EXPLANATION OF PLATE VI

FIGS. 1-2. *Tilia americana* L. Bracts. X 1

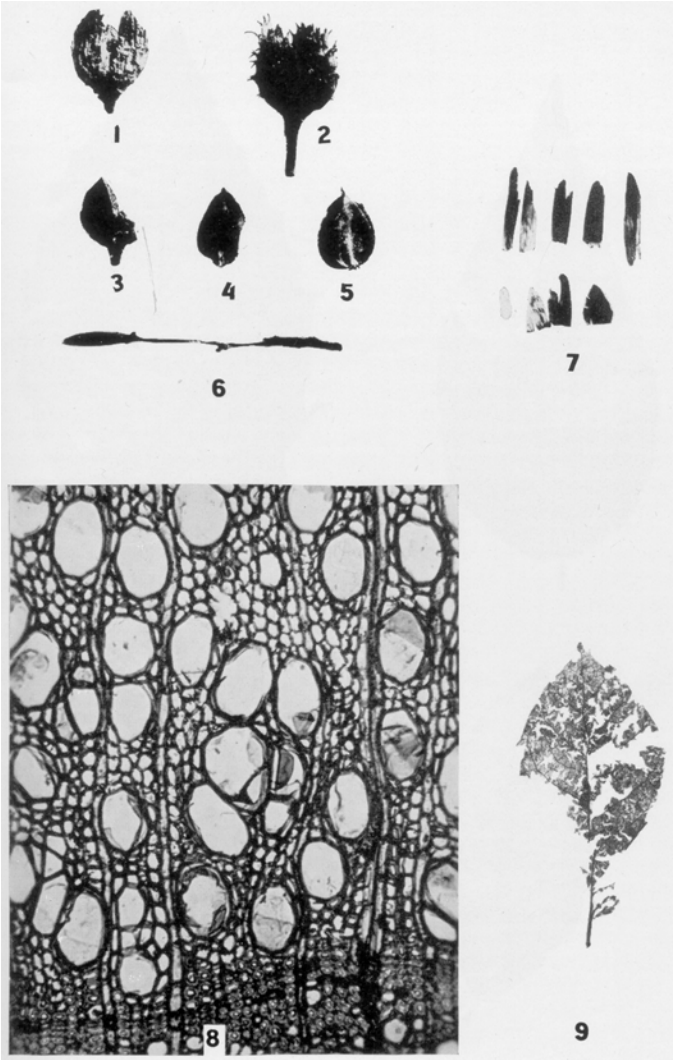
FIG. 3. *Tilia americana* L. Fruit. X 1

FIGS. 4-5. *Tilia americana* L. Fragments of leaves. X 1

FIG. 6. *Carpinus caroliniana* Walt. Leaf. X 1

FIG. 7. *Carpinus caroliniana* Walt. Seed. X 1

FIGS. 8-9. *Carpinus caroliniana* Walt. Bracts. X 1



EXPLANATION OF PLATE VII

FIGS. 1-2. *Fagus grandifolia* Ehrhardt. Fruits. X 1

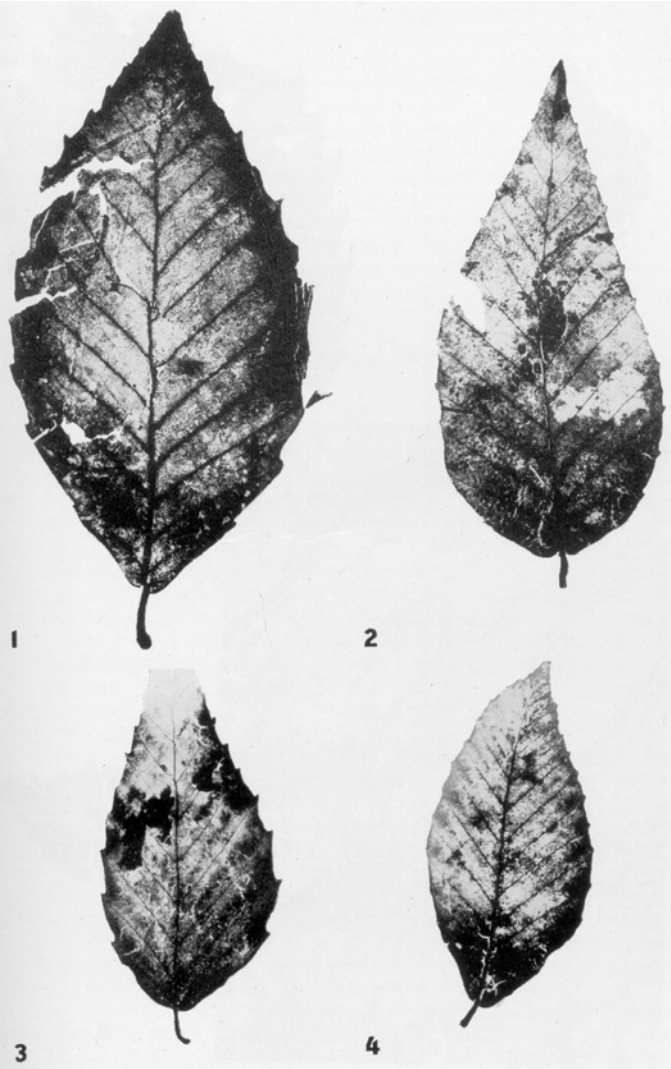
FIGS. 3-5. *Fagus grandifolia* Ehrhardt. Seeds. X 1

FIG. 6. *Fagus grandifolia* Ehrhardt. Twig. X 1

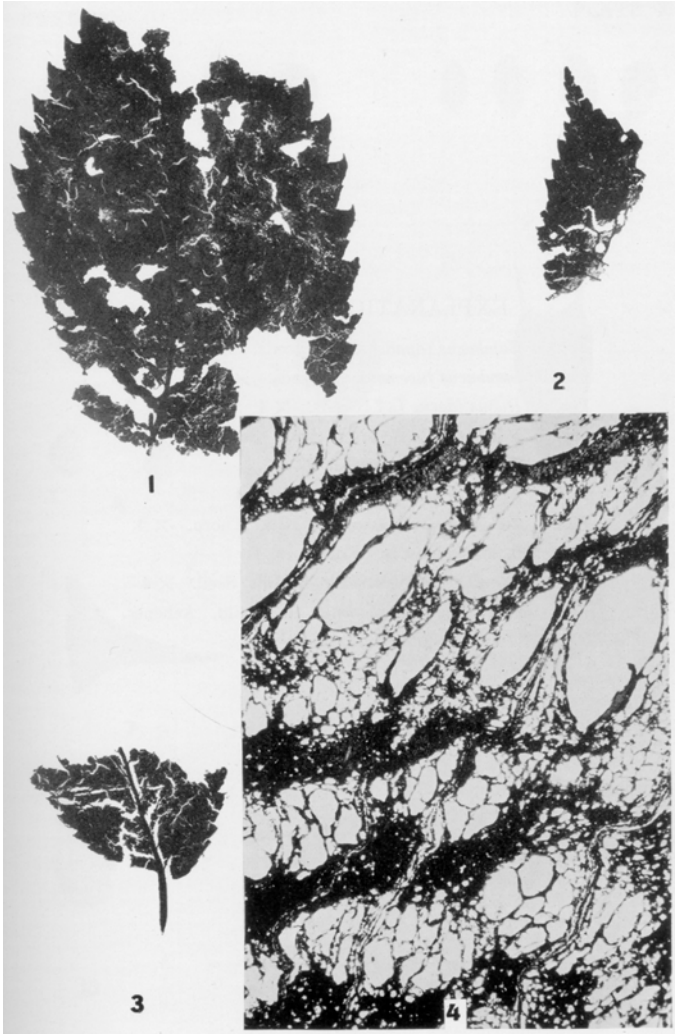
FIG. 7. *Fagus grandifolia* Ehrhardt. Bud scales. X 1

FIG. 8. *Fagus grandifolia* Ehrhardt. Transverse section of wood. X 125

FIG. 9. *Nyssa sylvatica* Marsh. Leaf. X 1



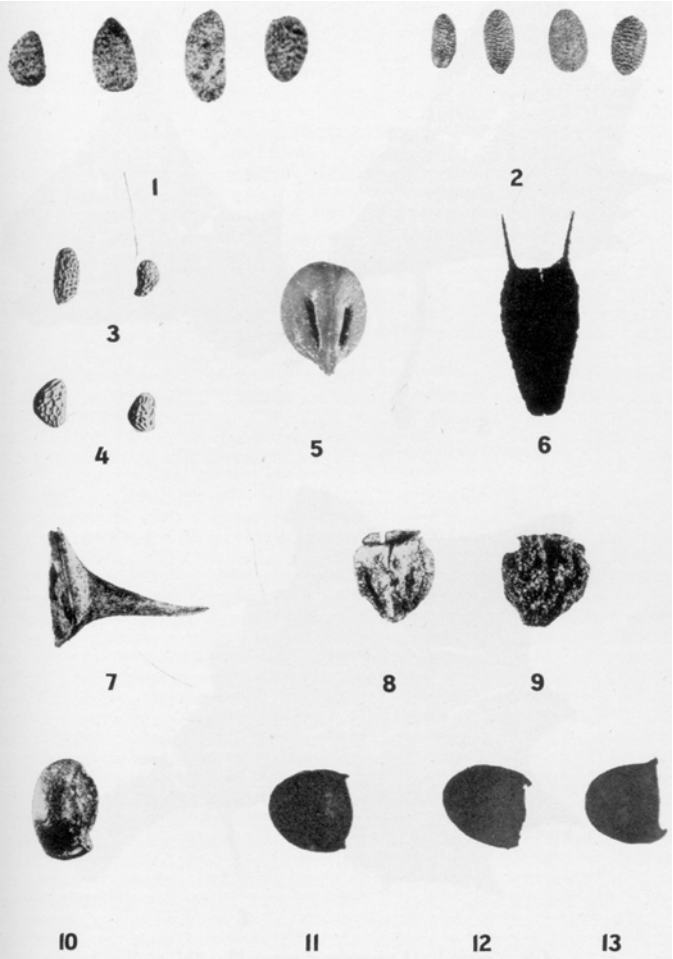
FIGS. 1-4. *Fagus grandifolia* Eherhardt. Leaves. X 1



Ulmus Americana L.

FIGS. 1-3. Leaves. X 1

FIG. 4. Transverse section of wood. X 125



EXPLANATION OF PLATE X

FIG. 1. *Sambucus canadensis* L. Seeds. X 4

FIG. 2. *Sambucus racemosa* L. Seeds. X 4

FIG. 3. *Rubus idaeus* L.? Seeds. X 4

FIG. 4. *Rubus allegheniensis* Porter.? Seeds. X 4

FIG. 5. *Vitis vulpina* L. Seed. X 4

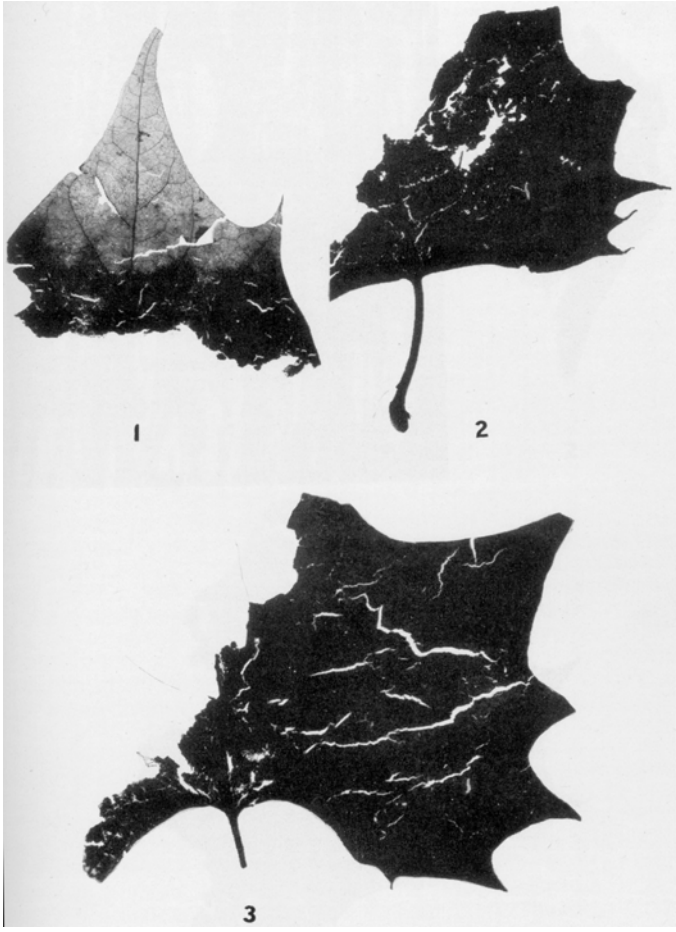
FIG. 6. *Bidens frondosa* L. Achene. X 4

