A

NOMINATION

TO DESIGNATE THE

MASON – DIXON LINE

A

NATIONAL HISTORIC CIVIL ENGINEERING LANDMARK

BY THE
WEST VIRGINIA SECTION
AND THE
PITTSBURGH SECTION
AMERICAN SOCIETY OF CIVIL ENGINEERS

(The landmark was added in 1977)

1. Significant Dates

The Mason-Dixon line forms a highly significant event: in the history of geodesic measurement and also represents a major national landmark of historic importance. Further, it represents an example of an early form of technology assessment in which the ablest scientific and technological minds of the time were called upon to assess alternative solutions to a practical problem of great urgency. Prior to the time when the boundary survey was performed by Charles Mason and Jeremiah Dixon during 1763-1768, principles of geodesic measurement were largely of theoretical or scientific interest. There had been no practical need to apply such methods in the survey of boundaries of extensive length, where the earth's curvature could cause complications. However, the boundary controversy between the Calverts and the Penns which occurred in the colonies during the period of 1681 to 1732 identified the need to both develop and apply sophisticated methods for establishing extensive boundaries.

The Calverts had been granted Maryland by King Charles I in 1632 and the Penns had been granted adjacent land by King Charles II in 1681. As expressed by language, only in the respective charters, the boundaries could not be precisely located, and even appeared to overlap. This led to many controversies over right of title and payment of taxes for land on the border. There were repeated riots and disorders along the border which created friction in high places in the English government. The King of England, in Council, ordered the governors of Pennsylvania and Maryland to suppress lawlessness along the boundaries and make no further grants of land. This led to an agreement in 1732 between the Calverts and the Penns, which was recognized as binding by England's High Court of Chancery. However, though the agreement signified a mutual desire to resolve the dispute, and contained clear

language on the location of the boundary, the language was not clear enough to resolve all issues pertaining to the measurement of the line. In addition, the state of the art of geodesic measurement was not sufficiently advanced to provide the necessary methodology and equipment. Major ambiguities in language included the following: there were disagreements over whether distance was to be measured horizontally or over the surface of the ground; whether a "twelve-mile circle" meant a circle of 12-mile radius, diameter, or circumference; and whether an "east-west" line meant a parallel of latitude or a line at 90° to a meridian. Finally, existing instruments to establish latitude did not have adequate precision for the survey. Thus, the years between 1732 and 1752 were spent in litigation between Calverts and Penns, at great expense, and all attempts made to perform a physical survey ended in failure. In the 1750's, technical expertise was sought from numerous scientists and academicians in both the colonies and in England.

In the words of Cope and Robinson, who have researched the Mason-Dixon line, "from the early 1750's, scientists and technologists gradually replaced political and legal advisors in the issues of boundary surveys." A final agreement on the language of the document defining the boundaries was reached in 1760. Distance was to be measured horizontally, a circle was to be measured by its radius, and an east-west 1ine was to mean a parallel of latitude. The remaining problems were to secure personnel with expertise to develop and conduct the technical methods of the survey, and to develop highly precise measuring instruments. Charles Mason and Jeremiah Dixon were selected to conduct the survey by the eminent English scientists of the day on the basis of there previous achievements in practical astronomy.

The survey occupied them on a full-time basis (except during winter) from December of 1763 to January of 1768, and produced the boundary lines which separate the western side of Delaware from Mary1and, and Maryland from Pennsylvania. By extending the line beyond the western boundary of Maryland, they also established a portion of the boundary between Pennsylvania and Virginia. During the Civil War, this was to become the boundary between West Virginia and Pennsylvania. Their survey of the east-west parallel of latitude ended on Brown's Hill, near the present-day community of Morgantown, West Virginia. The line was not surveyed to the southwestern corner of Pennsylvania because Indians would not permit a continuation; the southwest corner was established in 1784, but not by Mason and Dixon. It is fortunate that the survey and events leading up to it are well documented. An appendix lists major articles, from which were taken most of the facts presented in this nomination.

2. Key Personnel

The Original Mason-Dixon Survey. Charles Mason and Jeremiah Dixon designed and conducted the physical survey. However, there were other scientists who made essential contributions to the development of the methodology and should be mentioned in order to place the survey in a correct historical perspective.

