of one dollar.

SEC. 26. It shall be the duty of every manufacturer to brand or mark with durable paint every cask or barrel of salt manufactured by him, with the surname at full length of the proprietor or owner of the manufactory at which the same shall have been made, and the initial letters of his Christian name, and if the same shall have been manufactured for a company or association of individuals, he shall mark or brand, in like manner, upon every such cask or barrel, the name by which the company is usually called; *Provided*, That no second-quality salt shall be so marked.

SEC. 27. No inspector or deputy inspector shall inspect or pass any barrel, cask, box, or sack of salt which shall not be marked or branded in the manner prescribed in the last section, and the inspector or deputy shall not affix his brand to any barrel of salt which shall not have been so branded by the manufacturer offering the same for inspection; *Provided*, That none of the provisions of this section shall apply to second-quality salt; *And provided further*, That the inspector may, by regulations prescribed by him, provide that both the brand of the manufacturer and that of the inspector shall be put upon each package at the same time.

SEC. 28. Salt of an inferior quality—dirty, damaged, or condemned—may be sold loose, or in bulk, by the manufacturer thereof, at the works, the inspector making bills of the same, designating the quantity by weight, as in ordinary cases, and distinguishing the same as "second quality;" or such inferior salt may be packed in barrels, boxes, casks, or sacks, and branded by the inspector with the words "second-quality salt," in plain letters not less than one inch in length, and such inspector shall add the initials of his name, and no other or different brand shall be placed thereon; and said second-quality salt, subject to the provisions of this section, may be sold or exported by the owner as such.

SEC. 29. Every person who shall forge or counterfeit the name so required to be put on by the manufacturer, or shall cause or procure to be put on any barrel or cask in which salt shall be packed the name of any person other than that which properly should be placed thereon, according to the provisions of this act, shall, for every such barrel, cask, or sack, forfeit the sum of one hundred dollars, and shall also be liable for all damages to the party aggrieved.

SEC. 30. The inspector shall, by regulation, from time to time, specify the quantity of salt that shall be contained in bags or other packages which shall be offered for inspection; and it shall not be lawful for him to authorize the inspector's brand to be placed upon any package that does not correspond with said regulation.

SEC. 31. The inspector shall, by regulation, require that all ground salt manufactured and put up for the market shall be legibly marked on each keg, box, sack, bag, or other package containing the same, with the words "ground solar," or "ground boiled," or "ground steam," or "ground Chapin," as the fact may be; such marking to be done in letters of not less than an inch in length.

SEC. 32. If the inspector shall consent to, connive at, aid or abet the smuggling of salt, or the transportation of the same away, so as to evade the inspection thereof, or shall accept of any bribe, or sum of money, or any gift or reward whatsoever, upon any express or secret or implied trust, or confidence that he shall connive at, or

consent to any evasion of the laws for the inspection of salt, such inspector shall forfeit his office, and pay to the use of the people of this State the sum of one thousand dollars.

SEC. 33. If any deputy inspector shall be guilty of the offences specified in the last section, or any of them, the inspector appointing such deputy shall forfeit to the use of the people of this State the sum of two hundred and fifty dollars, for the recovery of which his bond shall be put in suit.

SEC. 34. The inspector and each of his deputies shall be exempt from serving on juries, and from all military service, except in case of actual invasion or insurrection; and the commission or appointment in writing of any such officer or deputy shall be evidence of the facts stated therein.

SEC. 35. The inspector shall have power, from time to time, to make and ordain such necessary rules and regulations as he may deem expedient, concerning—

First. The manufacturing and inspection of salt not inconsistent with the provisions of this act.

Second. The daily examination, and the reporting by his deputies, of the operation and extent of the several salt manufactories, so as to determine whether the quantity of salt inspected at each manufactory is equal to the quantity actually manufactured thereat.

Third. The districting of the salt-making territory in this State, and the duties of his deputies under this act, and he may alter and revoke such rules and regulations at his pleasure.

SEC. 36. The inspector shall have power to annex penalties, not exceeding ten dollars in any case, to the violation of such rules and regulations. Such rules and regulations shall be printed and posted up in the office of the inspector, and in each manufactory, and published at least once in some newspaper in each county where salt is manufactured, and shall, after they have been posted and published as aforesaid for one week, be binding upon all persons concerned.

