H

Halley, Edmond. Born 29 October 1656 at Haggerston in the parish of St. Leonard, Shoreditch, during the Commonwealth (Interregnum), Edmond Halley died at Greenwich 14 January 1742. On 20 April 1682 Halley married Mary Tooke; they had two daughters and a son. Halley lived during the reigns of seven English monarchs. From each of these Halley, "a truly great man of prodigious versatility and most attractive personality," received favors (Bullard 1956, 189). Halley's father (also Edmond) was a wealthy merchant (Salter's Company member), a Yeoman Warder of the Tower, and a property owner in London, where young Halley's formal education began when he entered St. Paul's School. There he was influenced by the high master, Thomas Gale, a notable classical scholar who also appreciated scientific learning. It was as a schoolboy at St. Paul's in 1672 that Halley made his first recorded observation. This was on the variation of the magnetic compass, the difference between true (astronomical) and magnetic (compass) north, which was published with other such observations in the *Philosophical Transactions* of the Royal Society of London in 1683.

In 1673 Halley entered Queen's College, Oxford University. There he continued his scientific observations with astronomical instruments his father provided for him. In 1676, while still an undergraduate, Halley published the first of many scientific papers he was to contribute to the *Philosophical Transactions*. Before receiving a BA degree, Halley left Oxford to join an East India Company ship, which would take him to the island of Saint Helena. There he spent a year observing constellations visible in the Southern Hemisphere. As on his outward voyage, during his return Halley made magnetic observations. He also observed the directions of prevailing winds, published as "An Historical Account of the Trade Winds" (*Philosophical Transactions,* 1686), including a chart (see fig. 776).

Almost immediately upon his return to England from Saint Helena, Halley set about putting his astronomical observations into published form. This work, *Catalogus stellarum australium* (1679) was accompanied by a large star chart, or celestial planisphere (see fig. 154). Copies were presented to King Charles II, who ordered that Halley be awarded the MA degree without "performing any previous or subsequent exercises for the same" (Thrower 1981, 1:20). Halley was also elected a fellow of the Royal Society on 30 November 1678.

On behalf of the Royal Society, but at his own expense, Halley then traveled in Europe, visiting the astronomer and cartographer Johannes Hevelius in Danzig, where they observed together in 1679 and subsequently corresponded. At the end of 1680 Halley departed on his "grand tour," visiting the astronomer and cartographer Jean-Dominique Cassini (I) at the Paris Observatory on the way. Talented in foreign languages, he became clerk to the secretaries of the Royal Society. On being denied appointment in 1691 to the vacant Savilian Professorship of Astronomy at Oxford for which he had applied, Halley requested from the joint monarchs, King William III and Queen Mary II, a ship in which to pursue his magnetic observations over the deep oceans. For this purpose, he was appointed as a temporary captain in the Royal Navy and as commander of a small vessel, the pink HMS *Paramore*.

During two voyages, 1698 to 1700, Halley observed and mapped the earth's magnetic field in the Atlantic from 50°00′N to 52°24′S latitude. Often considered as one of the earliest purely scientific voyages, Halley returned to England with a rich harvest of data. These were published in 1701 as a sea chart with "*Curve-Lines*" depicting lines of constant magnetic variation or isogones (fig. 348). Halley's map is credited as the first *published* isoline map of any phenomena (Thrower 1981, 1:57). Two Dutch manuscript isobathic river charts (by Pieter Bruinsz., 1584, and by Pierre Ancelin, 1697) predate Halley's isogonic map of the Atlantic, but Halley was unlikely to have known of these. In 1702 Halley published an isogonic chart of the Atlantic and Indian Oceans, with data for the latter supplied mainly by captains of East India Company vessels. Because magnetic

FIG. 348. GEOMAGNETIC MAP. Edmond Halley, *A New and Correct Chart Shewing the Variations of the Compass in the Western & Southern Oceans*. An early state of the first edition, copper engraved and hand colored, from about 1701. Size of the original: 58.5 × 49.5 cm. Image courtesy of Barry Lawrence Ruderman Antique Maps, La Jolla.

variation itself varies over time, such charts have to be periodically updated, as Halley advised in the letterpress description that accompanied the map and explained its use (Thrower 1981, 1:365–67) (see fig. 442).

But Halley was not yet finished with his naval activities, and he requested the use of the *Paramore* for a third voyage to study the tides in the English Channel. This was approved, and he spent from June through September 1701 on this assignment. Unlike previous surveys of the phenomena, where the magnetic compass had been used to measure directions of the tides, Halley used the sun, a more accurate method, to determine the angles. He also provided a formula for estimating the height of the tides at certain places and times, as detailed on his resulting chart.

Halley's last important map is of the shadow of a solar eclipse over England, 1715 (see fig. 793). By the time it was published, Halley had reentered academic life through his appointment as Professor of Geometry at Oxford University in 1704. This was the period of Halley's observations on comets that have overshadowed all of his other accomplishments, including those in cartography. In 1713 Halley became secretary of the Royal Society. After the death of John Flamsteed in 1719, Halley was appointed the second astronomer royal at Greenwich Observatory in 1720.

Halley wrote a foreword, "To the Reader," for the *Atlas maritimus & commercialis* (1728), with recommendations on the uses of map projections. He opined there and elsewhere that the Mercator projection of 1569 ought to be called the "Nautical" projection (Thrower 1981, 1:78n1). Perhaps he knew that Erhard Etzlaub had anticipated Mercator in this projection in 1513, and that Edward Wright, in *Certaine Errors in Navigation* (1599) explained its mathematics for the first time. Throughout his life, Halley was interested in, and contributed greatly to, the science of mapmaking.

NORMAN J. W. THROWER

SEE ALSO: Celestial Mapping: Great Britain; Eclipse Map, Solar; Geographical Mapping: Great Britain; Greenwich Observatory (Great Britain); Isoline; Longitude and Latitude; North, Magnetic and True; Science and Cartography; Thematic Mapping: Great Britain

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Hase, Johann Matthias. Johann Matthias Hase (Haas, Hasius) was born in 1684 in Augsburg and died on 24 September 1742 in Wittenberg. He studied theology and mathematics in Helmstedt (1701–4) and in Leipzig (1704–7) with Christian Wolff, where he earned the title of Magister philosophiae in 1707. After returning to Augsburg in 1708 as house tutor for the aristocratic von Schnurbein family, he moved to Leipzig with his employer's son, Gottfried von Schnurbein, where he soon began lecturing at the university. By the end of 1719 Hase had become mathematics professor at the University of Wittenberg, where he also filled the roles of rector (1728) and dean of the philosophy faculty (1737) until his death (Bonacker [1967], 276–78).

Hase is regarded as one of the most innovative cartographers of the eighteenth century. As he emphasized in the posthumously published *Anmerkungen über seine Landkarten von den grossen Weltreichen* (in *Kosmographische Nachrichten und Sammlungen auf das Jahr 1748*, 1750), he followed the path determined by Guillaume Delisle, applying stringent critical interpretation of all materials available to him. Thus, he created distinctive maps that distinguished him among German cartographers of his time and placed him in the intellectual trajectory from Delisle to Jean-Baptiste Bourguignon d'Anville. Hase's map of Africa (fig. 349), which incorporated only reliable information, is a noteworthy illustration of his approach, foreshadowing by twelve years d'Anville's *Afrique* (1749), which would provoke great sensation.

In addition, Hase's numerous historical maps mark a paradigm shift in historical cartography by breaking from the "Ortelian pattern," in place from the end of the sixteenth century (Goffart 1995; 2003, 147–49, 256–59). Hase treated not only the common subject of antiquity but also the Middle Ages and contemporary time, thus demonstrating a universal historical interest: in his *De magnitudine comparata et determinata urbium* (appended at the end of his *Regni Davidici et Salomonæi descriptio geographica et historica,* 1739) twenty-four urban maps compare ancient cities like Babylon and Rome to modern cities like St. Petersburg, Stockholm, Lima, Beijing, and Tokyo. To illustrate political territorial relationships in different time periods, Hase employed separate copperplates for the six maps of his *Regni Davidici et Salomonaei descriptio geographica et historica*. Each plate overprinted a base map to show respective time periods by changing the borders of the extent of the kingdoms.

FIG. 349. JOHANN MATTHIAS HASE, *AFRICA SECUNDUM LEGITIMAS PROJECTIONIS STEREOGRAPHICÆ REGULAS* (NUREMBERG, 1737). First state, copper engraving, ca. 1:20,000,000. Size of the original: ca. 47 × 56 cm. Image courtesy of the Staatsbibliothek zu Berlin–Preußischer Kulturbesitz; Kartenabteilung (Kart. GfE I 1,50).

Hase had already planned an historical atlas by 1728, although the work did not appear until 1743, one year after his death. The *Tabvlae geographicae . . . de svmmis imperiis* that illustrated the third part of his *Historiae universalis politicae* (1743) comprised twenty-eight maps in quarto that treated the development of great empires from antiquity to the eighteenth century (see fig. 83). Using twentieth-century time divisions, about a third of the maps dealt with antiquity, close to one half with the Middle Ages, and just under a fifth with modern times, with only four maps. Eleven of the maps illustrate Arabic, Mongolian, and Ottoman Turkish history from the eighth to eighteenth century. Hase's historical maps, published between 1739 and 1750 by the Homann Heirs in separate editions, were integrated with his seven maps of the history of France and of the Holy Roman Empire of Charlemagne to Charles VI (the *Tabvlae IV. Imperii Francici vel Imp. Romano-Germanici s. Romani Occidentalis,* Schemata I–VII) in his *Atlas historicvs* (1750).

RENÉ TEBEL

SEE ALSO: Atlas: Historical Atlas; Geographical Mapping: Enlightenment; Historical Map; Homann Family

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Height Measurement.

ALTIMETRY
LEVELING

Altimetry. Although altimetry, or hypsometry, is generally understood to mean any measurement of height, it has in modern times come to refer specifically to height measurement with instruments other than those commonly used by surveyors. In the long eighteenth century, this meant the use of mercury barometers and, very occasionally, thermometers in the study of the atmosphere and mountains (Broc 1969, 71–96; Feldman 1985). Such barometry was fraught with error and ambiguity for several reasons. Until the refinements publicized by Jean-André Deluc in 1772, the portable barometer remained an inexact instrument (Middleton 1964, 134–39). Each set of barometric observations was necessarily calibrated against other height determinations, whether by leveling or geometrical calculations, which were often of poor quality. The rules advanced to relate changes in pressure to changes in height were therefore not robust and were routinely refined in light of each new round of barometric observations (Feldman 1985 gives full details). Not until 1796 did Pierre-Simon de Laplace advance a simple and universal model of atmospheric behavior that could support a pragmatic and straightforward methodology. Before Laplace, geography and cartography benefited only indirectly from altimetry, but his work enabled Alexander von Humboldt to embark on a comprehensive barometric mapping of the Andes that finally integrated altimetry within cartography (Feldman 1985, 188–95).

Barometric height determination originated in the so-called Torricellian experiment. In June 1644, Evangelista Torricelli described an experiment to create a vacuum by inverting a meter-long glass tube filled with mercury so that it stood upright in a mercury-filled basin. He concluded that the vacuum caused at the top of a tube was limited not by nature's *horror vacui* but by the weight of air pressing down on the basin, which forced the column of mercury just so far up the tube. He also inferred that the lesser weight of air atop a mountain would result in a lower height of mercury. Torricelli's inference was demonstrated in 1648 when Florin Périer, at the behest of his brother-in-law Blaise Pascal, found that the height of a Torricellian tube atop the Puy-de-Dôme in the Auvergne was 3 pouces 1.5 lignes (8.5 cm) lower than that in a second tube left in Clermont, far below. Already, two instruments were being used to determine relative differences in pressure and so height within a constantly changing local air mass (Middleton 1964, 19–32; Feldman 1985, 129–30).

There quickly followed a widespread effort to correlate differences in height and pressure in order to investigate the hydrostatic properties of air, to determine the height of the atmosphere, and to develop models of atmospheric behavior. Thus, Jacques Cassini (II) took numerous barometric readings atop mountains throughout the early eighteenth century, not to assist in the geodetic survey of the arc of the meridian but to test the law relating the pressure and volume of gases independently developed by Robert Boyle and Edme Mariotte. Several natural philosophers—including Edmond Halley, Mariotte, and Cassini II—proposed rules of atmospheric behavior (Feldman 1985, 131–38). More overtly cartographic was the use of barometers during the expedition to Peru, when Pierre Bouguer and Charles-Marie de La Condamine used a complex mix of geometry and barometry to determine the height of their primary baseline and so reduce their measured length of a degree to the desired equivalent at sea level (Broc 1969, 83–85).

In 1705–6, an interest in natural history and a desire to prove that the Alps were indeed the highest mountains in Europe led Johann Jakob Scheuchzer to measure the heights of a number of the lower Alps; to do so he used a crude Torricellian barometer calibrated against a single inexact measurement of the height of a cliff (Feldman 1985, 137–38). Scheuchzer did not include his results in his several maps, save for a lone spot height on his *Nova Helvetiae tabula geographica* (1712; see fig. 771), but his work seems to have prompted Christopher Packe to use barometry in studying the relief and hydrology of eastern Kent (Packe 1743, 81–83, 92–94). Packe located many spot heights on his own map (fig. 350).

In the first volume (1749) of his *Histoire naturelle, générale et particulière*, Georges-Louis Leclerc, comte de Buffon, argued that the earth's rotation meant that the tallest mountains would be in the tropics, the lowest in polar regions (Broc 1969, 78–79). Although Buffon later retracted this claim, it established a concern with the comparative distribution of mountains as a factor in understanding orogenesis. The issue led Deluc, a Genevan textile merchant, to begin barometric measurements of the Alps in 1754. Aghast at the inexact procedures and idiosyncratic

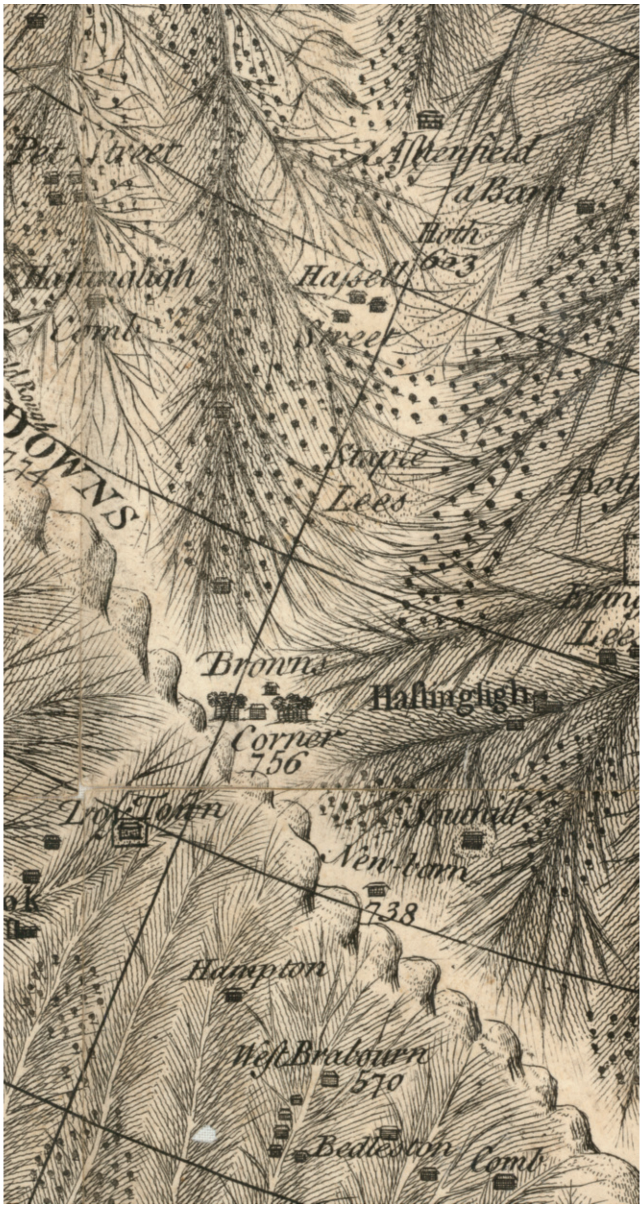

FIG. 350. SOME OF THE SPOT HEIGHTS ON CHRISTOPHER PACKE'S *A NEW PHILOSOPHICO-CHOROGRAPHICAL CHART OF EAST-KENT* (LONDON, 1743). Packe determined all his heights in feet above sea level with a portable barometer compared against a stationary barometer of similar manufacture kept at his home; he calibrated his portable barometer against the height of the main tower at Canterbury Cathedral. Note that Packe disturbed the planimetric form of his map with only a few lines of imprecise hills drawn in profile to indicate the main ridge lines. Otherwise he delineated the courses of streams and rivers so he could readily locate spot heights precisely. The full four-sheet map is reproduced as figure 622.
Size of each sheet: 60 × 65 cm; size of detail: ca. 16.0 × 8.5 cm. Image courtesy of the National Library of Scotland, Edinburgh (EME.s.130).

results of barometry, Deluc began an exhaustive program to perfect the portable barometer, its use, its correction with the thermometer, and its calibration against carefully leveled heights. His approach was strictly empirical and inductive: he reduced his field observations into a rule relating height differences to atmospheric pressure without reference to the nature and behavior of the atmosphere. Deluc also investigated the use of the thermometer to determine heights by measuring the temperature of boiling water; the instrument he designed for this purpose, the hypsometer, would be widely used in the nineteenth century (Feldman 1985, 152–56; 1998).

Deluc's exhaustive treatise, *Recherches sur les modifications de l'atmosphère*, finally appeared in 1772 in two volumes. At about the same time, the collapse of the Genevan economy led him to migrate to Britain. London proved fertile ground for his empirical approach, prompting first William Roy and then George Shuckburgh (Sir George Evelyn-Shuckburgh) to undertake extensive barometric measurements. Roy seems to have been particularly interested in developing a better topographical understanding of Britain. In 1774 and 1776 Roy and Shuckburgh together tested Deluc's procedures and rule at Schiehallion, the site of Nevil Maskelyne's measurement of gravitational attraction, for which Maskelyne had used a portable barometer made by Jesse Ramsden (Feldman 1985, 153–56, 162–77).

Deluc's extensive improvements to the portable barometer might have made barometric measurements more reliable, but his work still did not provide any certainty over atmospheric behavior, and Roy and Shuckburgh promptly modified his rule. Further work in the Alps, especially by Shuckburgh and Horace-Bénédict de Saussure, continued to complicate matters (Feldman 1985, 178–79). The proliferation of work in the Alps is apparent from the first published list of mountain heights, compiled by the French military engineer François Pasumot. Pasumot listed 107 mountain heights, as determined both by geometry and barometers, not counting another 45 Alpine heights provided by Jacques-Barthélemy Micheli du Crest, whose measurements he found manifestly untrustworthy. To compare the heights of mountains of the Eastern and Western Hemispheres, which he summarized in a diagram (fig. 351), Pasumot drew on La Condamine's observations in Peru, those by Cassini II and himself in France, and a variety of work by Scheuchzer, Deluc, Schuckburgh, Saussure, and others in the Alps (Pasumot 1783).

In 1796, Louis François Elisabeth Ramond de Carbonnières began his own barometrical observations in the Pyrenees. At the same time, Laplace cut through all the empirical complexities when he analyzed atmospheric behavior from first principles and derived, in just two pages in his *Exposition du système du monde*, a universal rule complete with simple corrections for

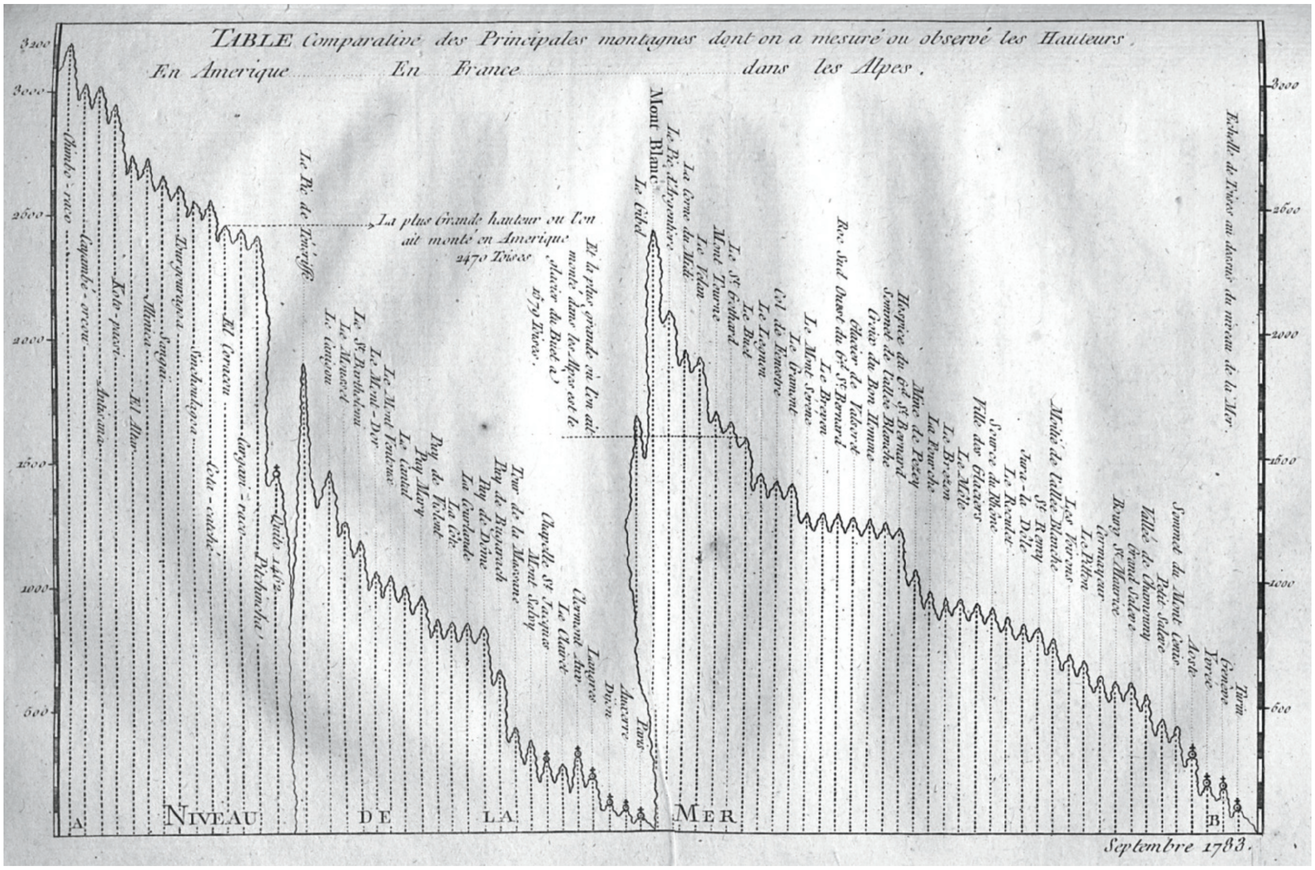

FIG. 351. THE FIRST COMPARATIVE DIAGRAM OF THE HEIGHTS OF MOUNTAINS IN THE NEW AND OLD WORLDS. François Pasumot, "Table comparative des principales montagnes dont on a mesuré ou observé les hauteurs en Amerique, en France, dans les Alpes," in Pasumot 1783, opp. 240. This diagram accompanied the first listing of mountains whose heights had been determined by barometric and geometrical measurements; barometric measurements were limited to peaks below the horizontal lines indicating the highest ascents by climbers.

Size of the original: 15.3 × 21.3 cm. Image courtesy of the Department of Special Collections, Memorial Library, University of Wisconsin–Madison.

temperature (Laplace 1796, 1:144–45). Ramond de Carbonnières thought Laplace's key coefficient too small when compared with his own observations, leading him to undertake more tests and correct Laplace's coefficient. In a series of memoirs, presented in 1804–9 and published together as *Mémoires sur la formule barométrique de la Mécanique céleste* (1811), he further simplified the process of barometric height determination to make it usable by any observer in the field. Only then could altimetry fulfill its promise as a fast and easy process well suited for areas as yet unmapped by the laborious process of high-order triangulation (Feldman 1985, 179–86).

MATTHEW H. EDNEY

SEE ALSO: Geodetic Surveying; Heights and Distances, Geometric Determination of; Packe, Christopher

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Leveling. Leveling is the process of determining how much higher or lower one point on the earth's surface is than another one. These points are related to a line (a

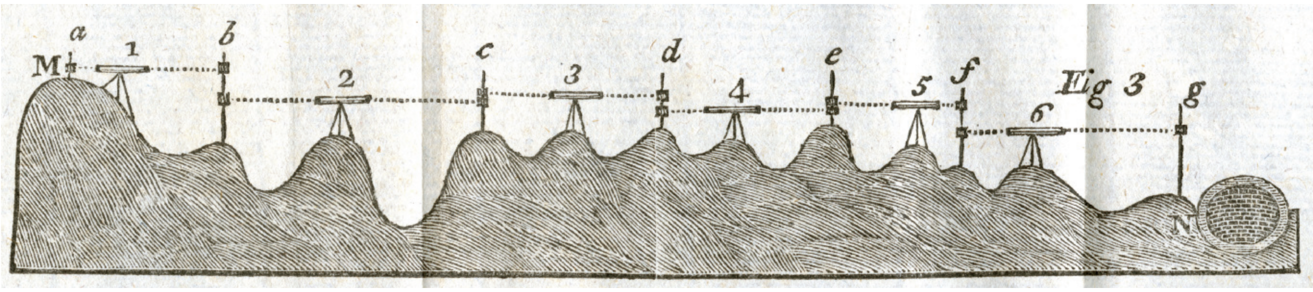

FIG. 352. LEVELING USED TO DETERMINE WATER FLOW. From William Davis, *A Complete Treatise on Land Surveying, by the Chain, Cross and Offset Staffs Only,* 2d ed. (London: Printed by Knight and Compton, 1802), pl. 7, fig. 3 (between 286 and 287). This diagram shows how to determine whether water can be brought from a spring at M to a reservoir at N by leveling at each end and at five intermediate stations.

