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A CARTOGRAPHIC CAVALCADE

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It might be expected that the President of The Ohio Academy of Science would be the spokesman for the scientific community of Ohio. In a sense I look upon this situation as a challenging opportunity and a responsibility. My worthy predecessors in this position have discharged their obligations well and I am the beneficiary of their good works. And, before this day is done, the mantle of responsibility will be passed to the new President.

It would be presumptious, indeed, if I should undertake to speak with authority for the biological sciences represented in The Ohio Academy of Science. In spite of something more than a casual or cursory knowledge of these fields I must leave to others more competent than I the responsibility for interpreting the findings of biological science to the professional and lay audience. Two years ago this was ably done by Dwight M. Delong, a distinguished entomologist and colleague at The Ohio State University.

By training and by long service in one of the earth sciences I feel a little more at home among the physical scientists than among the biologists. Yet the subject matter of the physical sciences including the earth sciences has become so rich and diversified that the geologist, the meteorologist, the physicist, and the chemist must specialize in some segment of his field. I remember with great pleasure Glenn H. Brown's presentation a year ago on the "Structure of Liquids and Solutions."

In the Academy other fields such as conservation, science education, and anthropology and sociology are now represented by organized sections with the usual complement of officials and dedicated members. In the fields of conservation and science education I have a special interest but there are others who are competent to speak eloquently about the contributions of these fields to the larger body of knowledge commonly known as science.

In searching for a title for these random remarks on cartography I have found it easier to choose a title than to compose an essay to fit the title. I rather like as a title "The Craft of the Cartographer" but this sounds a little too pretentious considering the fact that cartography has been more an avocation than a profession with me. I believe, however, that a few maps of mine may stand the test of time and serve as landmarks in the evolution of the science or art of cartography (fig. 1). I considered as a title, "Landmarks in Cartography" but in surveying the long history of cartography I have found it very difficult to make a meaningful choice of significant events or developments. Furthermore, my selection probably would not be acceptable to other cartographers. The euphonious title, "A Cartographic Cavalcade" appeals to me because it permits me to present cartography without applying necessarily the test of scientific and historical

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significance. I hope that my remarks may not be entirely random and that you as a discerning listener or reader may detect or recognize a sense of chronology.

In a very real sense you are a captive audience and I cannot resist the temptation to hold forth at length on cartography. It is not my purpose to make you learned in cartography but to suggest that you take a careful look at maps and develop, if you can, an appreciation of the cartographer's problem, that of assembling an array of symbols to give a meaningful impression of an area and selected phenomena represented by the symbols.

Cartography may be regarded by some as a mighty slender sliver of the larger disciplines of astronomy, geography, mathematics, and other closely related fields but cartography has enjoyed a long history and permits, because of its dimensions,