FIG. 7. *Zanthoxylum americanum* Mill. Thorn. X 4

FIGS. 8-9. *Agrimonia sp*. Fruits. X 4

FIG. 10. *Zanthoxylum americanum* Mill. Seed. X 4

FIGS. 11-13. *Laportea canadensis* (L.) Gaud. Achenes. X 6

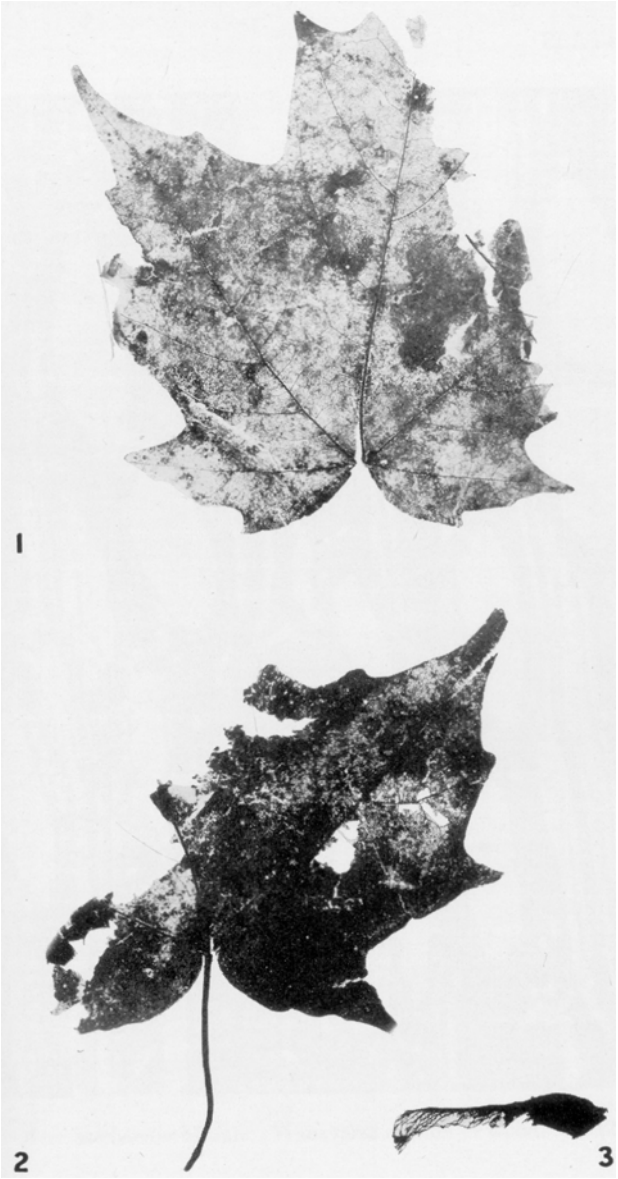


FIGS. 1-3. *Platanus occidentalis* L. Leaves. X 1

FIG. 1. *Platanus occidentalis* L. Transverse section of wood. X 125

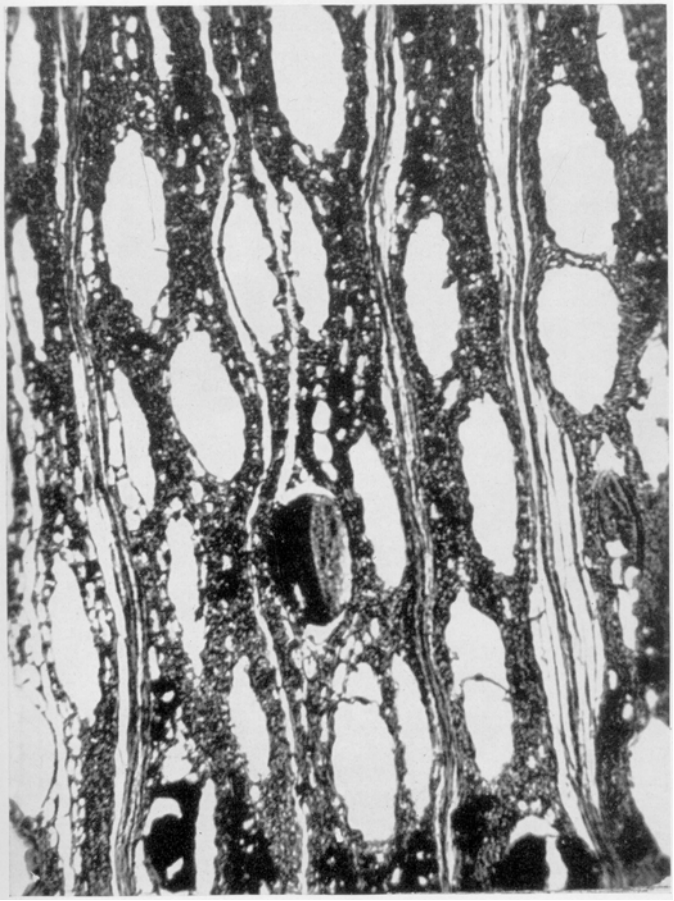
FIG. 2. *Crataegus sp*. Leaf. X 1

FIG. 3. *Platanus occidentalis* L. Part of a leaf. X 1

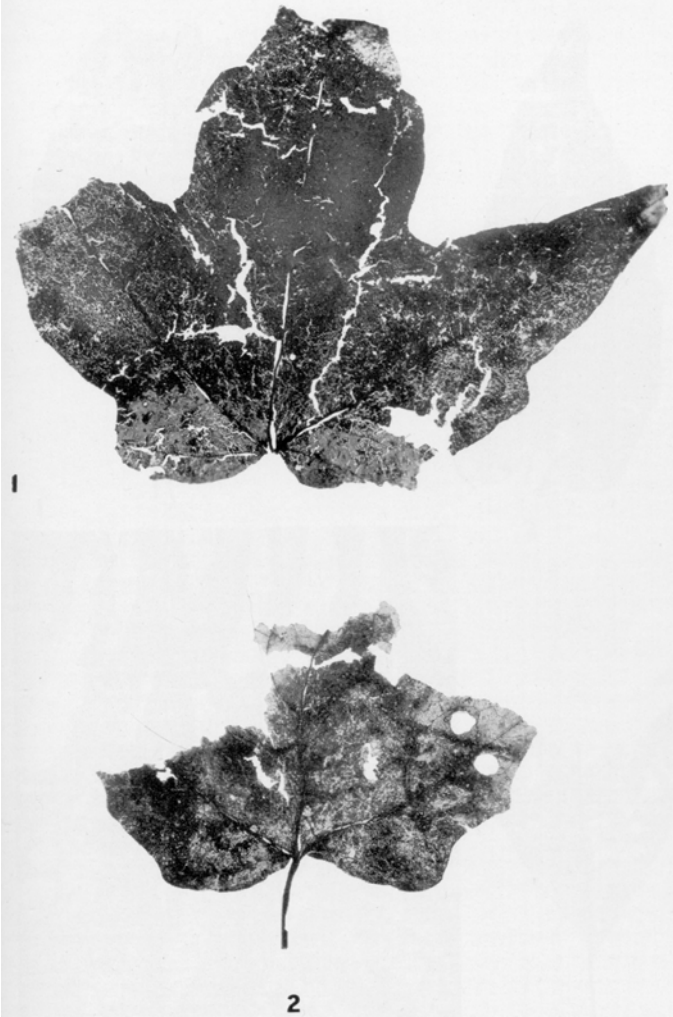


Acer saccharum Marsh. X 1

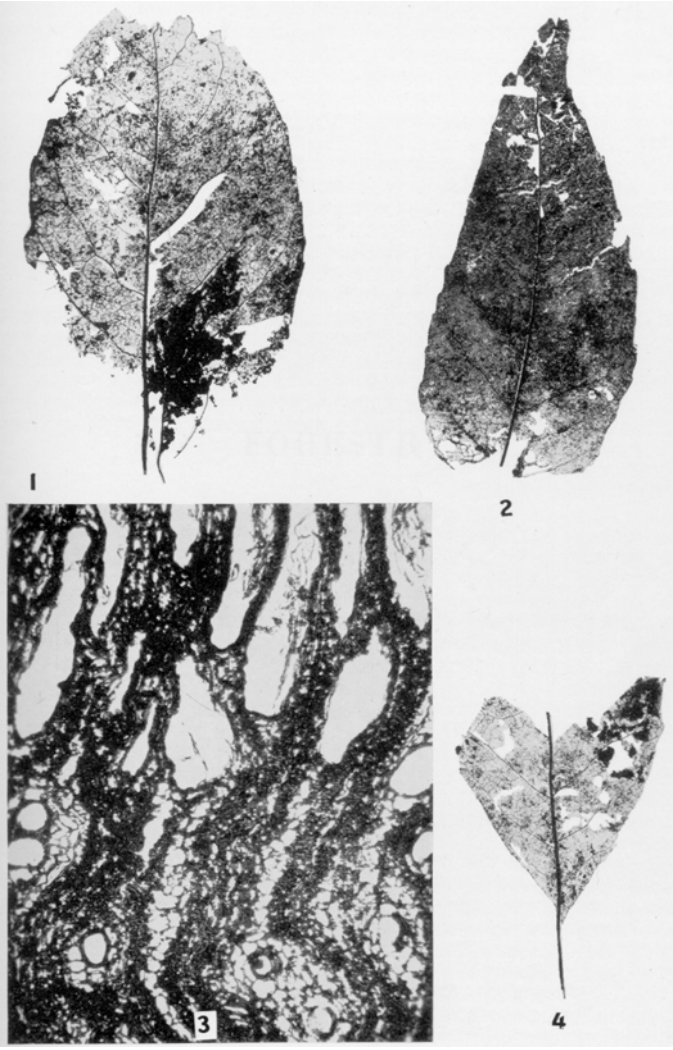
FIGS. 1-2. Leaves. FIG. 3. Seed



Acer saccharum Marsh. Transverse section of wood. X 125



FIGS. 1-2. Leaves of *Acer saccharum* var. *Rugelii* Rehd. (?) X 1



FIGS. 1, 2, 4. *Fraxinus sp*. Leaflets. X 1

FIG. 3. *Fraxinus nigra* Marsh. Transverse section of wood. X 125

AN IMPROVED (POLAR) LOBATE GLOBOID GRID FOR A POLAR MAP OF THE WORLD AND ITS SIGNIFICANCE IN AIR NAVIGATION

FLOYD A. STILGENBAUER

THE human race has entered a new period of civilization — the Air Age. Through scientific and industrial achievement stimulated by the world wars, man has come to think in terms of greater speed and shorter space time. He has created superbombers, powerful transport planes, high-speed engines and propellers; pressure, temperature, and oxygen controls for the high altitudes; radio signals to enable him to hear and establish position, automatic piloting devices, and radar instruments to determine altitude, as well as to provide eyes to view the earth through darkness, clouds, and haze. He has become air-minded by exploring and utilizing vast spaces of the atmosphere. He envisions air transport as the keystone of the transportation structure in the modern world. He considers the airplane a vital instrument in a nation's defense. That it is an essential and established machine in transportation, communication, aeroscopy, aerial photography, and national defense cannot be denied. Progress in aircraft construction calls for improved aeronautical technique. Better maps displaying earth features and human-occupance patterns on the surface of the earth, together with improved methods of charting, are needed to help the navigator guide a plane through the atmospheric medium to chosen airline centers.

A recent Associated Press dispatch from Washington, D.C. is significant: "The Government is taking steps to protect the nation from air attack through its unguarded approaches, coincident with warnings from top American Air Force generals that the United States is vulnerable to attack through the polar regions. Polar-projection maps must take precedence in defense planning over the old Mercator projection, which was designed for an era when transportation was confined to the surface." This is to say, projections must be more globelike or conformal in conception in order to present a world map with exact data giving distance, direction, position, form, and area relationships.

Undoubtedly the Mercator chart will continue to be useful, chiefly for navigation in lower and middle latitudes. It is my conviction, however, that for general air navigation symmetrical interrupted polar projections combined with aeronautical airline pole charts will be among the essential major guiding equipment for the airplane navigator. Such maps and charts will show natural and cultural features on the earth's surface, great-circle terminal poles, great-circle routes, direction angles of travel, location of radio-beam stations, surface identification markings, distances to destination, sites of airfields, size and area of urban centers along the route, flying time in relation to speed, and other significant related information. This material, together with radio

communication, position observation and calculation, as well as radio beam, automatic pilot, and radar mechanism will be the fundamental guides for the airplane of the future.

Rapid development in air communication and transportation demands sound geographical thinking and planning to prevent costly maladjustments. With a favorable position and generous financial assistance Wayne University, of Detroit, Michigan, set up a laboratory for air-transportation study and experiment called Air Cargo Research, under the direction of Spencer A. Larsen. This foundation has published the results of several exhaustive studies and experiments. Creation of a suitable globoid grid for mapping certificated airlines, commodity production, and population distribution; charts of airline terminal poles with great-circle routes; and tables of great-circle distance between terminal poles comprise the geographer's contribution to the Air Cargo Research effort.

Like national defense, air-cargo transportation demands accuracy in the conception of intercommunication and interregional relationships dealing with distance, direction, and area. The correct display on the map of natural resources in relation to environmental conditions pertaining to the production, processing, and marketing of commodities is a vital geographic contribution to the economic system in this modern air age. Maps showing such relationships for air-cargo purposes will be forthcoming. Recent cartographic research at Wayne University has resulted in a five-point improved lobate globoid grid for a polar map of the world, a mathematically correct interrupted conformal grid, symmetrical in form, equal in area, extraordinarily correct in shape, direction, and distance relationships.

Let us review briefly the construction of the improved globoid grid. In the drawing (Fig. 1) we are looking at the face of an east-west hemisphere showing *E-Q* the horizontal equatorial plane intersection, and *N'-S''* the axis or right-angle vertical plane intersection, and *C* the center of the earth. Ten-degree angles are measured off together with their intercepting arcs on the semicircumference *N'-E-S''*. Line *A-B* is the intersection of a parallel plane passed through the 40-degree point and parallel to the equatorial plane. The line *A-B* is, therefore, the cosine of 40 degrees and is the radius of the parallel circle of 40 degrees in a horizontal plane. Likewise, *D, R, F*, etc., are cosine values and radii for parallel circles of 10, 20, and 30 degrees respectively.

Each 10-degree parallel can now be projected downward and correctly drawn in the equatorial plane and viewed as if we were looking down on the Northern Hemisphere from an infinite distance (Fig. 2). The Southern Hemisphere parallels, if likewise projected, would coincide. Therefore, it is logical and more convenient in polar projections to construct all parallels equidistant and concentric with the North Pole as the center.

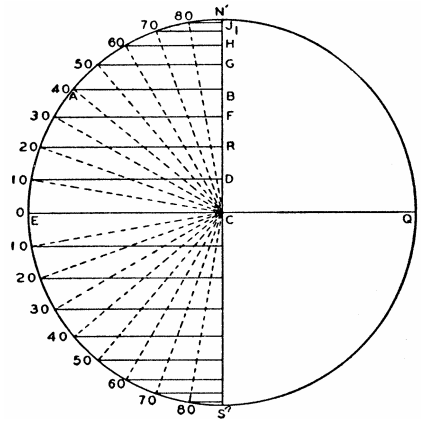


FIG. 1. Vertical east-west hemisphere face of the earth, with the equator *E-Q,* the axis *N'-S''*, and the center *C*. Planes are passed through each 10-degree point on the circumference, parallel to the equatorial plane. Then *A-B* is the cosine of 40 degrees and is the radius of the parallel of 40 degrees. Other radii are similarly determined

The 10-degree meridians of the global grid are projected to the equatorial plane (Fig. 3), which gives all the required lengths for spacing correctly the meridians along the parallels for a conformal polar lobate globoid projection. The length of a 10-degree arc of each of the 10-degree parallels of a globe of 3-inch radius is computed through the use of the cosine and arranged in Table I.

TABLE I

TABLE FOR SPACING MERIDIANS

(Globe of three-inch radius)

Cosine 0 = 1	3×1 = 3	(2×3.1416×3) ÷36 =	.5235 in.
Cosine 10 = .9848	3× .9848 = 2.9544	(2×3.1416×2.9544) ÷36 =	.5175 in.
Cosine 20 = .9397	3× .9397 = 2.8191	(2×3.1416×2.8191) ÷36 =	.4920 in.
Cosine 30 = .8660	3× .866 = 2.5980	(2×3.1416×2.598) ÷36 =	.4535 in.
Cosine 40 = .7660	3× .766 = 2.2980	(2×3.1416×2.298) ÷36 =	.4010 in.
Cosine 50 = .6428	3× .6428 = 1.9284	(2×3.1416×1.9284) ÷36 =	.3365 in.
Cosine 60 = .5000	3× .5000 = 1.5000	(2×3.1416×1.5) ÷36 =	.2618 in.
Cosine 70 = .3420	3× .3420 = 1.0260	(2×3.1416×1.026) ÷36 =	.1790 in.
Cosine 80 = .1736	3× .1736 = .5208	(2×3.1416× .5208) ÷36 =	.0909 in.
Cosine 90 = 0	3×0 = 0	(2×3.1416×0) ÷36 = 0	

A polar projection determined from one pole keeps the hiatuses at a minimum and all parallels equidistant. The semicircumference of the east-west hemisphere plane is rotated to a straight-line position with the fortieth parallel as a fulcrum until this straight line meets the axis of the earth extended to *N* (Fig. 4). The line *N-S'* is then the element of a secant cone with the selected standard parallel at 40 degrees north, with the North Pole position fixed by the length of the meridian from the fulcrum, and with the second standard parallel taking an interposition. This element is then rotated to form a cone *N-A-F-D*, which will carry the polar globoid grid. Ten-degree arcs are measured off on the fortieth parallel, and lines *L-N*, etc., are drawn for meridians inside the fortieth parallel. The cone is then cut along the eighty-fifth meridian and laid out flat to form a plane.

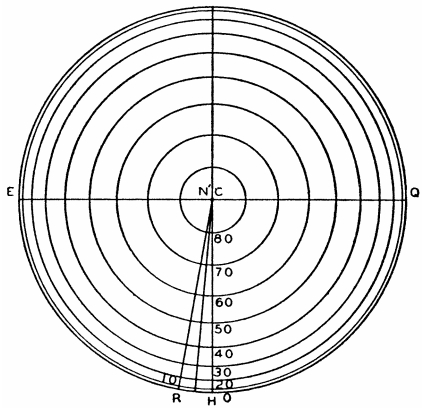


FIG. 2. The 10-degree parallels of the earth projected to the equatorial plane from an infinite distance retain their true size

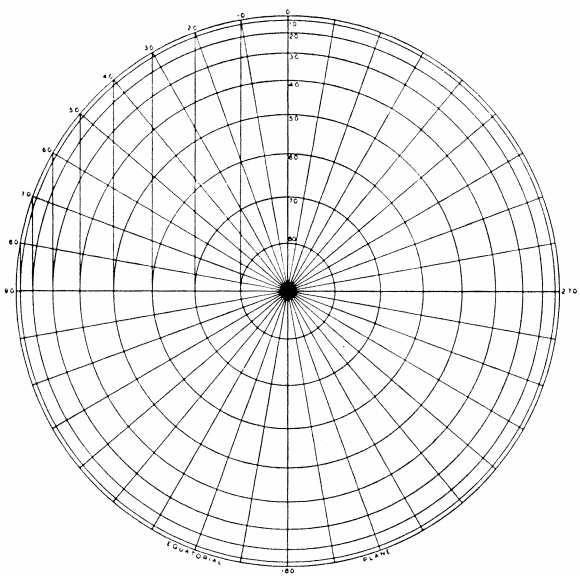


FIG. 3. The 10-degree parallels and meridians projected to the equatorial plane. The cosine length or radius for each successive parallel circle is shown in the upper left-hand quadrant

On the original grid there are three primary lobes with 155 degrees east, 35 degrees east, and 85 degrees west as standard meridians for lobation. One hiatus begins at the North Pole from 95 degrees east, two hiatuses begin at the fortieth parallel at 140 and 30 degrees west (Fig. 5). Two standard meridians were selected at 110 and 60 degrees west, and another hiatus begins at the equator from 85 degrees west. The grid is capable of several variations, as shown by the dashed lines. A recent four-colored certificated airline map of the world was made on the original polar globoid grid. Continental distortion and the splitting of Asia may be objectionable, but distance and direction are reasonably correct. The around-the-world flight by the United States Army was plotted and scaled on the globoid map at 23,105 miles (Fig. 6). Army flyers logged the distance at 23,125 miles, a difference of only 20 miles. The 0.09 of 1 per cent error is very small indeed.

Hiatuses and standard meridians can be shifted to any convenient position. In the first attempt to overcome the undesirable features of the original grid two primary lunar lobes were constructed (Fig. 7). These were further divided into five lobes, which results in two short breaks into Asia on opposite sides of India.

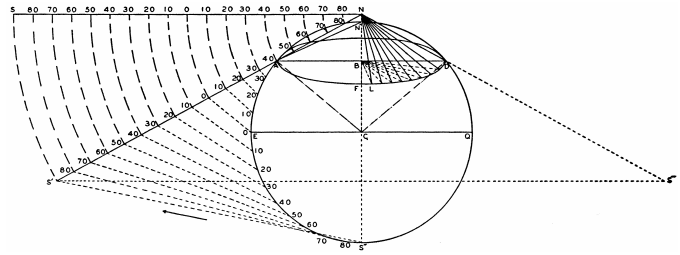


FIG. 4. Basic construction for the (polar) lobate globoid grid. The meridian *N'-S''* is swung out in the vertical plane to become a straight-line element with *A* as a fulcrum and to touch the axis *N'-S''* extended to *N*. The element is then revolved to form a secant cone upon which the grid is constructed

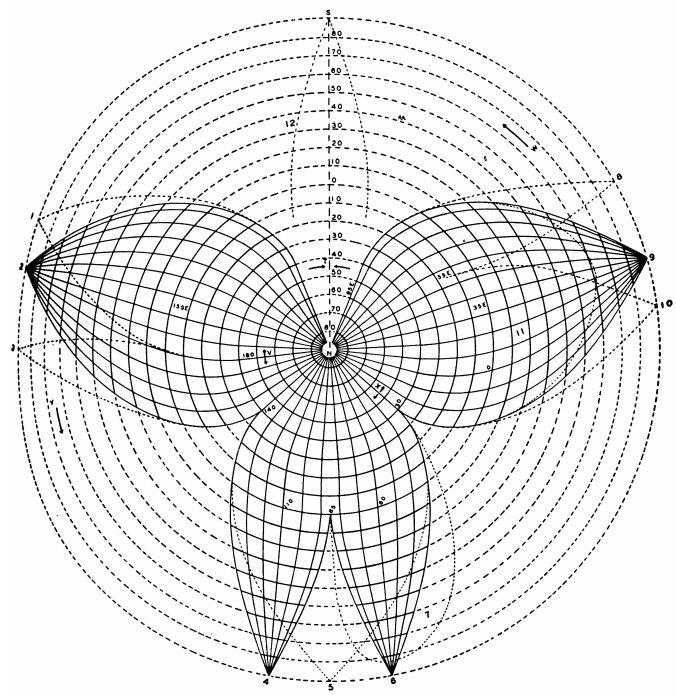


FIG. 5. Position of selected standard meridians; size, position, and number of hiatuses. Size, position, and number of the lobes permit many variations of the grid

In the improved globoid grid the standard parallel is 70 degrees north, the North Pole is nearer the true North Pole, and the second standard parallel is approximately 75 degrees. Standard parallels are not needed if the North Pole is selected for the contact point. The 105-75-degree meridian is taken as the primary standard for the two lobe portions of the grid (Fig. 8). If no standard parallel is used, the grid is made conformal throughout. In either case we have a correct mathematical reproduction of the global grid on a plane surface that preserves in appearance the spherical nature of the world. The final result is a rather symmetrical globelike grid with two primary lunar segments. These are further interrupted and form two secondary lobes of 75 degrees each, two lobes of 90 degrees each, and one lobe of 30

degrees centered on Eurasia to bear the map of India. By zigzagging the margin of the lobes where necessary, by placing the standard parallels and meridians as indicated, and by the apparent swinging of the secondary lobes out into the polar disc so that the standard meridians meet the parallels at right angles, it appears that we obtain a nearly perfect map of the world.[1]

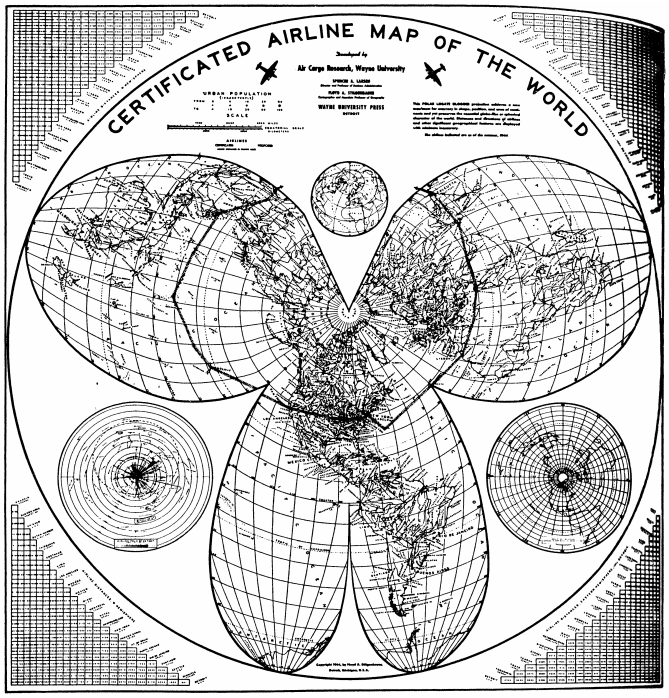


FIG. 6. The original (polar) lobate globoid grid, with the around-the-world route of United States Army fliers plotted to scale, with only 0.09 of 1 per cent error in distance

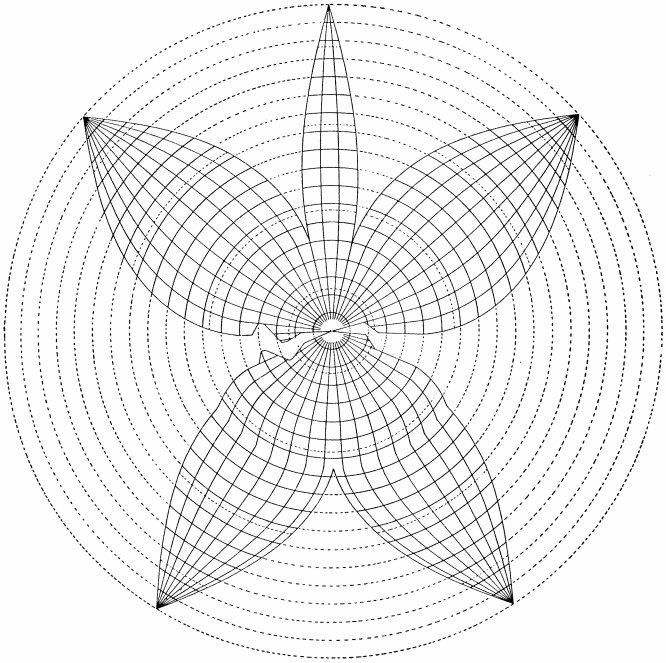


FIG. 7. An intermediate five-point grid of like construction resulting in two objectional breaks which would enter the Eurasian land mass