Size of the entire original: 18.8 × 19.8 cm; size of detail: 3.2 × 16.5 cm.

great circle) equidistant at every point from the earth's center. Because the radius of the earth is large, a small arc of this great circle is considered to be a straight and level line. Many seventeenth- and eighteenth-century surveying textbooks describe the technique and give examples of its use in determining the flow of water (fig. 352), drainage work and the construction of canals, and military applications.

The principles underlying the methods of leveling have remained unchanged since the seventeenth century. If the two points whose heights are to be compared can both be observed from the same station, then the first point is sighted and a vertical staff erected there. The height is read at which a horizontal line from the instrument to the point crosses the staff. Then, a vertical staff is erected at the second point and the height read at which the horizontal line from the instrument (which, depending on the instrument, might have had to be rotated 180°) crosses the staff. The difference in elevation is equal to the difference in the readings on the two staffs.

If the two points are not both visible from the same station, then intermediate leveling points must be used. The instrument is placed midway between the first two points and the differences in elevation read as before and recorded in a log. The first staff is then moved to the second point, the second staff to the third point, and the instrument placed between them. A sight is read back to the second point and forward to the third and the elevations recorded again. This process is repeated until the end point is reached. The overall difference in elevation is the difference in readings between all the measurements made on the first staff and all of those made on the second. In the seventeenth and eighteenth centuries, most authors recommended that the horizontal distances between the staffs be measured using a chain. There was little discussion about making corrections for the curvature of the earth and for refraction, subjects that were more frequently discussed in texts published from the nineteenth century onward.

In the seventeenth century, leveling was often carried out over short distances and with unsophisticated instruments. A plumb bob or long needle was used to ensure that the instrument was level with the horizontal. Several water levels were developed; credit for the invention of the spirit level using a bubble is usually given to Melchisédech Thévenot in 1666, but its introduction was slow both in continental Europe and in England because of difficulties in constructing the containing tube (Richeson 1966, 136–37). Before the introduction of telescopic sights, a small circular board about ten centimeters in diameter was fixed on the leveling staff and covered with white paper with a black line drawn across the middle. This was moved up and down the staff until the black line could be seen through the sights on the instrument.

While the water level remained in use throughout the eighteenth century, especially in France, an increasingly popular instrument had telescopic sights leveled by a bubble or spirit level. Jonathan Sisson and Thomas Heath competed in devising improved instruments and publicized them in surveying texts. Sisson's Y level, communicated to the Royal Society in 1736 and published in William Gardiner's *Practical Surveying Improved* the following year, became the standard into the nineteenth century. Foresights and backsights could be taken without rotating the instrument and thus introducing errors.

SARAH BENDALL

SEE ALSO: Instruments for Distance Measuring: Level; Topographical Surveying; Transportation and Cartography: Canal Survey

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Heights and Depths, Mapping of.

RELIEF DEPICTION
RELIEF MAP
ISOBATH
BATHYMETRIC MAP

Relief Depiction. The cartographic depiction of the physical shape of the landscape in the Enlightenment perpetuated the same proliferation and inconsistency of signs as had been deployed on Renaissance maps (Delano-Smith 2007, 531–32). A review of the maps reproduced throughout this volume reveals significant variation according to the intended functions of the maps and the particular styles and skills of individual surveyors, draftsmen, and engravers. Even so, the institutional growth of topographical engineers throughout the eighteenth century led to significant efforts to standardize procedures for relief depiction, at least for larger-scale topographical maps. Thus, as Eduard Imhof (1965, 10) observed, the eighteenth century was the era with the greatest variation in forms for depicting relief on maps.

At the smaller geographical scales of maps of regions and of the entire world, relief was conceptualized in terms of ranges of hills and mountains, whether as areas of little settlement or as barriers to movement and communication. Renaissance geographers had developed a number of strategies for depicting hill ranges, whether nonpictorial linear signs or small icons of individual mountains, perhaps shown individually but commonly arrayed in lines or grouped en masse (Delano-Smith 2007, 547–51). Enlightenment geographers followed suit, and the great majority continued to use icons but without any consistency. The icons generally featured shading to enhance the sense of oblique or bird's-eye perspective but otherwise differed according to their spacing or grouping; their shape: from rounded "molehills" to sharply peaked mountains; their size: from small, delicate outlines to large, baroque masses; their aesthetic complexity: from simple triangles to "realistic" renditions with multiple peaks; their angle of view: some icons in profile, most oblique; and whether particular mountains were emphasized by being drawn larger than surrounding hills. The eighteenth-century innovation in small-scale relief depiction, informed by larger-scale practices, was to sketch the planimetric extent of slopes and escarpments with hachures or form lines (*Schraffen, Geländestriche,* or *hachures figuratives*). The bands of these hachures, in which the lines run down the slope, enclose the hills to give an impression of the overall landscape (fig. 353). At smaller scales, this practice produced the caterpillar-like ridge delineations with which Philippe Buache and Edme Mentelle indicated the distribution of mountain chains (see figs. 133 and 291) and which would become common on nineteenth-century regional maps.

The larger-scale detailed mapping of landscapes and urban places by military and civil engineers featured a fundamental tension between two representational strategies for depicting relief that was not resolved even by the end of the eighteenth century. Echoing previous commentators, Louis-Nicolas de Lespinasse specifically noted in his *Traité du lavis des plans* (1801, 41) that the topographical engineer could choose whether to represent the geometrical measure of a landscape feature in a proportionally correct orthographic plan or by the visual appearance of the feature in profile or as an oblique or perspectival view (Bousquet-Bressolier 1995, 105; Godlewska 2003). Perspective depictions of relief were built on long-established artistic practices that sought "realistic" imitations of landscape. Such perspectives were sometimes referred to as *perspective cavalière* (*Kavalierperspektive*) because they had originated in the elevated viewpoint of an observer mounted on horseback; they would later be geometrically codified as a form of low-angle perspective without a vanishing point, in which distant features do not get smaller. But in cartographic practice, perspective views of relief gave rise to "heterogeneous and hybrid images" (Nuti 1995, 65) that combined multiple visual angles and scales (fig. 354). Orthographic relief depiction had also developed in the Renaissance, with the use of both hachures and shading to indicate the extent and perhaps degree of slopes. Various attempts were made during the eighteenth century to regularize and refine those techniques, but in practice styles were varied and depended on personal ability, on techniques and training, and on the progressive institutionalization of military topographical efforts. The limitations of printing in rendering manuscript shading and color further influenced developments in depiction. Some novel works were produced, such as Christopher Packe's 1743 map of eastern Kent, in which he mapped all streams, down to the smallest rills, leaving ridge lines in white (see figs. 350 and 622), but these lacked wider influence.

In much of Europe, and especially in France, topographical engineers sought to resolve the tension between profile and planimetric views by perfecting a method of shaded relief depiction. This approach was codified, building on principles of architectural drawing, by Louis Charles Dupain de Montesson in his *La science des ombres par rapport au dessin* (1750), *L'art de lever des plans* (1763), and *Le Spectacle de la campagne* (augmenting his *La science de l'arpenteur dans toute son étendu* starting with the 1775 edition). Drawing slopes

FIG. 353. DETAIL OF ESCARPMENTS AND SLOPES. From Carsten Niebuhr, *Karte von dem groessten Theil des Landes Jemen*, new ed. (Vienna: Franz Anton Schrämbl, 1789), ca. 1:200,000.

Image courtesy of the Delft University of Technology (TRL 7.3.1.25).

from an orthographic perspective, topographers darkened the eastern and southern slopes as they would be in shadow were the sun located to the north and west. The darkening was accomplished by color (in manuscript), by cross-hatching (in print), or by varying the width of the still impressionistic hachures. For more level surfaces, however, where they needed to distinguish surface features, from fields and woods to towns and fortresses, topographers continued to sketch in slopes and escarpments (Bousquet-Bressolier 1995). Such techniques were applied to many of the topographical maps produced by French engineers, such as the seventy-six-sheet map at 1:28,800 including the border regions with Italy, from Nice to Grenoble, produced in 1749–54 under the direction of Pierre-Joseph de Bourcet (Konvitz 1987, pls. 1-2).

In Switzerland, shaded relief was used for the multisheet *Atlas Suisse* (1796–1802) by Johann Heinrich Weiss and Joachim Eugen Müller, financed by Johann Rudolf Meyer. The maps' authors succeeded in creating a surprisingly vivid map image dominated by the blue glaciers that were printed with a second copperplate (see fig. 861). This was the first application of multicolor printing to relief depiction and set the trend for nineteenth-century developments (Klöti 1997, 24). The steeper sections are accented by black cross-hatching, and in the high mountains there were often deviations from the originally planned vertical illumination; the northwest illumination accentuated the narrow ridges.

German military topographers did not use shaded relief, but rather sought to apply planimetric hachures in a more meaningful way by varying their thickness according to the steepness of the terrain. The goal was to give staff officers an immediate view of those places where the ground was too steep for troop movements. Rather than long, figurative form lines, this process produced sets of shorter hachures (*Böschungsschraffen* or *hachures normalisées*). The development can be traced in several maps produced in the German states, from Isaac Jacob von Petri's twelve-sheet *Accurate Situations-Charte von einem Theile des Churfürstenthums Sachsen* (1759–60), at 1:32,000, undertaken as a result of Prussia's invasion of Saxony, to the 270-sheet "Schmettausche Kabinettskarte" of Prussia (1775–87), at 1:50,000 (see fig. 829), to the 445 *Meilenblätter* (mile sheets) of Saxony (1780–1825) at 1:12,000, begun by Friedrich Ludwig Aster (fig. 355). The especially large scale of the

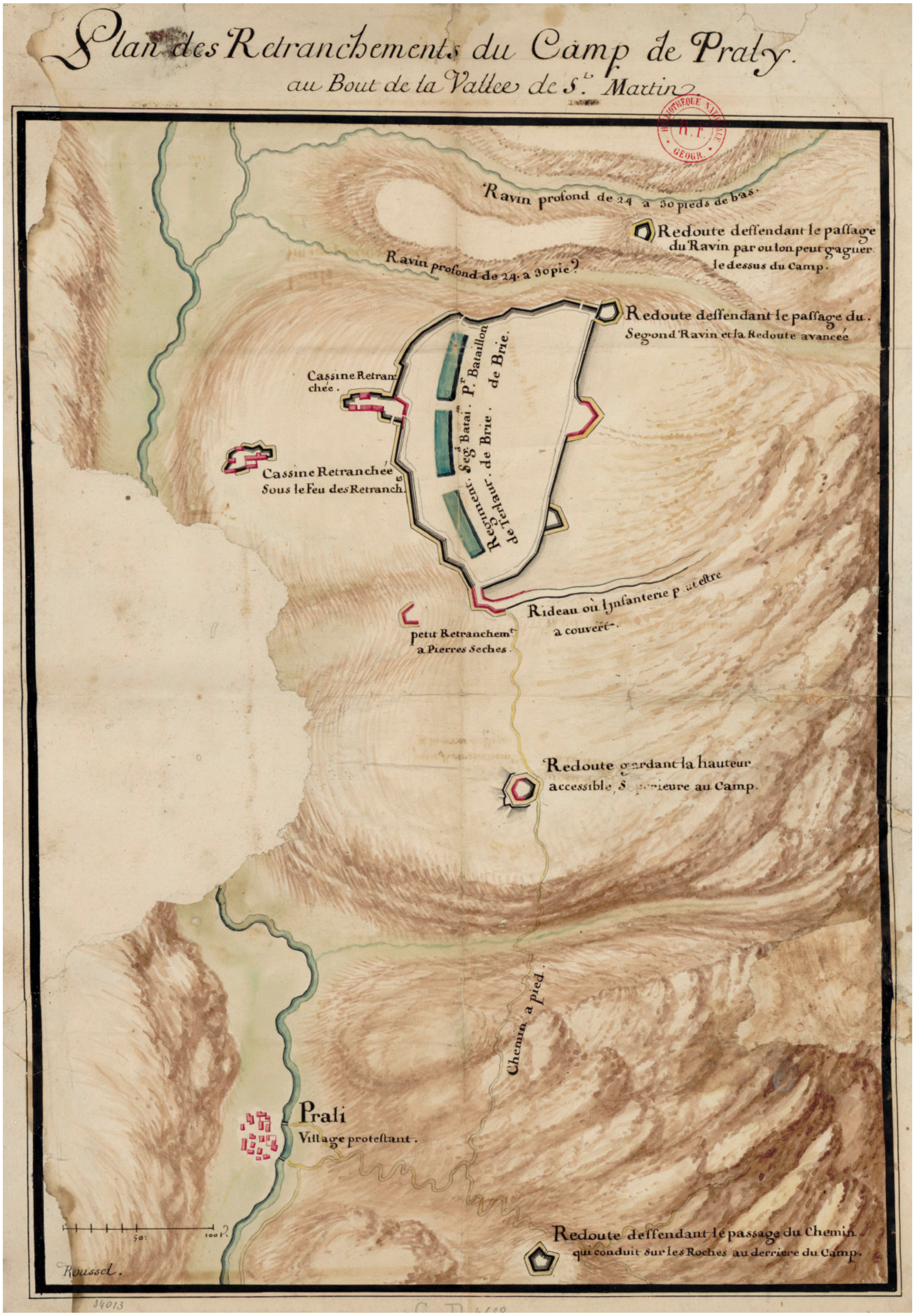

FIG. 354. LE SIEUR ROUSSEL, "PLAN DES RETRANCHEMENTS DU CAMP DE PRALY AU BOUT DE LA VALLÉE DE S^T^. MARTIN," 1704, CA. 1:3,000. The map has a complex mix of perspective views of relief. A note on the verso indicates that this plan was sent by Roussel from the camp of Louis d'Aubusson de La Feuillade at Pignarol (Pinerolo), near Turin, on 24 July 1704 during the Savoy campaign of the War of the Spanish Succession.

Size of the original: 53 × 37 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge D 4658).

FIG. 355. KÖNIGSTEIN AND OTHER TOWNS ON ONE SHEET OF THE *SÄCHSICHE MEILENBLÄTTER*, 1782. Size of the original: ca. 57 × 57 cm. Image courtesy of the Staatsbibliothek zu Berlin—Preußischer Kulturbesitz (Kart. M 14433, Blatt 332).

Meilenblätter allowed for detailed terrain representation covering not only the mountainsides but also valley floors—a level of comprehensive detail enabled by a triangulation framework and the measurement of relative relief (Brunner 2010).

Implicit in such work was the conceptual division of slopes into bands of equal height. When implemented rather crudely, this led to hills being depicted as slabs arranged in steps (see figs. 41 and 353). A more refined development of the technique led, at the very end of the century, to Johann Georg Lehmann's scheme, first developed in 1793, to construct slope hachures according to strict mathematical rules. Lehmann explained the scheme in detail in his *Darstellung einer neuen Theorie* (1799): each hachure would run in the direction of slope between imaginary contours at constant intervals, so that flat terrain received long hachures and steep terrain short hachures; moreover, hachures would vary in thickness according to the angle of slope, so that the steeper the slope, the darker the representation

FIG. 356. CONSTRUCTION OF VARIABLY SPACED HACHURES VIA CROSS-SECTIONS AND EXAMPLE MAPS. From Johann Georg Lehmann, *Darstellung einer neuen Theorie der Bezeichnung der schiefen Flächen im Grundriß oder der Situationszeichnung der Berge* (Leipzig: Johann Benjamin Georg Fleischer, 1799), figs. 20–23. These images demonstrate the connection between Lehmann's scheme and the results of shaded relief and field sketching.
Image courtesy of the Lehigh University Libraries Special Collections, Bethlehem.

(fig. 356). Lehmann first taught this scheme to Saxon army cadets in Dresden. Following his rules, several topographers could work on the same map series without any noticeable difference in style in depicting relief. However, Lehmann's system eliminated the immediacy of the topographer's sketching of landscape in the field by requiring the hachures to be carefully constructed in the office from heights defined by extensive leveling and triangulation surveys.

The topographers' division of relief into bands of constant relative height, evident in figures 355 and 356, seems to have given rise to some of the proposals from the later eighteenth century—all apparently made independently of each other—to draw only the lines that represent the boundaries between the bands as they intersect with the earth's surface, which is to say contours. The relationship is evident in John Churchman's proposal of 1804 that contours could be directly surveyed with a theodolite fitted with a level (Ravenhill 1987). It is also evident in French practices for mapping fortifications: in 1749 Louis Milet de Mureau proposed a scheme of determining multiple spot heights around a fortress, measured from *below* the local high ground (the highest point being zero), which were then color-coded within bands of relief; Milet de Mureau's scheme was widely implemented after 1761 (see fig. 231). In order to be able to compare plans of different fortifications, Jean-Baptiste Meusnier de La Place proposed in 1777 that the spot heights be determined *above* sea level, and he further suggested that contours should be interpolated from those spot heights; however, he was able to implement his scheme only for a bathymetric survey of Cherbourg harbor in 1789 (Dainville 1958, 202–5; Konvitz 1987, 96–99) (see fig. 363).

Other schemes for the construction of contours were not beholden to topographical practices. Like Meusnier de La Place, Charles Hutton, in 1778, also interpolated contours between the spot heights created for the 1773–74 survey of Schiehallion in collaboration with Nevil Maskelyne's attempt to measure gravity; professor of mathematics at the Royal Military Academy in Woolwich, Hutton may have developed his ideas based on military renderings of topography (see figs. 267 and 745). That contours and isobaths actually represent the same phenomenon—different levels of inundation as the sea rises and falls—was realized by Marc Bonifas, dit Du Carla, apparently as early as 1765, as part of his general studies of geophysics. In his *Expression des nivellemens* (1782), published by Jean-Louis Dupain-Triel *père*, Du Carla addressed the concepts of the contour (*arc de niveau*) and of using sea level as a baseline, despite its innate variability, but he did not explain how contours were actually to be constructed. Perhaps motivated by his father's work in preparing a mineralogical map of France, Jean-Louis Dupain-Triel *fils* soon used the results of the triangulation of France and the leveling undertaken by the Ponts et Chaussées to apply Du Carla's concepts to a map of France in 1791 (fig. 357), which he

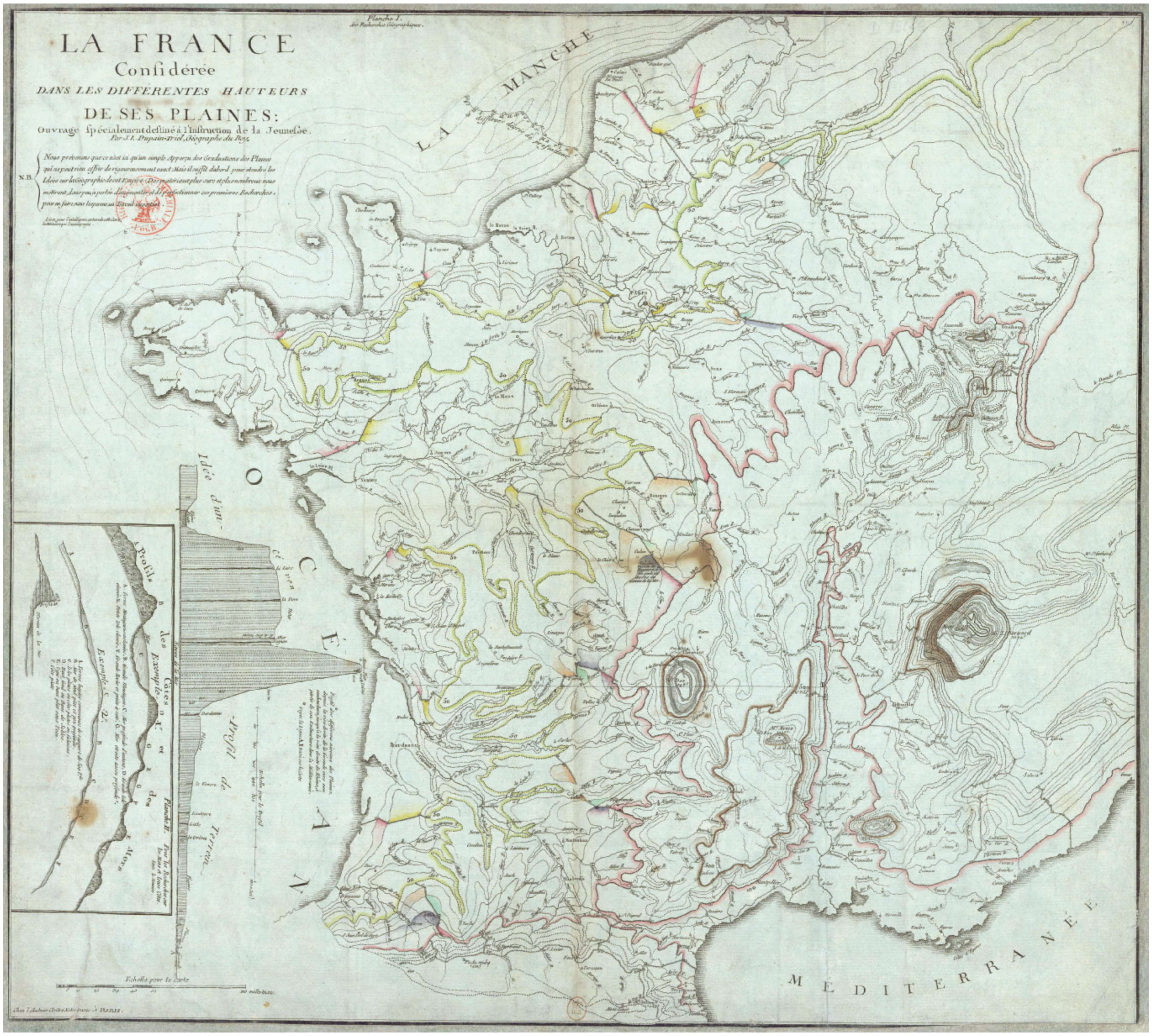

FIG. 357. JEAN-LOUIS DUPAIN-TRIEL *FILS*, *LA FRANCE CONSIDÉRÉE DANS LES DIFFÉRENTES HAUTEURS DE SES PLAINES* (PARIS, 1791). The map accompanies Dupain-Triel's *Recherches géographiques sur les hauteurs des plaines du royaume* (1791).

Size of the original: 46.0 × 53.5 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge D 15126).

described in terms of the established topographical concept of relief as stepped planes (Dainville 1958, 201–2; Konvitz 1987, 77–81; Lamandé 2009, 24–25).

By the end of the eighteenth century, several methods for relief depiction competed for the attention of topographical engineers. Reviewing the options in 1802–3, the French Commission topographique offered unanimous support for the use of contours but abandoned the idea because of the rigorous training required of surveyors and the length of time required to make sufficient observations. In addition, the commission thought that the average map reader would not be able to easily interpret relief from contours (Lamandé 2009, 24, 29), in a manner similar to when the Académie des sciences had rejected Du Carla's proposal in 1771. Instead, the commission recommended contours be used only for the large-scale and limited scope of fortification plans and that shaded relief be used at all other scales; but after staff officers objected, because they found the false northwestern illumination to be unnatural, the French military shifted to Lehmann-style planimetric shading in 1818.

MADLENA CAVELTI HAMMER

SEE ALSO: Commission topographique of 1802; Engineers and Topographical Surveys; Heights and Depths, Mapping of: Isobath; Isoline; Military and Topographical Surveys; Military Cartography; Military Map: *Plan-relief*; Packe, Christopher; Topographical Survey Map; Topographical Surveying; Urban Map: Urban View

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Relief Map. A relief map replicates the forms and contours of the earth's surface in three dimensions, employing a variety of materials and formats. These three-dimensional scale models, called simply "models" or "reliefs" or "plans in relief," were prized for furnishing princes and military commanders with all-encompassing visions of places, facilitating the perception and immediate comprehension of a territory and its topography, of a city, and of a city's fortifications. This type of relief cartography at various scales was practiced throughout Europe during the period 1500–1800 with three styles of models: fortified cities, theoretical fortifications, and topographic models.

The most common type of three-dimensional relief map of the period was the scale model of a fortified city. These models had multiple uses: they were at once tools for conceiving fortification projects and for assessing at long distance the management of ongoing work; they were aids for following and studying siege operations directed against a stronghold; finally, they were expressions of royal power over a city and embodied the material evidence for centralized control over the defense of territorial frontiers (see the articles in Corvisier 1993 for discussion of many of the following fortified city models and collections).

The first known three-dimensional relief map designed for military use could be that of Rhodes, created in 1521 for Pope Leo X in order that he might follow the Ottoman Empire's ultimately successful siege of the city. In subsequent years numerous models were created throughout Europe, most frequently intended for collections, but sometimes created as isolated works (for example, the *plan-relief* from the middle of the sixteenth century of the citadel of Jülich, Bayerisches Nationalmuseum, Munich, and the *plan-relief* of the Siege of Ostende of 1603, Museo Nazionale di San Marco, Florence). These collections and individual models, created from the end of the seventeenth and through the eighteenth century, were initiated by enlightened sovereigns, ministers, or military men of culture, smitten with the sciences.