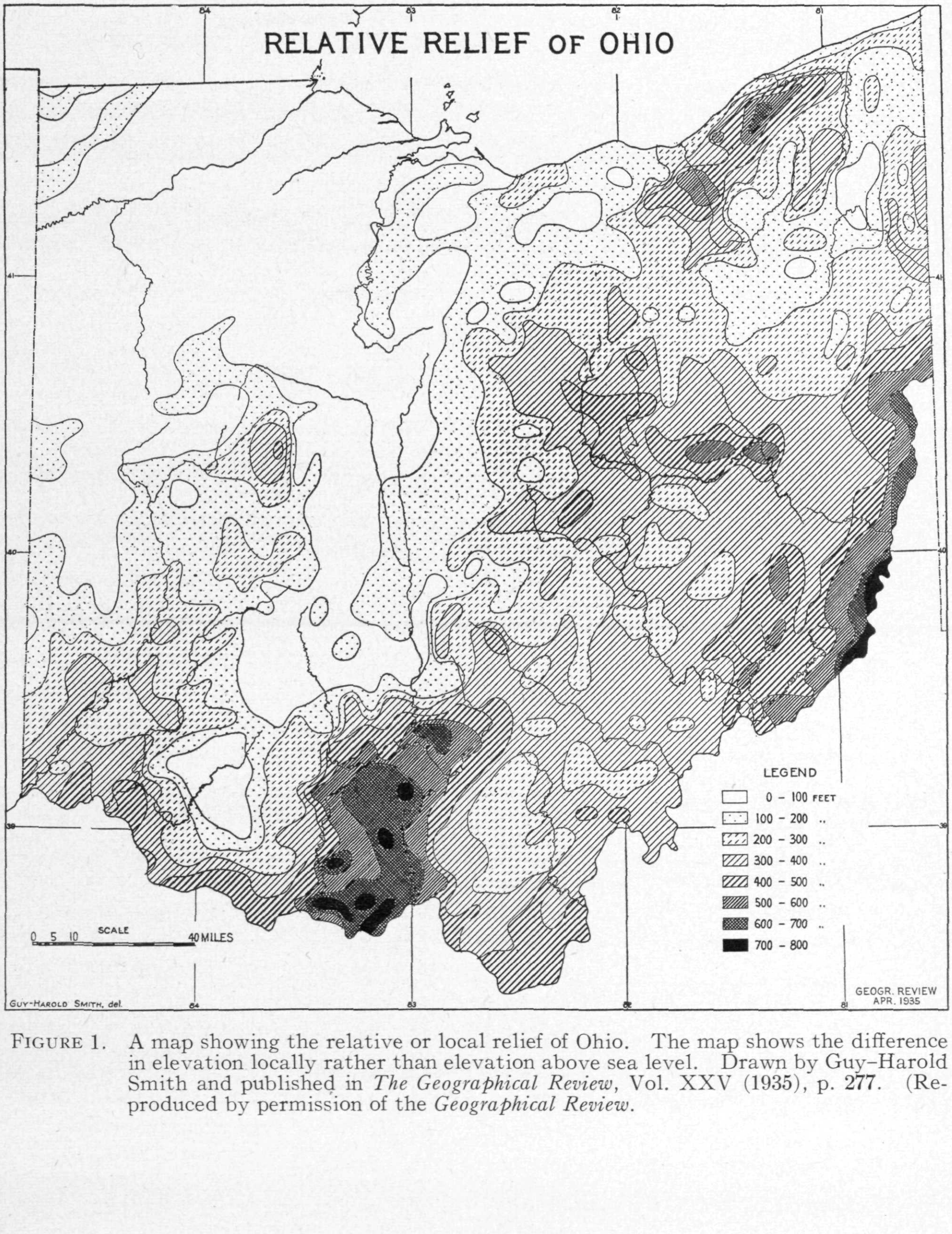


FIGURE 1. A map showing the relative or local relief of Ohio. The map shows the difference in elevation locally rather than elevation above sea level. Drawn by Guy-Harold Smith and published in *The Geographical Review*, Vol. XXV (1935), p. 277. (Reproduced by permission of the *Geographical Review*.

specialization within the subject. For example, there are cartographers who are essentially craftsmen and make their chief contribution by the drawing skills they bring to their work. Others with little skill in drawing may be concerned with the mathematical aspects of the subject. Their principal contribution will be in the arrangement of the meridians and parallels or the design of map projections. Others may take the long view and give their time to the study of the evolutionary history of the subject. At the risk of sharing a little splintered learning with you I would like to select a number of cartographic ideas for discussion and development.

Every time a specialist tries to give his knowledge penetrating depth to prove his expertness he is in danger of narrowing his concept of the broader aspects of his subject. To the extent that he concentrates his interest on his own specialty and adjacent fields the more limited the time he will have to investigate more remote fields.

The Classification of Maps

He who would undertake to classify the great variety of maps that have been devised and produced during the past three or four thousand years is confronted with a formidable task. But classification is not impossible. A simple classification may be based upon scale though the categories such as plans, large scale, medium scale, and small scale maps cannot be exactly defined. Maps may be classed as general or special. On general maps the terrain, the hydrography, the culture and other features may be highly generalized or simplified. The symbolism must be chosen with care to achieve the desired results. A special map is usually devised to show a particular phenomenon and all of us are familiar with maps showing roads, current weather conditions, population, the distribution of disease, the intensity of cosmic rays, the distribution of fallout, soil groups, forests, geological formations, the boll weevil, etc. Long ago, before the large cities became strongly Democratic, a wit noted that there was a similarity in the distribution of the boll weevil and Democratic voting. To give equal space to the Republican Party, it was Frederick Jackson Turner who noted the similarity in the distribution of continental glaciation and Republican voting in the United States.

Cartography—A Science Or An Art?

Anyone who would be bold enough to confront an audience of scientists such as this is under some obligation to do a little explaining. A recent book on cartography carries the subtitle *The Art That Became A Science* (Brown, 1960). Cartography or map-making is older than writing as a graphic art. Before man could read or write he was drawing pictures of animals on the walls of caves and we know that some of the earliest maps were nothing more than simple sketches showing the location of hunting or fishing grounds, a route to neighboring peoples either friend or for, or the location of islands in the wide spaces of the ocean. One is often perplexed by the fact that so few of the ancient maps have been preserved. The materials used such as parchment were not indestructible and as a consequence have not survived the ravages of time. By fire, theft, and carelessness many ancient maps have perished even though there is evidence of their early existence. Some were deliberately destroyed to keep them from falling into the hands of the enemy. Seafaring men who charted their routes across the Atlantic and around Africa to the rich spice lands of India and the Far East weighted their charts with lead so they could be dropped overboard when confronted with imminent and certain capture by an enemy.

From earliest times the craftsmen known as cartographers have striven to retain something that may be regarded as the art of map-making and at the same time they have made a serious effort to tap the rich technical and scientific resources of astronomy, mathematics, geodesy, physics, chemistry, biology, and other scientific fields. In the more modern period when cartography has advanced to a more sophisticated stage of development it retains, fortunately, much that may be properly regarded as art rather than science.

In spite of the rapid development of cartography, utilizing to the fullest extent the contributions of aerial photography, photogrammetry, and the latest techniques of reproduction and printing, map-making to a certain extent is still a lonely art. It is the cartographer who selects the data to be represented, works with lines, colors, lettering, and a great variety of symbols to produce a map that has functional value or usefulness and at the same time is pleasing to the eye. The more learned the cartographer is in the fields of design, composition, and color value the more attractive a map becomes as a finished piece of work (Robinson, 1962).

The Image of A Cartographer

If I were to help you form your image of a cartographer I might suggest that he is round-shouldered from leaning over a drawing table, bespeckled to see more clearly his handiwork, and intently conscious of the demands of his craft. His drawing table is cluttered with the tools of his trade: a T-square, curves, triangles, rulers, scales, a reading glass, and a collection of assorted pens and holders. His workroom has high windows that let the sunless light in from the left. A globe, an ancient one at that, stands on a table and is more ornamental than useful. Nearby a map case, partly open, shows a number of maps, some printed, others showing the craftsmanship of the cartographer.

He is thought of as a lonely worker, indifferent to the people around him. He is socially withdrawn and his community status depends in large measure on his wife. He enjoys a degree of respect from people of lesser skills. He is not unlike a person who enters a holy order, for to become a cartographer he, to a degree at least, must take a vow of poverty. At best he can hope for only a modest competence. Out of his loneliness he derives great personal satisfaction from his work but he may receive little recognition or public acclaim for his tedious and exacting work.

What I have said here applies to the cartographer of an earlier day. The present-day cartographer is more likely to be a craftsman with very special talents and responsibilities. The preparation of a modern map may be essentially the job of a task force. One specialist may be responsible for the control, that is, the arrangement and spacing of the meridians and parallels and the location of numerous fixed points. A second draftsman may be responsible for the drainage lines, another for relief, and another for the culture. Finally the lettering whether done by hand or stuck on requires a specially skilled craftsman. The resulting map does not express in a singular manner the creative talent of a single individual but the skills of several people, compilers, draftsmen, and editors, whose work reflects the nature and the adequacy of the cartographic shop or laboratory that produced the map.