First, the background of Mason and Dixon will be presented. Charles Mason (1728-1786) was an English astronomer and geodist. In 1756, he joined the staff of the Royal Observatory of Greenwich and served under the famed astronomer, Dr. James Bradley, as his assistant. In 1761, he and Jeremiah Dixon, also with the Royal Society, performed

measurements of the transit of Venus for purposes of determining the earth's parallax, or distance from the sun. This established his competence and led to his appointment to conduct the boundary survey. Among his accomplishments following the boundary survey, Mason conducted an experiment to determine the mass and density of the earth, and calculated it to within twenty percent of current values. Mason also calculated the positions of 387 fixed stars precessed to 1760 and developed a set of lunar tables of latitude and longitude, both of which were pub1ished in the Nautical Almanac. In 1786 he returned to America and, falling ill, died shortly.

Jeremiah Dixon (1733-1779), also a mathematician and astronomer, was less well known. He accompanied Mason when the transit of Venus was measured in 1761. Following the survey he performed observations for the Royal Society until 1769, then it appears that he retired.

Other scientist and technologists of significance include the following, each of who made a contribution to the original survey by recommending and evaluating alternative methodologies.

1. John Robertson, scientific advisor to the Penns, First Master of the Royal Nava1 Academy at Portsmouth (1755-1766) and Fellow of the Royal Society. His major contribution was the suggestion that a zenith sector be used to take measurements for latitude, as opposed to other instruments. Use of a zenith sector automatically qualified Mason and Dixon to be employed, since they were experienced with its use. Robertson also suggested use of tiangu1ation principles for running the north-south line between Delaware and Maryland. Such techniques had been used by the French in Lapland, in the 1730's, but were evaluated by other advisors to the Penns and found not suited for the survey in the colonies.

2. Dr. John Bevis, Fellow of the Roya1 Society and scientific advisor to Lord Baltimore. Dr. Bevis was a co-worker of John Robertson, Edmund Halley (the second Astronomer Royal), and James Bradley. In 1750, Dr. Bevis had been involved in running a parallel of latitude on the Salisbury Plain using an advanced transit or equatorial telescope. He recommended its use as a means for measuring latitude. Mason and Dixon evaluated it and found it not to possess the necessary level of accuracy.

3. Daniel Harris, mathematician and astronomer, master of the Royal Mathematical School in Christ's Hospital and advisor to the Penns. Harris suggested a method for running the east-west parallel and the line for the Maryland-Delaware border. Apparently his advice was well received, for his and Dr. Bevis's suggestions were adopted by the commissioners of the survey and given to Mason and Dixon as a set of “hints".

4. Dr. John Blair, Fellow of the Royal Society and chronologist. Dr. Blair approved Robertson's methodology and further stated a belief that the zenith sector was the appropriate instrument, rather than the transit.

5. John Bird, cloth weaver who became an expert in dividing clock dials and later developed instrumentation for the Rev. James Bradley, Astronomer Royal. His instrumentation made possible the epoch work of the Reverend Bradley. John Bird made the zenith sector employed by Mason and Dixon, the most accurate instrument developed to that time for measuring the zenith distance of stars.

6. The Rev. James Bradley, third Astronomer Royal. Though ill and unable to participate in the Mason-Dixon effort (he died in 1762), he had discovered precession and nutation of the earth's axis in 1747 and thus developed the basis for improved measurement of latitude. Mason, who served with Bradley beginning in 1755, was to use his discovery to

make corrections for precession and nutation during the boundary survey. Earlier Bradley had developed the theory of the aberration of light and calculated the speed of light in space quite precisely with the use of a zenith sector made by Bird's mentor, George Graham.

7. Nevil Maskelyne, fifth Astronomer Royal. Maskelyne, who was a colleague of Mason and Dixon, discovered a fundamental fault in the design of previous zenith sectors which introduced an error of a few seconds of arc due to the manner in which a plumb line was suspended. John Bird's zenith sector produced for Mason and Dixon was the first to incorporate an improvement recommended by Maskelyne which eliminated this error. Maskelyne also developed the secant method of establishing a parallel of latitude which was used by Mason and Dixon.

