THE BLUE HOLE OF CASTALIA.

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INTRODUCTION.

The Blue Hole of Castalia, famed for its beauty and one of the scenic spots in Ohio, is located on the northern outskirts of the village of Castalia, seven miles southwest of Sandusky and about three miles from the Erie-Sandusky county line, which at one time marked the western boundary of the Connecticut Western Reserve.

The earliest historical record of the springs at Castalia is that in the report of Major Robert Rogers of New Hampshire.[1] After the fall of Quebec, Major Rogers left Montreal to take over the western forts held by the French and Indians. At Presque Isle he met Pontiac and was escorted to Detroit. Having secured the post at Detroit, Rogers returned by way of the Sandusky and Tuscarawas Trail which passed near the head of Cold Creek where the Castalia springs are located. In his observations of September 13, 1760, he remarks, "there is a remarkable spring at this place rising out of the side of a small hill with such force that it boils out of the ground in a column three feet high. I imagine it discharges ten hogsheads of water a minute."

This area was frequently occupied by the Ottawa and Wyandot Indians, the latter establishing a village on the present site of the town of Castalia. The springs furnished a plentiful supply of clear, cold water and Cold Creek leading from them, in its natural course, flooded much level land which was a paradise for muskrats, otter and mink. Deer and wild turkey were also numerous.

TOPOGRAPHY AND GLACIAL HISTORY.

In order that one may appreciate the geology of the area in which the Blue Hole is located, it is necessary to include the territory bounded by Sandusky Bay on the north, by

[1]Peeke, "History of Erie County," Lewis Publishing Company, Chicago, 1916.

parallel 41° 15′ north latitude on the south, and by meridians 82° 30′ and 83° W, essentially the area included within the Sandusky and Bellevue quadrangles.

The topography of this area, which lies wholly within the Erie Lake Plain of the central lowlands, is without any marked features. It is generally level and slopes gradually northward to Sandusky Bay which is considered the drowned pre-glacial channel of the Sandusky River. In pre-glacial time the Sandusky River flowed eastward past Johnson's Island to the trunk stream which is believed to have occupied the basin of Lake Erie and drained eastward from Detroit to Niagara.

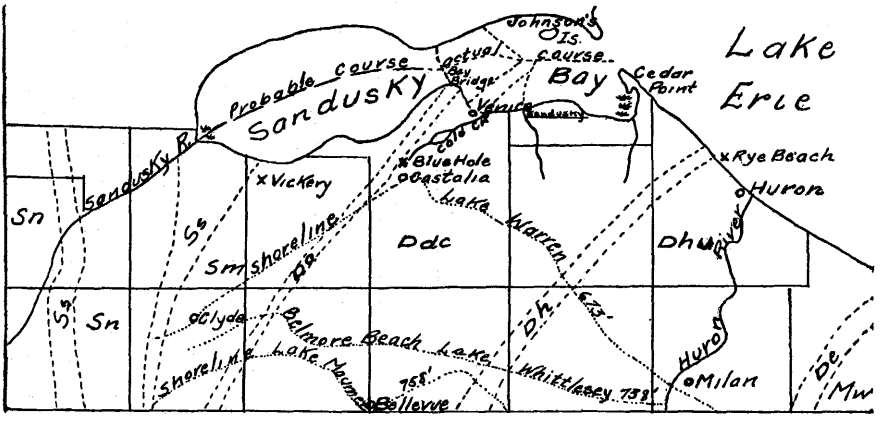

FIG. 1. Map of the Castalia area, showing formations, beach ridges and pre-glacial drainage. Legend: Niagara, Sn; Salina, Ss; Monroe, Sm; Oriskany, Do; Delaware and Columbus, Ddc; Hamilton, Dh; Huron, Dhu; Erie, De; Waverlyan, Mw.

Professor E. L. Mosely[2] has traced the course of the Sandusky River in the eastern half of the bay by means of auger drillings. Cold Creek, which obtains its supply of water from springs at Castalia now empties into Sandusky Bay at Venice, but originally continued in a northeasterly direction for two miles and joined Mill Creek which flowed into the old Sandusky River south of the western end of Johnson's Island.