Between 1568 and 1574 the cabinetmaker Jakob Sandtner created five highly detailed wooden models of the cities of Bavaria for its sovereign, Albert V. Another collection preserved in the Museo Storico Navale, Venice, was constituted between 1571 and 1707 to represent the twenty fortresses belonging to the Re-

FIG. 358. WOOD MODEL OF THE CITY OF FAMAGUSTA. It is mistakenly identified as Maina in Morea and is dated 1686. The model was restored in 1872. From the collection of the Republic of Venice.

Museo Storico Navale, Venice, Italy/Cameraphoto Arte Venezia/Bridgeman Images.

public of Venice, situated in the Aegean and Adriatic Seas (fig. 358). In France the collection of *plans-reliefs* of Louis XIV, initiated in 1668 but not completed until 1870, was the most prestigious in Europe for its breadth of coverage and for the detail of its execution.

In Sweden, General Erik Dahlbergh had fifteen relief models built between 1674 and 1703, representing the fortresses of the Swedish provinces in northern Germany and the Baltic states. They were created to show to the king and his government the situation of strongholds in faraway parts of the kingdom, just after their final construction campaigns.

The Kingdom of Piedmont-Sardinia assembled a collection of its principal fortifications as of 1717. Of the fifteen scale models created in Italy, only three are preserved today: one in the Musée des Plans-reliefs, Paris, and two others in the Istituto Storico e di Cultura dell'Arma del Genio, I.S.C.A.G., Rome.

The ambitious program of the Spanish Crown to create scale models of its fortifications, both on the Iberian Peninsula and in its South American possessions, was established in 1723 and taken up again in 1777, but never fully developed. Carlos III of Spain created a Gabinete de relieves designed to develop and house a collection of models of fortresses of Spain based on the French model. The effort was short lived, and only one model was created, Cádiz (Museo Histórico Municipal, Cádiz), on the very large scale of ca. 1:252 and covering 100 square meters, dimensions that proved too costly to either transport or store (Granado-Castro and Martín-Pastor 2016).

Around 1740–50 Charles Alexandre, duc de Lorraine, governor of the Austrian Netherlands, ordered the creation of an ensemble of seventy models in sculpted wood of small dimensions, which was preserved in the Grande Bibliothèque of the Palais d'Orange, Brussels. They represented the strongholds in Hungary, in the Balkans, in the Rhine Valley, and in northern Italy: the principal theaters of European wars of the seventeenth and eighteenth centuries. The collection was destroyed in 1780.

In the same period, Giovanni Carafa, duca di Noja, celebrated author of the first topographical survey and map of Naples (1775), created for Carlos III of Spain, king of Naples and Sicily, a group of very precise models of ten forts of the king's territories. Eight are still preserved in their respective cities (L'Aquila, Bari, Trani, Barletta, Syracuse, Sant'Elmo di Napoli, Monopoli, and Porto Longone [Porto Azzurro]).

The relief models mentioned here fall into two distinct groups. The first, of simple manufacture, show only the outlines of the fortifications and in a summary way the urban blocks with painted rectangles or in relief (e.g., the collection in Venice, and those of Dahlbergh in Stockholm). Those created in the eighteenth century go to greater pains to show the interior of cities and fortifications with some precision in imitation of the collection of *plans-reliefs* of Louis XIV. Only the French collection represents extensive territory around each stronghold.

The second type of scale model, the theoretical fortification model, was progressively created in Europe from the early 1600s and used by the military to teach the art of fortification to student engineers in the army, a practice that parallels the pan-European growth of military academies and engineering training schools. The Flemish mathematician and engineer Simon Stevin seems to have been the first to advocate for the use of scale models for pedagogical purposes. At the behest of Prince Maurits van Nassau, in 1600 within the University of Leiden he created a school for military engineers, the Nederduytsche Mathematicque. His program of instruction stipulated that the students should build scale models of fortresses in wood or clay in order to put into practice the forms and measurements studied in their theoretical courses (Van den Heuvel 2004, 110).

Elsewhere in Europe, there are collections of models representing the design of fortifications and fortification systems that were created from the beginning of the eighteenth century. These theoretical models reproduced in three dimensions the plans, perspective views, and profiles found in different treatises on fortification, both printed and manuscript, then circulating in Europe. The models allowed students to study and compare, in a simple yet lifelike way, the forms and evolution of different fortification systems proposed and elaborated by well-known European engineers of the sixteenth century.

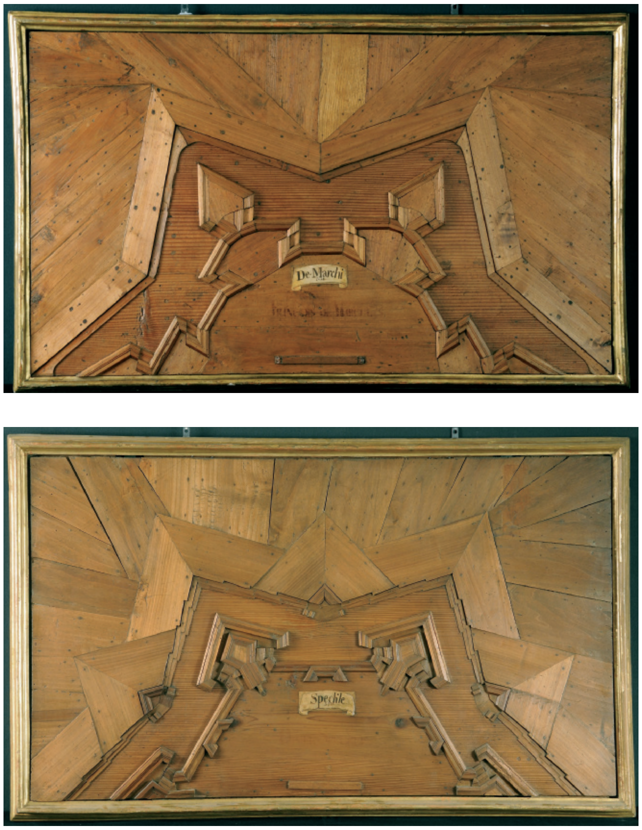

FIG. 359. TWO MODELS OF THEORETICAL FORTIFICATION SYSTEMS. The systems of Francesco de Marchi (above) and Daniel Specklin (below). From the collection of Luigi Ferdinando Marsigli (cataloged as "Marsili"); wood.
Size of each original: 60 × 103 cm. Both photographic reproductions were provided by the Museo di Palazzo Poggi–Sistema Museale di Ateneo–Alma Mater Studiorum Università di Bologna (MPPAM084 and MPPAM092).

Thus, in 1711 Count Luigi Ferdinando Marsigli, military officer and man of science, established the Istituto delle Scienze in the Palazzo Poggi in Bologna, starting with his own collection of natural and scientific history. Among the collections still in the Palazzo (now Museo) is a group of forty-two scale models built between 1702 and 1711, which served as the basis for the curriculum of this military school dedicated to the teaching of artillery officers and engineers (fig. 359). In Spain, numerous pedagogical models in woods, designed for teaching geometry, fortification, stereotomy, and siegecraft, were created between 1720 and 1776 in the heart of the Real Academia Militar de Matemáticas de Barcelona, opened in 1720. In Istanbul, the French-trained engineer François Kauffer built relief models of fortifications for pedagogic purposes in the school of mathematics, Hendeseḫāne (later Mühendisḫāne) (Hitzel 2000, 238).

In France, the gallery of *plans-reliefs* of the king produced some fortification models from 1712, parallel to the fabrication of *plans-reliefs* of strongholds. These scale models reproduced the theoretical fortified forms as conceived by French and foreign engineers. This collection was considerably enriched and diversified in the course of the nineteenth century (Warmoes 2013, 35–46).

Finally, topographical relief models of extensive territories at a small scale began to appear in the course of the last third of the eighteenth century. These models seem to have been produced in response to the problems of representing topographical relief on two-dimensional maps, particularly for mountainous regions. Swiss cartographers were the pioneers in the development of this type of topographical cartography designed for nonmilitary use.

The oldest relief map of this type, known as the "Relief der Urschweiz," is preserved in the Gletschergarten in Lucerne, Switzerland. It was created between 1762 and 1786 by Franz Ludwig Pfyffer, an officer in the Swiss Guard, for the king of France. The model represents in three dimensions the region of the Lake of the Four Cantons (Lake Lucerne) in the center of Switzerland, a territory of more than 3,500 square kilometers (Bürgi 2007b). In order to create it, Pfyffer used the techniques of triangulation survey for the first time in the Swiss Alps (fig. 360). Some years later, between 1789 and 1797, Joachim Eugen Müller, a self-educated cartographer, created a large model at ca. 1:60,000 that represented a large part of the Swiss Alps. Because of its great precision, the model, which was destroyed in 1903, served as the basis for the creation of the *Atlas Suisse* by Johann Rudolf Meyer and Johann Heinrich Weiss, published between 1796 and 1802 at ca. 1:120,000. This atlas remained the best map of Switzerland until the middle of the nineteenth century. The fabrication of

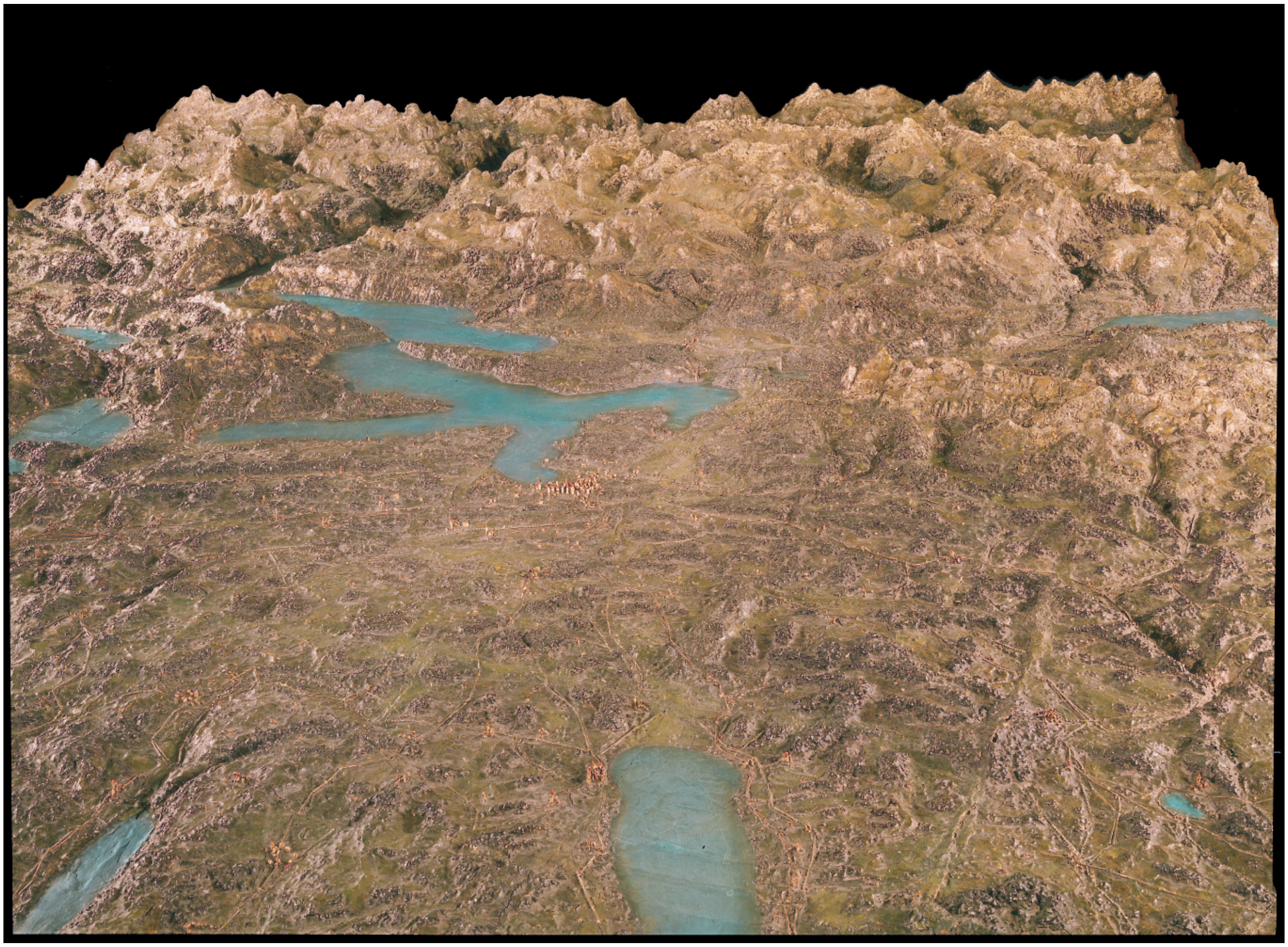

FIG. 360. TOPOGRAPHICAL RELIEF MODEL, THE "RELIEF DER URSCHWEIZ." Created between 1762 and 1786 by Franz Ludwig Pfyffer using techniques of triangulation survey to assemble the data. Plaster, sand, beeswax, wire, fragments of brick and ceramic, and cloth; ca. 1:11,500. Size of the original: 3.9 × 6.7 m; 26 square meters. Image courtesy of the Glacier Garden (Gletschergarten), Lucerne.

geographical, topographical, and even geological relief maps was an important development in Switzerland and the rest of Europe throughout the nineteenth century.

ISABELLE WARMOES

SEE ALSO: Globe: Relief Globe; Military Map: *Plan-relief*

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Isobath. An isobath (also named depth contour or bathymetric contour) may be defined as: "A line on a map joining points on the bed of the sea, or other body of water, situated at an equal vertical distance beneath the surface" (Neumann 1997, 174). The isobath developed as one type of isarithm (isoline).

In 1584, Dutch cartographer Pieter Bruinsz. drew a single line through points of equal water depth on his manuscript map of the Spaarne River and thus receives credit for using the first isobath on a map for navigation purposes (Wallis and Robinson 1987, 224). It was over a century later that Pierre Ancelin, on his map of the Maas River and environs in 1697, is given credit for the next extant map depicting an isobath. Perhaps the earliest printed map with an isobath appears in Luigi Ferdinando Marsigli's *Histoire physique de la mer* (1725) (fig. 361) (Gercsák 2009).

Published on two sheets in Leiden in 1729–30, Nicolaas Samuelsz. Cruquius's isobathic map of the Merwede River was the first to use a series of isobaths created from a large number of depth soundings to illustrate submarine features (see fig. 33). Cruquius's map employed a fully developed use of a series of isobaths to depict the river bottom and could be used for navigation purposes. The use, need, and eventual requirement for maps with isobaths by city-states and nations gradually evolved during the eighteenth century.

The isobath technique is inferential. It uses data from soundings to allow users to infer qualities and characteristics about the sea bottom the details of which cannot be seen or accurately known. The difficulty in producing a map with isolines lay in securing a sufficient number of accurate points to create a meaningful chart. The use of isobaths parallels the slower development of isolines for land surface topography in the form of contours. While it was equally difficult to measure height consistently and accurately to acquire the number of data points necessary for useful contours, the land surface configuration could be observed, whereas the sea bottom topography could not.

The technique of using multiple isobaths spread from its use for navigation of rivers and estuaries to the representation of the depth of open waters of seas and oceans; it became a tool of analysis and hypothesis about the nature of the ocean floor and submerged land connections. Philippe Buache depicted multiple isobaths on his chart of the English Channel, *Carte physique et profil du canal de la Manche et d'une partie de la mer du Nord*, presented to the Académie royale des sciences in 1737 and published in 1756 (see fig. 133). Johan Carl Wilcke similarly used isobaths on his chart of Landskrona Harbor in his presentation to the Kungliga Vetenskapsakademien in 1775 to show possible submarine land connections across a channel (Ehrensvard 1991) (fig. 362). By the end of the eighteenth century, hydrographers began to respond to growing requirements for maps with multiple soundings in open waters, but the collection of such data was limited by the dearth of personnel sufficiently capable of locating soundings accurately. The isobath would not become the standard means of expressing depth until the nineteenth century.

JOEL L. MORRISON

SEE ALSO: Cruquius, Nicolaas Samuelsz.; Isoline; Sounding of Depths and Marine Triangulation

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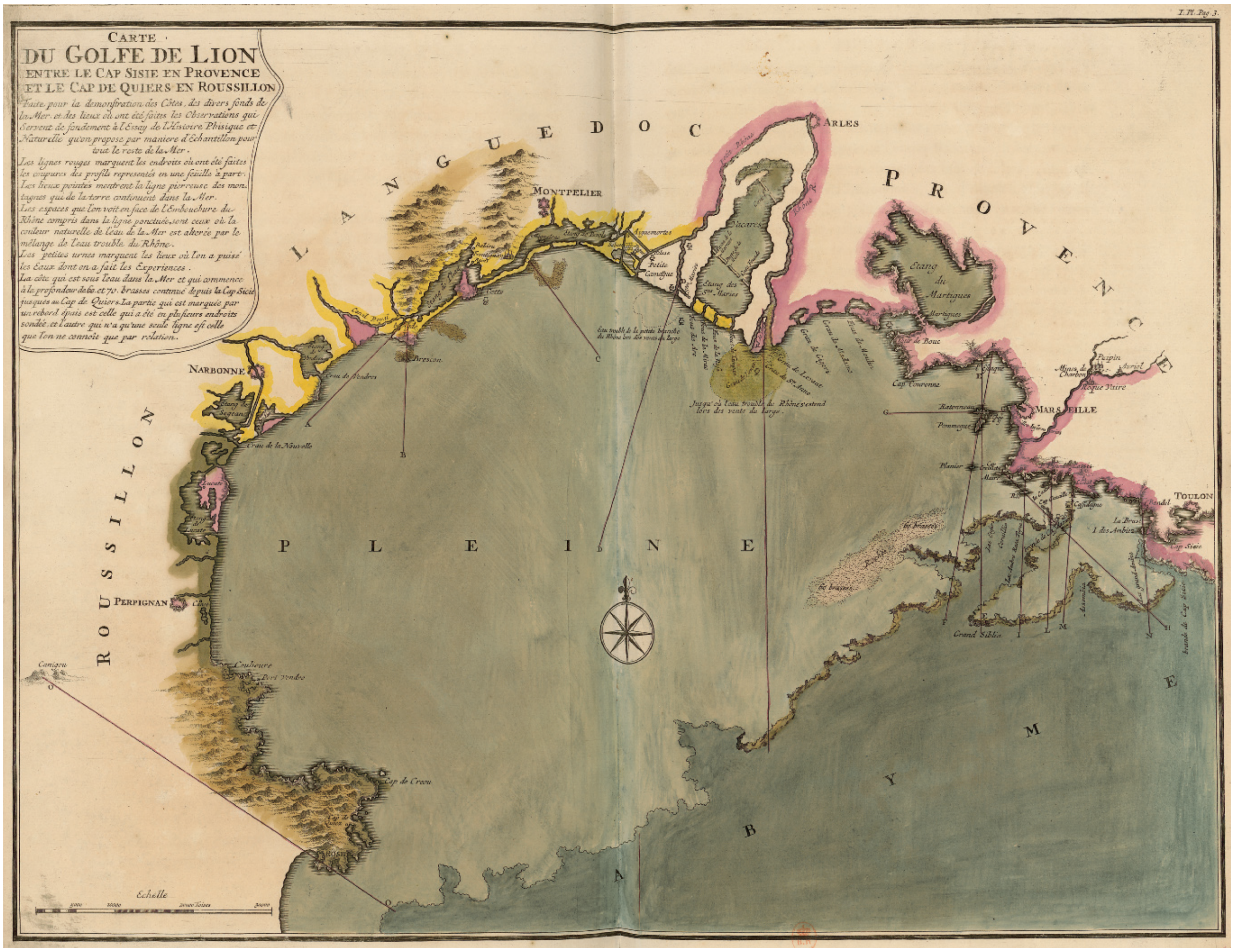

FIG. 361. LUIGI FERDINANDO MARSIGLI, *CARTE DU GOLFE DE LION*, 1725. From Marsigli's *Histoire physique de la mer* (Amsterdam, 1725), foldout between pages 2 and 3. This is an early and perhaps the first printed map to use isobaths—in this case a single line connecting the depth measurements of 60 to 70 brasses (a sea depth of between 95 and 130 meters). The thicker line in the eastern portion of the gulf was based on Marsigli's direct measurements; the thinner line in the western portion on measurements reported to him by others. On this particular copy, added color emphasizes the change of depth on either side of the contour line.

Image courtesy of the Bibliothèque nationale de France, Paris (Réserve livres rares R-1024).

Robinson, Arthur H. 1976. "Nathaniel Blackmore's Plaine Chart of Nova Scotia: Isobaths in the Open Sea?" *Imago Mundi* 28:137–41.
Wallis, Helen, and Arthur H. Robinson, eds. 1987. *Cartographical Innovations: An International Handbook of Mapping Terms to 1900.* Tring: Map Collector Publications in association with the International Cartographic Association.

Bathymetric Map. In addition to its etymologic sense—measuring depth—bathymetry translates the topography of the ocean floor into a graphic configuration of submarine relief, often by using isobaths (lines joining points of equal depth, a type of isoline) or contour lines. Its first expression on maps was accomplished by means of soundings. During the 1670s in France, Jean-Baptiste Colbert ordered coastal surveys (Chapuis 2007, 107–14), which were used for the first edition of *Le Neptune françois* in 1693 (Chapuis 1999, 101). The atlas included soundings of a density theretofore unequalled (Chapuis 2007, 110). However, soundings remained quite scattered on most maps, and isolines only delimited banks or reefs; anything else was pure experimentation. Hydrography took the lead from topography to express relief (Dainville 1958, 207), but the same could not be said regarding triangulation and the positioning of soundings (Chapuis 1999, 31, 87–132).

Beginning in the seventeenth century, maps regularly represented lines of highest and lowest tides (Chapuis 2007, 88), constituting the first de facto contour lines (Dainville 1958, 198), as did the representations of

FIG. 362. JOHAN CARL WILCKE, MANUSCRIPT CHART OF THE HARBOR AT LANDSKRONA IN SKÅNE, 1775. After his investigation of the harbor in 1770, Wilcke prepared a 265-page manuscript report, "Historiska och physiografiska underrättelser om Landscrona stad och hamn" (1770), and he drew two similar manuscript charts of the harbor in 1775. The chart shown here, titled "Modell-karta öfver hamnbankarna och sjöbottnen omkring Landskrona," contains a breakwater in the middle that is not shown on the other version (reproduced in Ehrensvard 1991, 111 [fig. 2]).
Size of the original: 73 × 105 cm (sheet); ca. 67.5 × 80.0 cm (to neatline). Image courtesy of Krigsarkivet, Stockholm (Svenska stads och fästningsplaner Landskrona 387).

riverbeds in estuaries by Pieter Bruinsz. (1584) and Pierre Ancelin (1697). However, the delineation of shoals that developed during this period might be considered pseudo-isobaths (Chapuis 2007, 101). Englishman Edmond Halley had already used isolines to indicate points of equal magnetic declination (see fig. 348); other earlier exponents included Italian Jesuit Cristoforo Borri, who taught navigation in Portugal and used curved isogonic lines around 1620 on a map now lost (Jonkers 2007, 432–33). Nathaniel Blackmore used isolines on his manuscript map of Nova Scotia in 1715 (Robinson 1976). Nonetheless, close study shows he did not provide them with an explicit key or with the correct progressive soundings except around Cape Sable (see fig. 862).

The *Histoire physique de la mer* (1725) by the Italian Luigi Ferdinando Marsigli contained the *Carte du Golfe de Lion* with one isobath (see fig. 361). Marsigli had taken soundings of up to 250 meters at a time when one rarely went deeper than 100 fathoms (162.40 m) to 150 fathoms (243.60 m) and usually not nearly that deep (Dainville 1958, 199). The limit of the continental shelf was the single isobath traced on Marsigli's map.

