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Samplers, Map. In the last quarter of the eighteenth century, embroidered map samplers became a popular schoolgirl assignment in the British Isles and the fledgling United States. At that time, educational philosophies were rapidly changing, especially for girls. In the early 1700s, upper-class girls were taught "accomplishments" such as music, dance, drawing, and ornamental needlework; all girls, regardless of station, were taught sewing and plain needlework. By the late eighteenth century, there was increasing criticism of these ornamental studies; many believed that they made girls shallow and frivolous. "Solid" subjects that included reading, arithmetic, writing, and geography were introduced into girls' schools as ornamental fields were slowly eliminated. During this transition period, samplers, which had existed for at least two centuries, were adapted to teach both needlework and solid subjects. Thus, we find not only the usual alphabet samplers, but also embroidered multiplication tables, almanacs, and maps. These have all been designated samplers by needlework historians not because they show a sample of different stitches (some use only two or three) but because they are schoolgirl products. Although some may have been made by grown women, the overwhelming majority were made by girls as young as seven, not at mother's knee, but at dame schools and boarding schools (fig. 738).

Geographical map samplers, which were used to teach locations, appear to have originated in the British Isles and diffused to the United States. They were not widely made in any other countries. Although three map samplers made in France are known, it is not known if they were made by French girls at English schools or if they were made by adults as presentation pieces.

The earliest map samplers were hand drawn on linen, fine wool, or silk, copied by eye from published maps or perhaps drawn from memory. These simplified maps offered sometimes distorted representations of England and Wales, Scotland, and Europe. One unusual example reflects large-scale property mapping skills in its display of fields and acreages of a farm in Essex (see fig. 672). By the late 1770s, magazines, such as the London *Lady's Magazine*, regularly printed needlework patterns. Some of these were map patterns that accompanied an article on the place shown.

Map publishers began printing paper patterns specifically for needlework maps, and by the 1780s, when printing on fabric became common, they printed maps on silk "for young ladies' needlework" (Tyner 2015, 18). Two London publishers that printed such maps were Bowles & Carver and Laurie & Whittle. Bowles & Carver's 1795 catalog listed "*Twenty Oval and Circular Maps, for Screens*, &c. printed on one sheet of fine royal paper"; each sheet of exemplars sold for 1 shilling (1795, 18).

Although two copies of a 1797 Laurie & Whittle pattern for a map of Scotland still exist, it is rare to find such paper map patterns, either from a map publisher or from a magazine, because the methods used to transfer the pattern to cloth destroyed the pattern. The usual methods were "prick and pounce" or stitching through a pattern pinned to the fabric. Tracing paper had not been invented. In prick and pounce, small holes were pricked in the paper, which was then pinned to the cloth, and pounce, a powdered charcoal, was rubbed through the holes producing an outline on the cloth (Tyner 2015, 31).

Hundreds of map samplers were made in the British Isles in the late eighteenth and early nineteenth centuries. Two design schemes may be discerned, showing differences between maps made at Quaker and non-Quaker schools. Those from non-Quaker schools usually have ornate floral borders; needlework skills were emphasized over geography. Quaker maps are much simpler in design owing to the Quaker rejection of the ornamental; they resemble paper maps of the period.

It is difficult to determine in which school specific samplers were made because only rarely did the stitcher include that information. In fact, unlike alphabet samplers, the girl often didn't even include her name. Two English schools that are known to have produced several

FIG. 738. SAMPLER OF ENGLAND COMPLETED IN 1780 BY STUDENT ANN RHODES, AGE THIRTEEN. The map is bordered by latitude and longitude marks and includes ships and boats and an elegant compass rose. Linen embroidered with silk thread.
Size of the original: 62.2 × 54.6 cm. Image courtesy of V & A Images, London (V&A inventory number 497-1905)/Art Resource, New York.

map samplers are the Quaker Trinity Lane School in York and an unnamed school in Tottenham. The majority of the York samplers identified represent Ireland, while those of Tottenham represent England and Wales.

The samplers made in the United States during this period were far fewer; the period of greatest activity was from 1801–40. The American samplers, like their British counterparts, were schoolgirl products. Samplers probably spread to the United States in three ways: via patterns found in imported magazines, by teachers who had emigrated from England, or by parents educated in the British Isles. American schoolgirl Ann Smith stitched a map of Europe in 1787 from a pattern in the 1778 *Lady's Magazine* (Tyner 2001, 37). As for teachers, newspaper advertisements for new schools often stressed that a teacher was "newly arrived from England" (Tyner 2015, 68) and noted geography and the "working [i.e., stitching] of maps" as subjects taught (Tyner 2001, 41).

In the United States, as in England, several map sampler traditions can be identified based on school or region. For the most part, making samplers was confined to New York, Pennsylvania, Maryland, and New Jersey. The two largest groups are Maryland samplers and Pleasant Valley samplers (the majority of American map samplers cannot yet be tied to a specific school).

A group of ten surviving map samplers of Maryland are the earliest that can be definitely identified as American made. They appear to have been copied from Samuel Lewis's map of Maryland published in Mathew Carey's *The General Atlas for Carey's Edition of Guthrie's Geography Improved* (1795). The largest group of samplers was made at the Pleasant Valley Boarding School, a Quaker school in the Hudson River Valley of New York. The twenty-three known Pleasant Valley map samplers include world maps in two hemispheres, North America, and the United States as well as two of New York State.

Over thirty other American-made map samplers are known, but only a few can be identified as to the school or teacher. These include two maps of Boston Harbor made at Susanna Rowson's school and three maps of Washington, D.C., that are believed to have been made at a school in Baltimore run by Mrs. Robert O'Reilly. Samplers made at as yet unidentified schools include those depicting maps of the world, of the United States, and of individual states, including Pennsylvania, New York, and Virginia (Tyner 2015, 123–24).

In both England and the United States, the popularity of map samplers as well as samplers in general declined around 1830. The reasons include new fashions in needlework, the invention of indelible ink for marking clothing (no need to learn to stitch alphabets), and the invention of the sewing machine. The primary reason for the demise of map samplers was probably the complete replacement in girls' education of the accomplishments by the solid subjects. Map samplers were transitional objects that were tied to changes in education and educational technology including the tools that children used. Paper had become less expensive and therefore children could create maps on paper with ink and paint rather than stitch maps on cloth with thread.

JUDITH A. TYNER

SEE ALSO: Consumption of Maps; Education and Cartography; Household Artifacts, Maps on

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Sanson Family. Nicolas Sanson (1600–1667) was the first person to hold the title *géographe du roi*, created under Louis XIII. His abundant cartographic oeuvre, noted for its emphasis on clarity and homogeneous design, exemplified the emergence of original geographical map production in France in the face of Dutch hegemony. His heirs maintained the commercial success of his work, which endured in France and throughout Europe long after his death.

Born in Abbeville (Picardy), Sanson was the scion of a well-to-do merchant family whose members held various municipal offices. His father's interests in geography included mapmaking, a predilection he passed on to his eldest son, whose education at the Jesuit college in Amiens further inspired a taste for mapmaking: when he was eighteen or nineteen he created a map of ancient Gaul based on ancient authors. Sanson married Elisabeth Le Moictier from Abbeville, and the couple had four daughters and five sons, three of whom would join him in the map trade. After an initial but unsuccessful career as a merchant, his bankruptcy in 1627 turned him to geography with the publication of the *Galliæ antiquæ descriptio geographica*, which he brought to Paris in 1627 to be engraved on six sheets (by Robert Cordier, also from Abbeville). The publication of the map introduced him to the circles of power and the milieu of map editors in Paris, where he moved in late 1639 or 1640. He was noticed by Armand Jean du Plessis, Cardinal Richelieu, and introduced to Louis XIII, to whom he gave geography lessons (Pastoureau in Sanson 1988, 16–17). Thus began Sanson's career devoted to fulfilling and soliciting public commissions (e.g., from Richelieu, Chancellor Pierre Séguier, the Assemblée du clergé, and Jean-Baptiste Colbert) aimed at providing complete and homogeneous geographical coverage of France (Pelletier 2007, 1497). For Sanson, these commissions garnered support, recognition, and access to unpublished documents. Sanson also provided the results of his scholarly works to the public by publishing them, whether by himself (1644–48) or in partnership with a series of printsellers, including Melchior II Tavernier (1632–43) and the Mariette family (1648–71) (Pastoureau in Sanson 1988, 13–28; Hofmann 2007, 1580–82).

In addition to his family's civic duties and his classical education, Sanson's background also included experience, albeit brief (1638–39), as an *ingénieur des fortifications* in Picardy and *conducteur des travaux* in Abbeville at the end of the Thirty Years' War. This varied training encouraged Sanson to create both historical maps (including Gaul, Greece, and Italy) and administrative maps (e.g., of the administrative areas of France, the dioceses of the church, and the taxation regions, such as those for the *grande gabelle*). For every map, Sanson's method was that of the *géographe de cabinet*, compiling medium- to small-scale maps from a variety of sources; his supporting documentation came mostly from a disparate array of books (ancient writers, travelers, and missionary reports). A gifted teacher, he gave his maps coherence and clarity by establishing an innovative hierarchy of geographic nomenclature: using the same sinusoidal projection for all his maps, so it is now known as the Sanson (or Sanson-Flamsteed) projection (Snyder 2007, 372); counting longitudes from the meridian of the Île de Fer (Ferro); and expressing scale as a function of the fixed value of the mille (1 mille = 1 minute of a degree of latitude).

Among his numerous printed productions (348 maps), several works stand out. Sanson's two thematic maps of France—the *Carte geographicque des postes qui traversent la France* (1632) (fig. 739; see also fig. 865) and the *Carte des rivieres de la France cvrievsement recherchee* (1634)—were particularly innovative (Pelletier 2007, 1501–2). His nearly forty geographic tables (1644–45) classified and ordered place-names hierarchically by continent and country. He prepared and published the first world atlas made in France, the *Cartes generales de tovtes les parties dv monde* (1658). His atlas of France, the *Cartes particulieres de la France* (1656–76), published with his son Guillaume (1633–1703), collected the diocesan maps, each at a scale of ca. 1:234,000, which could be combined to make a map of the entire kingdom.

Three of Sanson's sons continued his work. The eldest, Nicolas II (1625–48), also *géographe du roi*, was tragically killed while escorting Chancellor Séguier across Paris during the Fronde. His death may have contributed to his father's decision to collaborate with Pierre I Mariette. After his father's death, Guillaume joined Alexis-Hubert Jaillot in 1671 to publish the monumental *Atlas nouveau* (1681) and his father's *Introduction à la geographie* (1681). Although they enjoyed fame, titles of *géographe du roi* and related appointments, revenues from the sale of maps, and a subsidized residence in the Grande Galerie du Louvre, Guillaume and Adrien Sanson (1639–1718) encountered major financial problems. Their impoverished state required them to sell the family's geographical collection in 1692 to their nephew, Pierre Moullart-Sanson (d. 1730), who published a catalog of the collection in 1696 and produced a new edition of the world atlas.

Despite their commercial renown, the heirs of Sanson were accused in learned circles of being content to reprint maps without making the corrections rendered necessary by the progress made in mapmaking under the aegis of the Académie des sciences. The astronomical determinations by Philippe de La Hire and Jean Picard along the coasts of the realm between 1679 and 1682, sponsored by the Académie, had given France a new, slimmer silhouette, magisterially revealed when the corrected coastline was superimposed upon that of Sanson (see fig. 625), leading Louis XIV to jest that La Hire and Picard's "travels had caused him nothing but loss" (Fontenelle 1741, 79). Thus, the scientific credibility of the Sanson family was shaken at the very moment when, paradoxically, its commercial reputation was at its peak, especially outside of France, thanks to the pirated versions of the *Atlas nouveau* published in Amsterdam by the Huguenot Pieter Mortier in 1692 and 1694.

The existence of two rival camps within the French mapmaking community cast a shadow over French geography in the first half of the eighteenth century. The Sanson family and their successors (Moullart-Sanson, the Jaillot heirs, and the Robert de Vaugondy family) sought to defend the heritage of Sanson, a "Prince among Geographers of his age" (Lambert 1751, 3:41), while reformist geographers aligned themselves behind the work of Guillaume Delisle, the *premier géographe du roi* and member of the Académie des sciences.

Shortly after the death of Moullart-Sanson in 1730, the Sanson collection passed to three friends, one of whom was the mathematician Gilles Robert Vaugondy. About forty Sanson maps, in reworked and supplemented form, continued to be produced until the end of the eighteenth century (Pedley 1992). Both Gilles and his son Didier Robert de Vaugondy, careful to reconcile

FIG. 739. NICOLAS SANSON'S MAP OF POST ROUTES IN FRANCE. First published in 1632 by Melchior II Tavernier, this copperplate map by Sanson was the first of its kind to show the post routes in the kingdom of France, displaying a network of routes used by official couriers and fortunate travelers at the end of the reign of Louis XIII. This particular impression was published in about 1640 under a new title (*Carte generale de tovte les poste et traverse de France*) by Nicolas I Berey and includes a series of vignettes of ten principal cites of the kingdom, in profile or perspective view, along the side margins. The decorative upper border consists of engravings of two coaches heading at speed toward Paris.

Size of the original: 40 × 53 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Reg. C 18550 [268]).

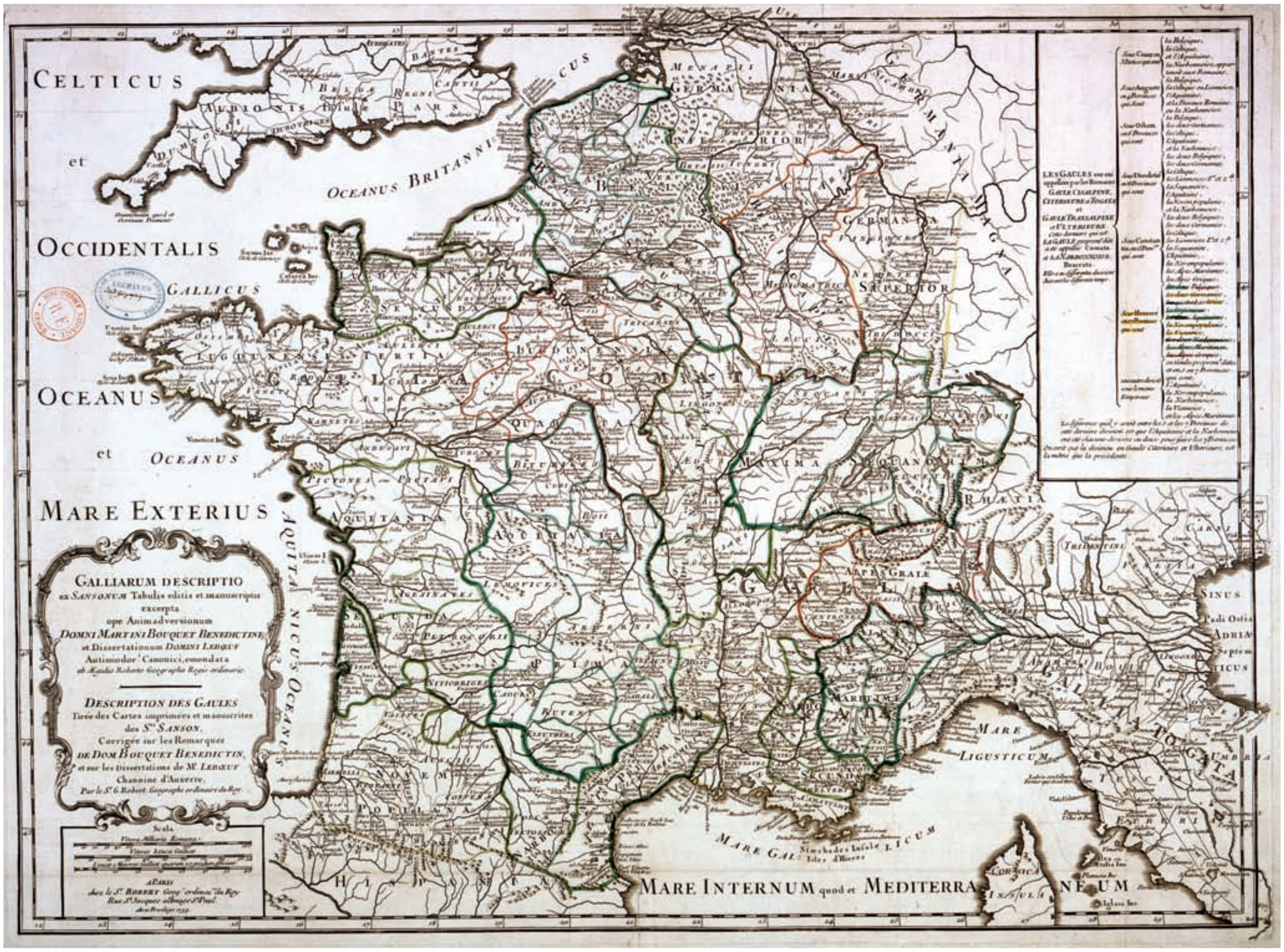

FIG. 740. GILLES ROBERT [VAUGONDY], *GALLIARUM DESCRIPTIO EX SANSONUM TABULIS . . . DESCRIPTION DES GAULES TIRÉE DES CARTES IMPRIMÉES ET MANUSCRITES DES S*[RS] *SANSON* (PARIS, 1738). Engraved map with outline color added according to the Sanson style table, top right. An example of a map originally prepared by the Sansons and corrected and completed by Gilles Robert Vaugondy at the beginning of his career as a geographer.
Size of original: 55.5 × 75.0 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge DD 2987 [9786 B]).

science, utility, and aesthetics, carried on and renewed the work of the Sansons through their own (fig. 740).

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SEE ALSO: Geographical Mapping: France; Map Trade: France; Reproduction of Maps: Engraving and Printing; Robert de Vaugondy Family

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Sarychev, Gavriil Andreyevich. Gavriil Andreyevich Sarychev was born in 1763, the son of a navy ensign from the nobility of Bryansk *guberniya*. In 1775, he entered the navy cadet corps, Morskoy kadetskiy korpus, and graduated with the rank of cadet. In 1780, aboard the *Ne tron' menya* he sailed from Arkhangelsk to Kronstadt and was promoted to midshipman. Aboard the same man-of-war in 1781–82, he traveled from Kronstadt to Livorno, Italy. In 1784, he took part in surveys

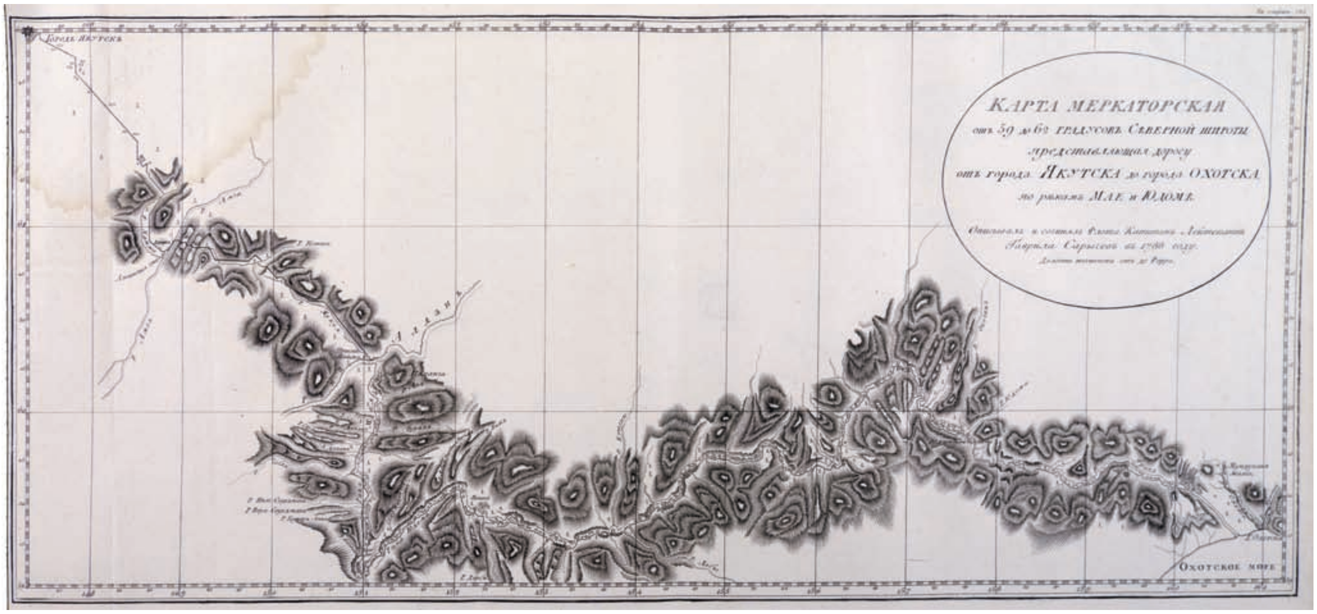

FIG. 741. *KARTA MERKATORSKAYA*, 1788. Sarychev's map of the route from Yakutsk to Okhotsk. From Sarychev 1802. Size of the original: ca. 45 × 100 cm. Image courtesy of the Newberry Library, Chicago (Ayer 124.R98 S25 1802).

and charting of the Dnieper River and its tributary, the Sozh.

