reduction in mean depth from 20.01 to 5.26 feet. An increase in area by 74.09 per cent (from 4,859,000 to 7,459,000 sq. ft.) from the original to the high-level basin emphasizes the fact that there was relatively little filling in of sediment around the edges of the basin. This is shown, also, by the accumulation of 84 feet of sediment in the center of the depression (boring 53), whereas the topmost contour (isolation contour) was raised only 30 feet during the Algonquin period. The reduction in volume (63.42 per cent) was likewise considerably greater than that in the Fairy Island depression, where the filling was largely around the periphery during the same period. A reduction of 91.89 per cent in mean slope (from 6.34 to 0.51 per cent) during this period follows from the increase in area and the reduction in depth. Some decrease in irregularity in the shoreline is shown by the decrease in shoreline development from 1.3 to 1.2 per cent.

Owing to the more rapid accumulation of sediment around the periphery than in the center of the basin, shown by the reduction of 74.26 per cent in area and the relatively slight reduction in maximum depth of 18.18 per cent, the morphometrical changes in this depression during the time subsequent to the Algonquin period (the period of the high-level and the present basins) are of a kind diametrically opposite to those that took place from the original to the high-level basin. The volume was reduced by 62.85 per cent. The rate of reduction in area, which was faster than that in maximum depth, caused an increase in mean slope from 0.51 to 1.87 per cent.

The present basin of Bogardus Point depression is in reality only an embayment, but the mouth of the bay was arbitrarily taken as the limit of the lake ward side of the basin.

It is evident that Bogardus Point depression filled in a manner exactly opposite to that of Fairy Island, Maple Point, and Grapevine Point depressions at corresponding periods.

Boys Camp depression. — It is impossible to learn whether or not the filling of this basin took place more rapidly around the periphery than in the center, since the basin was completely obliterated during the Algonquin stage of the lake, but it undoubtedly did fill in the center at a rapid rate, which puts the basin in the same class as Bogardus Point depression during the Algonquin period. No filling has occurred since the Algonquin stage.

South Fish-Tail Bay depression. — Uniquely, no appreciable amount of sediment settled around the periphery, and very little did so in the center in the Algonquin stage of this depression (Fig. 5). The change in the isolation contour from 70 to 40 feet between the original and the high-level stages makes a deceiving situation, since it suggests considerable filling around the edge, but the 30-foot elevation is due to the plugging of a narrow channel connecting the depression to the main body of the lake (compare Figs. 2-3) and not to deposition within the basin itself. This elevating of the isolation contour is chiefly responsible for the increase in area (69.78 per cent), maximum depth (12.50 per cent), mean depth (16.16 per cent), and volume (97.16 per cent). Since the area increased more than the maximum depth, the mean slope shows a decrease (10.20 per cent). Volume development, length of shoreline, and shoreline development also increased. The mean depth of sediment which accumulated during this period was only 9.36 feet, which is less than one third of the average amount that accumulated in the other nine basins during the same time (Table II).

In sharp contrast to the morphometrical changes that occurred during the Algonquin stage every morphometrical feature shows a decrease in value from the beginning of the high-level stage. The average depth of sediment accumulated during this later period is 25.46 feet. Most of it settled in the central deep part of the depression (Fig. 5), which is shown by the facts that there was only a 10-foot elevation in the isolation contour and that the maximum depth decreased 31.75 per cent.

North Fish-Tail Bay depression. — Since about the same amount of sediment accumulated around the periphery as in the center, both during the Algonquin stage and subsequently (Fig. 5), North Fish-Tail Bay depression might be taken as the mean of the ten depressions. The justification for this conclusion is found in the morphometrical changes (Table II) that took place during the two periods; they are all negative except volume development and shoreline development, both of which increased between the original and the high-level stages. For example, between the original and the high-level stages the area decreased 31.81 per cent, maximum depth 58.54, mean depth 28.45, volume 73.51, mean slope 60.44, and length of shoreline 9.90. The average depth of the sediment that formed here is 24.18 feet. The corresponding figures for the changes from the high-level to the present stage are considerably greater; they show acceleration in the same trends, which is undoubtedly due to the greater relative quantity of sediment that accumulated during this time, namely, an average of 33.83 feet.

Stony Point depression. — This depression formed an arm of Grapevine Point depression during the Algonquin period (Fig. 2) but was cut off as an independent depression as early as the time of the high-level stage by a ridge of sediment that formed across the base of the arm (Fig. 3). During the high-level and the present stages of the lake there has been a fairly uniform accumulation of sediment over the entire basin, which has reduced moderately the area, maximum depth, mean depth, volume, slope, and volume development (Table II). The length of shoreline and the shoreline development increased slightly. These changes are very much like those that occurred in North Fish-Tail Bay depression during the same period. The average depth of sediment deposited is 13.32 feet.

Roberts Point depression. — The striking feature about Roberts Point depression is that between the original

and the high-level basins it shows, among all the depressions, the greatest change in elevation of its isolation contour (from 60 to 20 feet), owing to the damming of the basin at the southeastern and northwestern corners rather than to an accumulation of sediment around the periphery (compare Figs. 2-3). These changes caused the greatest relative increase in area in all the depressions (204.66 per cent). This increase was partly because most of Boys Camp depression became incorporated with it by the time the high-level stage had been reached. There was an increase in maximum depth of 20.51 per cent, which is the greatest increase in depth that took place in all the depressions. The fact that the area increased more than the volume and the maximum depth caused decreases in mean depth (12.96 per cent) and mean slope (38.85 per cent). The volume increased by 165 per cent. The volume development decreased 27.27 per cent. This gave the high-level basin the lowest value in volume development (0.8) in all depressions at any stage. Length of shoreline and shoreline development both increased (97.30 and 9.09 per cent). About an average amount of sediment (23 feet at boring 6) settled in the center of the basin during the Algonquin stage.

From the high-level to the present basin every morphometrical feature changed in a manner opposite to that noted above for the changes from the original to the high-level stage (Table II). Fifty-one feet of sediment accumulated during this period at the point where boring 6 was made. That most of the sediment accumulated in the center of the depression during this period is shown also by the lack of any elevation in the isolation contour.

Sedge Point depression. — Of all the depressions this one was originally the smallest in area, volume, and length of shoreline, but it was one of the deepest (83 feet maximum depth from the isolation contour). The small area and the great depth account for the unusual steepness of its mean slope (13.49 per cent). It filled rather slowly around the periphery but rapidly in the center during the Algonquin stage (Fig. 5). The depression increased in area (44.31 per cent) and decreased in maximum depth (44.58 per cent) and mean slope (59.30 per cent). The length of shoreline increased 11.32 per cent. Volume decreased (27.81 per cent), as did volume development (8.33 per cent) and shoreline development (8.33 per cent).

During the high-level and the present stages of Sedge Point depression sediment settled slightly faster around the edges than in the center, since there was a decrease in area of 24.37 per cent and in maximum depth of only 15.22 per cent. These changes caused an increase in mean slope of 19.31 per cent. Volume development increased by 18.18 per cent. Except for volume development between the original and the high-level stages, Sedge Point depression shows the same trends in morphometrical features (but to a less degree) that Bogardus Point depression did at corresponding stages. This is probably because both basins filled in the center faster than around the edges during the Algonquin stage and faster around the edges than in the center during the high-level and the present stages.

3. COMPARISON OF THE MORPHOMETRICAL CHANGES IN THE LAKE BASIN CONSIDERED AS A WHOLE

When Douglas Lake is considered as a whole, it is found that its area decreased 13.04 per cent from the Algonquin to the high-level stage and 7.7 per cent from the high-level to the present time. Maximum depth decreased little (3.98 per cent) from the Algonquin to the high-level stage because of the small amount of filling in Fairy Island depression (the deepest place), but maximum depth decreased 53.89 per cent during the high-level and the present stages because Fairy Island depression filled absolutely more than any other depression (104 feet). Mean depth decreased 40.19 per cent during the Algonquin stage and 36.59 per cent subsequently. The decrease in volume was 55.60 and 56.16 per cent; in mean slope, 36.86 and 24.44 per cent. Volume development decreased during the Algonquin stage 28.57 per cent but reversed this trend and increased in the subsequent stage by 20.00 per cent.

These morphometrical data indicate that during the Algonquin period the lake (as a whole) filled around the edges faster than in the deeper parts but filled in the depressions almost exclusively during the high-level and the present stages. Comparison of Figures 1, 2, and 3 (contour maps of the original, high-level, and present stages) and examination of Figures 4 (cross-section profiles) and 5 (graph of areas of contours) will make this generalization evident.

4. BOULDER BELTS

Boulders of considerable size (up to two feet in diameter) are found at several places around the edges of Douglas Lake. Some of them lie on deposits of sand many feet in depth. They were noted near borings 11, 21, 22, 38, 40, 49, 59, 71, 102, and 105 (Fig. 1). The texture of the material that makes up the shore in most localities mentioned is not such as to suggest that the shore is their source.

5. SAND STRATA IN DEPRESSIONS

Fairy Island depression had a layer of washed sand and gravel (up to 5 mm. in diameter) twenty feet in thickness at boring 2 and with an estimated thickness of thirty-five feet at boring 37, which lies between the marl of the warm-water deposit and the pink clay of the Algonquin (cold-water) deposit. Roberts Point depression had an eighteen-foot deposit of washed sand at boring 7 overlying the original bottom.

The depressions mentioned above accumulated very little deposit in their centers during the Algonquin stage and, consequently, their maximum depths were reduced only slightly. They are the basins that had the largest volumes as well as the steepest slopes at the end of the

Algonquin stage. These findings make it seem likely that they were occupied longest by blocks of ice.

Volume of Sediment and Percentage of Filling of Basins

Table III shows the volumes of sediment of the various basins and the percentage of their filling. With the exception of Roberts Point and South Fish-Tail Bay depressions the absolute volumes of sediment that settled in the original depressions during the Algonquin stage of the lake (original to high-level in the table) were greater than those winch accumulated subsequently (high-level to present in the table). The reverse is true, on a percentage basis, for all but Sedge Point depression. More than twice as much sediment settled in the lake as a whole during the first period as subsequently (4,582,776,000 and 2,058,089,000 cubic feet).

TABLE III

Volumes of Sediment (in Thousands of Cubic Feet) and Percentage of Filling of Basins

Names of depressions	Original to high level		High level to present		Original to present	
	Volume of sediment	Percentage of basin filled	Volume of sediment	Percentage of basin filled	Volume of sediment	Percentage of basin filled
Fairy Island	836,101	57.08	546,560	77.07	1,465,188	90.00
Grapevine Point	345,135	58.69	168,880	69.52	456,768	86.05
Maple Point	180,782	78.77	57,615	93.90	254,745	98.55
North Fish-Tail Bay	132,349	80.97	55,279	96.50	185,185	98.93
Bogardus Point	252,813	86.56	86,256	85.54	287,069	98.55
Roberts Point	128,816	30.00	184,432	61.35	152,915	56.77
South Fish-Tail Bay	24,945	12.92	115,119	54.73	121,836	56.13
Sedge Point	56,738	58.25	31,778	51.28	78,877	72.33
Stony Point	...	...	9,657	66.50	...	...
Boys Camp	112,248	100.00	...	...	...	...
Lake as a whole	4,582,776	47.99*	2,058,089	41.44*	6,640,865	69.54*

* Exclusive of that part of the basin above the present water level.

The average depth of sediment (Table II) that settled in the various depressions at the several periods shows the differences that have taken place in the rate of sedimentation. Considering the lake as a whole (exclusive of the basin lying above the present water level), the average depth of sediment that accumulated during the Algonquin period was 22.97 feet and that during the periods following, 11.86 feet. Conspicuous differences among the depressions occur between the Algonquin and the subsequent periods. For example, in Fairy Island depression an average of 30.30 feet settled in the first period and 60.30 feet afterward; for Bogardus Point depression the figures are 52.03 and 11.56 feet, respectively. The figures for the other basins range somewhere between these extremes.

Comparison of the average depths of sediment among the various depressions reveals striking differences for corresponding periods. For example, in Fairy Island depression during the high-level and the present periods 60.30 feet was deposited; in Grapevine Point depression, 24.84 feet; in Roberts Point depression, 15.50 feet; and in Sedge Point depression, 13.10 feet. These thicknesses are in great contrast to those the writer found in the several depressions (much shallower) in Winona and Tippecanoe lakes in Indiana (Wilson, 1936, 1938), where the average depths of sediment were much the same.

Examination of the locations of the depressions in Douglas Lake (Fig. 2) shows that those in the most wind-exposed positions have the least average depth of sediment for the warm-water period; they are Sedge Point, Stony Point, and Roberts Point depressions. Fairy Island depression is in an exposed position and at the same time has the greatest average depth of sediment for the warm-water period (60.30 feet), but it lies at the lee end of the lake. It seems likely that swift currents over the wind-exposed basins do not give time for sediment to settle into them, whereas in Fairy Island depression less swift currents and the possibility that considerable quantities of sediment may be carried ultimately to that part of the lake by return currents could account for the great quantity of sediment that has settled there.

Discussion

The foregoing pages have described the diverse types of morphometrical changes that took place in the different depressions of Douglas Lake, the deposition of boulders over deep-sand deposits, the interpolation of sand and gravel layers between the Algonquin and subsequent deposits that occur in some depressions, and the thick deposits of pink clay (Algonquin deposits) around the margins of some depressions where there is scarcely any such deposit in the center. These phenomena can be adequately explained if it is assumed that the great ice blocks that occupied the depressions at the outset of the Algonquin period persisted for varying lengths of time in different depressions and did not disappear in Fairy Island depression until near the close of the Algonquin period. Such a theory implies that, where the ice blocks were thin, as they were around the margins of depressions, in the relatively shallow interdepression zones, and in shallow depressions, they melted early, and such localities became the first repositories of sediment and, therefore, accumulated the deepest deposits of cold-water sediment. Conversely, the deepest and most voluminous basins (at least in their centers) would be expected to become free of ice last and would accumulate the least deposit of cold-water sediment. It would be inferred that, after all the glacial ice had melted, deposition of sediment would take place according to the distributive factors inherent in the lake as a whole and in the individual depressions.

These expectations are amply verified by the evidence. For example, it has been shown that during the Algonquin stage the very large Fairy Island depression filled almost exclusively around the margin, where the original block of ice was thin and undoubtedly melted early, whereas at the opposite extreme there stand Boys Camp and Bogardus Point depressions (that were originally shallow depressions), in which the ice melted early in the centers of the basins as well as around the edges and became filled almost entirely with pink-clay deposit. In South Fish-Tail Bay depression, which , had

very steep sides and was deep and well protected by Grapevine Point, its ice block apparently melted very little until late in the Algonquin period and, consequently, the depression has relatively little pink-clay deposit. The other depressions are intermediate between those already discussed.

That ridges on the original bottom of the lake began deposition early because they became free of ice seems well illustrated at boring 4, between Fairy Island and Roberts Point depressions. Here the original depth was only 42 feet (from the surface of the present basin), and there are only 25.5 feet of pink-clay deposit and one-half foot of recently deposited sandy organic matter. A similar example occurs at boring 8, in the interdepression zone, where there is a 42-foot pink-clay deposit that reaches to the base level of wave action and over which only one-half foot of sandy organic matter lies.

According to the general theory presented above, the boulder belts superimposed on sand could be explained by assuming that the sand deposits over which the boulders are lying were made around the margins of the depressions while the ice blocks in the centers of the depressions were anchored to the bottom. It may be assumed that during such a time wave action and currents were adjusting the shoreline and carrying sand into the water near shore. The melting block of ice may have contributed some sand to this zone. Finally, when the ice block in a depression freed itself from the bottom and floated, it may have drifted toward the shore and melted and thus have dropped its boulders on the previously deposited sand.

The presence of the sand and gravel layers interpolated between the cold- and warm-water deposits in the deepest depressions can be explained in two ways: (1) One might assume that after the ice blocks had melted the increased wave action caused violent shore adjustments in which considerable sand was carried to the center of the depressions, where it settled before the deposition of warm-water sediment began; (2) The ice block could have dropped its burden of sand and gravel directly into the depressions as it melted, after it had become detached from the bottom and was floating.

The place of deposition of sediment during the Algonquin period was controlled to a large extent by the blocks of ice that occupied the depressions and, as has been shown, most of the sediment settled around the periphery of the depressions during that time. During the high-level and the present stages of the lake the controlling factors in distribution of sediment have been those inherent in the shape and form of the basin itself. In these later periods nearly all the sediment has settled in the centers of the depressions and very little around the periphery of the lake. This is what is to be expected in a lake as large as Douglas Lake, the long axis of which lies in the direction of the prevailing winds. That is, wave action is so vigorous that the shore out to the base level of wave action is being eroded and the abraded material is being carried away to settle in the depressions. Undertow and return currents down to the level of the thermocline and currents below that level at the spring and autumnal overturns probably keep the fine sediment suspended until it reaches the depressions, where it can settle to the bottom permanently.

HEIDELBERG COLLEGE
TIFFIN, OHIO

LITERATURE CITED

LEVERETT, FRANK, AND TAYLOR, FRANK B. 1915. The Pleistocene of Indiana and Michigan and the History of the Great Lakes. U. S. Geol. Surv., Mon. 53, pp. 314-315.

SCOTT, I. D. 1921. Inland Lakes of Michigan. Douglas Lake. Mich. Geol. and Biol. Surv., Publ. 30, Geol. Ser. 25 (1920), 106-117.

WELCH, PAUL S. 1928. Limnological Investigations on Northern Michigan Lakes. I. Physical-chemical Studies on Douglas Lake. Pap. Mich. Acad. Sci., Arts, and Letters, 8 (1927): 421-451.

—— AND EGGLETON, FRANK E. 1932. Limnological Investigations on Northern Michigan Lakes. II. A Further Study of Depression Individuality in Douglas Lake. *Ibid*., 15 (1931): 491-508.