The cartographer of today is likely to be in the employ of a governmental agency concerned with map production, or in the employ of a private map-making and map-publishing firm. He may be an instructor in cartography in a college or university who has an opportunity to ply his craft as a cartographer. He may be a person who is employed in some other occupation that permits him to work at map-making as an avocation. Out of this last-named group of craftsmen one might expect something unusual or creative such as R. Buckminster Fuller's Dymaxion Globe or Irving Fisher's icosahedron.

The cartographer is not unlike a painter. "His business is not to convey topographic information, but to express some emotion" (Montague, 1924).

The Earth Takes Shape

In the minds of early men the shape of the earth was as uncertain as the location of heaven and hell. Students of astronomy, geography, mathematics, and cartography generally credit Pythagoras with the formulation of the concept that the earth was spherical in shape. Pythagoras established a school of philosophy in 523 B.C. which held as one of its tenets that the earth was not flat or disc-shaped but generally sphere-like. No doubt, earlier scholars and philosophers had prepared the way for Pythagoras to formulate his proposition that the earth was a sphere.

For hundreds of years the sphere-like earth had few adherents because the number of learned men in relation to the total population was small. Most people who had ideas about the shape of the earth believed it to be flat and circular in shape and surrounded by *Oceanus* or the ocean stream. Homer's world of 500 B.C., that is, a flat circular earth, lasted for more than 1500 years even though a small minority of people knew that the earth was spherical in shape.

The flat, circular maps were generally drawn so that east was at the top. The Mediterranean Sea constituted a broad and irregular band of water penetrating deeply into the known land masses with Europe on the left or north and Africa on the right or south. To the east the Black Sea and the Red Sea along with the Mediterranean produced the rough outline of the letter T. The circular land area was washed by the waters of *Oceanus*. The maps showing this arrangement of water both internal and external and the known land areas were known as T-in-O maps.

During the Dark Ages when knowledge of the earth was largely in the hands of the clerics T-in-O maps were drawn and preserved for future generations to see and study. One of the most noted maps of this period is the map in the Hereford cathedral which was drawn in 1275 A.D. Another well-known map of this period is the Leardo Map of the World, 1452 or 1453, now in the collections of the American Geographical Society (Wright, 1928). The flatness of the earth, its circular shape, and its orientation so that east or Jerusalem was at the top represented the state of geographical knowledge as the Dark Ages came to an end and the age of discovery engaged the energies and imagination of men.

This presentation is concerned chiefly with small-scale world maps which can be derived from a sphere-like earth but the cartographer who would map the world or parts of the world on a large scale and with great accuracy must recognize that the earth is an oblate spheroid. For geodetic purposes and for precise mapping an ellipsoid of great accuracy is required (Deetz and Adams, 1945). It is known that the earth is not spheroidal in shape but actually geoidal. This means that the earth is peculiarly earth-like in shape, but for cartographic purposes the deviations from a precise ellipsoid can be ignored.

The Development of Map Projections

Mathematics, particularly geometry, had developed early enough to be used in conjunction with the beginnings of cartography. Almost before Pythagoras had conceived of a spherical earth Thales had devised a projection on which to represent the surface of the earth. He had conceived of the earth as a sphere inside a cube with the sides tangent at six points. From the center of the sphere the surface was projected onto the plane surfaces or the sides of the cube. This is the gnomonic projection invented or designed by Thales in 548 B.C., the oldest projection known to cartography.

The gnomonic is only one of the projections developed upon a plane tangent to the sphere. Collectively these are known as the azimuthal projections and the gnomonic projection has been in use for more than 2500 years and probably is more widely used today than at any time in the past (fig. 2).

Other surfaces such as those derived from a cone or from a cylinder were developed to serve the needs of cartography. It is not known when the first conic projection was developed but it probably had some usefulness in projective geometry before it was given application for map-making. The first conic projection may have been related to the gnomonic in that the point of vision or center of construction was the center of the earth and from the point of origin the surface of the earth or at least the grid of meridians and parallels was projected onto the cone. The surface of a cone is a developable surface and can be converted into a plane without introducing any alteration in the relationship of the meridians and parallels.