There were many other less notable scientists who also participated in the debate on methods of geodesy for the survey. However, their ideas were not as significant in the final design of the survey methodology.

Establishment of The Southeast Corner in 1784

The western terminus of the boundary was finally established in 1784 as a result of a land controversy between Pennsylvania and Virginia. Participants included, from the Virginia side, the Right Rev. James Madison, Bishop of Virginia, the Rev. Robert Andrews, John Page and Andrew Ellicott of Maryland; and from the Pennsylvania side, John Lukens, Surveyor General, the Rev. John Ewing, D.D., David Rittenhouse and Thomas Hutchins. Several of these people had played advisory roles or acted as observers in the boundary controversy leading up to the Mason-Dixon survey. Among them were the Rev. John Ewing, provost of the University of the State of Pennsylvania, who had documented previous attempts to survey

the boundaries up to 1763. His work was of high quality, and the knowledge he gained through his association with the Mason-Dixon survey was applied to set the western terminus. Also, David Rittenhouse had observed Mason and Dixon and perhaps assisted them in taking observations at New Castle and Middle Point. He extended the western border of Pennsylvania upward to the Ohio River in 1785. In 1774, he began the survey of the northern border of Pennsylvania using Bird's zenith sector and determined the boundary line between New York and New Jersey. Rittenhouse was both astronomer and engineer, and became famous for designing an orrery to represent motions of the planets. He was also later to be recognized for his skill in building astronomical telescopes. John Lukens had taken part in establishing the line which determined the mid-point of the Delmarva Peninsula prior to Mason and Dixon.

Andrew Ellicott was perhaps the most noted surveyor among the group. He did not participate in Mason and Dixon's effort which occurred when he was a boy. Following the extension of the Mason-Dixon line, he subsequently ran the northern and western boundaries of Pennsylvania in 1785-1788, surveyed the boundary between the United States and Florida in 1796-1800, and surveyed the Georgia and South Carolina boundary in 1811. He also performed numerous important mapping duties for the early government and became Surveyor General of the United States.

Thomas Hutchins was a military engineer who became Geographer-General of the United States in 1781. He was not a participant in the original Mason-Dixon survey either. He had responsibility for the survey of the Western Territory and personally drew the east-west base line for the entire survey in 1785-1789; he also drew the boundary line between New York and Massachusetts in 1787. Thus, by 1784 a group of surveyors had developed

expertise in the methods used by Mason and Dixon and applied them to boundary surveys e1sewhere in the early years of the United States.

The Mason-Dixon line was resurveyed in 1883 by C.H. Sinclair, a geodesist with the Coast and Geodetic Survey. He ran a line eastward from the southwestern corner of Pennsylvania and determined that the line passed within 1.5 inches of Mason and Dixon's station on Brown's Hill. Sinclair set the stone which presently exists.

3. Historical Significance

The art of surveying and mapping have been practiced from ancient times. However, modern precise surveying and navigation resulted from the application of the science, of astronomy or developed from the 17th century and later.

Since the political boundaries of Europe had long been established on the basis of geographic features such as rivers or mountains the Mason-Dixon Line represents the first precise boundary, on a large scale, ever laid out. It became the model for many other later surveys in this country and elsewhere in the British Empire. Because of its importance in the subsequent history of the United States it may well be the most famous border ever established on the basis of surveying methods. The accuracy of its line was and is astonishing, with an error of less than two-inches in a distance of two hundred and thirty miles. The survey set a new standard of accuracy for surveying and confirmed the use of the British sector method which was used in many subsequent important boundary surveys.

4. Unique Features and Characteristics

The line surveyed by Mason and Dixon forms, with minor exception, the current boundaries between Pennsylvania and Maryland and West Virginia, and between Maryland and Delaware. When the line was surveyed in 1763-1768, Delaware belonged to Pennsylvania and West Virginia was part of Virginia. Thus, the surveyors were primarily concerned with establishing the boundary between Pennsylvania and Maryland. As stated in the agreement of 1732 (see figure 1):

l. There was to be an equal division of the Delmarva Peninsula from Cape Henlopen northward.