In 1785, as a lieutenant, Sarychev was appointed second-in-command to Captain Joseph Billings, who led a geographical and astronomical expedition to the North Pacific and Chukchi Peninsula. In 1787, Sarychev was promoted to lieutenant commander, and in July of the same year he took command of the *Yasashna* and sailed her down the Kolyma River to its mouth. Joining forces with Billings aboard the *Pallas*, Sarychev three times tried to sail from the mouth of the Kolyma into the eastern Siberian Sea and around the Chukchi Peninsula (fig. 741). Hard ice stopped the two ships near Cape Baranov Kamen'. In the spring of 1789, he returned to Okhotsk, described and surveyed the joint mouth of Okhota and Kukhtuy Rivers, compiled the plan of Okhotsk harbor, and surveyed the coast west of Okhotsk up to the Aldoma River.

In 1790, aboard the *Slava Rossi*, Sarychev took part in hydrographic surveys near the Aleutian Archipelago and reached Kodiak Island. In May 1791, aboard the same ship, he sailed to Unalaska Island and then to St. Matthew Island. Sailing north, he explored St. Lawrence Island, the eastern coast of the Bering Strait, and the Diomede Islands. Near the Chukchi coast in the St. Lawrence Bay, Sarychev became the commander of the oceanic part of the expedition, while Billings landed for his trip across the northeastern extremity of Siberia. Sarychev returned to Unalaska, where he was joined three days later by Billings's mate, Roman Romanovich Gall, aboard the *Chërnyy Orël*. Sarychev transferred Gall to the command of the *Slava Rossii* and took the *Chërnyy Orël*. In the beginning of October, Sarychev sent geodesist Osip Khudyakov to perform the hydrographic survey and description of Unimak and Sanak islands and Alaska Point. During February and March 1792, Sarychev explored the bays and coasts of Unalaska (excluding the southern part) and compiled its first description. Most of the surveys conducted during the expedition were carried out by Sarychev and his main surveyor geodesist Khudyakov, who further succeeded in uniting precise scientific methods of surveying and charting with comprehensive use of native information (Postnikov 2005, 6–9).

On the basis of surveys of the Billings and Sarychev expedition of 1790–92, fifty-seven charts were compiled of Kamchatka, the Aleutian Islands, Chukotka, and the coast of North America. These are reproduced in part in facsimile (Efimov 1964). The results of the expedition were reflected in a chart published in Petersburg: *Merkatorskaya karta ot 47 do 71 severnoy shiroty i ot 125 do 217 dolgoty ot Grinvicha* (1794) (Postnikov 1996, 75, fig. 47). Sarychev returned to St. Petersburg in 1794. In 1802, as a captain of the first rank, he was appointed the commander of the Baltic Sea hydrographic survey, which continued until 1817. During the survey, in 1803, Sarychev was promoted to rear admiral and in 1808 to vice admiral. In 1809, he was elected an honorary member of the St. Petersburg Akademiya nauk. In 1827, Sarychev was appointed general hydrographer of the Morskoy shtab. He became a full admiral in 1830. In the next year, he died in St. Petersburg from cholera.

ALEXEY V. POSTNIKOV

SEE ALSO: Marine Charting: Russia

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Satire. See Allegorical and Satirical Maps

School Atlas. See Atlas: School Atlas

Science and Cartography. In exploring the terms "science" and "cartography," it is important to recognize that, like maps, words have a history. In the eighteenth century, the word "cartography" did not exist. "Science," although in common usage, was not always employed in the senses understood by later commentators. Strictly, "cartography" is a nineteenth-century invention, a term adopted in the 1820s to describe the professionalization and formalization of shared practice in mapmaking. In the eighteenth century, science meant various things. Earlier uses of the term or related adjectives—such as "sciential" or "scientifical"—had given way to three main and related meanings by the early 1700s. The first was science as knowledge as opposed to belief or opinion. The second was science as a particular branch or order of knowledge in the sense of a recognized department of learning. In this context, the term was often prefaced by a specific descriptor—geological, botanical, and the like—more common later in the eighteenth century than earlier. The third was more restricted, embracing not just a branch of study but the methodology of demonstrated truths, observed facts systematically classified, and general laws by which new understanding was attained. The emphases on subject and method now more usually expressed by the term "science" were then understood as natural philosophy: "science and cartography" would be, in eighteenth-century parlance, "natural philosophy and mapping."

The relationships between scientific inquiry and the processes of mapping in the eighteenth century may usefully be examined in terms of four related themes. Mapping was itself increasingly understood as a science, a branch of knowledge that, in the form of what was known as mathematical cosmography, aimed at the rational measurement and representation of the earth and its contents. In the physical sciences, cartography helped depict a natural world revealed through direct observation, realistic description, systematic classification, and comparative method of explanation. Mapping was also used to understand the human sciences or what contemporaries variously understood as the "moral condition" of humans or the "science of man," albeit less clearly so than for the physical world since the Enlightenment study of society did not lend itself as readily to the authority of science. Finally, there is a metaphorical utility here in that charting the location and distribution of scientific activity can reveal a cartography of science as well as help us understand cartography and science.

The emergence of science as subject knowledge and method in the eighteenth century was the result of new ways of reading and interpreting the book of nature—what later historians have termed the "Scientific Revolution"—and, crucially, of the widespread adoption of Newtonian methods in philosophical reasoning. Modern scholars are not agreed upon the nature, timing, and principal features of the Scientific Revolution, one even doubting its existence as a single and revolutionary phenomenon (Shapin 1996). Nevertheless, from the late seventeenth century, natural philosophy was characterized by direct observation more than by faith in the claims of others or unswerving belief in the Scriptures, by experimentation more than experience, and by rigor in method and language. Mathematics increasingly replaced the Bible as the means to explain nature's diversity.

A key work in this respect was Sir Isaac Newton's *Philosophiæ naturalis principia mathematica* (1687). Newton laid out the laws of gravity and the foundations for classical mechanics, effectively establishing the mathematical principles for natural philosophy, that is, scientific method. His work was not easily understood or agreed upon everywhere; his influence depended in part upon later authors disseminating and popularizing his work and upon the practical testing of his propositions. As one proponent noted, "The manner, in which Sir Isaac Newton has published his philosophical discoveries, occasions them to lie very much concealed from all, who have not made the mathematics particularly their study" (Pemberton 1728, 1). Newton emphasized an attention to cause and effect, based on observation within limits—"The philosopher's first care must be to distinguish, what he sees to be within his power, from what is beyond his reach" (Pemberton 1728, 13–14)—and a concern for truth to be "discovered by experiment and observation, with the aid of geometry, only" (that is, mathematics) (Maclaurin 1748, 90–91).

In terms of science and cartography, Newtonian mathematical principles were more significant than his legacy in other respects, certainly in eighteenth-century Britain (Henry 2004). The mathematical and empirical procedures evident in Newtonianism and those concerns for regulating the study of the world that resulted from the Scientific Revolution were primal in mathematical cosmography. In general terms, this embraced the mathematical study of astronomy and of geometry. Astronomy was the study of the earth, its dimensions and meridians (what in combination was understood as "terrestrial astronomy"), and the heavens (in terms of planetary motions, for example, and so was recognized as "celestial astronomy"). Geometry was divided into theoretical and practical parts. The first incorporated the study of latitude and longitude and of trigonometry and triangulation in mapmaking. The second addressed the construction of terrestrial and celestial globes and other instruments of measurement, such as armillary spheres, as well as maps themselves (Edney 1994). Mathematical cosmography had institutional expression—in the Kosmographische Gesellschaft of Nuremberg, in London's Royal Society, and the Académie des sciences in Paris, as well as in other institutions. In its practical operation in expeditions and in instrumental refinements, mathematical cosmography embraced astronomy, geography, mathematics, and mapping not as separate subjects or, in modern terms, disciplines, but as a conceptual fusion directed at the ordered understanding and representation of the earth and its relationship with other celestial bodies.

The connections between science and cartography were forged at sea and on land as well as in celestial measurement. Edmond Halley's voyages on HMS *Paramore* between 1698 and 1701, in which he studied wind and tide directions and variations in terrestrial magnetism, among other topics, provided what may be seen as the Enlightenment's first sea-based scientific survey (Thrower 1981). On land, geodetic expeditions concerned with that great question of Enlightenment earth science—what was the shape and size of the earth?—sought to test competing scientific theories and drew upon mathematical cosmography and mapping in doing so.

In his *Principia*, Newton argued that the earth, a homogeneous fluid mass, had been acted upon by universal gravitation and centrifugal forces resulting from its rotation. As a result, the earth bulged at the equator and was flattened at the poles. For Newton, the earth was thus a flattened spheroid. Empirical observations undertaken in French Guiana by mathematicians from the Académie des sciences seemed to support him. But not everyone agreed with Newton's view of the earth or with his underlying mathematical principles. Jean-Dominique Cassini (I) and his son Jacques Cassini (II) found, in their measurements of an arc of the meridian of Paris, that the length of a degree was shorter, not longer, to the north so that the earth had to be elongated, or squeezed at the equator. Differences in the early eighteenth century over these two philosophical views of the earth's shape initially and broadly followed national and institutional lines—the French and the Académie behind empirical observation and René Descartes's celestial mechanics, and the British, in the Royal Society, supporting Newton's mathematical model of gravity. In the 1730s, this cartography of scientific affiliation was complicated by strong advocacy for Newton's claims from the leading French mathematician, Pierre Louis Moreau de Maupertuis.

Maupertuis argued that in order to determine the shape of the world precisely, it was vital to measure the earth's shape in those places where it was presumed to differ most—at the equator and the poles. The result was two geodetic expeditions, supported by the Académie des sciences. One, under Maupertuis's command, headed into Lapland (as far north as was easily possible) in 1736. The other, under the direction of the geographer Charles-Marie de La Condamine, went in 1735 to equatorial locations in the Viceroyalty of Peru. Both expeditions also undertook measurements of the earth's gravitational field and produced maps of the regions in question based on triangulation and trigonometry. Maupertuis's account of the Lapland work, *La figure de la Terre* (1738), if part self-laudatory heroic narrative, is also "a detailed technical record of sophisticated science" (Terrall 2002, 115). Maupertuis's expedition was the more successful and, with other later work, helped establish the authority of Newton's views.

Even so, geodesy and global metrology, the science of measurement, remained a concern of mapmakers throughout the century. For the French, mapping their nation through triangulation was an aid to the science of government. Building upon earlier schemes from 1733 on, the French, under the leadership of Cassini II and his son, César-François Cassini (III) de Thury, and employing coordinated parties of *ingénieurs géographes*, undertook the world's first scientific trigonometrical survey at a national scale. Global cartography did not always proceed with the same instrumental precision and governmental support. In the later 1780s, William Roy, who had overseen the Military Survey of Scotland between 1747 and 1755 and who was then involved in schemes for the mapping by triangulation of southeast England and the fixing of the longitudinal separation of the Paris and Greenwich Observatories, wrote that further Northern Hemisphere work was required "by way of confirmation or correction of the Lapland measurement, which yet stands single and by itself, without any collateral proof of its exactness" (Roy 1787, 225).

At sea, the search for scientific exactness was a question of time. Calculating latitude, distance north or south of the equator, was reasonably straightforward. Determining longitude, the distance east or west from a specific meridian, was not, especially when different sites such as the Paris and Greenwich Observatories were used to define the zero meridian. Knowing longitude depended upon reliable seaborne instruments for timekeeping, since differences in longitude equate directly to differences in time. Two solutions were developed: John Harrison created the marine chronometer, one of the great achievements of eighteenth-century metrological science, while astronomers perfected the observation of lunar distances. But the social implications of science's advances were not evenly dispersed. Few oceanic navigators had access to chronometers before 1800, and the astronomical method was too complex for most mariners. French astronomers Jean-Baptiste-Joseph Delambre and Pierre-François-André Méchain attempted, between 1792 and 1799, to determine a standard length for the meter, and their work reflected philosophical intentions to order the globe through scientific study, which could be compromised in the process by instrumental error and geographical variation (Alder 2002).

As it helped order the terraqueous globe, mapping was also crucial to the development of particular sciences of the earth, both in terms of what contemporaries often called a primary survey—the location, distribution, and measurement of natural phenomena—and in the form of the map as a scaled depiction of such phenomena. Description of the physical geography of earth had various names depending upon national context—*mineralogische Geographie* in Germany, *géographie souterraine* in France, in Italy *anatomia della terra*, and commonly in English, geognosy. But it shared an attention to the mapping of surface distribution for utilitarian ends (for example, in terms of mineralogical deposits like coal and metal ores and topographic features as they affected road and canal building) and as clues to the nonvisible world. Whether in multivolume texts such as the *Histoire naturelle* of Georges-Louis Leclerc, comte de Buffon, Johann Friedrich Wilhelm von Charpentier's mineralogical charts, or James Hutton's Scottish fieldwork, mapping was vital to the Enlightenment's investigation of earth's history and to the depiction of its surface geography (Rudwick 2005).

Mapping plant distribution was a limited feature of early Enlightenment botanical science—for example, in Joseph Pitton de Tournefort's *Elemens de botaniqve* (1694) and, more notably so, in Carl von Linné's works of the 1730s and the 1750s. In Jean-Louis Giraud-Soulavie's studies in the 1780s in the Vivarais region of France and, most evidently, in the work of Alexander von Humboldt in South America between 1799 and 1803, plant geography and its cartographic and visual representation reflected and constituted the merging of ecological, meteorological and physiographical facts and helped form a new regional science altogether (Humboldt 1805).

Cartography featured in the development of the oceanographic sciences, the study of the world's seas and their content, principally in the form of hydrography, the science of marine mapping. As they did in terrestrial triangulation, the French led Enlightenment Europe in mapping the seas, establishing the Dépôt des cartes et plans de la Marine in 1720 (which served as a model for the Real Observatorio de Cádiz [1753] and the Hydrographical Office in Britain [1795]). The work of Jacques-Nicolas Bellin, *ingénieur hydrographe*, is notable in this respect. Alexander Dalrymple and James Rennell were equivalent figures in Britain and its colonies in India. Bellin's *Hydrographie françoise* (with many versions, 1756–1806) brought together work in French marine cartography undertaken between 1737 and ca. 1772 on ocean currents, magnetic variation, oceanic wind directions, and coastal soundings, among other topics (fig. 742). In his *Recueil des mémoires* (1751), Bellin provided written descriptions of the mapping process involved in many of the earlier maps. This association between memoir and map was a feature of mapmakers' practical and philosophical procedures that illuminated their emergent scientific method, which combined textual narrative, mathematical principles, and descriptions of the management of instruments and personnel in the field.

Individual scientific phenomena were also the subject of cartographic attention. Halley, for example, used his 1715 solar eclipse map of England and Wales as a predictive device and called on the public to transmit their observations to him (see fig. 793). In 1747, American botanist John Bartram sketched maps of the location of seashell fossils found on the summits of the Appalachians (fig. 743). Natural philosopher Benjamin Franklin, with others, produced charts of the Gulf Stream derived from measurements of ocean temperatures (see fig. 346). Constantin-François de Chasseboeuf, comte de Volney, produced maps of soil types and wind directions in helping explain the physical characteristics of North America. More than simply illustrating the new scientific knowledge of the world's diversity, cartography was part of science's advance and an important means for the visual depiction of scientific phenomena (fig. 744).

FIG. 742. JACQUES-NICOLAS BELLIN, *CARTES DES VARIATIONS DE LA BOUSSOLE ET DES VENTS GÉNÉRAUX QUE L'ON TROUVE DANS LES MERS LES PLUS FREQUENTÉES*, 1765. Appears as map 5 in volume 1 of Bellin's *Hydrographie françoise* (1792).

Size of the original: 58 × 90 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge SH 18 PF 1 DIV 0 P 20).

Voyages of discovery and exploration provided a further context for cartography in publicizing the dimensions and content of the globe. Between the voyages of Halley and William Dampier in the late 1690s and those of Nicolas Baudin and Matthew Flinders in the early 1800s, the world's oceans—notably the Pacific—were crossed by numerous expeditionary natural philosophers. The voyages of James Cook, Vitus Bering, Louis-Antoine de Bougainville, Johann Reinhold Forster, Joseph Banks, Jean-François de Lapérouse, Alejandro Malaspina, and George Vancouver were expeditions of international significance. They were also demonstrations of the cosmopolitanism of science. In 1761 the French-led Pacific voyage to plot the transit of Venus also involved British, Swedish, German, Italian, Portuguese, Danish, and Russian astronomical observers in various locales (Woolf 1959). Through terrestrial triangulation, seaborne instrumentation, and firsthand survey, these and other *voyageurs-naturalistes* gave new and accurate shape to maps of the world, notably of the continental margins of Australasia, northwest America, and the islands in the Pacific.

Encountering and mapping the Pacific world was significant to the emergence of the human sciences in the Enlightenment. In the Pacific, European seaborne cartographic and scientific expeditions encountered great variety in human cultures and in systems of social organization. In making sense of that variety, eighteenth-century commentators often thought in and used terms that differ from those in use in the twenty-first century. Phrases such as "the natural history of man" or the "science of man" were, effectively, the result of a new "geography of man" (Withers 2007, 136–39). Conceptions of what it meant to be human and of what was understood to be the human sciences—what would become anthropology, linguistics, sociology, and human geography to name only a handful—depended on bringing the methods of the natural sciences to bear upon the human world. This was most clearly expressed in 1739 by Scottish philosopher David Hume, the subtitle of his *A*

Treatise of Human Nature declaring the work to be "An Attempt to Introduce the Experimental Method of Reasoning into Moral Subjects." As Hume noted, "We must glean up our experiments in this science from a cautious observation of human life, and take them as they appear in the common course of the world, by men's behavior in company, in affairs, and in their pleasures" (quoted in Olson 2003, 437). The oft-cited view that Hume's ambition was to be "the Newton of the moral sciences" must be treated with care, given Newton's diversity of thought and method and differences of opinion among both contemporaries and modern scholars as to Hume's indebtedness to Newton (McIntyre 1994).

The emergent human sciences were realized in cartography in a number of ways. In 1724, Joseph-François Lafitau provided what might be considered a primitive ethnographic map of the Americas in the *Carte de l'Amerique* accompanying his *Mœurs des sauvages ameriquains, comparées aux mœurs des premier temps*, noting broad aboriginal regions and linguistic diversity. Forster produced a comparative word chart of islands' names ("Tupaia's map") derived from native testimony as part of his 1778 *Observations Made during a Voyage Round the World* (Finney 1998, 446–51). Maps of human cultural and racial difference were often based on an assumed social and intellectual hierarchy that privileged European values. Thematic cartography was apparent in more evidently utilitarian maps of roads and post systems, for example, and in maps of county administration and economic survey as part of

FIG. 743. EARLY MAPPING OF FOSSIL DISTRIBUTIONS. A detail from John Bartram's manuscript map, from the 1750s, showing the locations of fossil seashells found in limestone deposits at the top of the Allegheny Mountains in the middle colonies in North America. This map was owned by Benjamin Franklin, who presented it to the philosophical society.

Size of the entire original: 31 × 38 cm; size of detail: ca. 15.5 × 21.0 cm. Image courtesy of the American Philosophical Society, Philadelphia (At61mvc Small).

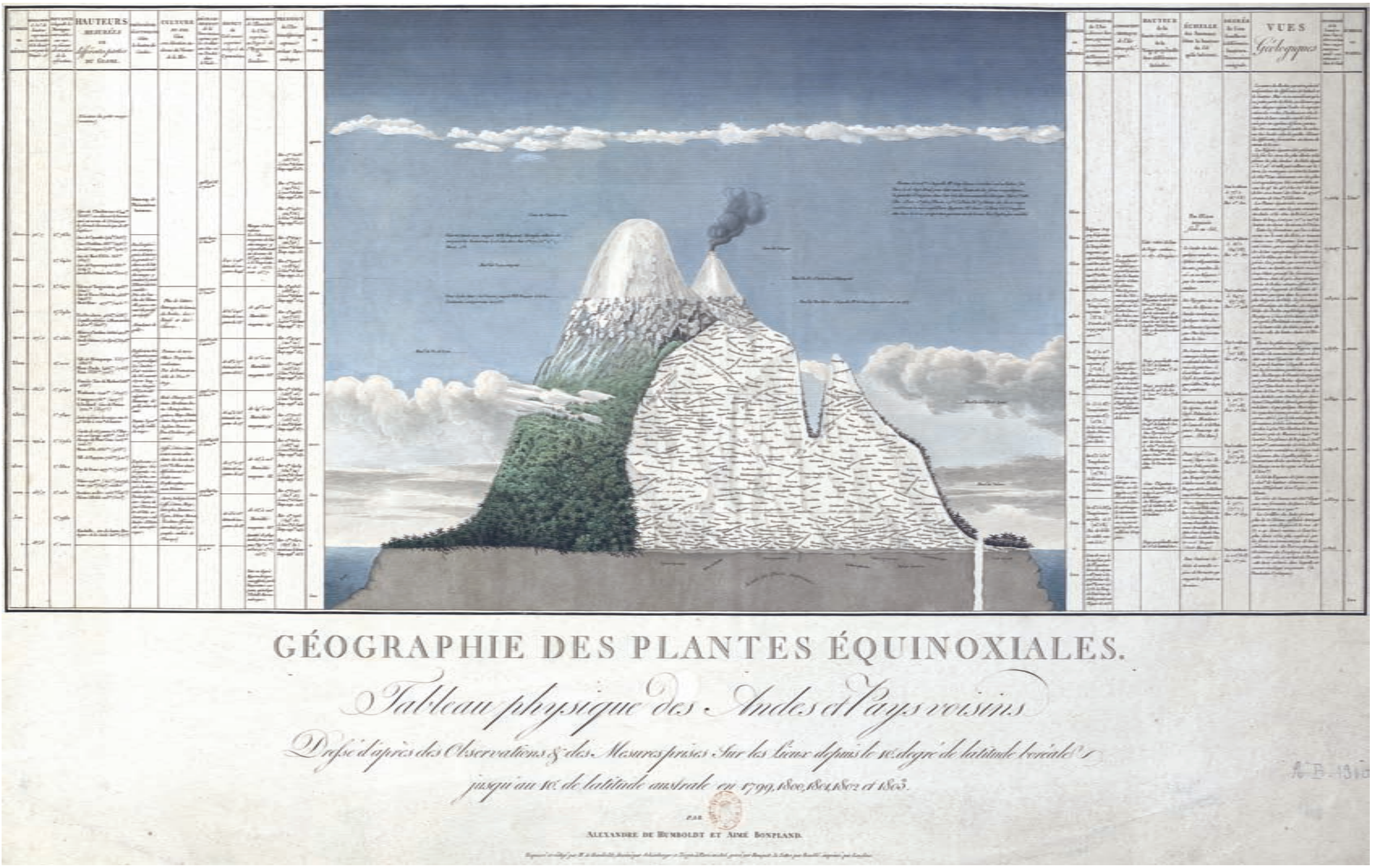

FIG. 744. NEW FORMS OF CARTOGRAPHY AND SCIENTIFIC REPRESENTATION. Humboldt and Bonpland's *Géographie des plantes équinoxiales*, which appears in *Essai sur la géographie des plantes*, pt. 5 of *Voyage de Humboldt et Bonpland: Voyage aux régions equinoxiales du nouveau continent*, by Alexander von Humboldt and Aimé Bonpland (Paris: Levrault, Schoell, 1805).
Size of the original: 60 × 100 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge C 11167).

developments in the science of government. Attempts by natural philosophers to make connections between the human sciences and the environmental sciences—in eighteenth-century terms, to explain human nature and cultural behavior as environmentally determined—were apparent in the use of cartography in the medical sciences: in France, for example, there were maps of medical and moral topography and in America, Germany, and Italy maps were used as tools to explain the prevalence of diseases.