—— —— 1935. Additional Data on Submerged Depression Individuality in Douglas Lake, Michigan. *Ibid*., 29 (1934): 737-750.

WILSON, IRA T. 1936. A Study of Sedimentation of Winona Lake. Proc. Indiana Acad. Sci., 45 (1935): 295-304.

—— 1938. The Accumulated Sediment in Tippecanoe Lake and a Comparison with Winona Lake. *Ibid*., 47 (1937): 234-253.

—— 1941. A New Device for Sampling Lake Sediments. Journal of Sedimentary Petrology, 11 (1941): 73-79.

—— AND POTZGER, JOHN E. 1943. Pollen Study of Sediments from Douglas Lake, Cheboygan County, and Middle Fish Lake, Montmorency County, Michigan. Proc. Indiana Acad. Sci., 52 (1942): 87-92.

PHOTOGRAMMETRIC MAPPING AND THE WAR

TALBERT ABRAMS

IN AN interview with the press several years before the Munich incident a high German army officer made the following statement: "The nation that has the best maps will win the war." In view of this statement the odds against the Allies were terrific when the United States entered the war late in 1941. Only one fifth of the land area of the world had been mapped in sufficient detail to make the small-scale charts that the Army Air Forces required if we were to avoid the unnecessary loss of our military aircraft in their operations around the world.

Aerial photography or photographic aviation has grown by tremendous strides, owing to the impetus of war. This science has a history of some eighty years. In this short period of time it has expanded from an aviation hobby to a recognized science and is now officially credited with obtaining 90 per cent of our military intelligence.

The end uses of photographic aviation are the making of mosaic and topographic maps and photographic interpretation. In order to compile a good map the operator should first be able to read one. A map speaks a language, and through the efforts of national cartographic societies the language is fast becoming a universal language.

Map reading was one of the weak points in our army training previous to this war. Many mistakes in maneuvers and installation planning have been traced to the inability of junior officers to orient themselves correctly and to ascertain their position and destination on their maps To remedy this condition there were set up throughout the United States training centers or schools in terrestrial and aerial surveying, photographic interpretation, general mapping, and map reading. These schools were conducted by and for all branches of the armed services and were designed to give thorough training in cartography in a minimum of time.

Several of these schools were conducted by private organizations under contract with the armed services. These companies had been practicing aerial mapping for many years. Their experience qualified them as able and efficient instructors for the carefully chosen enlisted personnel the armed services detailed to these schools. This training was planned by the different staffs of the contracting companies in cooperation with ranking marine, military, and naval officers and was outlined to give a review of the fundamentals of mathematics up to and including spherical trigonometry, elements of topographic drafting and surveying, and the basic principles of photogrammetry.

The students in these special training courses consisted of a large group of commissioned officers and enlisted men. They were in attendance ten hours a day six days a week for a period of three months. Upon completion of their course they immediately joined the Pacific Fleet, where their work as mapping units won for them the praise of the Supreme Command in the Southwest Pacific and other theaters of operation. They were first at Guadalcanal, Tulagi, and adjacent islands when we started our invasions of Japanese-held territory.

The first group of students was followed by a second, and then a third. For each group the training became more severe and thorough. As the courses progressed, meetings were held by officers in charge and the instruction staff to suggest ideas and methods, and to stress plans and programs of major importance. The making of photogrammetric engineers for the immediate use of the Army, Navy, and Marine Corps was their main objective. Upon completion of these intensified training courses the members of the various classes were shifted to battle fronts around the world, where they have since played splendid parts in compiling invasion maps of enemy-held territory.

This teaching of a course in photogrammetry with a scope that covered the entire subject material from planning the photographic mission or flight to compilation of the finished map was an event unique in the history of the science. There were no precedents to serve as a guide, nor were there any standard types of photogrammetric instruments. Under the stress of war research work was instituted on newer and faster methods of utilizing aerial photographs by the Army Air Forces, Navy Bureau of Aeronautics, and the Corps of Engineers. By 1942 much of the research had crystallized with suggestions incorporated into a standard practice, but the need for this type of precision equipment had far outgrown the supply. Although photographic aviation has a historical background of eighty-one years, the first fifty years was a period of research in processes, cameras, lens, filters, and paper.

So far as is known, the earliest aerial photograph for military purposes was taken in 1861 by the Balloon Corps of the United States Army with the camera installed in a special-type kite. The airplane was first used as a medium for transporting the camera in 1909, when Wilbur Wright conducted experiments on the feasibility of using heavier-than-air craft for photographic work. The achievement was followed by many others, of course, but practical aerial photography dates from the early days of World War I, and even then its adoption as a regular military accessory met with much skepticism in high circles.

After being shown aerial photographs of enemy territory, the Allied Command became intensely interested, and vigorous efforts were started to acquire equipment and to formulate methods of procedure. No aerial cameras were available, so that hand-held ground cameras with glass plates were used, but research was instituted immediately on this type of instrument and soon special types were developed.

In the early years of aerial photography all cameras were operated manually from different parts of the plane. The

British held their cameras over the sides of the cockpit, while the French suspended theirs through holes in the floors of their planes. Photographic information of enemy territory had proved so valuable in a few months that in the Meuse-Argonne offensive some 60,000 prints were supplied the American forces in just a few days. No attempt was made at that time to utilize the pictures for anything but individual photographic interpretation, although in some cases overlapping photographs were mounted on a card and studied by means of the hand-held stereoscope that was standard parlor equipment at that time.

Despite this research on equipment and methods, it is generally known that Germany and Italy had accomplished far more along the same lines, but as history shows, other combatants were making great strides in the same direction. The introduction of aerial photography materially changed the conduct of the war so far as hiding troop movements and camouflaging installations were concerned.

The period following World War I and extending up to the beginning of the present conflict saw a slow, steady growth of the practical application of photogrammetry to peacetime pursuits, developments, and explorations. At the same time, because it was considered a definite part of any peacetime military program, the armed services continued their training schools, though on a reduced scale with a moderate research and testing program.

The value of stereoscopy and stereoscopic models for interpretation work had been realized for some time prior to 1925, but to obtain prints suitable for use with a stereoscope required the proper amount of overlap of the pictures along the line of flight. The problem of achieving this overlap taxed the camera man and often resulted in taking more pictures than were required or in making a reflight because of insufficient coverage.

Researchers began working on devices to control the interval between pictures automatically and developed what is known as the “intervalometer.” With the aid of a view finder, ground-speed indicators, or optical sights the interval required between pictures to give the proper overlap can be determined, and a proper setting of the intervalometer will control the automatic or mechanical operation of the camera, and thus regulate the distance between pictures or their running overlap.

Today's intervalometer (Pl. I, Fig. 1) has completely outgrown its initial crude design, capable of performing only one job, and is a precision instrument with many modes of control. The latest type which is being procured by the Army Air Forces can be used on four different kinds of timing operations. This instrument plays such an important part in helping to record the results of a reconnaissance or bombing mission that its operation is coordinated with that of the bombsight.

Better control of the interval between pictures naturally created a wider use of stereoscopic pairs of photographs, and hence a desire for a more practical and efficient stereoscope. The stereoscope itself has changed materially from the old hand-held instrument to the large mirror magnifying model, to the smaller binocular type, and then to the magnifying lens stereoscope with the adjustable interpupillary distance and folding legs. This CF-8 type (Pl. I, Fig. 2), which just fits the soldier's pocket, is found in all theaters of operation wherever photographic interpretation is carried on.

The application of aerial photography to peacetime operations created a desire for a composite map or for some method by which many adjacent photographs could be used together, either glued or stapled down to a flat surface. A method of procedure was devised whereby overlapping photographs could be superimposed one on another and matched detail to detail. Any print displacement of ground objects caused by tip or tilt of the plane made the matching of detail a difficult task for the area around the edges of the print. This area can easily be trimmed off the print by cutting completely around the picture with a razor blade, leaving only the center portion, where the scale is more accurate. The center is used in making the composite. The adhesives are gum arabic, mucilage, paste, or rubber cement.

Mosaics are typed according to the degree of accuracy of the finished product. The uncontrolled mosaic in which no means are available for orienting the prints with respect to one another and which is satisfactory where the relative location of detail only is required is the least accurate. The semicontrolled mosaic is made up from photographs upon which a small amount of measured control has been established. This type is somewhat more accurate than the uncontrolled. This measured control exerts its influence on accuracy of the mosaic by forcing the mapper to pay close attention to the expansion and contraction of the prints. The most accurate is the rigidly controlled mosaic, which is constructed on a network of points plotted on a base by means of their absolute coordinates.

Owing to their overall representation of the included area, mosaics have come to be used universally as map substitutes. In peacetime they give to the city and highway engineers, council chamber, real-estate development company, and mineral and petroleum prospectors a composite picture with detail delineated with 100 per cent accuracy. In military usage a mosaic presents to the intelligence officers a bird's-eye view not only of their own positions but also of those of the enemy. With directions and scale accurately shown, they can even be used for artillery purposes.

Photogrammetry could never attain the status of a mapping method unless it included some means of determining elevations or interpreting contours from the photographs themselves. The evident height as shown in the third dimension of the spatial model is only a quantitative one. From the science of physics it was known that there is an evident parallax or horizontal displacement of points in a photograph due to elevational differences. The problem was simply that of

devising a way to measure this horizontal displacement. By means of a contour-finding instrument (Pl. II, Fig. 1) it is now possible to make this measurement. The measuring unit of this equipment consists of several precision gages graduated in millimeters and two small pieces of plexiglass. These plexiglass parts have a very small red dot approximately at their center and are about two and one-half inches apart in a horizontal direction. By placing the instrument over a pair of prints having the proper amount of overlap existing between them it is possible stereoscopically to fuse these two dots at any predetermined elevation of the ground shown in the prints, and when the instrument is moved to another part of the print where the ground is of a different elevation, the two dots separate. The particular amount they must be moved to be fused again is a measure of the difference of elevation between the two settings of the instrument on the prints and is proportional to the altitude of the photographic plane, focal length of camera, and the distance between principal points of the photographs.

Thus the contour finder was developed, and it has proved a boon to the science of photogrammetry. We are now able to fly a mission and to produce a finished contour map. If the size of the project permits, we can interpret contour lines in one tenth the time required by field-surveying methods. The military soon adopted this instrument and used it to a great extent in mapping their more permanent bases and laying out improvements. Speed is the byword in all military movements, and this method of contouring satisfied the demands of the armed services.

It can readily be understood that aerial mapping and ground surveying are very closely interrelated. In order to tie an aerial survey accurately to its correct ground position, a few points whose absolute coordinates are known must be established on the ground in the area of the survey and be identifiable in the photographs. These ground points are located by surveying methods, and if they were to appear on each photograph their exact location in the field would require an enormous amount of precise surveying. The object of aerial mapping is to eliminate unnecessary field-control work. By making use of the old geometric principle that three lines must intersect to locate a point engineers are now able to space their ground control from fifteen to twenty prints apart. Construction of mechanical triangulator templates built up on carefully selected picture points (Pl. II, Fig. 2) makes it possible to extend the rigid control exerted on the flight by any one survey point over the intervening prints to the next survey point.

Of the inherent errors present in aerial photography, tip and tilt resulting from natural flying conditions present the greatest obstacle to accurate mapping. This has been partially overcome by the use of the automatic camera mount (Pl. III, Fig. 1), which is so actuated by a photoelectric cell as to correct instantly the position of the camera for any deviation of the plane from a straight and level flight. Distortion in detail caused by tip and tilt occasions much extra work when transferring planimetry from the prints to the map base sheet.

Let us consider for a minute the problem of adjustment when attempting to make a map to a scale 1 inch = 800 feet with prints ranging in scale from 1 inch = 790 feet to 1 inch = 810 feet. One might ask, “Why this difference in scale?” It is possible to compute the height necessary to fly to produce any desired print scale. Because of flying conditions and changes in elevation of the terrain, however, it is difficult to maintain this height. In mountainous country the plane would have to fly at many different heights to obtain the same scale for each print. It would be impossible to do this. The practical procedure is to fly at as uniform a height as possible and to secure an overall scale of prints as close to that desired as feasible, and then to use a vertical sketchmaster (Pl. III, Fig. 2) to correct for scale errors or variations in each print. The vertical sketchmaster is an instrument with adjustable legs, a front-surface reflecting mirror, and a half-silvered mirror and is used to transfer the print detail to the base sheet. Basically, it is similar to an epediascope and prints of a size nine inches square can be used in it. By means of the adjustable legs a print, when inserted in the vertical sketchmaster, can be so oriented as to correct for tip, tilt, and scale distortion and thus be put in the same position the negative was when the picture was taken. When the detail is projected down to the base sheet it is in the correct scale of the desired map (Pl. III, Fig. 2).

In the early part of 1941 conditions in the Pacific apparently were tranquil, but to some people this peacefulness forecast a coming storm. We should thank certain of our military personnel who were awake to conditions and saw the necessity of having available some permanent lines of communication with our outposts in Alaska and the Aleutians. As a result of such thinking the Alcan Highway project was developed.

It was realized that this project might require an immense amount of ground surveying and an even greater amount of vertical aerial photography. Speed was essential, and ordinary methods would not suffice. After much deliberation a procedure for mapping this territory from the air was worked out combining oblique aerial photography, which is the accepted practice in Canada, and vertical aerial photography, up to this time the standard method for aerial surveying in the United States. Since three cameras are used in accomplishing the photography the method is officially called the “trimetrogon system.”

The three cameras are synchronized, one being aimed vertically downward, the other two at a sixty-degree angle to the vertical at right angles to the line of flight. Three pictures are taken at one time, with resulting photographic coverage from horizon to horizon. This great coverage makes it possible to have the flight lines fifteen or twenty miles apart, instead of the customary one to three miles.

By skillful use of trimetrogon charting methods the United States was able in the time interval between spring and December 7, 1941, to photograph upwards of 500,000 square miles. The results of this survey speeded location work on the Alcan Highway, and a completely American method solved the problem of a continuous and uninterrupted line of communication with our outposts.

In the beginning trimetrogon was a charting system, but with the aid of research such scientific equipment as the rectoblique plotter (Pl. IV, Fig. 1) for making distances and directions on oblique prints compatible with those on the vertical, the oblique sketchmaster (Pl. IV, Fig. 2), which handles oblique prints as the vertical sketchmaster does the vertical prints, and the long-armed mechanical triangulators are fast changing it to a precision mapping system.

Briefly summarizing photogrammetric mapping and its war applications, we shall go back to the First International Congress of Photogrammetry, which was held in Rome, Italy, in 1938. It was the author's privilege to attend that congress as a representative of the American Society of Photogrammetry. Germany had moved into and occupied Czechoslovakia, and World War II was on its way. Instrument makers in Europe were developing and manufacturing many pieces of scientific equipment for photogrammetry, but all were ostensibly for making precision surveys in areas already well mapped. Our thinking in the United States was much different. We needed charts for aerial navigation and maps of large areas that were to be mapped for the first time. No charts were available for the new network of aerial routes the War and Navy departments were planning in order to extend the activity of their air arms to all possible battle fronts.

One of the first moves at the outbreak of this war was to organize the Map and Chart Division of the United States Army Air Forces, which absorbed the existing civil mapping agencies. The Lambert Conformal method of projecting the spherical surface of the earth to a plane surface was accepted as the basis for the new aeronautical charts.

Available camera equipment was consolidated into the trimetrogon system, and the four instruments, namely, the vertical sketchmaster, oblique sketchmaster, rectoblique plotter, and mechanical triangulator were selected as the general type of equipment to be used in the map compilation from the horizon to horizon pictures.

Ground surveyors trained in the use of astrolabe equipment proceeded into the wilds of unexplored countries to get the geodetic control necessary to chart the rapidly expanding routes that were being planned to cover the world. The entire program is now rapidly advancing, and the trend of the present conflict gives evidence that it was justified.

On the battle fronts pictures are being used by the million to map and study enemy-held territory before every advance. Stereoscopes, contour finders, and pictures are being issued to small military groups on many occasions, and photographic interpretation units have developed a science all their own as a part of military intelligence.

In the last war aerial photography was a by-product of an observation squadron, whereas in this war complete wings of the Army Air Forces are devoted to aerial photography in all its ramifications, and special squadrons for trimetrogon mapping reconnaissance, bomb recording, military intelligence, and training instruction are organized to expedite the war.

The future of aerial mapping is very promising. The entire world is still inadequately mapped for peacetime international planning. At present, only maps for military purposes are being stressed. Reconstruction periods, which follow every chaotic era such as this, will demand maps of all kinds. The huge development programs, boundary surveys, and the like will require maps of various degrees of accuracy. The world is now map-conscious, and we shall see huge mapping projects of entire nations and continents being carried out. By using ordinary ground surveying these projects would be improbable, if not impossible, whereas photographic aviation and photogrammetry can be used to accomplish them in a comparatively short time.

ABRAMS INSTRUMENT COMPANY
LANSING, MICHIGAN

EDITOR'S NOTE —The reader of this article will doubtless infer, rightly, that the author has been making an important contribution to the war effort. He invented several of the instruments shown in the plates and introduced refinements in others. He developed improved methods of using equipment already available. The company of which he is president has been supplying standardized photogrammetric instruments to our armed services, and telegrams from officers of the United States Fleet operating in the Pacific Ocean attest their value in the conduct of the war.