South of Sandusky Bay the gently rolling, monotonous topography, characteristic of the prairie regions, has been produced by the planing action of glaciation and the expanded

[2]Mosely, E. L., "Formation of Sandusky Bay and Cedar Point," Ohio State Academy of Science, Vol. IV, Part V.

post-glacial lakes of Pleistocene time. As a result of glaciation, drift deposits of clay covered the region but these were largely removed by the post-glacial lakes. The withdrawal of the lake resulted in a fine, rich soil which is now covered by grass and sparsely timbered. The Castalia Blue Hole area is about one hundred and eighty feet above the level of Lake Erie, toward which consequent drainage is effected by numerous surface streams and the Huron River to the east. The absence of surface drainage is very noticeable in the limestone sink area, extending southwest of Castalia.

The history of the shrinking post-glacial lakes is readily determined by the old Lake beaches that roughly parallel the present Lake Erie from west to east. The first lake formed in the northeastward retreat of the Wisconsin glacier was Lake Maumee whose outlet was located at Fort Wayne, Indiana, through the Wabash and Mississippi rivers. This was the highest and oldest lake formed by the impounding of glacial water in front of the Labradorian ice sheet. The Maumee beach may be seen in the western part of Bellevue and the southeastern portion of Norwalk. It follows approximately the 750′ contour line and extends from the southeast corner of the area, three miles south of Clyde, through Bellevue and Norfolk. The next lowest beach parallels that of Lake Maumee at an altitude of about 738′ above sea level, one hundred and sixty-five feet higher than Lake Erie. The third and last beach in this area is that of Lake Warren, a lake of great size, the outlet of which was by way of Ubly, Michigan, Lake Chicago and the Illinois River. This beach is quite distinct and serves as the route for the Clyde-Castalia road or State Highway 101. It extends from Clyde in a northeasterly direction, a distance of fourteen miles to a point beyond Castalia, where it bends to the southeast toward Milan and Berlin Heights, parallel to the present shore of Lake Erie. Between the Lake Warren beach, one hundred feet above Lake Erie, northward to the shore of Sandusky Bay, the topography is flat and gently sloping. Castalia lies at the base of a limestone promontory that extended into the waters of Lake Warren. This position, at the base of a limestone drainage area to the south, is responsible for the outlet of the springs at Castalia and elsewhere to the west, such as the Rockwell Springs.

STRUCTURE.

Castalia is located on the Columbus limestone of Middle Devonian age which is underlain by the Monroe limestone of the Upper Silurian. All the formations of the area dip to the southeast at a low angle. Castalia stands on the eastern flank of the Cincinnati arch or geoanticline, near the axis, which bends to the east across Lake Erie into Ontario. In consequence of this dip the rock outcrops in Ohio are roughly arranged in north and south bands across the state. The rock outcrops in the Castalia area extend in a southwest-northeast direction, due to the curve of the axis of the Cincinnati arch. Early Waverlyan, or Lower Mississippian sediments appear on the east, followed by the Ohio shales of the Upper Devonian which are more than three hundred feet thick. Sandusky and Castalia are located on the Onandaga (Columbus and Delaware) limestone of Middle Devonian age which is underlain by the Monroe limestone of Upper Silurian (Cayugan) age. The Monroe limestone is a typical dolomite about one hundred feet thick and it is in this horizon as well as the Columbus and Delaware formations that the underground streams in the region about Castalia have carried on their work. The Cincinnati arch flattens out at its crest in western Ohio, in consequence of which the Monroe formation outcrops extensively. It is in this formation that the caves of west-central Ohio, at West Liberty and Zane were formed. Sink-hole topography is best developed in the Bellevue-Castalia area.

GENERAL DISCUSSION.