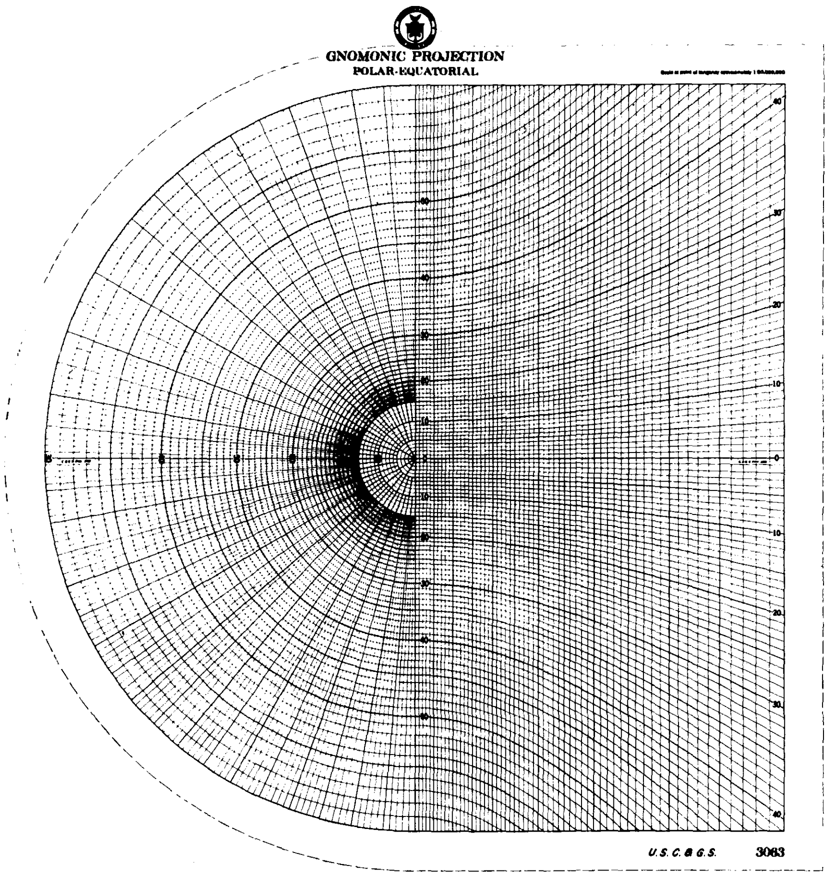


FIGURE 2. Gnomonic projection, polar aspect on the left and equatorial aspect on the right. The point of vision or center of construction is at the center of the earth and the meridians and parallels are projected onto a tangent plane (United States Coast and Geodetic Survey).

Two conical projections, both based upon two standard parallels are in wide use today. The first of these was the work of Johann Heinrich Lambert (1728–1777), a native of Alsace, who had a genius for the solution of difficult mathematical problems. After 1764 when he had taken up residence in Berlin and had become a favorite of Frederick the Great he developed an orthormorphic or conformal conic projection which bears his name and which is probably the map projection most widely used for aerial navigation in middle latitudes. At the Aeronautical Chart and Information Center at St. Louis thousands of maps on this projection are turned out every year.

The other widely used conical projection is equal area rather than conformal and was devised in 1805 by H. C. Albers (Deetz and Adams, 1945). Little is known about him or his work but for more than 30 years it has become a highly acceptable equal-area map for the United States and other areas with a predominantly east-west dimension.

The origin of the oldest map of a cylindrical projection is likewise lost so far as the records of cartography are concerned. It may have been what is known today as the central cylindrical in which the surface of the earth or at most a part of the surface is projected from the center of the earth onto the surface of the cylinder and since the cylinder is a developable surface it can be rolled out flat without deformation.

Whereas the origin of the first cylindrical projection is unknown or at best obscure at least three or four can be dated with reasonable accuracy. The most famous of all, the Mercator, discussed elsewhere, was devised in 1569 and perfected by Wright in 1599, exactly 30 years later. Gall's projection based on a secant

FIGURE 3. Van der Grinten's projection of the surface of the earth in a circular plane. The projection is neither equal-area nor conformal. (Drawn by Guy-Harold Smith).

cylinder cutting the earth at 45° N and 45° S was devised in 1855 and is widely used in England and the Commonwealth countries as a base map for wall maps and atlas maps of the world.

To prove that anyone with an inventive and mathematical mind can create something new in the field of map projections O. M. Miller of the American Geographical Society may be cited as a living example. A little more than 20 years ago he designed a cylindrical projection of the world to change the character of the exaggerations in other cylindrical projections particularly the Mercator and Gall's. His projection was described in 1943 and has become known as Miller's cylindrical projection (Miller, 1943) and in twenty years has become widely accepted as well suited for a map of the world where equivalence of area or conformality are not required.

In addition to the map projections derived from a number of geometrical figures, cartographers have used their imagination to create designs to represent all or parts of the surface of the earth. The meridians and parallels are arranged within circular, elliptical, rectangular, and heart-shaped areas to achieve equivalence of area, conformality, or an acceptable compromise (fig. 3). There is no reason to believe that new designs will not be created to meet the needs of a world of high technological development. For example, Mollweide and Hammer designed equal-area maps of the world within an elliptical area. Werner developed a heart-shaped map of curious interest to all people who believe in Valentine's Day. Van der Grinten, an immigrant cartographer, employed by Rand McNally and Company in Chicago devised in 1899 a map of the world within a circular plane.

On occasions the interests of cartography can best be served by developing the transverse or oblique aspect of a map projection. In the case of the transverse aspect the projection is developed or constructed by rotating the reference figure 90 degrees from the usual orientation. For example, the cylindrical projections are drawn with the axes of the cylinder and the earth in a relationship of coincidence with the cylinder tangent at the equator. In the transverse cylindrical projection the reference cylinder is tangent along a pair of meridians which together constitute a great circle.

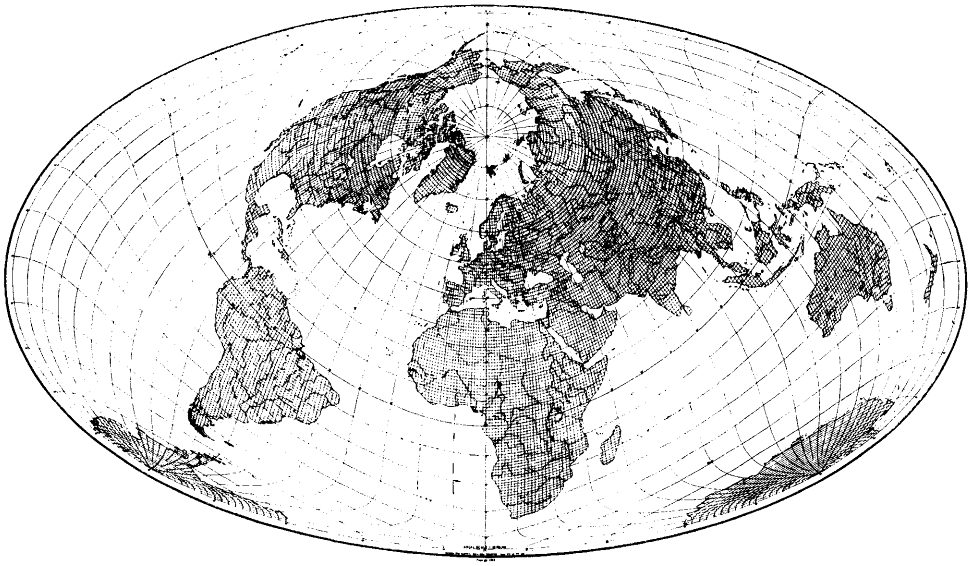


FIGURE 4. Briesemeister's oblique adaptation of Hammer's equal-area projection of the world within an elliptical plane. Drawn by William Briesemeister and published in *The Geographical Review*, Vol. XLIII (1953), p. 261. (Reproduced by permission of the American Geographical Society of New York).