Mapping was both a part of science and a means through which mathematics and mathematical reasoning were established, practiced, and disseminated in individual sciences. The science of what would come to be called "cartography" was concerned with the order, distribution, and location of natural and, to a lesser degree, cultural phenomena. Mapping was itself a form of science that was concerned with ordering space and depicting spatial relationships. This was evident at a variety of scales: globally, in geodetic and metrological projects; nationally, as individual countries began to rule themselves through trigonometry and triangulation; thematically, as in hydrography, geology, and natural history; and at the level of individual towns and cities, where maps assisted in the medical interpretation of outbreaks of disease, for example, or as maps with graphs and diagrams helped establish new forms of scientific and pictorial literacy.

At the same time, science itself had its own map in the Enlightenment. Most science and mapping work was promoted through academies, societies, and national agencies rather than through universities. Western Europe dominated in the making of science and of cartography although there were important sites in India and the Americas. While science and cartography helped constitute one another and, together, helped reveal the world, not everyone in the Enlightenment world was equally involved in these connections.

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SEE ALSO: Academies of Science; Celestial Mapping; Enlightenment, Cartography and the; Geodesy and the Size and Shape of the Earth; Geodetic Surveying; Geographical Mapping: Enlightenment; Halley, Edmond; Indigenous Peoples and European Cartography; Longitude and Latitude; Public Sphere, Cartography and the; Statistics and Cartography; Thematic Mapping; Zach, Franz Xaver von

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Scotland, Military Survey of (Great Britain). Surveyed and drawn between 1747 and 1755, the Military Survey of Scotland was undertaken as a consequence of the need for maps of Scotland following the Jacobite Rebellion of 1745–46. Known to contemporaries as the "Great Map," the survey is commonly termed the "Roy Map" after its principal surveyor, William Roy. Roy attributed the survey's conception to Lieutenant-Colonel David Watson, a subengineer and quartermaster in the Corps of Engineers who supervised the work, but recognized its undertaking as largely his own: "this officer [Watson] . . . first conceived the idea of making a map of the Highlands. As assistant Quarter-Master, it fell to my lot to begin, and afterwards to have a considerable share in, the execution of that map" (Roy 1785, 386). As Roy noted, the project originated in military imperatives. "The rise and progress of the rebellion which broke out in the Highlands of Scotland in 1745, and which was finally suppressed . . . at the battle of Culloden in the

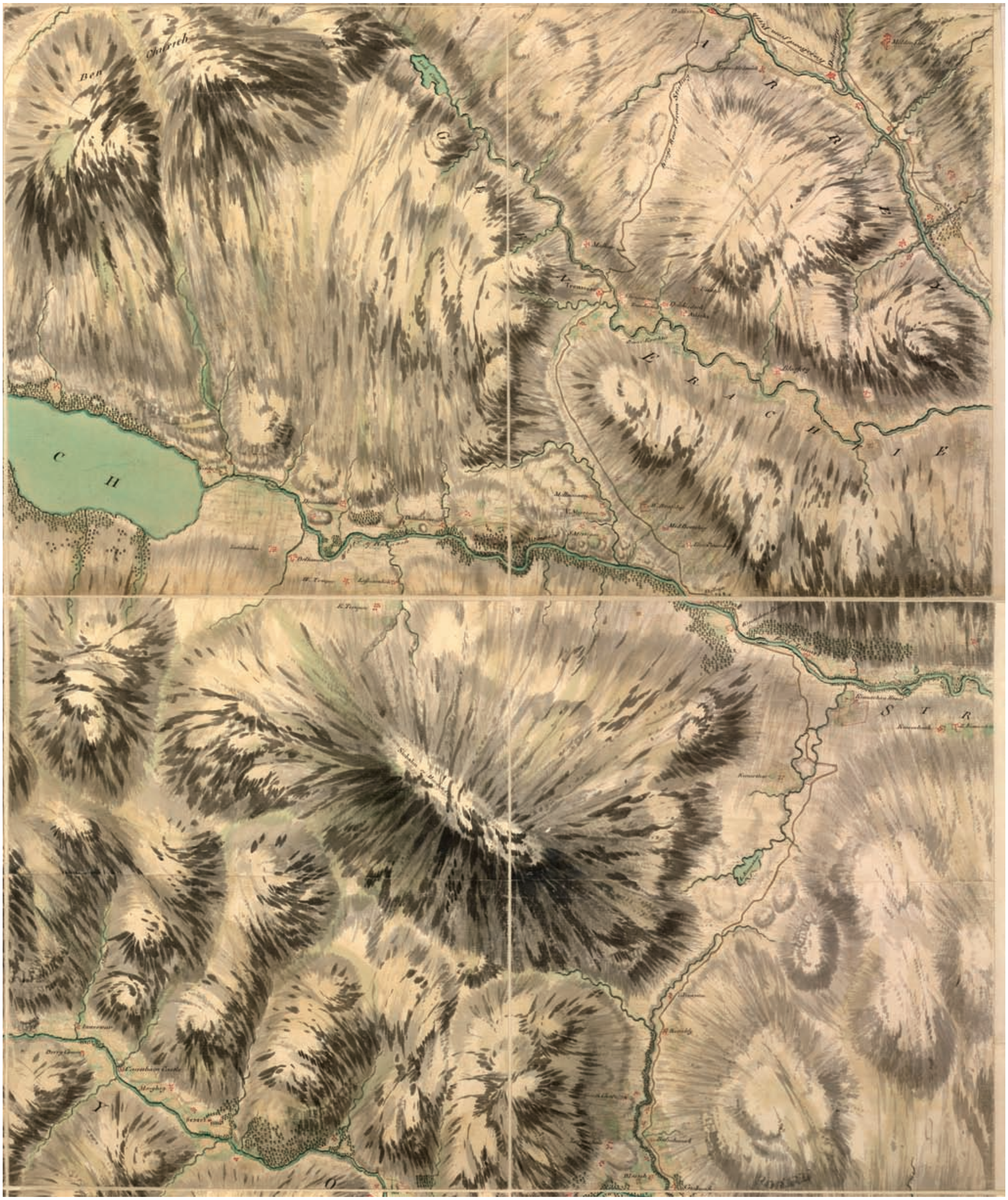

FIG. 745. DETAIL OF SCHIEHALLION AREA FROM THE MANUSCRIPT FAIR COPY OF WILLIAM ROY'S MILITARY SURVEY OF SCOTLAND (1747–55). This image—which shows part of the central Highlands of Scotland near the east end of Loch Rannoch—is characteristic of the Military Survey's representation of topography and habitation: note the use of hachuring for slope steepness and direction, the stylized woodland, and clusters of red rectangles for the *fermtouns* and other rural settlement. Schiehallion ("Shihalin or Maiden Pap," the elongated summit in the lower part of the image) was the site of geodetic experiments in 1774 undertaken by Nevil Maskelyne, Britain's astronomer royal, as part of investigations into the earth's density and dimensions (see fig. 267).

Size of the detail: 42 × 37 cm. Image courtesy of the National Library of Scotland, Edinburgh. Permission courtesy of the British Library, London (Maps K.Top.XLVIII.25-1b, dissections 16.5e, 16.5f, 16.4b, 16.4c).

following year, convinced Government of what infinite importance it would be to the State, that a country, so very inaccessible by nature, should be thoroughly explored and laid open, by establishing military posts in its inmost recesses, and carrying roads of communication to its remotest parts" (Roy 1785, 385–86). Although Board of Ordnance engineers had earlier provided military maps and sketches of locations in the Scottish Highlands, the Military Survey was a novel and major undertaking (Anderson 2009).

Initially, all the surveying was done by Roy himself, then with Paul Sandby, the topographical artist. From 1748, more engineers were sent to assist the survey and, by the 1750s, seven surveying parties were at work, eight men to each party, the surveyor, a noncommissioned officer, and six soldiers: "One carried the Theodolite; Two measured with the Chain; Two for the fore and back Stations, and the remaining one acted as Batman, or attendant on the party" (Arrowsmith 1809, 7) (see fig. 221). From 1752, southern Scotland was included—its inclusion a matter of completeness of national coverage rather than, by then, any perceived or actual military threat. The Military Survey was based on the use of chains, rods, and a circumferentor, with the survey parties traversing rapidly in order to maximize coverage. The fieldwork comprised measured traverses along important roads and rivers, other landscape elements being fixed with varying accuracy by the intersections of bearings taken from the traverse points; minor detail was then sketched in by eye.

The survey was completed by December 1755, but its final production was much delayed by war, as a result of Roy's other mapping and military work—as Aaron Arrowsmith put it, "his Military and Scientific Occupations intervened" (1809, 10)—as a result of changes in administration, and from failure to complete all the parts of the map to a common standard. The surveyors' field measurements and sketches—the original sketchbooks and records of measurement are presumed lost—were worked up in the Board of Ordnance's Drawing Room in Edinburgh Castle during the winter months into an "original protraction" at a scale of one inch to one thousand yards (1:36,000). A fair copy of the map from this protraction was intended. However, only Scotland north of a line between Clyde and Forth was drawn as a fair copy in pen-and-ink with a vibrant color wash (fig. 745); only the original and uncolored protracted copy exists for southern Scotland. What is today known as the "Complete Fair Copy" (in the British Library, London) was produced between 1829 and 1844: an amalgamation of the fair copy from the northern surveys and the only copy of the southern surveys.

Roy considered the Military Survey "rather . . . a magnificent military sketch, than a very accurate map of a country" (Roy 1785, 386–87). Accuracy was overshadowed by the demands of speed. Instruments were "of the common, or even inferior kind," the funding "inadequate" (Roy 1785, 386). Roy included numerous military antiquities, some items being added to the map by Roy after the survey had been completed. Many place-names are missing, notably in the Gaelic-speaking areas; urban settlements have, relatively, a high level of accuracy, the rural *fermtouns* less so; arable land is given too great an extent, enclosed land is more accurately depicted. Yet the Military Survey of Scotland is a magnificent achievement and a formative influence on the future Ordnance Survey, and it provides an important view of a country in the throes of agrarian improvement and Enlightenment. A modern facsimile with related essays has made this important work more readily available and understood (Roy 2007).

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SEE ALSO: Military Cartography: Great Britain; Roy, William; Topographical Surveying: Great Britain

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Sea of the West. The Sea of the West (Mer de l'Ouest) was an apocryphal body of water in western North America providing a short route from Europe to the Far East; for two centuries it was an inspiration of cartographic invention. Jacques Cartier was among the first to search for a northwest passage through North America to Cathay (China). The Jesuit missionaries who followed to New France repeated accounts from evangelized Native Americans of foul-smelling waters that ebbed and flowed in the northern regions, perhaps referring to the lakes around Lake Winnipeg. From these indigenous

FIG. 746. EARLY PRINTED APPEARANCE OF THE SEA OF THE WEST. Nicolas Bion, *Globe terrestre sur le quel les principaux points sont placez sur les dernières observations de M.[rs] de l'Academie royale des sciences*, 1712. Copied from the printed world map of Jean-Baptiste Nolin, 1700, which was in turn copied from the manuscript globe of Guillaume Delisle, the ensuing lawsuit resulted in Nolin having to eradicate the Sea of the West from the copperplates and destroy the offending world map. But Bion, whose workshop on the quai de l'Horloge was near that of Delisle, incorporated the mythical sea, crediting only indigenous reports.
Diameter of the original: 25 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge A 402 [RÉS]).

reports, the Jesuit missionary Claude Dablon conjectured and named the Sea of the West in 1669 (Dawson 2000, 118–19, 276n13). These Jesuit relations plus other expeditionary reports persuaded French geographers Claude and Guillaume Delisle to incorporate the hypothetical sea in their manuscript map compilations, globes, and memoirs; the image of the sea appeared (briefly) on the work of two other French geographers (fig. 746). Yet the sea never appeared on Guillaume's own published maps or globes, either because of secrecy surrounding discoveries (Lagarde 1989, 25) or uncertainties concerning the claim (Dawson 2000, 117–23).

English interest in a northern passage was manifest in 1708, when the London *Monthly Miscellany, or, Memoirs for the Curious* published a letter (April, 123–26) from a mythical Spanish admiral, Bartholomew de Fonte (Fuente), who claimed to have sailed along the western coast of North America to 53°N, whence he traveled from the Pacific through a succession of rivers and lakes to Hudson Bay, where he encountered a ship from Boston. This letter, probably a fabrication by Jonathan Swift, Daniel Defoe, or James Petiver, may have been intended to motivate the English, installed on Hudson Bay, to search for a western water route to the Pacific. In the following decades, English and French adventurers used maps and reports for raising capital to confirm the Sea of the West's existence. In 1718, a Lazarist priest at Versailles, Jean Bobé, composed the "Carte des mers et des pays qui sont a l'ouest" with an accompanying memoir (Lagarde 1989, 28–29), postulating a North America with a westward bulge toward Tartarie, an area he named Bourbonie. The proximity of North America to Asia on this map played well with potential investors in the Compagnie des Indes (Dawson 2000, 133–40). Nonetheless, French expeditions in North America during the 1730s failed to corroborate a water route or the Sea of the West's existence. English ventures in the 1740s fared no better, but at least one published map (Dobbs 1744) attempted to reconcile the Fonte reports with indigenous accounts: *A New Map of Part of North America*.

The Sea of the West appeared frequently on printed maps in Europe only after the astronomer Joseph-Nicolas Delisle returned from twenty years in Russia. In a presentation to the Paris Académie des sciences in April 1750 (published in 1751) he described recent Russian discoveries along with the text of Admiral Fonte. In 1752 he published an illustrative map by his nephew-in-law Philippe Buache, *Carte des nouvelles découvertes au nord de la Mer du Sud* with an *Explication*, which showed the Russian discoveries from the Bering expeditions in the northern Pacific (including the route of Joseph-Nicolas's brother, Louis Delisle de La Croyère) alongside the speculative "discoveries" of Fonte and the

Sea of the West (see fig. 390). Delisle's further publication on Fonte maps in 1753 drew on his brother Guillaume's manuscript renderings as supporting evidence. Buache's map was a sensation and caused a veritable intoxication with the subject in France and England. Buache, now *premier géographe du roi*, adopted Fonte's hypothetical geography, which corroborated his own theories of physical geography, presented in 1752 to the Académie. He prepared eleven plates of maps and five plates of views to accompany his *Considérations géographiques et physiques sur les nouvelles découvertes au Nord de la Grande Mer* (1753–55), a cartographic essay on understanding the northern Pacific Ocean (Lagarde 1989, 31–35).

While French cartographers Jacques-Nicolas Bellin and Didier Robert de Vaugondy were violently opposed to Buache's theories, other enlightened thinkers—Georges-Louis Leclerc, comte de Buffon, in France, Benjamin Franklin in America, and Alexander Dalrymple, hydrographer of the East India Company in England—believed in the Sea of the West, or at least in a northwest passage.

Attempts were made to verify the sea's existence and to map the northwest region of North America: the Spanish sent several expeditions beginning in 1769, and James Cook searched for a passage from the Pacific Ocean between 1776 and 1779, but all without success. In France, Jean-Nicolas Buache took up his uncle's theories by attempting to reconcile Cook's work with the Fonte account, in the *Nouvelle carte de la partie septentrionale du globe comprise entre le Kamtchatka et la Californie* (1781). After Jean-François de Lapérouse encountered neither the Sea of the West nor a western passage in 1786, the Sea of the West gradually faded from the cartography of North America.

LUCIE LAGARDE

SEE ALSO: Buache, Philippe; Delisle Family; Geographical Mapping; Imaginary Geographies and Apocryphal Voyages; Northwest Passage

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Seutter, Probst, and Lotter Families. The intertwined Augsburg families of Seutter, Probst, and Lotter produced some of the most prominent map engravers and publishers of eighteenth-century Germany. They were particularly important for broadly diffusing geographical knowledge throughout central Europe. The classic studies by Christian Sandler (1894) and Franz Grenacher (1968) have been corrected in important points by recent scholarship by Michael Ritter, who provided a genealogical tree (2001, 131).

Matthäus Seutter, the dynastic founder, was the son of an Augsburg goldsmith of the same name. He learned the art of map engraving from Johann Baptist Homann in Nuremberg, after 1697, and later worked for the Augsburg publisher Jeremias Wolff. After marrying in 1707, Seutter founded his own graphics press in his hometown.

Seutter engraved and published the complete spectrum of maps: world and regional maps, globes, celestial maps, city maps and views, special maps of post routes and of the provinces and monasteries of Catholic orders, war maps, historical maps, tables of distances, theoretical and fantasy maps, and genealogical illustrations. Seutter compiled his maps into a variety of folio atlases of different lengths, from the twenty-sheet *Atlas compendiosus* (from 1720) to the *Grosser Atlas* with over four hundred sheets (after 1731–32). Seutter's *Atlas novus*, with a complete index of the places shown on each map, appeared from 1728 in both Augsburg and Vienna, where it was published by Johann Peter van Ghelen. Starting in the 1740s, Seutter offered small-format maps (ca. 20 × 25 cm) in an inexpensive school atlas, the *Atlas minor*; its editions were of variable length and could contain more than sixty maps.

Seutter received the honorary title of imperial geographer (*Sacrae Caesareae Maiestatis Geographus*), presumably when he dedicated the *Grosser Atlas* to Charles VI in 1731–32. He noted the title on his maps mostly in abbreviated form ("S.C.M.G." or "Sac. Caes. Mai. Geogr."). In 1741, he also received a privilege for publishing maps in parts of southern Germany (*Cum gratia et privilegio Sacri Romani Imperii Vicariatus in partibus Rheni, Sveviae et Juris Franconici*); this, too, is recorded in abbreviated form on his maps.

Lacking an academic environment in Augsburg that would have supported more scholarly endeavors, Seutter built his oeuvre by copying and compiling from others, mostly Homann and Guillaume Delisle. He did bring some manuscript works to press, mostly of parts of southern Germany modeled on military maps (fig. 747) and Switzerland (e.g., Gabriel Walser's canton maps). Seutter borrowed Homann's recipe for success: the rich ornamentation of maps with decorative cartouches, vignettes, and figures that made aesthetically appealing baroque designs (fig. 748); Latin titles; a high density of place-names; a consistent page format; attractive coloring; and low prices. As capable an engraver as he was industrious, Seutter engraved many maps himself, though he also employed other engravers in his workshop, notably his son-in-law Tobias Conrad Lotter, husband of his daughter Euphrosina.

FIG. 747. SHEET 3 OF *SUEVIA UNIVERSA*, CA. 1725, BY JACQUES MICHAL, MILITARY ENGINEER. This nine-sheet map of Swabia was Matthäus Seutter's most important original map. Size of the entire original: ca. 145 × 155 cm; size of sheet: ca. 48 × 51 cm. Private collection. Image courtesy of Michael Ritter.

Seutter's sons were not committed to the family business. Georg Matthäus worked briefly as an engraver for his father—enough for historians to confuse the two—but he had left Augsburg by 1729. Albrecht Carl also first worked as an engraver; he took over the business in 1757 but produced only about fifteen new sheets in five years. His widow then sold the copperplates and map inventories to Lotter and to Johann Michael I Probst, the brother of Albrecht Carl's first wife (Ritter 2001, 132–33).

Probst was a grandson of Matthäus Seutter's old employer, Jeremias Wolff. He acquired approximately two-thirds of Seutter's cartographic estate in 1762. He kept the Seutter name on the maps, adding only a note that they were now available from his publishing house. His sons Johann Michael II, Johann Georg, and Johann Conrad continued the business under their father's name. They produced some sixty new maps in folio and over fifty small maps, most of which they compiled into atlases, but even so the Probst publishing house steadily declined in importance.