Caves and sink holes are characteristic of a limestone region. Prominent cave and sink-hole areas in the United States occur in north-central Florida, Virginia, and central Kentucky. The celebrated Mammoth Cave and the Luray Cave are large scale examples of the same processes which formed the underground passages near Castalia and the caves of Put-in-Bay, Ohio. The surface water with the aid of carbon dioxide and organic acids in solution, dissolves the limestone along every crack it penetrates and forms a connecting system of underground channels by which all drainage of the region is effected. In limestone areas streams may disappear beneath the surface and after flowing underground for great distances reappear, issuing forth as a stream or a

huge spring. Similar fountains occur in foreign countries, notably Greece where the classical Clitumnus burst forth at the base of a limestone mountain. This spring was famous for its cerulean blue water and was sacred to Apollo and the Muses.

A glance at the Sandusky and Bellevue topographic maps discloses the extensive development of underground drainage which has undermined the Columbus and Delaware limestone, causing it to slump into the cavities below, forming sink-holes. These are depressions with no outward drainage and surrounded by inward facing cliffs, formed when the roofs of the caves collapse. Perhaps the largest and most typical example in this area is located a mile south and east of Castalia, where a sink-hole includes several acres without surface inlet and faced by cliffs of rock still in their original position.

The sink-holes are concentrated south and southwest of Castalia toward Bellevue, nine miles to the south, and Clyde twelve miles to the southwest. The Silurian-Devonian contact (Monroe-Columbus) cuts diagonally across the Bellevue quadrangle from Bay Bridge on Sandusky Bay to the southwest corner of the Bellevue quadrangle, passing about a mile and a half east of Clyde. The Upper Devonian-Middle Devonian (Huron-Columbus) contact describes an arc from a point about two miles southeast of Bellevue to Rye Beach on Lake Erie. Between these limits is the outcrop of Delaware and Columbus limestone and the area of sink-hole distribution. Sink-holes do not appear on the Monroe outcrops to the west but numerous springs issue forth; those at Vickery are examples. To the south in Ohio, along the Silurian-Devonian contact, the writer did not find any sink-hole development comparable to that in the Bellevue quadrangle. The number of sinks decreases rapidly in Seneca County on the south but are numerous north and west of Bellevue. This city is known for its lack of a sewer system. The amount of sewer pipe is almost negligible, for all the inhabitants need to do is to drill a hole of sufficient depth in the Delaware and Columbus limestone through which all the sewage escapes and is carried away through subterranean channels. The popular concensus of opinion is that the outlet is unknown, that the source of the Blue Hole water has not been determined, and that the depth of the vivid blue water is limitless. Mosely introduced corks and cork dust into the sinks at Bellevue. These were looked

for by the residents of Castalia, but never found; they were doubtless filtered out as is most solid matter in ground water. Nevertheless, since the watershed slopes from Bellevue north to Sandusky Bay, the water coming from the springs in Castalia must obviously come from the south, according to geologic reasoning. During the heavy rainfall of the spring of 1913 which occasioned the Sandusky River floods, the amount of run-off was so great that the channels draining the Castalia-Bellevue area were filled beyond their capacity, resulting in the flooding of low places in Bellevue and the fields to the north by water which came forth from openings where normally it entered. In the spring of 1930 many acres were flooded and the Castalia-Bellevue road, four miles north of Bellevue was impassible. Here water, three to four feet deep, issued from the ground, where before and after no openings were discernible. What seems to be conclusive proof that the underground drainage is from Bellevue to Castalia, is supported by the results of investigations made by Dr. F. M. Houghtaling, Erie County Health Commissioner. He writes,[3] "Several years ago I was quite concerned about the water supply of the Blue Hole at Castalia and made repeated bacterial examinations and found nearly all deep water wells between Bellevue and Castalia and the flowing wells in the region of Vickery contained B-coli in sufficient numbers to make the water unsafe for domestic use. The waters of the Blue Hole will develop gas-forming bacilli within twenty-four hours with a high bacteria count when plated. As no doubt you are aware, there is no sewage disposal at Bellevue. It has been the custom for years to drill wells until the drill drops into a cavern, and then pull the tools and test it by putting a fire hose in for several hours. It was evident to me that this was the source of contamination. To prove my judgment I placed one pound of Uraline dye in a flush bowl in Bellevue. This colored the water definitely for a distance of three miles on the Bellevue-Castalia road. I had a faint reaction five miles from Bellevue and three miles from Castalia. I am satisfied that if I had used two or three pounds of dye I would have made the Blue Hole a bright green color. The expense stopped me from further experiment. When you consider the amount of water that this dye will color, and the distance in which the dilution