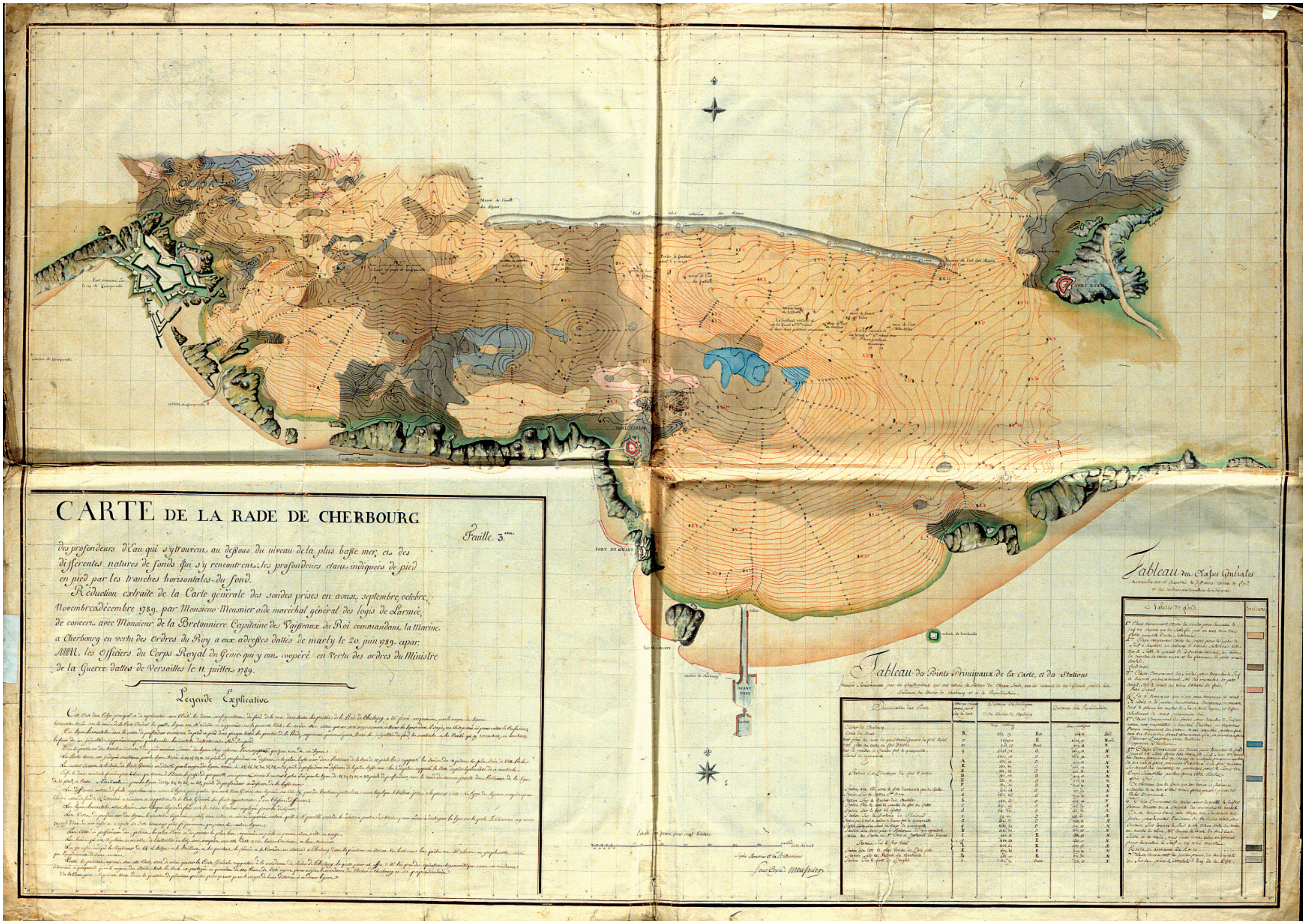

FIG. 363. MEUSNIER DE LA PLACE AND LA BRETONNIÈRE, "CARTE DE LA RADE DE CHERBOURG," 1789. Manuscript map, surveyed at a scale of ca. 1:4,320 for the soundings and reduced to ca. 1:7,200 for the outlines of the isobaths (at an interval of one foot, i.e., the pied du roi, whose value is now determined at 324.84 mm). These two scales are exceptionally detailed for the hydrography of this period and make this a foundation for the representation of terrestrial relief in the nineteenth century.

Size of the original: 96 × 139 cm. Image courtesy of the Cartothèque, Institut géographique national, Saint-Mandé (IGN 232-D).

The Dutch engineer Nicolaas Samuelsz. Cruquius—who encountered Marsigli in Holland during his 1721–22 visit—imagined true contour lines using an interval of ten feet; they appear on his 1729–30 map of the Merwede River and on his 1733 map of the island of Goeree (Dainville 1958, 199, pls. IV, V) (see figs. 33 and 190).

In 1737 the French geographer Philippe Buache presented to the Académie des sciences his manuscript "Cartes et coupe du canal de la Manche" showing "*la pente du fond*" (the slope of the bottom) of the English Channel. Published in the *Mémoires de l'Académie, année 1752* (1756) as *Carte physique et profil du canal de la Manche et d'une partie de la Mer du Nord* (see fig. 133), it employed isocurves equidistant (10 brasses = ca. 16 m) from one another based on the soundings taken from *Le Neptune françois* and from the work of Halley (Dainville 1958, 200–201, pl. VI). In 1771, Marc Bonifas, dit Du Carla, submitted his system of contour lines to the Académie des sciences, along with a theoretical map (see fig. 419); both were published in 1782 in the *Expression des nivellemens, ou Méthode nouvelle pour marquer rigoureusement sur les cartes terrestres & marines les hauteurs & les configurations du terrein* (Dainville 1958, 201–2, pl. VIII). In 1777, the abbé Jacques-François Dicquemare, native of Le Havre, deposited at the Académie de marine his "Mémoire sur le fond de la mer et les cartes qui le représentent" (Service historique de la Défense, Ms. ARM, cor., t. II, f. 21–33).

However, the most remarkable works were undoubtedly those of Jean-Baptiste Meusnier de La Place, *ingénieur du Génie* and *adjoint* of Gaspard Monge at the École du Génie de Mézières. Meusnier de La Place and *lieutenant de vaisseau* Louis-Bon-Jean de la Couldre de La Bretonnière produced the "Carte de la rade de Cherbourg," 1789 (fig. 363). They had overseen the surveys of the Channel first in 1771 and then in 1776 along with Pierre-François-André Méchain. In 1777, they were at Cherbourg, where later the difficult construction of the seawall began in 1784 (Chapuis 2007, 221).

Meusnier de La Place and La Bretonnière used horizontal, equidistant contour lines on their map, surveyed at a scale of 1:4,320 for soundings and then reduced to 1:7,200 for the drawing of isobaths. The interval between isobaths was one foot, making it an exceptional document at this scale for the period; it was not intended for navigation as it was too thick with details (Chapuis 2007, 262–63). Monge referred often to this foundational map in his lectures on descriptive geometry, given first at the École normale, then at the École polytechnique during the French Revolution (Chapuis 1999, 554). In the nineteenth century, it became a model for the representation of terrestrial relief, appearing two years before the 1791 map of France by Jean-Louis Dupain-Triel *fils*, the first with contour lines, framed with pseudo-isobaths (see fig. 357). On French marine maps the representation of isobaths experienced a true and systematic development only with Charles-François Beautemps-Beaupré between 1801 and 1804 (Chapuis 1999, 552–54).

OLIVIER CHAPUIS

SEE ALSO: Isoline; Marine Chart; Marine Charting; Marsigli, Luigi Ferdinando; Sounding of Depths and Marine Triangulation

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Heights and Distances, Geometric Determination of.

Geometrical surveying techniques provide the ability to determine both the distance to and the relative height of an otherwise inaccessible place. The techniques of measuring distances directly, with rods, chains, or perambulators, could not be used to measure the width of a river; nor could the direct techniques of leveling or altimetry be used to measure the heights of high mountains that had yet to be climbed. The two problems came together in the artilleryman's need to establish the horizontal and vertical distances to a target that could not be approached. The basic geometrical techniques were developed in the Renaissance and were codified after 1650 for a wide variety of instruments, from the quadrant to the plane table (notably in Manesson-Mallet 1702).

If just one unknown were to be found, whether the height of or the distance to a feature, then surveyors could use a simple technique based on the geometry of similar triangles (fig. 364). This was the technique used, for example, in 1754 by Jacques-Barthélemy Micheli du Crest when held prisoner in Aarburg. He constructed a seven-meter-long water level (equivalent to DC in fig. 364) equipped with a vertical, graduated "sight" at one end; looking from the other end of the level to mountains in the Alps, Micheli du Crest used the sight to measure the "height" (CE) of each peak. He took the distance from Aarburg to each peak (DA) from Johann Jakob Scheuchzer's *Nova Helvetiae tabula geographica* (1712; see fig. 771). These values allowed him to calculate the

FIG. 364. THE USE OF SIMILAR TRIANGLES TO FIND A SINGLE UNKNOWN LENGTH. To find the height of the wall, AB, the surveyor places a vertical stick CE in the ground and then finds point D such that E and B are aligned; the triangles ECD and BAD are similar, so the ratios of their sides will be the same: DC/CE = DA/AB. The lengths DC and DA are measured, CE is known, so AB can be calculated as DA × CE/DC, as shown in the lower left corner. From Manesson-Mallet 1702, 21 (pl. 9).
Size of the original: 14.3 × 10.3 cm. Image courtesy of the Bibliothèque nationale de France, Paris.

relative height difference (AB) from Aarburg to each of the Alps, although not with great accuracy; he established the height of Aarburg above the Mediterranean Sea by barometric measurement. Micheli du Crest published his results in a 1755 panorama, *Prospect geometrique des montagnes neigées* (Rickenbacher 1995).

Other geometrical techniques made use of observed angles and trigonometrical functions. Tables for these functions (sine, cosine, and tangent) and for their logarithmic versions were completed in the early seventeenth century and were available in a variety of printed versions after 1650, although their use required a greater mathematical competency than that required for common surveying. For example, in Glasgow in 1661, George Sinclair used a single triangle to determine the height of Tinto Hill in order to calibrate a barometer for further altimetric measurements. He measured the vertical angle from Glasgow (equivalent to J in fig. 365) to the hill's summit (C) and took the locally accepted value for the distance to the hill from the city (JD); from these he calculated the hill's

FIG. 365. THE KINDS OF TRIANGLES THAT COULD BE SOLVED WITH TRIGONOMETRY. In the middle of this image, an unmarked observer (who for convenience can be labeled as J) is shown forming a single triangle with a vertical tower. If the distance JD from the observer to the tower is known, then the height of the tower CD is JD × tangent(vertical angle at J). At the rear of the image, the measured horizontal angles at G and H and baseline GH can be used to determine the lengths of the sloping sides GB and HB via the law of sines: HB = GH × sine(angle at G) ÷ sine(angle at B [i.e., 180°–G–H]). From these sides, plus the vertical angles from G or H to B, the surveyor can then calculate the horizontal distance, from G, as GB × sine(vertical angle at G), and the vertical distance, from G, as GB × cosine(vertical angle at G). Those results can then be used in a similar manner to determine horizontal and vertical distances from both B and G to A. From Manesson-Mallet 1702, 3 (pl. 1).
Size of the original: 14.9 × 10.2 cm. Image courtesy of the Bibliothèque nationale de France, Paris.

FIG. 366. PROFILES OF THE ANDES MOUNTAINS, MEASURED GEOMETRICALLY. Pierre Bouguer and Charles-Marie de La Condamine calculated the relative heights of each mountain above their baseline at Yaruquí by geometry; CCCC marks the permanent snow line. They determined the height of the baseline above sea level (AAAA in the figure) by a complex mixture of geometry and barometric altimetry. From Pierre Bouguer, *La figure de la Terre, déterminée par les observations de Messieurs Bouguer, & de la Condamine, de l'Académie royale des sçiences, envoyés par ordre du roy au Pérou, pour observer aux environs de l'equateur* (Paris: Charles-Antoine Jombert, 1749), unnumbered plate opp. cx. La Condamine also provided his own profile in plate 2 of his *Mesure des trois premiers degrés du méridian dans l'hémisphere austral* (Paris: Imprimerie Royale, 1751).
Size of the original: ca. 21 × 47 cm. Image courtesy of the Bibliothèque nationale de France, Paris.

height (CD) as 500 paces (762 m) (Cajori 1929, 501–2). If the distance from the observer to the hill or tower could not be measured or was otherwise unknown, then a baseline could be measured pointing directly at the target; measuring the angular heights of the target from each end of the baseline permitted calculation of horizontal and vertical distances (Manesson-Mallet 1702, 67, pl. 30, center image and diagram lower left); Louis Feuillée used this technique in 1724 to measure the height of the peak of Teneriffe as 2,213 toises (4,313 m) (Cajori 1929, 496–97). Alternatively, a lateral baseline could be used (as in the upper part of fig. 365), either in isolation or as the first step in a triangulation. During their geodetic survey in Peru, in the 1730s-40s, Pierre Bouguer and Charles-Marie de La Condamine used these procedures to determine the relative heights of the stations in their triangulation but also to determine the heights of mountains too high to climb. They each presented the results in profiles of the Andes Mountains (fig. 366).

Increasing interest in the natural history of mountains and in the comparison of the heights of the mountains in the new and old worlds led after 1750 to sustained efforts to measure mountain heights by geometry, altimetry, and leveling (Broc 1969, 71–96). In some cases, engineers prefigured the work of nineteenth-century government surveys by constructing detailed topographical models from triangulated frameworks. In particular, a French-trained general, Franz Ludwig Pfyffer, undertook a triangulation of Central Switzerland (Uri, Schwyz, Obwalden, Nidwalden, Zug, and Lucerne cantons) for this purpose in 1760–61, which he described in correspondence in 1761 with Micheli du Crest. A careful triangulation between intervisible stations formed the primary geometrical framework, supported by a primary baseline 5.5 kilometers long with five more baselines across Central Switzerland with which to check his work; from this he observed horizontal and vertical angles to particular points to establish a dense field of locations with known heights with respect to the surface of Lake Lucerne. From this work he created both a remarkable 7 × 5 meter relief model of Central Switzerland, finished in 1786 (see fig. 360), and his *Carte en perspective du nord au midi* (1786) (Bürgi 2007).

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SEE ALSO: Height Measurement; Instruments for Angle Measuring; Topographical Surveying

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Hevelius, Johannes. Born into a prosperous brewing family in Gdańsk, Poland, on 28 January 1611, Johannes Hevelius acquired a particular interest in mathematics as a child in secondary school. The astronomer Peter Crüger tutored him outside of school, and, in addition to teaching him the basics of astronomy, advised Hevelius to learn drawing, engraving, and instrument construction—talents that would fortuitously prove useful later in life. He studied at the University of Leiden for one year in 1630 and then traveled to London in 1631 and France in 1632, making the acquaintance of many of the prominent scientists with whom he would later correspond. Returning to Gdańsk in 1634, he concentrated on the brewing industry until Crüger’s death in 1639 inspired him to return to studying astronomy. While juggling his brewing career, his duties as a town magistrate and councilman, and his scientific endeavors, Hevelius was able to construct an elaborate observatory that spanned the tops of three adjacent townhouses. In the same space, Hevelius built workshops for instrument-making, engraving, and printing in order to produce his own equipment and publications. After the death of his first wife, Katharina Rebeschke, in 1662, he married the much younger Catherina Elisabetha Koopman; the latter began to serve as her husband’s astronomical assistant (fig. 367) and is considered to be one of the earliest accomplished female astronomers in Europe. Through his extensive correspondence, famed observatory, and numerous lavish publications, Hevelius gained a considerable reputation among his contemporaries and received pensions from both Louis XIV of France and Jan III Sobieski of Poland. A disastrous fire in 1679 destroyed his home and observatory, and little was saved except for many of his books and manuscripts. After the fire, he rebuilt the observatory and continued his observations and publications, but at a reduced scale. Nearly a decade later he died on his seventy-sixth birthday, 28 January 1687.

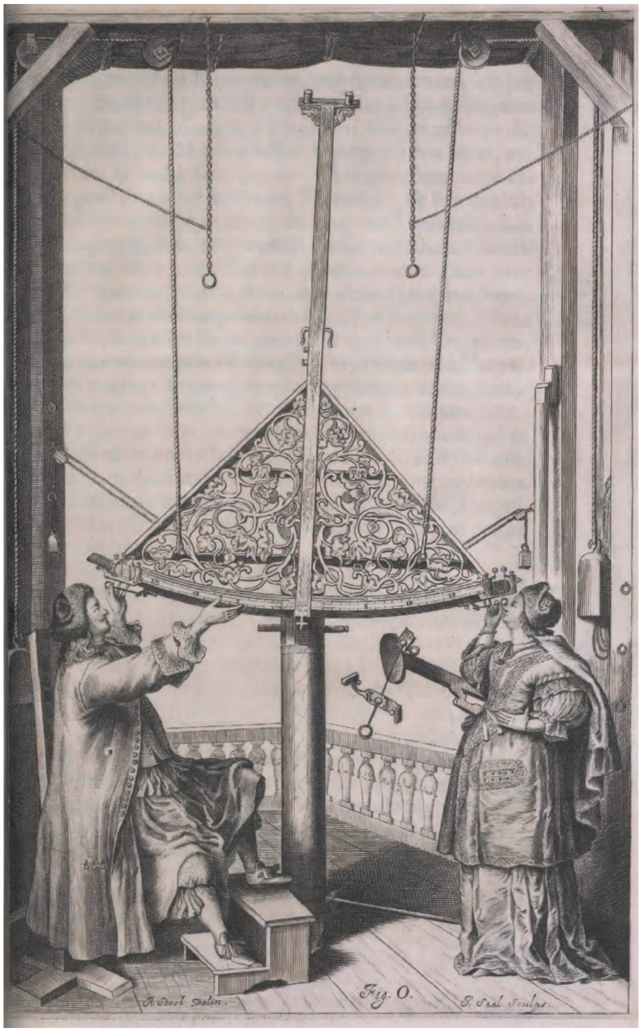

FIG. 367. JOHANNES HEVELIUS AND HIS WIFE ELISABETHA OBSERVING TOGETHER. From *Machinæ coelestis pars prior* (Gdańsk: Simon Reiniger, 1673), fig. O (following 254).
Image courtesy of the Smithsonian Libraries, Washington, D.C.

Although he produced many magnificent publications that were well received during his day, Hevelius is perhaps best known to the history of astronomy for his argument with Robert Hooke over the value of open sights versus telescopic sights, a dispute spurred by Hooke’s publication of *Animadversions on the First Part of the Machina Coelestis of . . . Astronomer Johannes Hevelius* (1674). Although an avid telescope user himself (for observations of the moon, comets, and other such celestial bodies), Hevelius thought that at the time telescopic sights would introduce too much error to be of use in making stellar observations (due to optical distortions). Hevelius was also known for his particularly keen eyesight—he was said to have had the eyes of a lynx by colleagues (Béziat 1875, 598)—which perhaps allowed him to achieve more precision of measurement with the naked eye than his contemporaries. Because the bulk of his work was observational rather than theoretical, and what theories he did propose proved to be unremarkable, Hevelius is often neglected in studies of Enlightenment science. Yet he was a dedicated observer who produced detailed observations of the moon, constellations, sunspots, comets, and a variety of other astronomical phenomena. He innovated a number of forms of cartographic representation of such observations and refined and expanded others.

Hevelius's *Selenographia, sive lvnæ descriptio* (1647) may be his greatest cartographic work, featuring over sixty-five maps of the moon that are considered to be among the finest ever produced. Most of his lavishly illustrated volumes feature maps, including those on subjects such as comets, solar and lunar eclipses, transits, and occultations. *Prodromus astronomiæ cum catalogo fixarum & firmamentum Sobiescianum* (1690), Hevelius's star atlas and catalog (see fig. 153), is notable for being the last produced entirely from observations made with the naked eye (with the exception of the inclusion of Edmond Halley's telescopically observed data from the Southern Hemisphere), and as such was quickly eclipsed by John Flamsteed's atlas a quarter century later. In his catalog and atlas, Hevelius introduced eleven new constellations to the canon, seven of which are still used today including the eponymous Lynx.

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SEE ALSO: Celestial Mapping: Enlightenment

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Historical Atlas. See Atlas: Historical Atlas

Historical Map.

"Historical map" refers to two very different objects: maps having intrinsic historical or documentary value (typically, city plans of contemporary date); and maps retrospectively illustrating historical lands, scenes, or moments (such as "The Biblical Exodus" or "Europe after the Treaty of Westphalia"). Only historical maps in the second sense are discussed here; maps as historical documents are treated elsewhere in this volume.

"Historical cartography" has only recently acquired its current, illustrative sense. Until the nineteenth century, ancient geography, "classical and sacred," was considered no more or less historical than modern geography, and comparisons of the two were a frequent and admired exercise. When ancient geography became outmoded, all maps of ancient, biblical, medieval, and modern history turned into the homogeneous subbranch of mapmaking that they are today. In the Enlightenment, however, the majority of historical maps probably fell within the purview of ancient geography.

The idea of projecting historical, primarily Holy Land, information onto maps reaches back at least to late antiquity (the Madaba map) and continued to be implemented in the Middle Ages (for example, the Hereford world map). By the 1650s, a large printed repertory had accumulated in the modern Ptolemy-derived style. Its subjects included not only biblical history, but also lands and moments of classical antiquity and even two postclassical scenes—the Anglo-Saxon Heptarchy and the Empire of Charlemagne (Goffart 2003, 52–57, 69–74). This stock was often reprinted and continually augmented, sometimes with improved geographical backgrounds. Cartographers in the Enlightenment were not innovative in the design of historical maps; they are more noteworthy for bringing the historical atlas to its mature form.

The main seventeenth-century home of historical maps was France, where Nicolas Sanson and his associates dramatically enlarged the sacred and classical repertories. The very extensive copying of Sanson maps outside France in the century after his death, and their adaptation by such successors as Gilles Robert Vaugondy, have left a singularly large mark in historical cartography. Outside the Sanson tradition, the forays of Guillaume Delisle into this branch were particularly skilled and original in choice of subjects (fig. 368). The contribution of German publishers, such as Homann Heirs and Seutter, became considerable in the eighteenth century, notably in the evocation of medieval German territories. In France again, Jean-Baptiste Bourguignon d'Anville gave an especially scientific cast to ancient geography. Many minor and anonymous cartographers were also involved.

Historical maps functioned mainly as aids to reading; few of them embodied discernible ideological motives. Delisle compiled but did not publish maps of early France for schooling the underage Louis XV; pedagogy tended to be monopolized by maps of ancient geography. Besides appearing in single sheets, historical maps illustrated Bibles, editions of the classics, and other books. The dispersal of map illustrations among countless books impedes any attempt to identify the full range of historical maps, which atlases only imperfectly reflect.

The lavish borders of figured roundels and other pictorial schemes that sometimes graced early historical

FIG. 368. GUILLAUME DELISLE, *THEATRUM HISTORICUM AD ANNUM CHRISTI QUADRINGENTESIMŪ,* 1705. The extended title of Delisle's map of Europe and the Near East in two sheets explains that it "shows the condition of both the Roman Empire and the barbarians living around it" in 400 A.D.

Size of the original: 49 × 120 cm. Image courtesy of the David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

maps are almost wholly absent in the Enlightenment. Symbols, usually lines, depicting movement (typically, the biblical Exodus or the travels of Saint Paul) were an established explanatory feature but only intermittently deployed; a solitary instance of tracks with arrows occurs in 1718 (Goffart 2003, 133–34, 191–92). Whereas ancient geography could be verified in widely known sources, the evidence underpinning maps of postclassical history was very variable. Some maps were imaginary or vague, some excellent and scrupulous (Goffart 2003, 231–39, 147, 209). An appropriate legend often turned maps of modern territories into witnesses to the past (for example, southeastern France labeled as "Royaume de Bourgogne et d'Arles"; Goffart 2003, 66–67). Then, as later, documentation was rarely cited. Interpretive comments only occasionally accompanied historical maps.

Without contesting the primacy of ancient geography, Enlightenment mapmakers notably widened the repertory of postclassical history. The range of subjects down to 1800, though large, consisted mainly of territories: the world as conceived by ancient geographers (Pomponius Mela, Ptolemy); ancient and later empires (Assyrian, Roman, Byzantine, Islamic, Mongolian, Holy Roman, Russian), kingdoms (Judea, early England, Hungary), and principalities (Hebrew tribes, Roman provinces, Benevento, Saxony, Dauphiné); Christian ecclesiastical districts (patriarchates, dioceses, religious orders); administrative subdivisions (especially French); city plans (Paris, Amsterdam). There were rare attempts at portraying movement (the dispersal of the sons of Noah, the Exodus, the barbarian invasions). Other subjects were medieval and modern voyages (Benjamin of Tudela, Marco Polo, Ferdinand Magellan) and the travels of literary figures (Abraham, Aeneas, Anacharsis, Don Quijote). Selected tracks of famous navigators added a historical touch to many world maps.

WALTER GOFFART

SEE ALSO: Atlas: Historical Atlas; Geographical Mapping; History and Cartography; Map Trade

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History and Cartography. Early modern scholars interested in the past form two main groups differentiated in part by the spatial scale of their inquiries. Scholars concerned with the broad landscape of the past, whether sacred or profane, practiced history per se, a field intimately intertwined with geography and geographical mapping. Antiquaries (as they were known in Britain) were more focused on the character of particular regions and places and with the ancient artifacts found in them; they had an abiding interest in both chorographical-scale geographical mapping and still more precise topographical mapping. These two communities were not completely distinct; for example, the English historian of the Roman Empire, Edward Gibbon made extensive use of both geographical maps and detailed archaeological plans. Nonetheless, this entry considers each community in turn to explore their respective engagements with mapping.

A commonplace for Renaissance and Enlightenment writers, echoing Cicero, was that history had two eyes: chronology and geography (Hofmann 2000; Mayhew 2003; Davis 2015, 119–22). The consistent expression of this sentiment should not, however, be mistaken for constancy in historical and geographical practice. By the later seventeenth century, Renaissance historical practices—moralistic and didactic in nature and pursued within the then-private domain of politics—had been transformed into a public pursuit grounded in new historical methods for systematically arranging historical data. History sustained a shared understanding of the key periods and continuities of the past among Europe's educated population. Moreover, historical knowledge had acquired such social prestige and value that historical writing constituted the primary genre of Enlightenment literature (Woolf 2005; Grafton 2007).

Increasingly analytical practices in geography and chronology underpinned the transformation of historical practice. Historians recognized that in order to reconstruct the past, they had to situate each new historical fact gleaned from newly uncovered manuscripts and artifacts within its proper time and place by means of systematic, comprehensive, and broadly comparative analyses. Scholars needed to work at their own chronologies and geographies in order to develop their understanding of the past. Enlightenment historians thus developed a deep appreciation for contemporary maps (i.e., contemporary to the historian), which provided a spatial framework for understanding the past, for locating past events, and for identifying and elucidating ancient toponyms. Gibbon (1994, 76) accordingly reminisced that, in 1751, when still a youth, he had found that "vague and multifarious reading could not teach me to think, to write, or to act." Rather, only his "early and rational application to the order of time and place"—an order provided by chronologies such as James Ussher's *Annales veteris testamenti* (1650) and *Annalium pars* *posterior* (1654), and by atlases such as Christophorus Cellarius's ancient geography, *Notitia orbis antiqui* in two volumes (1701–6), and Edward Wells's *A New Sett of Maps Both of Antient and Present Geography* (Oxford, [1700])—could "[dart] a ray of light into the indigested chaos" that history otherwise presented.