Tobias Conrad Lotter was an active and entrepreneurial engraver in the mold of his father-in-law; indeed, he had been Matthäus Seutter's most important associate. On Seutter's death in 1757, he immediately began to build up his own press. In 1758 alone, he engraved at least twelve new maps; some time later he acquired over twenty maps that Johann Friedrich Probst, Johann Michael I's brother, had inherited from Wolff. Lotter's catalog expanded still further in 1762 with the purchase of around one hundred maps from the Seutter estate; unlike Probst, Lotter replaced the name of Seutter on these maps with his own. As a publisher, Lotter retained Seutter's diverse offerings, including several editions of atlases, although he did not produce any globes. His work for other publishers, such as for Petrus II Schenk in Amsterdam, brought him a transnational reputation.

Lotter's sons Matthäus Albrecht, Georg Friedrich I, and Gustav Conrad began to be identified on maps as engravers in the 1760s. After Lotter's death in 1777, his two eldest sons continued to work together. (Gustav Conrad's widow eventually auctioned off her share of the firm in 1789; Johann Martin Will and Johannes Walch used it to establish their own map publishing house.) Accomplished engravers, Matthäus Albrecht and Georg Friedrich I turned away from their father's and grandfather's baroque designs almost completely; they replaced the Latin in the titles with French, English, and German. While lacking scientific credentials, their maps stand out for their clean, fine engraving and attractive, professional appearance. Like the Probst brothers, they produced many maps for practical use (e.g., post and travel maps) and of areas of political interest (such as North America, Poland, and the Balkans). Still, for the most part they could no longer ride on the coattails of their forefathers.

When Matthäus Albrecht died in 1810, his sons Gabriel and Georg Friedrich II assumed leadership of the

FIG. 748. TITLE CARTOUCHE FROM *LES PROVINCES DES PAIS BAS AUTRICHIENS*, CA. 1744 (MATTHÄUS SEUTTER).This twenty-four-sheet map of the Austrian Netherlands was based on work by Eugène Henry Fricx and shows Seutter's typically baroque design with ornaments and figures. Size of the entire original: 75 × 145 cm; size of detail: 19.5 × 25.5 cm. Private collection. Image courtesy of Michael Ritter.

Lotter house. They seem to have been content to rest on their family's accumulated fortune. They engraved a few maps, but these were of such poor quality that they found almost no market. Both brothers remained unmarried and died in advanced aged as men of independent means (*Privatiers*). With their deaths, the map publishing houses of Seutter and Lotter ceased to exist.

MICHAEL RITTER

SEE ALSO: Cartouche; Geographical Mapping: German States; Homann Family; Map Trade: German States

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Sextant. See Instruments for Angle Measuring: Octant and Sextant

Sibbald, Robert. A leading figure in the intellectual life of early Enlightenment Britain, Sir Robert Sibbald was born in Edinburgh in April 1641 and died there in 1722. Educated in Edinburgh and Padua, he also spent time in Paris and in London, meeting other leading natural philosophers. Knighted by King Charles II in 1682, the year in which he was appointed geographer royal and the king's physician in Scotland, Sibbald was a key figure in the promotion of mapmaking, geography, and utilitarian science.

Sibbald's commission from 1682 was to produce a natural history and a geographical description of Scotland. He did so in order to improve upon earlier works and as part of his own natural philosophical inquiries. He undertook this work by soliciting responses to his circulated *Advertisement in Respect of General Queries*, a related broadside *In Order to an Exact Description* (both 1682), and in advertising his 1683 *Account of the Scottish Atlas, or the Description of Scotland* (Withers 1999, 507–8). His plans for the atlas as a two-volume work—*Scotia antiqua*, in Latin, engaging with ancient sources and intended to cover the nation's historical development, and *Scotia moderna*, in English, based on contemporaries' own words and intended to describe contemporary Scotland on a county-by-county basis, illustrated by maps—were never realized. However, Sibbald's preparation of the work, as evidenced in surviving manuscript collections, including maps, and in numerous published regional descriptions, shows that he acted effectively as a center of geographical and cartographic collection.

Sibbald used his influence to gather extant maps and manuscripts, appointed John Adair to survey new maps (Withers 1999, 506), and, most importantly, collected the manuscript maps of Timothy Pont, who had undertaken a chorographic survey of Scotland in the late sixteenth century and whose work was the basis for the maps of Scotland in Joan Blaeu's *Atlas novus* (1654). Sibbald intended to replace Blaeu's maps with up-to-date work. In a letter of 1707, Sibbald wrote, "I have all the originall mapps and surveys and descriptions of Mr. Pont, the Gordons and others, who have laboured that way, and severall mapps never printed" (Withers 1996, 53), but it is not always clear when he took possession of these originals.

Roger L. Emerson (1988, 62) rightly noted that Sibbald's surveying and map collecting were "a continuation of the efforts of men such as Timothy Pont, Robert Gordon of Straloch, James Gordon of Rothiemay, and others who had sought to map and describe Scotland," and that "the Scottish surveyors in the 1680s, like other cartographers" in later centuries, "were participating in a common European activity which had been pursued longer in France and England." In that respect, Sibbald's antiquarian pursuits and his natural history work, including his foundation of Edinburgh's botanical gardens and of what would become Edinburgh University's museum collections, were all elements consistent with his geographical enquiries and with his collation of other peoples' maps. Geographical description and the practice of surveying as both textual and cartographic endeavors were vital means to know one's nation the better to improve it.

CHARLES W. J. WITHERS

SEE ALSO: Adair, John; Geographical Mapping: Great Britain

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Signs, Cartographic. The signs used on printed maps in the period of the Enlightenment remained much the same as those used during the Renaissance (Delano-Smith 2007). There was still no specific term for these marks, which continued to be referred to descriptively ("Towns and Places are generally represented by the shape of a little House"; Alingham 1703, 30) or by generic terms in Latin or the vernacular (*notae, caracteristiques, marques, Zeichen, segnales*). The phrase *signe conventionnel* (conventional sign) was established in the military context by the Dépôt de la Guerre's Commission topographique only in 1802, although similar words (e.g., *signes de convention*) had been used in the text accompanying the plate for geographical engraving in the *Encyclopédie* (Anonymous 1767, 2). The signs themselves remained traditional in composition, constructed from points, lines, and area shading, although usually smaller in size and stylistically neater. In meaning, too, they were still inconsistent, their significance on a particular map only sometimes explained in a key that might or might not be comprehensive.

As in the Renaissance, the impulse toward specialization in the use of signs tended to come from some specialist contexts of map use. Separate entries in this volume on map types and on individual modes of cartography describe how factors such as shifts in intellectual interest, changing patterns of readership, and expanding administrative and economic demands were reflected in the signs used on these other types of maps. The quantification of a state's economic, demographic, and natural resources led to additional signs for the new data being mapped thematically; accelerated scientific curiosity about the natural and human world created signs for such matters as magnetic variation, winds and air pressure, visibility of celestial phenomena, and human form and languages. New special purpose maps, such as those focusing on roads, routes, rivers, and canals for trade and transport, added to the traditional range of signs. However, it was military surveying for warfare, whether for siege or field battle, that promoted experimentation with methods of depicting relief and troop movement while developing the range of signs for settlement and other features of human geography.

Representation of Map Content For geographical and topographical maps, nearly every basic category of information had been represented in some way on earlier maps of the same genre, meaning that as far as possible the usual signs could, and did, still serve mapping needs adequately. By the end of the seventeenth century, however, and still more during the eighteenth century, mapmakers and engravers had to accommodate an exponentially increasing amount and variety of information. Demographic expansion, industrialization, and urbanization were transforming the rural and urban landscapes of Europe, and maps had to keep pace. Whereas an aggregate of some seventy different geographical features was noted for the entire period ca. 1470–ca. 1640 from all maps sampled (Delano-Smith 2007, 540), one printed eighteenth-century map might have at least that number; César-François Cassini (III) de Thury noted that a single sheet of the *Carte de France* could contain over five hundred different features (1783, 16). Despite the incompleteness and selectivity of the keys on eighteenth-century maps, they do give an idea of this expanding content. In contrast to the usual half-dozen or dozen items explained on earlier maps, the key to Joseph Jean François de Ferraris's *Carte chorographique des Pays-Bas autrichiens* (1777) contains sixty-three items (fig. 749), and Johann Matthias

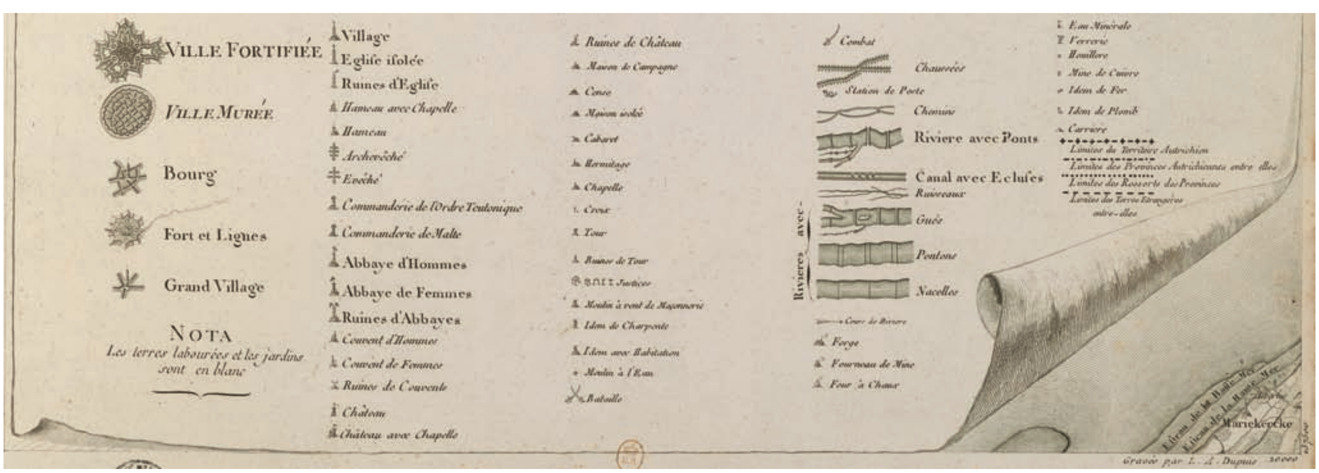

fig. 749. DETAIL OF THE "EXPLICATION" SHEET OF JOSEPH JEAN FRANÇOIS DE FERRARIS'S *CARTE CHOROGRAPHIQUE DES PAYS-BAS AUTRICHIENS* (1777). The influence of military mapping on printed geographical maps is evident in the attention paid to such features as ruined buildings and the different types of river and canal crossings. Image courtesy of the Bibliothèque nationale de France, Paris (VG 64 FOL).

Korabinsky's economic thematic map of Hungary has ninety-one signs for its economic and demographic information alone (Dörflinger 2004, 166–67). Where the French engineer and surveyor Nicolas Buchotte had advocated over sixty signs for *cartes particulières* (geographical maps of provinces, administrative districts, and kingdoms) in the first edition of *Les regles du dessein, et du lavis* in 1721 (fig. 750), the number had risen to ninety in the 1743 edition (fig. 751), with another twenty-five signs specified for *cartes des elections* (electoral districts). Color had also been used on Renaissance maps to extend the cartographic vocabulary, or for emphasis, but as it still had to be applied by hand or by using specialized printing techniques, its use as a map sign in the eighteenth century remained restricted.

The scale of the map was largely irrelevant when it came to the design for signs on printed geographical and topographical maps between 1640 and 1800, and the general situation in the workshop remained as before. The draftsman and/or engraver still had to choose whether to represent each feature pictorially or with an abstract mark, whether to show it in plan or in profile, and how far to generalize the style of a pictorial sign (Delano-Smith 2007, 540–41). Pictorial signs still predominated over abstract signs and were often augmented by graphic codes (called *signes annexes*; Dainville 1964, 222; Delano-Smith 2007, 541–80) to qualify the nature of the place and indicate its special functions. Common to all place signs was the traditional small circle, with or without a central dot, indicating the location from which distances were to be measured. A further option for mapmakers and engravers who used pictorial signs was to portray the feature in strict profile or with a degree of perspective (indicating pitched roofs, doors and windows, and distinguishing church spires from towers in a settlement sign, for example) or to represent it schematically with tiny rectangles of different sizes, the largest of which was topped by a short horizontal line and a vertical spike. The trend toward the planimetric view in city and town signs continued and was sometimes specifically requested by map publishers (Pedley 2005, 181–82). Abstract signs used alone were little favored; crosses for archbishoprics and bishoprics and crosiers for monasteries and convents (turned one way for males, the other way for females), for example, were by preference added to a building or group of buildings as a *signe annexe*.

Coastlines began to be emphasized by continuous parallel lines, decreasing in thickness seaward, instead of short hatching perpendicular to the shore. According to Augustin Lubin (1678, 248), though, such lines were disliked by engravers. Hence, perhaps, the mimetic

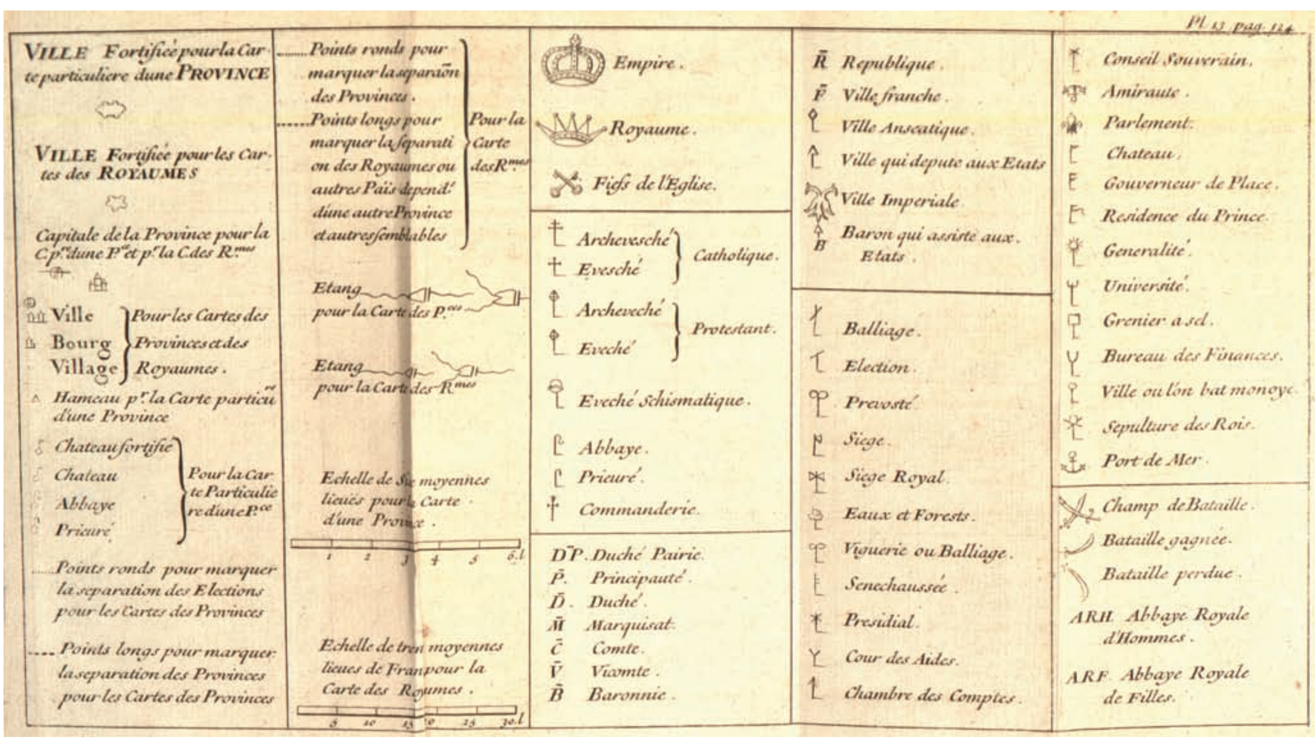

FIG. 750. PLATE 13 FROM THE FIRST EDITION OF BUCHOTTE'S *LES REGLES*, 1721. One of two engraved plates showing recommended signs for military and civilian mapping. Size of the original: ca. 15.5 × 28.0 cm. Image courtesy of the Special Collections Library, University of Michigan, Ann Arbor (UG 460 B75).

inverted V's for the waves crashing on the beach on the *Carte de France*, while on other maps the traditional hatching continued. On the exemplary *Carte de France*, small lakes and ponds were often stylized, with two straight lines across one end even when there was no dam, and rivers were filled with continuous flowlines rather than stippling or cross-hatching, as earlier, but an arrow might indicate the direction of flow. As before, canals were identified from the angularity and unnatural curves of the line and the presence of locks. Vegetation continued to be pictorial on all types of maps. An isolated tree of historical significance or important as a landmark could still be found, otherwise tree signs were scattered sparingly as space fillers. Extensive forests were indicated by more or less densely massed tree signs traversed, on the *Carte de France*, by networks of tracks. Signs for marsh, heath, meadow, and vineyards were the customary ones, varying only in the detail of their composition (Delano-Smith 2007, 574–77). Different sizes or styles of lettering in place-names continued to be used to identify settlement hierarchy and regional and administrative units. The labeling of unusual or significant features could be idiosyncratic; on the thematic map of Gottfried Hensel's *Evropa poly glotta* (1741; see fig. 781) the first words of the Lord's Prayer were distributed across Europe in the language appropriate to the region.

EXPLAINING THE SIGNS An explanatory panel for the signs used on a map might seem, particularly in the light

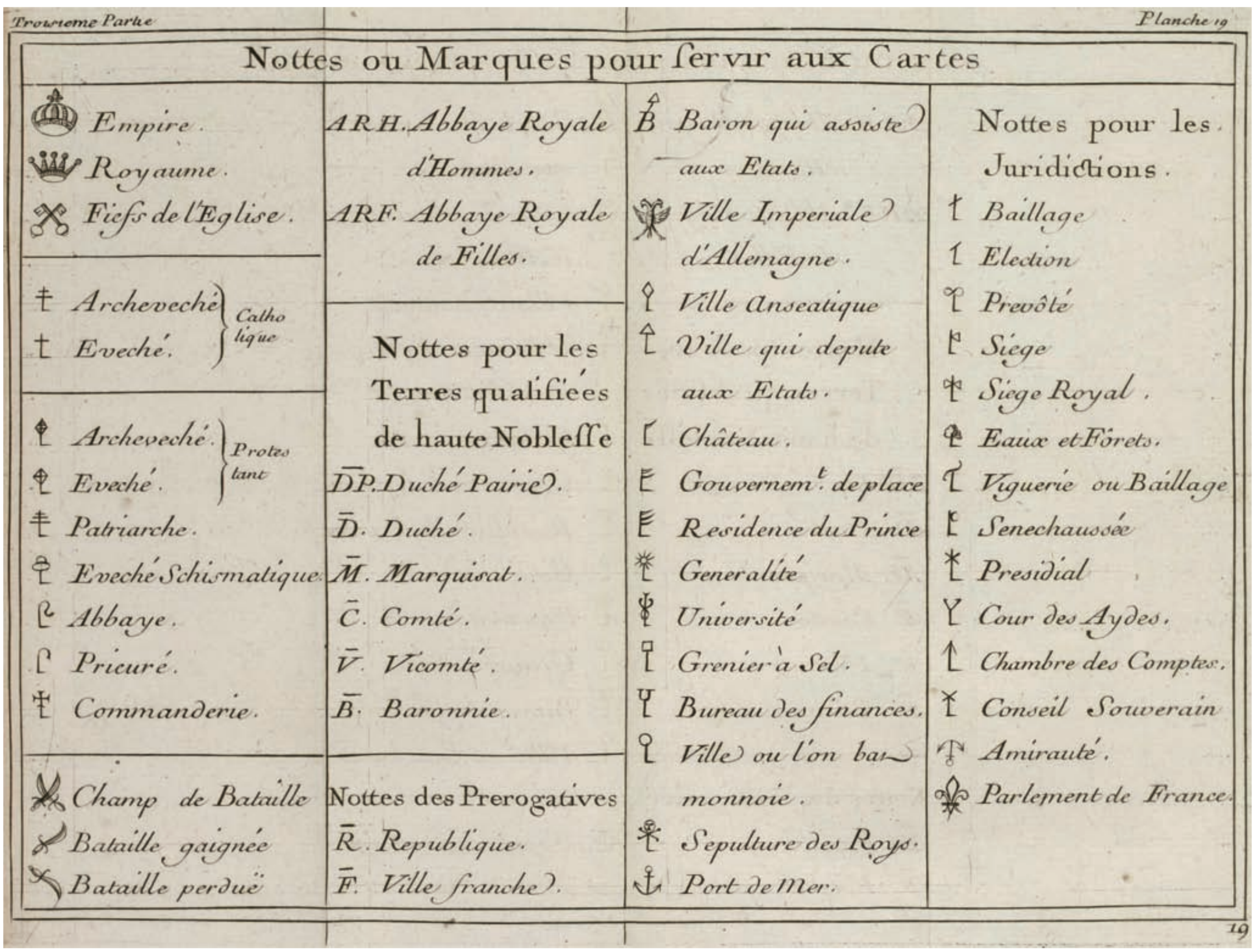

FIG. 751. *NOTTES OU MARQUES POUR SERVIR AUX CARTES*, FROM BUCHOTTE'S EXPANDED 1743 EDITION OF *LES RÉGLES*. For this edition, Buchotte not only reorganized and expanded the layout to present the signs in three plates (the first is shown here), but also made minor changes to a number of signs; compare, for example, *Amirauté, Residence du Prince, Université*, and *Sepulture du Roy* with those in figure 750. From *Les régles du dessein, et du lavis*, new ed. (Paris: Ch. Ant. Jombert, 1743).
Image courtesy of the Bibliothèque nationale de France, Paris (Arsenal 8-S-14692).

of complaints about inconsistency and differences in meaning, a sine qua non, but that was not the case even late in the eighteenth century. In the military context, with its emphasis on oral training and communication, a key would have been thought unnecessary if not unwise. For other maps, some treatise writers assumed a key would be provided (Alingham 1703, 31–32; Lubin 1678, 361–62), but others apologized for having to spoil the look of a map with an intrusive cartouche. Those commissioning maps of the dioceses of Languedoc in the 1770s from Cassini III and the directors of the *Carte de France* had the idea that a key was a *usage gothique*, an opinion not shared by all contemporaries but one that resulted, as François de Dainville has observed, in their "omission, so often inconvenient, on so many fine maps from the end of the eighteenth century" (1961, 137). None of the sheets of the *Carte de France* carried a key, nor did Cassini III produce a general one. The "Explication des caractéres géographiques employés" printed on, or attached to, three index sheets were a later compilation by Jean-Claude Dezauche, Louis Capitaine, and Charles Picquet for the benefit of map users (Pelletier 2013, 239–48). When keys were provided, they varied in comprehensiveness, but the trend on larger-scale maps was complete lists, while smaller-scale maps left the user to work out the unexplained signs.