FIG. 1. The intervalometer, an automatic electric timer, with four modes of operation

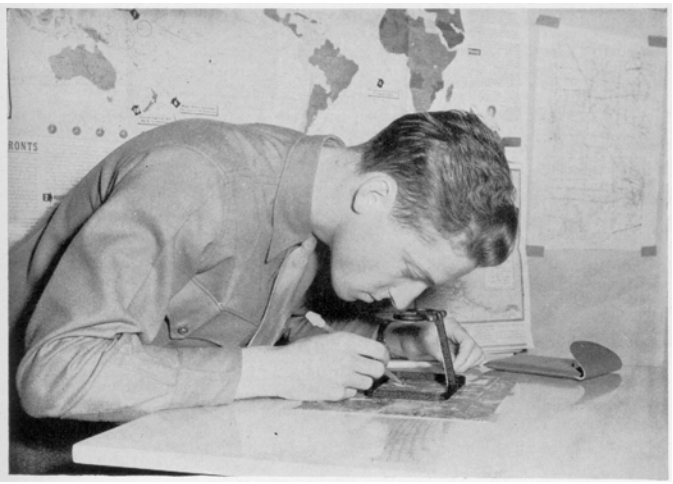


FIG. 2. A military student studying photographic interpretation with the stereoscope

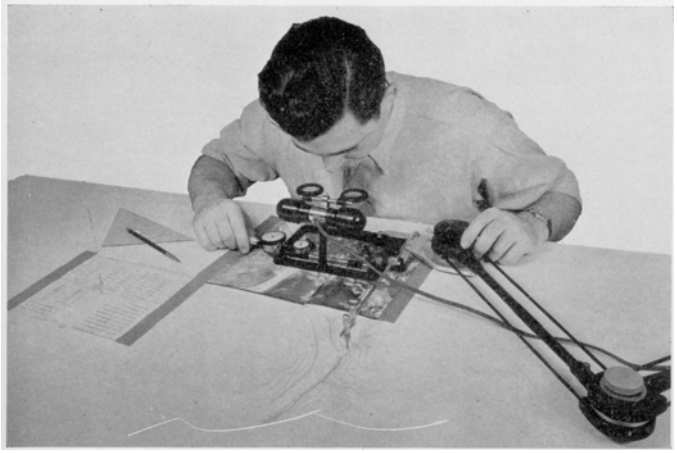


FIG. 1. An operator tracing contours with the contour finder

FIG. 2. Complete network of control built up with lazy-daisy mechanical triangulators

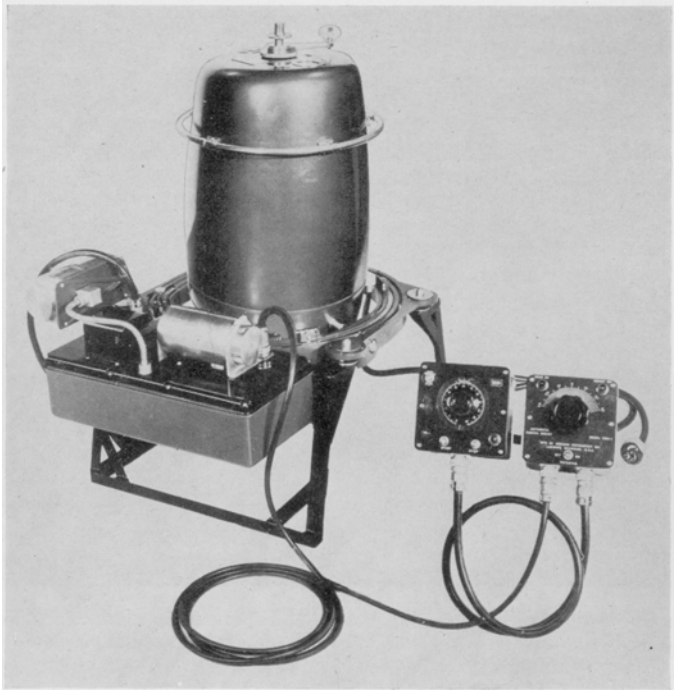


FIG. 1. Automatic camera mount

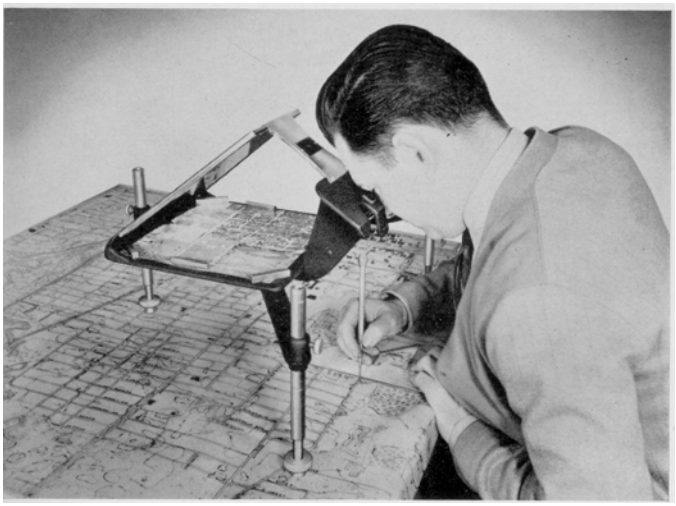


FIG. 2. An operator tracing planimetry from a vertical print with the vertical sketchmaster

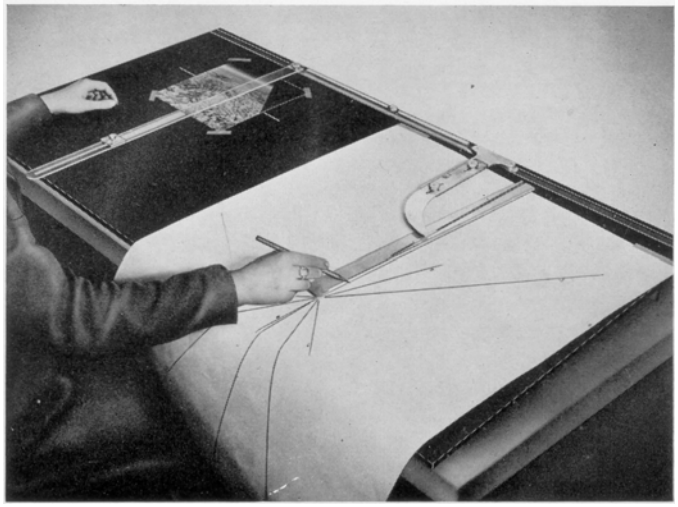


FIG. 1. Rectolique plotter board used to project distances and direction from trimetrogon oblique prints to the same plane as the accompanying vertical print

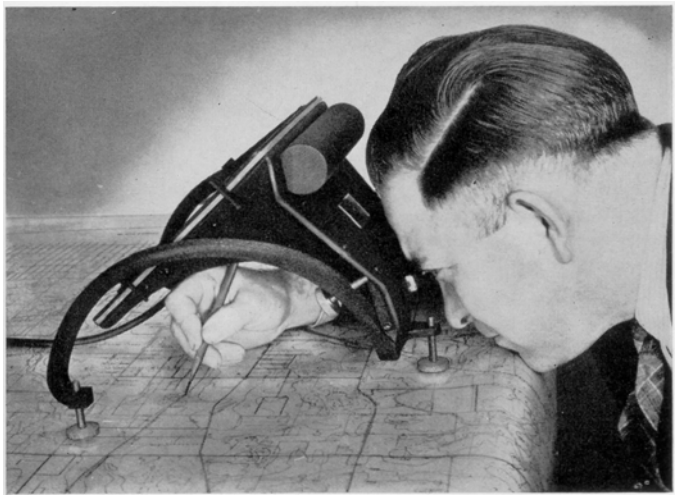


FIG. 1. Tracing planimetry from an oblique print on a base sheet with the oblique sketchmaster

THE ORIGIN OF THE GUMBOTILS OF THE UPPER MISSISSIPPI VALLEY

WILLIAM HERBERT HOBBS

STUDY of the periglacial area of the Greenland continental glacier has shown that, where this glacier is bordered by out-wash, the outward-blowing winds of the glacial anticyclone have lifted sand, silt, and clay of the glaciofluvial deposits and dropped them over an extramarginal area. This extramarginal area was not reached by floods on the plains, and in consequence a tundra flora could take root and retain the dust deposits. The coarser sand is usually separated from the silt (loess), but pebbles as much as an inch in diameter are sometimes carried into the loess deposits by saltation.[1]

These effects are brought about by the contrasted processes which obtain during the summer and winter seasons. In the summer the thaw water from the glacier front builds up the outwash plain of gravel, sand, silt, and clay, with many stranded boulders; while during the next winter, when the plain has dried up, it becomes a deflation area over which silt, sand, and small pebbles are lifted by the outward-blowing storm winds and leave behind a pebble pavement — an armored surface which protects the underlying layers from the wind. The stranded boulders are at this time drilled by the sandblast so as to leave harder layers in relief on those boulders which are of heterogeneous composition, and to produce faceted ventifacts out of boulders and pebbles of more uniform or finer-textured rock.

In each succeeding summer the stranded boulders are pushed about, rotated, and overturned by the floating ice blocks and the swirling currents about them. With each ensuing winter they therefore expose new faces to the sandblast, and so tend to assume an ellipsoidal form — they are never one-sided."

The loess is laid down only outside the range of the floods of the outwash, since these inhibit the growth of the tundra grasses. The loess deposit is thickest just outside the flooded area, and it thins out with distance from this border.

If the glacier front retreats, the flooded area draws in its margins, and the grasses encroach upon the plain and the loess deposits there. Thus a thin deposit of loess now begins to form over the plain itself, thinning out in the direction of the retiring glacier front (Fig. 1).

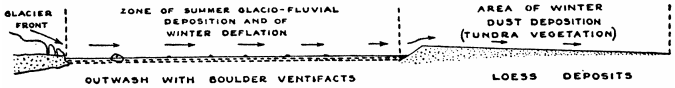


FIG. 1. Glacier front zone of deflation, loess deposits and, later, thin loess layer encroaching on the outwash as the glacier front retires (latest deposit not represented)

The conditions described above obtain wherever glaciofluvial deposits are laid down off the front of a continental glacier, though not *where the surface melting of the glacier remains above the bottom layers,* in which alone there is englacial rock debris. Wherever, therefore, glacier wastage goes on in the bottom layers, outwash deposition is to be looked for and, if found, deposits of loess are inevitable within the extramarginal zone to the outwash. Their age is that of the glacier itself, not that of an interglacial or postglacial period, as has heretofore quite generally been assumed for Pleistocene glaciations.

In a paper published by the American Philosophical Society[2] it has been shown that the surface loess of the upper Mississippi Valley, hitherto described as "Peorian" and "Iowan," is in reality the loess of the Wisconsin glaciation, to which it occupies an extra-marginal zone, resting for the most part on the pre-Wisconsin glacial formations. This aspect of the behavior of continental glaciers requires that similar but more weathered loess deposits should be looked for in each of the older glaciations — the Illinoian, Kansan, and Nebraskan.

The deposits, described as "gumbotils" by their distribution, by their composition, both mechanical and chemical, and by their contacts, correspond well with such weathered loess deposits. These are the so-called "Kansan Gumbotil" with the "Illinoian Gumbotil," and the so-called "Nebraskan Gumbotil" *when overlain by the Kansan drift*. On the assumption that the gumbotils are weathered loess, that which overlies Nebraskan drift may otherwise be correlated with the "Kansan Gumbotil," which would be of Illinoian age.

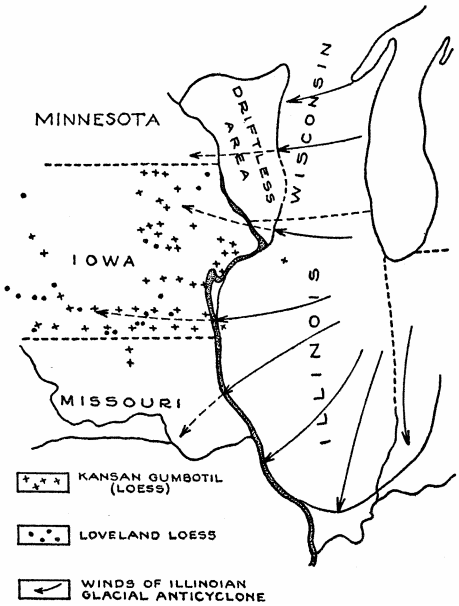


FIG. 2. Map showing the wind directions of the Illinoian glacier and over the post-Kansan gumbotil

Let us first consider the gumbotil of Iowa, which Kay and others have regarded as a weathered surface zone of the Kansan drift.[3] This gumbotil rests upon the pre-Illinoian (mainly Kansan) drift, and is within the periglacial zone of the Illinoian glacier but outside its narrow zone of outwash. The Illinoian Mississippi flood plain was at the time the zone of marginal drainage (Figs. 2-3).

In its physical composition the gumbotil in Iowa is a loess with small included pebbles, also containing concretions and characterized by parting. This gumbotil was regarded as loess by Bain,[4] who said: "It seems to be a deposit closely akin to the loess and is probably genetically related to it. Very likely it is but a phase of that deposit, though differing from it in its plasticity, color and density." Udden also held this view and wrote: "Probably it is mostly an old loess, which has been clogged up by interstitial deposition of fine ferruginous material through the agency of the ground water."[5] Except by Kay and his collaborators the gumbotils have generally been so regarded.

FIG. 3. Profile showing position of Illinoian loess

The following partial analyses show the close chemical relation of gumbotil to loess:

ANALYSES OF GUMBOTIL OF IOWA [6]

	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO
Foster, Monroe Co.	72.03	4.18	12.27	1.33	2.29
Murray, Clarke Co.	70.46	4.17	12.04	1.21	0.55
Warren, Carroll Co.	71.59	4.35	12.79	1.26	0.93
Fort Madison, Lee Co.	71.07	4.24	14.91	0.79	0.85

ANALYSES OF LOESS [7]

	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO
Cherokee, Kan.	69.66	4.89	12.71	1.09	1.28
Dubuque, Iowa	72.68	3.53	12.03	1.59	1.11
Kansas City, Mo.	74.46	3.25	12.26	1.69	1.12
Terre Haute, Ind.	72.87	6.75	11.25	0.69	1.06

The profiles of gumbotil which have been published nearly always display a sharp contact with the underlying Kansan or Nebraskan, not a gradation into it; and generally the Kansan beneath shows a surface-weathered zone that is quite distinct from the overlying gumbotil, which is remarkably uniform throughout (Fig. 4). In one or two places where a gradational lower contact to the gumbotil has been described, the published photograph reveals a sloping surface with many small gullies suggesting a slumping of the material. Moreover, in the interpretations made the winds of the glacial anticyclone have not been taken into consideration as supplying a possible cause of the deposit.

An older gumbotil which rests on Nebraskan *till and definitely underlies the Kansan till* has been found by Kay and Pearce[8] in southern Iowa, by Shipton[9] in northern Missouri, and by Lugn[10] in Nebraska.

The Loveland loess found farther to the west in Nebraska has been placed below with the "Kansan Gumbotil" by Lugn.[11] In their generalized section in Figure 4 Kay and Apfel have placed the Loveland above the gumbotil, but it occurs in the same horizon in separated localities.

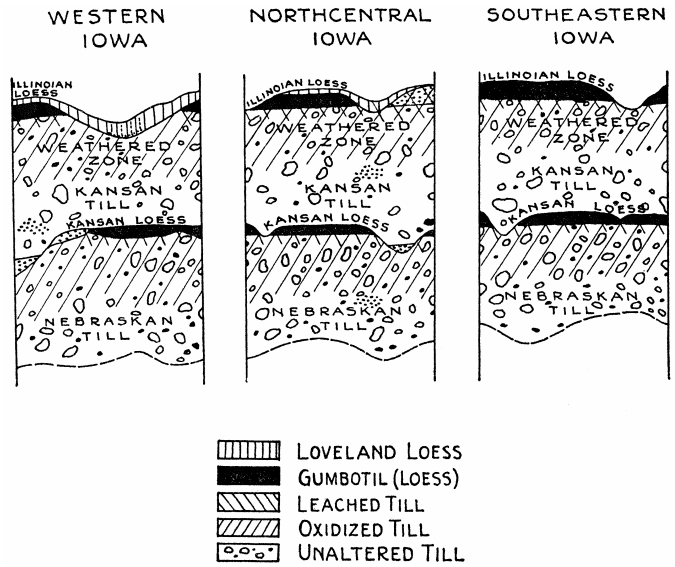


FIG. 4. Sections after Kay and Apfel, but with some names altered and upper portions omitted

A very thin layer of gumbotil has been found above the Illinoian loess in Lee County close to its border in southeastern Iowa, and also at other localities in Illinois, for example, at Galva in Henry County, some twent3f-nve miles inside the margin. These gumbotil deposits on the Illinoian have a thickness of a few feet only, whereas those near by on the Kansan are two to three or more times that thickness. It seems quite possible to explain these thin super-Illinoian deposits as having been formed when the glacier front was retiring, or, in part, after the planetary winds had invaded the waning anticyclone of the Illinoian from the west, and brought the dust which was raised by herds of bison, elephants, deer, and antelope that roamed the prairies of the Kansan. Such dust is elevated some tens of feet into the air and settles ever farther to the east. During the millenniums of the Illinoian-Wisconsin interglacial period such a thickness could be accounted for, and migration of loess in China along traffic lanes seems to warrant such an assumption.

UNIVERSITY OF MICHIGAN
(March, 1944)

[1] Hobbs, Wm. H., "Loess, Pebble Bands, and Boulders from Glacial Out-wash of ths Greenland Continental Glacier," *Journ. Geol.*, 39: 381-385. 1931. *Idem*, "The Origin of the Loess Associated with Continental Glaciation Based upon Studies in Greenland," *Compt. rend. Congrès internal, géog.* (Paris, 1931), II: 1-4. *Idem*, "Winds — the Dominant Transportation Agent within Extra-marginal Zones to Continental Glaciers," *Journ. Geol.*, 50: 556-559. 1942.

[2] Hobbs, Wm. H., "The Glacial Anticyclone and the Continental Glaciers of North America," *Proc. Am. Philosoph. Soc*, 86 (3): 368-402. 1943. *Idem*, "Wind and Soil," *Scientific Monthly*, 57: 289-300. 1943.