2. The northern boundary of Lord Baltimore's grant was to be fifteen miles south of the city of Philadelphia.

3. The northern boundary of present Delaware (then the "Three Lower Counties" of Pennsylvania granted to the Penns in 1685) was defined by a circle of twelve miles radius around the center of New Castle. The center of New Castle was agreed upon by the survey commissioners in 1750 as being the belfry of the county courthouse.

4. A line was to be run from the midpoint of the southern border of Penn's domain to a point tangent to the circle of twelve-mile radius, then to follow the circumference of the circle until a point was reached where the line could be run due north from the tangent point to the northern boundary of Lord Baltimore's domain.

5. The western limit of Penn's domain was to be 5° of longitude west of Delaware Bay.

Of these boundaries the midpoint of the Delmarva Peninsula had already been determined by local surveyors in 1751, who had set a line which turned out upon subsequent

inspection to be a portion of the arc of a great circle, rather than *a parallel of latitude (hand corrected to read: a meridian of longitude.)* However, the line had been accepted by the disputing parties, so Mason and Dixon did not correct it. Further, Mason and Dixon did not survey the entire arc of twelve-mile radius around the courthouse at New Castle, but only that portion along the boundary between the disputing parties. The order in which Mason and Dixon proceeded was as follows:

1. Establishment of the north wall of, a house on the south side of Cedar Street, as the latitude of the southernmost point in Philadelphia (December, 1763).

2. Establishment of a point exactly 15 miles south (and 31 miles west-ward to avoid crossing the Delaware River) (January-April, 1764). The latitude of the point was determined to be 39°-43' -17.4"[1] and would serve as a reference point for measuring the distance along the westward line.

3. Proceed to the "middle-point point" of Penn's southern boundary and run the tangent line northward along a great circle arc to intersect the circle of twelve-mile radius (June-November, 1764)

4. Run the "West Line" which would form the northeast corner of Maryland (March-May, 1765.

5. Establish the arc of the circle of twelve-mile radius and the line northward from the tangent point, which cut the circle as a secant (June, 1765).

6. Extension of the west line of Maryland to a distance of 117 miles, 12 chains and 97 links west of the reference point, a point 2.99 miles east of the northeast corner of Maryland (June-November, 1765).

7. Extension of the west line westward to a distance of 165 miles, 45 chains, 88 links near Fort Cumberland (March-September, 1766).

8. Extension of the line westward to Brown's Hill, the terminus, a distance of 233 miles, 13 chains, 68 links from the beginning, and 230 miles, 18 chains and 21 links from the northeast corner of Maryland. This point is on Brown's Hill in Monongalia County, West Virginia, and Greene County, Pennsylvania. In 1767, this area was sparsely settled. Indian massacres had recently occurred. The surveyors were not allowed to extend the line a full 5 degrees westward but were stopped short of the goal in a firm but friendly manner by Indians who were accompanying them. However, they had come within 21 miles, 769.1 feet of their goal (June-November, 1767)

Thus, the five 1ines attributable to Mason-Dixon are reported by, Hughlett Mason[2] to be:

1. "The West Line, or border between Pennsylvania on the north and Maryland and Virginia (now West Virginia) on the south, which extends 230 mi1es, 18 chains, 21 links west from the northeast corner of Maryland.

2. “The East Line, which extends as a secant through the northern portion of De1aware. The length from the northeast corner of Maryland to Delaware Bay is 14 miles, 20 chains, l5 links. This distance was desired in order to ascertain when five degrees of longitude west of Delaware Bay had been reached. This line was of no importance to Maryland though that colony sustained half of the expense of running it.

3. “The Tangent Line, which extends from the Middle Point to the Tangent Point for a distance of 6558.31 chains or 81 miles, 78 chains, 31 links.

4. “The Arc Line, which follows a part of the curve of the circle of twelve-mile radius around New Castle Courthouse. This subtended secant is 1.451 miles, giving the length of the arc 1ine as 1.452 miles.

5. "The North Line, which is the distance from the Tangent Point to the northeast corner of Mary1and less that portion of the line which is a secant to the circle of twelve miles radius. This equals 5.019 miles less 1.451 miles = 3.568 miles.”