The legibility of a printed map and its signs was of interest to the public who relied on published guides for their understanding and use of maps. By the early seventeenth century, manuals had started to give advice on the proper behavior of the nobleman, which included the coloring of maps as an educational exercise (Peacham 1622, 65), but it was not until the last quarter of the seventeenth century that treatises describing the signs used or to be used on geographical maps became generally available. In France, Lubin (1678) filled four hundred pages with his explanation of geographical terms and comments on the number of features represented on maps; Guillaume Sanson's *Introduction a la geographie* (1681, 100–102) described twenty signs, and Jacques Ozanam (1693, 178), the six maritime signs for a coastal map. Soon after, in England, William Alingham (1703, 30–31) advocated eight signs, and John Green (1717, 9–11) twenty-nine signs. In Germany, Johann Hübner offered thoughts on the use of color as a map sign. Not only were the descriptions at odds with one another, but the authors themselves commented on the inconsistency with which signs were deployed on geographical maps. Some merely warned of the variety of ways in which a particular feature might be shown; other authors were overtly critical. Ozanam disliked the arbitrariness of the signs and the way "each [mapmaker] uses them according to his whim" (1693, 176), and Antoine-Augustin Bruzen de la Martinière admitted that although a mapmaker had the authority to change signs (provided this was explained in the key) "it would however be better to fix and agree once and for all the exact meaning of these signs" (1730, 315). Dainville tabulated thirty-eight signs relating to ecclesiastical matters on French diocesan maps published between 1652 and1769 by fourteen mapmakers, none of whom used the same signs (1956, 201–3).

STANDARDIZATION Instruction as to which signs were to be used on military maps and charts had long circulated within closed or specialist map-using circles where consistency in the presentation and meaning of signs on maps and charts was essential for operational safety. In the same way as one group of English navigators had been issued around 1582 with a list of signs for the charts they were to compile (Delano-Smith 2007, 536–37), Carl Gripenhielm, director general of Lantmäteriet in Sweden, specified some ninety signs for survey maps in 1687 and issued further instructions in 1688. Printed military treatises explicitly urging uniformity in the presentation of manuscript surveys, and the printed maps that came from them, were disseminated throughout Europe in translation and plagiarized editions, although some acknowledged their sources, like Manoel de Azevedo Fortes's *Tratado do modo o mais facil, e o mais exacto de fazer as cartas geograficas* (1722, "Proemio"), which credited its French sources, such as the work of Jacques Ozanam. Such handbooks recommended the use of pictorial signs, prescribed colors, and urged representational techniques that imitated nature. In so doing they entered the contemporary debate on how best to represent landscape in two dimensions (Bousquet-Bressolier 1999; Svennigsen 2016). In France, Buchotte included two engraved plates of signs among the fourteen plates in the first edition of his treatise in the express hope that signs might "all come to have the same meaning" (1721, 100). Similarly concerned, Louis Charles Dupain de Montesson compiled his training manual to teach military mapmakers how to convey to their officers "in the best way possible" what the territory was really like (1750, 95). To this end he included a matrix of nine models (fig. 752), augmented by 1776 to twenty-three.

As a growing number of military academies prepared curricula that included mapmaking, the demand for such handbooks increased. Despite their advocacy of signs of standard appearance and meaning, semiotic uniformity eluded most military institutions throughout the eighteenth century. Individual attempts were made, as in Russia when Ivan Kirilovich Kirilov insisted on standard signs for cities, villages, and mills, among other features, in a 1723 manual, "Instruktsiya dlya geodezistov," for surveyors and cartographers and when, in the 1760s and 1770s, imperial surveyors provided all

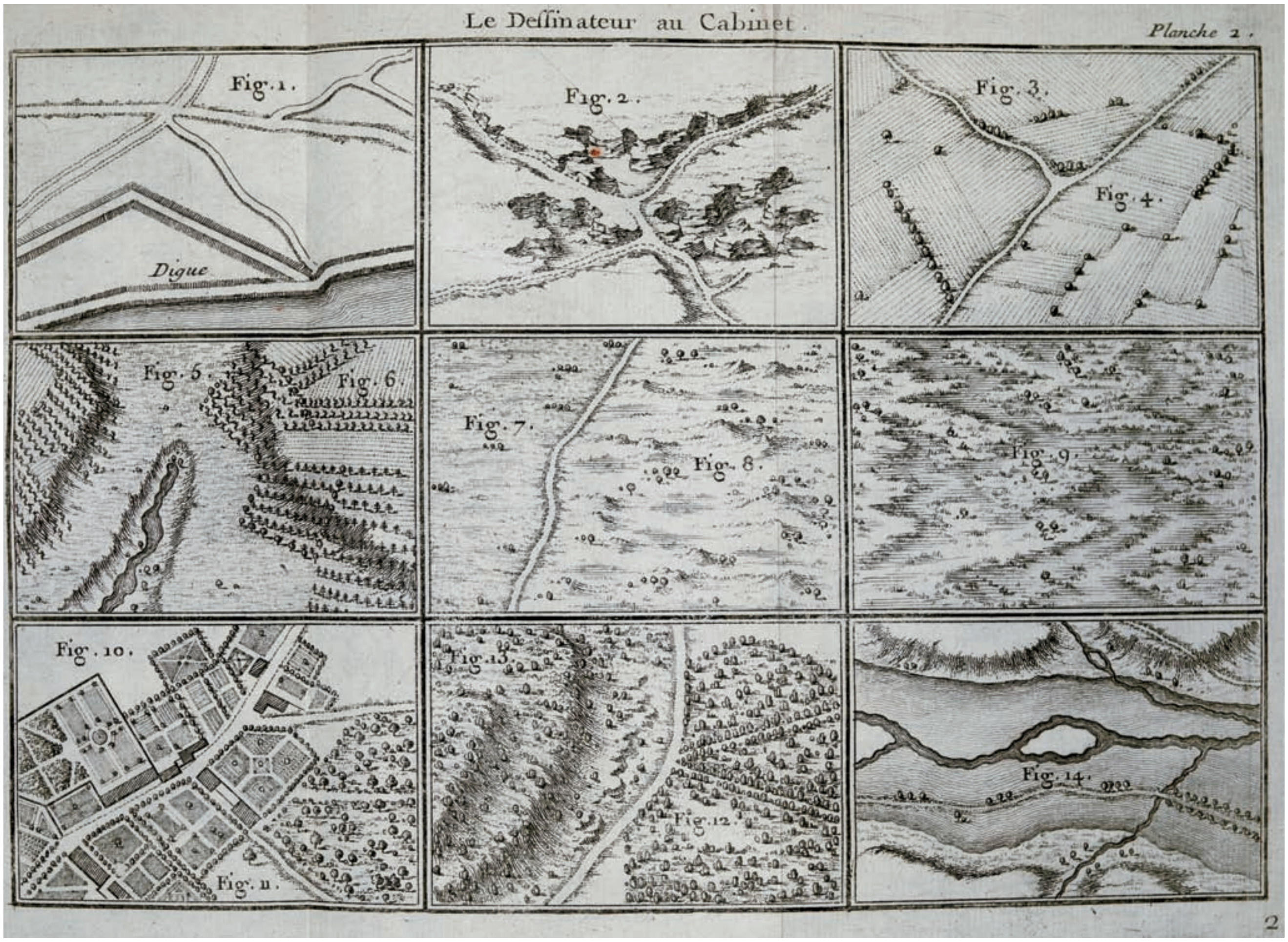

FIG. 752. LOUIS CHARLES DUPAIN DE MONTESSON'S MODEL LANDSCAPES FOR MILITARY DRAFTSMEN. From *Le dessinateur au cabinet et a l'armée*, in his *La science des ombres, par rapport au dessein* (Paris: Charles-Antoine Jombert, 1750), 95–168, pl. 2.

mapping offices with an engraved table of 228 model signs drawn up by B. A. Steynkhel (or Steinheil) for the corps of cadets, Shlyakhetnyy kadetskiy korpus, with a second detailed table published in 1794 (Postnikov 2006, 130–31). As other European states undertook large-scale surveys of the realm, the military example of using the same signs from sheet to sheet and map to map was sometimes followed. In Austria, the signs for the manuscript (and highly secret) Josephinische Landesaufnahme (1763–87) were copied from the *Carte de France*.

It may be assumed that much of the military surveyors' cartographic vocabulary and their growing concern for standardization gradually passed into printed civilian geographical maps, but how this came about has yet to be fully explored. It would have been a slow process, unaided by the statement of a universal code of practice for maps for the general public. One way of moving toward uniformity could have been through the use of mechanical reproduction of signs, but there is little evidence for this. Engravers prided themselves on their personal skill and would have been reluctant to invest in a set of tools that might not conform to the demands of different publishers. Metal punches for map signs had existed since the early sixteenth century (Delano-Smith 2005), and eight punched signs, with two punches, were illustrated in the *Encyclopédie* (1767) (fig. 753). However, instead of the empty double circle produced by the positional punch (*poinçon positionnaire*) illustrated in the *Encyclopédie* and said to be "sometimes used" to mark the location of places, such a circle has not been observed and common practice was to show the precise location of a town or village by a single little round circle, with or without a central point. In fact, the advice given a few lines below was that "it is better to engrave all the locations represented by the punches than to strike them" (Anonymous 1767, 1), which accords with

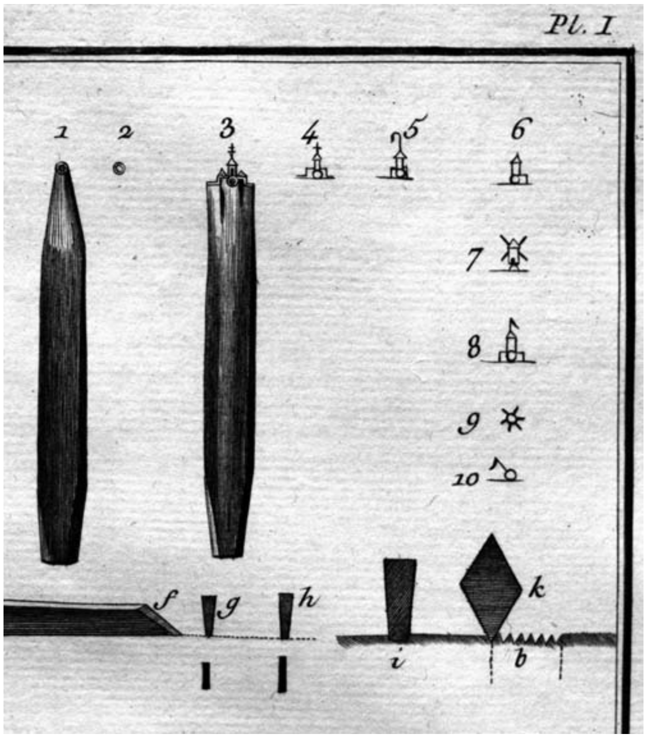

FIG. 753. MAP SIGN TOOLS, 1767. Detail from "Gravure en lettres," in Denis Diderot and Jean Le Rond d'Alembert, eds., *Encyclopédie, ou, Dictionnaire raisonné des sciences, des arts et des métiers*, 17 text vols. and 11 plate vols. (Paris: Briasson, David, Le Breton, Durand, 1751–72), *Recueil de planches, sur les sciences, les arts libéraux, et les arts méchaniques, avec leur explication*, plate vol. 5 (fourth installment) (1767), "Gravure en lettres, en géographie et en musique," pl. I.
Size of the entire original: 21.3 × 35.6 cm; size of detail: ca. 11 × 10 cm. Image courtesy of the Department of Special Collections, Memorial Library, University of Wisconsin–Madison.

Philippe Buache's stipulation in a contract made in 1748 that the tool for the open circle of a location dot would be used for the positional ○ in signs for medium and small settlements only; the dot in the sign for the largest places would be engraved *au burin* (Dainville 1961, 121). On close inspection, the inconsistency of settlement signs on, for example, Johann Baptist Homann's *Arena Martis in Belgio* (ca. 1730–40) suggests that the apparently similar stylized signs did not come from a single punch but from a combination of engraver's hand and tool. Where the engraving was not well done, as on Homann's map where the vertical spikes are detached or distant from the towers representing the town, the signs appear incomplete and untidy (fig. 754).

It is not difficult to establish that the draftsmen of large-scale manuscript military surveys were instructed in the use of signs, but the extent of a similar process in printed work, where the engraver rather than the draftsman had the final word, is unclear. Writing retrospectively in 1783, Cassini III hinted that instructions had been issued from the start regarding the design and size of the signs to be used on the *Carte de France* as well as the need for consistency: "We had to train the engravers [and] select from models . . . it was desired that all would conform" (Cassini III 1783, 18). Even so, although the *Carte de France* and associated maps may boast at first glance an unprecedented consistency in their signs, closer inspection reveals that uniformity was not the rule. Engravers' personal styles apart, signs for the largest towns and cities, for example, are not identical from sheet to sheet, and those for middle-sized places are not well differentiated.

Geographical mapmakers who compiled their work into published atlases advertised uniform design as a selling point. John Ogilby described in words how readers were to understand his portrayal of the roads of England and Wales in the preface to *Britannia* (1675). In the *Atlas universel* (1757, 19), Gilles Robert Vaugondy and Didier Robert de Vaugondy promised to simplify their signs for easier comprehension. Specialist marine signs were expected to be unfamiliar to the general reader, and J. F. W. Des Barres gave examples in the prefatory material to *The Atlantic Neptune* (1774–82). When the

FIG. 754. DETAIL FROM JOHANN BAPTIST HOMANN, *ARENA MARTIS IN BELGIO*, FROM THE *ATLAS NOVUS TERRARUM ORBIS IMPERIA, REGNA ET STATUS* [1730–40]. This detail shows signs that could be mistaken for having been made with punches, but close inspection reveals the hand of a less skilled engraver who left the vertical spike detached from the central tower of the town signs. Compare figure 753.
Size of the entire original: 48.2 × 56.5; size of detail: ca. 6.5 × 8.0 cm. Image courtesy of the William L. Clements Library, University of Michigan, Ann Arbor (Atl 1702 Ho [Vol. 1, no. 35]).

publisher was also the author of the atlas maps, he could in theory exert significant control over the engraving, but where the publishers hired geographers to construct maps and engravers to render the design to a copperplate, a house style was rarely, if ever, achieved.

Some publishers helped their audience decode the signs. Gilles Robert Vaugondy included a model map, *Introduction à la coñoissance et à l'usage des cartes*, in his *Atlas portatif universel et militaire* (1748; see fig. 735) and a similar model map, *Essai du genre de gravure pour la nouv[le]. Carte des Pays-Bas*, was used to promote the sale of the *carte marchande* of the Ferraris *Carte chorographique des Pays-Bas autrichiens*. Between 1741 and 1756, Matthäus Seutter produced a similarly instructive sheet map showing an imaginary coastal region, on which every geographical feature is labeled, with a key in Latin and German for forty signs (*Mappa geographiæ naturalis sive tabella synoptica*, ca. 1730). In general, throughout the long eighteenth century, geographical and topographical maps represented everything that, as Cassini III remarked in connection with the *Carte de France*, "could perhaps be of some use" (Cassini III [1756], 7). Skilled engraving realized the period's increasingly widespread aspiration to comprehensiveness as well as mathematical accuracy on the best maps of the period. It also imparted an unprecedented neatness to poorly executed maps. In all cases, though, the signs themselves were essentially those of old, as was the inconsistency in their use. Universal insistence on uniformity in meaning and homogeneity in appearance of a specific map series or atlas was yet to come.

CATHERINE DELANO-SMITH

SEE ALSO: Art and Design of Maps; Boundary Survey Plan; Celestial Mapping; Color and Cartography; Commission topographique of 1802; Geographical Mapping; Historical Map; Marine Chart; Property Map; Thematic Map; Topographical Survey Map; Urban Map

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Society of Jesus (Rome). In 1534 Ignatius of Loyola took the first steps toward the founding of the Society of Jesus (also known as the Jesuit Order) in Rome in the context of the movement known as the Counter-Reformation or the Catholic Reform: the Catholic Church's reaction to the expansion of Protestantism in Europe. The Jesuit Order was a product of modernity and responded to the expansion of European knowledge of the world resulting from the great voyages of exploration. Accordingly, the Society of Jesus distinguished itself from other religious orders that had existed since the medieval period by the itinerant character of its members, who, in their fourth and final vow, committed to dedicate themselves to the conversion and expansion of Catholicism, wherever the faithful might be. Because of its fundamental missionary purpose, the Society of Jesus established itself throughout the globe, particularly in regions like Asia and the Americas, recently "discovered" by Europeans.

Another central feature of the order was the importance that it placed on the acquisition of knowledge and academic excellence, both in the sciences and in the humanities. Within the Catholic world, many Jesuits were noted intellectuals—becoming tutors, confessors, and counselors to princes and kings. They established an educational presence at every level, including universities, seminaries, missions, and secondary schools affiliated with the Society, and exerted a profound influence on mathematical and scientific training during the seventeenth and eighteenth centuries in Europe and abroad. The pedagogical method adopted in these institutions was expressed in the *Ratio atq[ue] institvtio stvdiorvm*, called the *Ratio studiorum*, the treatise promulgated in 1599, which elaborated the notes about education made by Ignatius himself and created a unified Christian pedagogy at all levels. Based in rigorous discipline and humanistic studies, the *Ratio studiorum* encouraged academic excellence and the exercise of moral virtues through religious training. Among the subjects taught were grammar, orthography, Latin, Greek, oratory, rhetoric, philosophy, morals, writing, history, mathematics, astronomy, and geography. There was an emphasis placed on the study of classical authors like Aristotle, Cicero, Ovid, Horace, Isocrates, and Homer, and also Thomas Aquinas. Initially, Jesuit pedagogy submitted the study of geography to history and restricted it to a knowledge of the Old World and to the history of the church and the lives of the saints. The order soon extended geography to incorporate exploration of the New World as its missions spread to every corner of the globe. The Jesuits became great masters of evidence-based geography and cartography not only because they taught these subjects in their educational institutions, but also because they were recording geographical knowledge themselves through their travels, missions, and regular reports. In addition, they used maps as missionary tools in their preaching and conversion activities (Buisseret 1997, 117; Reitinger 2005). Their application of astronomical observations in the creation of maps and their participation in geodetic surveys ensured their role both in seventeenth-century debates concerning cosmographic systems and also in the eighteenth-century determination of longitude and the shape of the earth.

A third aspect of the order that set it apart, both as a religious institution and an intellectual force, was its military structure, with concomitant emphasis on the obedience and reliability of its members. Nearly every Jesuit was required to travel at some point in his career to wherever the order felt he was needed and to report frequently (sometimes weekly, often monthly) on the work of the mission to his superiors in the province, who in turn reported to their superiors in the Assistancy (the administrative territory upon which the province was dependent), who reported to the superior general of the order (Harris 1999, 218–22, figs. 9.1 and 9.2). Letters and reports were combined, edited, and circulated again to the members of the order and were printed for the general public in annual reports known as the *Litterae Annuae*.

Nothing escaped their curiosity: travel, observation, collection, measurement, and description were integral to their mission. Their reports were required to follow certain patterns of form and content in order to be reliable. Jesuit reports provided the Society with valuable information for the superiors to make decisions about further missions and approaches to current missions. The emphasis on reliability coincided with the Enlightenment scientific agenda of hypothesis and experimentation: the repeated gathering of data provided reliability and increased accuracy in science (Harris 1999, 212–19). Beyond the physical maps, their vast correspondence and missionary accounts constitute true mental maps of the regions in question. Cosmography was directly related to their religious conceptions because the domination and understanding of earthly space were fundamental to the Society's missionary activities, which had reached their peak by the mid-eighteenth century. The geographic knowledge they acquired was important to the growing network of geographers in both the Catholic and non-Catholic world. As a result, Jesuit teachers powerfully influenced mapmaking.