SEC. 37. It shall be the duty of the inspector and of his deputies, upon being applied to by any manufacturer to inspect salt in his district, to inspect the same forthwith; and in no case shall the inspector or any deputy delay the inspection of salt beyond twelve hours of daylight, excluding Sundays, after such application, unless such manufacturer shall consent to the delay. For a violation of this section by the inspector, or any one of his deputies, the inspector and his sureties shall be liable to the party aggrieved in the sum of fifty dollars over and beyond all actual damages sustained.

SEC. 38. Nothing contained in this act shall be construed so as to prevent the sale or exportation of the bitterns from any manufactory of salt, such bitterns to be sold or exported in bulk, or if in casks or barrels, to be branded as bitterns, and sold or exported as such.

SEC. 39. In case of any vacancy, from any cause, in the office of the inspector, the deputy who has been longest continuously in office shall possess the powers and perform the duties of inspector until such vacancy shall be filled; and the bond of the inspector and his sureties shall continue to be liable for the acts of all the deputies, until such vacancy shall be filled.

SEC. 40. The inspector shall annually, in the month of December, and on or before the fifteenth day thereof, make a report to the Governor of this State, which shall contain—

First. The number of districts into which the salt-producing territory of this State may then be divided, with the name and locality of each, and the number and capacity of the works of each district.

Second. The quantity and quality of salt inspected in each district during the preceding year.

Third. The amount received and expenses incurred under this act for the preceding year, in detail.

Fourth. Such suggestions and recommendations as he may think proper to make concerning the manufacture of salt, and the operation of the inspection laws upon the same, and as to what further legislation on the subject, if any, would be advisable. A copy of such report shall be published immediately after its date, in some newspaper in the Saginaw valley.

SEC. 41. The inspector shall establish a grade of "fine" salt, the grain of which shall be at least as fine as the average grain of salt made in kettles. He shall cause the word "fine" to be marked on the packages containing such salt, in large letters, and the word "fine," with or without qualification, shall not, under any circumstances, be placed on salt of coarse grain; but all other grades shall be designated on the packages by some truly descriptive mark or brand, and the inspector may mark salt "second quality" for imperfect grain, as well as for any other defect.

SEC. 42. Nothing in this act contained shall be construed to prevent the sale or shipment of salt in bulk, after the same shall have been duly inspected and a certificate thereof given by said inspector or any deputy; and nothing in this act shall be construed to prevent manufacturers from putting such private trade-mark or brand on their salt as they may see fit; *Provided,* It contains no untruth or statement calculated or intended to deceive the purchaser.

SEC. 43. In case the inspector shall, at the time of making any annual report, have a surplus of money arising from the inspection fees, in this act provided for, in his hands, he shall apportion back and pay such surplus to the persons, firms, or corporations for whom salt has been inspected during the last preceding year, in proportion to the amounts paid by them respectively for inspection fees.

RULES AND REGULATIONS ORDAINED BY STATE INSPECTOR OF SALT.

1. It is hereby *Ordained,* that, in the manufacture of salt by fire heat, the brine when received into the cistern shall remain at least forty-eight hours after the first plunging before it shall be drawn thence into the kettles or pans. The use of lime or any other substance in the manufacture of salt, by being mixed with or added to the water in any stage of the process, without permission of the inspector, is hereby expressly forbidden.

2. The cisterns of each block shall be thoroughly cleansed at the opening of the manufacturing season, and as often and whenever it may be required afterward by the inspector, and it is required that each block shall have at least four cisterns of the ordinary capacity.

3. The connections by which water shall be drawn from the cisterns into the blocks shall be inserted so as to receive the water at least six inches above the bottom of the cisterns.

4. Each manufacturer shall provide a good basket, of sufficient capacity to hold one entire drawing for each kettle in operation, into which the salt shall be drawn and there remain over the kettle for thorough drainage before being discharged into the bin, and the basket shall be well cleansed before being replaced over the kettle, and such salt shall remain in full view until the inspector, in his daily examination, shall have an opportunity to see it before it is broken to pieces.

5. The bins shall be kept clean and no salt put therein except such as is of first quality. After a bin has been emptied, it shall be washed out and so cleansed that the opening in it shall admit of the proper drainage of the salt. The floor of all salt houses shall be raised at least six inches from the ground to allow drainage, and there shall be a sufficient number of bins attached to each block, of convenient size, for storage of all the salt which may be made at such block while it is undergoing the process of drainage.