[3] Kay, George F., and Pearce, J. Newton, "The Origin of Gumbotil," *Journ. Geol.*, 28: 89-125. 1920. Kay, George F., and Apfel, Earl T., "The Pre- Illinoian Pleistocene Geology of Iowa," *Iowa Geol. Surv.*, 34: 1-304. 1928. Kay, George F., and Pearce, J. Newton, "The Pre-Illinoian Pleistocene Geology of Iowa," *Iowa Geol. Surv.,* Spec. Rep., 282 pp. 1944.

[4] Bain, H. F., "Geology of Decatur County," *Iowa Geol. Surv.*, 8: 292. 1897. *Idem*, "Geology of Keokuk County," *ibid.*, 4: 302. 1894.

[5] Udden, J. A., "Geology of Pottawattamie County," *Iowa Geol. Surv.*, 11: 258. 1900.

[6] Kay, George F., and Pearce, J. Newton, "The Origin of Gumbotil," *Journ. Geol.*, 28: 116-118. 1920.

[7] Leverett, Frank, "The Illinois Glacial Lobe," *U. S. Geol. Surv.*, Mon. 38: 164. 1899.

[8] Kay and Pearce, *op. cit.*, pp. 98-99.

[9] Shipton, Washburne D., "The Occurrence of Nebraskan Drift in Northern Missouri," *Wash. Univ. Stud.*, 12 (Science Series 1): 53-71. 1924.

[10] Lugn, A. L., "Nebraska in Relation to the Problems of Pleistocene Stratigraphy," *Am. Journ. Sci.*, 237: 855.

[11] Lugn, *op. cit.*, p. 84, fig. 3. *Idem*, "The Pleistocene History of Nebraska," *The Compass* of Sigma Gamma Epsilon, November, 1941, p. 22, fig. 2.

THE HOPEWELLIAN IN THE DETROIT-WINDSOR AREA

EMERSON F. GREENMAN

IN A former publication (3, 1939) I listed the sites of the Owasco aspect which were known for Michigan and Ontario at that time. Two more may be added, one at Clearville in Kent County, Ontario, where one of three components representing the second or intermediate occupation of the site allies it with the others in this list (7, p. 3, and pls. IV-XII), and another in Ash Township, Monroe County, Michigan. In 1940 the latter site was the scene of test excavations by Mr. Ralph Patton for the Museum of Anthropology of the University of Michigan, and the specimens brought forth, including crania with post-mortem perforations and disks cut from the occipital region (6), place the site in the Owasco aspect. This paper concerns only two of these eight sites, Rivière au Vase, near Mount Clemens, and Gibraltar, near the village of that name about fifty miles to the south at the mouth of the Detroit River. The pottery of both components of the Rivière au Vase site is described in another paper in the present volume (5).

At Rivière au Vase some three hundred burials in various degrees of fragmentation were excavated during the seasons of 1936 and 1937. Most of them were in a low elongated rise of ground at about the center of the site, an area which also contained a large number of refuse pits that had disturbed many of the burials. Toward the other end of the site at a distance of about a hundred feet, where the surface was level, there were five burials which appeared to represent a different occupation because of (1) their isolated position, (2) the fact that the skeletal material was in an advanced state of disintegration as compared with that of the other burials, and (3) the different character of the artifacts found with three of them. Two of the three, Numbers 2 and 5, consisted of adult skulls at depths of sixteen and nineteen inches in the light-gray sand of the site. Both skulls were brittle, white, and badly pitted and flaked, and large portions were missing as a result of disintegration. The other, Number 1, a torso of a young child, accompanied by the mandible and a humerus, lay at a depth of thirty inches. There was little left of the vertebrae besides cancellous tissue, but the surfaces, if present, were white and brittle, which was true of the humerus also. The two remaining burials, Numbers 3 and 4, were in refuse pits which apparently belonged to the Owasco component. Number 4, an adult skull at a depth of only six inches, was in the same condition of decay as Numbers 1, 2, and 5. The only artifacts were a pot and eight chips of gray flint. Number 3 consisted of the pelvis and articulated leg bones of an adult, flexed, with a few ribs, hand bones, a radius, and two lumbar vertebrae, at a depth of twenty inches. With this deposit of bones were a pot (Pl. I, Fig. 5) and six pieces of split bird-leg bones. There is some doubt whether these two burials belong to this group. They are included because of their proximity to the others and because of the Woodland type of vessel found with each one, though since they were in refuse pits the association is questionable in both cases.

The only diagnostic Hopewellian trait exhibited by this group of burials was a copper rod with bone handle, found with Number 1, but many of the other objects with this burial and with Numbers 2 and 5 are of types that occur also at Gibraltar, where the Hopewellian designation rests on better evidence. The other artifacts with Number 1 are as follows: one quartz crystal, abraded at one end, one quartz flake, one projectile point of gray flint, triangular-unnotched, one truncated blade of black flint (Pl. II, Fig. 17), one T-shaped flint drill, one rectangular slate knife (Pl. II, Fig. 16), one small spatulate point of slate, and thirty-four cylindrical copper beads 4 mm. to 12 mm. long. The copper rod (Pl. II, Fig. 8) is 9.4 cm. long and 2.5 mm. square in cross section. One end is blunt, the other pointed, and the bone piece into which the point was inserted when found is 9 mm. long. This is without doubt all that remains of a handle which was originally a centimeter or two longer. It is the same type of implement as two others from the Seip mound (11, pp. 393, 410, fig. 34), one of which is much larger. Another (Pl. II, Fig. 9) was found in a circular depression about twenty feet in diameter in Waterloo Township, Jackson County, Michigan, by Mr. William H. Buettner, of the Museum of Paleontology of the University of Michigan, in 1923. It was at a depth of four feet. The cross section is square, and the remains of the bone handle still adhere firmly to the base of the rod. This depression, which was about eighteen inches deep at the center and surrounded by a rim of earth not more than six inches high, is described by Mr. Buettner as being too symmetrical to have been the result of the excavation of a small mound at the center. Mr. Buettner also recovered a slate pendant (Pl. II, Fig. 14), a flint flake, and the vessel shown in Plate I, Figure 6, which has a notched lip and a design of diagonal incised lines in the neck area.

With Number 2 there were one pot, two pieces of two pendants of slate, each perforated, four projectile points of gray flint, six roughly oval to triangular blades of dark bluish-gray flint up to 4.5 cm. long (one is shown in Pl. II,

Fig. 10), twelve flakes and blocks of the same type of flint, one half of a small disk of brown stone about 3 cm. in diameter, a piece of deer-leg bone, and a piece of antler, both unworked. Number 5 was accompanied by one pot, one granite celt (Pl. I, Fig. 1), one T-shaped drill of gray flint, fourteen flakes and blocks of bluish-gray flint, one ovate reject of the same material, one flake of black flint, and the base of an un-notched blade of brown flint, thin and well made.

In 1937 the Gibraltar site was discovered by unknown individuals and excavated in an unsystematic manner. This work attracted the attention of members of the Detroit Aboriginal Research Club, which, during independent excavations, found the Hopewellian material. Later on week-end excavations were carried out by them under my direction. Though several burials were uncovered during this period there was nothing to indicate Hopewellian affiliations. Most of that material was associated with burials evidently at greater depths than those ascribed to the Owasco aspect, and there is no information to the effect that any of it came from the surface or was between the original placements and the surface. There are likewise no data indicating whether the graves containing this material were dug down from the present surface or whether their tops were covered by subsequent accumulations during the occupation which deposited the Owasco materials. As at Rivière au Vase, the great majority of burials were in a low rise of ground not more than six feet above the general level, but those of the Hopewellian component were also in this knoll.

In Plate II, Figures 3-4, is a platform pipe which was excavated from the lower level of the site by Mr. Jerry McKenzie, of Detroit. It is about 13 cm. long, and the material is probably steatite. The bowl is so thin as to be slightly translucent. In Plate II, Figures 1-2, is a much larger pipe of another type. It is an effigy of a flying bird, and the material is greenish-gray steatite. The length is about 20 cm. This pipe, found by Mr. Harry Hosack, of Detroit, was associated with a burial and the following objects: one end scraper of dark-blue flint, one roughly ground stone celt, one projectile point with oblique corner notches, one oval gorget-like piece of sheet copper nearly 10 cm. long with a small hole at the middle of one side, and three disks of bluish-black flint (Pl. II, Figs. 5-7).

In addition to these objects there are about one hundred and fifty in private hands or in the Museum collections as loans. Many are of types common to Hopewellian sites but are not diagnostic. Especially numerous are unnotched blades of dark-blue flint, ranging in length from 4 to 22.5 cm. and with bases straight or rounded. The bases of most of them are slightly constricted with reference to the widest portion. The largest of these (Pl. II, Fig. 18) is 22.5 cm. long and is one of five found with a burial by Mr. Norman Grogitsky, of Dearborn. The others are smaller, but all are thin and skillfully made. One blade of this same material is stemmed on one side only (Pl. II, Fig. 15). There were three unusually well made celts, two of black slate and a third of a closely textured dark-green material (Pl. I, Figs. 2-3; Pl. II, Fig. 12). One of the three (Pl. II, Fig. 12), which is about 20 cm. long, is flat on the side opposite that shown. The cross section of the shorter one is rectanguloid, and the two faces are slightly convex. Another specimen (Pl. I, Fig. 3) is oval in cross section, and the upper half is abraded and recessed on the sides as a hafting expedient.

A great many of the flint projectile points from the site are of the oblique corner-notched type (Pl. II, Fig. 11) common on Hopewellian sites in Ohio (11, fig. 48, lower row, the three at left). There are also several triangular-unnotched blades, most of them over 5 cm. long. One fragment of a stemmed blade of argillite, of a type found on the surface in Michigan and regarded as representing a very early occupation, is among the materials from Gibraltar, but its association is unknown. There are three T-shaped flint drills, one of them with side notches, several end scrapers of blue flint, and one “bunt.” Objects of copper are represented by beads, the oval gorget already described, and a copper rod with a bone handle. There are thirty-three copper beads, which are cylindrical and of the same size as those from the Rivière au Vase. The one copper rod with a bone handle, found by Robert Schneider, of Detroit, is 11.5 cm. long and 3 cm. square in cross section. The end set into the handle is pointed and penetrates it to a depth of 1 cm. The bone part is 1.5 cm. long and resembles that part of the similar specimen from Rivière au Vase (Pl. II, Fig. 8). Another copper rod, 3 cm. long and also square in cross section, is in the collection of Mr. Schneider. The copper gorget is 10 cm. long and has a small hole near the edge of one side. Several slate pendants came from the site, all with outlines similar to that of one from the Schneider collection (Pl. II, Fig. 13).

The pottery associated with the Hopewellian materials from the Gibraltar site is of the Woodland type like that from the corresponding component at Rivière au Vase. A typical one is shown in Plate I, Figure 4. Complete vessels range from 17 to 25 cm. in height and are so proportioned as to give a globular rather than an elongated appearance. This ware has moderately conical bases and wide mouths, and curved flaring rims predominate, though the straight rim, vertical or slanting outward, is present. On one vessel the rim is elevated to make four opposed points (Pl. I, Fig. 7), and on another, one of the few with a rounded base, the rim has one low scallop about 3 cm. long. The vessel is restored, and may originally have had more than one scallop. Surfaces are roughened by impression with cords or other implements, chiefly in blocks at various angles to one another. Decoration is incised or punctate, with the latter type dominant as linear patterns formed by impression at the end of a stick, with a cord-wrapped stick, or with the side of a stick in the lip. On two vessels there are cross-hatched bands of incised lines in the neck area, and on one of them the band is delimited by incised lines about 3 mm. wide. Another vessel has a crescent-shaped punctate pattern repeated on four sides

of the body. On the vessel in Plate I, Figure 6, which has a more elongated appearance than any from the two sites under discussion, an incised zigzag pattern is crossed by horizontal lines. The whole design is carelessly executed over the cord-roughened surface.

This type of pot is one of the most important links between the Hopewellian and other phases of the Woodland pattern. It is found in the larger Hopewell mound groups in Ohio (12, pp. 90-93) and was formerly described as of Algonkian utilitarian type to distinguish it from the more ornate Hopewell type of pot, which was regarded as an expression of ceremonial attitudes toward the remains of the dead (11, p. 436). This ware occurs at the Esch group (1; 4), and it is the same as that found in Hopewellian burial mounds in southwestern Michigan and northern Indiana (8, Pl. XVI, Figs. 7-8).

From this brief account of the finds at Rivière au Vase and Gibraltar it should be clear that the two sites have a Hopewellian component. At Rivière au Vase it was separated from the Owasco horizontally, whereas at Gibraltar the available evidence indicates that the separation was vertical. The only diagnostic Hopewellian trait in the Rivière au Vase component is the copper rod with bone handle, but objects of pure quartz and cylindrical copper beads are characteristic of that phase. The Hopewellian components at these two sites have the following traits in common: slate pendant, highly finished celt with rectangular cross section, flint projectile points with oblique corner notches, unnotched flint blade with flat restricted base, unnotched leaf-shaped flint blade, and the triangular-unnotched flint blade of the Woodland type; the T-shaped drill of gray flint, notched and unnotched, copper rod with bone handle, the cylindrical copper bead, and pottery of the same Woodland type, similar in size, shape, decorative techniques, and position of decoration. Three of these traits are represented in the material secured by Mr. Buettner from the site in Jackson County — the copper rod with bone handle, the slate pendant, and the Woodland type of pot.

The platform pipe from the Gibraltar site, which is of the plain type, is usually made of steatite and is found on Hopewellian sites marginal to the centers of more complex development such as that in southern Ohio. A pipe like this came from the smaller of the two Esch mounds near Huron, Ohio (1), where it was with a burial accompanied by other objects of types occurring at Gibraltar, namely, leaf-shaped blades of dark-blue flint, blades with straight bases (though not constricted), the Woodland type of triangular-unnotched flint blade with broad base, a slate pendant, and a small copper rod with bone handle and circular cross section.

A historical connection between the Gibraltar site and the Genesee mound in Livingstone County, New York (9, p. 32, fig. 2), is indicated by the finding in that mound of two pipes, one of the simple platform type like that from Gibraltar and the other of the zoomorphic effigy type, of green sandstone. These two pipes are miniatures. The platform pipe is only $1^{7}/_{16}$ inches in length and the other is 2⅞ inches in length. The latter is described as a platform pipe, but I believe it to be a miniature of the large zoomorphic effigy type of pipe like that found at Gibraltar and at the Seip mound (11, p. 422, fig. 43). In this connection it is of interest that one of the two mounds of the Esch group contained also a zoomorphic effigy pipe, the subject of which is an alligator, but the shape is not like that of the pipes from Gibraltar and the Seip mound, and the material is Ohio pipestone (Sciotoville flint clay). The pottery of the Geneseo mound (9, p. 34, fig. 3) is similar to that of the Hopewellian components at Gibraltar and Rivière au Vase.

It cannot be shown either at Gibraltar or at Rivière au Vase that there was a developmental connection between the Hopewellian component and that component which predominated on both sites, which, whether it is finally termed Owasco aspect or not, in any event has in it elements of both the Woodland pattern and the Iroquois aspect. Nevertheless, more than a mere areal association is suggested by the presence of the Hopewellian on two different sites of the same character. The Hopewellian, even though its relationship to other phases of the Woodland is little understood, contains elements which could have initiated and maintained a development in the direction of the Owasco as that is represented in Michigan and Ontario, and the occurrence of Hopewellian on a sufficiently ample scale at two Owasco sites is consistent with such an interpretation. It is important to recall in this connection that the postmortem perforation of crania and the removal of a circular disk from the occipital region (6; 2, pp. 35-42, 50, 54-55), two traits which are highly specific for the Owasco of the Detroit-Windsor area, are recorded for Mound 3, and Marriott Mound 1, of the Turner group (12, pp. 60-61, 124, pl. 27), and Mounds 7 and 25 of the Hopewell group (10, pp. 38, 93). Both traits occur also on at least two sites attributed to the Iroquois: the Lawson site in Middlesex County, Ontario (14, p. 36, pl. 13), and the Uren site in Norfolk County, Ontario (6, p. 9; 13).

UNIVERSITY OF MICHIGAN

LITERATURE CITED

1. GREENMAN, EMERSON F. The Esch Mounds, Huron County, Ohio. Ohio State Archaeol. and Hist. Quart. (*In preparation*.)

2. —— 1937. The Younge Site. Occas. Contrib. Mus. Anthropol. Univ. Mich., No. 6.

3. GREENMAN, EMERSON F. 1939. Cultural Relationships of Archaeological Sites in the Upper Great Lakes Region. Pap. Mich. Acad. Sci., Arts, and Letters, 24, Part 4 (1938): 1-10.

4. GRIFFIN, JAMES B. The Ceramic Complex at the Esch Mounds and Heimberger Village Site. Ohio State Archaeol. and Hist. Quart. (*In preparation*.)

5. HARPER, VICTORIA G. 1945. A Ceramic Study of the Rivière au Vase Site in Southeastern Michigan. Pap. Mich. Acad. Sci., Arts, and Letters, 30 (1944): 479-491.

6. HINSDALE, WILBERT B., AND GREENMAN, EMERSON F. 1936. Perforated Crania in Michigan. Occas. Contrib. Mus. Anthropol. Univ. Mich., No. 5.

7. JURY, WILFRED. 1941. Clearville Prehistoric Village Site in Orford Township, Kent County, Ontario. Bulletin of the Museums, University of Western Ontario, No. 2.

8. QUIMBY, GEORGE I. 1941. The Goodall Focus. Indiana Historical Society, Prehistory Research Series, Vol. II, No. 2.

9. RITCHIE, WILLIAM A. 1938. Certain Recently Explored New York Mounds and Their Probable Relation to the Hopewell Culture. Research Records of the Rochester Museum of Arts and Sciences, No. 4.