If some great circle other than the equator or a meridian circle is used as the circle of tangency the projection may be described as the oblique aspect of a cylindrical projection. There is only an occasional need for the oblique aspect of the cylindrical projections.

Obliqueness may have greater usefulness where applied to projections such as Mollweide's or Hammer's (Briesemeister, 1953). The arrangement of the meridians and parallels may be rather startling to the uninitiated but the finished map may be unusually effective as a visual or graphic device (fig. 4).

The Portolani

One of the great landmarks in the history of cartography was the development of the harbor-finding charts known as the *portolani*. Originally these portolan charts were designed to accompany the *peripli* or coast pilots, guide books used by the navigators as they sailed their ships along the shores of, and across the broad waters of the Mediterranean and other marginal seas. The *peripli,* useful as they were to the navigators who used them, were greatly enhanced in usefulness by the portolan charts. The *peripli* and the *portolani* in combination made it relatively easy for the early mariners to navigate unknown waters safely and put into port without the danger of being wrecked on the reefs and shoals at the harbor's entrance.

More than a thousand years, perhaps 2,000 years, before the time of Christ the Phoenicians began the navigation of the eastern Mediterranean. The primitive charts used by the Phoenicians and other seafaring people were the forerunners of the *portolani* which did not attain their identifying characteristics until the year 1300.

The typical portolan chart consisted of a series of east-west horizontal lines, a series of north-south lines, and a great number of rhumb lines radiating out from well-placed compass roses. On this framework of parallels, meridians, and rhumb lines the coastline was carefully delineated and the names of a great number of coastal towns were lettered on the map.

The *portolani* reached their highest state of development in the period just before the discovery of America. In a period of 300 years these popular aids to navigation had been improved and extended to include all of the Mediterranean and both shores of the Atlantic Ocean. The city of Genoa became one of the chief centers for the production of these famous charts. *Portolani* were made in other Mediterranean ports to provide useful charts for the many navigators who were venturing westward across the Atlantic and around Africa to the Far East. Most commonly they were drawn on parchment. When several skins were mounted on thin boards they could be bound together to form a portolan atlas (Brown, 1949). Generally the numerous straight lines and the coastline were drawn in black but other colors such as red, blue, green, and yellow were used. Place names, mainly coastal towns, were lettered in black, though red was also used. From 1300 to 1600 and even later the *portolani* were the harbor-finding charts of all of the great navigators who sailed out of the ports of Europe to explore the unknown seas and shores of equally unknown lands. With the rise of Portugal as a seafaring power, Lisbon became a center for the drafting and production of *portolani* of high quality (Cortasao and da Mota, 1960).

The Mercator Projection

The *portolani* with a rectangularity derived from the right-angle crossing of the meridians and parallels and a spacing of the parallels vaguely related to the pattern of rhumb lines or loxodromes were the immediate forerunners of the Mercator projection which has been the sailor's chart for more than 400 years. Seafaring required increasingly accurate charts and the need commonly existed for a number of years before the cartographers could respond with the chart that exactly satisfied the need.

As the Dutch became increasingly important as a maritime people the companion activity of map-making was transferred from the Mediterranean borderlands to the Netherlands. One of the most famous craftsmen who became a cartographer of international repute was Mercator, born Gerard Kremer in 1512. Mercator had been identified with the map business for more than 30 years when he undertook the then difficult task of designing a projection that would meet the needs of the navigators. Essentially his task was to devise a projection on which the meridians would be a series of equally spaced parallel straight lines. He next sought to arrange a spacing of the parallels so that a spiral loxodrome which intersects the meridians at a constant angle would be shown as a straight line. This resulted in a spacing of the parallels in such a manner that the east-west elongation of the parallels was matched by a similar elongation or stretching of the meridians at the point of intersection. All students of geography are familiar with the distortions that result from the use of this projection for a map of the world or other large areas but the projection is conformal and shapes of small areas are shown correctly and at any point on the map or projection the scale is true in all directions and azimuths are shown correctly.

Mercator and the projection that bears his name are often linked with that of Edward Wright, a professor of mathematics at Cambridge University. Mercator's projection was devised and first published or printed in 1569 but it was 30 years later when Edward Wright published his *Certaine Errors in Navigation*, which in effect was a mathematical treatise or explanation of Mercator's projection.

Great as was the need for improved charts Mercator's contribution was not immediately accepted by the mariners who were unwilling to adopt a new projection or chart they did not fully understand. But in time maps of the sea, commonly called charts, were almost universally drawn on the Mercator projection. Most of the major maritime powers have their own chart-making establishments and thousands of charts on the Mercator projection are in use every day. Only maps on Lambert's conformal conic and the polar stereographic, used in aviation are as satisfactory for navigation. Both of these have the quality of conformality as does the Mercator.

When J. Paul Goode of the University of Chicago completed his *School Atlas* (1923) he had this to say about the Mercator projection:

> In all previous atlases Mercator's projection has been used almost exclusively for world distributions, and this in spite of the fact that (1) it is impossible with it to show the earth's surface entire, the north and south poles being at infinity; and (2) distances and areas grow rapidly larger with increase in latitude, becoming enormous in the higher latitudes. . . . Population density, density of existing forests, annual rainfall, comparison in size of states and empires, all are untrue and inexcusable as shown upon a Mercator chart.