As the Catholic nations of Europe, especially Portugal, Spain, and France, expanded their empires abroad, their monarchs supported the arrival of the Jesuits in India in 1542; Congo in 1547; Morocco, Ceylon, and the Spice Islands of present-day Indonesia in 1548; Brazil and Japan in 1549; China in 1552; Ethiopia in 1555; Peru in 1567; Mexico in 1572; and New France in 1611. During this period of expansion, the Jesuits became important agents in the acquisition and dissemination of geographic and cartographic knowledge of these territories.

There are many examples in the seventeenth and eighteenth centuries of Jesuit travels resulting in maps that served to expand the geographic knowledge of regions that were practically unknown by Europeans. Samuel Fritz traveled through the Amazon, descending the Amazon River from Peru all the way to the city of Belém, in Brazil. Fritz's handwritten account was used by the

Jesuit Pablo Maroni as the basis for his "Noticias autenticas del famoso Rio Marañon" (1738). Jacques Marquette arrived in New France in 1666 and explored part of the Mississippi River during an expedition in 1673; his account was published in Melchisédech Thévenot's *Recueil de voyages* in 1681. In 1668, Claude Dablon surveyed the region of Lake Superior in North America and the western territories of Canada, and he wrote a report in 1670–71 to which he appended the first Jesuit map of that lake based on his observations. Between 1688 and 1694, Pierre Raffeix traveled to North America and drew several maps, two of them of the Great Lakes and the St. Lawrence (Heidenreich 1978, 88, 98–99). As Matteo Ricci had done in the early seventeenth century, Martino Martini, Jean de Fontaney, and Louis Le Comte each traveled through China, where they made countless geographic observations (Yee 1994, 170–85; Hsia 2009). Martini's cartographic compilations were published by Joan Blaeu in 1655 as the *Novvs atlas sinensis*. Le Comte published his own account in France in 1696–97, titled *Nouveaux memoires sur l'Etat present de la Chine*, in which he not only described the local geography but recorded numerous measurements of latitude and longitude based on astronomical observations. Ippolito Desideri, after arriving in Goa, traveled through northern India and Tibet from 1713 to 1721. After returning to Europe in 1727, he wrote "Notizie istoriche del Tibet." Eusebio Kino, a missionary in New Spain between 1681 and 1711, reported his activities through extensive correspondence with the Society; his printed work included the *Exposición astronómica*, a pamphlet describing a comet seen in the region in 1680, and his diary, *Favores celestiales* (Buisseret 2007, 1157; 1997, 117–18; Burrus 1965).

Another team of twenty-seven Jesuits, many French operating under the Portuguese, performed surveys in China between 1708 and 1717 to create the maps of Chinese regions gathered into the *Huangyu quanlan tu* 皇輿全覽圖 (Map of a complete view of imperial territory) completed in 1718 and published shortly thereafter (Yee 1994, 180–85; Hsia 2009). Joseph Tieffenthaler traveled through India from 1729 and related his observations in volume one of the *Description historique et géographique de l'Inde* (1786), which included maps and plans based on his sketches; his *Carte générale du cours du Gange et du Gagra* appeared in Paris in 1784. Missions in Africa resulted in the map of Ethiopia by Manuel de Almeida in his manuscript history of Ethiopia published posthumously in 1660. In 1710, *Oriente conquistado* by Francisco de Sousa contained the first description of the extent of Lake Maravi and the kingdom of the same name, situated between the lake and the Zambeze River.

As the Jesuit missionaries spread over the world collecting scientific information based on their observations, their superiors in Europe, many of whom held positions in the principal Jesuit universities in the order's Assistancies of Germany, France, Italy, Spain, and Portugal, edited and disseminated this information through printed books and articles, creating a significant collection of geographic texts and maps. It is estimated that nearly eight hundred titles relating to geography and natural history were published during the sixteenth, seventeenth, and eighteenth centuries, representing around one-seventh of all scientific Jesuit publications (Harris 1999, 213). The spread of this knowledge not only reinforced the intellectual impact of the Jesuits but served as an important vehicle of propaganda for the Society's missionary role. Such publications as the *Relation de ce qui s'est passé en la Novvelle France* (*The Jesuit Relations and Allied Documents*, edited by Reuben Gold Thwaites, 1896–1901) formed part of the regular dissemination program that included cartography. Another series, the *Lettres édifiantes et curieuses* (1702–76) was initially the responsibility of Charles Le Gobien, trustee in Paris of the Jesuit Missions in China, and from 1711, Jean-Baptiste Du Halde, who coordinated the collection, which included the annual letters, diverse accounts, geographic descriptions, and maps portraying and describing the vast regions where the Society was active. *Der Neue Welt-Bott*, the German-language collection of the descriptions and annual reports concerning the New World, was published under the auspices of the Society in Augsburg and Graz, later Vienna, between 1726 and around 1758–61 (Hsia 2009, 206); it divulged to the Germanic world knowledge of the geography and nature of recently explored regions of the globe.

In 1728, Du Halde, as editor of the *Lettres édifiantes et curieuses*, contracted the French geographer Jean-Baptiste Bourguignon d'Anville to produce maps to accompany his *Description géographique, historique, chronologique, politique, et physique de l'empire de la Chine et de la Tartarie chinoise* (1735). D'Anville based his maps on the Jesuit surveys and astronomical observations found in the *Huangyu quanlan tu*. Du Halde's work was translated into English by John Green in 1738–41 and into German in 1747, showing that the wide circulation of Jesuit academic production throughout Europe was not restricted to Catholic nations. For the first edition of Du Halde's book, d'Anville produced three general maps and several specific ones, including the *Carte generale de la Chine* (1730; see fig. 392), the *Carte générale du Tibet* (1733), and the *Carte la plus generale et qui comprend la Chine, la Tartarie chinoise, et le Tibet* (1734). In 1737, Du Halde financed the publication of *Nouvel atlas de la Chine*, by d'Anville, which included forty-two maps and accompanied the publication of a new edition of his book on the Netherlands.

FIG. 755. HEINRICH SCHERER, *REPRÆSENTATIO TOTIVS ORBIS TERRAQVEI CVIVS PARTES, QVÆ VMBRA CARENT, FIDE CATHOLICA IMBVTÆ SVNT, RELIQVÆ OMNES INVMBRATÆ RELIGIONIS CATHOLICÆ EXPERTES SVNT*, 1703. Copperplate engraving. From Heinrich Scherer, *Geographia hierarchica, sive Statvs ecclesiastici romano-catholici* (Munich: Mariæ Magdalenæ Rauchin, Viduæ, 1703), facing 36. Scherer's map, drawn on a polar projection, uses shading to show areas of the world susceptible to Catholic proselytizing.
Size of the original: ca. 23.5 × 35.0 cm. Image courtesy of the Glen McLaughlin Map Collection, Stanford University Libraries (map number 1070).

The *Nouvel atlas* was expanded and published in Paris in sixty-four sheets. Finally, in 1785, d'Anville's *Atlas général de la Chine*, expanded to forty-six maps on sixty-six sheets and incorporating corrections of the earlier work, was published in tandem with the *Description générale de la Chine* by abbé Jean Baptist Gabriel Alexandre Grosier, which was a compilation of letters and reports made by Jesuit missionaries in China (Cordier 1905, 398–99). D'Anville's maps provided a more detailed cartography of the interior of China than heretofore available and "from these maps, western Europe obtained the first reasonably accurate and comprehensive conception of the geography of a large part of eastern Asia" (Crone 1978, 90).

German Jesuit Heinrich Scherer, a professor in Munich and tutor to the princes of Mantua and Bavaria, also compiled geographic knowledge from the reports of Jesuits throughout the world, creating hundreds of maps, books about geography, and a seven-volume atlas. Through the innovative use of light and dark shading, he highlighted regions in the world susceptible to conversion to Catholicism, thus using the most recent geographic information as an important means of propaganda for the missionary role of the Jesuits. Scherer's maps in general contributed to establish the conception of the world current in Europe at the beginning of the eighteenth century (fig. 755).

Active participants in the creation and publication of knowledge, the Jesuits were involved in various scientific undertakings that mobilized enlightened intellectuals throughout the eighteenth century. One effort fundamental to the development of geographic knowledge was the improvement of longitude measurements, to which the Jesuits contributed by making observations to determine longitudes and latitudes not only in Europe but also in distant territories where they worked as missionaries. Their training emphasized mathematical and astronomical skills and mastery of instruments such as the pendulum clock and the quadrant; thus, they were highly competent in the methods of longitudinal measurements based on lunar distances or the eclipses of Jupiter's moons (Dainville 1940, 449–50). Such skills were in high demand. For example, among the Jesuits who participated in the survey of China six were French Jesuits, led by Fontaney, designated as *pères mathématiques* by Louis XIV in 1685. Trained personally by Jean-Dominique Cassini (I), director of the Paris Observatory, they brought instruments including telescopes, quadrants, and pendulum clocks, as well as instructions from the Académie royale des sciences in Paris to undertake astronomical and geodetic observations throughout Chinese territory (Cams 2017). One member of the party, Guy Tachard, published the first measurements taken at the Cape of Good Hope and in Louvo, Siam, in the *Voyage de Siam, des peres jésuites* (1686) (Hsia 1999, 244). Within the Portuguese Empire, Diogo Soares, Domenico Capassi, and Giovanni Battista Carbone were designated *padres matemáticos* by João V (fig. 756). In 1722, the arrival of Capassi and Carbone in Lisbon from Naples had a significant impact on the knowledge and teaching of astronomy and geography in Portugal, as their work was based on new methods of measuring longitude. In 1723, Capassi and Carbone were appointed to conduct a new geographic survey of Portugal. They worked from the recently built observatory in the royal palace as well as from the Jesuit Colégio de Santo Antão, from which Jesuits had already made many astronomical observations of eclipses of the moon and of the satellites of Jupiter, using these new methods to establish the longitudinal distance of Lisbon from the Paris meridian. In the manuscript "Lusitania astronomicae illustrata," Capassi compiled all of the astronomical measurements he had taken between 1726 and 1727 in Lisbon, Porto, and Braga. Soares and Capassi were sent to Brazil in 1729; the following year, they established distances from the meridian of Rio de

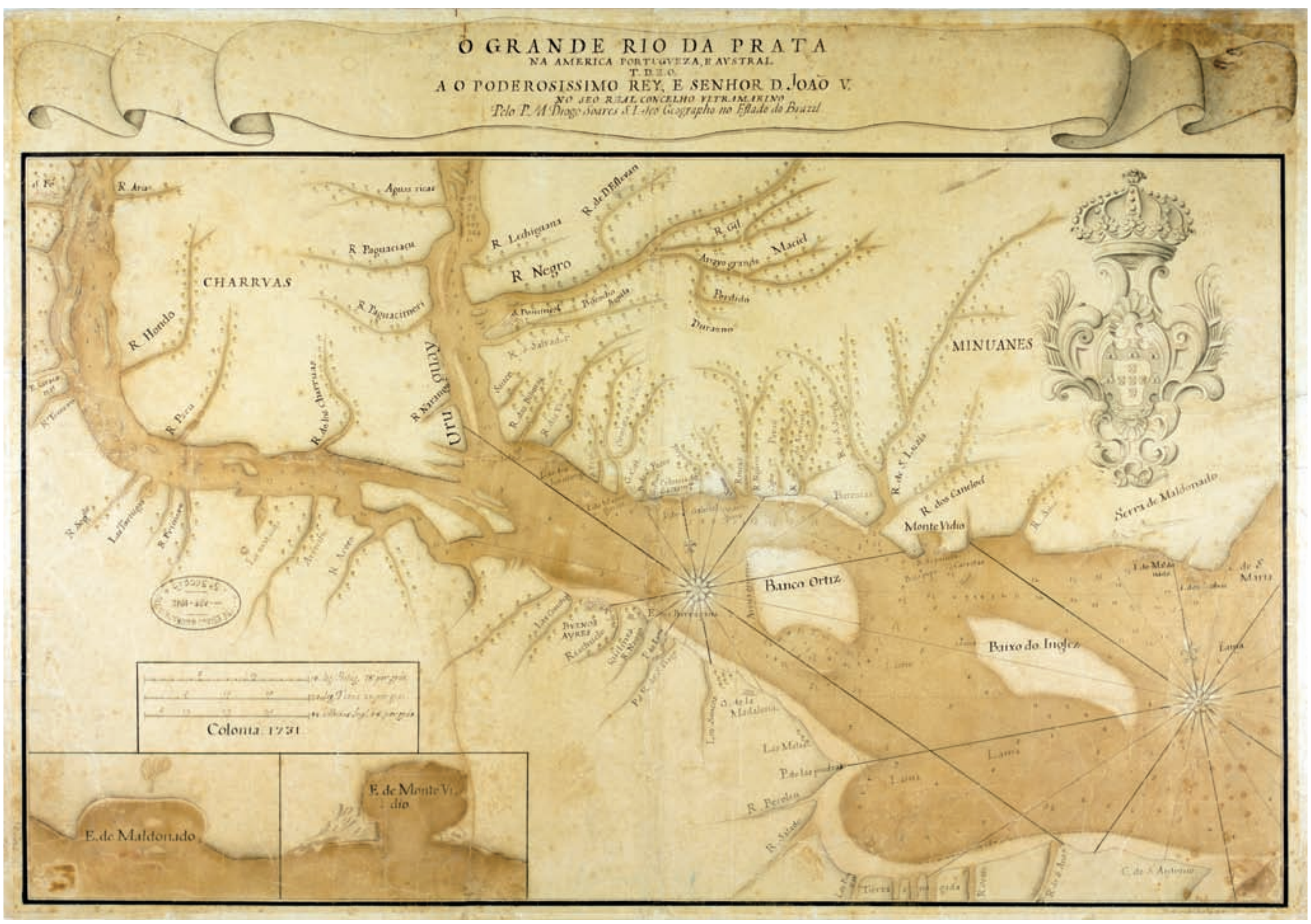

FIG. 756. DIOGO SOARES, "O GRANDE RIO DA PRATA," 1731. Manuscript. Soares was one of the *padres matemáticos* sent to Brazil in 1729 where they established the meridian of Rio de Janeiro, which was used as basis for mapping Brazil, including the region of the Rio da Prata.
Size of the original: 41.3 × 69.8 cm. Image courtesy of the Arquivo Histórico do Exército, Rio de Janeiro (018/M-11/G-2-B-10).

Janeiro, on the basis of which they organized all of their maps of Brazil, including portions of Rio de Janeiro, São Paulo, Minas Gerais, the Colônia do Sacramento, Río de la Plata (Rio da Prata), Rio Grande (do Sul), and Santa Catarina (Almeida 2001).

Jesuit work on the question of longitude and geodetic surveys was not limited to their overseas missions. In Europe, Jesuit activity teaching geography, mathematics, and astronomy in their schools and colleges influenced geographers such as Claude Delisle, astronomers like Jean-Dominique Cassini, and globemakers and surveyors like Peter Anich. Their work helped to measure meridians at various points in Europe. Jesuit scientists Ruggiero Giuseppe Boscovich and Christopher Maire measured the meridian from Rome to Rimini in the Papal States under the auspices of Pope Benedict XIV from 1750 to 1753. Joseph Liesganig, the director of the observatory in Vienna, performed similar work from Vienna to Brün in 1759 at the order of Empress Maria Theresa.

The relationship of the Society of Jesus to other corporate, governmental, educational, and formal and informal scientific institutions was constant throughout the first half of the eighteenth century. Although the Jesuits were directly subordinate to the pope according to their statutes, they often found themselves aligned to and defenders of the national interests of the monarchies they served. Jesuits worked intimately with monarchs and other authorities as well as local institutions, particularly in education, but also for administrative purposes, such as the general map of Spain surveyed by Carlos Martínez and Claudio de la Vega from 1739 to 1743, at the command of Zenón de Somodevilla y Bengoecha, marqués de la Ensenada. Because of their important role in the development of various areas of scientific knowledge, Jesuits were admitted into the Académie royale des sciences in Paris with special privileges, and in exchange they agreed to communicate all their discoveries to the institution (Hsia 1999, 244). For this reason, a great number of observations relating to astronomy, natural history, and geography were published in the *Journal des Sçavans* and in the *Mémoires de l'Académie des Sciences*, official publications of the French academy, further enhancing the importance of Jesuit contributions to geographic knowledge, especially in India, China, Japan, and the Americas. As the Jesuits participated with the other members of the academy to compile a new form of cartographic representation, the resulting maps were introduced in Jesuit colleges, thereby modifying the teaching of geography in their various institutions (Dainville 1940, 455–57). Their maps followed a standardized pattern with north orientation, the presence of scale, and a grid of longitude and latitude based on personal observations (Buisseret 2007, 1157).

Because of their alliance with Catholic monarchs, the Jesuits also became involved in many geopolitical issues during the eighteenth century, particularly the renegotiation of the border between Portugal and Spain both in the Americas and in the East Indies (Moluccas). The boundary surveys occasioned by the Treaty of Madrid (1750) directly affected the Society. Initially, the Jesuits participated positively, understanding that the treaty was designed to create binational parties that would establish a border between the two countries by installing physical markers. Some Jesuits with deep knowledge of mathematics, geography, and the techniques of measuring longitude and latitude were recruited to participate in the surveying parties. The Portuguese team included the Italian Jesuit astronomers Bartolomeo Panigai, Bartolomeu Pinceti, and Estevão Bramieri, who were to make astronomic observations and draw maps in South America (Ferreira 2001, 260–62). However, their participation was truncated by the impact of the Treaty of Madrid on the Jesuit missions in the regions of Paraguay and Amazonia. The treaty required that the region of Sete Povos das Missões, under the coordination of Spanish Jesuits, be handed over to the Portuguese in exchange for the Colônia do Sacramento, the Portuguese enclave north of the Río de la Plata's falls in Paraguay, where Portuguese Jesuits were active and had established a college. Jesuits themselves had provided the geographic knowledge for these regions at stake in the treaty; for example, in 1719 when the Portuguese ambassador in Madrid, Luís da Cunha, needed a map of the Colônia do Sacramento for his negotiations with the Spanish, he had turned to Joseph Pablo Castañeda, the general coordinator for the West Indies, who provided one (Furtado 2012, 59–60).

In fact, knowledge about the territory of Paraguay, where both Portuguese and Spanish Jesuits had established around thirty missions by the eighteenth century, was accessible only through reports by the Society. The annual letters concerning Paraguay, written between 1608 and 1763, were fundamental to the expansion of geographic knowledge of the area. Notable among them are those of Pedro Lozano, the secretary and historian of the Paraguayan missions between 1735 and 1743, on which he based his manuscript "Historia de la conquista del Paraguay, Río de la Plata y Tucamán and his História de las revoluciones de la provincia del Paraguay," published only in the nineteenth century (Franzen 2005, 87–95). From compilations of Jesuit material, three different maps of the region of Paraguay appeared. In 1726, one map of Paraguay was prepared, published, and attributed to the missionary Juan Francisco Dávila; it served as the basis for the map of the province of Paraguay published by the German mapseller Matthäus Seutter in 1732, both under the name *Paraquariæ provinciæ Soc. Iesu* (fig. 757) (Ferreira 2007, 56). As

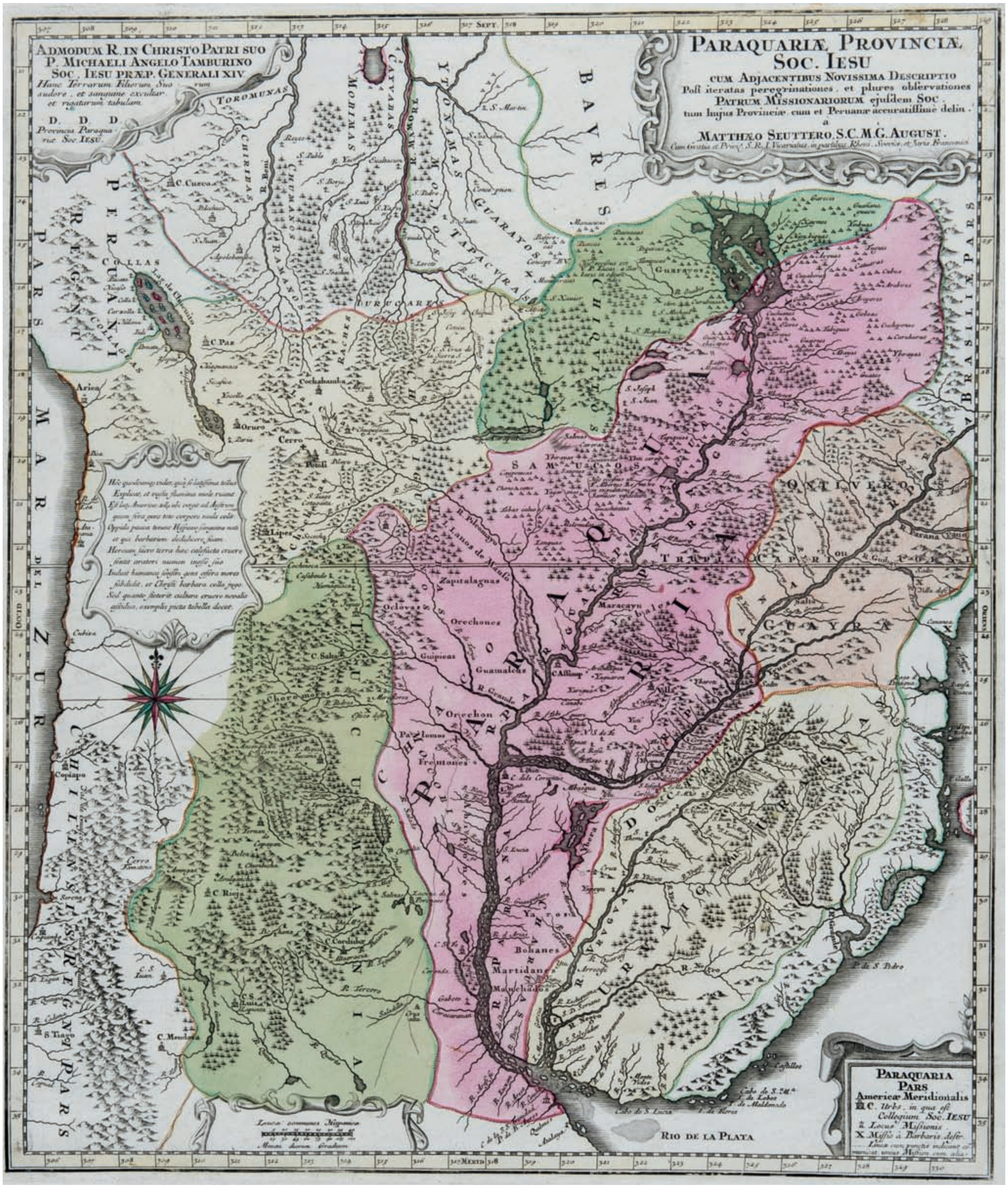

FIG. 757. MATTHÄUS SEUTTER, *PARAQUARIÆ PROVINCIÆ SOC. IESU*, AFTER 1741. Copperplate engraving. The German mapseller and printer Seutter based this map of Jesuit missions in Paraguay on a map of the region by the missionary Juan Francisco Dávila in 1726, first published in Rome in 1732.