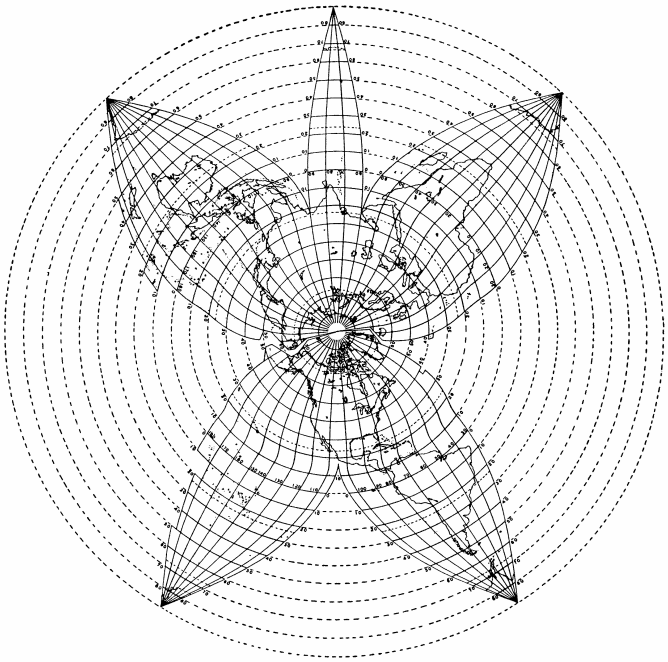


FIG. 8. The improved (polar) lobate globoid grid, which is likewise a secant cone construction, with the standard parallel moved up to 70 degrees north. The portion of the grid below 70 degrees north is lobated and conformal to give correct shape, area, essentially correct distance, and direction relationships. There are no breaks in the land masses except in Antarctica

TABLE II

APPROXIMATE AZIMUTHS OF GREAT-CIRCLE ROUTES FROM SELECTED AIRLINE POLES TO DETROIT

Place	Degrees	Direction	Place	Degrees	Direction
Aden	37	W of N	Honolulu	50	E of N
Asuncion	20	W of N	Magallanes	8	W of N
Bahia	37	W of N	Makassar	23	E of N
Batavia	10	E of N	Melbourne	64	E of N
Cairo	43	W of N	Mexico City	27	E of N
Calcutta	8	W of N	Mozambique	50	W of N
Capetown	57	W of N	Omsk	17	W of N
Colombo	15	W of N	Perth	46	E of N
Darwin	36	E of N	Pitcairn	33	E of N
Freetown	50	W of N	Tehran	34	W of N
Guam	36	E of N	Wellington	61	E of N

The Detroit airline pole was computed with a global great-circle direction finder pinned to the globe at the position of the city and oriented with the true north-south meridian. The zero-degree mark on the great-circle tape was fastened in the same position underneath and made to rotate freely around the surface of the globe. Great-circle distances are read on the tape, and great-circle angles (true azimuths, Table II) are observed on the vertical edge of the global protractor, both of which are projected to a plane which is perpendicular to the zenith and tangent to the earth at Detroit (Figs. 9-10). This is the airline pole of Detroit. Concentric circles measure true global distances on the airline pole, and cities are plotted in their exact distance, position, and direction from Detroit as the center. The equator, true north-south direction, true east-west direction, projected meridians, compass-arc direction angles, flying distance, flying time, radio-beam stations, airfields, azimuth angles of great-circle direction, and other identification markings

can be plotted on the Detroit air-line pole to help the navigator.

Plotting the course of an airplane from the Detroit airline pole to successive poles along a route around the world is done by rotating and orienting the plotting chart to each landing center in order. The route selected and the necessary data for circumnavigation of the earth are given in Table III. Realism enters into the determination since the plotting chart is carried with the airplane and plotting is done in flight steps.

TABLE III

DATA FOR CIRCUMNAVIGATING THE EARTH

Flight leg	Miles	Going great-circle angle	Return great-circle angle
		Degrees	Degrees
Detroit to Horta	2,795	15 N of E *	23 N of W
Horta to Lisbon	1,050	8 N of E	5 N of W
Lisbon to Cairo	2,350	1 S of E	28 N of W
Cairo to Calcutta	3,550	8 N of E	22 N of W
Calcutta to Manila	2,168	8 S of E	20 N of W
Manila to Guam	1,568	1.5 S of E	8 N of W
Guam to Wake	1,504	20 N of E	13 S of W
Wake to Honolulu	2,270	11 N of E	3 N of W
Honolulu to San Francisco	2,395	37 N of E	17 S of W
San Francisco to Detroit	2,060	22 N of E	6 N of W

* Complement of the azimuth angle of great-circle direction.

At the terminal pole three determinate planes representing true north-south direction, true east-west direction, and true azimuthal great-circle direction are made to intersect the zenith of Detroit. For the start of the flight the plotting plane is perpendicular to the zenith and tangent to the earth at Detroit (Figs. 10-11). True north direction must be measured, plotted, and checked at each landing point and at intermediate points when necessary. The true azimuth angle of great-circle direction from Detroit to Horta, and from Horta back toward Detroit must be known. For instance, Detroit azimuth complement 15 degrees north of east is the great-circle direction to Horta, and this is plotted on the pole chart for the exact distance of 2,795 miles and likewise on the navigator's chart (Figs. 12-13). The flight angle from Horta to Detroit is 23 degrees north of west. Therefore true north at Horta is 90 degrees — 23 degrees or 67 degrees measured to the right of the true azimuthal great-circle course. This true north-south direction, together with the right angle east-west direction, is plotted on the navigator's chart at the position of Horta. The procedure is repeated between Horta and Lisbon, 1,050 miles apart and with azimuth complements of 8 degrees forward and 5 degrees back. In like manner the navigation traverse is plotted to Cairo, Calcutta, Manila, Guam, Wake, Honolulu, San Francisco, and Detroit. Therefore the total traverse of a round-the-world route consists of orienting together the airline pole charts of each landing center in accordance with the angle azimuth of the great-circle route from each center to the next landing point.

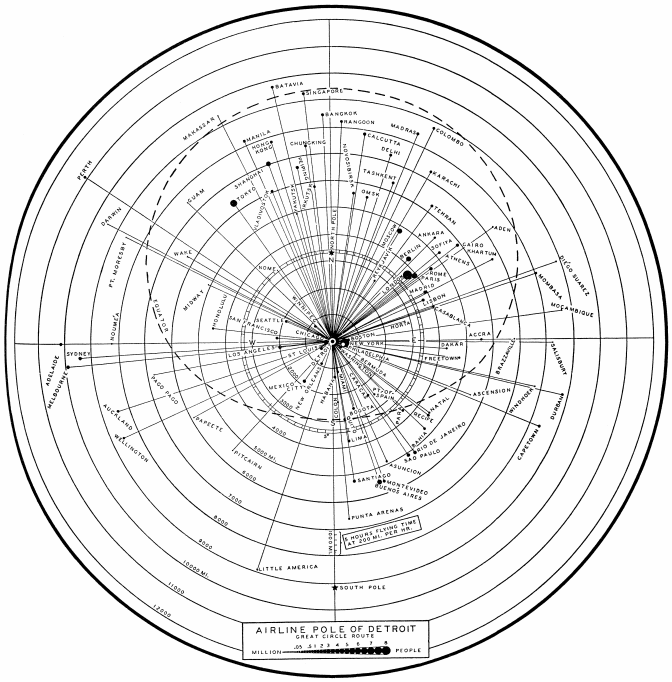


FIG. 9. The airline pole chart of Detroit, with great-circle routes plotted to many centers throughout the world. Azimuthal angle of direction and great-circle distance are very accurate. Average flying time and approximate population of cities are shown

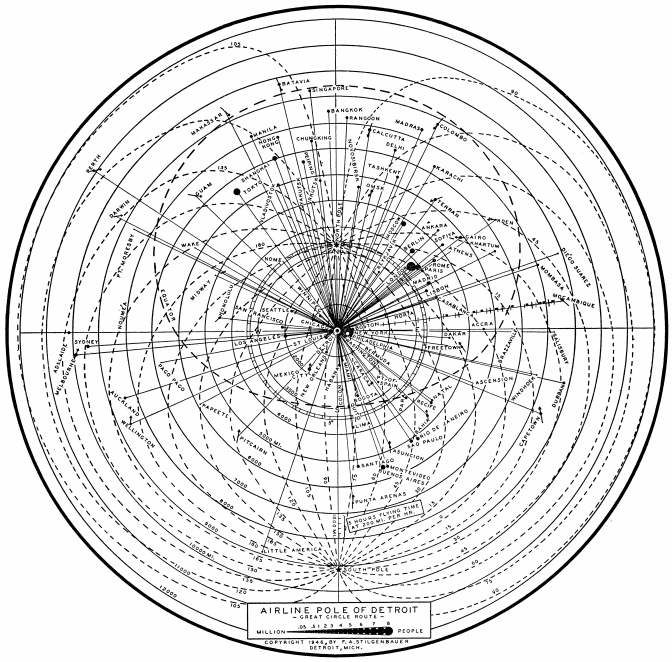


FIG. 10. The equator, poles, and all meridians swing out onto the Detroit airline pole plane to show position of airline centers from one another. True global north is indicated at some centers by an arrow. Airfields, radio beam, and angle of flight and return are shown on the Detroit-to-Mozambique route

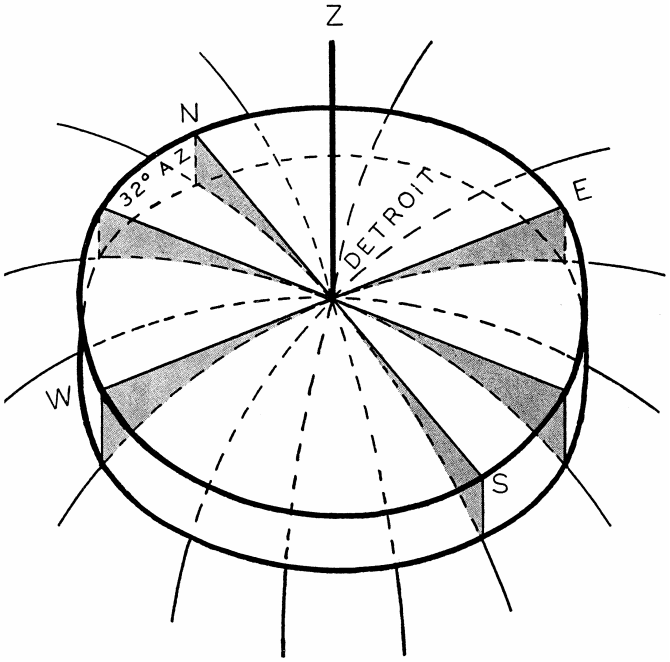


FIG. 11. Diagram showing how the airline pole plane of Detroit is constructed perpendicular to the zenith and tangent to the earth. Other planes perpendicular to the airline plane cut the center of the earth and show true north-south, true east-west, and true azimuthal direction of a global great-circle route of angle 32° west of north

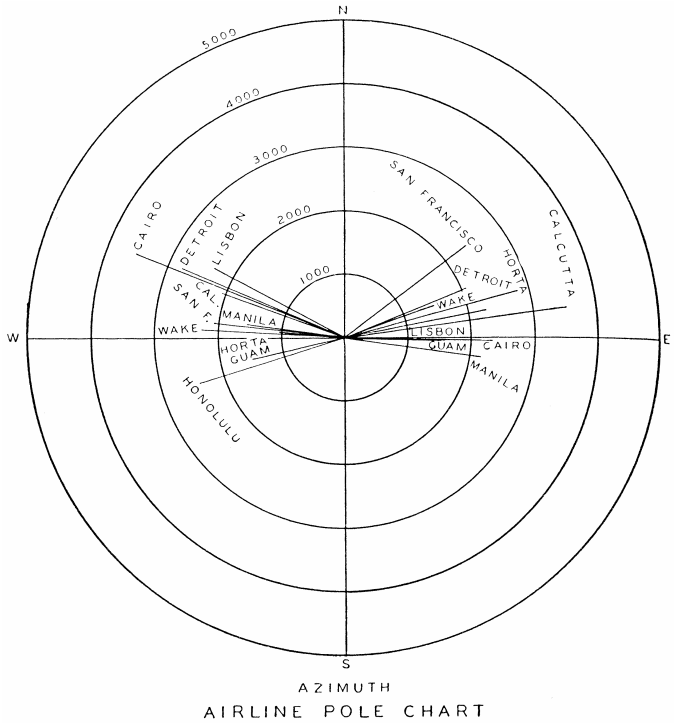


FIG. 12. Superimposed airline poles of each landing point on world route. The diagram shows the going and returning azimuthal angle for the around-the-world airline traverse

After plotting the global traverse course for true direction and on true azimuths which fix true north at each successive landing point, the meridians and parallels are plotted to exact scale along the route (Fig. 13). At Detroit the actual surface distance between the fortieth and the fiftieth parallels is plotted to scale, which fixes the position of the city at 42.2 degrees north latitude. At Horta, the thirtieth, fortieth, and fiftieth parallel positions are plotted so as to place this landing point at its correct position of 38.2 degrees north. A like procedure is carried out for each section of the chart. One intermediate position on the nearest parallel to the traverse is calculated and plotted. With three points on the parallel fixed the center for swinging the parallels is now determined for plotting in each section. Parallels are plotted as curved dashed lines. Only the parts needed for the flight traverse are placed on the chart.

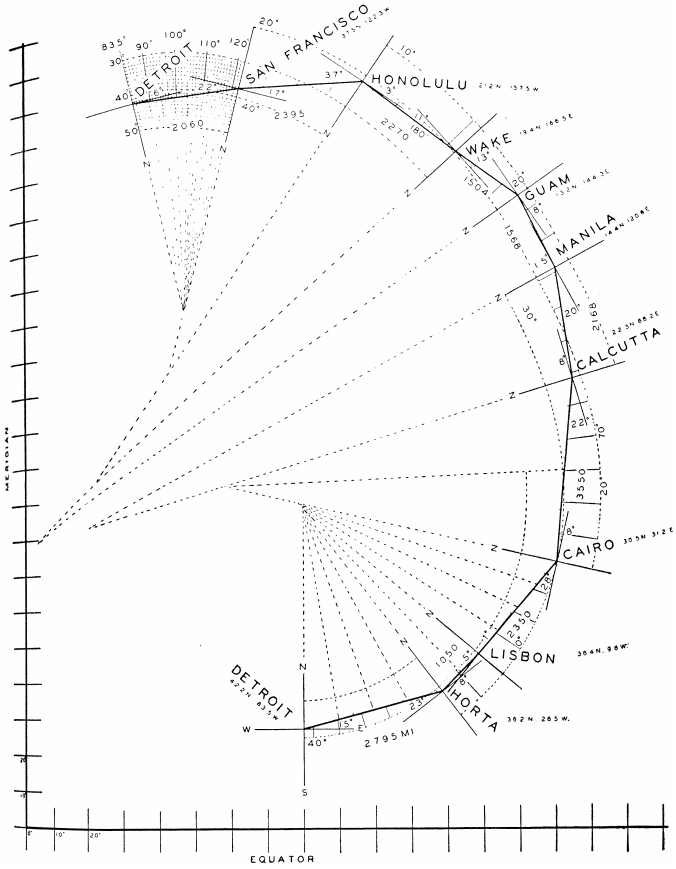


FIG. 13. Around-the-world airline traverse route plotted to scale for exact distance, direction, position in terms of latitude and longitude, true directions at the landings and intermediate points, so that the navigator can find his position at all times

The meridians are plotted by extending the true north lines of direction at two successive landing points until they intersect to form the pole of that section. From the longitude of the landing points the 10-degree meridians are calculated for number and fixed for position. These are drawn, with the determined center of north, as solid lines from the airline traverse to the nearest right-hand parallel. The straight dashed lines on the left-hand side of the airline traverse divide the route into equal mileage segments. Small marks along the traverse measure 1,000-mile units in each section. On the left-hand side of the San Francisco-to-Detroit section 100-mile and 250-mile segments are marked off along the traverse. On the right-hand side square degrees are plotted. The navigator can easily find his latitude and longitude at any

position along the route through application of these two scales.

On enlarged sectional charts of the traverse all necessary surface information can be plotted for contact flying. Radio-beam stations, urban forms, landing fields, emergency fields, beacon lights, shorelines, lakes, rivers, forest areas, mountain peaks, and the like are indispensable features in navigation of the contact type. On all established airlines such traverse charts will simplify the work of the navigator and guarantee greater accuracy and safety for air transportation. This method of charting also establishes a unified system for navigation which can be used in travel to any part of the world. The global airline traverse is comparable in form and accuracy to the land-survey traverse when careful instrument measurements are made and the results are plotted with care.

The plotted traverse route could not be a closed line since we are rotating the actual global route to a plane surface. If we navigate north and south around the world along the Detroit meridian or any other one, the navigation traverse of O azimuth would be a straight north-south line. If we navigate from any point on the equator directly around the world on the equator, the traverse of azimuth 90 degrees is a straight east-west line. All other navigation routes will result in a broken traverse falling between these perpendicular straight lines as limits. Conversion of the meridians on the globe is the obvious reason for these limits.

Great-circle routes are plotted on the improved globoid map from Detroit to many centers throughout the world. One around-the-world route is plotted as a series of broken great circles. It will be observed that the great-circle routes are curved lines (Fig. 14). The curving decreases with approach to the standard meridian trends, or to any of the poleward parallels. For instance, the Detroit-to-Calcutta route trends with the major midmeridian of 105-75 degrees and is only slightly curved. The curving increases toward the apparent bending of the meridians in the lower middle latitudes and toward the outer edge of the lobes.

For navigation purposes it is quite obvious that the globoid map and the aeronautical pole chart must be used together when piloting a plane about the earth. The angle of starting direction at Detroit is coincident with the angle of great-circle direction (true azimuth) on the airline pole chart. How the pilot is flying with respect to the meridians and parallels along the route can be viewed by the navigator on the improved globoid map, or can be plotted on the airline pole or traverse charts. His position can be checked by instrument observation, by identifying marks and features of orientation, by radio beam, and by radar calculations.

Careful globe, chart, and map measurements have been taken and recorded to determine error (Table IV). It is assumed that there are mechanical errors in the map construction. Reconstruction on a large scale with great detail and reduction will minimize such irregularities.

Obviously, the error on the globoid projection is surprisingly small. Because of the symmetrical nature of the grid the error has been found to be along definite lines of direction and can be calculated to be used as percentage-of-correction error in determining distance along airline routes. The greatest error lines are in the direction of Aden and Makassar from the Detroit pole. It is hoped that with skilled assistance these navigation aids may be made more nearly perfect and become highly essential instruments in the hands of the trained air navigator.