6. All salt shall stand in the bins at least fourteen days before packing, and the term will be taken to commence from the last discharge of wet salt into the bin. Salt in the bins shall be levelled off evenly at the top and so kept; nor will the packing of any such salt be allowed until the same has been declared fit for that purpose, upon actual examination by the inspector; and the packing of any salt without express permission, although fourteen days may have expired, will not be allowed.

7. Whenever it shall be found that salt has been pickled, or otherwise packed in a wet condition, so that the barrels will drain, it will have to be emptied again, and the persons packing such salt will be held liable to a penalty of ten dollars for each and every offence.

8. It is hereby declared unlawful for any manufacturer, boiler, or packer of salt, or any other person by their permission or procurement, to throw water upon or otherwise wet any salt in the bin or in the barrel before, whilst, or after packing the same; and the same is expressly forbidden. Any person so offending shall forfeit and pay a fine of ten dollars for each and every offence. Nor shall any such person discharge any wet salt into the bins or upon salt previously deposited therein, under a penalty of ten dollars.

9. Salt of an inferior quality that has been condemned by the inspector may be sold in bulk as "second quality," and if packed must be branded in large letters "second quality," payment of dues being made in the usual manner.

Every manufacturer of salt shall be provided with a suitable place of deposit for "second quality" and "refuse" salt, where the same shall be discharged and shall remain subject to the observation of the inspector; and such inferior salt shall not be mixed with nor sold as best salt. Whenever required by the inspector, the person in charge of a manufactory shall cause any wet or inferior salt to be removed to the place of deposit for such salt, or, at his option, and in his presence, may return the same to the cisterns to be dissolved.

10. The quantity that may be packed in each barrel shall be 280 lbs. of salt. Solar, ground, dairy, and table salt may be packed in quantities of 280 or 320 lbs., at the option of the manufacturer, and the latter qualities, if intended for market, in sacks, may be packed in barrels, in sacks, or put in barrels with the empty sacks. The tare of barrels is fixed at 22 lbs. for staves of soft and 25 lbs. for staves of hard wood.

11. Each packer shall make a hole $\frac{7}{8}$ inch in diameter in one head of each barrel packed, for the convenience of the inspector, and shall aid the inspector at all times in weighing the packages of salt.

12. All ground salt manufactured and put up for the market shall be legibly marked on each keg, box, sack, bag, or other pack age containing the same, with the words "ground solar," "ground steam," as the fact may be, such marking to be done in letters.

13. The average grain of salt boiled in kettles shall be the standard of "fine salt," and shall be branded as such. All salt coarser than the average grain of kettle salt manufactured by Chapin, steam, pan, or other process, shall be branded "packers," and the coarsest salt made by same processes shall be branded "C packers C." Solar salt shall be branded "solar," and if screened the two qualities shall be designated "C solar C" for coarse, and "F solar F" for finer. No salt shall have these brands unless of first quality, of its respective grain in all respects. Salt discolored in the manufacture or from any cause not of first quality shall be branded "second quality" in letters two inches in length, and have no other inspection-mark. But the manufacturer may work all such salt over again if preferred. Lower grades of salt may be put in old barrels, and shall be branded "refuse" without other marks.

14. Every manufacturer shall keep his premises used for the storage of salt in packages in a neat and clean condition, so that salt, while awaiting inspection or shipment, shall not be liable to be rendered wet or dirty, and shall keep the same protected from the weather; and all salt not kept in a state of preservation, and neatly and carefully packed in tiers not more than three barrels high, so as to remain in sound, merchantable condition, after the same has been inspected and branded, shall be repacked or otherwise disposed of according to its quality.

18. For any neglect or refusal to comply with either or any of the foregoing rules or regulations, or for any evasion or violation of the same, on the part of the manufacturers of fine or steam salt, or any person or persons in their employ, a penalty of ten dollars is hereby imposed, to be paid to the inspector or his deputies, on demand or record in a court of justice, with costs as provided by law. All the regulations shall be held to apply to the manufacturer of salt by other processes than boiling in kettles.

19. All salt finer than the average grain of fine salt may be branded "Dairy Salt," if found of sufficient purity, after having been submitted to a chemical analysis, otherwise no salt shall be branded "Dairy Salt."