Size of the original: 58.2 × 49.6 cm. Image courtesy of the William L. Clements Library, University of Michigan, Ann Arbor (Maps 2-E-1740 Se).

editor of volume 21 of the *Lettres édifiantes et curieuses* (1734), Du Halde commissioned d'Anville to produce a map of Paraguay. For his base maps, d'Anville used "many maps brought to light by the Jesuit missionaries in the region" (d'Anville 1734). Jesuit cartography was not neutral in relation to the interests of the two Crowns. In 1749, José Quiroga made a map of the two Paraguayan missions, the first to be drawn and based on local longitudinal measurements, clearly favoring Portuguese interests (Ferreira 2007, 52–53).

The Amazon region was also the focus of a similar territorial dispute between Spain and Portugal, in which Jesuit cartography was represented by the work of Fritz, who designed at least four maps of the region. Fritz's work provided a foil for the later cartography of Charles-Marie de La Condamine (see fig. 431), who brought Fritz's manuscript "Mapa geographica del Rio Marañon o Amazonas" back to Europe in 1745 (Almeida 2003, 113–19; Buisseret 2007, 1162–64). Fritz's version is accompanied by an explanatory note describing the geography of the river and its inhabitants. A printed map, drawn to a smaller scale, had been engraved in Quito at the Jesuit college in 1707 and was incorporated with only minor changes into volume 12 of the *Lettres édifiantes et curieuses* (1717), becoming well known throughout Europe. The *Mapa de la provincia, y missiones de la compañia de IHS del nuevo reyno de Granada*, by José Gumilla, in 1741, presented the entire Orinoco River and was often referenced in later representations of this river (Ferreira 2007, 65).

The eighteenth century was the apex of the Society of Jesus, and "allowing for obvious overstatement, it might be said that between 1570 and 1760 the Catholic world had become one great Jesuit school" (Bangert 1972, 430). Indeed, by 1749 there were around 669 Jesuit colleges in Europe, 176 seminaries, and an estimated 22,000 missionaries worldwide (Zermeño 2006, 18). Paradoxically, such strength may have led to the Society's decline and suppression. The territorial disputes between Portugal and Spain provoked conflicts both between the Jesuits who served the two Crowns as well as between the Society and the Portuguese monarchy. The Guerra Guaranítica (or War of the Seven Reductions, 1754–56), in which the Spanish, with the help of the Jesuits, armed thousands of Indians to resist turning the disputed regions of Paraguay over to the Portuguese, was fundamental to the perception on the part of the Portuguese authorities that the Society was a hindrance to its plans to expand the borders of Brazil, a move central to the empire's economy. Conflicts also occurred along the Amazonian border, where measurement was also being established and where Jesuit missions controlled not only the indigenous population but also the prosperous commerce of drugs from the jungle. Throughout the empire, the Society of Jesus hegemonized the teaching institutions, controlled the Inquisition, and occupied important positions within the upper administration, which hindered the consolidation of royal power in Portugal. The result of these conflicts was the expulsion of the Society from the Portuguese Empire beginning in 1759, during the reign of José I, by order of the first minister, Sebastião José de Carvalho e Melo, later marquês de Pombal. Like falling dominoes, within an atmosphere of intense anti-Jesuit propaganda promoted by Portugal and England, the Society was suppressed in France in 1761, and expelled from Spain in 1767, until its entire extinction was decreed by Pope Clement XIV in 1773. From this point on, the Society of Jesus remained active only in Russia, until its restoration, initiated by Pope Pius VII in 1814.

In spite of its eclipse, the contributions made by members of the Society of Jesus to cartography constitute an important scientific legacy, with its regular use of observed longitudes and latitudes, scale, and compass orientation and the inclusion of information provided by indigenous peoples both in the form of place-names, group names, and the rendering of space. The intellectual impact of the work of the Society of Jesus was deeply ingrained in approaches to the textual analysis and description of method as found in the cartographic memoir and the emphasis on personal observation and measurement.

JÚNIA FERREIRA FURTADO

SEE ALSO: Boscovich, Ruggiero Giuseppe; Boundary Surveying: Spanish America; Geodetic Surveying: (1) Austrian Monarchy, (2) Italian States; Geographical Mapping: (1) Portuguese America, (2) Spanish America; Liesganig, Joseph; Pardies, Ignace-Gaston; Topographical Surveying: Spain

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Sørensen, Jens. Jens Sørensen was born in Sølvesborg in 1646, before the loss of Skåne (Scania) to Sweden in 1658. Continuing wars between Denmark and Sweden and the confiscation of his business by the Swedes forced him to move to Copenhagen in 1676. From childhood he traveled on the ships of his father and grandfather, and on these trips he became acquainted with the poor sea charts of the time. Trained as a merchant and navigator, he made charts accordingly, without projections or astronomical methods.

In 1688, Sørensen proposed to the Danish king that he would make sea charts of all Danish waters in return for being appointed in charge of all sea charting. His bid being much cheaper than the plan proposed by the mathematician and surveyor Jørgen Dinesen Oxendorph, Sørensen was appointed *søkortdirektør* (director of marine charting) in 1689. For thirty-five years, until his death in 1723, he constructed charts of all Danish waters, from which he compiled a much better map of Denmark than those of his predecessors (see fig. 509). He recorded his journeys and chartmaking methods in his diaries. However, his maps were seen as state secrets that were too dangerous to publish, and they remained largely concealed in the archives. His charts and diaries only began to be made public with the publications of Johannes Knudsen (Sørensen 1916; Knudsen 1918, 1921).

Although using very simple methods, Sørensen was able to produce hundreds of precise maps. He used compass, plumb bob for sounding the sea floor, and a special cart (fitted with an odometer) for measuring distances on land. From 1690 to 1714 he made five summer trips in Danish waters, each lasting several months, a long journey in 1695 along the western coast of Jylland (Jutland) from Skagen in the north to Holstein in the south, as well as several shorter trips and some winter excursions over iced seas between 1703 and 1714. The result was hundreds of sea charts at many different scales. Some of his maps are very large, measuring up to five meters in length, while others are small, detailed maps of specific areas (fig. 758). The first maps he produced were of the Swedish coast, which were valuable to the Danish king. In his last years, he also produced topographical maps of Copenhagen and maps showing areas belonging to the queen of Denmark.

FIG. 758. AN EXAMPLE OF JENS SØRENSEN'S EARLY WORK. A detail from an unfinished and untitled manuscript chart from 1692 of the shallows between the islands of Ærø and Langeland, just south of the island of Fyn, and also the lines of soundings that Sørensen took in open water. Size of the entire original: 230 × 112 cm; size of detail: ca. 28.0 × 51.5 cm. Image courtesy of Det Kgl. Bibliotek; The Royal Danish Library, Copenhagen (KBK 1111,23-0-1692).

Despite promises from the king and several proposals, Sørensen never succeeded in getting any of his maps printed. Copies of his maps probably were made for use on naval ships, but soon after his death they were forgotten; the navy returned to using older Dutch sea charts on their ships. Sørensen died in Copenhagen a poor man, embroiled in a fight with his children, and unremarked by Danish society. He was buried in Holmens Kirke in central Copenhagen. His manuscript maps are today located in the Statens Arkiver, the Søkort-Arkiv (part of Geodatastyrelsen), and the Kongelige Bibliotek; some of his Norwegian charts are located in Norwegian archives.

HENRIK DUPONT

SEE ALSO: Marine Charting: Denmark and Norway

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Sounding of Depths and Marine Triangulation. Soundings are measurements in units of feet or fathoms of the depth of a vertical column of water, shown on charts as representing the measurement during the lowest tides possible or from the mean low water spring tidal level. While the number of soundings on a chart varies according to its scale, soundings remained relatively few on the marine charts of the eighteenth century, with some notable exceptions, such as charts of harbors and the mouths of busy rivers. However, a large number of soundings did not necessarily mean they were accurate, even if they sometimes were. To affirm accuracy, for example, a chart of the coast between Les Sables-d'Olonne and the mouth of the Gironde by La Favolière (1674; see fig. 511) showed that the soundings had been certified by the local pilots who had affixed their red wax seals (Chapuis 2007, 110–13).

The accuracy of charted depths depends first on the sounding technique. In the eighteenth century, as earlier, soundings were made with a simple tallow-coated lead at the end of a hemp cord. In tidal waters, the soundings were reduced from a specified chart datum or hydrographic zero. In *Le Neptune françois* (1693), this chart datum corresponded to the lowest tides possible (Chapuis 1999, 733). Other nations chose different datums; Great Britain used the mean low water spring tidal level. Ultimately the quality of each sounding depended on the more difficult question of its position, whether out of sight or in sight of land. In practice, the hydrographers did not attempt to position each sounding point until the very end of the eighteenth century, when horizontal sextant angles and other reflecting instruments enabled more frequent fixes along lines of soundings.

Yet, without a means of calculating longitude, sometimes even without measurement for latitude, soundings provided a form of security for navigators when approaching a coastline, assuring them of sufficient water to proceed safely and allowing them to determine position by reference to a chart with soundings. Thus, when approaching land, the mariner could detect his crossing onto the continental shelf, insofar as contemporary technology permitted. Depths of 100 fathoms (162.40 m) to 150 fathoms (243.60 m) were plumbed with difficulty; usually the depths were much less, although some remarkable measurements were made: 250 meters measured in the Gulf of Lion by Luigi Ferdinando Marsigli in 1725 and 1,250 meters near Spitsbergen in 1773 (Rice 2007, 463). The edge of the continental shelf appeared only very rarely on nautical documents, but a navigator (provided he was at the right latitude) knew from experience its distance from the coastline and its countless dangers.

Sounding was practiced more frequently in navigation than is evident from the depths shown on charts. The submerged sounding line was a positioning tool for determining location, along with the color of water or the presence of a certain species of seabird. Another positioning method involved a sailor comparing his personal knowledge or the text of nautical instructions with the sediment brought up in the tallow of the cavity at the bottom of the lead (mud or sand of different kinds, or nothing, meaning rock bottom). Yet sediment information, also used for anchoring, was only occasionally shown on coastal charts.

MARINE TRIANGULATION The precise location of each sounding was a challenge eventually resolved by the process of "marine triangulation." In the latter half of the seventeenth century in France, minister Jean-Baptiste Colbert had ordered careful soundings to be made in the entrances to the main military ports along the coast (Chapuis 2007, 107–13). But control of the positioning of the soundings remained very imprecise since the absolute position of the primary points, such as those of the main ports, was still not defined (Chapuis 2007, 114). After these early missions, *Le Neptune françois* (1693) appeared as the first maritime work, and one of the first atlases, to benefit from the astronomical observations of the Académie des sciences (Chapuis 1999, 102), though these determinations were integrated only subsequently. These observations constituted a basic framework on which the charts of this marine atlas relied to a certain extent. However, in spite of its numerous innovations, *Le Neptune françois* did not benefit from a geodetic framework. Despite the maritime initiatives of later scientifically inclined officers, such as Charles-Pierre Claret de Fleurieu and Jean-Charles Borda, who meticulously used the triangulated *Carte de France* (1744), a similar geodetic framework did not exist for the French coastline (Chapuis 1999, 105). Whereas *Le Neptune françois* remained an essential reference until at least 1800, though static and largely outdated, there were no French marine charts in the eighteenth century based on France's geodetic grid, with rare exceptions, described below (Chapuis 1999, 106–10).

The situation in Great Britain, ever focused on the sea, was precisely the opposite of that in France from a geodetic point of view. While terrestrial triangulation in Great Britain did not begin in earnest until 1784, the Scotsman Murdoch Mackenzie the Elder applied the main principles of triangulation in hydrography much earlier (Chapuis 1999, 111). The story of the measurement of the baseline for the survey on a frozen lake is better known (Ritchie 1991, 17) than Mackenzie's own explanation of his method in his atlas, *Orcades* (1750), a volume of eight charts (one general and seven more detailed, at ca. 1: 65,000), and one of the best examples of marine cartography of the mid-eighteenth century. The large scale required the undertaking of good triangulation onshore, from whose stations marine landmarks and dangers could be observed and their positions precisely determined. The marine features could then be plotted in their exact location, a sine qua non for positioning and precise navigation in sight of land (fig. 759). Mackenzie's success is affirmed by his general outline of the Orkneys being closer to today's view than that of Greenvile Collins of 1693 (Chapuis 1999, 113–14; Robinson 1962, 61–66).

The *Orcades* nonetheless had its limitations and flaws, which were highlighted in the subsequent decades (Chapuis 1999, 114–15). Yet Mackenzie's *A Treatise of Maritim Surveying* (1774) assures his place as the first real theorist of modern hydrography. In it, Mackenzie summarized his theoretical and practical experience of coastal surveying, reviewing the main ways to survey a

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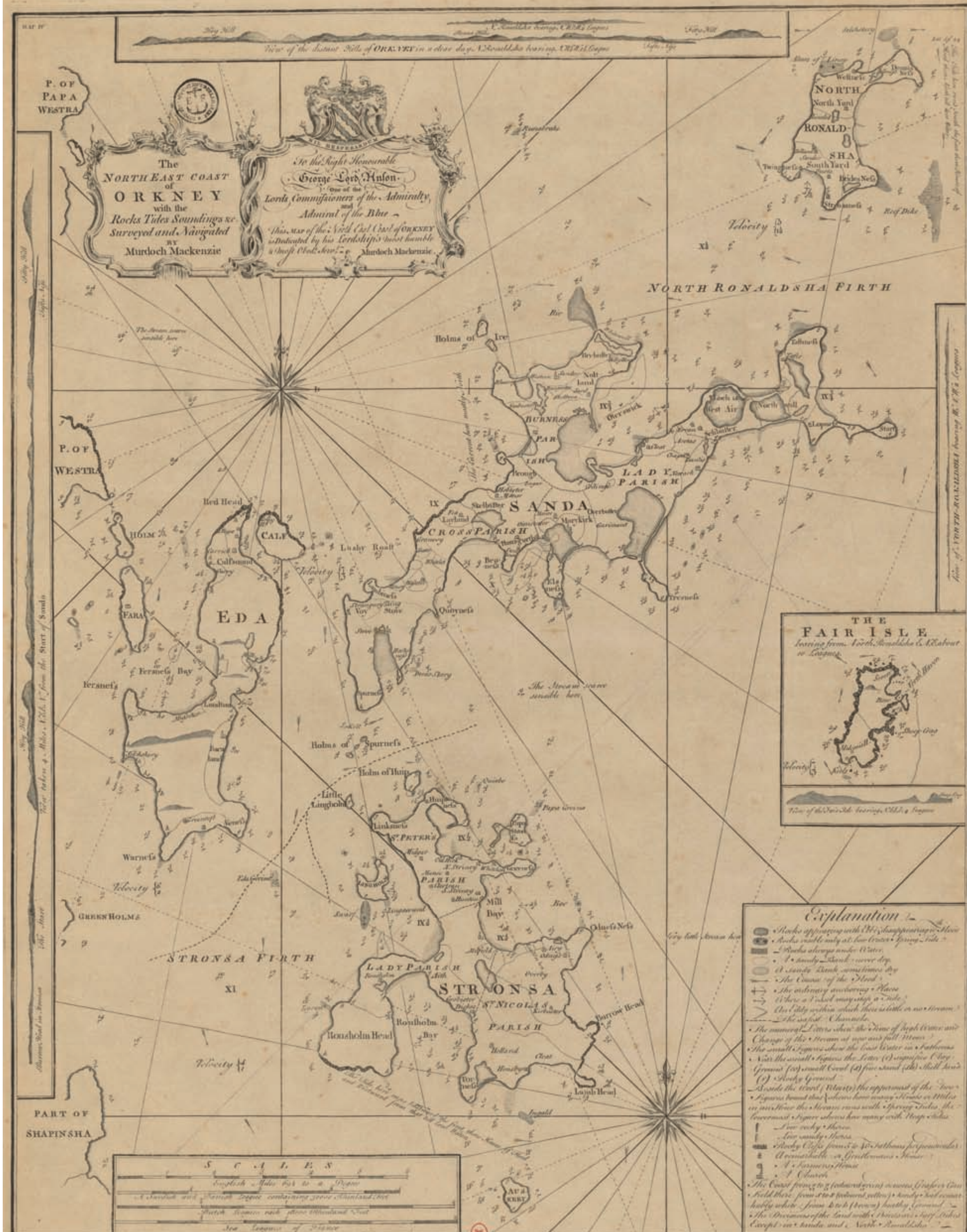
The NORTH EAST COAST of ORKNEY with the Rocks Tides Soundings &c. Surveyed and Navigated BY Murdoch Mackenzie
To the Right Honourable George Lord Anson. One of the Lords Commissioners of the Admiralty, and Admiral of the Blue.
This MAP of the North East Coast of ORKNEY is Dedicated by his Lordship's most humble & most Obed.t Serv.t Murdoch Mackenzie.
NIL DESPERANDUM
P. OF PAPA WESTRA
P. OF WESTRA
NORTH RONALDSHA
NORTH RONALDSHA FIRTH
SANDA
BURNESS PARISH
LADY PARISH
CROSS PARISH
Holms of Ire
Red Head
CALF
HOLM
EDA
FARA
Fersness Bay
Warness
GREENHOLMS
STRONSA FIRTH
STRONSA
LADY PARISH
St. NICOLAS PARISH
St. PETER'S PARISH
Mill Bay
Rousholm Head
Burrow Head
Lamb Head
Quoyness
Holms of Spurness
Little Linghold
AUSKERRY
PART OF SHAPINSHA
THE FAIR ISLE
Explanation
SCALES
English Miles 69½ to a Degree
Dutch Roomen each 18000 Rhinland Feet
Sea Leagues of France
Velocity

marine chart, from astronomical observations to soundings and also using magnetic declination and terrestrial triangulation to fix landmarks on shore. Whatever the omissions in his work, Mackenzie was the first hydrographer to speak out clearly for a method of trigonometric surveying to create a land-based "stasimetric" framework of fixed points from which locations on water may be determined (Mackenzie 1774, 65; Chapuis 1999, 115–17).

Another Scotsman, Alexander Dalrymple, had already published his manual on hydrography, *Essay on the Most Commodious Methods of Marine Surveying* (1771), in which he recommended using a reflecting instrument, Hadley's octant, for measuring horizontal angles less than 90° at a station. Only in the new edition of his manual (1786) did Dalrymple refer to the sextant for measuring horizontal angles (up to 120°), though it had been available at least since 1757 (Chapuis 1999, 118). Dalrymple explained the use of this instrument in the three-point fix method of resections and intersection survey by horizontal angular observations—called *arcs capables* in French—with a reflecting instrument, based on simple geometry (Chapuis 1999, 558–61). As Dalrymple himself explained: an observer at the point of sounding (position K in fig. 760) measures the horizontal angle between two fixed objects on land (A and B); this angle allows the observer to determine the circle on which A, B, and K lie. The observer measures simultaneously (without moving) the horizontal angle between fixed object A and a third fixed object (D), thus determining a second circle, on which A, D, and K lie. (In choosing A, B, and D the observer must ensure that they do not lie on the circumference of the same circle). The two circles intersect at two points, and a simple compass bearing is sufficient to determine which of the points is K (observer and sounding) (Dalrymple 1771, 5–7). Except for this last step, the unsophisticated compasses of the day were otherwise generally useless because of the magnetic errors.