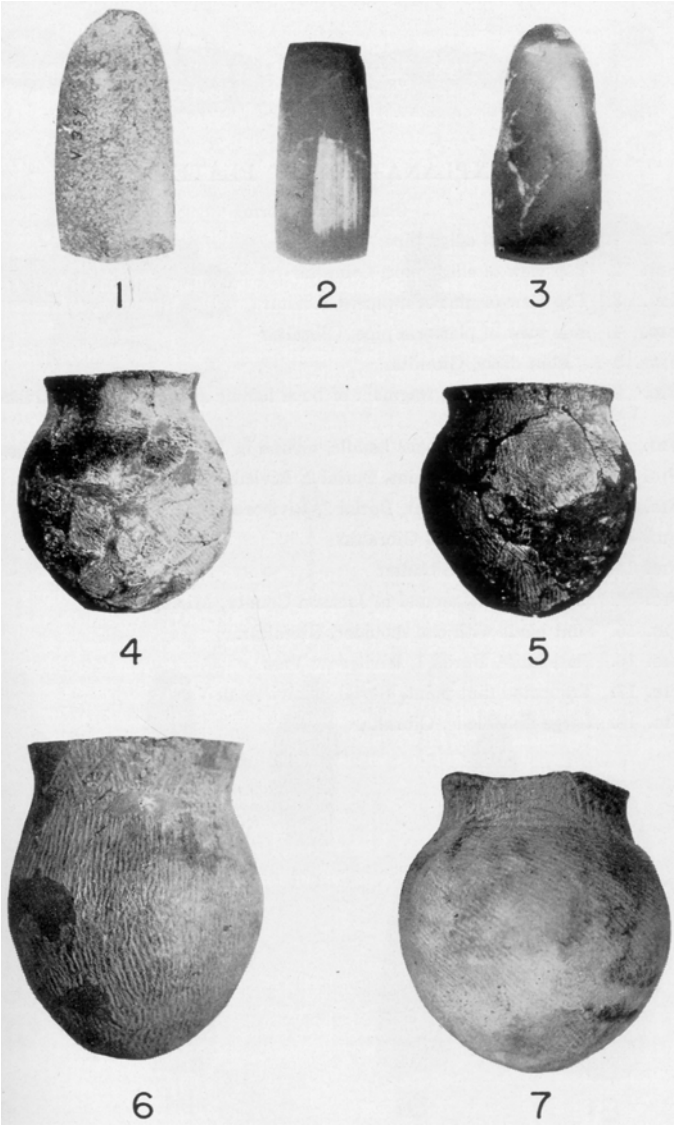
10. SHETRONE, HENRY CLYDE. 1926. Explorations of the Hopewell Group of Prehistoric Earthworks. Ohio State Archaeol. and Hist. Soc, Vol. 35.

11. —— AND GREENMAN, EMERSON F. 1931. Exploration of the Seip Group of Prehistoric Earthworks. *Ibid*., 40: 343-509.

12. WILLOUGHBY, CHARLES C, AND HOOTON, EARNEST A. 1922. The Turner Group of Earthworks, Hamilton County, Ohio. Pap. Peabody Mus. Am. Archaeol. and Ethnol., Harvard University, Vol. 8.

13. WINTEMBERG, WILLIAM J. 1928. Uren Prehistoric Village Site, Oxford County, Ontario. Canada Department of Mines, National Museum of Canada, Bulletin 51, Anthropological Series, No. 10. Ottawa.

14. —— Lawson Prehistoric Village Site, Middlesex County, Ontario. Canada Department of Mines and Resources, Mines and Geology Branch. National Museum of Canada, Bulletin No. 94, Anthropological Series, No. 25.

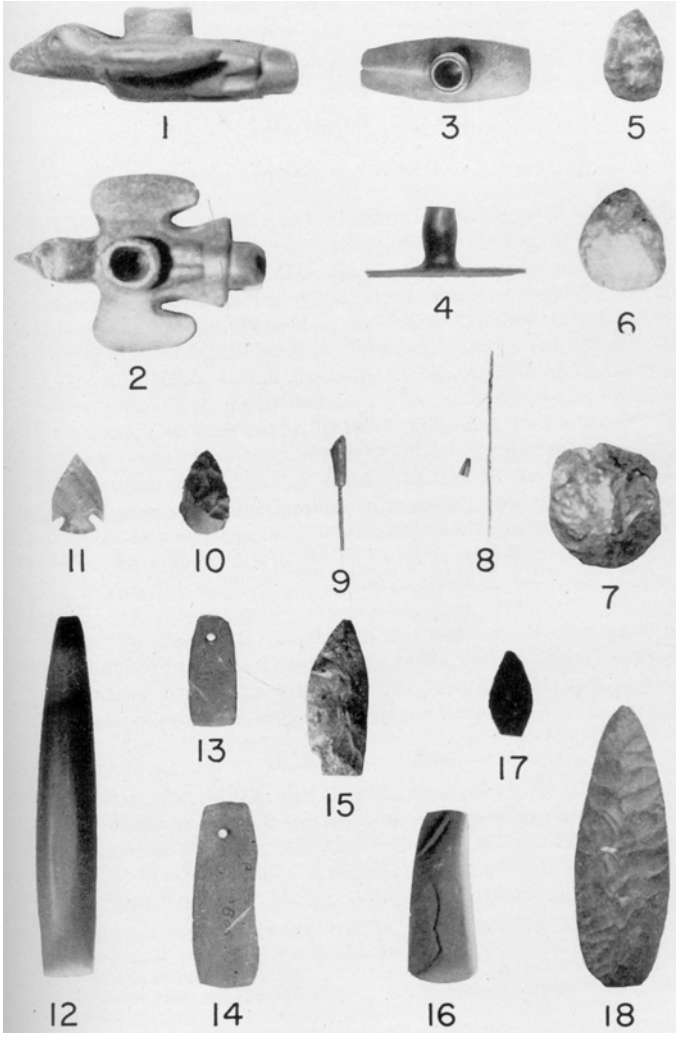


Celts and vessels from various sites

EXPLANATION OF PLATE I

(Scale not uniform)

FIG. 1. Granite celt, Rivière au Vase
FIG. 2. Slate celt, Gibraltar
FIG. 3. Celt of green stone, Gibraltar
FIG. 4. Vessel, Gibraltar
FIG. 5. Vessel from Burial 3, Rivière au Vase
FIG. 6. Vessel from mound in Jackson County, Michigan
FIG. 7. Vessel, Gibraltar



Pipes and instruments from various sites

EXPLANATION OF PLATE II

(Scale not uniform)

FIG. 1. Side view of effigy pipe, Gibraltar
FIG. 2. Top view of effigy pipe, Gibraltar
FIG. 3. Top view of platform pipe, Gibraltar
FIG. 4. Side view of platform pipe, Gibraltar
FIGS. 5-7. Flint disks, Gibraltar
FIG. 8. Copper rod, with fragment of bone handle at left, Burial 1, Rivière au Vase
FIG. 9. Copper rod with bone handle, mound in Jackson County, Michigan
FIG. 10. Leaf-shaped flint point, Burial 2, Rivière au Vase
FIG. 11. Flint projectile point, Burial 2, Rivière au Vase
FIG. 12. Slate celt or chisel, Gibraltar
FIG. 13. Slate pendant, Gibraltar
FIG. 14. Slate pendant, mound in Jackson County, Michigan
FIG. 15. Flint blade with one shoulder, Gibraltar.
FIG. 16. Slate knife, Burial 1, Rivière au Vase
FIG. 17. Truncated flint point, Burial 1, Rivière au Vase
FIG. 18. Large flint blade, Gibraltar

CERAMIC COLLECTIONS FROM TWO SOUTH CAROLINA SITES

JAMES B. GRIFFIN

FOR various reasons South Carolina archaeology has not been developed so fully or so systematically as that of her neighboring southern states. The large and impressive mounds and village sites of the later aboriginal periods which enticed field archaeologists into Georgia, Tennessee, and North Carolina do not appear to be common in South Carolina. Thomas described but one site, the McDowell mounds, in his discussion of the mounds of the eastern United States,[1] and mentioned only a few sites for South Carolina in his catalog of sites known to the Smithsonian Institution in the latter part of the nineteenth century.[2] Holmes' study of the pottery of the eastern United States called attention to the prevalence of stamped ware in South Carolina with some traces of cord-marked and fabric-impressed pottery from along the Atlantic Coast.[3] The most recent publications on South Carolina are about the Beaufort area and are the result of survey work carried on by W. K. Moorehead.[4]

The two sites to be discussed in this paper are located near the Piedmont border of the Coastal Plain in the valleys of the Congaree and Wateree rivers. They are the first sites from this area to have their pottery described in present-day terminology.

THOM'S CREEK SITE

In November, 1942, the Ceramic Repository for the Eastern United States received a shipment of pottery from Colonel Dache M. Reeves, of the Army Air Forces, from a site six miles south of Columbia, South Carolina. Colonel Reeves had been taken to the site by Dr. Chapman J. Milling, of Columbia, whose recent book on the history of the Indian groups of the Carolina area has been an outstanding contribution.[5] The site is on the south side of the Congaree between the river and the old state road running from Columbia to Charleston. It is about six miles south of Columbia and is on both sides of Thom's Creek, although the major occupation was apparently on the south bank of the creek on land held by Ernest Hall.

In his book Milling suggests that the site of the Congaree village in 1715, located 120 miles from Charleston, was at a place three miles below Columbia, near Granby, which is locally known as "The Congarees."[6] He now believes their location to have been on Thom's Creek, his revised opinion being based on the large number of trade-pipe fragments found on it. The Congaree tribal group was a small one and even in 1701, according to Lawson, was comprised of fewer than a dozen houses. In the Indian Census of 1715 the Congaree are credited with one village, and their total number, including the related Santee, is given as 125. Thus the small size of the group and their evident frequent movements would

not suggest any great depth of deposit from their occupation of a site.

TABLE I

POTTERY FROM THOM'S CREEK SITE

Type or dominant surface finish	Rim	Body	Total
Stallings Plain	1	..	1
Thom's Creek Punctate	7	12	19
Fabric-impressed	1	..	1
Cord-marked	..	2	2
Simple-stamped	..	2	2
Deptford Check Stamp	8	58	66
Plain-surfaced	2	17	19
Complicated-stamped (late period)	1	10	11
Total	20	101	121

All the pottery from the site can be said to belong to the early Woodland pottery tradition in the southeast, except for the complicated-stamped and some of the plain-surfaced specimens, which form a minority of the total recovered. The latter belong to the protohistoric and early historic period in the Georgia-Carolina area and were perhaps deposited at the same time as the large number of European white-clay pipe fragments and glass-bottle fragments found on the site.[7]

Stallings Plain. — One sherd, the only representative of its type, but in all probability further search and excavation will bring more specimens to light. It corresponds closely to the published description of this type,[8] but has a larger proportion of granular rock fragments in the paste than do the sherds from the Chester Field site. There is a biconical hole 1.5 cm. below the lip (Pl. I, Fig. 1E).

Thom's Creek Punctate. — A group of pottery fragments, probably the most interesting from the site. Their decoration is very close to that of Stallings Punctate and is probably derived from that type (Pl. I, Fig. 1A-D, F-L). Whereas Stallings Punctate sherds are fiber-tempered, these specimens either have very little tempering or are grit-tempered with a relatively small amount of crushed-rock particles resembling the material used in the Deptford Check Stamp type at this site. Another noticeable difference is that they average 5 to 7 mm. wide and are thus noticeably thinner than the usual fiber-tempered ware of the coastal area. Almost all the punctations are placed in horizontal rows paralleling the lip. Three out of the nineteen sherds have them in an arrangement which has been called "linear-punctate" (Pl. I, Fig. 1A). These, as well as the majority of the punctations, could best have been placed on the vessel when it was held by the left hand with the orifice to the right. Some of the rim sherds indicate a wide-mouthed bowl with almost vertical walls and flattened lips, whereas others indicate an incurving rim markedly restricting the orifice, and on these the lip is rounded, or narrowed and rounded. The color is usually light buff to light brown on both surfaces and in the cross sections. The hardness is 2-2.5. The pottery was coiled or built by annular rings, and both surfaces were smoothed before they were decorated.

Fabric-impressed. — A fragment belonging to the early fabric-impressed types of the southeast, already well described in the literature. This particular sherd apparently was locally made, as is indicated by the strong resemblance of its paste and tempering material to the dominant Deptford Check Stamp type. The warp impressions are horizontal to the lip on the outer rim; on the inner rim similar impressions are placed vertically (Pl. I, Fig. 1M). The lip is narrowed and rounded.

Cord-marked. — Body sherds also to be associated with the Deptford period at this site (Pl. I, Fig. 10).

Simple-stamped. — Two body sherds. One of them with this type of surfacing is connected with the Thom's Creek Punctate type on the basis of the width of the body wall and the relatively sparse tempering, whereas the other is thicker, has a considerable amount of crushed-rock temper, and in those respects resembles the Deptford pottery (Pl. I, Fig. 1P).

Deptford Check Stamp. — Specimens having, almost without exception, coiled-fracture surfaces on either their upper or lower margins. One fragment is a single coil width, 1.2 cm. in height (Pl. I, Fig. 2G). The majority of the sherds are of this type, which has been competently described by Caldwell and Waring.[9] The full description has not yet appeared in print, so that it is necessary to discuss these sherds in some detail.

The tempering material is fine to medium-coarse sand particles, rounded to subangular, and varying considerably in color. There is a high proportion of sand to clay. Some of the interior surfaces have the appearance and feel of sandstone. The texture is medium-fine to medium-coarse, and the hardness is 2-2.5. The exterior surface is almost always a reddish to yellowish buff and, in an unusually high percentage of the pieces, this color penetrates through the core to the inner surface. This suggests firing in an oxidizing atmosphere, but some specimens, otherwise exactly the same, were fired in a reducing atmosphere, as is indicated by their dark-brown to black cores. These latter sherds have only a thin layer of light-colored clay on the surface, which is sometimes eroded away, revealing the unoxidized interior.

The inner surfaces were smoothed, but only rarely were they worked sufficiently to bring the finer clay particles to the surface to form an even uniform film over the tempering particles. Consequently the temper protrudes with a resultant sandstone-like appearance. The exterior surface was given some preliminary working before the application of the check stamp, but it also was not carefully prepared for the stamping.

In the mimeographed description of the Deptford pottery types two divisions of Deptford Check Stamp are recognized. These are called "linear-check stamp" and "bold-check stamp." The original descriptions are adopted here with but little modification. The linear-stamped impressions could have been rouletted or rocked on the vessel wall with a carved wooden rocker or cylinder. This is indicated by the great length of the

individual impressions, by the warping of the design (Pl. I, Fig. 2K), and by overstamping (Pl. I, Fig. 2J). The impressions could also have been made by a single notched, narrow wooden or bone stamp. The design consists of a repeated parallel arrangement of two longitudinal lands,[10] which contain a series of finer transverse lands. The application of the stamp was often so carefully made that the entire series of longitudinal lands has the superficial appearance of having been executed by a single stamp. The longitudinal lands are invariably heavier and usually higher than the transverse lands. There is considerable variation in the width of the longitudinal lands themselves, which range from 2 to 6 mm. They may be either rounded, sloped, or flat. The stamp impressions were applied either obliquely (Pl. I, Fig. 2A, D, F, I, N), slanting from the lip downward to the right or parallel to the lip (Pl. I, Fig. 2B, C, H). The impressions were applied over the entire exterior surface.

There are a few sherds from the Thom's Creek site which indicate that a stamp was used producing three longitudinal rows of square depressions (Pl. I, Fig. 2E). Another sherd has the exact appearance of the dentate stamping on the fiber-tempered ware from northern Alabama,[11] and of dentate-stamped early Woodland pottery from the northern sections of the country (Pl. I, Fig. 2M).[12] One or two examples may have been paddled with a larger implement, such as was used by Holmes.[13] One of these sherds shows very small depressions (Pl. I, Fig. 2L).

The rim shape is straight, vertical, or slightly flaring. The lip is rounded and may also bear stamped impressions. There are no folded rims. The bases are rounded or conoidal on the majority of known specimens, but some basal fragments from this site suggest a conical tetrapodal support (Pl. I, Fig. 20). The thickness ranges from 5 mm. to 1.2 cm., with the majority of the sherds having a thickness of 7 to 9 mm.

Plain-surfaced. — One rim and two body sherds of a group, probably belonging to the type called "Thom's Creek Punctate" (Pl. I, Fig. 1Q). The others have a paste analogous to that of the complicated-stamped specimens to be described below.

Complicated-stamped. — Fragments belonging to the late ceramic period of the South Appalachian area, when there was a noticeable decline in the skill and effectiveness with which the vessel walls were stamped. The designs on the specimens are indistinct, but some are concentric diamonds and others are concentric circles (Pl. I, Fig. 1S-U). The single rim sherd has a horizontal row of incised squares 1 cm. below the lip (Pl. I, Fig. 1R). A single sherd is decorated with a curvilinear double row of small punctations bordered by a narrow shallow incised line (Pl. I, Fig. 1N). Its paste characters resemble Thom's Creek Punctate. The exact affiliations are unknown. A complicated-stamped sherd has paste characteristics like the Dept-ford Check Stamp and probably belongs to the early period at this site (Pl. I, Fig. 2P).

DISCUSSION

The majority of the pottery from the Thom's Creek site very clearly belongs to the Deptford complex, which can be considered an early Woodland manifestation in the southeast.[14] The closest related pottery is to the south and southeast of Columbia, in the Augusta and Savannah areas of Georgia. If any of the pottery from the site was made by the Congaree around 1715, it would be the complicated-stamped pottery. This site would evidently well repay excavation and should help to settle the question of the types of native pottery which were common at this late contact period. If the Congaree made predominantly complicated-stamped pottery during the early historic period, it would agree with the possible Sewee ceramic complex along the coast.[15] On the other hand, most of the complicated-stamped pottery of this period was apparently made by the eastern Muskhogean and Cherokee groups, with a less marked use among North Carolina Siouan tribes. Further field work in this area should supply a definite answer to the question of the type of pottery made by the South Carolina Siouan tribes.