[3]Personal communication, 1932.

was so great that it faded out, proved to me that there is a large body of water under this area."

The Castalia springs are four in number and discharge into a pond a few acres in extent, located in the central and east portions of the village. About twenty-five thousand gallons of water are supplied to the pond per minute. This volume formerly flowed across the prairie on the north and through the marsh southeast of Bay Bridge by means of a stream, now extinct. This creek flowed northeast four miles from the shore of Sandusky Bay, at a point one and one-fifth miles east of Bay Bridge and joined the old Sandusky River a quarter of a mile upstream from Mill's Creek near Johnson's Island. With the advent of man, the prairie to the north and west of Castalia was too wet for trees. This area has been artificially drained by canals, leading the water north and northeastward into two branches of a creek flowing into the bay at Venice. The entire stream course has been known as Cold Creek.

The great marl beds used for cement by the Sandusky Portland Cement Company at Bay Bridge were formed in the flooded area north of Castalia, from the spring waters which contain a high percentage of calcium carbonate. The abundance of tufa at the surface makes it impossible to plow the land, which can be used for pasturage only. The marl bed area has always presented dismal agricultural prospects and it required little persuasion for the owners to sell their land to a "sporting club organization." Chemical analysis revealed the great value of the tufa deposits which are in demand for cement and other products. The tufa was formed by a plant known as the chara which grows in water containing carbonate of lime. This it takes from the water in which it lives; after it dies the resulting travertine becomes encrusted with the same substance, forming tufa. Travertine or tufa is composed of about 97% of calcium carbonate, 1% of magnesium carbonate, and lesser quantities of barium sulphate, aluminum, iron and silica. Willow Point, located half-way between Bay Bridge and the mouth of the Sandusky River is a gravel beach half a mile long, several yards wide and rising not more than three feet above the usual bay or lake level. The marsh back of the beach contains no tufa and therefore the pebbles must have been derived from the marl beds underlying and below the level of the bay. Marl is excavated by the Sandusky Portland Cement Company in

many places at a depth of five or more feet below the level of the bay. This is evidence that the lower reaches of the Sandusky River have been drowned producing an estuary, Sandusky Bay.

The Blue Hole is not more than one hundred and ten years old; it came into being about 1820 when the pressure caused by the rising of the water of the upper pond in Castalia, as the result of a dam, weakened the strata above the Blue Hole and occasioned its collapse into the cavernous depth. This dam was located in front of the church in the center of the village where the pond emptied into the outlet stream. The new spring has since had a sympathetic relationship with the larger and less beautiful pond to the south. Undermining has proceeded since the original collapse, for early in 1914 another cave-in occurred leaving the Blue Hole with its present dimensions, roughly circular, averaging seventy-five feet in diameter. The Blue Hole did not gain wide publicity until about 1879, because it was inaccessible except by boat. The organization of the Cold Creek Trout Club, brought about the banking of the marshy edges of the Blue Hole so that one could walk about the orifice. Today the area to the south and less to the east and west is still very moist and few trees of any size can grow there.