Chronology suffered under the new approaches to historical practice, especially by comparison to the other eye. As Jacques Barbeu Du Bourg noted in his *Chronographie, ou description des tems* (1753): "Geography is a pleasant and gratifying study. It places before us an image of the world entire, which we may traverse quickly and return to with pleasure. In it, the world is familiar: we see the world's peoples; we measure distances at a glance of an eye or with a compass in hand; we trace the contours of the map so deeply in our imagination that they can never be fully erased. The same cannot be said for chronology, a field so dry, difficult, and thankless that it offers nothing more to the spirit than a multitude of ugly dates that overwhelm and frustrate the memory and are then easily forgotten" (quoted by Rosenberg and Grafton 2010, 96; Davis 2015, 133–36).

Perhaps reflecting an older conceit that chronology was the map of time (Woolf 2005, 41; Davis 2015, 122–24), cartographic strategies were increasingly applied to make chronologies appealing. Some authors added maps to their chronologies, as in 1768 when John Blair added fourteen maps of ancient and modern geography, together with a historical essay on the development of geography, to his already well-known *The Chronology and History of the World* (1754). But the chronological lists themselves could be reorganized to create intricate diagrams and structured tables, some of which featured historical and contemporary maps (fig. 369) (Rosenberg and Grafton 2010, 96–128; Davis 2015, 124–27).

These early modern changes in chronology, geography, and history were manifested in the character of geographical atlases. Abraham Ortelius had established the character of the Renaissance atlas-cum-history with his *Theatrum orbis terrarum* (1570), a work that he "dedicated to the understanding of history" (quoted in Goffart 2003, 1). The *Theatrum*'s maps were of contemporary geography backed with narrative accounts of the geographical and historical curiosities of the regions in question. (Ortelius would add maps of the past in the *Parergon* appended to later editions of the *Theatrum*.) Such narratives fell away from atlases after 1650, and an entirely new genre of specifically historical-chronological atlases developed after 1700. These new atlases combined data-heavy tables and diagrams with maps of contemporary geography to celebrate spatio-temporal factuality, from the seven-volume *Atlas historique* (1705–20), probably by Zacharias Châtelain, to the amazingly successful Atlas Le Sage, i.e., the *Genealogical, Chronological, Historical, and Geographical Atlas* (1801) written by Emmanuel Las Cases under the pseudonym of "Mr. Le Sage" (Goffart 1995, 50; 2003, 4, 132–33, 303–14, 522–25).

The precise analytical function of geographical study in history was most apparent in the analysis of toponyms recorded in ancient sources, especially Ptolemy's *Geography* and the so-called Peutinger map. The late editions of the *Geography* that appeared between 1695 and 1730 used reworked plates from Gerardus Mercator's 1578 edition (Van der Krogt 1997, 1:491–95) and treated the ancient text as a work of strictly historical interest. Two eighteenth-century studies extended the critical analysis to include the history of the work itself: Georg Martin Raidel, *Commentatio critico-literaria de Clavdii Ptolemaei Geographia* (1737), and Jean-Nicolas Buache, "Mémoire sur la Géographie de Ptolémée" (in the *Memoires* of the Académie des sciences for 1787 [1789]). The Peutinger map had of course been studied since its discovery at the end of the fifteenth century and its initial reproduction in 1598. Historians produced a second, reduced-size facsimile and toponymic index in 1652 and then a third in 1753, after the original scroll's acquisition by the Habsburg Hofbibliothek in 1737 made it accessible for study once again (fig. 370). The purpose of these historical studies was to clarify and confirm the scroll map's information about routes and places, information that was then included in other historical maps and texts (Talbert 2010, 10–72). The geographical study of ancient, and also medieval, history was especially developed in Paris within the Académie des inscriptions (Abbattista 1997, 47–48, 56–57).

More generally, the assertion that geography was one eye of history reflected the practices of writing and presenting history (the past) and geography (the world) to a growing public eager for such basic knowledge. Justified and shaped by the historical-geographical scholarship of classical authorities, notably Strabo and Polybius, Enlightenment authors so intertwined the domains of historical and geographical knowledge that it makes little sense to impose modern disciplinary conceptions by classifying some works as "histories" and others as "geographies." Numerous "geographical and historical" accounts explained the present character of the world, its peoples, and their productions in terms of past events and explained how past events had played out on the world stage (Mayhew 2003, viii–ix). In doing so, some scholars implicitly argued for the superiority of modernity over antiquity, of the moderns over the ancients (Heffernan 2014, 8–9).

Historians relied on published maps to develop their sense of the past. Gibbon stands as an exemplar in this respect; his memoirs record his continual and intense efforts to use geography as a "mode of thought which

FIG. 369. AN INNOVATIVE CHRONOLOGICAL MAP, 1718. Girolamo Andrea Martignoni abandoned the standard format of chronological list in this remarkable four-sheet circular diagram, which he called a "carta istorica" and explained in his *Spiegazione della carta istorica dell'Italia* (Rome, 1721). The upper half of the circle depicts the regions of Europe and Asia Minor during the centuries of Roman hegemony, while the lower half shows the same areas during the centuries from the birth of Christ to 1700. Concentric circles are numbered at one-hundred-year intervals. Each sector of the circle represents a specific region, with rivers of time flowing into the metaphorical sea of the Roman Empire.
Size of the original: 57 × 56 cm. Image courtesy of the Institut Cartogràfic de Catalunya, Barcelona (RM.223645).

strove to apprehend facts which were at once historical and geographical." In the 1760s, Gibbon poured over maps and other geographical texts to refine Hannibal's route through the Alps and to understand the distribution of peoples in ancient Italy (Abbattista 1997, quotation on 46). Gibbon himself built up a large collection of contemporary maps, especially those by Jean-Baptiste Bourguignon d'Anville, to which he repeatedly turned in order to understand where the past had happened (Fernández-Armesto 1991; Abbattista 1997). Gibbon was by no means unique. In another instance, Pedro Rodríguez Campomanes, director of the Real Academia de la Historia (1764–91 and 1798–1801), sustained his historical investigations with a large collection of maps that eventually became the core of the academy's map collection (Arias 2007, 127).

Historians also reconstructed the geography of the past according to contemporary geographical frameworks. Much of this work was textual, as when Gibbon composed his *Nomina gentesque antiquæ Italiæ* (written 1763–64 and published later) as a verbal map and geography of ancient Italy or when he began his magisterial *The History of the Decline and Fall of the Roman Empire* (1776–88) with a description of the provinces of the later Roman Empire (Abbattista 1997). But such work was also often graphic and produced historical maps and atlases. Particular staples of the map trade were atlases that compared ancient and modern geography to provide a summa of geographical knowledge, such as Philippe Briet's bestselling three-volume *Parallela geographiæ veteris et novæ* (1648–49). The premier intellectual successor to this tradition in the eighteenth century was d'Anville, the highly respected French geographer who was also a prominent member of the Académie des inscriptions and produced several ancient atlases (Goffart 2003, 473–74). The textual and mapping components of ancient geography came together in Cellarius's *Notitia orbis antiqui*, which is lauded as "the first complete and systematic treatise" on ancient geography. Cellarius also prepared a comprehensive medieval geography, but the project lapsed on his death in 1707; his maps for this project were eventually printed in 1776 (Goffart 2003, 140–43, quotation on 140).

Of particular interest is the manner in which accounts of Europe's imperial endeavors necessarily relied on a geographical framework and routinely featured maps of the relevant regions for their readers' benefit. For example, the first volume of Cotton Mather's detailed account of Puritan settlement in New England, the *Magnalia Christi Americana* (1702), included both the author's own textual Ecclesiastical Map of the County—a hierarchical list on two pages of the colonies, counties,

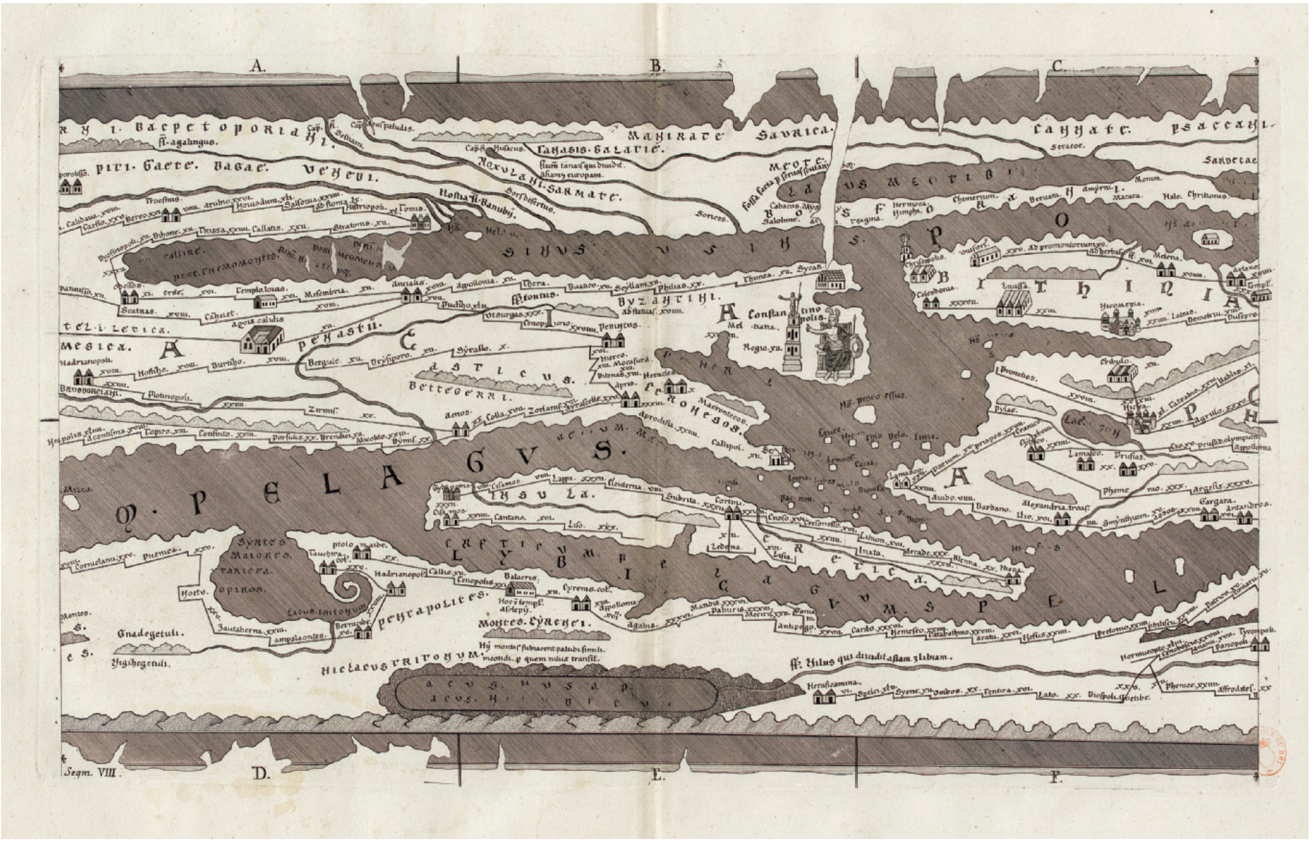

FIG. 370. FACSIMILE OF THE PEUTINGER MAP, 1753, SHEET 8, WITH CONSTANTINOPLE. From Franz Christoph von Scheyb, *Pevtingeriana tabvla itineraria qvae in Avgvsta Bibliotheca Vindobonensi nvnc servatvr adcvrate exscripta* (Vienna: Typographia Trattneriana, 1753).

Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge DD 1285).

and congregations (bk. 1, 27–28)—as well as a map of contemporary geography added by the publishers in London for the benefit of the work's readers in Britain (bk. 1, preceding 1). The work by historians in preparing accounts of the East India Company's activities in South Asia (by Robert Orme) and of the Spanish empire in the Americas (by Juan Bautista Muñoz) actively promoted new mapping activities by the respective imperial agencies (Tammita Delgoda 1992, 373–74; Arias 2007, 129). Enlightenment writers thus established the practice of imperial history, which is to say the writing of historical events as they unfurl on a seemingly preexistent and predefined stage.

In contrast to the wide-ranging scope of Enlightenment history, antiquaries were motivated by a variety of familial, communal, religious, institutional, and political sentiments to resurrect the past in order to celebrate the present. The hallmarks of their scholarship were a precise spatial focus on a region or particular place and an unquenchable thirst for facts about and artifacts from the past. In their chorographical descriptions, they blended local topography, archaeology, ethnography, bibliography, and natural philosophy in a complex mix that defies easy description. By the end of the eighteenth century, these historical magpies would be increasingly mocked for their lack of scholarly rigor and historical system (Walters 1988, 542).

Local regional mapping was so significant for the antiquarian project that antiquaries generally posed with plans and maps in their portraits (Walters 1988, 531). While antiquaries consumed topographical and chorographical plans of their specific subject areas, they also worked with maps prepared as part of more general geographies. Gwyn Walters (1970, 1976, 1988) explored how several British antiquaries in the late seventeenth and eighteenth centuries made new county maps as integral elements of their own publications to set the spatial stage for their celebratory accounts.

The eighteenth-century push to organize archives and libraries and so recover materials of antiquarian importance steadily unearthed a variety of recent and less-than-recent maps. As these early maps were found and publicized, antiquaries opportunistically described their content and occasionally produced facsimiles. For example, William Stukeley published a facsimile of a medieval copy of a map of Roman Britain that provided well over a hundred previously unknown toponyms as the frontispiece to his *Account of Richard of Cirencester, Monk of Westminster, and of His Works: With His Antient Map of Roman Brittain* (1757); however, the map and its parent work were proved in the nineteenth century to have been faked by Stukeley's Danish informant (Piggott 1950, 154–63). Johann Gabriel Doppelmayr included a description and facsimile of Martin Behaim's globe of 1492 in his *Historische Nachricht von den nürnbergischen Mathematicis und Künstlern* (1730), while Girolamo Francesco Zanetti included a brief passage on sea charts in his celebration of Venetian arts, *Dell'origine di alcune arti principali appresso i Viniziani* (1758).

The identification of maps depended on local traditions of antiquarian scholarship. In Germany, Eberhard David Hauber compiled a long and detailed bibliography of the maps of southwestern Germany. He further indicated the curious features that could be found on each map and also described, in a separate section, some surviving manuscript maps of Württemberg (Hauber 1724: map bibliographies, 1–38, 69–105, 105–14 [manuscript maps], 114–22, 148–80; discussions of curious features, 38–52, 123–37). In his ambitious summary of the antiquities of Britain, *British Topography* (1780), Richard Gough devoted substantial space to medieval maps of, or made in, Britain that others had found and publicized. Among these medieval maps were such major cartographic monuments as the Hereford *mappamundi* and the now-eponymous Gough map of Britain. He described the content of each map, focusing on British place-names, and he reproduced ten of them in full or part. He then, with neither break nor heading to warn the reader, provided a bibliography of printed Renaissance maps of Britain and its counties, which in turn became a catalog of modern maps of regions, counties, and roads, which was then complemented by a list of modern charts of the British coasts (Gough 1780, 1:57–113).

The antiquaries' special focus was, however, on the character and heritage of particular places. Thus, they pursued topographical as well as chorographical mapping. Throughout the long eighteenth century, they prepared detailed architectural and archaeological plans of ruins, relicts, and general sites of interest (fig. 371). The results of this proto-archaeology are evident in any number of maps of landscapes and urban places. British engineer William Roy's fascination with Roman and Celtic remains established the eventual practice of the nineteenth-century Ordnance Survey to map the locations of ancient sites on its larger-scale topographical maps (Hodson 2011); nor can we ignore the careful archaeological mapping of classical monuments in Giovanni Battista Nolli's large plan of Rome (1748) (see fig. 610). Probably the most assertive antiquarian survey was that undertaken by Marie-Gabriel-Florent-Auguste, comte de Choiseul-Gouffier, who in 1776–79 toured the islands and coasts of the Aegean with a small flotilla of artists and engineers trained at the École des Ponts et Chaussées. They painted and mapped contemporary places and peoples, architectural remains, and the landscapes of ancient sites. The products informed not only his own three-volume *Voyage pittoresque de la Grèce* (1782–1822) but also subsequent accounts of ancient

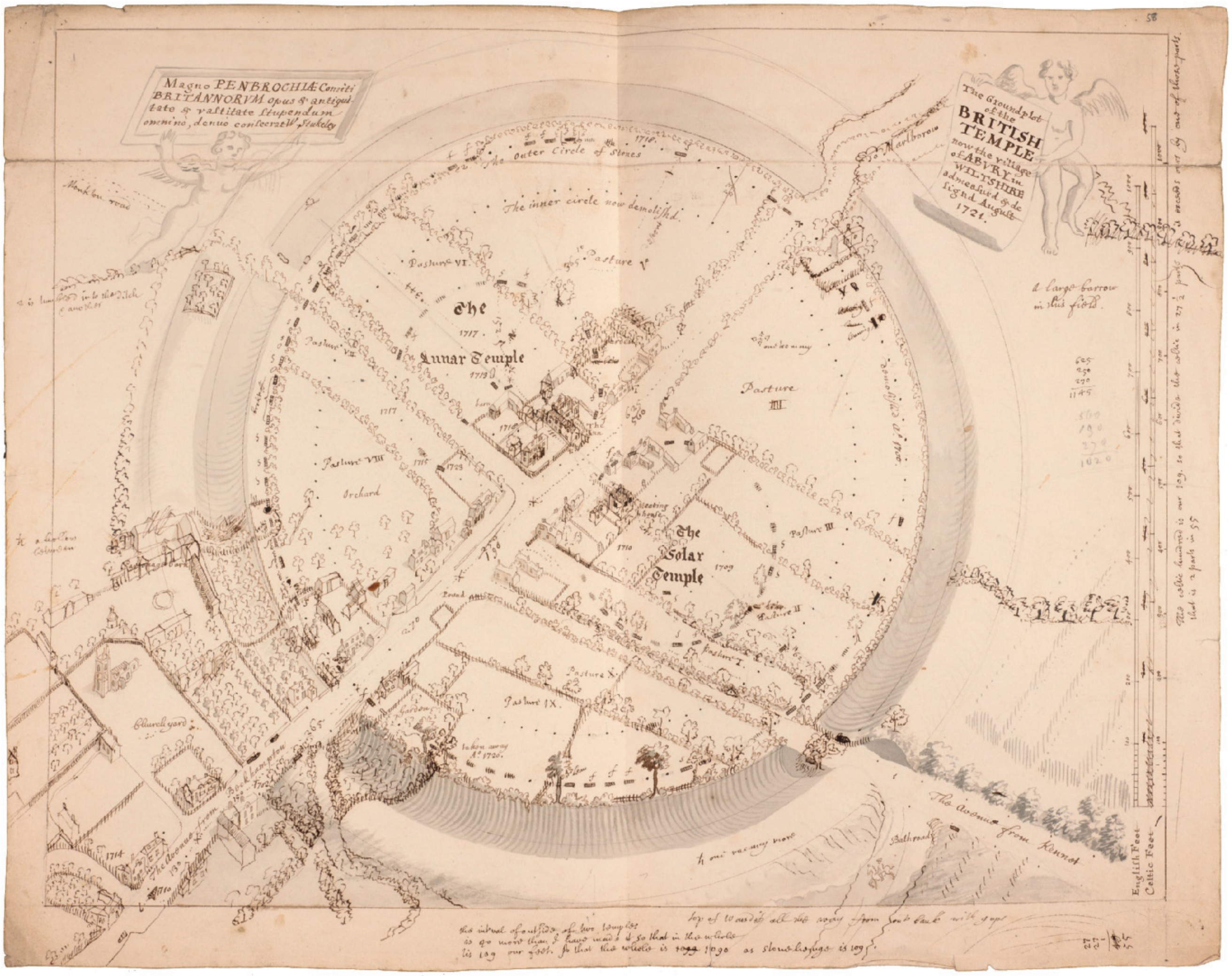

FIG. 371. AN ANTIQUARY'S PLAN OF ANCIENT REMAINS. William Stukeley prepared this manuscript—"The Groundplot of the British Temple Now the Village of Abvry in Wiltshire Admeasurd & Designd August 1721"—in the midst of several years' fieldwork at the great stone circle at Avebury, Wiltshire. His final plan (1724) would be engraved with remarkable sensitivity as the frontispiece to his *Abury: A Temple of the British Druids* (1743).
Size of the original: ca. 37.5 × 47.5 cm. Image courtesy of the Bodleian Library, University of Oxford (Western MSS Gough maps 231, fols. 57v–58r).

Greek civilization, especially via the work of d'Anville's protégé, Jean-Denis Barbié Du Bocage, who curated Choiseul-Gouffier's collections and later prepared the plans and views for the highly popular *Voyage du jeune Anacharsis* (1788) (fig. 372) by Jean-Jacques Barthélemy (Edney 1999, 178–85; Tolias 2005). Such topographic work could have an overtly and narrowly social focus, as when in 1702 the Shropshire yeoman Richard Gough (no relation to the other Richard Gough) idiosyncratically mapped both the "ancient" and contemporary social structure of his community through maps of pew ownership in the parish church (Gough 1981, 80–83).

Focused as they were on the mapping of their home regions, antiquaries were well attuned to how well topographical plans and chorographical maps depicted the immediate landscape. As Hauber and Gough listed and described maps, they accordingly outlined their flaws. Hauber (1724, 53–68, 137–47) detailed the "defects and flaws" in regional maps as a plea for their improvement. Gough was imprecise in his criticisms and provided only blanket condemnation: "Notwithstanding the assertions of [Emanuel] Bowen, [Thomas] Kitchen [i.e., Kitchin], and other modern makers, that their maps are framed from *actual new* surveys, there is scarce a single one which does not abound with faults: and a set of correct maps remains to be hoped for from the undertakers of surveys of counties; though it were much to be wished the abilities of some of these were more answerable to the encouragement afforded them. The same may be said of all the republishers of [the road maps by John] Ogilby."

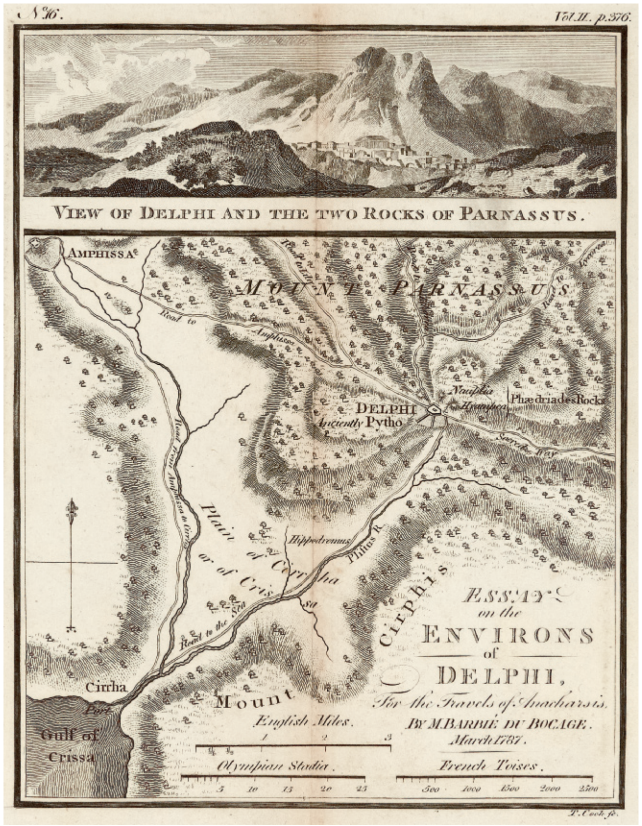

FIG. 372. TOPOGRAPHY OF AN ARCHAEOLOGICAL SITE. One of Jean-Denis Barbié Du Bocage's images for Jean-Jacques Barthélemy's *Voyage du jeune Anacharsis* (1788), from an English-language edition (1792), depicting the site of the oracle at Delphi.
Size of the original: 18.3 × 14.3 cm. Image courtesy of the Osher Map Library and Smith Center for Cartographic Education at the University of Southern Maine, Portland (OS-1792-13).

Gough further repeated the claim made by Anton Friedrich Büsching (1754, 39) that of the 16,000 "general and particular" maps supposed to have been published since the invention of printing, "not above 1700 are originals" (Gough 1780, 1:108–9). While such criticism by antiquaries mirrored that leveled by geographers against geographical maps, they were made from a topographical and chorographical perspective. Thus, they indicate the growing awareness in the eighteenth century of the ability of civil and military engineers to extend detailed surveys across large regions and therefore of the potential to reform all mapping from the ground up, as it were, and they point to the eventual formation of the modern cartographic ideal in the nineteenth century.

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SEE ALSO: Antiquarianism and Cartography; Anville, Jean-Baptiste Bourguignon d'; Atlas: Historical Atlas; Geographical Mapping; History of Cartography; Historical Map; Public Sphere, Cartography and the; Religion and Cartography

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History of Cartography. "The principal concern of the history of cartography is the study of the map in human terms" (Harley 1987, 1). In considering the application of this description to cartography in the European Enlightenment, distinction may be made between the history of cartography in the Enlightenment as contemporaries then understood their work and its relationship to that of earlier cartographers and the work of modern scholars looking at Enlightenment cartography as one period in a longer history.