CUT-OFF ISLAND

The pottery in the Ceramic Repository from Cut-Off Island was presented by Mr. E. Y. Guernsey, who collected it during the last world-war period. The material was gathered from the surface of the site. Mr. Guernsey says: "I have never seen more pottery at any location, and I presume even a casual 'dig' would have been most productive."[16] The site is on a small island in the Wateree River almost due east of Lugoff, Kershaw County, South Carolina. It is probably the area called "Friend's Neck" on the Hagood Quadrangle sheet of the United States Geological Survey. There is also the possibility that it is the "cut-off area" identified by Squier and Davis,[17] which is across the river from a fairly large group of mounds. The Wateree were living in this area around 1700,[18] but there is no indication of trade connections with Europeans in the collection made by Mr. Guernsey, although the pottery does not suggest any great antiquity.

TABLE II

POTTERY FROM CUT-OFF ISLAND

Surface finish or decoration	Rim	Body	Total
Check stamped	1	2	3
Punctate	..	1	1
Fabric-impressed	1	..	1
Straight-line stamped	4	21	25
Cord-marked	..	3	3
Complicated-stamped	..	1	1
Incised	2	..	2
Plain-surfaced grit-tempered	4	1	5
Plain-surfaced shell-tempered	..	1	1
Total	12	30	42

With the single exception of the plain-surfaced shell-tempered sherd all the pottery from this site is grit-tempered. Since the pottery types for this area have not been defined and since this collection is too small, the

pottery is described below in the discussion of the surface finish or decoration.

Check stamped. — Rectangular stamp impressions, applied by a true grid stamp of either clay or wood. The rim sherd is from a vertical-walled bowl (Pl. II, Fig. 1F). The lip is crudely flattened and is of uneven height around its circumference. The interior is roughly smoothed and bears finger impressions where the inner wall was held during the application of the stamp. The tempering is crushed rock, and the texture is medium. The color is smoke-blackened gray. One of the body sherds is of the same tempering material, a light-gray exterior and a dark unoxidized core (Pl. II, Fig. 1G). The second check-stamped body sherd has a sandy paste and a light-brown exterior (Pl. II, Fig. 1H).

Punctate. — A medium-coarse grit-tempered buff-colored sherd from the lower-rim area. There are three horizontal rows of left oblique deep, narrow rectangular punctates (Pl. II, Fig. 2H). I do not have any record of a similar type.

Fabric-impressed. — A sherd with medium-coarse abundant crushed-rock temper. It has a brown exterior and interior surface and a black core. It is related to the widespread fabric-impressed Woodland ware, which begins as one of the earliest types in the area but which also continues up to the historic period in the eastern Virginia-North Carolina area to the north. Unfortunately the impression of the positive is indistinct but indicates narrow-warp strands 3 mm. apart and irregularly spaced narrow-weft strands with an over-one-under-one plaited weave (Pl. II, Fig. 1L). The appearance of the sherd and the fabric are not duplicated in the collections in the Ceramic Repository. The lip is flattened and fabric-impressed. The vessel was a shallow basin much like the Middle Mississippi salt pan in shape. The body thickness is 7 mm.

Straight-line stamped. — The predominant surface finish. Some of the sherds so classified may have been malleated with a cord-wrapped paddle, but in such a manner that the cord impressions are not distinct.[19] The impressions range from a close approach to a simple stamped or brushed appearance to one which is a "straight-line stamping" to simple cord-marked (Pl. II, Fig. 1A-E).

All the sherds are grit-tempered, with some variation in the amount and type of tempering material. A few have a sandy appearance and feel. The majority contain granular particles which appear to be predominantly quartzite. The texture is medium-fine to medium-coarse. These sherds are gray to grayish buff. The core is almost entirely dark gray to black. Both surfaces are poorly smoothed, so that the tempering material is often quite distinct. The lip is rounded to slightly flattened. The rim shape indicates a vessel with a vertical rim and a rounded to slightly conoidal base. One sherd possesses a biconical hole 1.5 cm. below the lip such as was used in the crack-lacing method of preserving a cracked vessel (Pl. II, Fig. 1D). One rim has a short everted upper segment with a closely spaced row of punctations on the lip. This is the only example of rim embellishment such as becomes common on the rims of the Irene-Lamar period complicated-stamped jars (Pl. II, Fig. 2E).

Cord-marked. — Three body sherds that may actually belong in the same division as the straight-line stamped sherds, but the cord impressions are clearly seen on the surface. Two of the sherds have a very sandy feel and a light buff exterior, and are somewhat thicker than the sherds listed as straight-line stamped (Pl. II, Fig. 1J-K). The third body sherd had limestone temper, but the particles were leached (Pl. II, Fig. 1I).

Complicated-stamped. — A sandy-tempered sherd having a dark-reddish exterior with a curvilinear rather shallow stamp impression (Pl. II, Fig. 2G). The inner surface is well smoothed and smoke-blackened.

Incised. — Two very sparsely tempered thin (4-5 mm.) rim sherds with an incised design on the outer rim and with vertical lines intersected by horizontal lines (Pl. II, Fig. 2I-J). I do not know of any similar examples.

Plain-surfaced grit-tempered. — Specimens with crushed-rock temper of noticeably smaller size than the straight-line stamped sherds and a medium-fine texture. Three of these are bowl rims. The largest sherd has a small horizontal lug 2 cm. below the lip, with six small punctate impressions on its surface (Pl. II, Fig. 2A). A similar row of closely spaced punctates is placed on the lip surface, which is flattened and slopes inward. On the other two bowl rims there are punctate impressions on the surface at the lip level (Pl. II, Fig. 2B-C). These are larger and deeper and are spaced farther apart than those on the largest rims. Both exterior and interior surfaces of all three bowl rims are well smoothed. The fourth plain rim is from a wide-mouthed jar with an everted rounded lip which has a closely spaced row of small punctate impressions on the lip surface (Pl. II, Fig. 2F). It is of the same type of tempering material, texture, and smooth blackened interior of the complicated-stamped sherd.

Plain-surfaced shell-tempered. — A sherd having a small amount of shell temper, which was leached from both surfaces (Pl. II, Fig. 2D). The exterior and interior surface color is a reddish tan; the core is a light blue gray. This sherd has the appearance of the body sherds from the small log town-house sites in the Norris Basin.[20] It is an anomaly at the site.

DISCUSSION

It is difficult and perhaps even foolhardy to attempt an allocation of this ceramic complex to a chronological position, yet on the basis of the material at hand suggestions toward that end will be made. The absence of the pottery types of the early Woodland period of the southeast, such as those from a site in Barnwell County,[21] which are now in the Ceramic Repository, and the small number of sherds of the full-blown Irene-Lamar

complexes suggest that this site was occupied just before the period when the complicated-stamped was the most prominent method of surfacing the jars and bowls.

That such a late occupation had residence in this area is indicated by the pottery, illustrated in Schoolcraft, which was obtained near Columbia after a flood in the Congaree in 1852.[22] This material includes wide-mouthed jars with curvilinear and rectilinear complicated-stamped patterns and the check stamp as well. A specimen of a jar of this shape was 19 inches high and had an oral diameter of 14 inches. Another vessel was about 14 inches high, with a lip diameter of 13 inches. The bowls have a plain surface and a flat circular base with outslanting sides and an incurving rim. The lip is turned toward the interior and is sometimes plain and sometimes crimped or serrated. The measurements of one such vessel give a diameter of 16 inches and a height of 5¾ inches; the flat base has a diameter of 4 inches. Such pottery was in style during a period which is now estimated to have been approximately from 1550 to 1700. The pyramidal mound across the river from Cut-Off Island should be culturally connected with pottery types similar to those just described and to the bowls and complicated-stamped sherd from the Cut-Off Island site.[23] The illustration in Schoolcraft of a ceremonial axe which was obtained from near Camden also belongs to this same general aboriginal period.[24] Part of the ceramic complex from Porcher's Bluff near Charleston, South Carolina, is also corroborative of the presence of established populations in southern South Carolina from the coast to the mountain area during the late Middle Mississippi period.[25]

SUMMARY

Though the additional evidence of the prehistoric occupation of South Carolina presented in this paper is admittedly not extensive or conclusive, certain valuable statements can be proposed. The area south and west of the Wateree-Santee drainage has had a lengthy occupation beginning at least as early as the introduction of fiber-tempered pottery into the southeast. Following this, the early check-stamped types, as exemplified by the Thom's Creek site, show the influence of ideas continuing from the preceding period and also of concepts which are associated with the Woodland cultures to the west and north.

If the Cut-Off Island pottery complex of straight-line stamping, cord-marked, and check-stamped is found at other sites in the area, considerable support will be given to the hypothesis that such an association of ceramic elements is subsequent to the early Woodland sites. In the late aboriginal sites, dating roughly from 1500 to 1650, the complicated-stamped pottery becomes dominant and in the major sites is associated with the pyramidal mounds. This should be true of the McDowell site across the river from Cut-Off Island. The possibility is presented that both the Congaree and the Wateree were making complicated-stamped pottery as late as 1700-15, but this association, suggested by the remains from the Thom's Creek site, could hardly be regarded as demonstrated.

UNIVERSITY OF MICHIGAN

[1] Thomas, 1894, pp. 326-327. The mounds are evidently across the river from the Cut-Off Island site described in this paper.

[2] Thomas, 1891, pp. 194-196.

[3] Holmes, 1903, pp. 139, 147-148.

[4] Flannery, 1943; Griffin, 1943.

[5] Milling, 1940.

[6] *Ibid*., p. 213.

[7] Dr. Milling has kindly furnished considerable additional information and specimens.

[8] Griffin, 1943, pp. 159-160.

[9] Caldwell and Waring, 1939.

[10] "Land" is used here in sense 8 of *Webster's New International Dictionary*, Second Edition.

[11] Griffin, 1939, pp. 139-140, 158-160.

[12] Ritchie, 1940, Pl. XXX; Wilford, 1941, p. 241.

[13] Holmes, 1903, p. 78.

[14] Caldwell and McCann, 1941, pp. 50-51.

[15] Gregorie, 1925, Pl. VIII.

[16] Personal communication from E. Y. Guernsey.

[17] Squier and Davis, 1848, Pl.-XXXVII, No. 2.

[18] Mooney, 1894, p. 81.

[19] Griffin and Angell, 1935, Pl. II, Fig. 2.

[20] Griffin, 1938, pp. 289-293.

[21] Early Woodland material has also been reported from the Piedmont area. Fewkes, 1928, Fig. 187 A.

[22] Schoolcraft, 1852, Vol. II, Pl. 16.

[23] Thomas, 1894, pp. 326-327.

[24] Schoolcraft, 1857, Vol. VI, Pl. 44.

[25] Gregorie, 1925, Pl. VIII

LITERATURE CITED

1. CALDWELL, JOSEPH, AND MCCANN, CATHERINE. 1941. Irene Mound Site, Chatham County, Georgia. The University of Georgia Press.

2. —— AND WARING, TONO, JR. 1939. News Letter, Southeastern Archaeological Conference, I, 5 and 6. (*Mimeographed*.)

3. FEWKES, J. WALTER. 1928. The Archeology of the Piedmont Region of South Carolina. Explorations and Field-Work of the Smithsonian Institution in 1927, pp. 157-164.

4. FLANNERY, REGINA. 1943. Some Notes on a Few Sites in Beaufort County, South Carolina. Bur. Am. Ethnol., Bull. 133: 143-153.

5. GREGORIE, ANNE KING. 1925. Notes on Sewee Indians and Indian Remains. Contributions from the Charleston Museum No. 5.

6. GRIFFIN, JAMES B. 1938. The Ceramic Remains from Norris Basin, Tennessee. Bur. Am. Ethnol., Bull. 118: 253-359.

7. —— 1939. Report on the Ceramics of Wheeler Basin. *Ibid*., Bull. 122: 127-165.

8. —— 1943. An Analysis and Interpretation of the Ceramic Remains from Two Sites near Beaufort, South Carolina. *Ibid*., Bull. 133: 155-168.

9. —— AND ANGELL, CARLETON W. 1935. An Experimental Study of the Technique of Indian Pottery Making. Pap. Mich. Acad. Sci., Arts, and Letters, 20 (1934): 1-6.

10. HOLMES, WILLIAM H. 1903. Aboriginal Pottery of the Eastern United States. Bur. Am. Ethnol., Ann. Rep. 20.

11. MILLING, CHAPMAN J. 1940. Red Carolinians. The University of North Carolina Press, Chapel Hill.

12. MOONEY, JAMES. 1894. The Siouan Tribes of the East. Bur. Am. Ethnol., Bull. 22.

13. RITCHIE, WILLIAM A. 1940. Two Prehistoric Village Sites at Brewerton, New York. Research Records of the Rochester Municipal Museum, No. 5, Rochester.

14. SCHOOLCRAFT, HENRY R. 1851-57. Historical and Statistical Information Respecting the History, Condition, and Prospects of the Indian Tribes of the United States (6 vols.), Parts 1-6, Philadelphia.

15. SQUIER, EPHRAIM G., AND DAVIS, EDWIN. 1848. Ancient Monuments of the Mississippi Valley. Smithsonian Contributions to Knowledge, Vol. I.

16. THOMAS, CYRUS. 1891. Catalogue of Prehistoric Works East of the Rocky Mountains. Bur. Am. Ethnol, Bull. 12.

17. —— 1894. Report on the Mound Explorations of the Bureau of Ethnology. Bur. Am. Ethnol., Ann. Rep. 12.

18. WILFORD, LLOYD A. 1941. A Tentative Classification of the Prehistoric Cultures of Minnesota. Am. Antiq., 6 (3): 231-250.

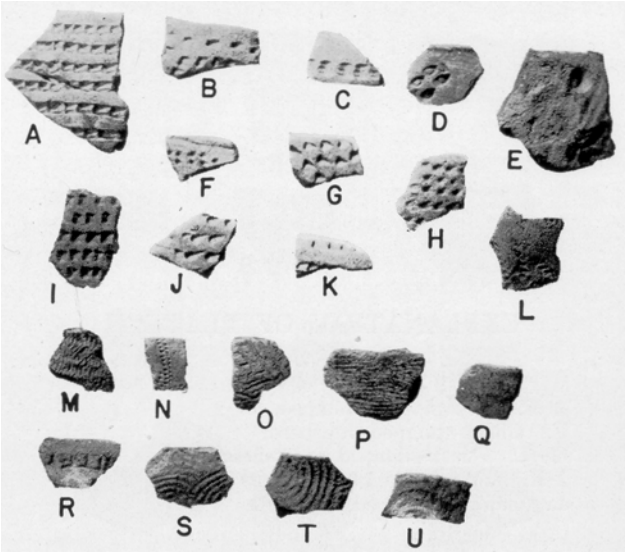


FIG. 1

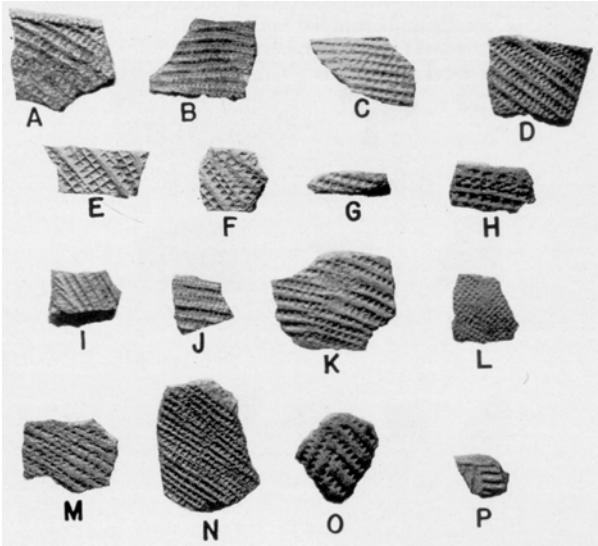


FIG. 2
Pottery fragments from the Thom's Creek site

EXPLANATION OF PLATE I

FIGURE 1

A-D, F-L. Thom's Creek Punctate
E. Stallings Plain
M. Fabric-impressed
N. Punctate
O. Cord-marked
P. Simple-stamped
Q. Plain rim
P. Beaded rim of late ceramic period
S-U. Complicated-stamped sherds of late ceramic period

FIGURE 2

A-D. Deptford Check Stamp rim sherds
E-K, N-O. Deptford Check Stamp body sherds
L. Check-stamp sherds with unusual small pattern
M. Deptford dentate-stamped sherd
P. Complicated-stamped sherd of Deptford period

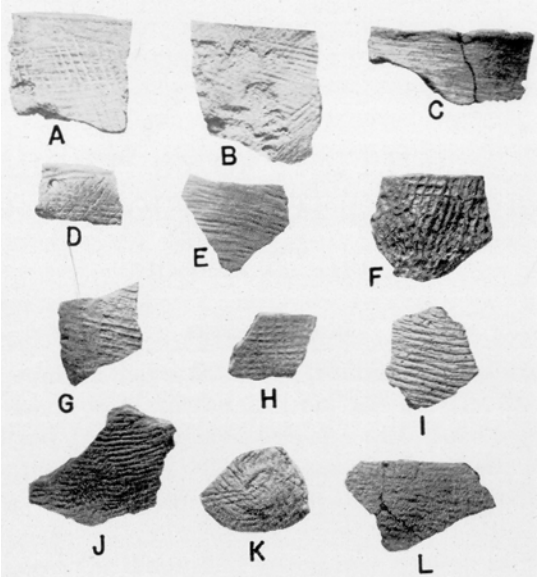


FIG. 1

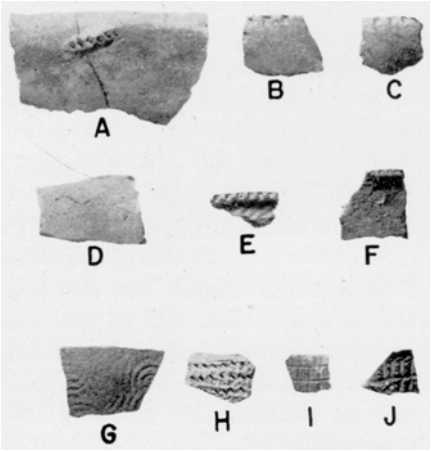


FIG. 2
Pottery fragments from the Cut-Off Island site

EXPLANATION OF PLATE II

FIGURE 1

A-E. Straight-line stamped
F. Check-stamped rim sherd
G-H. Check-stamped body sherds
I-K. Cord-marked body sherds
L. Fabric-impressed rim sherd

FIGURE 2

A-C. Plain bowl rims
D. Plain shell-tempered body sherd
E-F. Jar rims with punctations on the lip surface
G. Complicated-stamped body sherd
H. Horizontal rows of punctuations
I-J. Incised rim sherds

A CERAMIC STUDY OF THE RIVIÈRE AU VASE SITE IN SOUTHEASTERN MICHIGAN

VICTORIA G. HARPER

INTRODUCTION

IN THIS study I have done two things: first, I have made a ceramic analysis of materials from the Rivière au Vase site; and, secondly, I have compared this site with three near by on the basis of ceramic analysis. The others are the Wolf, Furton, and Younge sites. The problem of comparison is of considerable interest because of the diversity of classification of the four sites. Greenman (3, p. 35) places the Younge, Furton, and Rivière au Vase in one focus and assigns the Wolf site to an entirely different phase.