Contrary to prevalent belief, the depth of the Blue Hole is not unknown, but has been sounded and found to be about forty-three to forty-five feet deep. The deepest point is near the south margin, where on a sunny day one may follow the descent of a small object through the limpid water to the mysterious depths below. The sun must be shining in order to penetrate the depths, for the surface otherwise acts as a mirror. Therefore the summer time is the best season in which to fully appreciate the vast, quiet beauty of the Blue Hole. The surface remains undisturbed, even though there is a constant volume of water coming from below. About five thousand gallons of water per minute escapes from the Blue Hole, through two outlets, over artificial cascades made to aerate the water which is lacking in free oxygen. Trout cannot live in the Blue Hole because of the lack of free oxygen. The volume of water and its temperature remain remarkably constant throughout the year. Drought and rainfall show a slight influence; the flow is regulated beneath the surface in a manner comparable to the regulatory influence that a mantle

of trees and grass has over the surface drainage. During and after the drought of 1930 the Blue Hole showed no noticeable volume change. The temperature of the water does not vary appreciably during summer and winter; the maximum fluctuation is about 5° Fahr., that is from 46° to 51°. This fact, and the huge volume of water supplied by all the springs, prevents Cold Creek from freezing during the winter. Consequently, mills were established at an early date along the

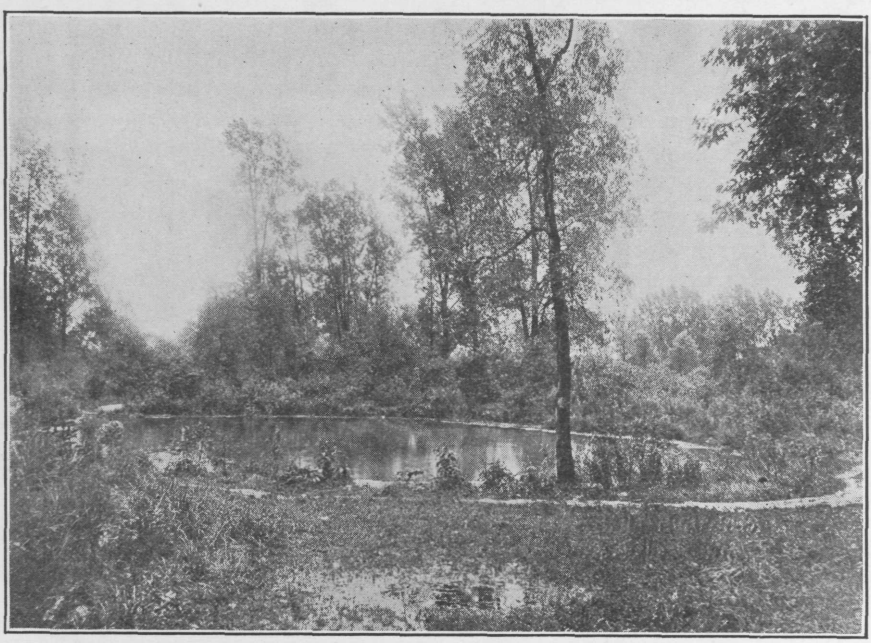

FIG. 2. The Blue Hole of Castalia.

five-mile length of Cold Creek to Sandusky Bay. The constant source of power throughout the year was of great value to the early pioneer.

The Blue Hole and other springs at Castalia send out thirty thousand gallons of water per minute into the canals which extend north a mile and a half to the club house of the Castalia Sporting Club, where they join in a single straight channel, the length of which extends an equal distance to the northeast. To this point the fall averages seven feet per mile and now descends by two cascades into a natural stream

course ten feet below. Here is the site of a stone mill which was originally built in 1839 and destroyed by fire in 1888. The ruins are now seventy feet from the cascades; in forty-five years the falls have retreated this distance. Castalia (640-650 feet) is approximately seventy feet above mean lake level (573 feet) and Cold Creek has a fall of fifty-seven feet to Gallagher's Mill at Venice where the only mill along the creek is located.