For J. B. Harley (1987, 9–10), cartography in the Enlightenment was distinguished by a belief in the accuracy of measurement "as the sine qua non of cartographic progress"; by "an increasing emphasis in mapping on original survey, on more precise instruments, especially at sea, and on more detailed cartographic representation as an end in itself"; by the fact that practicing mapmakers increasingly distanced themselves from their predecessors' maps; and by a general attention to maps both as documents of and licenses for discovery and as part of strengthening interests in history and ancient geography (fig. 373). Other features of the period included a rise in biobibliographical studies, in which lists of mapmakers and their works were compiled (Höhener 1995; e.g., Gregorii 1713), an increased interest in map collecting (Skelton 1972, 70–73), and a recognition of the mapping capacities of non-Europeans and nonliterate peoples, although Eurocentric views dominated what cartography was held to be. Even so, because by 1800 maps were seldom contemplated and analyzed as artifacts, because relatively little notice was taken of the methods by which they were constructed and drawn, and because no consideration was given to the study of cartographic form as a mode of communication, "the history of cartography had yet to be born as a subject we would recognize today" (Harley 1987, 12).

Evidence from Enlightenment cartographers illustrates, complicates, and, to an extent, contradicts these claims. One theme evident in Enlightenment commentary was a sense of national mapping capability relative to other countries. For France, Didier Robert de Vaugondy (1755) traced the rise of more accurate mapping to the establishment of the Académie des sciences and its patronage of astronomer-geographers while also dismissing the aberrancy of earlier Dutch and English works. In Scotland, geographer royal Sir Robert Sibbald promoted his own atlas plans from the 1680s by likewise dismissing others' earlier work, chiefly that of the Dutch mapmakers Willem Jansz. Blaeu and Joan Blaeu. A related and prevalent theme was the dismissal of earlier individual mapmakers as errant and thus their maps as out-of-date and unreliable. John Blair considered the rise of geography and cartography in Britain synonymous, while earlier classical maps were little more than "rude Outlines and topographical Sketches" (Blair 1768, 4). Yet although he invoked a linear and progressive "improvement" in both subjects since the Greeks, largely because of increased accuracy in maps, his conclusion was more circumspect than many: "Maps in general ought to be considered as *unfinished Works*, where there will be always found many things to be corrected and added, and that they ought to have a kind of *floating Title* affixed to them, expressive of their imperfect State" (Blair 1768, 19–20). For Britain, the antiquarian-topographer Richard Gough similarly associated improvements in geography with advances in mapmaking and accorded England primacy: "If England did not teach other nations the art of making or engraving maps, she is preceded by very few" (Gough 1780, iii).

Enlightenment cartographers judged themselves better not only in relation to the capacities of their predecessors but also often with respect to their contemporaries in other nations. They commonly did so by reference to precedence, appeals to accuracy and novelty, and dependence on science and direct observation. For John Green, improvement in maps required not just teaching "the Student how to draw Maps," but also warning mapmakers and map users alike of the "Defects of former Geographers and Travellers" (Green 1717, preface). Green's remarks illustrate a further sense in which Enlightenment mapmakers and commentators understood their work in historical perspective, namely its heightened utilitarian value. One expression of this, for example, was that maps helped both stimulate and reflect connections between the improvement of geography and the results of exploratory inquiry. As a result, geography books, which as a genre aimed at textual descriptions of the world, began to incorporate maps as accurate representations of that world and as visual accompaniments to written texts by which readers could better locate themselves and others. Map production and book reading together be-

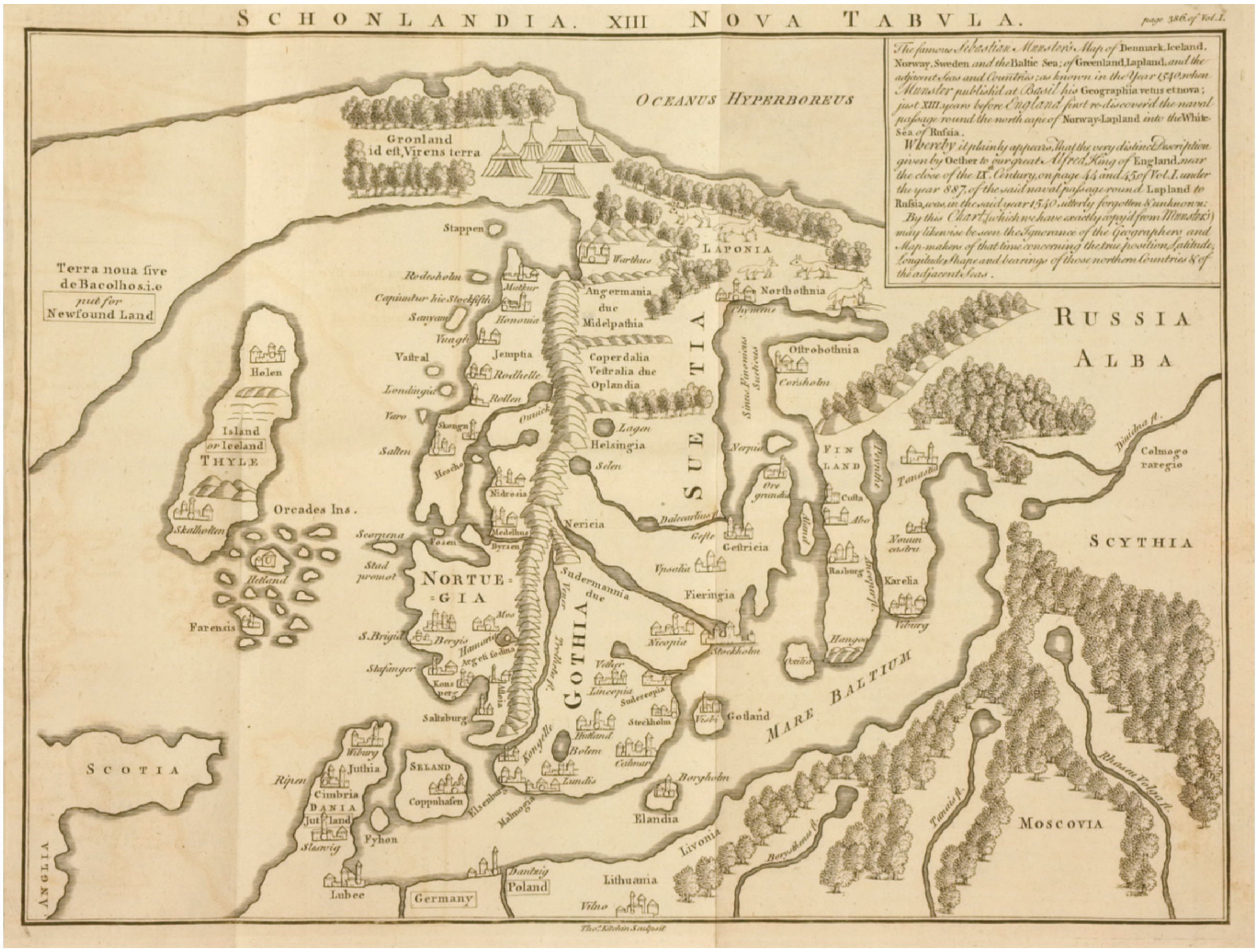

FIG. 373. A FACSIMILE OF SEBASTIAN MÜNSTER'S "SCHONLANDIA. XIII NOVA TABVLA" OF 1540. Engraved by Thomas Kitchin in Adam Anderson's *An Historical and Chronological Deduction of the Origin of Commerce, from the Earliest Accounts to the Present Time*, 2 vols. (London: Andrew Millar et al., 1764), opp. 1:386. Anderson used the map to show how a ninth-century Anglo-Saxon voyage to the White Sea was by 1540 "utterly forgotten & unknown," in the process asserting a primacy for English navigation.
Size of the original: ca. 27 × 35 cm. Image courtesy of the Special Collections Library, University of Michigan, Ann Arbor.

came a means to understand better what maps did, even when the maps provided limited coverage. Enlightenment maps did not always have to pretend to completeness to have value as "better" maps. Drawing upon the work of Guillaume Delisle in particular, Green noted that accuracy and improvement depended not on the inclusion of features on maps of the world simply in consequence of more knowledge being known, but from the judicious omission of such information unless it was known with certainty: "It may be ask'd, if *De Lisle's* MAPS be an Improvement, how comes it that many of them are not so full of Places as former MAPS? The Reason is, doubtless, because he was cautious of inserting any Place whose Situation was altogether uncertain" (Green 1717, 147). As he further cautioned, "A Geographer should never insert any Place, the Situation of which is uncertain, or whose Distance from some remarkable Town is not observ'd by some Author; 'twere better a MAP were empty of Names than fill'd after this Manner" (Green 1717, 155). In Green's view, the history of cartography had been significantly advanced in this respect by Delisle: it was he who "undertook to disabuse the World, and put a Stop to those spurious Draughts that were daily obtruded on the Publick, by making a compleat Sett of MAPS, both of Old and New Geography, corrected and improv'd from the Surveys several *European* Nations had made of their respective Countries, the Observations of the best Travellers in all Languages, and the Journals of the Royal Societies of *London* and *Paris*" (Green 1717, 132).

Yet a note of caution is necessary here. The claims made by Enlightenment cartographers as to their own maps' accuracy or novelty were often more rhetorical than real and were often denied by the maps themselves. Simply, the notion of accuracy—made for reasons to do with market competition, to connote associations with the latest discoveries or instrumental methods and so to attain greater credibility and social status—was in many Enlightenment maps more common *as a claim* than as a real practical consequence. What Green alluded to in 1717 in noting that "our MAP-makers have seldom any Interest in View but their own, which may be one Cause why their MAPS are copy'd from the Old, and without Care" (Green 1717, 149), and Blair hinted at in 1768, Gough in 1780 put more forcefully: "Notwithstanding the assertions of Bowen, Kitchen [*sic*], and other modern map makers, that their maps are framed from *actual new* surveys, there is scarce a single one which does not abound with faults" (Gough 1780, 84).

Enlightenment mapmakers and geographers thus understood theirs to be a period in which their cartography (and geography) was an advance on that of their predecessors and was so because of its accuracy, itself the result of reliable measuring instruments, direct observation, and the incorporation of up-to-date information (even when that was not always actually so). Enlightenment cartography was thus synonymous with contemporary notions of progress, improvement, and utility.

In the nineteenth century, the history of cartography in general, and attention to the history of Enlightenment cartography in particular, was stimulated by institutional developments in geography, the growth of specialist map libraries, and a rise in the collecting of old maps. In the first half of the twentieth century, the slow emergence of a scholarly identity for the history of cartography was evident in several ways. In 1935, *Imago Mundi,* an international journal devoted to the subject, was first published. Several general histories were written: Bagrow (1964), Crone (1953), and Skelton (1972) built in one way or another upon the major accounts by Sandler (1905) and Eckert (1921–25), each tending to treat Enlightenment cartography as a story of progressive accuracy and enhanced utility for maps. Most significantly, such a progressivist history of cartography reflected the growing status of cartography itself: "the emergence of cartography as an independent academic and practical discipline providing new theoretical frameworks as well as a reinforced raison d'être for the study of cartographic history" (Harley 1987, 23).

The evidence in Enlightenment cartography about claims to accuracy thus has its parallels in more modern scholarship. Where, broadly, Enlightenment commentators understood a map's "accuracy" to mean both a closer correspondence between the real world and the map as its stylized representation, and an improvement upon earlier efforts, a prevalent theme in the modern history of cartography has been the presumed association between the map and its mimetic capacity—between cartography, progress, science, and the capacity to reveal the "truth" of the world. For Crone (1953, xi), "the history of cartography is largely that of the increase in the accuracy with which . . . elements of distance and direction are determined." Skelton emphasized accuracy and technical advances, notably in printing, in his introductory survey of the history of cartography (Skelton 1972, 3–25). The tendency to assume fidelity between maps and the object they represent and to read the history of cartography as the shedding of error in the progressive pursuit of that fidelity was reinforced by the rise of cartography as a science-led discipline from the 1960s.

Yet, and at the same time, other approaches were focusing on the map not as a faithful mirror to the world but as a social product. Thus, "by 1980 the history of cartography was at a crossroads. The divergence was not only between its historical associations with geography and map librarianship and its newer, enhanced role within an increasingly independent cartography. It was also between its traditional work in the interpretation of the content of early maps as documents and its more recently clarified aims to study maps as artifacts in their own right and as a graphic language that has functioned as a force for change in history" (Harley 1987, 39). Harley was a leading figure in the more recent historiographical "deconstruction" of the map as a "text" (Harley 1989; for a fuller overview, see Edney 2005). Harley drew upon the idea of discourse and the work of social theorists such as Michel Foucault and Jacques Derrida to emphasize the map as a social document infused with power. "The interpretive act of deconstructing the map," Harley considered, "can serve three functions in a broad enquiry into the history of cartography. First, it allows us to challenge the epistemological myth (created by cartographers) of the cumulative progress of an objective science always producing better delineations of reality. Second, deconstructionist argument allows us to redefine the historical importance of maps . . . .Third, a deconstructive turn of mind may allow map history to take a fuller place in the interdisciplinary study of text and knowledge" (Harley 1989, 15). Others followed this interpretive turn. Matthew H. Edney's 1993 critique of cartography's "empiricist presuppositions" discussed the way "the modern discipline of cartography justifies and legitimates its empiricist claims to objectivity and neutrality by pointing to its past progress," and, conversely, how "historians of cartography have defined their subject in terms of their *a priori* assumptions of mapmaking's objectivity, neutrality, and progressiveness" (Edney 1993, 54).

Within Enlightenment writing and modern scholarship, then, the history of cartography has been characterized by a persistent progressive rhetoric in terms of what a map is, what a map does, and what the history of cartography has been taken to be. Within modern study, attention to the map as text or to cartography's modes has moved us beyond the map as simple mirror to nature. Yet even as we moderns recognize the need to understand maps in their social and historical context—since, as Harley emphasized, "the history of cartography represents more than a technical and practical history of the artifact" (Harley 1987, 5)—it is all the more important that we must also learn to read Enlightenment maps through the eyes of their makers and contemporaries.

CHARLES W. J. WITHERS

SEE ALSO: Geographical Mapping; Green, John; History and Cartography; Map Trade

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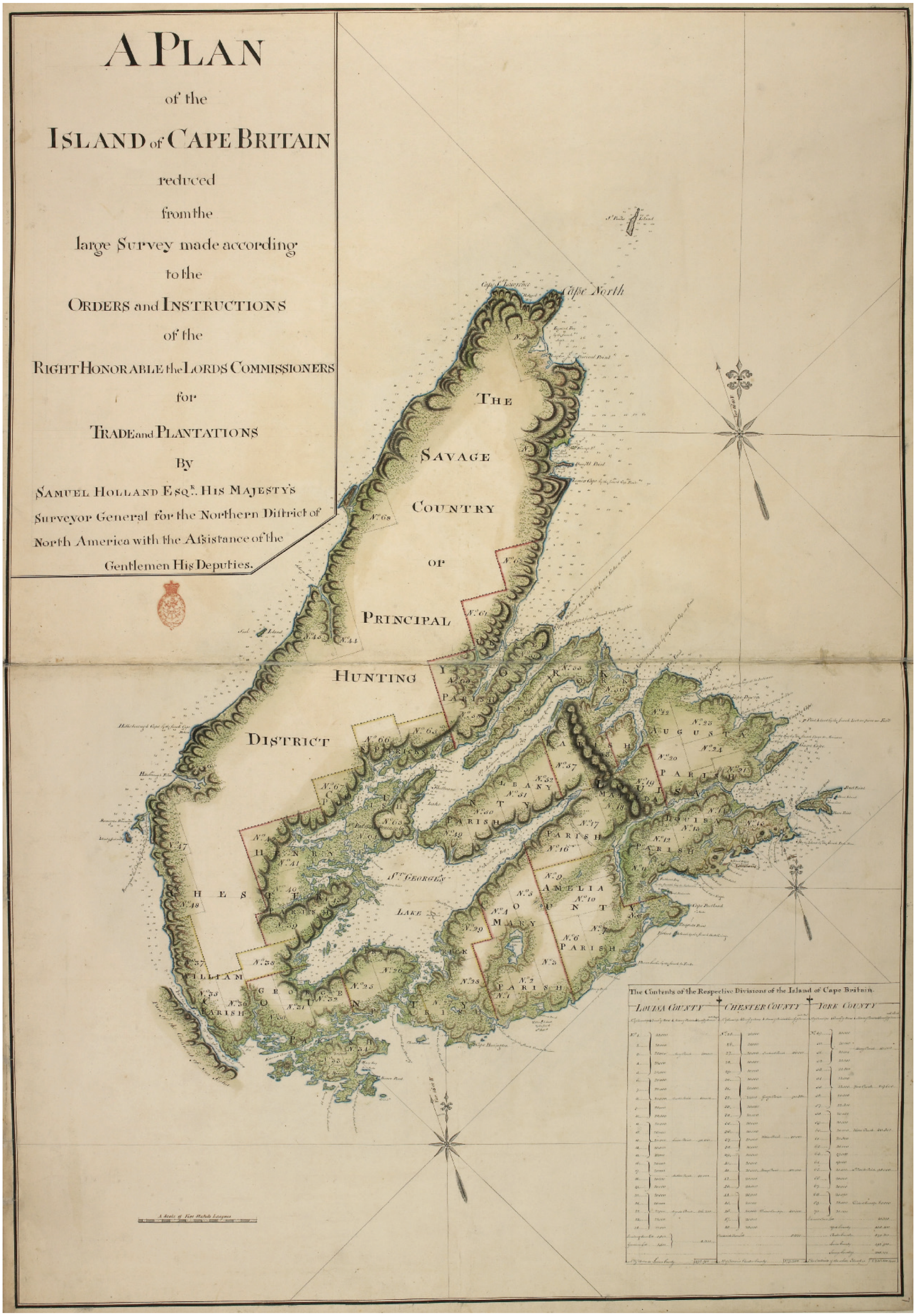
Holland, Samuel (Johannes). Born in 1729 in Deventer, Netherlands, Samuel Holland began his career as a surveyor early in his life. In 1745, during the War of the Austrian Succession, Holland entered the Dutch artillery, and, in 1747, made plans of Bergen op Zoom and 's Hertogenbosch. In 1754 he emigrated to England, possibly sponsored by Charles Lennox, third duke of Richmond, and joined the Royal American Regiment, part of the British Army. In 1756, Holland was deployed to the American theater of the Seven Years' War and prepared a map of New York province. In 1758, he took part in the Siege of Louisbourg and tutored the future explorer James Cook on surveying techniques, then collaborated with Cook to create a chart of the Gaspé Peninsula. He also made plans of Quebec and Halifax, Nova Scotia. In 1759, Holland allegedly was one of the few officers present at the death of General James Wolfe at the Battle of the Plains of Abraham.

In 1761, General James Murray ordered Holland and John Montresor to survey the Saint Lawrence Valley at the large scale of 800 feet to an inch (see fig. 838). The colossal Murray Map (1761–62) was a device of military control, many of its sheets depicting properties and indicating the number of men of fighting age in each parish. In 1763, the Board of Trade approved Holland's proposal that they sponsor a systematic survey with the ultimate objective of creating a general map of Britain's newly enlarged colonial domain.

In 1764, Holland was appointed surveyor general of the northern district of the General Survey of British North America. His associates included Charles Blaskowitz, James Grant, Thomas Wheeler, and George Sproule. All surveying was to be based on astronomical observations to fix latitude and longitude, and Holland's results were published in the *Philosophical Transactions* of the Royal Society (1768–74). As the official blueprint for the settlement of what is now Prince Edward Island, Holland's "Plan of the Island of St. John" (1765) was more than 13 × 9 feet in size, was copied in manuscript in a smaller format (see fig. 26), and was later published in several states. It was followed by his "Plan of the Island of Cape Britain" (1768) (fig. 374).

(*facing page*)
FIG. 374. CAPE BRETON ISLAND, NOVA SCOTIA, CANADA, 1768. Samuel Holland, "A Plan of the Island of Cape Britain Reduced from the Large Survey Made According to the Orders and Instructions of the Right Honorable the Lords Commissioners for Trade and Plantations," likely drafted by Thomas Wright. Colored manuscript; 1:253,440. This finely drafted topographical map divides the island into numbered townships within parishes, their acreages being detailed in the table (lower right). It was meant to accompany Holland's "Description of the Island of Cape Britain," which emphasized the island's potential for forestry, fisheries, and most importantly its colliery. The use of English place-names, many with their French equivalent, is a toponymic act of possession. One of only three known copies, this example from the collection of Sir Jeffrey Amherst.
Size of the original: 103.0 × 71.5 cm. © The British Library Board, London (Western Manuscripts, Add MS 57701, map no. 7).

A PLAN
of the
ISLAND of CAPE BRITAIN
reduced
from the
large Survey made according
to the
ORDERS and INSTRUCTIONS
of the
RIGHT HONORABLE the LORDS COMMISSIONERS
for
TRADE and PLANTATIONS
By
SAMUEL HOLLAND ESQ^R. HIS MAJESTY'S
Surveyor General for the Northern District of
North America with the Assistance of the
Gentlemen His Deputies.



The Contents of the Respective Divisions of the Island of Cape Britain.

LOUISA COUNTY — CHESTER COUNTY — YORK COUNTY

In 1768, Thomas Jefferys published a map of New York by Holland attributed to "Authentic Surveys." While based on the composite map Holland had prepared for John Campbell, fourth earl of Loudoun, in 1758, a resentful Holland, noting that he made no such surveys, exclaimed that Jefferys simply "wants a name for his catch-penny, though of course has made free with mine" (Holland 1768, ff. 50–51).

In 1769, with David Rittenhouse, Holland demarcated the New York–New Jersey line. From 1770, he supervised teams that mapped the coast of New England, with the charts of Maine being of extraordinary technical merit (see fig. 839), and those of Boston Harbor and Narragansett Bay of great military utility (see figs. 502 and 507). Holland's surveys of the interior led to *A Topographical Map of the Province of New Hampshire* (1784).

The General Survey was halted by the advent of the American Revolution in 1775, and Holland removed to London. There he was engaged by George Germain, first viscount Sackville, to assist J. F. W. Des Barres in preparing his maps for inclusion in *The Atlantic Neptune* (1774–82).

Promoted to major in 1776, he was sent to New York and became leader of the Guides & Pioneers, a reconnaissance unit, producing "A Plan of the Forts Montgomery & Clinton" (1777). In 1779, he was recalled to Quebec by Sir Frederick Haldimand, where he spent the rest of his life as surveyor general. Accommodating an influx of Loyalist settlers, he oversaw the mapping and cadastral division of Upper Canada (Ontario) and Quebec's Eastern Townships. He died on 28 December 1801 in Quebec.

ALEXANDER JAMES COOK JOHNSON

SEE ALSO: *Atlantic Neptune, The*; Topographical Surveying: British America

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Holy Roman Empire. See Austrian Monarchy; German States

Homann Family. Born in 1664, Johann Baptist Homann moved to the imperial city of Nuremberg in 1687, where he acquired and perfected his skill as a copperplate map engraver within only two years. In the following thirteen years until the founding of his publishing house, he collaborated on mapping projects in Nuremberg and Leipzig, gained experience in the map publishing industry with David Funck, and presumably acquired some modest capital as well. In 1702 he founded his own publishing house specializing in mapmaking. The firm, over nearly 150 years, had three distinct phases of large production (fig. 375).

The heightened public interest in information about the regions affected by the War of the Spanish Succession (1701–14) helped Homann's firm be successful in the marketplace. In 1707 Homann published the *Atlas bestehend in auserlesenen und allerneuesten Land-Charten über die gantze Welt* comprising his first thirty-three maps (fig. 376); this atlas was to become the main product of the publishing house. Although for financial reasons the maps were almost exclusively copied from existing works, they were purchased and favorably reviewed. This success brought Homann into contact with scientists such as the astronomer Johann Gabriel Doppelmayr and the educator Johann Hübner. As early as 1712 the firm was sufficiently stable financially for Homann to cautiously invest resources in newly compiled maps (e.g., *Hydrographia Germaniæ* by Philipp Heinrich Zollmann; see fig. 296). The firm's early prosperity, both qualitative and quantitative, was evidenced by Homann's admission in 1715 to the Akademie der Wissenschaften in Berlin and by his being conferred the title of *Kaiserlicher Geograph* in 1716. In the years leading up to his death in 1724, Homann intensified his scientific affiliations (e.g., with Eberhard David Hauber in Württemberg, and the czar's court in Russia), which allowed him to publish several newly compiled maps (e.g., one of the first printed maps of Kamchatka). Homann himself published 183 atlas maps in folio format.

The firm was inherited by Homann's son, Johann Christoph, who finished his medical degree in 1725 and did not return from a trip to the Netherlands and Great Britain until about 1727; in the meantime, the copperplate engraver Johann Georg Ebersberger managed the company. Johann Christoph added new touches by furnishing new editions of every map with a date and in 1729 acquired an imperial printing privilege against engravings copied from any of the publishing house's maps. It was extended until 1750 and again from 1762 to 1806.