LOCATION OF THE SITE

The Rivière au Vase site is located in southeastern Michigan about three miles northeast of Mount Clemens and one-half mile inland from the shores of Lake St. Clair. It is near a small creek on a low, sandy ridge which runs parallel to the shores of the lake. Geologically the area is within the Port Huron morainic system of the Huron-Erie ice lobe, which dates from the last stage of Pleistocene glaciation. The ridge upon which the site is situated is probably an old beach of Lake St. Clair.

There were, and still are, ample resources here for the development of the ceramic art by the Indian, and an abundant supply of clay is to be found on the banks of a neighboring stream also; the whole region is fairly rich in a good-quality clay which is used commercially today (1, p. 314). In addition to clay, many kinds of tempering materials occur, including a red-burning sand and many kinds of rock, mainly granites and syenites, with some sandstone, quartzite, and flint, all of glacial origin. There was also ample wood in the area at the time of Indian occupation.

CERAMIC MATERIALS

The pottery obtained from the site, a crude, grit-tempered ware, is characteristic of the Woodland culture. Greenman (4, p. 461) has described one of the two components on the basis of style and decoration. The first component, the later one, belongs to the Owasco Aspect of the Northeastern Phase of Woodland culture. The range in style of shape and design is from pure Woodland to Iroquois with incised chevron designs and castellations along the vessel rims. The second, which is the earlier, is a Hopewell-like component, so classified on the basis of the stone and copper artifacts found at the site. The pottery is finer-textured, and the walls of the vessels are thinner, with characteristically Woodland shapes and decorative technique.

A total of 1,044 sherds from the collection of about 3,000 from the first component was examined under a binocular microscope in order to determine differences in tempering material. Fifteen sherds and seven pipestems representative of the ware from the first component were thin-sectioned for detailed petrographic study.

Materials from the site were tested so that comparisons could be made. The only clay near by was a dark, bluish-gray variety on the bank of the dredged Rivière au Vase. A sample of the ridge-forming sand, as well as numerous rock types, was obtained for experiment. I wished to see just how closely these materials would resemble the sherds already gathered. The following tests were made: materials (under the microscope), firing, water of plasticity, and linear-drying shrinkage.

MICROSCOPIC EXAMINATION

The clay from the site was subjected to various tests to determine its mineral composition. It proved to be rather calcareous, reacting readily when tested with hydrochloric acid. A bromoform heavy mineral separation yielded only hornblende, magnetite, and a few fragments of zircon. Examination of thin sections of clay pellets fired to 800° C. revealed the following minerals: quartz, orthoclase, and an acid plagioclase, probably albite. None, however, occurred in abundance, and all were under 0.073 mm. in size. A microscopic study of sand from the ridge revealed, aside from the main quartz constituent, microcline, orthoclase, and albite. The size of these minerals ranged from 0.073 to 0.292 mm. Hornblende and magnetite as large as 0.146 mm. were also found.

A study was made of a thin section of a clay pellet containing 25 per cent, by weight, of crushed rock temper, composed of rock obtained from the site. Many of the minerals already observed were present in large amounts as rock constituents. They included quartz, feldspar, mainly microcline, orthoclase, and an acid plagioclase; as well as biotite, hornblende, augite, and the alteration products sericite and kaolinite, which thickly covered the feldspars. A thin section of a pellet composed of clay and 20 per cent, by weight, of sand was also examined. The minerals already listed for the sand were noted, namely, quartz, microcline, orthoclase, and albite, together with hornblende and magnetite. The mineral particles were rounded for the most part and were within a maximum size of 0.292 mm.

My analysis of materials from the site gives a picture of the nature of the materials available for ceramic manufacture. The composition of clay and the variety of tempering material is known. With this information in mind we can now study the sherds and compare their composition with materials from the site. In this way it is possible to learn more exactly the provenience of the pottery — whether it was local or imported.

Of the 1,044 sherds of the first component examined for tempering material under a binocular microscope 998, or 95.6 per cent, showed a grit temper, rock particles made up of quartz, mica, and a feldspar; the remaining 46 sherds, or 4.4 per cent, revealed little or no temper. The tempering material consisted of sand and crushed rock, mainly sandstone and granite, with a little syenite. Quartz, orthoclase, acid plagioclase, sericite, kaolinite, biotite and muscovite, magnetite, and hornblende were found, quartz being the most abundant and hornblende very scarce. The range of size for the various minerals was from 0.073 to 2.2 mm. Quartz and the feldspars are the most important groups of minerals. Most of the feldspar occurs within the sherds as a rock constituent along with pieces of quartz and the micas, muscovite and biotite. Because of the occurrence of these types of feldspars we are able to identify the rock used as granites and syenites, for these members of the feldspar group occur only in these rocks. It will be remembered that granite was found in abundance at the site, and much of it was extremely weathered and very friable. In addition to the minerals noted above, blackish and reddish lumps of iron were observed frequently in all sherd slides. These indicate a rather ferruginous clay, poorly fired, as is shown by the black iron lumps, and a clay also poorly pulverized, as one might infer from the size of the lumps, which range from 1 to 1.5 mm. The clay itself exhibits a varied appearance under the petrographic microscope; most of it seems to be low-fired, with much carbon in the interior, whereas the outer edges are reddish and rather bright in polarized light. At higher firing temperatures the organic matter which gives the black appearance to the core would be oxidized to carbon monoxide and carbon dioxide, and thus be burnt out of the clay.

Study of the thin sections of sherds from the first component has shown that all the pots were made from the same clay and much the same tempering material. In a few slides there are isolated rounded quartz particles, which suggest a stream clay, but in others the quartz is not so obvious. This might indicate a small local variation in the clay deposit, particularly if it was obtained from the banks of the Rivière au Vase.

The much more finely made pottery from the second component, though it appears quite different in gross aspect from the first component, looks quite similar under the microscope. Tempering material is finer and sparser, however, but again the most abundant mineral is quartz, and the size range is microscopic to 1.46 mm., about half as large as that in the first component. The feldspars, with the exception of microcline, the micas, biotite and muscovite, hornblende, magnetite, sericite, and kaolinite, are the other minerals noted in these sherds. Except for a very friable well-fired orange-colored sherd, which, however, had a similar mineral content, this group seems very homogeneous. It is probably safe to say that the pottery from this component was made of the same sort of materials as the ware of the later component. The rock temper, though a little different, is still granite, and the clay has the same appearance under the microscope. The difference seems to be not in materials used, but in the techniques of manufacture and firing.

The pipestem thin sections prove to be quite similar to those of the foregoing description. Though not very thoroughly fired, the pipes are rather well made, for the temper is fine, being almost a part of the paste. Quartz is again the most prominent mineral, and a few particles as large as 1.46 mm. are found. Muscovite and biotite, an acid plagioclase, magnetite, flint, sericite, and rock fragments complete the list. The sizes range from microscopic to 0.87 mm. The outstanding mineral, aside from quartz, is biotite, which occurs frequently throughout the sampling.

We may now draw a few conclusions. Perhaps the first and most obvious thing is the fact that the tempering material is not only coarse, but, for the most part, unnecessary. The texture of the temper would make the clay much more difficult to work than it would be if it were not tempered, and the volume of temper is far too large to serve efficiently as an aplastic.

A comparison of the sample materials from the site with the sherds indicates that the pottery was probably made from local materials. The granite found at the site was extremely weathered and friable. This condition shows up in the thin sections of the sherds owing to the presence of a large amount of sericite and kaolinite. The granite, it might be noted, would have been very easy to handle since the potter would have had only to crumble it up to make it ready for use.

There is a slight possibility that much of the clay may have been sandy, which would account for the abundance of quartz, but not many of the sherds have a distinctly sandy feel. To judge from the size of most of the quartz particles, it would seem that the quartz had been added in the form of sand and as a rock constituent. The clay gathered from the site has very little sand in its composition, another reason for assuming the addition of sand.

The pipestems are fairly uniform in appearance, and some of the thin sections give the impression of being untempered, but others have a little coarser texture. The potter may not have bothered to levigate the clay, or it may be that fine sand was added.

PHYSICAL PROPERTIES

Hardness

The hardness of the Rivière au Vase pottery of both components is well within the range of the major portion of the eastern United States ceramic material. According to Moh's scale of hardness (see 5, pp. 17-22), it ranges from 2.5 to (or almost to) 3. Even the pipestems, which are more homogeneous than the sherds, showed the same range. In terms of this scale this means a fairly soft ware. The pottery at the Younge,[1] Wolf, and Furton sites (3, p. 13) has much the same range, from 2 to 3.

Surface Finish

There is little variation in surface finish, for smooth-surfaced pieces are very common. The coarse tempering material seldom mars the smooth finish of the sherds, although it does show through in many places. All sherds are perfectly smooth and plain on the interior. Those from the second component, with few exceptions, are cord-marked, with a smoothed interior.

Texture

According to Miss Shepard's classification of texture (7, pp. 409-411), this pottery is very coarse because of the addition of large quantities of grit temper, which ranges from 0.5 to 2 mm. The sherds from the second component fall into the coarse to very coarse classification, and the temper averages about 0.5 to 1.3 mm.

Color

The Rivière au Vase sherds have the characteristic Woodland pottery colors — smoky grays and browns, with occasional well-oxidized pieces in light buffs and cinnamons. Color in pottery is, of course, significant. Differences in color may be due to the variety of materials, to variations in technique of manufacture, or to circumstances such as handling with dirty or greasy hands. Variations due to firing will be discussed later.

In establishing color groupings Robert Ridgway's *Color Standards and Color Nomenclature* (6) was used. Four hundred and seventeen sherds from the first component were divided into three groups. Group I, 24.5 per cent of the total, represents the well-fired sherds in the buffs and cinnamons. Group II, the largest one, comprising 52.2 per cent, is within the brown and grayish-brown ranges and contains many of the sherds that are covered with secondary carbon. Group III, with 23.3 per cent, contains sherds of mouse grays and dark grays. Of 181 sherds of the second component the majority fell within the buffs and grayish buffs. A small group of less than a dozen was in the orange-cinnamon range.

The pipestems, also, were quite uniform in appearance, although two color groups could be distinguished: brownish gray and the lighter buff colors. The first group contains 29 of the 60 pipestems; the second group, 31.

Working Properties

When clays are prepared for firing many properties can be determined which are very useful for descriptive and comparative purposes. Two of those most easily determined are the water of plasticity and the linear-drying shrinkage observed in working the clay preparatory to the firing. The water of plasticity is the amount of water needed to render the clay workable, that is, easily molded, and it is expressed in percentage of the dry weight of the clay. The untempered clay from Rivière au Vase had a range of water of plasticity from

36.6 to 39.09 per cent, which indicates a rather plastic clay. Rock-tempered samples showed only 19.2, to 22.6 per cent of water of plasticity, whereas the clay tempered with sand exhibited little decrease in water of plasticity from that of the untempered clay.

Linear-drying shrinkage is the difference between the plastic length and the dry length of the clay. The shrinkage of the untempered clay was 6.6 per cent; that of the rock-tempered clay was only 2.1 per cent. This illustrates the role of the rock temper in this particular clay.

FIRING

A series of sample pellets made of clay from the site and a number of sherds from each component were fired in an electric kiln in order to learn the firing properties of both clay and sherds when fired under known conditions. With the information obtained we can compare the firing properties of clay with the sherds to discover the relationship between them.

Pellets of untempered clay, pellets with 25 per cent by weight of added rock temper, and a series of pellets with 20 per cent, by weight, of added sand were fired in the kiln. Eight sherds from the first component and four from the second component were also fired.

The pellets were heated at fifty-degree intervals from 400° to 800° C. and held at each temperature for ten minutes, until a temperature of 800° C. was reached. After being heated up to 400° C. and held for the ten-minute period, one each of the untempered and the tempered pellets was taken from the kiln. At each increase of fifty degrees another set of pellets was taken out, so that, when the whole run had been fired, a complete color series from the raw clay to 800° C. had been obtained. It is quite interesting to observe the gradual change from the raw clay of a gray color to the well-fired clay, which became a light pinkish cinnamon at 800° C. It is important to note that a decided change occurs at a comparatively low temperature. At 400° C. the color of the pellets is a smoky gray; at 450° C. it changes to the reddish buffs. The rock-tempered pellets seem to oxidize at a slightly lower temperature than the fine clay ones because they are more porous, and it is easier for the large quantity of organic matter in the clay to be burnt out owing to this porosity.

Eight sherds from the first component and four from the second and one of the pipestems were then fired, in accordance with the procedure of increasing the temperature by fifty-degree intervals until 800° C. was reached. All color changes, especially oxidation of the core of the sherds, were noticed, and such changes were compared carefully with the series of test pellets. The similarity in colors and color range was very striking, for the sherds from both components were almost the same as or very close to the pellets.

A color change in the sherds was noted around 450° C, when oxidation had barely started. It was clearer in some of the very coarse textured sherds of the first component than in the finer sherds, which did not show any appreciable change until 500° C. Color is a very important property of the clay, and if changes at known temperatures and time spans are observed, they are a clue to the original firing temperature used on the pottery by the Indians. Thus, from the foregoing firing tests, we are most interested in the range between 450° and 550° C. We have noticed changes at 450° C, and by 600° C. oxidation is complete. It can be said that 450° to 550° C. is a critical temperature range and that the Indian potter probably did not fire her pots much beyond this temperature, for an open wood fire cannot attain a much higher temperature. When the Indian fires her pots in an open fire in haphazard fashion, she has very little or no control over the atmosphere of her fire. The open fire cannot be spoken of as oxidizing or reducing because the atmosphere varies from the time of starting until maximum heat is reached, and again until the heat dies down. Within the fire itself some parts might be quite smoky and others might burn efficiently, producing an oxidizing atmosphere. It is small wonder that these pots are poorly fired and have a mottled color effect. It is interesting to note that the majority of pots which appear oxidized on the surface, both inside and out, have a black or gray core signifying that the fire was not hot enough and that the pots were not left in the fire for a sufficient length of time to oxidize them throughout.

CONCLUSIONS

From the analysis of the Rivière au Vase sherds the most outstanding thing is the uniformity of the pottery within each of the components, borne out both by microscopic and by firing tests. The coarse grit-tempered ware is a widespread complex throughout the eastern United States, and its traits are not peculiar to this site or to this region.

Microscopic and firing tests indicate that the Indians probably used the easily worked clay at the site. Both sand and crushed rock served as tempering material. The minerals observed in studies of sand and sherds were the same not only in composition, but in size range, which indicates that sand rather than sandy clay was used as an aplastic. Very few sherds wholly devoid of temper were found, and it may be that the Indian potter did not even understand the function of the rock in her pottery. The mere fact that the grit temper complex was so widespread over a large area of the country would suggest a strong cultural tradition which would be hard to break. Perhaps they employed it for a decorative effect rather than to make the clay more easily handled, for the use of this coarse rock temper did not simplify the potter's problems. On the contrary, it is very difficult to work with such coarse-textured material.

A few conclusions can be drawn from the firing tests also. The most important fact derived from these tests is the match of the color of pellets and sherds of both components at various temperatures. This probably indicates that the pottery from both components was

made from the same clay found at the site or in the neighboring area. The firing test also indicates that the pottery was probably not fired above 500° C., for this temperature compares with the maximum degree of oxidation on the surface of the pots. One might also deduce that there was no uniform method of placing the pots in the fire, although most of them were more oxidized on the exterior surface than on the interior, but, to judge from the colors of rim sherds, it seems that the greater number of pots were fired upside down.

The potter did not exhibit any great artistic skill in manufacturing her wares, especially when the products of this site are compared with those of other centers of culture. That she did not understand or else did not care about accurate firing is evident from the study of sherd colors.

One is immediately impressed with the difference in appearance between the ware of the second or Hopewell-like component and the pottery of the first component, which is correlated with the Owasco Aspect. Chronologically, the second component is the earlier, and the pottery found was far less abundant. It is typically Woodland, and is finer and thinner than the newer ware. Firing appears to be more uniform. It is hard to explain the superiority of this pottery. The art may have held a greater interest then, and more attention may have been lavished on it, even though the pots served a utilitarian function.

It is interesting to conjecture about the fabrication of the pipe-stems. They are very different in appearance from the pottery; little or no fine temper was used. Possibly the women, who are normally the potters in a primitive society where the use of the potter's wheel is not known, were not allowed to make the pipes. It may be that, because they were the property of the men, they were made by them. This would account for the difference in manufacture.

All the materials observed in the finished product dug up by the archaeologist occur in abundance at the site, and it is reasonable to suppose that the Indians used for the manufacture of all the wares the clay at or very close to the site. Similar materials were available throughout a considerable portion of this region, and it is probable that all villages were consequently independent of one another in the matter of pottery manufacture.

