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ART. XXV.—*On the Saliferous Rocks and Salt Springs of Michigan;* by ALEXANDER WINCHELL.

THE perfectly dish-shaped conformation of the strata of the lower peninsula of Michigan, has prevented the escape to the sea of such soluble substances as were originally embraced in the marine deposits from which the rocks were formed. Were there any point in the margin of one of these rocky basins, lower than its central portions, chance for escape of all its soluble contents would have existed; and it is doubtful whether in such case, brines could have been retained to the present day, in any considerable quantity. Our subterranean peninsular basins are comparable with the superficial basins in which the salt lakes of the world are located. Neither class of basins has an outlet. The basin of lake Superior was once filled with water as salt as that of the Great Salt lake. Both have received accessions of fresh water; but while one has been drained by an efflux which has continually carried away some portions of the chlorid of sodium, the other has been drained only by evaporation. The saliness of one has been reduced almost to an infinitesimal quantity;* that of the other is unimpaired, if it has not

* Given the time required for the efflux through the Straits of St. Mary, of a volume of water equal to the usual contents of Lake Superior; given also the minute percentage of chlorid of sodium still remaining in the water of the lake; it is required to determine how long the processes of dilution through meteorological precipitation and drainage through the Straits must have been continued to reduce the sea-water which originally filled the lake basin to the degree of weakness which it has now attained: disregarding the chlorids derived from the drainage waters flowing into the lake.

actually been strengthened by the loss of more water than it has received.

The subterranean basins of Michigan furnish us with three "great salt lakes." The principal one of these is shown, for the first time, in the "First Biennial Report" of the geology of the State (1860), to occupy a position between the Carboniferous limestone and the sandstones at the base of the Carboniferous system —being on a parallel with the gypsiferous formation of Nova Scotia. It is a mass of argillaceous, gypseous and pyritous shales, with thin beds of arenaceous and magnesian limestone, and beds of pure gypsum from eleven to twenty feet in thickness. The aggregate thickness is from 180 to 200 feet. Its outcrop describes an irregular circle, embracing the central portion of the peninsula. It underlies an area of 17,000 square miles, embracing the whole of 19 counties and at least half of 16 others. This assemblage of strata, though probably included in the American representation of the Mountain Limestone of the Old World, has received the local designation of Michigan Salt Group.

Seven hundred and fifty feet below this is the Onondaga salt group, the circuit of whose outcrop is traced from Monroe county to Galt in Canada West, thence to Mackinac island, Milwaukie and southward. The supply of brine in these strata has not been ascertained. They are well stocked with gypsum and are known to be saliferous.

The third saliferous horizon has but recently been recognized. It was indeed known that brine of feeble strength exists in the coal measures, but only within a few days has it been proved that the salt wells at Bay City and vicinity on the Saganaw river, are supplied from this source. It *might* have been known from the first existence of these wells, if those having the boring in charge could have been induced to preserve specimens of the rocks. The Parma sandstone below the coal measures is the reservoir of this brine, as the Napoleon sandstone beneath the Michigan salt group is the reservoir of the brine from this group. It is now known that the Bay City wells terminated at the bottom of the Parma sandstone though bored to nearly as great a depth as the wells of East Saginaw and vicinity, which pierce the Napoleon sandstone. This fact being established, a new well near Bay City has been sunk to a greater depth, and at 916 feet the Napoleon sandstone has been struck as predicted; and at the depth of 74 feet in this rock, brine has been brought up *completely saturated*. This occurrence, no less than the success of the first well bored in the valley, becomes a very gratifying confirmation of geological inferences drawn from observations extended over thousands of square miles, and in great part, hundreds of miles distant from the points where success has been attained.

When the first geological survey of the state was organized in 1837, Dr. Houghton, the superintendent, was instructed to direct his attention to the development of the "State salt springs." In pursuance of his investigations, and with the liberal coöperation of the legislature, he began, in 1838, two salt wells—one three miles west of Grand Rapids, and the other in Midland county on the Tittabawassee river. The latter, after being prosecuted at intervals for four years, had reached the depth of only 139 feet when the work seems to have been obstructed by a "quartzose" boulder. The Grand Rapids well was sunk 473 feet but without success. In the mean time Hon. Lucius Lyon of Grand Rapids sank a well 661 feet at a point further east; and, obtaining water about one-fifth saturated, succeeded in manufacturing salt for a few years, at a time when salt was selling for $3.00 per barrel.

The cause of these early failures is now apparent. Dr. Houghton entertained erroneous views of the structural geology of the peninsula. He expressed the opinion (Report, 1839, p. 9) that the strike of the rocks was northeast and southwest across the peninsula—that Saginaw bay occupied a denuded space along the outcrop of "the sandstone" just where it comes in contact with "the limestone of the north"—that the coal on the Illinois river was on the strike of the coal-bearing rocks of Michigan—and the galeniferous limestone of Wisconsin and Illinois a prolongation of "a portion of the rock formation in the northern part" of Michigan. He further supposed that the brines of the state rose to the surface through fissures in the strata overlying the salt rock (Rep., 1838, p. 21; also special Rep., 1839, pp. 2 and 3), and that the geological positions of the state wells on the Tittabawassee and Grand Rivers were about the same (Spec. Rep., 1839, p. 6); while the latter was at least 360 feet below the former and separated from it by the whole thickness of the coal measures (see also Hubbard's Geol. Rep., 1841, pp. 132, et seq.).