TABLE IV

A Comparison of Great-Circle Route Distances in Miles between Detroit and Several Destinations

Great-circle route Detroit to	Measured on			Error	
	Globoid map	Detroit pole chart	Globe	max.	min.
Batavia	9,822	9,760	9,765	62	5
Buenos Aires	5,576	5,550	5,540	26	10
Calcutta	7,885	7,850	7,850	35	0
Capetown	8,369	8,400	8,374	31	26
Mombasa	8,162	8,030	8,035	122	5
Tokyo	6,571	6,525	6,535	47	10
Wellington	8,542	8,570	8,570	28	0

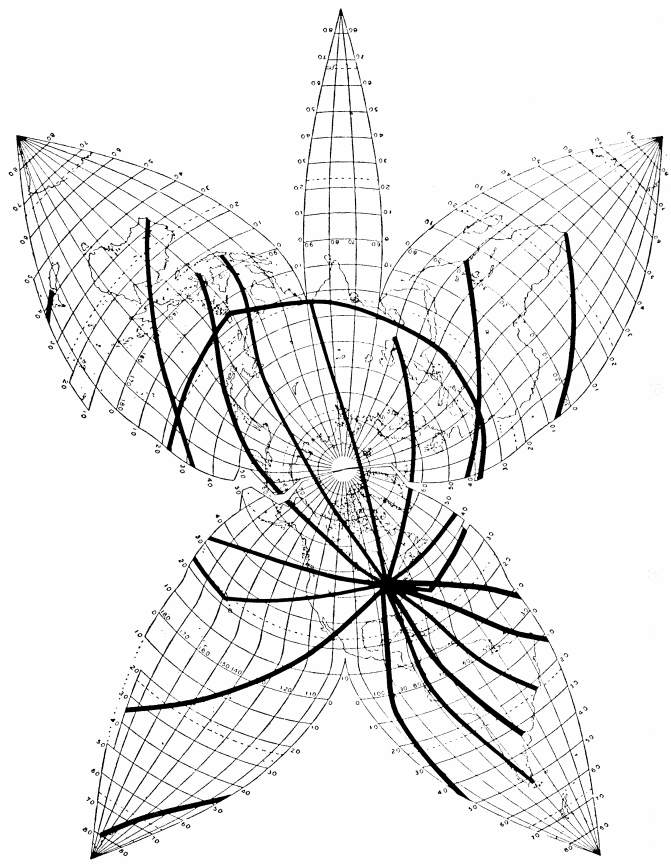


Fig. 14. Great-circle routes plotted on the improved (polar) lobate globoid map to many parts of the world. They are curved lines, but they correlate very closely in length and direction with similar routes on the pole and traverse charts when the same scale is used for both map and chart

In conclusion, let us review some of the merits of the improved polar lobate globoid map: (1) There are no interruptions in the land masses (Antarctica excepted); (2) There is shown a high degree of perfection in global

relationships of area, shape, size, and form of continents, as well as in interposition, direction, and distance measurements; (3) There are reflected a high degree of realism and an extraordinary exactness in computation, with actual surface measurements of a global grid used in the conformation; (4) The globelike nature of the world in the relation of one land mass to another is preserved; (5) Island groups are attached to the continents where their geographic significance is greatest; (6) Hiatuses are held to a minimum and are placed in the ocean areas so as to present the least inconvenience; (7) airline great-circle routes and other significant information can be plotted and measured with a high degree of accuracy; (8) The map can be suspended from any side and rotated about the North Pole, and each part of the world perceived from its correct viewpoint as on the globe; (9) Presentation of the hemispheres can be done with greater accuracy; (10) Finally, the streamlined grid is sufficiently accurate and globelike in character to be of extraordinary value for cartographic, geographic, economic, air-cargo transportation, navigation, and national defense purposes.

Concluding advantages of the airline pole system of navigation are as follows: (1) It eliminates the dissatisfaction now existing in air navigation by using a conformal, interrupted, symmetrical global grid which permits the correct plotting of great-circle routes between airline poles; (2) It makes possible one unified system for all types of air navigation; (3) Air-navigation routes are more correctly calculated from airline pole to airline pole with the North Pole used only as a direction determinate; (4) Travel is most frequent between populated centers, so that navigation by the airline pole method is more basically and geographically correct; (5) It eliminates distortion of the world and brings direction, distance, and area into essentially correct global relationship; (6) It uses correct azimuthal direction of great-circle route, zenith, true meridian direction, and true parallel direction at each flight-leg terminal through the use of planes intersecting at the zenith of each point of landing or observation; (7) It employs a plotting plane which is perpendicular to the zenith of each successive airline center or observation point, and thus gives a natural progressive moving aspect to navigation; (8) It disregards completely the partially outmoded Mercator chart, in which direction is made correct and fixed at the expense of area, distance, form, and length of great-circle route; (9) The new globoid system and airline pole chart make possible the interrelation between navigation chart and global world map, or sectional maps, so that radar, radio beam, radio, surface marking, and other related information can be correlated to advantage for the navigator.

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[1] Two maps of this kind are the B. J. S. Cahill octahedral projection and the J. Paul Goode polar equal-area projection.

NEW INTERPRETATION OF THE DEPOSITS OF THE PLEISTOCENE CONTINENTAL GLACIERS

WILLIAM HERBERT HOBBS

Pleistocene Continental Glacier Deposits Described as Though of Alpine Glaciers

WHEN in the early 1840's evidence was discovered that glaciers had been over northern Europe and northern North America the only ones known and studied were those high up in the Swiss Alps. Though none of these Alpine glaciers had dimensions of more than a very few miles, and though the earlier glaciers of Pleistocene time were soon found to have had continental extent, all the properties of the diminutive mountain glaciers, and no others, were carried over to them.

Yet even as Louis Agassiz, the discoverer of the evidence for these earlier continental glaciers, was promulgating his theory, three great national exploring expeditions were approaching and seeing for the first time the greater of the earth's two existing continental glaciers — that on the Antarctic Continent. Notwithstanding this, it was to be nearly a full century before the properties of a continental glacier were to be learned.

During that century a small army of glacialists studied in great detail the deposits left by the Pleistocene continental glaciers, and explained what they found with the picture of the Alpine glaciers always before them. Such a glacier as they envisioned — a continental glacier with the properties of an Alpine glacier — has never existed, and much that has been explained on this basis must now be reinterpreted with the picture of a real continental glacier before us. This will involve changes of fundamental character, and supposedly correct explanations now embedded in major monographs and in the most approved texts must be replaced by others which are in harmony with the later-acquired knowledge.

The Contrast between Alpine and Continental Glaciers

The most important of the differences between Alpine and continental glaciers derives from the observed fact that the latter are at all times overlain by a supervigorous centrifugal wind system and that they are nourished by snow deposited within a central area and from there swept outward to the margins. Next in importance in a geological sense is the seasonal alternation of summer and winter conditions. During the warm season melt-water deposits are laid down off the glacier margin, which in the winter are in part lifted and carried outward to form broad aprons of eolian deposits — loess.

The study of Alpine glaciers had revealed outwash plains always off the glacier front, but melt water flows

only over the depressed areas. In lobes of a continental glacier the outwash is quite as often at the side as at the front. Over this plain there move in the summertime rafts of ice detached from the thinned glacier front, and besides silt, sand, and pebbles which are embedded in them, there are boulders usually several feet in diameter. In the ice rafts the boulders float outward over the outwash and become stranded on the plain when the rafts have melted. In the winter the sand is driven against them, and they are transformed into ventifacts, “faceted” when of relatively homogeneous material (Windkanten), but “ribbed” or “recessed” when heterogeneous.

The principal contrasts between Alpine and continental glaciers are summed up in the following table:

CONTRASTS OF ALPINE AND CONTINENTAL GLACIERS

ALPINE (MOUNTAIN) GLACIER	CONTINENTAL GLACIER
Rests on steeply forward-sloping bed.	Forward slope of bed lacking.
Has an internal forward movement.	Forward internal movement lacking except in frontal zone, where there is a forward slope of ice surface.
Nourished at upper end by ascending air currents.	Nourished from central region by descending currents, with snow drifted outward toward margins.
Air circulation over glacier that of surrounding area, with wind direction changing with the weather	A supervigorous centrifugal air circulation (glacial anticyclone), with wind direction unchanging and following surface slope. Winds are of hurricane force and extend hundreds of miles beyond glacier margin.
Melt water issuing in summer season, with wastage of glacier at lower end, where the outwash is always found.	Summer melt water forming outwash apron only where land surface is depressed, and it may be at either the front or the side of a lobe.
Debris both superglacial and englacial, and the latter may be in any level.	Debris englacial and restricted to the lower glacier layers.
Recession at front and gradual, except for climatic oscillations.	Melts down from upper surface, and at first within successive marginal zones. When ice surface is lowered into debris layer near bottom, surface becomes rock-veneered. Ice now inactive (dead). Down-melting, now over an inner zone, floods outer zone with melt water, forming super-glacial lakes and rivers which divide outer glacier zone into ice islands, each charged with rock debris and boulders. Final stage one of floods over outwash with ice islands, which float out as one or more superglacial lakes are drained. Islands grounded on outwash leave behind massive boulders, which during winter seasons are drilled into ventifacts by the flying sand.
No wind-deposited silt (loess) surrounding outwash.	Owing to seasonal changes all melt water reaching outwash area during summer. At end of warm season outwash plain quickly dries out, and now the winds of glacial anticyclone pick up silt, sand, and small pebbles from outwash to transport them outward beyond outwash, where silt (loess) is deposited and held by vegetation. Larger pebbles are left behind as a surface “pebble band” like that of deserts. Sand carried in air drills into ventifacts the once rafted and now stranded boulders. In succeeding summers the stranded boulders are moved and rotated in water currents to expose ever new surfaces to sandblast and so become ellipsoidal.

For every continental glacier there has been an earlier stage of growth and expansion until its maximum size has been attained; and this has been followed by the progressive deglaciation until the glacier has disappeared. Of the earlier of these periods we know comparatively little, for no continental glacier is today in that stage, and the deposits of former glaciers of the earlier period are now generally covered up and hence removed from our view. The most we can do is to make inferences from our knowledge of the processes characteristic of the stage of liquidation.

Of the behavior of a continental glacier in its stage of deglaciation we can learn from both existing examples, and the character of the deposits can be compared with those which lie before us from the Pleistocene glaciers of both northern North America and northern Europe. It will be profitable, therefore, to treat first the later of these periods, liquidation, and then from what has been learned we may by inference form some picture of the earlier period of growth and expansion.

Continental Glacier Deglaciation

Liquidation of a continental glacier probably results, not from increased incoming solar radiation, or in the main by air at higher temperatures, but by surface evaporation

and by the precipitation of rain upon the surface. This occurs through invasion of the glacial anticyclone by the planetary air circulation. It is at first within an intramarginal zone owing to a decrease in vigor of the glacial air circulation — the glacial anticyclone. The wastage of the ice takes place, therefore, from the surface downward within the invaded area, not from the border inward, as with mountain glaciers. This is to be seen today from observation of the Greenland glacier on its western flank, where during the summer season cyclones on eastwardly directed tracks as they are deflected northward near the glacier margin invade the anticyclone to a depth of some tens of miles, or up to a *névé line* of perpetual snow. Outside this line all the outblown snow accretions of the preceding winter are melted by midsummer, and in addition a subjacent layer of older ice.

On the southwestern border of the Ross Sea, in South Victoria Land (Antarctic), though but little of the glacier bed has yet been exposed, considerable upper surfaces of once submerged glaciated *nunataks* (rock islands) have been uncovered by surface wastage of the glacier. In another area ice slabs are now separated from the parent glacier through the same downward wastage. One of these now unattached ice slabs, the Blue Glacier, is no less than twenty miles in length, and another has a length of eighteen miles. Such marginal detached glacier slabs have probably been generally characteristic of the final stage in the liquidation of continental glaciers, and, broken up, these slabs are later carried out in floods onto the outwash, propelled from behind by the winds of the expiring glacial anticyclone. If they contain boulders, these are carried out with them. After melting of the ice the boulders, sometimes of gigantic dimensions, are deposited over the central zone of the outwash. Here they are drilled by the winter sandblasts of the anticyclone and so are transformed into ventifacts.

In an earlier stage of this down-wastage of the glacier only melt water issues at the front, and it proceeds outward there only where the land surface is depressed. When down-wastage has reached the lower ice layers containing englacial rock debris, the emerging melt water carries in suspension large quantities of such debris ranging from fine silt to pebble size, but including also boulders floated out in ice blocks which become detached from the glacier front. The melt water now builds an outwash plain over all depressed areas off the glacier front. The deposits of this plain are imperfectly stratified, with some boulders embedded, but with many more boulders scattered over its surface. These deposits are laid down only during the summer season, when alone the rain-bearing cyclones are able to invade the glacial anticyclone. With the end of each summer season melt water ceases to issue from the glacier, and the outwash area quickly dries out to become a locus of intense deflation. The winds of the glacial anticyclone now lift from the area all rock debris up to small pebble size, and carry it outward to be halted and held outside the outwash area, where a tundra vegetation has developed. During its transit the sand is largely separated from the silt, and is left in dunes, with the silt deposited in a loess apron surrounding the outwash. While carried in the air the sand, which moves near the outwash surface, drills all exposed boulders so as to produce from them either “ribbed” ventifacts or *Windkanten*, according as they are essentially homogeneous or heterogeneous in structure. During the succeeding summer the incipient ventifacts, already drilled on a single surface, which was directed toward the glacier front, are whirled about in the water floods or are moved through collision with the floating ice blocks, so that a new face is exposed to the sandblast with each succeeding winter. The ventifacts therefore increasingly approach an ellipsoid in their shape.

Deflation during the winters, by removing all fine rock debris from the outwash plain, leaves behind a “pebble pavement” similar to that of deserts, and it is due to a similar deflationary action.

When this down-wastage of the glacier within an intramarginal zone has entered its lower layers, which alone are able to carry the englacial material, the glacier surface becomes rock- and clay-veneered, and may even support vegetation. But now a zone of the glacier farther in from the margin is also invaded by the cyclones, and melt water issues from superglacial rivers and lakes so as to cover the outer zone. Thus the rivers develop canyons that divide the ice into islands large and small. The amounts of thaw water which issue from the glacier in this stage are excessive, and at intervals ice islands heavily laden with boulders are propelled from behind by the anticyclone winds and so are floated out over the outwash. This occurs during a downpour of rain, usually with some of the superglacial lakes also drained. The final stage in the liquidation of an intramarginal glacier zone is therefore marked over the outwash plain by floods of exceptional magnitude. Thus are left behind great stranded boulders due to secular weathering.

Since these ice islands require a considerable depth of water to float them, they will be concentrated within the central area, while the flotsam of forests which had been overridden by the glacier will generally be left stranded within the shallower marginal areas. The silt apron left surrounding the outwash area will be thickest next to its margin, and will thin outward in all directions.

After the final liquidation of an intramarginal zone of the glacier much of its englacial material will be left behind distributed unequally as ground moraine (till plain). Owing to the internal frontal movement within the glacier the interior ground moraine will be surrounded by heavier deposits, the marginal moraine. Both ground and marginal moraines are unstratified (till) — glacial, not glacio-fluvial deposits.

With the complete liquidation of an intramarginal glacier zone the glacier front retires and the outer margin of the outwash recedes. Vegetation now encroaches from the surrounding loess apron. The silt which is still being carried in the air from the inner part of the outwash area

can now be laid down and held on the outer zone of the outwash itself, a deposit which thins in the direction of the glacier, instead of away from it. This veneer of loess also continues to be deposited over the main loess apron. Such outwash and loess aprons are inevitable deposits of liquidated continental glaciers.

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CONTINUITY OF STRATA IN THE NEWARK SERIES

DEAN B. MCLAUGHLIN

THE Newark Series (Triassic) is well exposed along the Delaware River and in part along its tributaries in Pennsylvania and New Jersey. The sequence there consists of three formations: the Stockton sandstone at the base, the Lockatong black and gray argillite in the middle, and the Brunswick red shale. Diabase sills occur chiefly in the upper portion of the Brunswick shale. The formations are repeated by faulting, and one fault which crosses the Delaware just south of Stockton, New Jersey, exposes the base of the series and the underlying Paleozoic rocks in the very center of the Triassic belt.

Broader features of the Triassic rocks have been discussed in previous papers.[1-2] In a recent series of papers[3-6] the writer has published detailed geologic maps of areas near the Delaware River, and has given measurements of sections along the river and along streams a few miles from it. The thicknesses of the three formations are approximately as follows: Stockton, 5,100 feet; Lockatong, 3,900 feet; Brunswick, 6,000 feet near the Delaware River, and considerably greater farther west.

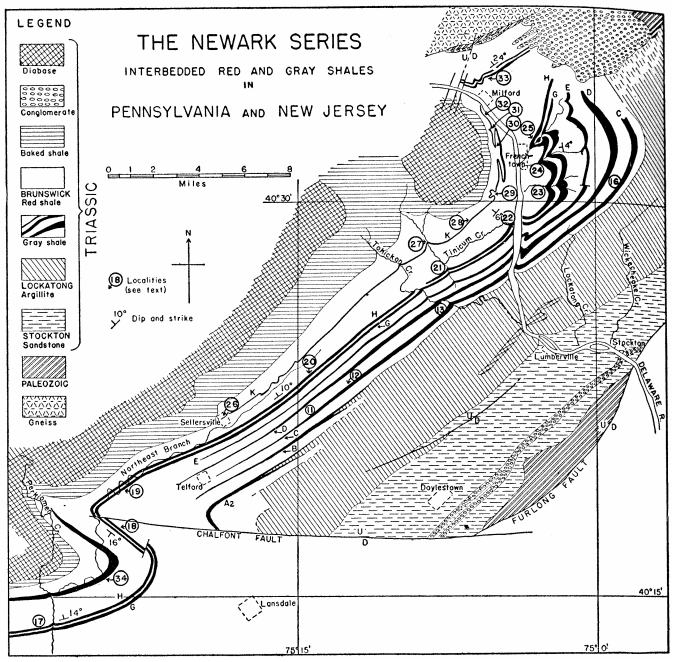


FIG. 1. Map of gray shale strata in the lower Brunswick formation in eastern Pennsylvania and western New Jersey. The area southeast of the Furlong fault is not mapped. Circled numbers are localities referred to in the text. Localities 1 to 10, 14, and 15 are marked on Figure 2

Several years ago the writer[7] pointed out the occurrence of extensive interbedding of red and black or gray argillites in the upper Lockatong and lower Brunswick formations in Pennsylvania. The present paper is concerned primarily with the continuity, along the strike,

of recognizable beds and groups of beds whose thicknesses are small compared with that of a formation.

Figure 1 is a map of the area that will be considered. It embraces nearly the entire known extent of the most widespread identifiable strata. Details of interbedding are not shown in the Lockatong formation, in order to avoid crowding in a map of such small scale. Several miles west of the Delaware River the Lockatong dark argillite becomes thinner through the extensive development of red argillites in its upper portion. This results in the "splitting off" of two thick gray shale members, at the top, from the main body of the formation. In accordance with a notation used in previous papers these are called A_2 and *B*. Above these, in the Brunswick formation, there are several conspicuous gray shale strata, designated *C* to *H* inclusive. The member *F*, which is thinnest and which disappears a short distance west of Tohickon Creek, is not shown in Figure 1. A thin member, *I*, is likewise omitted, and the next higher one, *K*, is indicated.

At their northeastern extremities all the shale strata pass along the strike into sandstone and conglomerate, near the north border of the Triassic belt, northeast of Frenchtown, New Jersey. There a large area of coarse conglomerate occurs in a reëntrant of the Triassic border. The writer interprets this body of conglomerate as an alluvial fan which formed at the mouth of a torrential stream that entered the Triassic basin from the high land to the north.

Of the gray shale members the two that are designated *G* and *H* have been traced for the greatest distance, from the hills northeast of Frenchtown to Perkiomen Creek and beyond (in the southwest corner of Fig. 1). Most of the others become thinner to the southwest and finally pinch out. The member *K*, however, runs into metamorphosed shale at Sellersville, where the diabase sill descends to a lower position in the series.

Another example of great extent along the strike is furnished by the thick conglomerate member several hundred feet above the base of the Stockton formation. Although its thickness varies from place to place, the stratum is certainly continuous. It is cut off by faults at both ends. Higher in the Stockton formation, the writer[8] mapped several thick members of hard arkosic gray sandstone which are separated by thick series of softer red and brown sandstones. These have been traced for about fourteen miles in uninterrupted outcrop.

Figure 2 is a large-scale detailed map of a small area near the Delaware River, where the interbedding of red and gray argillites is best developed in the Lockatong formation. Within the area of Figure 2 the thicknesses of the several members do not undergo great changes, and the rocks retain the same general character along the strike, except where the lower red argillite members near Lockatong Creek have been metamorphosed by a buried extension of the body of diabase that crosses the river at Point Pleasant.