For most of the 1920's and well into the 1930's Goode's condemnation of the Mercator projection except for navigation resulted in a whole generation of young men reaching maturity without learning about the Mercator projection. Many of these same young men found themselves in the armed forces, particularly the Navy where knowledge of the Mercator is of prime interest.

Cassini as a Map Maker

In 1679 Jean Domenique Cassini, a famous astronomer, drew a circular map 24 ft in diameter on the floor of the Paris Observatory (Brown, 1941). He called his map a "Planisphere." It was drawn on what is now known as the azimuthal equidistant projection centered on the north pole and extended to 60° South Latitude. Cassini undertook the revision of the map as new information became available on the location of cities, harbors, rivers and other places of importance. As a companion activity he tried to determine precisely the location of a number of places. His map showed 43 such locations most of which were in Europe but five were in China, four in the Malay Peninsula, two in India, two in the Indian Ocean, three in the West Indies, two in South America, one in Canada, and one in Mexico.

Cassini's map by the end of the seventeenth century was badly worn and became difficult to read. It was redrawn by the French Academy but in time it disappeared completely. But a copy on paper had been drawn so Cassini's projection of 1679 was not lost. In 1694 and again in 1696 Cassini's son engraved the map on copper but only four copies have survived. Later in 1712 the son again engraved a revision of the map on copper. The map itself was produced from a circular engraving. The decorations outside the map were produced from a second copper engraving. The decorative portion of the map was drafted by Jan Goere and the engraving, rectangular in shape, was done by G. van Gouwen. In the upper left hand corner the legend was given in French. In the upper right the legend was in Latin.

Cassini's "Planisphere" of 1679 has been reproduced many times since it was first published and became available to other cartographers. But the development of aviation brought new vitality to this projection now familiarly known as the azimuthal equidistant.

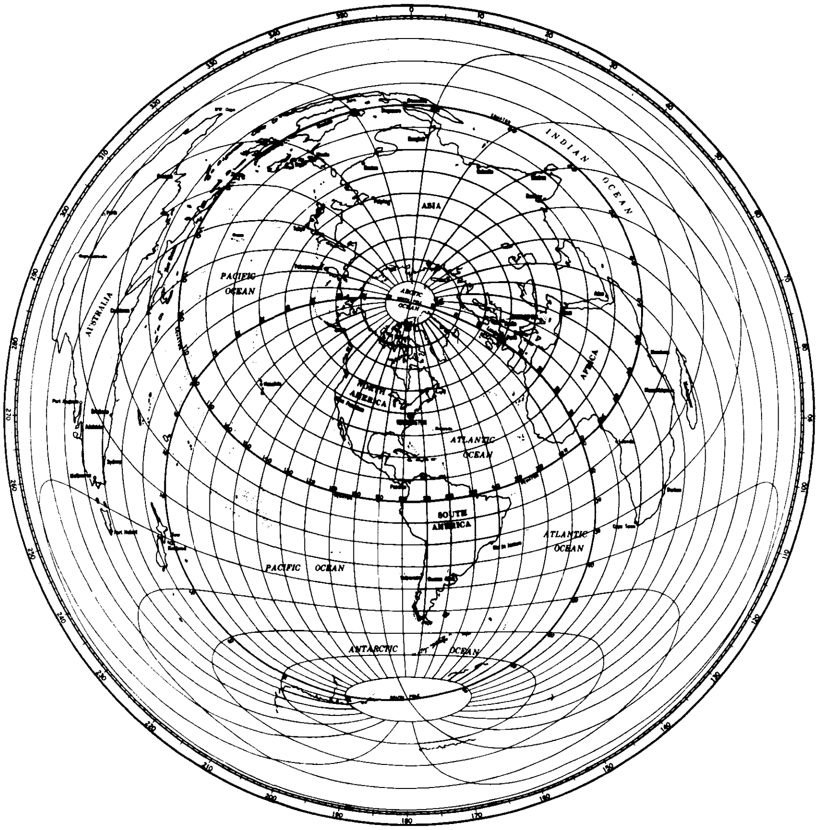


FIGURE 5. Chart of the world on the azimuthal equidistant projection centered on Washington, D. C. (Hydrographic Office, United States Navy).

During World War II a great many maps were drawn on this projection. It has an important quality that made it most useful in aviation and radio broadcasting. From the point of tangency or center of construction, whether it be London, Washington, Toledo, Cape Canaveral, or any other position, it shows the true direction and distance to any other place on the earth from the point of tangency (fig. 5).

A more recent and very significant adaptation of this projection is the symbol of the United Nations. Of course, it is not the only projection on which the whole world can be shown but its simplicity makes it a very appropriate symbol and all of us have noted its repeated use on publications and the postal issues of the U. N. (fig. 6).

The Toledo Strip

It is appropriate on this occasion when The Ohio Academy of Science is holding its annual meeting in Toledo to examine briefly the dispute which engaged the attention of citizens and public officials in both Ohio and Michigan in the early 1830's. The Enabling Act that made possible the admission of Ohio into the Union was passed on April 30, 1802. Within a year the conditions for statehood had been satisfied and Ohio became the first state north of the Ohio River to be admitted to the Union. However, the boundaries of the new state had not been delineated or demarcated to the satisfaction of all parties concerned. The northern boundary was not easily settled.

FIGURE 6. The original azimuthal equidistant projection known as Cassini's Planisphere. The map at the left centered on the north pole and extending to 60° South Latitude was originally designed by Jean Domenique Cassini in 1679. The design at the right is the official symbol of the United Nations which uses as its central motif the azimuthal equidistant projection (Courtesy of Roy Wenzlick).