When Johann Christoph died in 1730, only twenty-seven years old, his university friend Johann Michael Franz and Ebersberger each inherited half of the firm. Franz established the company name as Homann Heirs (Homannische/Homännische Erben, Homännische Officin, Heredes Homanniani, Homannianorum Heredes, Heritiers de Homann). In 1734 the owners acquired a prestigious building (now Fembohaus) but did not pursue a clear line of publications until approximately 1737. The *Atlas Silesiae*, commissioned by the Silesian government, was of great consequence and was published as the firm's first regional atlas in 1752. It also led to collaboration with the Wittenberg mathematician

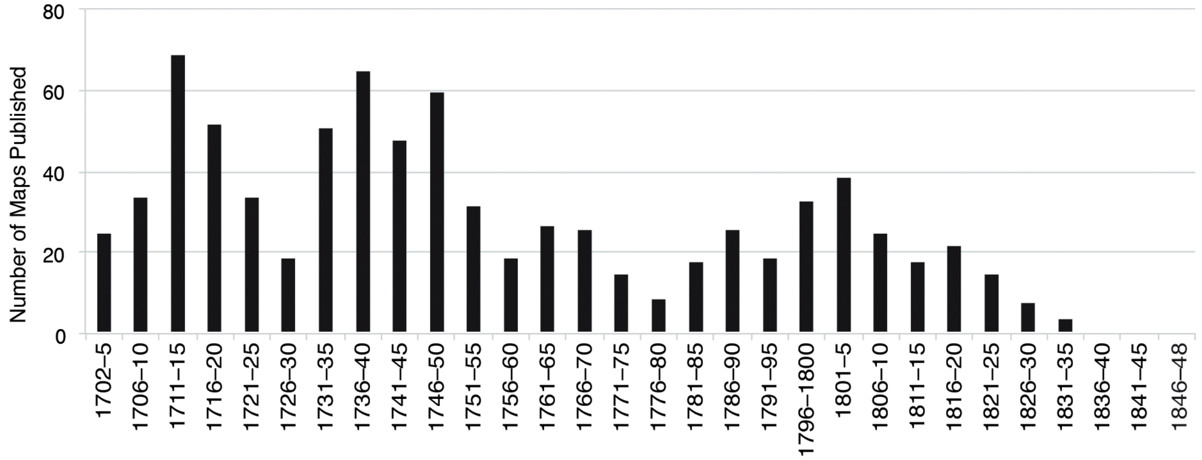

FIG. 375. NUMBER OF MAPS PUBLISHED BY THE HOMANN PUBLISHING FIRM DURING ITS LIFETIME. The most productive phases were between 1711 and 1724 and again between 1734 and 1750, when either Homann or Homanns Heirs had completed their start-up phases. The crisis in the late 1750s and the following frugal publishing policy until the 1780s explain the lower output during these thirty years. The rising numbers of the 1780s show the comeback, but during the 1790s these figures are surpassed by the new competitors, for example in Vienna. The peak around 1803 is explained by the publication of the *Kleiner Atlas . . . der Entschädigungs-Länder*, made by specially coloring twenty–two existing maps.

and historian Johann Matthias Hase, who worked on the map projections. With Hase as a collaborator, the firm could draw on the skill of one of the foremost cartographers of the eighteenth century. Hase was the first to make maps for the firm of continents and large regions outside of Europe based on critical assessments of every available source. He used a stereographic projection, and his work boosted the firm's cartographic quality to the level of the cartographers affiliated with the Académie des sciences in Paris. In addition, Hase compiled historical maps for Homann Heirs (see fig. 83), leading eventually to the *Atlas historicus* (1750), which was the first such work to include the Middle Ages and the modern period, as well as considering nations outside of Europe. From experience and the growing competition from the Seutter publishing house in Augsburg, the Homann publishing house and Franz in particular realized by the late 1730s that the firm's future lay in improving the quality of new editions. This policy was consistently pursued after Hase's death in 1742, as the astronomer Georg Moritz Lowitz and Tobias Mayer in particular became affiliated with the firm in 1745–46.

Realizing that the publishing house's capacity was insufficient for improving maps with such data as astronomically determined coordinates, Franz attempted to establish a state-funded Kosmographische Akademie, which could revolutionize cartography in everything from data acquisition to map production. In preparation, he founded the Kosmographische Gesellschaft, which involved the same scientists as those affiliated with the publishing house. They produced a great number of critically edited maps between 1737 and 1755, which established international standards in the German-speaking world and brought about the second heyday of the Homann publishing house. The new editions were always dated, and they identified the zero meridian in the marginal gradations of longitude; they also referenced their sources in their titles, and the sources were sometimes discussed in separately published memoirs.

At the same time, sales locations were organized across Europe. In 1750, fifty addresses were listed in the Holy Roman Empire and twenty-five in the rest of Europe, at which the entire stock of the firm could be acquired. The distribution of these addresses as well as the preserved atlases confirm that Homann Heirs was likely the leading map supplier in Central, Northern, and Eastern Europe (Diefenbacher, Heinz, and Bach-Damaskinos 2002, 106–11) (see fig. 470).

Similarly, production developed from modest beginnings in the home of Johann Baptist Homann's parents-in-law to become one of the largest printsellers in the German-speaking world. In order to keep stock replenished quickly, the firm's founder engraved two copperplates for each of the most important maps. In the 1740s, up to three identical copperplates of the maps of the Holy Roman Empire were simultaneously in use, and it seems that over thirty illuminators were employed to color the maps.

Although the Homann Heirs publishing house was one of the largest map producers in eighteenth-century Europe, it was apparent by around 1750 that the investments in quality exceeded the firm's resources. State support of the planned Kosmographische Akademie was not forthcoming, and the loans that Franz had

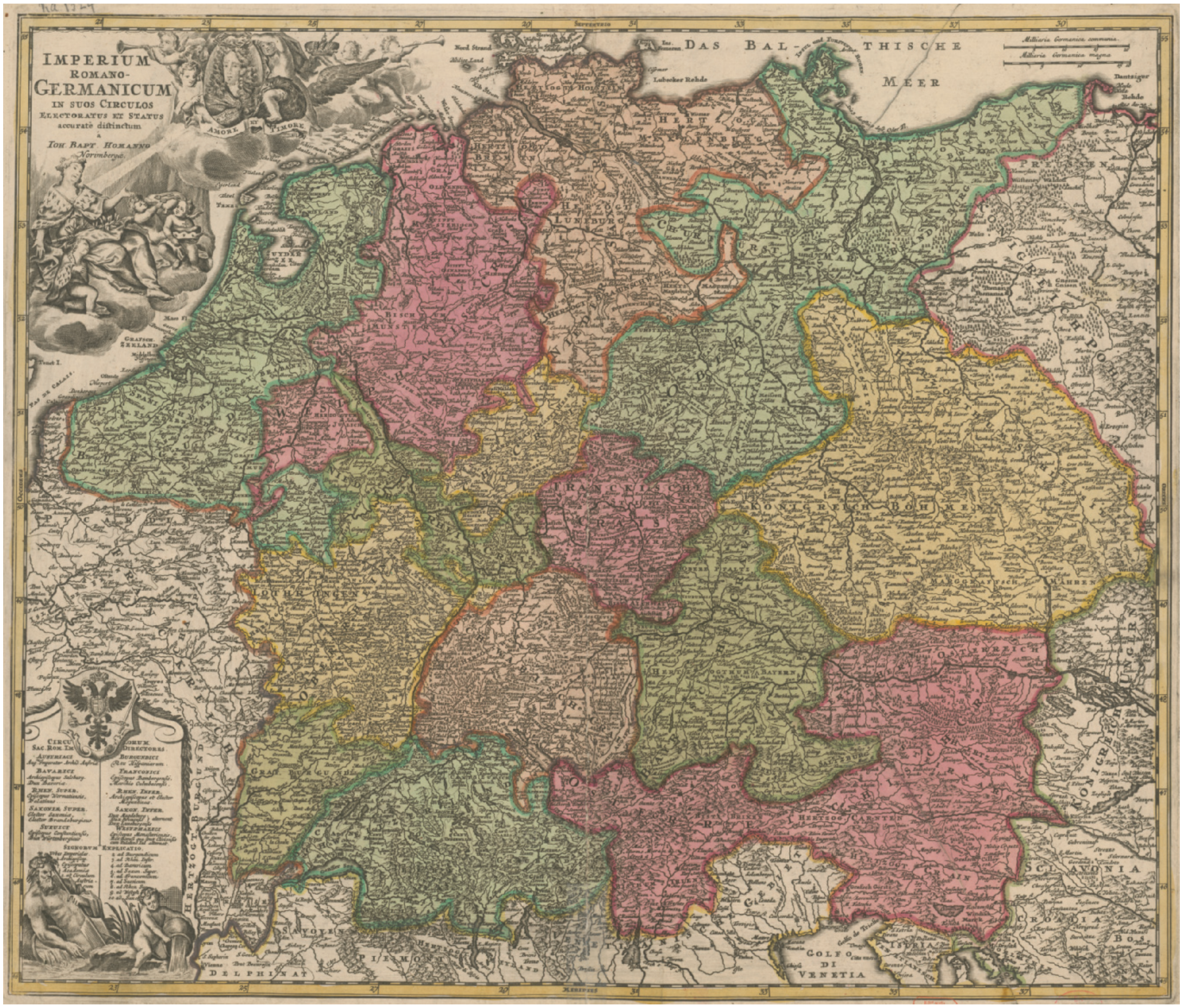

FIG. 376. JOHANN BAPTIST HOMANN, *IMPERIUM ROMANO-GERMANICUM* (NUREMBERG, 1702–7). First state, copper engraving, ca. 1:2,400,000. This map and its later variants probably were the top sellers of the Homann firm. Its full color, elaborate *parerga* (embellishments), and high density of place-names were typical of many Homann maps.
Size of the original: ca. 48.5 × 57.0 cm. Image courtesy of the Staatsbibliothek zu Berlin–Preußischer Kulturbesitz; Kartenabteilung (Kart. L 290).

taken out for this venture and for innovations at the firm could not be repaid. This brought his half of the firm into severe crisis. In 1751 Mayer left the firm, followed in 1755 by Lowitz, and also Franz himself, who left for an academic post at the University of Göttingen. In 1759 Franz sold his half of the publishing house to his brother Jacob Heinrich Franz and his brother's wife Anna Felicitas to repay debts of approximately 21,500 guilders. These debts corresponded to a sales value of over 130,000 maps. Yet the firm was able to overcome this crisis by employing a frugal publishing policy for about twenty years, attesting to its considerable commercial potential. It certainly helped that the other half of the firm was not affected, and Ebersberger was able to bequeath it, debt-free, to his daughter Barbara Dorothea Monath in 1760. After Jacob Heinrich Franz's death, his son Georg Christoph Franz was brought into the firm's management by his mother, although she did not transfer ownership to him. Thus, the revival of fortunes in the 1780s occurred when two women owned the publishing house. This third golden age is linked to the high-quality maps by the Weimar forest officer Franz Ludwig Güssefeld, who made 89 of the 103 newly published maps for the firm. For the third time, about 30 of the most important maps (which received special treatment and appeared in the majority of atlases throughout all three of the firm's large production periods) were updated or replaced with new designs. Meanwhile, new competition emerged from firms in Vienna, Nuremberg, Weimar, and Berlin, which often explicitly emulated the Homann firm and prevented it from recovering its dominant market position. Due to major territorial changes in the Napoleonic era, the demands for up-to-date maps grew. Homann Heirs lost its prominence in this period mostly because it was not able to update its 550 folio maps. In 1804 Friedrich Albrecht Monath and in 1813 Georg Christoph Franz each had to sell their half-shares in the firm to Christoph Fembo. By 1832 Fembo published 66 new maps, the current rarity of which is further proof that the company was now only of minor relevance. After Fembos's death in 1848, his son shut down the company and in 1852 sold all the printing plates to the bookseller Sigmund Beyerlein, who evidently made only minimal use of them. The firm's archives were probably lost in this period. In total the firm published 966 cartographic products, 39 prints, 84 atlas title pages along with sheets of tables of contents, and 116 separate text publications.

The folio maps emphasized historically evolving territories, included a high density of place-names within each region, and displayed impressive decorations (*parerga*) (fig. 377), characteristics that were stylistically

FIG. 377. JOHANN CHRISTOPH HOMANN, *TRACTUS NORWEGIÆ DANICUS MAGNAM DIOECESEOS AGGERHUSIENSIS PARTEM SISTENS* (NUREMBERG, 1729). Copper engraving, ca. 1:450,000. This map was probably based on new material. The detailed depiction of mountain mining activities reflects the relationship between the decorative but informational *parerga* and the map content.
Image courtesy of the Stadtarchiv mit wissenschaftlicher Bibliothek, Fürth (Objekt Nr. 112).

influential in the German-speaking world. This combination was even referred to as the Homann format. The centrally depicted territories were always colored, for which the firm used fixed templates that Hübner systematized from about 1710 (Diefenbacher, Heinz, and Bach-Damaskinos 2002, 98–102). The language used on the maps shifted from Latin to a combination of Latin and French in the 1740s, then to chiefly German from the 1780s. A distinguishing technical characteristic of the firm's mapmaking was not only the systematic coloring but also the precise duplicates of important copperplates.

The hallmark of the publishing house was the production of atlases, which one could assemble with relative ease from the separately published folio maps if the buyer did not want to follow the printed table of contents of 18 to 277 maps. From 1741, atlases in a bound format could be ordered. The *Kleiner Atlas Scholasticus,* compiled from eighteen ordinary folio maps by Hübner in 1710 is the first to mention school use in its title. Many atlases were compiled for this growing market, but only a few had specifically designed maps. Further specialties of the firm were regional and thematic atlases. Examples of early thematic cartography by the firm were the postal route map by Johann Peter Nell (1714), the linguistic maps by Gottfried Hensel (1741) (see fig. 781), and numerous historical maps and astronomic illustrations. Marine charts were not among the offerings, and the firm was hardly a noteworthy manufacturer of globes, contrary to many allusions in the literature. In all, the Homann publishing house played a leading role in providing cartographic information to half of Europe from about 1720 to 1790.

MARKUS HEINZ

SEE ALSO: Academies of Science: German States; Atlas: Historical Atlas; Color and Cartography; Geographical Mapping: German States; Historical Map; Map Trade: German States; Mayer, Tobias; Seutter, Probst, and Lotter Families; Thematic Mapping: German States

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Household Artifacts, Maps on. Maps on household items fall under the designation of "cartofacts" or cartographic artifacts: objects that include map elements but whose primary functions are other than cartographic. The sheer increase in the number of household artifacts and the subsequent decoration of many of them with maps are by-products of European exploration, expansion, and trade. In addition to being symbolic of the age, maps are also what are referred to in German as *Machtsachen* (power objects), commanding of attention and respect. During the Enlightenment, cartofacts took on numerous forms such as room screens, porcelain ware, textiles, clocks, fans, games and playing cards, and powder horns. Although relatively scarce, extant examples reveal much about their original owners and the age of which they were a part.

Room screens have a long and fairly well documented history. In China the oldest known examples date back more than two millennia. Oriental screens first appeared in Europe as luxury products of the new East-West trade in the late sixteenth century after the opening of the port of Nagasaki in 1571. Some large European Renaissance maps, such as the famous six-sheet portolan of the world of 1502 associated with Alberto Cantino, had already been used on occasion as screens or to cover things. The use of room screens reached a high point in Europe and its colonies in the seventeenth and eighteenth centuries, when screens became utilitarian parts of upper- and middle-class living environments. By the eighteenth century, screens were largely the works of homegrown and mostly unknown craftsmen, furniture-makers, and artists.

The larger high-ceilinged, box-like rooms of Georgian homes and clubs often were cold, damp, difficult to heat, and rife with drafts, thereby necessitating screening. In warmer months, screens were used to cover unused and unsightly fireplaces. Screens therefore not only helped to partition the living and working spaces, they also intercepted uncomfortable currents of air. As with earlier Asian screens, European screens could be taken apart so that individual panels could be used as wall hangings or coverings. Map screens readily lent themselves to this practice, which possibly was one of the sources of the architectural screens constructed for specific homes and other buildings.

Some of the earliest surviving European screens are map screens, but not so in Asia. With these household artifacts, cartographic cross-pollination seems to have been principally from the West to the East. Map screens appeared in East Asia mainly after Western contact, and their cartographic components were copied from Western maps. In Japan, for example, consumers could find hand-painted screens depicting the four major cities of Europe (Constantinople, Rome, Lisbon, and Seville), based on Georg Braun's *Civitates orbis terrarum* (1572), world maps by Abraham Ortelius, and works by Pieter van den Keere among others.

European screens with maps painted or mounted on their surfaces were of two main types. Screens were decorated with cartographic and other images perhaps supplied separately by the screen buyer and placed according to their wishes. Alternatively, one large multisheet map could conceivably cover the entire screen or the majority of it. Both types date back to the reign of Henry VIII in England and even earlier elsewhere in Europe.

Three fine examples of Enlightenment map screens survive in London. The oldest and largest of the three, dating from the 1720s, is privately owned, approximately 244 by 366 centimeters in five panels, and composed of twelve maps by Herman Moll from his collection, *The World Described.* The panels were laminated onto a canvas-like material and stretched over a wooden grid framework, probably to keep this cumbersome piece of furniture light enough to be moved freely. The screen functioned as an atlas and may also have served as an educational tool in a British household.

The other two examples of Enlightenment screens are in the British Library. One is a four-fold screen measuring 180 by 256 centimeters that was fabricated under the supervision of the British royal geographer Thomas Jefferys prior to 1760 (fig. 378). The maps are by Jefferys, George Willdey, and Samuel Parker; the screen was restored to its current state in the 1820s. The second screen stands about 214 by 366 centimeters in six panels and is constructed similarly to the other two. It dates to the late 1740s and is composed of maps by Moll, John Bowles, Emanuel Bowen, William Berry, and Henry Popple. The arrangement of the maps makes it conceivable that this screen was the property of a London merchant with interests in Western Europe and North America who displayed it in his home or business, perhaps as a form of advertising. Or it might have belonged to a British military officer who served in these theaters of war against France and Spain and through the maps recalled his campaigns. During this period, in a similar fashion to screens, traditional tapestries and other decorative textiles came to take on cartographic imagery, now usually embroidered or quilted by more practiced hands and learners.

The custom of scrimshawing, or engraving, powder horns, many with maps, reached its apex with ordinary frontiersmen and hunters, but especially among the members of the British and French colonial militias and their Indian allies, during the Seven Years' War (1756–63) in North America (fig. 379). Made from cheap, readily available cow horns with wooden and/or pewter spouts and end plugs, powder horns were the utilitarian receptacles on the frontier for powder propellant used by muzzle-loading rifles and other guns. They were light, comfortable, waterproof, unique, and easily identified. Native Americans used them for barter and presentation pieces (Grancsay 1945, 27). Like the engravings on whale and walrus ivory of the early nineteenth century, those on powder horns were usually primitive renderings done either with a knife by the horns' owners, who were often amateur and unnamed craftsmen, or with a graver and burin by professional silver engravers or gunsmiths, whose work is distinguished by fine lines (Grancsay 1945, 3, 82). Some of the maps on the horns were polychromatic; the engravings were colored with natural vegetable and mineral pigments.

Powderhorn maps, which also included town views, fortifications, and battles, undoubtedly recorded the campaigns of which the owners of the horns had been a part, and they were not seriously used for wayfinding, although several exist showing the main river routes from New York to Canada, as in figure 379 (Grancsay 1945, 4, 11–12). Surviving British horns record maps of forts Ticonderoga, Crown Point, Prince George, and Pitt as well as the cities of New York, Boston, Roxbury, Quebec, Charlestown, Saint Augustine, and Havana. There also are depictions of the colonies of New York, Pennsylvania, and the Carolinas as well as the Hudson River from New York City to Lake Champlain, and the Mohawk River from Albany to Lake Ontario. Extant French horns show the cities of Quebec, Louisburg, and Charleston. Powder horns remained popular as long as muzzle-loading rifles were in use. American horns from the Revolutionary War displayed maps of Philadelphia, Charleston, and other areas. Only one horn survives from the early nineteenth century, showing the Oregon Trail.

With the growth in the popularity of tea, coffee, and chocolate and inspired by the porcelains and other ceramics of Asia, the growing number of dishes and cups in use were occasionally decorated with map elements. Already in the late sixteenth century, Zurich silversmith Abraham Gessner created a number of globe wine cups, which were precursors to many similar objects that followed, including globe liquor cabinets in the twentieth century. By the middle of the eighteenth century and for the next hundred years, the West influenced Japan to produce numerous ceremonial blue-and-white porcelain cups and plates bearing Gyōki-style maps of the home islands for domestic use and export. These in turn inspired yet more copies in Europe. So too did ceremonial objects such as silk fans and bronze mirrors from Asia with cartographic images on them. Publishers such as Carington Bowles, Sébastian-G. Longchamp and Jean Janvier, and Thomas Balster demonstrated that essentially the same presses and techniques could be used to print maps on handkerchief fabric and fan silk as

FIG. 378. LARGE MAP SCREEN. In the 1750s, Thomas Jefferys acquired the plates for a series of maps made by George Willdey and Samuel Parker. With a common aesthetic—each of the twenty city or regional maps were set in a circular frame, referencing the hemispheres of the central world map—they make an attractive and coordinated map screen. The result is, in effect, a world atlas recast as furniture. Twenty-one engraved maps pasted on canvas and then attached to a pine frame. Size of the original: 180 × 256 cm. © The British Library Board, London (Cartographic Items Maps Screen 2).

FIG. 379. ENGRAVED POWDER HORN. Several members of the colonial militia during the Seven Years' War seem to have engraved maps of the northern reaches of the province of New York on powder horns as mementos of the conflict. In addition to the royal coat of arms and large views of New York and Albany, this horn shows two major corridors from the Hudson River to the St. Lawrence, via Lake George and Lake Champlain and via the Mohawk River, Lake Oneida, and Lake Ontario. Cow horn, with pewter cap and pouring spout. A horn with a very similar design, in a private collection, is signed "S. Goddard, 1761" (Du Mont 1978, 53).
Length of the original: 32 cm; widest diameter: 9 cm. Image courtesy of the Geography and Map Division, Library of Congress, Washington, D.C. (G3801.A9 1770.P6).

on paper. The production of map folding and paddle (screen) fans and other cartofacts thus broadened the markets for map publishers. European and American clock faces also depicted maps and were popular domestically and in the trade with China.

The increasing amount of leisure time of the middle and upper classes also helped stimulate the popularity of parlor games, especially board and card games. Since at least 1590, when William Bowes produced decks of cards with detailed county maps of England and Wales on them, games functioned socially as forms of entertainment, gambling, education, and propaganda. Board games are based on spatial relationships, but during the Enlightenment they were based on specific maps.

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SEE ALSO: Consumption of Maps; Decoration, Maps as; Games, Cartographic; Medals, Maps on; Samplers, Map

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Hudson's Bay Company (Great Britain). In 1667 Médard Chouart des Groseilliers and Pierre-Esprit Radisson took a rich cargo of furs from the Great Lakes, only to see it impounded by the government of Montreal. When their protests fell on deaf ears, the two traders went over to the English, offering to lead an expedition to Hudson Bay. Their new enterprise was a success. The Governor and Company of Adventurers of England Trading into Hudson's Bay, chartered in 1670, established several "factories" along the bay's bleak shore. These maritime bases drew on the same resources as the French fur trade to the south, though with far less expense than required for the difficult route between Montreal and Michilimackinac. For the next century the Hudson's Bay Company "slept at the edge of a frozen sea" (Robson 1752, 6), making reasonable profits despite occasional French attacks.

In its organization and sea trade the Hudson's Bay Company resembled the older, richer, larger East India Company. Both were English joint-stock ventures protected by royal charters; both gradually developed complex administrative structures and assumed the governance of regions where they traded. Both were closely associated with the Royal Society. Of the two ventures, the Hudson's Bay Company (HBC) was the poor cousin: while the East India Company sent out thirty ships a year, the HBC sent at most two.

For the first ninety years of its existence the HBC relied on charts produced in London, seven of the earliest by John Thornton, supplemented by a few traders' maps that recorded harbors, shorelines, and the mouths of rivers draining into the bay. Two midcentury events finally roused the company from its coastal torpor: Arthur Dobbs's campaign against the HBC charter monopoly, and the British possession of New France. In 1744 Dobbs published a map, purportedly drawn by a Métis trader, that showed the western limit of North America as an "Unknown Coast" sloping directly from Rankin Inlet to Cape Blanco. If the HBC monopoly could be broken, argued Dobbs, free trade would benefit British merchants and stimulate the search for a northwest passage. A parliamentary enquiry in 1749 upheld the company's right to exclusive trade. But by this time the French had penetrated northwest to Lake Winnipeg and the Saskatchewan River; furs that might have been taken to the bay were intercepted far inland. After the cession of New France in 1763, the Montreal trade was reorganized not only free of French governmental constraints but also heedless of the HBC charter. The old trade routes were soon busy again; HBC returns fell sharply. To remain competitive, the company was forced to explore, map, and establish resident outposts west of three bayside factories.