Mason and Dixon set granite markers at one-mile intervals along most of the boundary lines except when they began crossing the Alleghenies. In the mountains, they heaped piles of stones. Every fifth granite marker had the coat of arms of the Penns and Calverts carved on the sides.

Mason and Dixon employed the secant method of fixing the parallel of latitude which formed the east and west lines. This consisted of running arcs of great circles which intersected the desired parallel of latitude (see figure 2). The arcs were allowed to extend beyond the points of intersection. The arc of the great circle then formed a secant, and offsets from the arc were used to establish the location of the parallel. Mason and Dixon selected arcs of 10-minute length or approximately 11.5151 statute miles. Latitude checks were made at the ends of the arcs and corrections applied. The zenith sector developed by John Bird was indispensable for determining latitude to a very high accuracy. Corrections were made for nutation, precession, annual aberration, and refraction. Corrections for proper motions and parallax were not made because of either very minor effect, or lack of knowledge of their effect. Selected stars were utilized. A major requirement was the determination of bearing angles for running the arcs. Principles of spherical trigonometry were utilized to determine this. The zenith sector was the principal instrument utilized. Mason and Dixon also made use

of a direction transit, a Hadley navigator's quadrant, chains of 66 feet, an astronomical clock, wooden rods 16.5 feet long with spirit levels, and other rods. Of extreme significance were an up-to-date star catalog by Dr. Bradley, tables for astronomical corrections, and seven place logarithmic tables for numbers and sines and cosines. An additional piece of quality geodesic work was carried out by Mason and Dixon during the survey. At the instruction of the Royal Society, they measured the length of a degree of latitude on the Delmarva Peninsula, the first such measurement made in America. They determined it to be 68.8114 miles, or within 0.246 percent of the correct value of 68.981 meters based on the Clark spheroid of 1886.

5. Contribution to the Civil Engineering Profession

The Mason-Dixon line represented the first high precision boundary survey in the colonies. It was the first practical survey in the colonies, and perhaps the history of the world, to utilize the secant method and highly precise astronomical measurements for establishing a parallel of latitude. Though more complex approaches had been recommended prior to the survey, the secant method was simple to execute, yet extremely precise. The secant method later was utilized in other state boundary surveys in the early formative years of the United States; it was the method utilized to establish parallels of latitudes for the township system, and also the boundary between the United States and Canada. To this day it remains the most commonly employed method for establishing parallels of latitude. The zenith sector developed by John Bird was an early example of the type of instrument used by the U.S. Coast and Geodetic Survey until recent years. Thus, the Mason-Dixon survey resulted in the development and application of methods for conducting boundary surveys which were

utilized extensively throughout the development of the United States. In this sense, the survey is a highly significant event in the history of geodesic measurement.

Contribution to the Nation

The Mason-Dixon Line became the symbolic division between North and South in the years leading up to the War Between the States. It became a household word, known to every person familiar with the history of the United States. The term "Dixie-land," nickname for the South, was derived from Jeremiah Dixon's last name.

Aside from the role of the line in history, the methods and technique developed were also highly significant to the growth of the nation. They provided a non-controversial method for physically locating the boundary lines which divided the early territories into states and other political subdivisions. Though political controversy might arise over where to locate a boundary, once a resolution of political issues was achieved, the methods of the physical survey could establish the line with little opportunity for error. Thus, jurisdictional problems of the type which plagued the Penns and Calverts were avoided. Undoubtedly, the ability to precisely specify and locate the boundary lines of our major political subdivisions helped promote the development of the nation. The Mason-Dixon survey can be claimed as the earliest example of theoretically correct and highly precise boundary surveying.

NOTES

[1] This latitude is cited in the Mason-Dixon surveying notes for the beginning of the line. A latitude of 39° -43' -16.25" has recently been determined by the U.S.G.S. for the terminus of the line at Brown's Hill. This apparent discrepancy is being investigated.

[2] Mason, A. Hughlett. The Journal of Charles Mason and Jeremiah Dixon, transcribed from the original in the United States Archives with an Introduction by A. Houghlett Mason, American Philosophical Society, Philadelphia, 1769.

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