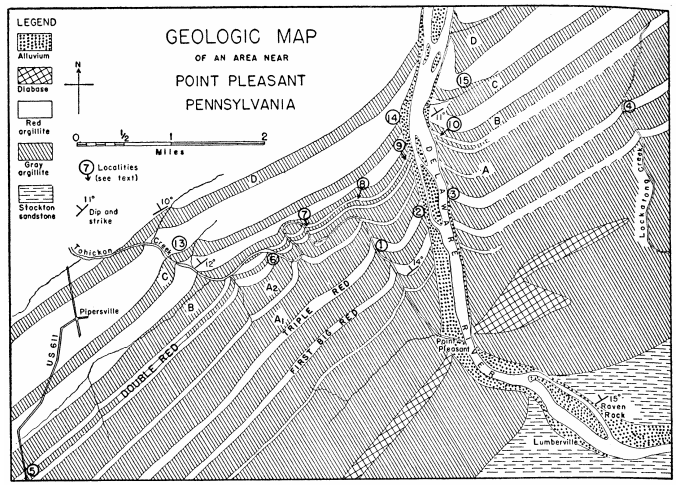


FIG. 2. Map of interbedded red and gray argillites near Point Pleasant, Pennsylvania. Circled numbers indicate localities referred to in the text

The red beds in the Loekatong have been named, for convenience, "First Thin Red," "First Big Red," "Triple Red," "Smith Corner member," and "Double Red." Beginning just above the "Triple Red" the designations of the gray argillite members are A_1, A_2, *B, C, D*, and so on. The top of *B* is considered the top of the Loekatong formation. Certain selected members will now be discussed in ascending order.

The "First Big Red" member is about one hundred feet thick and is well exposed in four sections: Tohickon Creek, the east bank of the Delaware, Loekatong Creek (where it has undergone contact metamorphism), and Wickecheoke Creek a few miles farther east, outside the border of Figure 2.

The "Triple Red" member especially shows good continuity of strata only ten to forty feet in thickness. Thus, at the localities marked 1, 2, 3, and 4 in Figure 2, the sections were measured, and are given in Table I. The section along Loekatong Creek (locality 4) is incompletely exposed, and the covered intervals have been associated with the several submembers in what is considered the most probable manner.

TABLE I

SECTIONS OF THE "TRIPLE RED" MEMBER

(Measurements are in feet.)

Locality	1	2	3	4
Red argillite	24	20	25	15 + 9 covered
Black argillite ...	33	26	25	5 + 32 covered
Red argillite	42	51	50	10 + 20 covered
Black argillite ...	21	13	9	16
Red argillite	18	21	40	40

The "Double Red" member is cut across in several places by Tohickon Creek and its tributaries and is well exposed on both sides of the Delaware. At the localities numbered 5 to 10 inclusive in Figure 2 sections were measured and are given in Table II. Several other sections were measured at intermediate places, and they show equally good agreement.

TABLE II

SECTIONS OF THE "DOUBLE RED" MEMBER

(Measurements are in feet.)

Locality	5	6	7	8	9	10
Red argillite	40 ±	37	38	39	34	36
Gray argillite	20 ±	32	30	32	29	36
Red argillite	40 ±	33	21	30	22	27

The gray argillite A_2 is noteworthy as the most extensive member that "splits off" from the Loekatong formation to the southwest. The "Smith Corner" red member which separates it from A_1 is only 30 feet thick at Tohickon Creek, but it thickens rapidly to the southwest and merges with lower red shales that have replaced A_1. At the Delaware A_2 is 270 feet thick. About 16 miles to the southwest, where it is cut off by the Chalfont fault, it consists only of two 35-foot gray members with about 50 feet of red shale between them. The beds are exposed in a large abandoned quarry close to the fault and are extensively shattered and sheared.

We omit details of the member ^{B} and simply refer to Figure 1 where its course is shown. It is the uppermost member of the Lockatong formation, and at its top in the Tohickon Creek section about 50 feet of interbedded red, gray, and chocolate-brown shale occurs.

The gray shale *C* contains a thick interbedded red stratum which is identifiable at many places a number of miles apart. At localities 11 to 16 inclusive, in Figures 1 and 2, measurements gave the sections listed in Table III.

TABLE III

SECTIONS OF GRAY SHALE *C*

(Measurements are in feet.)

Locality	11	12	13	14	15	16
Gray shale	10	10	33	30	25	23
Red shale	30	40	31	25	38	23
Gray shale	45	50	70	50	70	37

The writer omits detailed discussion of members *D, E*, and *F*. The courses of outcrop of *D* and *E* are shown in Figure 1. To the northeast they pass into sandstone; to the southwest they pinch out in the red shales near Telford.

The gray shale members *G* and *H* were called by the writer the "Graters" shales, from Grater's Ford (locality 17, Fig. 1) on Perkiomen Creek, where they were first studied.[9] At that place, and for several miles east and north, there are three rather than two gray members. But from the vicinity of Sellersville to the hills in New Jersey east of Frenchtown there are only two thick gray strata. At a few localities thin gray beds were found sixty to eighty feet above the thick member *H*. On the strength of this the two lower members are tentatively regarded as those which are continuous from New Jersey to west of Perkiomen Creek. Sections were measured at many places; the best were those at localities 17 to 25 in Figure 1. These are displayed diagrammatically in Figure 3.

The thin gray shale *K* is almost as easily traced as the thick members, and it maintains remarkably uniform thickness for several miles. It may disappear locally for one or two miles west of Tohickon Creek, but it reappears and continues several miles more to the southwest. Sections at localities 26 to 32 are shown in Figure 4. At ten to twenty feet below the main member there is a one-foot bed of soft bluish gray shale. This occurs in every well-exposed section except that of locality 26, which is far removed from the others. At some places there is a less persistent thin bed about fifteen feet above the main stratum.

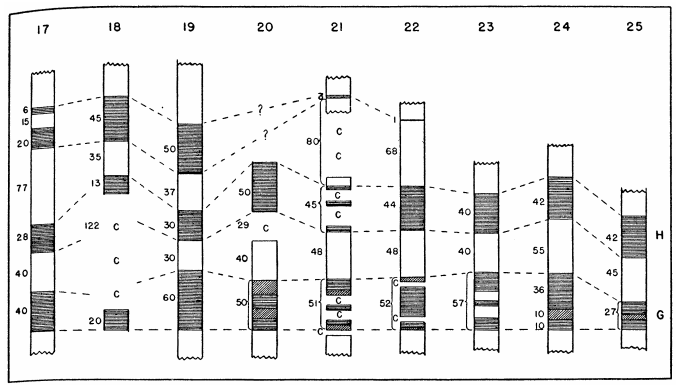


FIG. 3. Correlation of sections of the "Graters" shales at localities 17 to 25 (see Fig. 1). Symbols: open part of column, marked *C*, covered interval; unruled enclosed area, red shale; horizontal ruling, gray shale; diagonal ruling, brown shale or gradation from red to gray

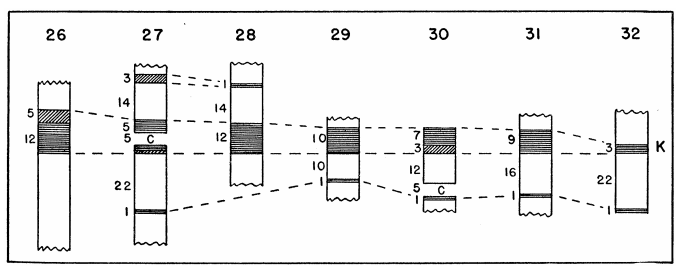


FIG. 4. Correlation of sections of gray shale member *K* at localities 26 to 32 (see Fig. 1). Symbols are the same as in Figure 3

North and northeast of Milford, New Jersey, two 50-foot strata of gray shale extend for a few miles (locality 33). On the assumption that there are no faults of appreciable displacement between Frenchtown and Milford, the computed height of these beds above the top of *H* is about 1,800 feet. Across the river, in Pennsylvania, a diabase sheet occurs at or below that horizon, and for many miles to the southwest either diabase or metamorphosed shale occupies that stratigraphic position. Near Perkiomen Creek, however, the intrusive is higher in the series, and a thick gray argillite member occurs 1,700 feet above the top of the Graters shales (locality 34). The Milford members are tentatively correlated with these beds some 30 miles away.

The fact that strata less than 50 feet thick retain approximately the same thickness and lithologic

character for 20 or 30 miles is a clear indication of uniform and fairly quiet conditions of sedimentation over areas of that extent. In particular, the persistence of the 15-foot member *K* for some 20 miles, and more especially the uniform thickness of the one-foot bed of blue shale just below it for 8 miles, suggest extremely quiet water. The Lockatong and other gray argillites and shales are very evenly bedded at many places, sun cracks and ripple marks are common, and calcareous beds are extensively developed at some horizons in the Lockatong formation.

The red shales generally are more irregularly bedded than the gray, and thin beds of fine sandstone are more widespread in them than in the gray. Evidently the deposition of red shale was associated with less quiet waters. On this point one observation that has been made at numerous places appears to the writer to be especially significant. At many of the contacts of red with gray shale there is a thin bed of brown shale, a true intermediate type. Where red overlies gray, such a place is often occupied by a sun-cracked gray stratum with red shale filling the cracks. In other places the gray shale has been reworked, so that the transition bed is composed of small angular fragments of gray in a dirty reddish or brown matrix. This "gray-in-red" breccia indicates the onset of the more turbulent conditions of red shale deposition. The converse, a "red-in-gray" breccia, has never been seen by the writer, though many contacts of gray shale above red have been examined.

During Stockton time the deposition was rather chaotic, and only large groups of beds a few hundred feet in thickness can be said to retain the same character for long distances. But during Lockatong time the region was occupied by a broad shallow lake, which frequently became dry. In Brunswick time more turbulent waters spread over the basin, bearing the red muds which formed the Brunswick shale. Several recurrences of the quiet lake conditions, however, gave rise to the extensive strata of gray shale in the Brunswick. Most of the sediment was probably brought into the basin from the north by torrential streams whose alluvial fans appear today as the bodies of conglomerate along the north border.

UNIVERSITY OF MICHIGAN

[1] McLaughlin, D. B., "A Great Alluvial Fan in the Triassic of Pennsylvania," *Pap. Mich. Acad. Sci., Arts, and Letters*, 24, Part IV (1938): 59-74. 1939.

[2] *Idem*, "The Distribution of Minor Faults in the Triassic of Pennsylvania," *ibid*., 27 (1941): 465-479. 1942.

[3] *Idem*, "The Revere Well and Triassic Stratigraphy," Proc. Penna. Acad. Sci., 17: 104-110. 1943.

[4] *Idem*, "Triassic Stratigraphy in the Point Pleasant District, Pennsylvania," *ibid*., 18: 62-69. 1944.

[5] *Idem*, "Type Sections of the Stockton and Lockatong Formations," *ibid*., 19:102-113. 1945.

[6] *Idem*, "The Triassic Rocks of the Hunterdon Plateau, New Jersey," *ibid*., 20:89-98. 1946.

[7] *Idem*, "A Note on the Stratigraphy of the Brunswick Formation (Newark) in Pennsylvania," *Pap. Mich. Acad. Sci., Arts, and Letters*, 18 (1932): 421-435. 1933.

[8] See note 5.

[9] See note 7.

THE BEVEL IN STONE AND STEEL TOOLS

AMOS R. GREEN

MANY theories have been advanced about the use of the beveled chipped point. It is the intention in this paper to present facts indicating that these beveled points have the characteristics of the pioneer's drill, a cutting tool designed to be revolved as it cut, and to compare beveled stone-cutting tools with beveled steel-cutting tools. In this article the bevel is regarded as a device to reinforce a cutting edge.

To facilitate comparison I have used letters to designate the various parts of the pioneer blacksmith drill[1] shown in Plate I, Figure 1: *A*, head; *B*, shank; *C*, right cutting bit; *D*, left cutting bit; *E*, cutting edge of right cutting bit; *F*, cutting edge of left cutting bit; *G* (not shown in Fig. 1), reinforcing bevel of right cutting edge; *H*, reinforcing bevel of left cutting edge. *CD* forms the face, and *JK* (not shown in Fig. 1) forms the back.

The pioneer blacksmith made his drill from a piece of steel bar. The cutting bits were formed by heating the piece of steel and hammering it out to the width of the diameter of the hole to be drilled and to a thickness that varied with the size of the hole. Then a V was formed of this flattened surface, the point of which was in line with the center of the square head at the other end. The cutting edge at the right upper side of the V, as the point of the drill is held facing one, was shaped by beveling the side back under; this bevel reinforced the edge so that, when pressure was applied to the shank as the drill was revolved, the cutting edge would not chip.[2] The drill was then turned 180 degrees, and the left cutting bit was made in the same manner.

If we compare the beveled stone point (Pl. I, Fig. 2) with the pioneer blacksmith drill, we may regard the notched base used to fasten it to the shank as part of the shank, *B*. We find two cutting bits *C* and *D*, on this chipped point. Comparing the right cutting bit *C* of the chipped point with the left cutting bit *D* of the pioneer drill we find a cutting edge, *F*, reinforced by a bevel, *H*, in each. Turning the chipped point over, as we did the drill, we discover that the cutting bit *D* has a cutting edge, *E*, reinforced by a bevel, *G* (not shown in Fig. 2), just as has the cutting bit *C* of the pioneer drill.

When the pioneer drill was placed in a hole the diameter of which was less than the diameter of the cutting bits, only the cutting edges touched the side of the hole, *E*, *F* (Pl. I, Fig. 6). Similarly, when the beveled point was placed in a hole the diameter of which was less than the

diameter of the cutting bits, only the cutting edges touched the side of the hole, *E*, *F* (Pl. I, Fig. 7).

When pressure was applied to the shank of the pioneer drill as it was revolved in a clockwise direction, *G* (Pl. I, Fig. 6), it cut the hole larger. When pressure was applied to the base of the beveled point as it was revolved counterclockwise, *G* (Pl. I, Fig. 7), in a hole in a lead bar, it cut fast enough to produce fine leaf shavings. When the angles of the bevels, *G* and *H*, of the cutting bits of the pioneer drill were measured in relation to their immediate face, *CD* (Pl. I, Fig. 1) and back (*JK*), they were found to be sixty-three and sixty-six degrees. In similar measurements of eleven of the beveled stone points, the angles of the bevels, *G* and *H* (Pl. I, Fig. 2), ranged from forty to sixty-eight degrees, with fourteen of the twenty-two bevels ranging from sixty to sixty-eight degrees. As much variation would probably be found in the pioneer drills if an equal number were available for measurement.

In the pioneer drill the cutting edges *E*, *F* (Pl. I, Fig. 1) are equidistant from a line drawn from the center of the head through the shank to the point of the V formed by the drill bits, so that both cutting edges bear equally on the edge of the hole being drilled. In the beveled stone point the cutting edges *E*, *F* (Pl. I, Fig. 2) are roughly equidistant from a line drawn from the center of the base to the point of the V formed by the cutting bits. The slight inequality could be compensated for in mounting the stone point on the shank.

The use of a bevel to reinforce a cutting edge is found in stone end and side scrapers, *A*, *B* (Pl. I, Figs. 3-4), which, as implements, have great antiquity. Side scrapers of the Mousterian period in France show this use of the bevel, *A*, *B* (Text Fig. 1). The stone scraper has one beveled cutting edge, as has the modern hand plane, and cuts on only one of the two strokes necessary in its operation, as does the hand plane. The shaper is a power tool with a single beveled cutting edge (Text Fig. 2) that cuts only on the forward stroke as it is operated by a reciprocating cam.

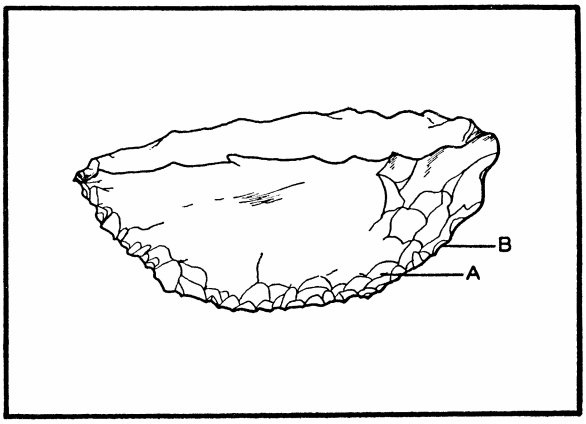


FIG. 1. Sketch of a stone Mousterian side scraper (from A. L. Kroeber, *Anthropology* [New York: Harcourt, Brace and Co., 1923], p. 159, fig. 18b)

In Michigan, as elsewhere, plowing brings to view stone axes and celts. These are tools designed to cut by striking heavy blows. Two bevels reinforce the cutting edge. The cold chisel, used for handwork or in the pneumatic hammer, is a present-day tool of this type. The method of use is changed in that the head of the chisel is struck a blow instead of the tool being swung on a handle and striking the blow, like the stone ax and celt. Little variation is found in the corresponding angles of the stone ax, the stone celt, and the cold chisel.

The comparison above shows that the stone-chipped bevel point has the characteristics of the pioneer blacksmith drill, a cutting tool that uses two beveled cutting edges designed to be revolved under pressure. The milling machine is a power tool with two or more beveled cutting edges revolving under pressure. The number of cutters depends on the type of work to be done.

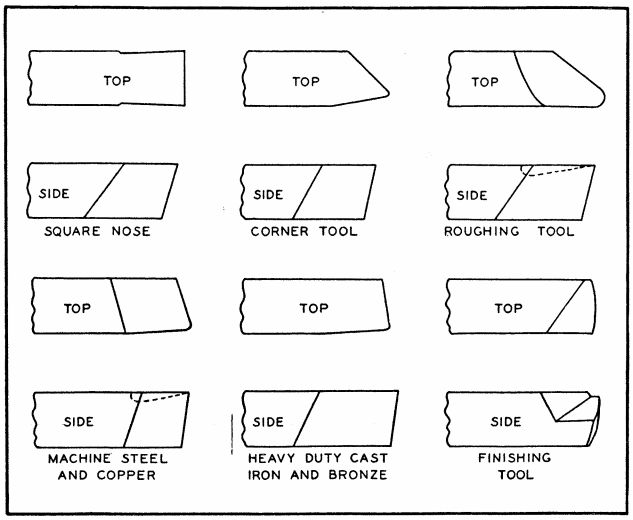


FIG. 2. Sketches of common types of shaper and planer bits that show the use of the bevel to reinforce the cutting edge (from Shop Theory Department, Henry Ford Trade School, *Shop Theory* [New York: McGraw-Hill Book Co., Inc., 1942], p. 114, fig. 484)

The planer is a power tool using one beveled cutting edge (Text Fig. 2). The principle on which the planer operates is the reverse of that of the stone scraper, the plane, and the shaper, for the object to be cut is moved back and cut on the forward stroke against the stationary beveled cutting edge.

The lathe, a very important power tool having one beveled cutting edge, reverses the operating principle of the beveled stone point, the pioneer drill, and the milling machine, for the object to be cut is revolved against a stationary beveled cutting edge, *A*, *B* (Pl. I, Fig. 5, and Text Fig. 3).

The stone scraper, hand plane, shaper, beveled stone point, pioneer drill, milling machine, stone ax and celt, cold chisel, planer, and lathe all illustrate the principle of reinforcing a cutting edge by means of a bevel. The scraper was the first tool fashioned by man for making other tools, and today we find the same device for

reinforcing the cutting edge used with special cutting materials inlaid on reinforcing steel bevels.