The Enabling Act gave the limits of the new state and made specific reference to an east-west" . . . line drawn through the southern extreme of Lake Michigan, running east . . . to Lake Erie." The Constitution of Ohio (Article 7, Section 6) used the same language as the Enabling Act but with this proviso:

> *Provided always, and it is hereby fully understood and declared by this convention,* that if the southerly bend or extreme of Lake Michigan should extend so far south, that a line drawn due east from it should not intersect Lake Erie, or if it should intersect said Lake Erie east of the mouth of the Miami River (now Maumee River) of the Lake, then, and in that case, with the assent of the Congress of the United States the northern boundary of this state shall be established by, and extending to a direct line running from the southern extremity of Lake Michigan to the most northerly cape of the Miami Bay, after intersecting the due north line from the mouth of the Great Miami River as aforesaid; thence northeast to the territorial line, and by the said territorial line to the Pennsylvania line (U. S. Geological Survey, 1930).

This proviso recognized the increase of geographical knowledge of the Great Lakes. There was good reason to believe that many maps of the period showed the southern extremity of Lake Michigan well north of its true location. In 1812 Congress authorized the survey of the east-west line in accordance with the authority contained in the Enabling Act of 1802. The line was not immediately surveyed but in 1817 William Harris ran a survey from the southern tip of Lake Michigan to the western boundary of Ohio. From the most northerly cape of headland of Maumee Bay another line was run westward and slightly southward. This latter line lay from five to seven miles north of the due east line. What is now Toledo lay in this disputed strip. Ohio claimed the more northern line and Michigan, naturally, disputed Ohio's claim. The dispute between the two states culminated in a real crisis in February, 1835. Both states assembled troops and threatened civil war. The good offices of President Andrew Jackson, the Congress, and the federal courts were called upon to prevent bloodshed. An act of Congress, approved on June 23, 1836, established the northern boundary of Ohio and cleared the way for the admission of Michigan into the Union.

Reference to Karpinski's *Historical Atlas of the Great Lakes and Michigan* (Karpinski, 1931) reveals that the boundaries of the Great Lakes were not clearly delineated until 1683 (Hennepin's map). For more than a hundred years, explorers, surveyors, and cartographers sought to give precision and definition to

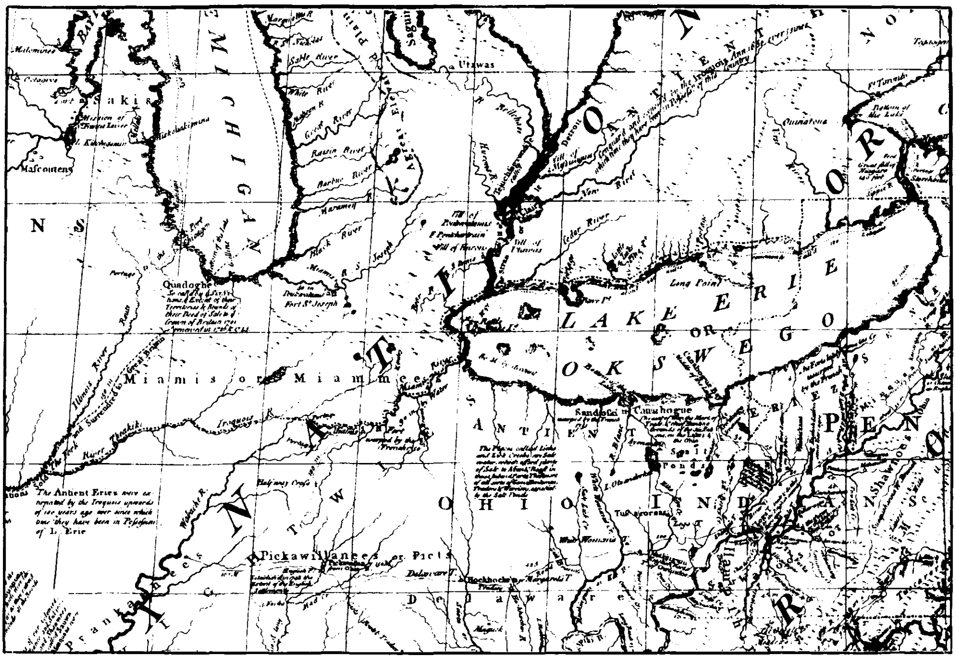


FIGURE 7. A section from the John Mitchell Map of the British and French Dominions in North America, 1755, showing that the south end of Lake Michigan lies too far north in relation to Lake Erie. This map and many others carried this same error and were responsible in part for the dispute between Ohio and Michigan over the Toledo strip in the early 1830's (From the first impression of the third edition of the Mitchell Map, 1755, *Boundaries, Areas, Geographic Centers, and Altitudes of the United States and the Several States* (Second Edition), Bull. 817, U. S. Geological Survey, Department of the Interior, Washington, D. C., 1930).

the Great Lakes. With characteristic originality cartographers copied the maps of their predecessors and as a consequence the errors or inaccuracies in boundaries were repeated again and again. For example, Delisle's map of 1700, Henry Popple's map of 1733, Charlevoix-Bellin map of 1744, Robert de Vaugondy's map of 1755, Danville's map of 1755, Lewis Evans' map of 1755, John Mitchell's map of 1755 and many others showed the southern extremity of Lake Michigan too far north when compared to the latitude of Lake Erie (fig. 7). However, by the end of the century the true relationship between Lake Michigan and Lake Erie had been determined.

The Mitchell Map of the British and French Dominions in North America

On January 2, 1930, Colonel Lawrence Martin, Chief of the Map Division of the Library of Congress, and I visited the library of the Ohio Archeological and Historical Society at the corner of 15th Avenue and High Street at the south side of the entrance to The Ohio State University in Columbus. The Colonel asked me to check the card file to see if the library might have a copy of the Mitchell map. The catalogue contained a card indicating that the library had a copy of the map. The card also carried a notation that the map was contained in a large shipping tube and was marked, "too fragile to unroll". We made our way to the basement room where the newspaper collection was then stored. We introduced ourselves to the librarian and after a few moments we asked to see the Mitchell map.

We withdrew the map from the tube and carefully unrolled it and began our search for its identifying characteristics. In a few minutes we were able to determine that this copy was in fact a first impression of the first edition of the John Mitchell Map of 1755, one of seven known copies.