York Factory, Churchill, and Albany launched inland explorations to enhance their trade. In 1754 Anthony Henday, a netmaker, was sent from York Factory to the western plains with instructions to keep a journal and to map his route. The HBC directors were dissatisfied with the crudeness of his map (now missing): "we apprehend Henday is not very expert in making Drafts with Accuracy or keeping a just Reckoning of distances other than by Guess which may prove Erroneous" (Hudson's Bay Company Archives, Provincial Archives of Manitoba, Winnipeg [HBCA] A.6/9, quoted in Henday 2000, 326). For the next twenty years employees were sent on similar missions, with equally disappointing results. Andrew Graham, an interim factor at York, commented in 1772 that nothing more could be expected, "they being ignorant poor labouring men of no abilities" (HBCA E.2/5). An exception was Samuel Hearne, mate of the Churchill sloop. Churchill's factor, Moses Norton, chose Hearne to explore a high-Arctic source of copper reported to him by Dene leaders Matonabbee and Idotlyazee. The two men had drawn a map for Norton that showed Great Slave Lake and rivers flowing into the Arctic Ocean. This map and another that Norton presented to the HBC Governor and Committee were clearly drawn by indigenous mapmakers (HBCA G.2/8, G.2/27). Native cartographic conventions puzzled the HBC directors; they welcomed Hearne's maps drawn on a familiar Mercator projection and sent home in 1772 (HBCA G.2/10; Minneapolis, James Ford Bell Library 1771MHE). Hearne's next assignment was to build the company's new settlement west of Lake Winnipeg and to map his route from York Factory (fig. 380). During the next decade, Edward Jarvis and John Hodgson recorded Albany's slow advance from Hudson Bay to Lake Superior. Gradually the company tried to assess the huge territory granted by its charter—its physical limits, resources, and transportation networks together with the location of inland posts.

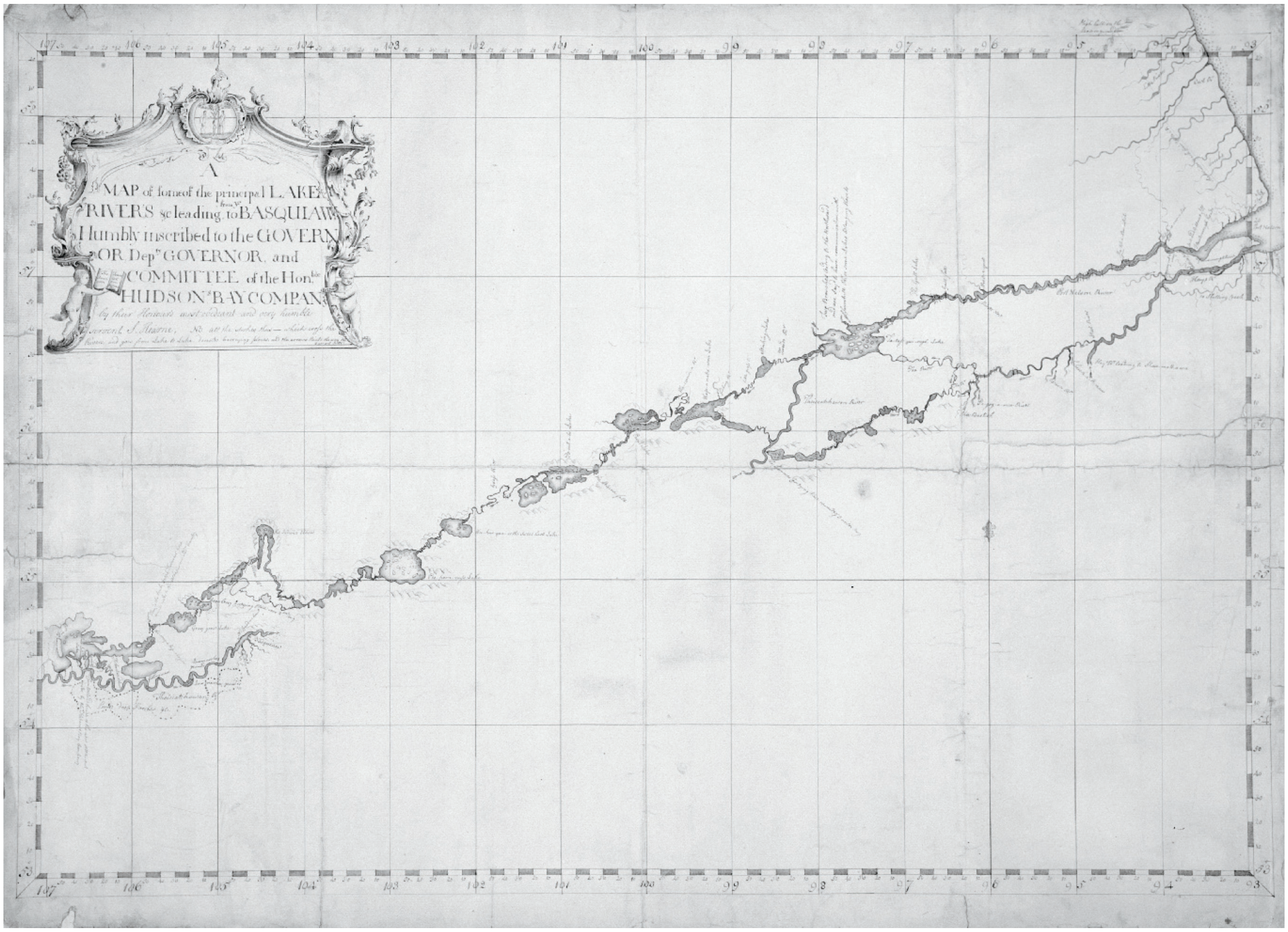

FIG. 380. SAMUEL HEARNE, "A MAP OF SOME OF THE PRINCIPAL LAKES RIVER'S &C LEADING FROM YF [YORK FACTORY] TO BASQUIAW," 1775. The graticule of latitude and longitude, rendition of rivers and elevations, and elaborate cartouche make Hearne's map an example of familiar European cartographic conventions; at the same time its employment of indigenous toponyms and its linear layout of connected waterways are reminiscent of Amerindian cartography and reflect the traders' emphasis on route finding over relatively flat, featureless terrain.

Size of the original: 55.5 × 75.5 cm. Image courtesy of Barbara Belyea. Permission courtesy of the Hudson's Bay Company Archives, Archives of Manitoba, Winnipeg (G.1/20).

Nevertheless, it was apparent that none of the company's overseas personnel had training enough to produce accurate, comprehensive European-style maps of the continental interior. On William Wales's recommendation, the HBC directors therefore appointed Philip Turnor to be the company's first official surveyor. Wales knew the rigors of living at the bay after observing the transit of Venus at Churchill in 1769 and may have encouraged Hearne's exploration of the Coppermine River. Turnor arrived at York Factory in 1778, traveled far up the Saskatchewan River, adapted well to fur-trade life, and even turned trader for several years. Despite repeated breakage and loss of his instruments, he made surveys in all of the regions where the HBC carried out inland trade (HBCA G.1/1, G.2/11). Turnor's early observations proved useful to Alexander Dalrymple, manager of the East India Company's map and chart collection and fellow of the Royal Society, who published a pamphlet in 1789 reviewing persistent arguments for a northwest passage. Dalrymple's confidence in Turnor's surveying skill led him to correct a key position on Hearne's map of the Arctic. As well as Jarvis and Hodgson, Turnor encouraged the mapping work by Malcolm Ross and Peter Fidler, who went with him to Lake Athabasca in 1790–92, and strongly recommended David Thompson to those in a position to help him. Fidler and Thompson would soon outstrip Turnor, not only by the extent of their explorations but also by the accuracy of their surveys. After his return to London in 1792, Turnor worked for

FIG. 381. DETAIL FROM PHILIP TURNOR, "MAP OF HUDSON'S BAY AND THE RIVERS AND LAKES BETWEEN THE ATLANTICK AND PACIFICK OCEANS," 1794. This detail shows Turnor's own explorations as far as Ile à la Crosse and the elbow of the North Saskatchewan River. The upper Saskatchewan River and its tributaries are copied from Peter Fidler's map sent to London in 1795. Aaron Arrowsmith's *Map Exhibiting all the New Discoveries in the Interior Parts of North America* (1795) showed only Turnor's explorations. When Turnor revised his manuscript map to include Fidler's survey and whether Arrowsmith copied this revision or Fidler's map directly are still open questions.

Size of the entire original: 193.5 × 260.0 cm; size of detail: ca. 44.5 × 69.5 cm. Image courtesy of the Hudson's Bay Company Archives, Archives of Manitoba, Winnipeg (G.2/32).

two years on a comprehensive map based on previous company surveys of HBC exploration west of Hudson Bay (fig. 381). The London cartographer Aaron Arrowsmith used Turnor's work as the main source for his *Map Exhibiting all the New Discoveries in the Interior Parts of North America* (1795). Arrowsmith's effusive dedication to the HBC Governor and Committee "in testimony of their liberal communications" did not name Turnor or the other HBC cartographers. Fidler's maps of 1796 and 1802, so important for "New Discoveries" of the Saskatchewan River, the Rocky Mountains, and the Missouri watershed, are now missing from the HBC archives. After consulting them, either Turnor or Arrowsmith failed to return them to the company (Ruggles 1991, 245–47).

Thompson, Turnor's immediate successor, defected to the Montreal-based North West Company in 1797, leaving Fidler as the Hudson's Bay Company's principal surveyor. Fidler continued in this appointment until the rival companies merged in 1821. During his long tenure, he put his own stamp on the position. Even as he prepared regional surveys for the company directors, he copied twenty indigenous maps and sixteen "sketches" drawn by fellow traders as well as producing many small maps of his own (fig. 382). None of these sketches followed European cartographic conventions; instead, they were a standard feature of his running surveys and borrowed from the puzzling Amerindian conventions that the company directors had first seen on Norton's maps. The HBC directors were uncomfortably aware of the difference between these drawings and the mapping conventions that were more familiar to them. Nevertheless, most of the company's overseas employees clearly preferred to draw and use sketches that resembled Amerindian maps.

Since trade, not political administration, was still the aim of the eighteenth-century Hudson's Bay Company, its maps documented access to markets rather than territorial extent and limits. The company directors were convinced that inland exploration required "a person capable of taking an observation for determining the longitude and latitude, and also distances, and the course of rivers" (from 1769; quoted in Hearne 1795, xxxiii). Hearne carried a sheet scored with a graticule on which he "pricked off [his] daily courses and distance" (Hearne 1795, xliv). But he was hardly more diligent than Henday in making the observations that would control his dead reckoning. Instead he "endeavour[ed], by a strict enquiry of the natives, to find out the communication of one river with another, as also their connections with the many lakes with which that country abounds" (Hearne 1795, xliv). Twenty years later, Jarvis explained that his regional map, "tho' in most it cannot have pretence to geographical accuracy, will serve to point out the connexion between your interior settlements" (HBCA A.11/5; quoted in Ruggles 1991, 58). The only practical way traders could identify a route was to select a string of connecting elements (lakes, rivers, a line of distant hills) and to impose the conceptual pattern of these connections on an otherwise insignificant ground. This solution was handed to the traders by their indigenous guides, who drew schematic maps showing only the line of connections, either as a pattern of linked waterways or as a "track" that crossed such features.

Fidler recognized the debt that overseas employees owed to Amerindian mapping and accepted their practical disregard of European-style cartography. Over forty traders are known to have drawn maps before the company's reorganization in 1821. Few of these maps were from carefully observed and measured surveys; most were small maps without scale or orientation. In 1815 the London directors shipped "blank maps" together with "traced copies" purchased from Arrowsmith's firm of "all those parts of the Company's Territories where it is desirable to gain further Information" (HBCA A.1/51, G.1/7–12); three years later the HBC Committee sent over more "plain Mercator Charts" (Ruggles 1991, 71). Meanwhile the HBC's overseas service was

FIG. 382. PETER FIDLER, MAP OF HOLY LAKE OR PEE SHE PAW WINNE PEE ["DEEP WATER LAKE," NOW OXFORD LAKE, MANITOBA] 1792. This map and forty others like it make up the visual component of Fidler's survey journal from York Factory to Cumberland House. Fidler copied his journal after 1794 and before 1806, the date of his observation for latitude at Oxford House, at the east end of the lake. The drawing indicates the lake's shape and extent, while the compass directions and distances marking Fidler's passage are given from left to right, in conformity with the journal narrative (the orientation is thus reversed, south is at the top). In this entry the map replaces the journal's verbal component by combining its numerical and visual components.

Size of the entire page: 38 × 24 cm; size of map detail: ca. 14 × 24 cm. Image courtesy of the Hudson's Bay Company Archives, Archives of Manitoba, Winnipeg (E.3/1, fol. 75).

organized into districts, for each of which a map was required. But the traders, including Fidler, returned district maps drawn "a la Savage" from 1815 to well into the nineteenth century (HBCA B.51/e/1). Although they were aware that their maps fell short of the company directors' expectations, the traders continued to draw small maps without coordinates and to leave the "blank maps" blank. European-style cartography had little appeal for overseas personnel until they assumed the powers and duties of territorial administration.

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SEE ALSO: Geographical Mapping: Great Britain; Indigenous Peoples and European Cartography; Northwest Passage

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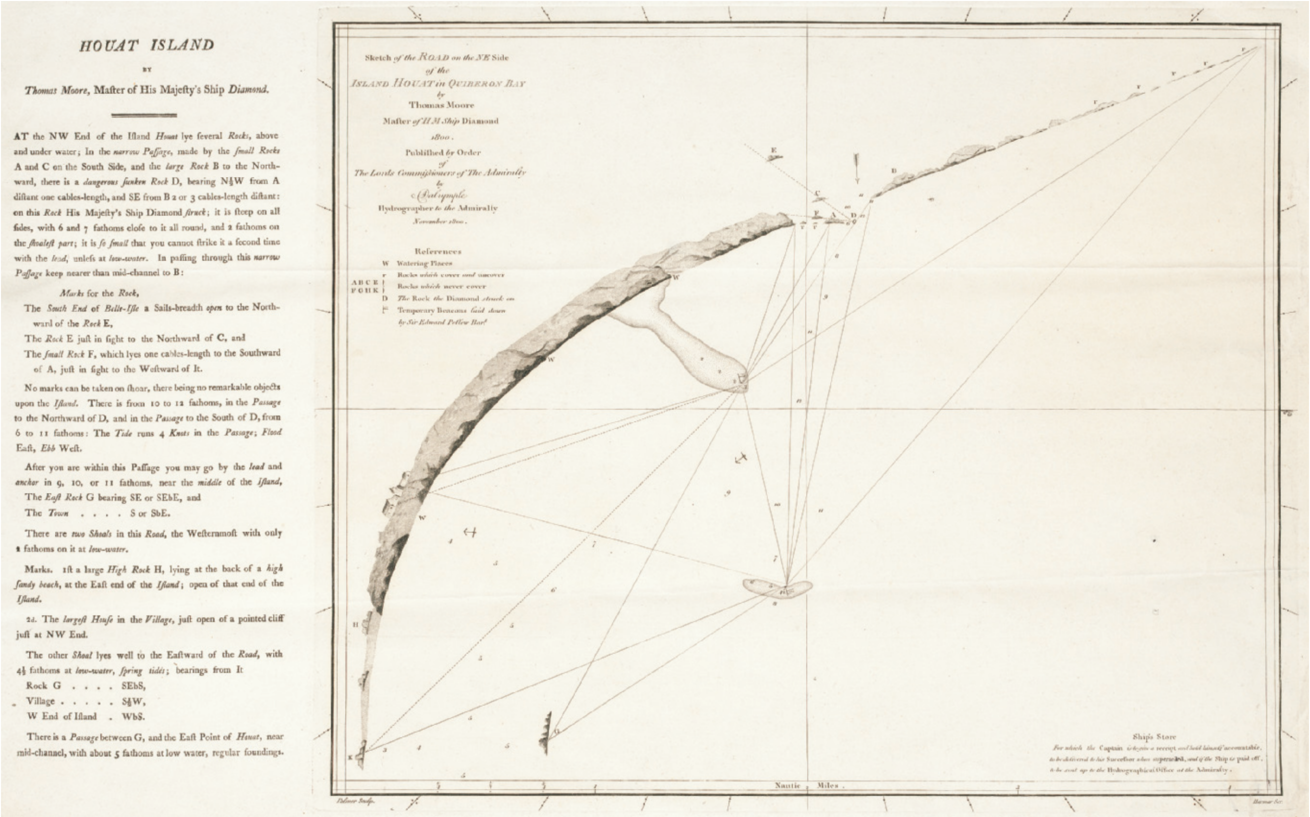
Hydrographical Office, Admiralty (Great Britain).

The Order in Council of 12 August 1795 creating the post of hydrographer to the Board of Admiralty complained of a "want of sufficient information" available to the Royal Navy to navigate safely in waters where the demands of war might direct them. The order further noted: "On a cursory examination of the plans and charts which have from time to time been deposited in the office, we find a considerable mass of information, which, if judiciously arranged and digested, would be found to be of the greatest utility." The Admiralty then gave examples of other European hydrographic offices, and proposed "that a proper person should be fixed upon to be appointed Hydrographer to this Board, and to be intrusted with the custody and care of such plans and charts as now are, or may hereafter be, deposited in this office belonging to the public, and to be charged with the duty of selecting and compiling all such information as may appear to be requisite for the purposes of improving the navigation, and for the guidance and direction of the Commanders of Your Majesty's ships" (quoted in Day 1967, 334). Alexander Dalrymple, already on retainer to the East India Company for "examining the Ships Journals" and publishing charts and plans (Cook 1992, 1:104), was formally appointed the following day. He had been increasingly used as a geographical and navigation expert by government officials in the 1790s. The plan to create the post of hydrographer and to appoint Dalrymple was orchestrated by Sir Philip Stephens, Evan Nepean, and William Marsden, the old and new secretariat of the Board of Admiralty, and long-time beneficiaries of Dalrymple's advice. By formalizing this process of consultation, they elevated their friend and colleague to an official position that let him investigate the Admiralty rooms of deposited surveys and so continue to give expert advice. Dalrymple advised Marsden in June 1798 on Red Sea navigation, supplied his East India Company charts to Admiral John Blankett's Red Sea expedition to Egypt, responded to questions from Nepean on foreign charts, and took in charts and journals from Joseph-Antoine-Raymond Bruny d'Entrecasteaux's voyage after it broke up in Batavia (Cook 1999, 59–60).

Naval officers had conventionally treated surveys made in the course of duty as their private copyright, and many, after submitting them to the Admiralty and receiving approval, had copies published through the map trade in London. Surveys commissioned directly by the Admiralty Board from appointed surveyors, such as Murdoch Mackenzie the Younger and Graeme Spence, also formed the nucleus of the collection entrusted to the hydrographer.

Dalrymple completed the organization of the accumulated charts and plans early in 1800, referring to it as the time "when the Hydrographical Office was made efficient" (quoted in Cook 1999, 60). He was assisted first by Aaron Arrowsmith, and from late 1796 or early 1797 by John Walker, an engraver long employed on his East India Company charts. Dalrymple and Walker compiled a list of charts and plans "fit to be engraved," and, though the Board envisaged only engraving and publication by the London map trade, Dalrymple received authority to install a rolling press from Matthew Boulton and to hire engravers and a printer (Cook 1999, 60–61). John Cooke and Isaac Palmer, plan engravers, joined John Walker, with two draftsmen and a copperplate printer, as the staff of the Hydrographical Office, with Thomas Harmar employed on piecework rates as



HOUAT ISLAND

BY

Thomas Moore, Maſter of His Majeſty's Ship *Diamond.*

AT the NW End of the Iſland *Houat* lye ſeveral *Rocks*, above and under water; In the *narrow Paſſage*, made by the *ſmall Rocks* A and C on the South Side, and the *large Rock* B to the Northward, there is a *dangerous ſunken Rock* D, bearing N¾W from A diſtant one cables-length, and SE from B 2 or 3 cables-length diſtant: on this *Rock* His Majeſty's Ship Diamond *ſtruck*; it is ſteep on all ſides, with 6 and 7 fathoms cloſe to it all round, and 2 fathoms on the *ſhaleſt part*; it is *ſo ſmall* that you cannot ſtrike it a ſecond time with the *lead*, unleſs at *low-water*. In paſſing through this *narrow Paſſage* keep nearer than mid-channel to B:

Marks for the *Rock*,
The *South End* of *Belle-Iſle* a Sails-breadth *open* to the Northward of the *Rock* E,
The *Rock* E juſt in ſight to the Northward of C, and
The *ſmall Rock* F, which lyes one cables-length to the Southward of A, juſt in ſight to the Weſtward of It.

No marks can be taken on ſhoar, there being no remarkable objects upon the *Iſland*. There is from 10 to 12 fathoms, in the *Passage* to the Northward of D, and in the *Passage* to the South of D, from 6 to 11 fathoms: The *Tide* runs 4 *Knots* in the *Passage*; *Flood* Eaſt, *Ebb* Weſt.

After you are within this Paſſage you may go by the *lead* and *anchor* in 9, 10, or 11 fathoms, near the *middle* of the *Iſland*,
The *Eaſt Rock* G bearing SE or SEbE, and
The *Town* . . . . S or SbE.

There are *two Shoals* in this *Road*, the Weſternmoſt with only 2 fathoms on it at *low-water*.

Marks. 1ſt a large *High Rock* H, lying at the back of a *high ſandy beach*, at the Eaſt end of the *Iſland*; open of that end of the *Iſland*.

2d. The *largeſt Houſe* in the *Village*, juſt open of a pointed cliff juſt at NW End.

The other *Shoal* lyes well to the Eaſtward of the *Road*, with 4½ fathoms at *low-water*, *ſpring tides*; bearings from It
Rock G . . . . SEbS,
Village . . . . . S¾W,
W End of Iſland . WbS.

There is a *Passage* between G, and the Eaſt Point of *Houat*, near mid-channel, with about 5 fathoms at low water, regular ſoundings.

FIG. 383. THOMAS MOORE, *SKETCH OF THE ROAD ON THE NE SIDE OF THE ISLAND HOUAT IN QUIBERON BAY,* NOVEMBER 1800. The chart of part of Ile Houat was the first to be engraved and printed in the Hydrographical Office. Remarks and directions were added by letterpress in the marigin of the chart. The imprint "Published" was used in expectation of a decision to publish, but no such decisions were taken until after 1810. Experimental charts such as that of Houat were not proceeded with, and consequently only proof copies exist.
Size of the original: 34 × 53 cm. Image courtesy of the U.K. Hydrographic Office, Taunton (Admiralty Library Vf 8/8).

writing engraver. The earliest chart known is that of the island Houat in Quiberon Bay, printed with a date of November 1800 (fig. 383). Dalrymple had no authority to commission surveys, only to engrave charts from materials supplied by ships' officers, supplemented by manuscripts in the Hydrographical Office and by foreign printed charts. Though charts were engraved with provisional "publication" dates and "Ship's Store" notices, Dalrymple's budget for presswork and paper allowed only for proof copies, twenty-five from any plate, and decisions to print in bulk for fleet issue would have required Board provision and approval.

Dalrymple organized the engraving of coherent series of charts for the south coast of England from the Thames to Land's End, as well as series of plans of Adriatic harbors and Sardinian anchorages, and charts of the approaches to Dutch estuaries. To encourage the supply of nautical information, Dalrymple designed (or revised) in 1804 a "Form of Remark-Book," giving guidance to ships' officers as to the headings under which to record information about ports visited (Cook 1999, 65). The Hydrographical Office received visits from Horatio Nelson and William Bligh, the latter assuming temporary charge during a time when Dalrymple was ill in spring 1804.

Changes in government ministries in 1806 and 1807, after the death of William Pitt the Younger, resulted in changes in the Board of Admiralty. In the space of a few months in 1806 Stephens and Nepean, successive holders of the first secretaryship from 1763 to 1804, retired, and when the political appointee William Wellesley Pole succeeded Marsden as first secretary in June 1807, and John Barrow resumed the permanent second secretaryship, the "office memory" of Dalrymple's appointment and achievement was effectively erased, and the focus of the office was changed. The new Board of Admiralty saw the Hydrographical Office more as a conduit for supplying charts, both commercial and official, to the Royal Navy. In May 1807 Dalrymple was requested to purchase "a compleat Set of all Charts published in England"; he produced a sixty-one-page catalog ("List of English Charts"), but declined the second request—to select "the best and most necessary"—on the grounds that few commercial charts had accompanying memoirs of authorities, and he suggested forming "a Committee of Officers" to make the selection (Cook 1992, 1:178–79). Exceptionally, he had supplied Admiral James Gambier's Baltic expedition of 1807 with commercially published charts and sailing directions, including proof copies of Thomas Atkinson's chart of the Great Belt, the only Hydrographical Office chart available.

The Admiralty Board appointed Home Riggs Popham, Edward Henry Columbine, and Thomas Hannaford Hurd as the Chart Committee in November 1807 to make the evaluation and to consider also Dalrymple's "List of Plates engraved, engraving and of Charts and Plans prepared for Engraving in the Hydrographical Office." After the committee's March 1808 report, Pole and Barrow came to rely on the Chart Committee, rather than on the hydrographer, for the provision of sets of publicly available charts. Pole used the planned "new arrangements of the Office" to try to persuade Dalrymple into retirement (Cook 1992, 1:182). Dalrymple declined, was provoked in May into refusing the Chart Committee's arbitrary request for the confidential security copies he had made of d'Entrecasteaux's charts of New Britain in 1795, and was dismissed by decision of the Admiralty Board on 28 May 1808. Hurd was immediately appointed hydrographer to effect the plans of the Chart Committee to purchase sets of commercial charts and to print Dalrymple's plates for fleet use.

Dalrymple left a functioning chart compilation, engraving, and proofing Hydrographical Office, with a relatively small output of completed charts and a large number in preparation, but he never claimed (nor was allowed the resources) to compete with commercial publishers to provide the general coasting charts the Admiralty increasingly expected.

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SEE ALSO: Dalrymple, Alexander; Map Trade: Great Britain; Marine Charting: Great Britain

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Hydrographie françoise, L'. See *Neptune françois* and *Hydrographie françoise*

Hypsometry. See Height Measurement: Altimetry