The Castalia springs at an early date attracted attention because of their cold water and constant flow throughout the year. Ideal conditions existed for the establishment of grist mills and many were built and operated during the past century. The village of Venice was founded at the mouth of Cold Creek in 1816 and became of increasing importance as a milling center. During the coldest winter ever recorded, Cold Creek was the only creek not to freeze over. All southern Michigan and northern Ohio were dependent on the Venice mill for the grinding of flour. During the dry summers when there was an insufficient supply of water to operate the mills the farmers brought their grain for great distances to the mill at Venice. Carp ponds now flourish at Venice; the cold water allows the fish to be kept healthy until ready for the eastern market. Distilleries, tanneries, paper mills and cotton mills have during the past one hundred and twenty years been established on Cold Creek and at Castalia because of the purity of the water, its low temperature and power. In 1868, Cold Creek was first stocked with speckled trout. It was not long until the Castalia Sporting Club was organized (1878). The next year the Cold Creek Trout Club originated. In 1887 the former reorganized as the Cold Creek Sporting Club and later again changed its name; this time to the present Castalia Trout Club whose club house is located just beyond the Blue Hole. Farther down stream is the "Lower Club" (Castalia Sporting Club). On the grounds of the younger club are twelve miles of trout stream supplied by a private hatchery located just east of the Blue Hole. German Brown Trout were once artificially propagated until it was discovered that they fed on the smaller trout. Nevertheless, this species still persists and on occasions some as large as eight pounds are caught. Rainbow and Steelhead trout are the other two species now stocked in the stream. Four to eight thousand fry are hatched every year and much care is taken to see that

the proper amount of food organisms are supplied to the growing fish. The Steelhead or Salmon trout were experimented with eight years ago by the Castalia Trout Club, but the fear that they would exterminate the other trout is the reason why the fry were freed in Sandusky Bay.[4] Lately fishermen have been catching seven, six and five year old Steelhead trout in Sandusky Bay, ranging up to twelve pounds in weight. This proves that this species of trout can spawn in these waters, probably opposite the mouths of the spring-fed streams that empty into the bay. Sandusky Bay is located, throughout its fifteen mile length, above the Monroe limestone from which cold springs well out under the bay and lower the temperature below that of Lake Erie, making it possible for Steelhead trout to multiply and provide sportsmen with a fighting game fish that is obtainable only in the Rogue River in Oregon. The full grown trout weigh twenty or more pounds. The State recently purchased a twelve acre area near Vickery; a huge volume of cold water from the springs there is ideal for fish propagation.

[4]Sadler, Webb, Member of Castalia Trout Club.

The Invertebrata.

For many years there has been a real need for a satisfactory one-volume text and reference work on invertebrate zoology—one that would embody the present-day knowledge of taxonomy, morphology, and phylogeny, and also emphasize the physiological and ecological aspects of the subject. The first volume of Parker and Haswell's Textbook of Zoology, which thirty-five years ago admirably filled this need, has undergone but little change in its successive editions; and no other work of comparable scope and size has appeared. The present volume, the work of English zoologists and English printers, comes closer to meeting the demand than any other book published in recent years.

The book is well organized, and shows evidence of much careful, painstaking work. The classification adopted combines conservatism with the utilization of the general results of recent taxonomic work. The chief emphasis throughout is morphological. However, the treatment of the theoretical side of invertebrate morphology, which can be used to such good advantage to give coherence and add interest to this subject, is extremely limited. The discussion of evolution and phylogeny also seems inadequate, and sometimes lacking in understanding. Thus the statement, (p. 2), that ". . . . the Platyhelminthes or flatworms seem to be related to the annelid stock. Their lack of coelom is a difficulty in this respect."

The typography, in general, is good. The type used for the text is slightly smaller and more closely spaced than is usual in zoological textbooks, and many of the drawings are on a smaller scale than might be desired, and these things detract somewhat from the attractiveness of the printed pages. Most of the illustrations are simple, clear line drawings; many of them have not previously been seen in textbooks.—W. J. KOSTIR.

The Invertebrata: A Manual for the Use of Students, by L. A. Borradaile and F. A. Potts, with chapters by L. E. S. Eastham and J. T. Saunders. xiv+645 pp. 458 figs. New York, The Macmillan Company (Cambridge, England: At the University Press), 1932. $5.50.