COMPARATIVE STUDY

A brief comparison will now be made of the Rivière au Vase pottery with that of three other southeastern Michigan sites. Technological detail will be omitted; only significant results will be pointed out.

The first of these sites is the Younge site near Imlay City, Michigan, about thirty-five miles north of Rivière au Vase. The other two are the Wolf site, three to four miles northeast of Rivière au Vase, and the Furton site, about a mile northeast of Rivière au Vase. The technological work on the pottery from the Younge site was done by Matson.[2] Temper sorting under a binocular microscope was carried out on 157 sherds from the Wolf site and,on 158 from the Furton. No raw clay was available for tests, but the thin-sectioned sherds, five from the Wolf site and four from the Furton, were retired.

The Younge site sherds of sandy clay are grit-tempered with rock fragments of granitic origin. The chief constituents of the tempering material are quartz, microcline and albite, biotite, hornblende, chert, and sericite.[3] These are the same as those found at Rivière au Vase, with the exception of the chert and a greater amount of quartz because of the sandy clay.

The chief constituents in the tempering material of the Furton and the Wolf sites are quartz, feldspars, including orthoclase and acid plagioclase, magnetite, biotite, hornblende, augite, sericite, and kaolinite. In the Furton material a considerable quantity of hornblende and augite occurs, and these minerals are easily visible without magnification. This sets the Furton pottery slightly apart from that of the other three sites. Hornblende and biotite are very prominent in the Wolf material. It is rather difficult to tell the Wolf and the Furton wares apart on the basis of material, but stylistically Greenman believes them to belong to two different archaeological phases, the Furton site being a Woodland site and the Wolf belonging to the Upper Mississippi Phase (3, p. 25). The tempering material as used in all four sites is similar; all of it is coarse and used in great abundance, some of it up to fifty per cent, by volume, of the paste.

There is not much variation in color of the fired wares from the four sites. The sherds from the Younge site range from gray shades through the orange series to pinks and reds.[4] Those from the Furton site are considerably darker, for some of the coloring is due to a secondary carbon deposit accumulated through use. The range is from a cinnamon drab through a light drab to the darkest sherds, which are almost black. In the Wolf sherds the dominant colors are the drabs, hair brown, and mouse grays, with an occasional black sherd. It will be remembered that the Rivière au Vase sherds ranged from light buffs and cinnamons to the grays and blacks. The redder colors of the Younge site are explained by Matson[5] as due to the presence of ferric oxide in the clay, but other than this, color is quite uniform. The majority of sherds from all sites have dark cores, which indicates a low firing temperature.

Firing tests carried out on the three sites show essentially the same results as those in the Rivière au Vase material. The sherds were heated in fifty-degree increments for ten minutes at each temperature until 800° C. was reached. In the Younge site material Matson observes the greatest changes occurring between 500° and 600° C.[6] The firing of the Wolf and the Furton sherds showed that oxidation had barely started at 400° C.; all but one of the sherds was completely oxidized at 600° C, and oxidation was complete at 650° C.

The color changes in the sherds from the four sites, when fired to 800° C, all came within the range of the cinnamon colors of Ridgway. This indicates that the clay in the whole general region is much the same, all of it being a fairly widespread lake deposit.

When these four sites are considered on the basis of ceramic tests, the most outstanding thing about each one is its uniformity of ware and the absence of intrusive sherds. It is hard to state positively on the basis of ceramic analysis that a site located within a glaciated area is an entity within itself, or that there has been no trade or communication of any sort in respect to pottery. This is necessarily true because of the variety and heterogeneity of material found in a region of this sort. From the study of temper and manufacture, however, one might conclude that all four sites are separate so far as pottery making is concerned. The use of available materials has varied a little, as we have pointed out in the dominance of hornblende, augite, and biotite at two of the sites and the occurrence of more acid rock at the other two. The condition of the rock employed as temper is another indication; the rock at Wolf and Furton is far more altered than the material at Rivière au Vase. The clay used at Younge, though similar in general character to that at the other three sites, is more sandy. This knowledge should be supplemented, of course, by an archaeological study of similarities and variations on the evidence of design and styles of decoration.

This study has attempted to give an objective description of the pottery from the Rivière au Vase site, and also to compare it briefly with three other sites upon which ceramic technological work has been carried out. Evidence of interchange of culture and ideas is not very strong, but undoubtedly this did occur to some extent. Naturally, the story of a whole culture cannot be built up on the evidence of the pottery alone, but, on the other hand, it must be remembered that the ceramic art is not just an entity in itself; it must be considered in relation to the culture as a whole. Ceramic technology helps to make clear this relationship, and it will prove of considerable aid to the archaeologist in the future.

UNIVERSITY OF MICHIGAN

[1] Matson, Frederick R., in Greenman (2, p. 102),

[2] See Greenman (2).

[3] *Ibid*., p. 100.

[4] Matson, in Greenman (2, p. 104).

[5] See Greenman (2, p. 105).

[6] *Ibid*., p. 118.

LITERATURE CITED

1. BROWN, G. G. 1924. Clays and Shales of Michigan and Their Uses. Mich. Geol. and Biol. Surv., Publ. 36, Geol. Ser. 30.

2. GREENMAN, EMERSON F. 1937. The Younge Site. Occas. Contrib. Mus. Anthropol. Univ. Mich., No. 6.

3. —— 1939. The Wolf and Furton Sites, Macomb County, Michigan. *Ibid*., No. 8.

4. —— 1945. The Hopewellian in the Detroit-Windsor Area. Pap. Mich. Acad. Sci., Arts, and Letters, 30 (1944): 457-464.

5. MARCH, BENJAMIN. 1928. Standards of Pottery Description. Occas. Contrib. Mus. Anthropol. Univ. Mich., No. 3.

6. RIDGWAY, ROBERT. 1912. Color Standards and Color Nomenclature. Washington, D.C.

7. SHEPARD, ANNA O. 1936. The Technology of Pecos Pottery. Part II in The Pottery of Pecos, Vol. II, by Alfred V. Kidder and Anna O. Shepard. Papers of the Phillips Academy Southwest Expedition, No. 7. New Haven, Connecticut.

RESTORATION OF FLAKES ON A QUARTZITE IMPLEMENT

MARION L. HREBEK

IN 1942, during excavations at Killarney, Ontario, under the direction of Dr. E. F. Greenman, of the University of Michigan, a large ovate blade was collected from a workshop site known as GL-1, on a former beach of Lake Huron 297 feet above its present level (4). Many of the implements and flakes, all of quartzite, are much worn on the faces and edges, a circumstance attributed to water action and indicating that they were made when the waters of Lake Huron were at the former level and when the edge of the Wisconsin glacier was within a hundred miles to the north.

The great majority of the specimens on this site are of white quartzite, but the blade under discussion (Pl. I, Figs. 1-4) is a pale green, and the presence of flakes of the same color in the immediate vicinity of the blade suggested that the original block of quartzite might easily be restored. A total of twenty-seven flakes was found, some in 1942, in the five-foot square occupied by the blade, and others in 1940, at a distance of twenty feet from the original location. In 1940 one section yielded over half of the flakes used, and most of them were picked up on the surface. All but four fit together to form the restored block.[1]

The blade (Figs. 1-2) is 18.4 cm. long, 8.3 cm. wide, and 5.5 cm. thick at the middle. It is not water-worn and shows no secondary flaking. There is a distinct natural cleavage line running the entire length, and from one face through to the other, and it may have been because of the likelihood of breaking that the blade was never finished. This cleavage line was evident also in the flakes and was a distinct aid in judging their positions in the restoration. The thickest portion of the blade is not in the center in relation to the width, but slightly to one side; in relation to the length the thickest part is in the middle. The base, which is rounded, shows a peculiar characteristic, a flat platform that slants from the edge toward the other end at about a 45-degree angle to the long axis of the blade (Fig. 3). In the laboratory this type of platform was obtained unintentionally when the base

was held nearest the body most of the time during experimental flaking of a piece of unworked quartzite collected from the neighborhood. Several other implements with thick bases from this site have the same feature.

This blade was flaked out of a larger mass of quartzite by the use of two different techniques, each of which left a distinctive type of flake scar on each face: those made by step flaking and those made by free flaking (1). The former are distinguishable in Figures 1 and 2 as dark lines running generally parallel to the long axis of the blade; the latter, which are larger, are outlined by ridges running transversely. In Figure 1 the scars caused by step flaking are on the right half of the blade, whereas those caused by free flaking are on the left half. In Figure 2, which shows the face opposite to that in Figure 1, the condition is the same. Thus the diagonally opposite half faces are alike with respect to the type of flaking. The right edge in Figure 1 has a battered appearance and is much less irregular and ragged than the opposite edge.

The flakes range in length from 4 to 9 cm.; in width, from 2.5 to 5.1 cm. None shows any sign of water action. The smallest are on the outer surface of the restored block, where they are more properly described as splinters, since there are more than two faces, and bulbs are absent. Exposure of the surface of the block to weathering, the greater force of the preliminary blows as indicated by the larger size of the percussion scars on the surface, and the coarse, loose texture of quartzite, all taken together, account for this condition. As compared to flint, quartzite has less tensile strength and the "landmarks" due to fracture are not so pronounced. Platforms are often difficult to identify since quartzite tends to break up under direct percussion and thus leaves only part of a weakly developed bulb. In the laboratory blows directed toward one spot on a block of quartzite will often detach splinters before the desired flake is removed (3).

Entire inner faces of the largest flakes do not make contact with the surface of the blade, and in the limited areas where contact is made it is always at or close to the median ridge, which is the thickest portion of the blade. Only three flakes fit completely into scars of the blade, and only one of these extends to the edge of the blade, but it is the side of the flake that does so, since the portion bearing the platform is absent. Another of these flakes extends beyond the edge of the blade and beyond the scar into which it fits. This would contradict the conclusion, to be discussed later, that the half face on which it fits was worked before the directly opposite half face on the other side of the blade, if it were not for the fact that the upper surface of this flake is part of the outer weathered surface of the original block of quartzite. It was among the first to be struck off, and the blow must have landed at a point at least 2 cm. above the present edge and, consequently, was not recorded on that edge.

Since not all the flakes were found, the restored block is not complete, but there are two faces, and possibly a third, of the original outer surface, at right angles to one another. The largest surface of the original block is that in Figure 3, and the other face terminates at the left edge in the same view. That these are original surfaces is indicated by discoloration due to staining and weathering. The third possible face lies at the upper edge in this view, where there is a flat area 1.3 cm. long at a right angle to the other faces, and bearing percussion scars. The minimum dimensions of this original block as shown by the restoration are as follows: length, 19 cm.; width, 12 cm.; thickness, 6 cm. The cleavage line previously mentioned is visible on the face in Figure 3. There are no percussion scars on this face, but they are very evident on the side and upper surfaces.

What is probably another original surface, but not at a right angle to any other one, is shown in the upper left-hand corner of the view in Figure 4. It is a corrugated surface identical with that which is common in the quartzite hills surrounding the site. It slopes off to the point of the blade at an angle of 40 degrees to the median plane, and the corrugations extend onto the tip of the blade itself. The tip is, therefore, over part of its surface, formed by the surface of the original block. As one looks down on the restoration from the top, that is, the point end of the blade, the blade is seen to lie in such a manner with reference to the restored block that the transverse axis becomes the hypotenuse of a triangle formed by it and the two sides that meet at a right angle. In other words, the blade is in a diagonal position with reference to the block from which it was made.

The point of chief interest concerning this blade is the alternation of step flaking and free flaking. Other implements from the site exhibit this same feature. In order to obtain a step flake the blow must be struck vertically into the edge of the blade. In free flaking the blow is struck on the edge, but away from the mass of the material. If one bears this in mind and assumes that the worker was right-handed, it would seem that, after removing the preliminary flakes from the block, he held the implement in the left hand, with the point away from the body. As indicated by flake scars on the blade and by percussion scars on the flakes, the worker, beginning at the stage just previous to that represented in Figure 1, struck the right edge away from the mass of the material, that is, as if vertically down at a right angle to the plane of the face shown, and obtaining the free-flake scars that are on the half face terminating in the same edge on the opposite side of the blade (the left half face in Figure 2). The implement was then turned one quarter of the way around, right to left, and blows were delivered on and directly into the edge toward the mass of the material,[2] and thus the step-flake scars on the right half face in Figure 1 were obtained. Then the blade was turned half way to the left and struck again on the edge into the mass of the material, causing the step-flake scars on the right half face in Figure 2. Turning the blade finally to the right one quarter of the way, he struck away from the mass of the material, getting the free flake scars on the

left half face of Figure 1. An alternative to this process would be to start on the right edge in Figure 2 and reverse the sequence. From the evidence of the flakes it cannot be said with which edge the worker started, but from the blade it can be seen which was worked last. By observing the outlines of the two edges it may be noted that one is more ragged than the other. The edge that is more even reveals the greater amount of battering; on the other this is less pronounced. In the laboratory step flaking has the effect of making the edge more even, whereas free flaking invariably leaves it ragged. This is illustrated in the difference between the two edges of the blade as shown in Figures 1 and 2. The little prominences on the right edge of Figure 2 would not have survived direct blows with a hammerstone into the edge in the same plane as the transverse axis of the illustrated blade. It was, therefore, the right edge of Figure 2 which was worked last, by hitting directly away from the mass of the material and thus forming the free-flake scars on the left half face of Figure 1. This is further correlated by the flakes which, by their positions, do show which had to be removed first.

The reduction of the original block of quartzite probably did not begin with the process of alternate free and step flaking just described, but the last stages of the work were accomplished in that manner. By this method, owing to rotation of the object from right to left, the direction of the blow and the motion of the forearm did not need to be changed. The motion of the forearm was vertically up and down, the easiest motion to use and the one by which blows can be directed with greatest accuracy and speed. The combination of this turning from right to left, or left to right, and the vertically directed blow, produced the alternate character of the four half faces of the blade.

UNIVERSITY OF MICHIGAN

[1] Two other restorations of this type have to do with specimens from an Acheulean deposit at Caddington, England. See Macalister (5) and MacCurdy (6).

[2] This method of flaking is described by Ellis (2), who terms it "percussion, direct rest edgewise on anvil." The specimen discussed in the present paper was held in the hand as it was worked, at least in the final stages, since otherwise the irregularities of the one edge (the left edge in Figure 1) would have been obliterated. Ellis states that the method of direct-edge percussion is usable "to greatest advantage in thinning down and roughing artifacts out from the raw material." He makes no mention of the step-flake scars produced by this method.

LITERATURE CITED

1. BURKITT, MILES C. 1933. The Old Stone Age, pp. 41-42. Cambridge, England.

2. ELLIS, H. HOLMES. 1940. Flint-Working Techniques of the American Indians; an Experimental Study. The Ohio State Archaeological and Historical Society, pp. 22-25, figs. VII-VIII.

3. GREENMAN, EMERSON F. The Flint Blade as a Flake Implement. (Report in preparation.)

4 —— AND STANLEY, GEORGE M. 1942. The Archaeology and Geology of Two Early Sites near Killarney, Ontario. Pap. Mich. Acad. Sci., Arts, and Letters, 28 (1943): 505-530.

5. MACALISTER, R. A. S. 1921. A Textbook of European Archaeology, 1: 266-269, fig. 64. Cambridge, England.

6. MACCURDY, GEORGE GRANT. 1926. Human Origins, 1: 122, fig. 52. New York.

FIG. 1

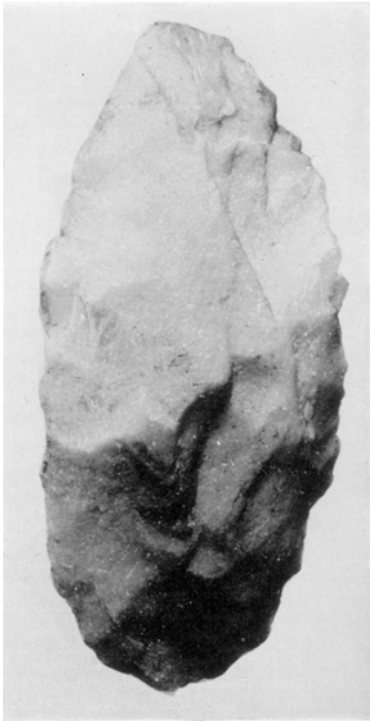


FIG. 2

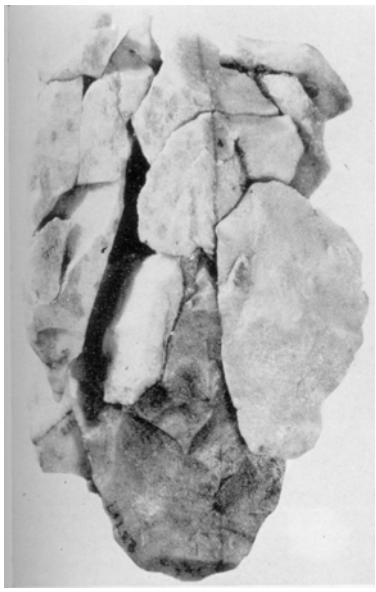


FIG. 3

FIG. 4

Restoration of flakes on a quartzite blade

EXPLANATION OF PLATE I

FIG. 1. Quartzite blade, showing step flakes on the right half face and free flakes on the left half face. The scars caused by free flaking are larger than those made by step flaking

FIG. 2. Reverse of the face shown in Figure 1, with step- and free-flake scars occupying the same positions with respect to the right and left sides

FIG. 3. Flakes restored on the blade as they were in the original block of quartzite. The mottled appearance in the upper left quarter of the picture is due to weathering on the surface of the original block, of which this is the largest face in the restoration

FIG. 4. Reverse side of Figure 3. The darker portions of the two flakes in the upper left are a weathered, corrugated surface, which also extends onto the tip of the blade itself, and is found on the semicircular flake adjacent to the right. In this view the flakes are fitted to a plaster cast of the blade