Colonel Martin and others have called "Mitchell's map the most important and the most famous map in American history." It was consulted by Benjamin Franklin and the British negotiators in connection with the Definitive Treaty of 1783 that ended the Revolutionary War. It was consulted many times after this date especially in connection with boundary disputes with Canada.

It is pure speculation but is entirely possible that the Mitchell map now in the possession of the Ohio Historical Library may have been consulted repeatedly by Ohio officials when the Toledo strip was in dispute.

I have taken more time than I originally intended to call your attention to the dispute over the Toledo strip and to the Mitchell map, one of a number of maps that contributed to the uncertainty about the northern boundary of Ohio.

Maps for Space Travel

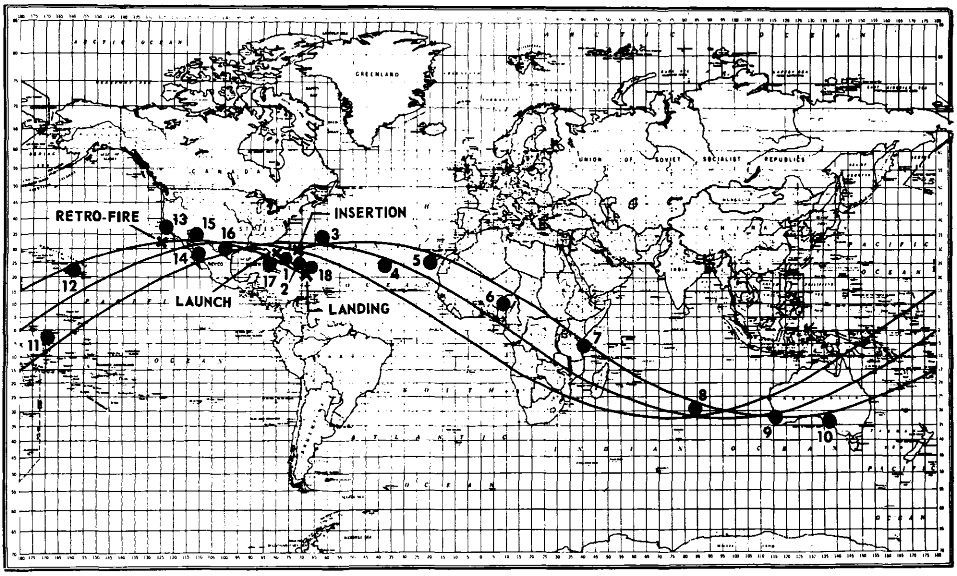
As suggested earlier cartography is responsive to the needs of the times, or more properly cartographers are ready to accept the challenge of the space age when orbital flight and eventually interplanetary travel will require specially designed maps and charts. No doubt many of the charts now in use for marine or aeronautical navigation can be used in determining the initial heading of a spacecraft and in its re-entry and recovery.

Selected maps and charts from the Coast and Geodetic Survey of the Department of Commerce, the Hydrographic Office of the Navy, and the Aeronautical Chart and Information Center are required in the planning of an orbital flight such as that of Colonel John H. Glenn Jr., in Friendship VII capsule on February 20, 1962. The actual flight path of a spacecraft, based on all known factors, is determined by high-speed computers and the actual ground track is plotted on relatively small scale maps of the world. The precise location of the flight path over or near the telemetering stations is necessary so that radio communication can be maintained at all times.

A space capsule in orbital flight follows a trajectory-like path except for minor deviations. The path lies closely within a celestial plane that passes through the center of the earth. Because of the rotation of the earth the flight path when plotted on a world map is shown in a course at positions well west of the previous pass of the capsule. This westward shifting of the route is related to the fact that the earth rotates beneath the orbital flight path of the capsule and the longitude or linear distance along the parallels between each transit represents graphically the period of time required for the spacecraft to orbit the earth. This is well illustrated in the map supplied by the National Aeronautics and Space Administration (fig. 8).

When the capsule re-enters the atmosphere and is recovered from the sea the usual marine charts, most of them on the Mercator projection are used by the destroyers, the aircraft carriers, the planes and helicopters deployed in the recovery area.

As man extends his interests and his travels into outer space special kinds of maps will be required. Next after orbital flight around the earth will come close inspection if not landing on the moon. Already detailed topographic maps of the visible parts of the moon are available. Improved maps will be prepared when it is evident that the need is great.



PROJECT MERCURY GROUND STATIONS

1. CAPE CANAVERAL
2. GRAND BAHAMA ISLAND
3. BERMUDA
4. MID-ATLANTIC SHIP
5. CANARY ISLANDS
6. KANO, NIGERIA
7. ZANZIBAR
8. INDIAN OCEAN SHIP
9. MUCHEA, AUSTRALIA
10. WOOMERA, AUSTRALIA
11. CANTON ISLAND
12. KAUAI, HAWAII
13. POINT ARGUELLO, CALIFORNIA
14. GUAYMAS, MEXICO
15. WHITE SANDS, NEW MEXICO
16. CORPUS CHRISTI, TEXAS
17. EGLIN, FLORIDA
18. GRAND TURK

FIGURE 8. The route followed by Colonel John G. Glenn's Mercury spacecraft, Friendship VII. His flight path was in a celestial plane passing through the center of the earth, but when the path or course is plotted on Miller's cylindrical projection it takes on a wave-like appearance (Map by courtesy of the National Aeronautics and Space Administration).

Concluding Remarks

In the beginning I indicated that cartography like almost every field of science borrows extensively from other disciplines. It has, however, a limited body of knowledge, some borrowed and some created within the field so that cartography has an assemblage of concepts, techniques, and identifiable ingredients that give it tangential status, at least, among the major disciplines.

Permit me to conclude these remarks by stating that cartography, the handmaiden of science, can and will play an important part in the roll-back of the frontiers of knowledge. The creative cartographers stand ready to meet the challenge of new demands that require their highest intellectual capacities and their greatest skills.

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