It now appears that while the well on the Tittabawassee was located far within the salt basin, that on the Grand River was upon the thinning out edges of the strata. The brine at the latter point, as well as in Macomb and Washtenaw counties is caused by a sort of exudation over the rim of this basin, and does not rise through fissures from a deeply seated rock.

When it became apparent that the deepest portion of the great salt basin was probably beneath the neighborhood of the confluence of the Cass, Shiawassee and Tittabawassee rivers, a boring was commenced at East Saginaw, which at 742 feet had passed through the Coal measures, Carboniferous limestone and Napoleon sandstone, and afforded a plentiful supply of brine nine-tenths saturated. This success was the signal for a general

onset; and within two years, twenty-three wells have been bored along the valley of the Saginaw, and new ones are continually undertaken.

The following is an average section of the rocks passed through in the borings in the vicinity of east Saginaw:

Alluvial and Drift materials,	100 ft.
"Woodville sandstone," brown and coarse,	65 "
Coal measures, consisting of shales with some sandstones and limestones and coal,	180 "
"Parma sandstone" white and porous,	115 "
Carboniferous limestome, often highly arenaceous; generally so below,	75 "
"Michigan Salt Group,"	170 "
"Napoleon sandstone," light buff, rather coarse and porous,	110 "
Total,	765

The Napoleon sandstone is underlaid by a red shale which has been pierced 64 feet.

From East Saginaw the depth of the wells increases southward, toward the center of the general basin; and also northward, so that in the vicinity of Bay City the bottom of the Napoleon sandstone is found at the depth of 1000 feet. We seem therefore to have a local basin toward the mouth of the Saginaw river, although the vicinity is ten or fifteen miles nearer the outcropping margin of the salt basin, which is found at the mouth of the Pigeon river and in Tawas bay, on opposite shores of Saginaw bay.* This local basin is filled by an extraordinary thickening of the shales of the Coal measures, almost exclusively. As the Parma sandstone, which furnishes the brine of the first wells at Bay City, is probably the equivalent of the saliferous "Conglomerate" of Ohio, it seems that the supply of brine at this horizon, bears a relation to the thickness of the overlying shales of the Coal measures. It also suggests that in the deeper portions of the general basin, the Coal measures must be found similarly augmented in thickness, and the Parma sandstone similarly charged with brine. This condition should be looked for, west and northwest into Gratiot and Midland counties.

The following are analyses of Saginaw valley brines. The first is by Prof. DuBois of the University of Michigan, from the Napoleon sandstone; the second by Jas. R. Chilton & Co., from the Parma sandstone.

* On page 72, vol. i, Geolog. Rep. Wisconsin, Prof. Hall states, undoubtedly through inadvertence, that the "Hamilton group is known upon Saginaw bay." The Hamilton group strikes the lake shores in Thunder and Little Traverse bays many miles further north.

	Saginaw City.	Bay City.
Specific gravity,	1·180	1·163
Chlorid of sodium,	19·246	19·692
" calcium,	2·395	0·742
" magnesium,	1·804	0·432
" potassium,	0·127	
Sulphate of lime,	0·534	0·145
" soda,		0·116
Bromid of magnesium,		0·013
Compounds of iron,	0·064	
Total solid matter,	24·170	21·140

The difference in the composition of these brines is in accordance with their difference of origin.

The average supply of the Saginaw wells is at least 25,000 gallons each, in 24 hours.

The creation of this new branch of local industry is destined to become a matter of very great general importance. Although but two years have elapsed since the production of the first bushel of salt in the Saginaw valley, there are now (Aug. 1st) no less than 22 blocks of kettles in actual operation, turning out 1210 barrels of salt per day, or, making an allowance for the effect of winter weather, 1,980,000 bushels per year. Here is a growth, at the end of two years, equal to that attained by the Onondaga Saltworks in 1834, at the end of 38 years after the salt springs passed under the superintendence of the State. In two months, seven more blocks will come into operation, increasing by nearly one third, the foregoing figures.

Such is the strength and abundance of the brine and cheapness of fuel, that a barrel of salt is made at a cost of 64 cents. The cost of a barrel at Syracuse is at least 95 cents, so that Saginaw salt would pay the manufacturer 48 per cent of profit if the price were put down to the prime cost of the article at Syracuse. Moreover the quality of the article has proved so superior, that the market is actually clamorous for an adequate supply.

When we consider the cheapness and quality of Saginaw salt, the inexhaustibleness of the supply of brine and the excellent facilities for shipment, it would appear that there is little danger of over estimating the future development of this new resource.

University of Michigan, Aug. 4, 1862.