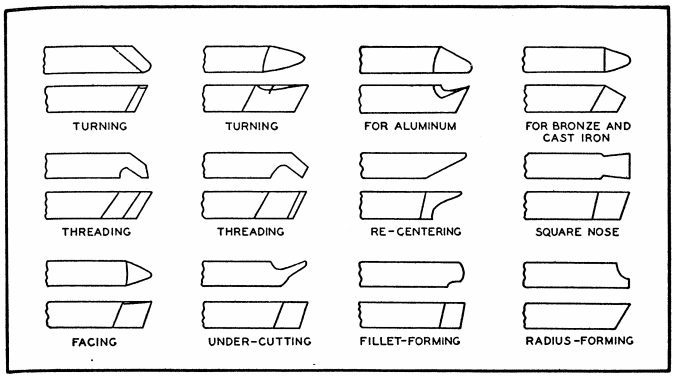


FIG. 3. Sketches of shapes of turning tools that show the use of the bevel to reinforce the cutting edge (from *Shop Theory* [as cited in caption of Fig. 21 p. 113, fig. 479)

ACKNOWLEDGMENTS

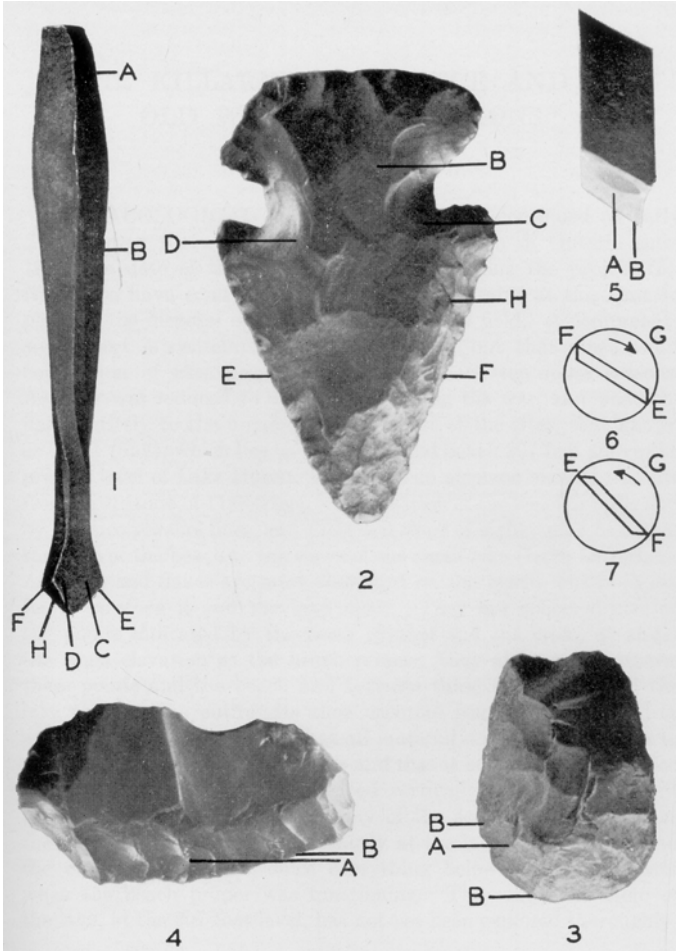
I am indebted to the McGraw-Hill Book Company for permission to reproduce Text Figures 2 and 3 from *Shop Theory* (see note 2). I am also under obligation to Messrs. Russel Thumm, James Olney, and Charles Borchers, mechanics, for information on power tools; to Mr. Richard Snodegrasse, of the University of Pennsylvania, for help with bibliography, and to Dr. Emerson F. Greenman, of the University of Michigan, for assistance in preparing the manuscript.

EAU CLAIRE, MICHIGAN

[1] This drill was made about 1880 by Mr. Francis Garrison, the son of a blacksmith who lived in Pipestone Township, Berrien County, Michigan.

[2] See *Shop Theory*, Revised Edition, Prepared by the Shop Theory Department, Henry Ford Trade School, Dearborn, Michigan (New York: McGraw-Hill Book Company, Inc., 1942), p. 112: "Do not grind more front clearance than is necessary, as it takes away the support from the cutting edge of the tool." The bevel in power tools is referred to as "clearance."

GREEN PLATE I



Beveled stone and steel tools

EXPLANATION OF PLATE I

FIG, 1. Steel pioneer blacksmith drill: *A*, head; *B*, shank; *C*, right cutting bit; *D*, left cutting bit; *E*, right cutting edge; *F*, left cutting edge; *H*, bevel reinforcing left cutting edge

FIG. 2. Chipped stone bevel point: *B*, shank; *C*, right cutting bit; *D*, left cutting bit; *E*, left cutting edge; *F*, right cutting edge; *H*, bevel reinforcing right cutting edge

FIG. 3. Stone end scraper found on surface in Berrien County, Michigan: *A*, bevel reinforcing cutting edge *B*

FIG. 4. Stone side scraper found on surface in Berrien County, Michigan: *A*, bevel reinforcing cutting edge *B*

FIG. 5. Cutting tool from small lathe: *A*, bevel reinforcing cutting edge *B*

FIG. 6. Sketch showing position of steel drill bits when placed in a hole whose diameter is less than the diameter of the cutting bits, with only the cutting edges *E* and *F* touching the side of the hole. *G*, direction in which drill is revolved to cut

FIG. 7. Sketch showing position of stone bits when placed in a hole whose diameter is less than the diameter of the cutting bits, with only the cutting edges *E* and *F* touching the side of the hole. *G*, direction in which point is revolved to cut

THE KILLARNEY SEQUENCE AND ITS OLD WORLD CONNECTIONS*

EMERSON F. GREENMAN

ARCHAEOLOGICAL excavations have been continued on early sites in the northern Georgian Bay region of Ontario since 1943, the date of the last publication concerning the project (5). New data have come to light which it is desirable at this time to place at the disposal of workers in the general field. A comprehensive report is contemplated for the future, but that must await completion of excavation, a matter of about ten more seasons. Activity was reduced to a minimum during the war, and was confined entirely to the uppermost and oldest of the sites, that known as GL-1 (5; 7), which lies on an abandoned beach 297 feet above the present level of Lake Huron. Plate I is an airplane view of this site from an altitude of 11,000 feet. The location of the beach is indicated by the two parallel lines, and there is a slope of eighty-nine feet from the base of the beach to the shore of the small lake (Lake Lumsden). Artifacts and flakes are most abundant on the beach, but both are found between it and the lake shore. They are collected also at the points indicated by the times symbol and the cross, at about the same elevation as the beach proper; they also occur between these points and the beach and between these two points and the lake shore. The entire site thus occupies some twenty or thirty acres, though it is probable that all material on the slopes down to the edge of the lake is not in place and that it has either been carried there by freshet streams or dropped vertically and to some extent horizontally with the washing away of the soil into the lake since the occupation of the site, necessarily at the level of the beach and the other two symbols, since everything below was under water when the beach proper was functioning. The southwest shore of the lake, at the 297-foot level, has not yet been explored thoroughly; but three or four specimens possibly of human origin have been found along the edge of the lake near its southern end. The site extends at least 300 feet north of the east end of the beach proper along the edge of the quartzite outcrops.

In 1942 a large thick ovate blade was unearthed at a depth of six inches in a section containing other implements and several thousand flakes of various sizes. Some of these flakes and others collected farther away in 1940, a total of 27, were later fitted to the implement, and a considerable portion of the original block of quartzite was restored (9).

In previous publications (5, p. 262; 7, p. 512) some doubt is expressed whether a specimen resembling an end scraper was more than an accidental form. In 1945 a specimen was recovered which can lay full claim to the designation, and the end scraper is an item in the trait list of this site (Pl. IIE), as it is for the other two sites (CH-1, KB-1) in this sequence at Killarney. The upper row in Plate II shows a suggested trend in the form and size of the end scraper from GL-1 to KB-1. The two from GL-1 and CH-1 are the only ones so far collected from those sites, but there are many from KB-1, all from the topsoil except one (Pl. II C), which is from the water-laid component of this site. Choppers of slate and quartzite occur on all three sites. They are for the most part roughly flaked in a rectanguloid form, or triangular, as is the one specimen from GL-1 (Pl. III, right), with the edge formed in three ways: by grinding, at KB-1 (Pl. IIF); by chipping, at KB-1 and CH-1 (Pl. II G, H); and by the original selection of a stone with a flat surface, or with two such surfaces intersecting at a low angle and utilizing them to form the edge. The lower third of the chopper from CH-1 (Pl. II G) is such a surface, and it forms the edge on the face shown. The opposite face is also a natural flat surface, sloping toward the edge but not intersecting at the right place. Coarse chipping half an inch up from the edge brought about intersection and completed the implement. Another chopper, from KB-1, has a very sharp straight edge formed by the intersection of two slanting cleavage surfaces, with no secondary chipping involved. The chopper from KB-1 (Pl. IIF) with a ground edge is the only such chopper from any of these sites, and all the choppers from KB-1 and CH-1 are from the topsoil or upper component, so far as can be determined. Though there is typological stratigraphy at CH-1 (6, p. 308) and though there are both typological and soil stratigraphy at KB-1 (Pls. IV-V), it is entirely possible, and even likely, that artifacts from the lower component at each site found their way to the zone of the upper component and were there collected. The large chopper from GL-1 (Pl. III, right) has its edge formed by the intersection of two natural cleavage planes. This specimen is 33.8 cm. long, 15.2 cm. wide, and 5.5 cm. thick. The last measurement was made 4 cm. to the right of the junction of the median ridge and the two lines forming the borders of the natural cleavage plane, as shown on the face in the illustration. In transverse cross section the outline is elliptical, as is that of the longitudinal cross section. This implement is regarded as a finished one, a chopper held in the two hands during use, the constriction to a point at the proximal end being intended to facilitate holding in the hands. In the outlines of its face and transverse cross sections it is similar to the neolithic ground celt, for which it could be regarded as a prototype. The edge has small flake scars, 4 mm. long at most, which may have been caused by use. The specimen to the left in Plate III is probably a heavy knife or saw. It is 30 cm. long, 13.5 cm. wide, and 5.5 cm. thick. The lower part of the specimen (see illustration) bears large flake scars on both faces. The upper part of the face shown is formed by two natural cleavage planes which make an approximately median ridge at their junction. The longest edge (that to the right) is formed by the intersection of the fracture plane shown and another on the reverse face. The latter is only 3 cm. wide and is coterminous with its complementary fracture plane, but much steeper. These two large implements lay side by side at the point indicated by the times symbol in Plate I, on the surface of a small dry channel bed in which a considerable number of flakes and small blocks of

quartzite, not yet collected, are exposed. The elevation appears, in the absence of exact measurement, to be close to that of the beach proper. These two specimens are not waterworn, and they were probably not far from their original positions, either vertically or horizontally. It is always the smaller flakes and artifacts that are found down the slopes and on the relatively level out washed sand which fringes the small lake.

The only other type new to this site which has not already been described in a publication is a narrow blade 11 cm. long and 3.1 cm. wide. It is evidently a spear point or a projectile point. There is a constriction at the base, both transversely and in longitudinal cross section. It seems to be a hafting expedient but is not too clearly intentional.

In Plate IV are shown other types in stone from KB-1. The leaf-shaped and stemmed points and blades in the upper row are all from the water-laid gravels from two to six feet below the surface, and were therefore contemporaneous with the formation of this beach when the waters of Lake Huron were twenty-eight feet higher than they are at present. The gorget end showing part of a drilled hole, and the unfinished rectangular gorget with concave sides, both of slate, are also from the water-laid component. These artifacts and the pottery from this component at KB-1 rather strongly suggest affinities with the Adena Aspect (4; 8; 14). The pottery (6, plate XXIIa; A, B, C), of which several rims and one conical base have been found, indicate large wide-mouthed jars with perpendicular rims and flat or slightly outsloping, or rounded, or edged lips. Decoration is lacking except for notches in the outer lip edge of one sherd, and this also bears a very indistinct imprint of a fabric on the outer surface. One body sherd shows paddle marking, but outer surfaces of all other sherds are smooth. The tempering material is granitic, of local origin, and the ware is friable.

The pottery from the topsoil of KB-1 (Pl. VA-L) indicates a smaller ware with thinner walls — wide-mouthed small jars with rims perpendicular or slightly flared outwardly. Decoration of rim sherds is abundant and consists chiefly of stamped or impressed elements made by the end of a stick (Pl. VE), by a notched stick (Pl. VB, F, H), by an implement with a serpentine edge (Pl. VC), by notching in the lip with the side of a stick (Pl. VA), and by incision (Pl. VE). Some rims are plain, like the sherds from the water-laid component (I-L). Those in Plate VJ-K, with vertical rims, are so similar to the rims from the lower component that they may have come from there. The larger (J) did, in fact, come from the bottom of a pit dug down from the surface, and there is another rim sherd of the same heavy undecorated type which came from a depth of 2.5 feet in the subsoil, a zone intermediate between the topsoil and the water-laid components for which the typology is not yet quite clear.

This pottery from the topsoil component at KB-1 has its closest affinities in the Brewerton focus of the Laurentian Aspect in New York (12, pp. 47-48, pls. XVI, XXX).

The typology of site CH-1 was not materially changed after a few weeks' excavation in the season of 1941 (6, pl. XXIIb), except for the addition of the chopper described in an earlier part of this report (Pl. IIG) and two pieces of pestle-like pecked slate, which may be unfinished forms.

In the typology and in the technique of implement manufacture site GL-1 shows mesolithic traits (5, p. 264), and the antiquity assigned to it through its relation to a post-Algonquin beach is a supporting factor (7, p. 528). A dominant feature of the stone-working technique of the mesolithic is the formation of an edge by very large flake scars which intersect at an angle sufficiently low to impart the proper amount of thinness back from the edge. Fine retouching for the purpose of forming a sharp edge, characteristic of the Mousterian handaxes (10, fig. 60, I:135) and the blades of the Solutrean (10, fig. 90, I:178), are for the most part absent from the mesolithic (compare 13, fig. 3, p. Ill; fig. 8, p. 118) on larger specimens. The edges of most of the implements from site GL-1 were formed in this way; the small amount of retouching that does occur is on small implements, and in all cases there is some doubt as to its intentional nature, except in the one end scraper from the site.

The *tranchet* type of edge, characteristic of the mesolithic and the early neolithic (10, fig. 261 g, II: 15; 13, 115), is suggested on at least two implements from GL-1 and on the large chopper from the same site (Pl. III, right).,

The semilunar blade is the major feature of the GL-1 typology both in point of the relative number and its scarcity elsewhere in the New World. This type of blade is a trait of the mesolithic of northern Africa (1, p. 102, and pl. 11, figs. 1, 3-6, 17), where they are made of flint and are retouched along the edges. Two of these types in the Museum of Anthropology, University of Michigan, collected near Birket-Quarun in the Fayûm,[1] are shown in Plate VM-N. On the larger specimen (N) the proximal end is specialized by blunted back retouching (along the left half of the curved edge), whereas the rest of this edge and also the straight edge are sharp as the result of retouching on both faces. The blade (O) is quite similar in outline to some from GL-1 (7, pl. IG) and to A and F in Plate VI.

Two semilunar blades of the same general type, in flint, are reported from a site near North Cape, Norway (11), where there are at least three sites which exhibit the same mesolithic techniques, and many similar artifact types, such as are found at GL-1 at Killarney (Pl. VID-E). Two types of semilunar blade occur here, that in Pl. VID-E and that in Plate VIG. The latter is of flaked slate, 19.5 cm. long and 7.5 cm. wide. A similar one from this site (11, fig. 4, p. 5) is 22 cm. long. Figures A-C and F of Plate VI are other types from these three sites (Nordskog, Kongshofmark, Hjemmeluft), and with small variations they are all duplicated at GL-1. Ground slate semilunar blades with a more upturned handle than that

in Plate VIG are common farther south in Norway (2, p. 65 and figs. 104-111).

These three sites in northern Norway lie at elevations between 24 and 30 meters above sea level and the artifacts from two (Kongshofmark and Hjemmeluft) lay on what was a beach at their respective levels (11, p. 36). The Tapes beach is at 20 meters' elevation and is placed in the Atlantic climatic phase, the period of the Littorina Sea (13, p. 325). Culturally this is the period of the Ertobölle, and of the Azilian in the British Isles (3, p. 325).

This manifestation of the semilunar blade in the European mesolithic and early neolithic, and at site GL-1 in Ontario, must be interpreted in connection with the presence of a semilunar implement, the ulu, in the Eskimo cultures. It is of further interest that the ground slate ulu is found on sites of the Laurentian Aspect in New York (12, p. 94), with which the upper component at KB-1 is related. There are three fragments from KB-1 and one from CH-1, two of flint and two of quartzite, which resemble the ends of small semilunar blades of the GL-1 type. Only a small part of the total area of each of these sites has so far been excavated, and it is quite possible that from the topsoil component of CH-1 through the water-laid component of KB-1 and on to the topsoil of that site a continuous occupation and a continuous development in artifact types may be represented. But it is too soon to do more than speculate on the possibility of a similar continuity between CH-1 and GL-1, which would under the present chronology involve some ten thousand years in a very restricted area (7, p. 528).

UNIVERSITY OF MICHIGAN

* The project has been supported since its beginning by grants from the Horace H. Rackham School of Graduate Studies, to which I am glad to acknowledge my obligations.

[1] Loaned to the Museum by Professor A. E. R. Boak, University of Michigan, who collected them from the surface in 1926.