The salt-producing territory of Michigan has been divided by the State Inspector of Salt into ten inspection districts, as follows:

District No. 1, East Saginaw.
" " 2, Saginaw City.
" " 3, Carrollton.
" " 4, Zilwaukie and Melbourne.
" " 5, Portsmouth and Bay.
" " 6, Bay and Essexville.
" " 7, Salzburg, Wenona, and Banks.
" " 8, Caseville, Port Austin, New River, and Port Hope, Huron Co.
" " 9, Sand Beach and White Rock, Huron Co.
" " 10, Oscoda and East Tawas, Iosco Co.

The salt-producing capacity of the State is 1,800,000 barrels, or 9,000,000 bushels.

Statement of salt made and inspected in the State since the establishment of the State inspection law in 1869:

Comparative statement to 1876.

		1869.	1870.	1871.
Fine salt,	barrels.....	513,989	568,326	655,923
Packers' salt,	"	12,918	17,869	14,677
Solar salt,	"	15,264	15,507	37,645
Second quality,	"	19,117	19,659	19,930
Refuse salt,	"	8,870	7,618	4,262
		569,688	628,979	732,437

		1872.	1873.
Fine salt,	barrels.........	672,034	746,702
Packers' salt,	"	11,110	23,671
Solar salt,	"	21,461	32,267
Second-quality salt,	"	19,876	20,706
		724,481	823,346

		1874.	1875.
Fine salt,	barrels........	960,757	1,027,886
Packers' salt,	"	20,090	10,233
Solar salt,	"	29,391	24,336
Second-quality salt,	"	16,741	19,410
		1,026,979	1,081,865

PRICES—MARKET PROSPECTS.

Statement of prices of salt received by the East Salt Manufacturing Company of East Saginaw:

Price per barrel, 1866........................	$1 80
" " " 1867........................	1 77
" " " 1868........................	1 85
" " " 1869........................	1 58
" " " 1870........................	1 32
" " " 1871........................	1 46
" " " 1872........................	1 46
" " " 1873........................	1 37
" " " 1874........................	1 19
" " " 1875........................	1 10

The markets for Michigan salt are the States of Ohio, New York, and Indiana, and through the entry ports of Buffalo, Erie, Ashtabula, Cleveland, Sandusky, and Toledo; throughout the West and Northwest, through the ports of Chicago, Milwaukee, and Duluth.

The prospects for an increased demand for Michigan salt are improving every year; and as long as a system of inspection is maintained, and a proper care is exercised by the manufacturer in the making of salt, this condition of the markets must continue.

COLLATERAL PRODUCTS OF MICHIGAN BRINES.

As shown by the chemical analyses, Michigan brines contain, besides salt, percentages of chloride of calcium, chloride of magnesium, and bromide of magnesium.

Chloride of calcium, which forms the largest proportion of the waste mother liquors, after the salt has been extracted from the brine, is now having a value for various purposes. Its concentrated solution is used as a bath in the putting up of canned fruit. It is also employed in the manufacture of chloride of barium and artificial sulphate of baryta.

In some localities, it has also found very extensive use in the manufacture of artificial stones by the Ransom patent. The process consists in mixing sand and silicate of soda by a pug mill into a mass of putty-like consistency. In this condition, it is pressed into moulds of any form and shape. After removing the pattern or mould, a strong solution of chloride of calcium is poured over the moulded form, which so hardens the surface that it can be removed to a tank containing a solution of chloride of calcium, in which it is allowed to remain a certain length of time until the entire form becomes perfectly hard. The decomposition which takes place in the stone between the silicate of soda and the chloride of calcium forming silicate of lime, which is the cementing material. The salt produced is afterward washed out by repeated soakings and washings in fresh water.

Artificial stone made in this way has a fine texture, great durability, and when properly and carefully made equals in most respects the best varieties of the native sandstone.

Chloride of magnesium also contained in the mother liquors of the salt works is a source for the manufacture of magnesia. A caustic solution of lime precipitates the magnesia as a hydrate, from which the calcined magnesia can be made by calcination. Magnesia finds considerable use in the manufacture of rubber goods and in pharmacy.

Bromine contained in the brines, as a bromide of magnesium, is now being extensively produced from the refuse bitter waters of the salt manufacture. Bromine is largely used in the arts and pharmacy. The annual American product of bromine is now over 130,000 pounds.

The refuse salt obtained from the waste brines has a value as a manure, and should find more general use.

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PART I. AND APPENDIX A.

APPENDIX B.