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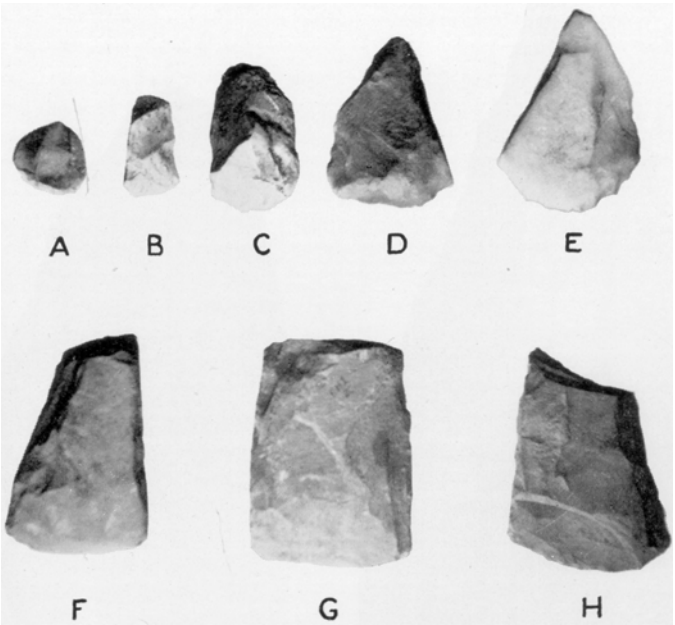
GREENMAN PLATE I

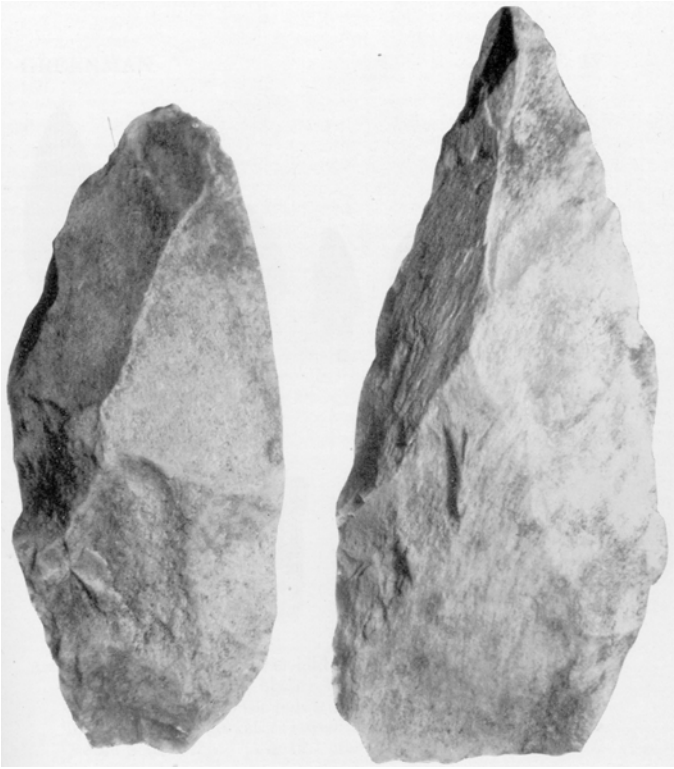
Airplane views of sites GL-1 and CH-1. The GL-1 beach is between the two parallel white lines. Site CH-1 is along the single white line crossing the road near the lower right corner. The lake is three quarters of a mile long

GREENMAN PLATE II



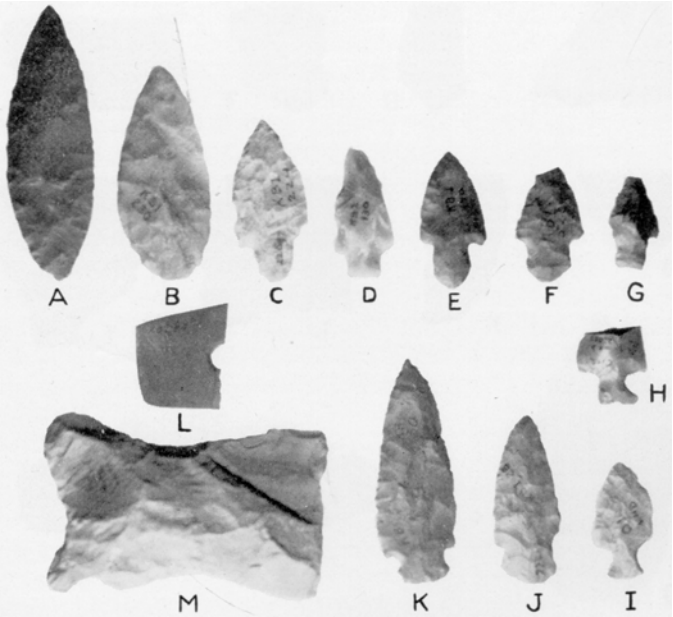
Scrapers and choppers from the three sites near Killarney. A, B, end scrapers from the KB-1 topsoil component; C, flint end scraper from the KB-1 water-laid component; D, quartzite end scraper from CH-1, probably from the water-laid component; E, quartzite end scraper, GL-1. F, H, flaked slate choppers, KB-1 topsoil; G, flaked chopper, CH-1 topsoil. G is 10.4 cm. long and the other figures are reduced on the same scale

GREENMAN PLATE III



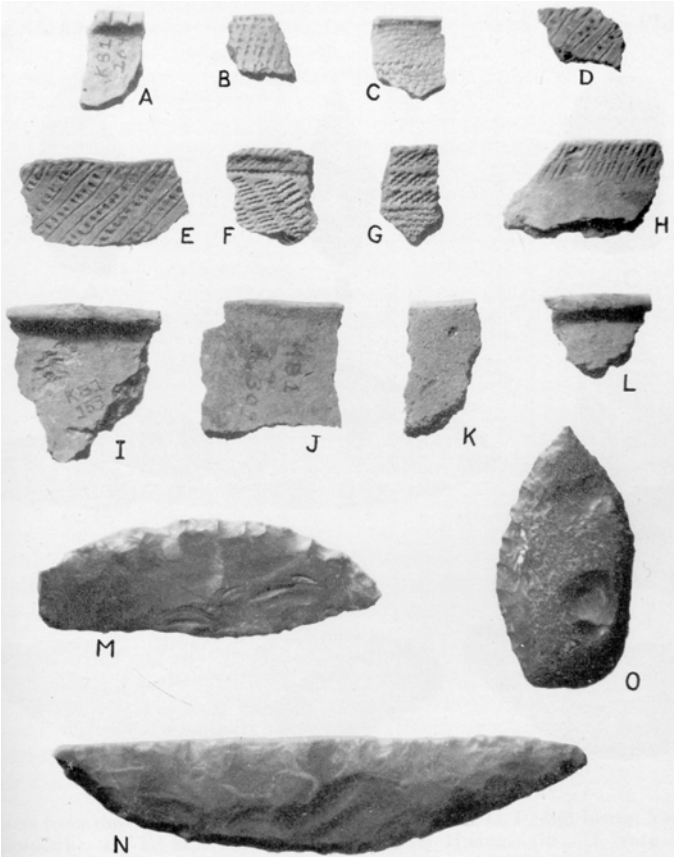
Two large quartzite implements from GL-1. Left, a knife or a saw, 30 cm. long. Right, a chopper, 33.8 cm. long

GREENMAN PLATE IV



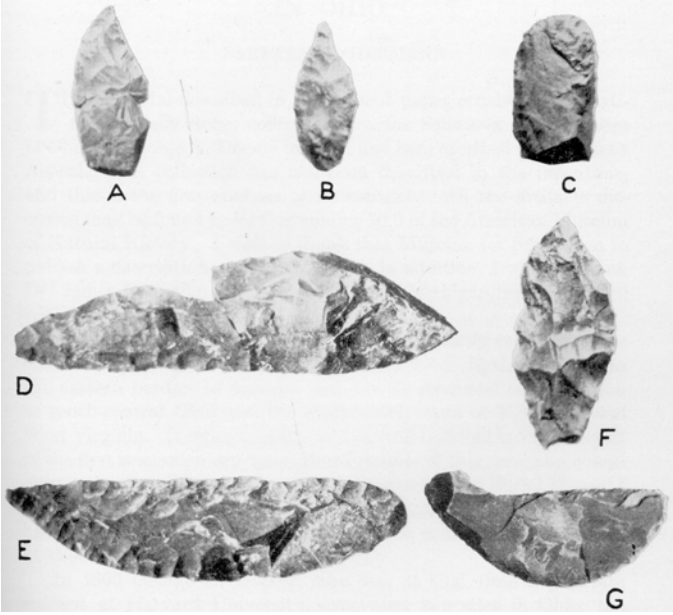
Artifacts from KB-1. Water-laid component: A, flint blade; B, quartzite leaf-shaped blade; D, quartzite projectile point; C, E, F, G, flint projectile points; L, portion of slate gorget; M, unfinished slate gorget. Topsoil component: H, I, J, K, projectile points, flint. A is 12.1 cm. long

GREENMAN PLATE V



Potsherds from topsoil component, KB-1, A-L. Flint implements from Birket-Quarun, Egypt: M, N, semilunar flint blades; O, ovate flint blade. Collected in 1924 by A. E. R. Boak

GREENMAN PLATE VI



Artifacts from three sites at North Cape, Norway. A, B, C, F, flint blades from Kongshofmark. D, E, flint semilunar blades from Hjemmeluft. G, slate semilunar blade from Nordskog. Scale not uniform. Rearranged from A. Nummedal, *Stone Age Finds in Finnmark*, Plates I, X, XII

AN ANALYSIS OF TWO ADENA SITES IN OHIO

BARBARA A. HERMANN

THE material described in the present paper consists of the artifacts, chiefly stone, collected from the Schwartz and Orr sites in Ohio by George A. Dorsey in 1895, and here ascribed to the Adena Aspect. The collection has not been described in the meantime, and this is the first analysis of its content.[1] All the artifacts discussed may be found in catalog volume 20.0 of the American Museum of Natural History. I wish to thank that Museum for permission to publish a description of this collection; in addition, I wish to thank Dr. James B. Griffin, of the University of Michigan, for his helpful criticisms and comments.

The Adena Aspect is a culture complex primarily confined to the central Ohio Valley.[2] It does not extend much farther west than the eastern borders of Indiana and has its strongest concentration in south-central Ohio and the neighboring areas of Kentucky and West Virginia. It represents the first mound-building burial complex of the first semisedentary agricultural peoples of this area, and consequently has been allocated by some authorities to the Burial Mound I period,[3] and by others to the Early Woodland.[4] It is regarded as having preceded the Hopewell Aspect of the same area and is dated at about 500 or 600 A.D.

In 1895 George A. Dorsey, who was at that time a graduate student at Harvard University, excavated two sites in Ohio, the first of which is described as the Schwartz site and the second as the Orr site. No field notes of any sort have been found concerning the excavations, although Dorsey in later correspondence insists there were some. Therefore any information on the two sites, other than that derived from artifact types, must be taken from, the correspondence of Dorsey with Professor Putnam, of Harvard University, and with Harlan I. Smith, of the American Museum of Natural History. But Dorsey's letters to Smith in 1905 contradict those to Putnam in 1895. Since it is felt that information set down at the time of excavation must be more accurate than that given from memory ten years later, only such scanty data as are available in the Putnam correspondence have been made use of here.

THE SCHWARTZ SITE

The Schwartz material came from two mounds and adjacent land in the Schwartz field, six miles south of the town of Newark, Licking County, Ohio. In a letter to Professor Putnam, July 24, 1895, written on top of one of the Schwartz mounds, Dorsey says:

> . . . this morning we began at seven in this mound — a quarter of a mile from Mr. Jury's place. There are two mounds in this field, one 9 feet high and 60 feet in diameter. I have four men on this (No. 1). The other mound is about fifty yards to the N.W. and I helped Hamilton stake it off and gave him two men. This mound (No. 2) is three feet high and 20 feet in diameter. Both have been plowed over about 25 years and the owner cleared off the timber and says he had always tried when plowing to level them as much as possible.

This letter is the primary source of firsthand information concerning the site.

In describing the Schwartz material, I have divided it into three groups, from the following locations: "Mound 1," "Mound 2," and "Schwartz farm." This was done on the basis of the listing of the materials in the American Museum catalog and on the slight amount of information in the Putnam correspondence.

Mound 1

Mound 1 was the larger of the two Schwartz mounds. Quite a few stone implements were found here, and, in addition, there were many flakes, which might be an indication of a workshop, where flakes had been chipped off cores to make implements.

Leaf-shaped points

Altogether, thirty-two leaf-shaped points were found in this mound. Twenty-four (the large majority) have planoconvex surfaces, five have biconvex surfaces, and the remaining three have biplane surfaces. All the points are shaped at the base; most are convex or rounded, but a few are almost pointed. They are of flint and range in color from black to gray to tan. The average length is 77 mm.; the average width, 26 mm.; and the average thickness, 9 mm.

Projectile points (stemmed)

There are ten stemmed projectile points; they are numbered and listed separately below, with measurements, since they exhibit considerable variation:

1. A gray flint point having a planoconvex surface, a straight base, and a stem with straight sides; 62 mm. long, 33 mm. wide, and 7 mm. thick.

2. A gray flint point having a biplane surface, a straight base, and a stem with straight sides; 88 mm. long, 33 mm. wide, and 7 mm. thick.

3. A tan flint point having a biconvex surface, a straight base, and a stem with straight sides; 57 mm. long, 21 mm. wide, and 7 mm. thick.

4. A gray flint point having a biconvex surface, a straight base, and a stem with convex sides; 62 mm. long, 25 mm. wide, and 8 mm. thick.

5. A broken, mottled gray flint point having a planoconvex surface and a straight base; broken in such a manner that measurements are of no value.

6. A black flint point having a planoconvex surface, a straight base, and a stem with straight sides; 77 mm. long, 36 mm. wide, and 8 mm. thick.

7. A gray flint point having a biconvex surface, a slightly convex base, and only a slight stem with convex sides; 48 mm. long, 24 mm. wide, and 9 mm. thick.

8. A light-gray flint point having a biconvex surface, a straight base, and a stem with straight sides; 40 mm. long, 23 mm. wide, and 8 mm. thick.

9. A dark-gray flint point having a planoconvex surface, a straight base, and a stem with slightly concave sides; 54 mm. long, 21 mm. wide, and 8 mm. thick.

10. A gray flint point having a planoconvex surface, a straight base, and a stem with convex sides; 89 mm. long, 30 mm. wide, and 10 mm. thick.

Projectile points (corner-notched)

Six corner-notched projectile points were found; they also exhibit considerable variation and are consequently listed separately below:

1. A gray flint point having a biconvex surface and a straight base; 33 mm. long, 33 mm. wide, and 8 mm. thick.

2. A gray flint point having a planoconvex surface and a straight base; 28 mm. long, 24 mm. wide, and 7 mm. thick.

3. A gray flint point having a planoconvex surface and a slightly concave base; 23 mm. long, 25 mm. wide, and 6 mm. thick.

4. A broken tan flint point having a planoconvex surface and a concave base; 23 mm. long, 38 mm. wide, and 9 mm. thick.

5. A broken pinkish-white flint point having a biconvex surface and a concave base; 73 mm. long, 32 mm. wide, and 8 mm. thick.

6. A gray flint point having a biplane surface and a convex base; 50 mm. long, 32 mm. wide, and 5 mm. thick.

Projectile points (side-notched)

Only one side-notched projectile point was found. It is an unfinished point of mottled pink-and-white flint, has a biconvex surface and a straight base, and is 27 mm. long, 21 mm. wide, and 6 mm. thick.

Unclassified projectile points

In addition to the points listed above, twelve projectile points were found which are either so unfinished or so broken that it is impossible to classify them.

Gorgets

Of the three gorgets found, one is of dark slate, slightly concave on both long sides, and straight on the two ends. The surface is biplane, and the holes are uniconical (drilled from one side only), 31 mm. apart, and 27 mm. from each end. The gorget is 112 mm. long, 66 mm. wide, and 9 mm. thick.

Another gorget is of gray slate, with superimposed black marks. This gorget is concave on the two long sides, straight on the two ends, and has a slightly biconvex surface. It has uniconical holes 27 mm. apart and 51 mm. from each end. The gorget is 144 mm. long, 61 mm. wide, and 10 mm. thick.

The third gorget, of gray slate, also has concave long sides, straight ends, and uniconical holes. Its surface, however, is planoconvex. The holes are 9 mm. apart and also 9 mm. from each end. This gorget is considerably smaller than the other two, being 46 mm. long, 28 mm. wide, and 8 mm. thick.

Pendants

Only one pendant was found at this site. It is of tan-colored stone, concave on both long sides, straight on the ends, and with transverse incisions on the lower edge. The surface is slightly biconvex. The pendant has only one hole, which is biconical (drilled from both sides). It is 96 mm. long, 23 mm. wide, and 10 mm. thick.

Celts

Of the two celts found in this mound, one has the poll broken off. This broken celt is of tan-colored granitic stone and has straight sides to the bit, which tapers very slightly. It is 69 mm. wide and 43 mm. thick.

The unbroken celt is of grayish-tan granitic stone, tapers slightly at the poll, and has a convex poll. It also tapers slightly toward the bit. It is 89 mm. long, 44 mm. wide, and 35 mm. thick.

Thumbnail scrapers

Two thumbnail scrapers were found. One of these is of light-gray flint and has a concavoconvex surface. There is a ridge slightly to one side, and the scraper has been flaked on both sides of the ridge. It is 31 mm. long, 21 mm. wide, and 8 mm. thick.

The other thumbnail scraper is of tan-and-white flint, with red marks. It, also, is slightly concavoconvex and ridged at one side, with flaking on both sides of the ridge. It is 25 mm. long, 18 mm. wide, and 6 mm. thick.

Side and end scrapers

One white flint scraper was found which is of the same pattern as the thumbnail scrapers but has secondary chipping on one side, as well as on the end, making it both a side and an end scraper. It has a planoconvex surface and is 98 mm. long, 26 mm. wide, and 7 mm. thick.

Side scrapers

A regular side scraper of gray flint was also collected. It has a planoconvex surface and is 37 mm. long, 29 mm. wide, and 10 mm. thick.

Pipes

One tubular pipe was found, a “blocked-end tube” of Ohio pipe-stone. This pipe is 159 mm. long and has a diameter of 20 mm. The diameter of the stem hole is 7 mm.; that of the bowl is 18 mm.

Gravers

A piece of worked grayish-white flint was collected which could conceivably be called a graver, for at one end there projects a small sharp point suitable for making incised lines. It has a planoconvex surface and is 47 mm. long, 16 mm. wide, and 4 mm. thick.

Abrading stones

The single rubbing implement collected is made of hematite, and is conical with a plane base; the surface has been worn smooth. It is 41 mm. in diameter and 33 mm. thick.

Pottery artifacts

Four orange-red (brick-colored) sherds were found at this site. These are body sherds, parts of two pottery vessels. They are thick (12-14 mm.), heavy, grit-tempered sherds that crumble very easily and have to be handled with considerable care. This is a plain ware, analogous in type to Fayette Thick.[5] which is relatively rare at Adena sites.

Mound 2

Mound 2 is the smaller of the two Schwartz mounds. Outside of three chipped flint fragments, the artifacts number only five in all. The three fragments are merely small pieces of flint which have been chipped from a core.

Projectile points (corner-notched)

Only two projectile points were found. One of these is of mottled pink-and-white flint. It has a biconvex surface, is corner-notched, and has a concave base. It is 17 mm. long, 20 mm. wide, and 6 mm. thick.

The other point is of tan-colored flint. It, also, has a biconvex surface and is corner-notched. The base, however, is straight rather than concave. It is 42 mm. long, 27 mm. wide, and 7 mm. thick.

Thumbnail scrapers

Two scrapers of the thumbnail or snub-nosed variety were found. One, of mottled pink-and-white flint with secondary chipping on the end and on one side, has a concavoconvex surface and no ridge. It is 41 mm. long, 23 mm. wide, and 7 mm. thick.

The other thumbnail scraper is of dark-gray flint, with a planoconvex surface and a ridge at one side. It is 24 mm. long, 14 mm. wide, and 6 mm. thick.

Side scrapers

Only one side scraper was collected. It is of mottled white flint and has a concavoconvex surface. It measures 72 mm. long, 17 mm. wide, and 7 mm. thick.

Schwartz Farm

The material listed here under “Schwartz farm” is believed to be that which Dorsey picked up in the fields near the mounds. It contains very few artifacts.

Leaf-shaped points

Of the two leaf-shaped points found, one is unfinished and the other is broken. Both are of mottled black-gray flint, with some brown, and have a planoconvex surface. The unfinished point has a convex base and is 98 mm. long, 45 mm. wide, and 8 mm. thick. The broken point has a straight base and is slightly larger, being 101 mm. long, 34 mm. wide, and 11 mm. thick.

Projectile points

Two broken projectile points were found, both of which are of whitish flint and have a planoconvex surface. One is stemmed, with the base of the stem broken; the other has the proximal end broken off. Each has an average length of 46 mm., an average width of 24 mm., and an average thickness of 7 mm.

Abrading stones

The single rubbing implement found is of a white, claylike stone, and is conical with a plane base. It is 55 mm. in diameter and 27 mm. thick.

Sandstone

A piece of brown sandstone was found which is plane on all four sides and worked smooth, the sides tapering off at one end. No use has been determined for this object, which is approximately an inch long and a quarter of an inch thick.

All the artifacts from the Schwartz site are of types that have been found in many Adena sites. No artifacts occurred that are not entirely Adena in type. This circumstance, as well as the paucity of artifacts and artifact types, is fairly conclusive evidence that the Schwartz site is an Adena site. It must be remembered, however, that this is primarily a typological study of artifacts, since no other information is available.

THE ORR SITE

The material from the Orr site was also collected by Dorsey in the summer of 1895. These finds were made on the Orr farms in Muskingum County, Ohio. Not only is there a complete absence of field notes relating to this material, but, unlike the Schwartz collections, it receives absolutely no mention in the correspondence between Dorsey and Professor Putnam.

A great many stone artifacts are listed in the American Museum catalog under the headings “Orr No. 1,” “Orr No. 2,” and so on, and “Orr General Diggings.” In order to handle the material more effectively, I have treated it under two headings only: “Orr Mounds” and “Orr General Diggings.”

This site is characterized by a greater variety of artifacts than is the Schwartz site, although examples of some of the types are not so numerous.

Orr Mounds

Leaf-shaped points

Five leaf-shaped points were found, two of which are broken. Of the three complete points, one is of gray flint and has a plano-convex surface and a convex base. It is 66 mm. long, 26 mm. wide, and 7 mm. thick.

Another of the complete points is of mottled gray-and-tan flint and has a biconvex surface and a straight base. It is 85 mm. long, 37 mm. wide, and 11 mm. thick.

The third complete point is of black flint and has a planoconvex surface and a convex base. It is 68 mm. long, 35 mm. wide, and 8 mm. thick.

Of the two broken points, one has a planoconvex surface and a straight base. No measurements of this point were taken, for they would not be informative enough to be of any value.

The other broken point is of mottled light-gray flint, with a slightly convex base. It is 38 mm. wide and 7 mm. thick.

Projectile points (stemmed)

Twelve stemmed projectile points were found. They are listed separately below, since they exhibit considerable variation:

1. A mottled gray flint point with a biconvex surface; broken, probably in manufacture; shape of sides of stem indeterminable because base is broken; 41 mm. long, 23 mm. wide, and 8 mm. thick.

2. A mottled pink-and-white flint point having a planoconvex surface, a convex base, and a stem with convex sides; 55 mm. long, 22 mm. wide, and 8 mm. thick.

3. A gray flint point having a planoconvex surface and a convex base; only slightly stemmed, the sides of the stem being slightly convex; 110 mm. long, 35 mm. wide, and 8 mm. thick.

4. A broken point of tan flint having a planoconvex surface, a straight base, and a stem with straight sides; 29 mm. wide, 8 mm. thick, length indeterminable.

5. A black flint point having a biconvex surface, a convex base, and a stem with slightly concave sides; 91 mm. long, 32 mm. wide, and 10 mm. thick.

6. A gray flint point having a planoconvex surface and a convex base; only slightly stemmed, the sides of the stem being slightly convex; 57 mm. long, 39 mm. wide, and 8 mm. thick.

7. A mottled gray flint point having a biconvex surface, a straight base, and a stem with straight sides; 112 mm. long, 34 mm. wide, and 10 mm. thick.

8. A broken black flint point having a planoconvex surface, a convex base, and a stem with convex sides; 7 mm. thick (the only significant measurement).

9. A dark-gray flint point having a biconvex surface, a slightly convex base, and a stem with straight sides; 67 mm. long, 24 mm. wide, and 8 mm. thick.

10. A broken black flint point having a biconvex surface, a convex base, and a stem with slightly convex sides; 67 mm. long, 34 mm. wide, and 7 mm. thick.

11. A broken black flint point with a planoconvex surface and a convex base; measurements indeterminable.

12. An unfinished point of mottled gray-white flint, with a concavoconvex surface; shape of base indeterminable; only partly stemmed; 76 mm. long, 27 mm. wide, and 8 mm. thick.

Projectile points (corner-notched)

Six corner-notched flint projectile points were found. These also exhibit considerable variation and are consequently listed separately below:

1. A mottled dark-pink-and-white flint point with a planoconvex surface and a straight base; 81 mm. long, 29 mm. wide, and 9 mm. thick.

2. A grayish-white flint point with a planoconvex surface and a straight base; 53 mm. long, 26 mm. wide, and 7 mm. thick.

3. A dark-gray flint point with a planoconvex surface and a straight base; broken in manufacture; no significant measurements possible.

4. A light-gray flint point with a biplane surface and a slightly convex base; 47 mm. long, 36 mm. wide, and 6 mm. thick.

5. A gray-and-rust-colored flint point with a biconvex surface and a convex base; 45 mm. long, 36 mm. wide, and 8 mm. thick.

6. A light-gray flint point with a planoconvex surface and a slightly convex base; broken in manufacture; 48 mm. long, 30 mm. wide, and 7 mm. thick.

Projectile points (side-notched)

Only three side-notched points were found:

1. A black flint point with a biconvex surface and a straight base; 41 mm. long, 20 mm. wide, and 7 mm. thick.

2. A gray-brown flint point with a planoconvex surface and a straight base; 54 mm. long, 31 mm. wide, and 8 mm. thick.

3. A light-gray flint point with a planoconvex surface and a convex base; 41 mm. long, 30 mm. wide, and 6 mm. thick.

Unclassified projectile points

In addition to the points described above, there are seven flint points which are so broken or so unfinished that they cannot be classified.

Celts (hematite)

Two hematite celts were found, both of which are very small and have biconvex surfaces. One is 55 mm. long, 34 mm. wide, and 11 mm. thick. This celt is very slightly tapered at the bit, the poll being broken. The other celt is so badly broken that measurements are of no value.

Celts (granitic)

Seven stone celts were found, two of which are broken; they are listed below:

1. A large celt of granitic stone, with the poll broken, but with considerable tapering at the bit; 141 mm. long, 66 mm. wide, and 48 mm. thick.

2. A celt of grayish-green granitic stone, with straight sides to the bit, but with slight tapering at the poll; poll convex; 95 mm. long, 53 mm. wide, and 23 mm. thick.

3. Another celt with straight sides to the bit and with tapering at the poll; poll convex; 83 mm. long, 46 mm. wide, and 21 mm. thick.

4. A celt of gray granitic stone, with slight tapering at the bit and at the poll; poll convex; 101 mm. long, 52 mm. wide, and 38 mm. thick.

5. A celt of tannish stone, with slight tapering at the bit and decided tapering at the poll; poll convex; 124 mm. long, 51 mm. wide, and 37 mm. thick.

6. A small celt with a very convex poll and considerable tapering at the poll, the bit being only very slightly tapered; 75 mm. long, 39 mm. wide, and 24 mm. thick.

7. A broken celt with slight tapering at the bit and with the poll broken off; 50 mm. long, 44 mm. wide, and 17 mm. thick.

Adzes

Three adzes of granitic stone were found. One of these is grayish-green, with slight tapering at the poll and with straight sides to the bit. It is 85 mm. long, 38 mm. wide, and 23 mm. thick.

Another is tan-colored, with tapering at the poll and with straight sides to the bit. It is 84 mm. long, 49 mm. wide, and 18 mm. thick.

The third is an unfinished adze which had been grooved to make hafting possible. There is decided tapering at the poll, but not at the bit. The bit edge is unfinished. This adze is 106 mm. long. There is decided tapering at the poll, but not at the bit. The bit edge is unfinished. This adze is 106 mm. long, 48 mm. wide, and 27 mm. thick.

Drills

There are two drills in this group. One of these is of black flint and has a biconvex surface and a straight, expanded base. It is 50 mm. long, 11 mm. wide (25 mm. wide at the base), and 7 mm. thick.

The second drill is of gray flint and is broken at the base end. It has a biconvex surface and is 46 mm. long, 16 mm. wide, and 7 mm. thick.

Abrading stones

One of the two abrading stones found is a white, chalklike hemisphere, the surface of which has been worn quite smooth. It is 24 mm. in diameter and 26 mm. thick.

The other is a semiconical tan-colored stone, the surface of which has been worn very smooth. It is 44 mm. long, 29 mm. wide, and 32 mm. thick.

Gorgets

Three gorgets were found, all made of slate. One of these is a rather greenish semikeeled bar gorget with two uniconical holes 50 mm. apart and 62 mm. from each end. It is 177 mm. long, 23 mm. wide, and 23 mm. thick.

Another of these gorgets is gray, and reel-shaped, with a biplane surface and uniconical holes 43 mm. apart and approximately 40 mm. from each end. It is 128 mm. long, 82 mm. wide, and 7 mm. thick.

The third, a bar gorget, had been broken, probably in manufacture. The one end remaining is straight, the two sides slightly convex. The surface of this gorget is slightly biconvex, and the holes are biconical. The gorget is 76 mm. long, 39 mm. wide, and 6 mm. thick.

Thumbnail scrapers

One scraper of the thumbnail or snub-nosed variety was found. It is an unfinished scraper of gray flint, with a planoconvex surface and a ridge just to one side. It is 28 mm. long, 17 mm. wide, and 6 mm. thick.

Hafted scrapers

Two hafted scrapers were found at this site. One of these is a side-notched scraper of light-gray flint, with a planoconvex surface and a convex base. It is 26 mm. long, 22 mm. wide, and 6 mm. thick.

The other hafted scraper is of grayish-tan flint, with a biconvex surface and a slightly convex base. It had been made from a stemmed point. It is 37 mm. long, 30 mm. wide, and 9 mm. thick.

Side scrapers

The single side scraper found is of mottled pink-and-white flint and has a planoconvex surface. It is 34 mm. long, 19 mm. wide, and 4 mm. thick.

Unclassified scrapers

An unfinished scraper of white flint with a planoconvex surface was collected. It is 45 mm. long, 30 mm. wide, and 9 mm. thick. This is probably a side scraper.

Pendants and ornaments

Three slate objects were found which may be described as pendants or ornaments. One of these, made of light-gray slate, is broken, but is best described as "shield-shaped." It is concave on both long sides, plane on one end and double-pitched on the other, and has a single biconical hole. It is 104 mm. long, 35 mm. wide, and 7 mm. thick.

Another is a gray-and-rust-colored slate ornament with slightly convex ends and sides and without holes. It was probably intended for a gorget, for it is broken where the holes would have been drilled. It is 142 mm. long, 51 mm. wide, and 9 mm. thick.

The third ornament is a drop-shaped pendant with a uniconical hole pierced at the small tapering end. It was impossible to obtain accurate measurements of the pendant.

Copper beads

What appear to be about six beads (several whole ones, the rest in fragments) were collected. The whole beads are rather long, their length (3-18 mm.) being about twice their diameter (2-6 mm.). These beads appear to have been made from sheet copper which was rolled and then cut. They are heavily encrusted with copper salts, but much of the original metal remains.

Copper bracelets

Two copper bracelets were found at this site. One of these, which now shows exfoliation and is heavily encrusted with copper salts, had been rolled from sheet copper. It is ellipsoidal, 91 mm. long, and 75 mm. wide. The diameter of the copper roll is about 6 mm.

The second bracelet, which is also heavily encrusted with copper salts, had been made from a rod of copper, with much of the original metal surface remaining. It is ellipsoidal, like the first, and is heavier in the middle and tapers to each end. It is 92 mm. long, 71 mm. wide, and 8 mm. thick at its thickest point.

Mica

Quite a few fragments of mica, as well as some rather large sheets of it, were found at this site. No definite designs or shapes can be recognized, however.

Fayette Thick pottery

Altogether, six sherds of a type analogous to Fayette Thick were found. They are all body sherds, parts of three pottery vessels, and are of a plain, thick, grit-tempered ware with a coarse texture. All are orange-red (brick-colored). The thickness varies from 15 to 16 mm. Some of the specimens became plastic on short immersion in water, indicating either a very low firing temperature or, perhaps, no firing at all.

Adena Plain pottery[6]

One sherd of the Adena Plain type was found. It is an orange-red rim sherd and is grit-tempered with a black material. The texture is medium-coarse, and the hardness ranges from 2.0 to 2.5.[7] In profile the sherd shows that the original pottery vessel was a jar with a rounded lip and a vertical rim. This ware is not nearly so friable or so heavy as the other sherds found at this site. Its average thickness is only 7 mm.

Orr General Diggings

Leaf-shaped points

There are two leaf-shaped points in this material. One of these is a broken point of dark-gray flint, with a biconvex surface and a convex base. It is 46 mm. wide and 16 mm. thick.

The other is an unbroken point of mottled gray flint, with a slightly convex base and with one surface plane, the other slightly convex. It is 107 mm. long, 56 mm. wide, and 10 mm. thick.

Projectile points (stemmed)

Of the three stemmed projectile points found, one is of mottled pink-and-white flint and had been broken in manufacture. It has a planoconvex surface, a straight base, and a stem with straight sides. It is 66 mm. long, 24 mm. wide, and 7 mm. thick.

Another stemmed point is of whitish flint, with a biconvex surface, a concave base, and a stem with slightly convex sides. It is 34 mm. long, 30 mm. wide, and 7 mm. thick.

The third stemmed point is also of whitish flint with a biconvex surface, a concave base, and a stem with slightly convex sides. It is 37 mm. long, 33 mm. wide, and 8 mm. thick.

Projectile points (corner-notched)

Two corner-notched projectile points were found. One of these is of gray flint and has a biconvex surface and a slightly convex base. It is 31 mm. long, 19 mm. wide, and 5 mm. thick.

The other point is also of gray flint, with a slightly biconvex surface and a straight base. It is 44 mm. long, 28 mm. wide, and 7 mm. thick.

Projectile points (side-notched)

Only one side-notched projectile point was found, a light-gray flint point with a biconvex surface and a straight base. It is 37 mm. long, 28 mm. wide, and 7 mm. thick.

Unclassified projectile points

In addition, there are four points that are either so unfinished or so broken that it is impossible to determine their type.

Gorgets

Only one gorget occurs in this group, a broken slate gorget with tapering sides and convex ends that may be

described as a bar gorget. It has a biplane surface and a single biconical hole. It is 82 mm. long, 35 mm. wide, and 6 mm. thick.

Thumbnail scraper

A single thumbnail scraper was found, an unfinished one of mottled light-gray-and-white flint. It has a planoconvex surface, but is without a central ridge. It is 33 mm. long, 23 mm. wide, and 4 mm. thick.

Although quite a few artifacts were collected at the Orr site, the actual number is really very small when compared with the great quantity found at Hopewell sites. This paucity, in conjunction with the fact that all the artifact types are ones that are consistently found at Adena sites, is enough, I believe, to permit us to consider the Orr site an Adena site, despite the lack of information concerning mound structure and burial traits. No artifact was found (with the possible exception of the shield-shaped pendant and the semikeeled bar gorget) that is not a common Adena type.

The trait list presented in Table I indicates the types of artifacts found at the Schwartz and Orr sites, as well as the exact number of examples of each.

TABLE I

COMPLETE TRAIT LIST OF ARTIFACTS FROM THE SCHWARTZ AND ORR SITES

Trait	Schwartz mound 1	Schwartz mound 2	Schwartz farm	Orr mounds	Orr general diggings	Total
Leaf-shaped points	32	0	2	5	2	41
Projectile points (stemmed)	10	0	1	12	3	26
Projectile points (corner-notched)	6	2	0	6	2	16
Projectile points (side-notched)	1	0	0	3	1	5
Projectile points (misc.)	12	0	1	7	4	24
Thumbnail scrapers	2	2	0	1	1	6
Side scrapers	1	1	0	2	0	4
Side and end scrapers	1	0	0	0	0	1
Hafted scrapers	0	0	0	2	0	2
Hematite celts	0	0	0	2	0	2
Granitic celts	2	0	0	7	0	9
Adzes	0	0	0	3	0	3
Pendants	1	0	0	2	0	3
Pendants (shield-shaped)	0	0	0	1	0	1
Bar gorgets	0	0	0	1	1	2
Semikeeled bar gorgets	0	0	0	1	0	1
Reel-shaped gorgets	0	0	0	1	0	1
Gorgets (misc.)	3	0	0	0	0	3
Tubular pipes	1	0	0	0	0	1
Gravers	1	0	0	0	0	1
Drills	0	0	0	2	0	2
Abrading stones	1	0	1	2	0	4
Sandstone objects	0	0	1	0	0	1
Fayette Thick sherds	4	0	0	6	0	10
Adena Plain sherds	0	0	0	1	0	1
Mica	0	0	0	*x**	0	*x**
Copper bracelets	0	0	0	2	0	2
Copper beads	0	0	0	6	0	6
Total	78	5	6	75	14	178

* Fragments.

COMPARISON OF SCHWARTZ AND ORR ARTIFACTS WITH THOSE FROM OTHER ADENA SITES

In order to have a more complete picture of the place of the Schwartz and Orr material in the Adena Aspect, I have carefully compared the data, artifact for artifact, with the data from eleven Kentucky Adena sites discussed by Webb in Volume V of *The University of Kentucky Reports in Anthropology and Archaeology*. In addition, they were closely correlated with Greenman's Adena trait list and with data from the type site, the Adena mound.[8]

Table II shows the percentage of similarity between the Schwartz and Orr sites and the eleven Kentucky Adena sites, as well as the Adena type site and Greenman's Adena trait list. The Schwartz and Orr sites are also compared with each other.

TABLE II

PERCENTAGE OF SIMILARITY BETWEEN SCHWARTZ AND ORR SITES AND OTHER ADENA SITES

Site	Percentage of similarity					
	Schwartz site			Orr site		
	Aspect	Phase	Pattern	Aspect	Phase	Pattern
Schwartz					37.0	..
Orr		37.0	..	..	..	..
Wright		22.8	..	..	27.7	..
Drake		..	18.0	..	..	16.0
Mt. Horeb		23.0	..	..	..	14.0
Morgan Stone		26.0	..	..	30.0	..
C. & O.		24.0	..	43.0	..	..
Robbins		28.0	..	..	29.0	..
Riley and Landing		..	18.0	..	..	12.5
Crigler		27.0	..	..	35.0	..
Hartman		27.0	..	..	22.0	..
Peter Village		30.0	..	..	36.0	..
Grimes		27.0	..	..	36.0	..
Adena		..	19.0	..	..	17.0
Greenman's trait list		28.0	..	..	33.0	..

Using the McKern Midwest Taxonomic Classification, we find that ten of the sites, as well as Greenman's Adena trait list, have similarities close enough to the Schwartz site to warrant placing them in the same phase. Three have similarities close enough to be within only a pattern relationship, and none are close enough to place them within the same aspect.

Applying the same criteria to the Orr site, we find that one site, the C. & O. mounds at Paintsville, Kentucky, has a percentage of similarity high enough to place the two sites within the same aspect. Nine are close enough to be considered members of the same phase, and four have only a pattern relationship.

Wherever there is a pattern relationship only, it is important to note that the lack of relationship is due to the fact that these sites, in comparison with the Schwartz and Orr sites, have relatively few artifact types. Thus, it is not that there are traits and that these traits are different, but that the site compared does not have many traits at all. This is also true to a significant extent in the phase relationships, for here, too, one of the sites compared usually has considerably more traits than the other.

This is, I believe, a weakness in following a rigid classificatory procedure, for even if every trait at a small site should match traits at a larger site, there would still be a very slight degree of relationship because of the relative number of traits. Of course, the numbers of traits exhibited are often significant, but only when they are outstandingly different, as they would be for traits found at an Adena site and a Hopewell site. For Adena sites, which consistently show few artifact types, there should be a system of classification that would depend not on the total number of traits, but on the percentage of traits at the particular site that are similar to those at

the other sites. In this way, sites that may be early in the period and have relatively few traits for that reason could still be compared fairly accurately with other sites having more artifact types.

CONCLUSIONS

Certain definite conclusions may be drawn from the description of the artifacts found at the Schwartz and Orr sites, from their comparison with more recent known Adena sites in Kentucky as well as with data on the type site and with Greenman's Adena trait list, and from a study of their distribution.

We find, on the basis of the twenty-seven possible comparisons, that nineteen sites are within a phase relationship, that one definitely has an aspect relationship, and that the remaining ones are at least in the same pattern. If we employed the modification suggested in judging the percentage of similarity, we should find an even closer relationship. The sites would be so closely related to each other that there could be no doubt that they were at least members of the large culture complex known as Adena that prevailed at an early time in the Ohio Valley.

Further evidence of this is the fact that all the artifact types from these sites (with the exception of the shield-shaped pendant and the semikeeled bar gorget) are consistently found at Adena sites, and in the geographical area comparable to that which the Adena complex occupied.

It is significant to note that every artifact collected at the Schwartz and Orr sites can be found in not one, but many Adena sites. Not all the types occur at every site, of course, but they do occur at a sufficient number of *known* Adena sites to leave no doubt as to their place as Adena types. In brief, all evidence indicates that the Schwartz and Orr sites cannot be anything but Adena sites with what is actually a high order of relationship, though this is not apparent in a strict taxonomic classification.

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[1] The collection is referred to, however, by Griffin, 1945.

[2] See Webb and Snow, 1945, Map I.

[3] Ford and Willey, 1941.

[4] Griffin, 1946.

[5] See Griffin, 1943.

[6] See Haag, 1940.

[7] See March, 1934.

[8] See Greenman, 1932.

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