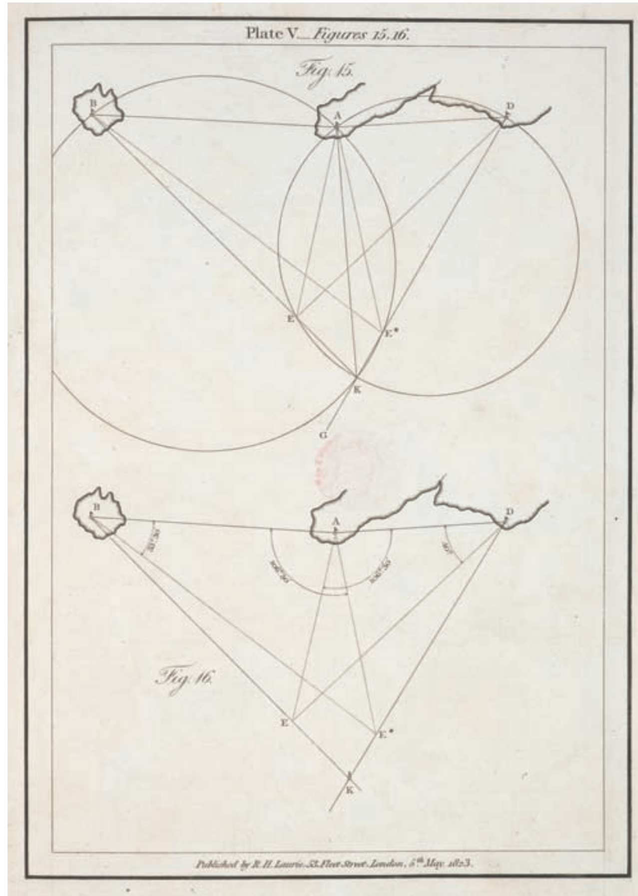

FIG. 760. ILLUSTRATION OF THE THREE-POINT FIX INTERSECTION METHOD OF MARINE TRIANGULATION. From the English translation of Charles-François Beautemps-Beaupré's treatise on nautical surveying: *An Introduction to the Practice of Nautical Surveying, and the Construction of Sea-Charts*, trans. Richard Copeland (London: R. H. Laurie, 1823), pl. 5, fig. 15.
© The British Library Board, London.

This geometrical process of fixing the location of a point on water with respect to known landmarks on shore is properly understood as marine triangulation. The method of the three-point fix intersection of two navigation circles using horizontal angles measured with reflecting instruments (quadrant, then octant, then sextant, then reflecting circle or new theodolite) offered a great advance in the position control of soundings. However, this resection method was limited by the extension into coastal areas of the network of fixed stations of higher-order land triangulation. Dalrymple had not himself developed the method that was already being used in land surveying; he credited the Reverend John Michell,

(*facing page*)
FIG. 759. MURDOCH MACKENZIE THE ELDER, *THE NORTH EAST COAST OF ORKNEY WITH THE ROCKS TIDES SOUNDINGS &C.*, 1750. One of eight plates in Mackenzie's *Orcades: Or a Geographic and Hydrographic Survey of the Orkney and Lewis Islands in Eight Maps*, the map shows marks and coastal views (with no mention of bearings) with fairways and best anchorages. Its large scale, ca. 1:65,000, allowed for a large number of soundings, though their accurate location may be doubtful, as the chart was made before the use of the three-point fix survey method of resections and intersection, the sextant, and the station pointer. Engraved map, published in London.
Size of the original: 77 × 53 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge SH 18 PF 28 P 34).

who had offered the three-point method in 1765 (Dalrymple 1771, 7–8; Chapuis 1999, 118, 558). Modern commentators such as hydrographer G. S. Ritchie found Michell's approach successful (Ritchie 1967, 23–24), although A. H. W. Robinson thought Michell was unable to solve this method of resections and intersection survey (Robinson 1962, 64). A limitation of this method was that plotting the three-point fix was cumbersome, involving the protraction of the line of position circles on tracing paper. In 1774 Mackenzie described for the first time an instrument, the station pointer (or three-arm protractor) (Mackenzie 1774, 24), which was probably developed by Mackenzie, his nephew Murdoch Mackenzie the Younger, and perhaps chiefly by their assistant hydrographer Graeme Spence (Fisher 1991, 122); certainly it was publicized by them (Robinson 1962, 64–70; Ritchie 1991, 17–18) (see fig. 517). This instrument allowed the three-point circle intersection to be plotted graphically, quickly and readily, essential during sounding operations where the quality depended on the density of data (fig. 761). Soundings that were tied into a triangulation scheme remained strictly limited to a small number of coastal areas in Europe and northeast North America (e.g., the impressive network of soundings in *The Atlantic Neptune* of J. F. W. Des Barres or those of James Cook) (Chapuis 1999, 121–23). The compass was sometimes still used on its own, without a reflecting instrument, for measuring horizontal angles. Thus, Dalrymple's brilliant idea was not actually put to use until the very end of the eighteenth century (Chapuis 1999, 117–20). Indeed, even in the latter half of the century, the trigonometric framework of the principal points of a marine chart, essentially land based, did not always guarantee that each sounding corresponded to an actual station point, determined by the three-point fix.

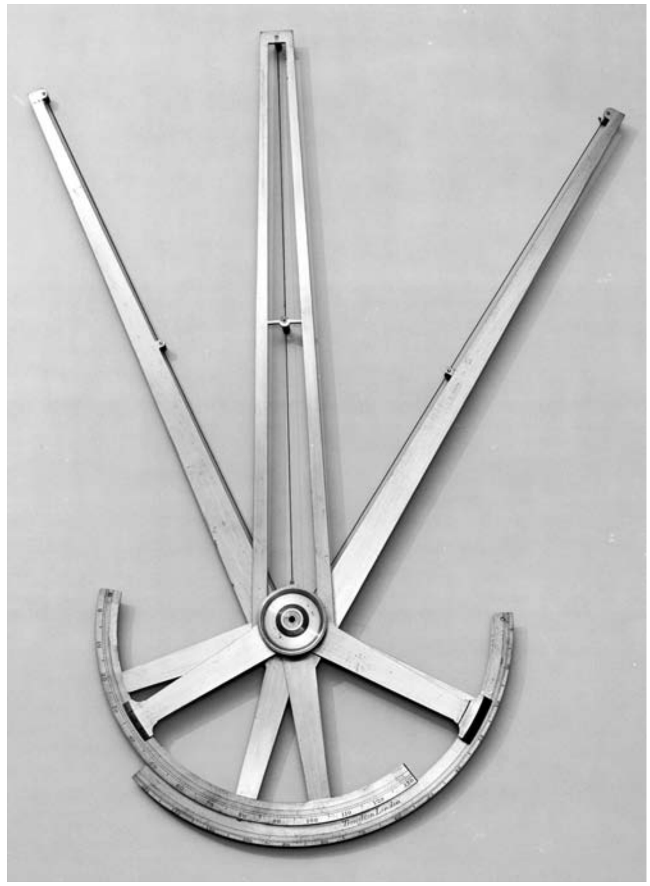

FIG. 761. STATION POINTER BY [EDWARD] TROUGHTON (CA. 1820). The instrument was used to facilitate the three-point fix method of marine triangulation. Brass; marked to 130°, vernier reads to 1′.
Size of the original: 4.0 × 4.5 × 25.0 cm. © National Maritime Museum, Greenwich, London (NAV0627.1). The Image Works.

Unlike Danish hydrographers, who began using land triangulation data in 1761 and benefited from the definition of the coastline, most other European hydrographers barely utilized established triangulation networks, which remained underdeveloped along the coasts. The French seemed incapable of going beyond the beach to apply to their sounding work the data from the large-scale (ca. 1:14,400) land survey carried out by the *ingénieurs géographes militaires* from 1771 to 1785 along the coast of Brittany (Chapuis 1999, 117–20), except in a few rare cases, such as Brest harbor, where exceptionally dense soundings were made (Chapuis 2007, 173–84). In Cherbourg the engineer, Jean-Baptiste Meusnier de La Place, a former assistant to Gaspard Monge at the École du Génie de Mézières, conducted a geometric survey at ca. 1:4,320 for the soundings, later reducing it to ca. 1:7,200 for the resulting chart (1789) with isobaths, a signal application of this technique (see fig. 363). The chart was included in the record of French ports produced during the reign of Louis XVI (Chapuis 2007, 262–63; Konvitz 1987, 98–99). In 1801–2, Charles-François Beautemps-Beaupré made his famous survey along the Flemish coast, positioning the very dense soundings with three-point fix method of circle intersection by horizontal angular observations with a Borda reflecting circle (see fig. 86). Published in 1804, Beautemps-Beaupré's chart also introduced an innovative color system for bathymetric classification, marking a significant transition between the two centuries with regard to soundings, their reduction using the closest possible observations of tidal graduated scales, and their control by connection to a land triangulation (Chapuis 1999, 552–54).

OLIVIER CHAPUIS

SEE ALSO: Beautemps-Beaupré, Charles-François; Dalrymple, Alexander; Engineers and Topographical Surveys; Heights and Depths, Mapping of: (1) Isobath, (2) Bathymetric Map; Instruments for

Angle Measuring: (1) Octant and Sextant, (2) Repeating Circle (Repeating Theodolite); Marine Charting: (1) Enlightenment, (2) France, (3) Great Britain; Navigation and Cartography

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Southern Continent. European perceptions of the landforms of the Southern Hemisphere were for long both hazy and derivative (Williams and Frost 1988, 1–26; Hiatt 2008, 65–223). Although the voyages of Vasco da Gama and Ferdinand Magellan had shown that the Indian Ocean was not enclosed by a great landmass as outlined in the *Geography* of Claudius Ptolemy, this knowledge failed to discourage belief in the existence of a southern continent. In the second half of the sixteenth century Abraham Ortelius's *Typvs orbis terrarvm* (1570) depicted a *Terra avstralis nondvm cognita* that occupied most of the temperate zone and whose northern extremities reached almost as far as South America, southern Africa, and New Guinea (Eisler 1995). Although there were always skeptics about its existence, this continent, "not yet known" (*nondvm cognita*), held the attention of cartographers and navigators until the late eighteenth century.

The Dutch explorations south of Java in the first half of the seventeenth century brought a new caution to cartographic representations of the region, and the circumnavigation of Australia by Abel Tasman in 1642–43, if at a distance, removed the possibility that the arid land known to the Dutch as New Holland was part of a vast southern continent (Schilder 1976, 139–87). Thereafter, the maps of cartographers such as Joan Blaeu and Frans Jacobsz. Visscher showed only what had been found, not what lay undiscovered, and they pushed the conjectural landmass back at least as far east as the isolated stretch of New Zealand coastline that Tasman had sighted (Schilder 1988, 102, 104–5). However, juxtaposed with the disheartening discoveries made by the Dutch was a continuing hope that somewhere in the southern stretches of the Pacific Ocean lay, in the words of William Dampier, who twice touched on Australian shores, "some fruitful Lands, Continent or Islands, or both" (Dampier 1709, 3).

The publication between 1694 and 1709 of the Dutch explorations and of Dampier's voyages led to the steady increase of interest in the southern continent in the first half of the eighteenth century. Utopian visionaries and social satirists set extraordinary lands and societies in the region they vaguely identified as *Terra australis* (Fausett 1993), while geographers offered a strange mixture of the real and the imagined. Recognizing that New Holland was probably of continental extent, but could not be the legendary *Terra australis*, they concluded that there must be two southern continents. The one comprised New Holland and its adjoining lands; the other, of which New Zealand was the western extremity, remained to be found. French and British geographers rivaled each other in brightening the somber image of New Holland left by the Dutch explorations. In 1714, Guillaume Delisle produced a *Hemisphere meridional* (fig. 762) to illustrate his thesis of a gigantic Australian continent that perhaps stretched as far east as Espiritu Santo (Vanuatu), discovered by Pedro Fernández de Quirós in 1606. In England, John Campbell in his collection of voyages of 1744–48 described an enlarged New Holland overflowing with riches, a vision illustrated by Emanuel Bowen in his *A Complete Map of the Southern Continent* (1744). In France in the same period, Georges-Louis Leclerc, comte de Buffon, and Charles de Brosses turned to the region farther south, where they postulated a continent as large as Europe, Asia, and Africa combined, whose discovery would rival that of America in importance. To support their ideas, Philippe Buache augmented his *Carte des Terres australes* in 1754—a map in which he had shown the island speck sighted by Jean-Baptiste Charles Bouvet de Lozier in the South Atlantic in 1738 as the outlying "Cap de la Circoncision" of a great continent whose misty shape swirled around the map in imposing if ill-defined fashion (Broc 1974, 180).

After the Treaty of Paris in 1763, expeditions left Britain and France for the Pacific, with the search for the southern continent among their objectives. The Scottish hydrographer Alexander Dalrymple drew on French, English, and Spanish materials to advance the case for a continent, of which he hoped to be the first discoverer. He argued that *Terra australis* extended along one hundred degrees of longitude across the southern Pacific Ocean from near Juan Fernández in the east to Tasman's

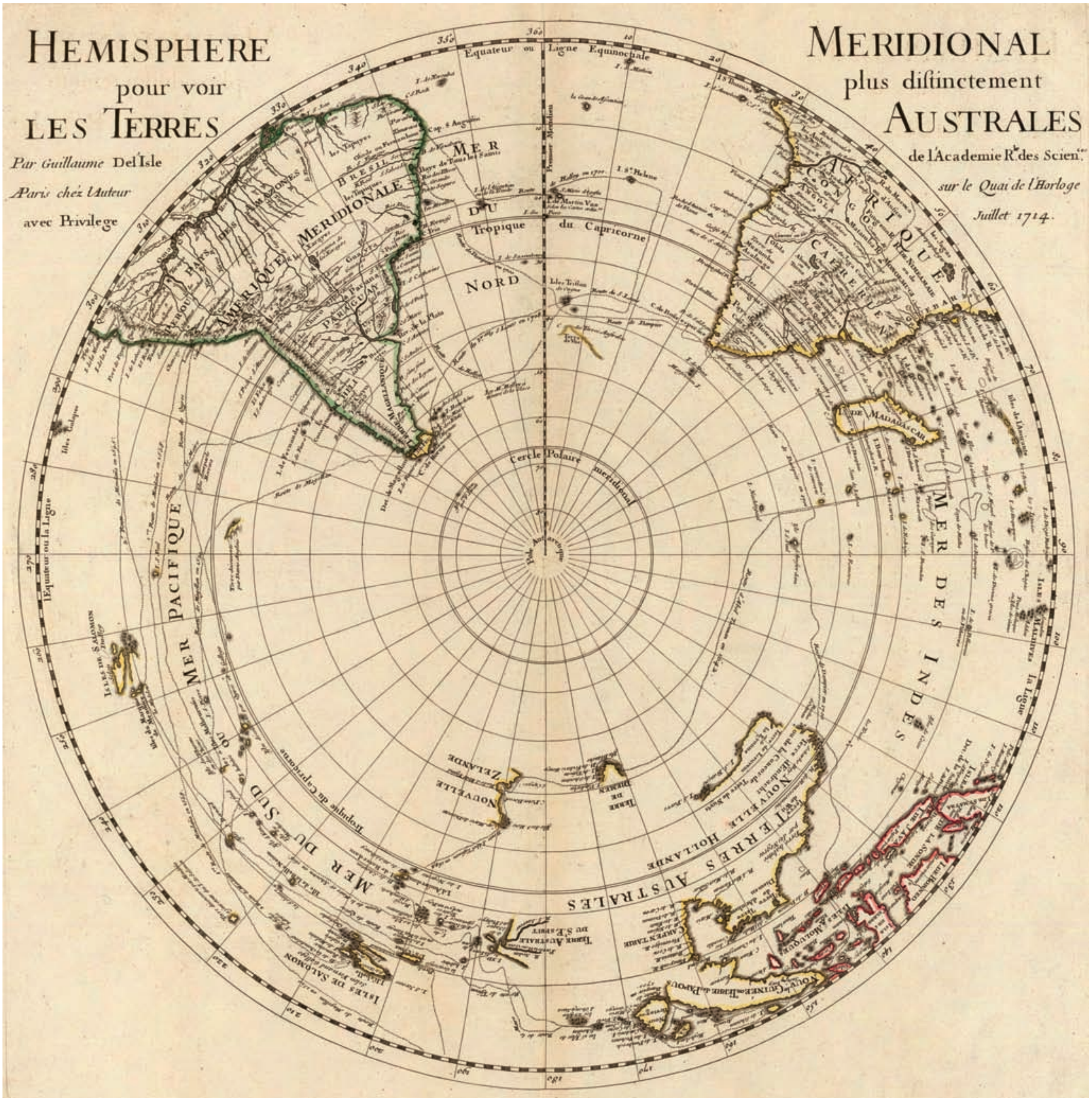

FIG. 762. GUILLAUME DELISLE, *HEMISPHERE MERIDIONAL POUR VOIR PLUS DISTINCTEMENT LES TERRES AUSTRALES* (PARIS, 1714). Guillaume Delisle, an important French cartographer of the early eighteenth century, produced this influential map that was reissued several times and was included in later work by Philippe Buache. The use of a polar projection sharpened the image of the south land revealed by the Dutch and Spanish expeditions, but it also brought to the fore the vast unexplored expanses of ocean in southern latitudes where a second, unknown continent might be hidden.

Size of the original: 46 × 46 cm. Image courtesy of the David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

New Zealand in the west. With a population of up to fifty million people, its trade would guarantee Britain's domination of the seas. All that was needed was an explorer of "*dauntless* and *perseverant* resolution" (quoted by Beaglehole 1955, cii–civ). Dalrymple's was the last major speculation about a southern continent, for his and other theories were now to fall under the dispassionate gaze of such a "dauntless" explorer as he had recommended—not himself as he had hoped but James Cook, who was to locate the east coast of Australia, chart the coasts of New Zealand, and in his oceanic sweeps toward Antarctica dispel the myths surrounding *Terra australis*.

GLYNDWR WILLIAMS

SEE ALSO: Geographical Mapping; Imaginary Geographies and Apocryphal Voyages

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Soymonov, Fëdor Ivanovich. Scientist, hydrographer, cartographer, and geographer, Fëdor Ivanovich Soymonov was born to a gentry family in 1692 in Moscow. In 1708 he entered the Moscow mathematics and navigation school, Moskovskaya matematiko-navigatskaya shkola. After graduating in 1713, he spent three years training in the Netherlands. Returning to Russia, he was made a midshipman and appointed to Peter I's flagship, the *Ingermanland*. In 1718–19, Soymonov, along with Aleksandr Bekovich-Cherkasskiy, Aleksandr Ivanovich Kozhin, Karl von Verden, and Vasiliy Alekseyevich Urusov, explored the Caspian Sea and produced a chart engraved in copper, *Kartina ploskaya Kaspiyskogo morya* (1720), with unusual speed (Postnikov 1996, 54).

Soymonov continued his surveys and studies of the Caspian during Peter I's Persian campaign in 1722–23 and subsequently as Astrakhan's hydrographer. In 1731, he published the first navigational atlas and sailing directions for the Caspian Sea, a publication that marked the beginning of specialized hydrographical work in Russia (see fig. 524).

Soymonov used survey methods he employed in the Caspian in his approach to charting the Baltic. Employing the results of Russian surveys and information from Swedish charts published in Swedish, Dutch, and English in 1696 in Amsterdam—already translated, revised, and published in Russian (1714, 1720, 1723) as *Kniga razmernaya gradusnykh kart Ost-Zee*—he produced an atlas of the Baltic Sea. *Svetil'nik morya* (1738), also called *Svetil'nik morskoy* or *Atlas Baltiskago morya*, was published by the naval academy, Morskaya akademiya, and contained eight Swedish charts, six new Russian charts based on his own surveys (fig. 763), and four charts from previous Russian surveys. This atlas and his short naval textbook on the art of navigation, *Ekstrakt shturmanskogo iskusstva iz nauk, prinadlezhashchikh k moreplavaniyu sochinënnyy v voprosakh i otvetakh dlya pol'zy i bezopasnosti moreplavateley* (1735), make him one of the founders of Russian scientific hydrography.

Soymonov rose steadily up the ranks. In 1730 he was made the Admiralteystv kollegiya's *prokuror* (supervisor), and in 1732 he became *ober-shter-krigs-komissar* (general quartermaster) of the navy. Leaving the navy for civil service in 1736, Soymonov was appointed the senate's *ober-prokuror* (senior supervisor) as a major general. In 1739, as the Admiralteystv's quartermaster and vice president, he ascended to the rank of vice admiral.

At the height of Soymonov's success, an act of court intrigue almost destroyed his career. In 1740, Soymonov was named as part of a palace plot led by Artemiy Petrovich Volynskiy. He was accused of high treason and sentenced to capital punishment. However, Empress Anna Ivanovna commuted his sentence to life in prison in Siberia. Soymonov served two years in Okhotsk, and on 14 March 1742, the new empress, Elizabeth, forgave him and permitted him to reenter the navy. From 1753 on he supervised a secret expedition to Nerchinsk, which charted and described the Amur River (Goldenberg 1966, 131–32). In 1757 Soymonov was appointed governor of Siberia, where he was noted for being a kind and fair administrator. In Siberia he founded navigation schools in Okhotsk and Nerchinsk (1754), as well as a school of geodesy in Tobol'sk (1758).

His reputation rehabilitated, Soymonov returned to Moscow in 1763 as senator, retiring in 1766 with the rank of *deystvitel'nyy taynyy sovetnik*, a civilian rank equal to a full admiral. His final scholarly achievement was a description of the Caspian Sea and of the Russian conquests there (*Opisaniye Kaspiyskogo morya i chinennykh na onom rossiyskikh zavoevaniy*, 1763) that brought together his lifetime of cartographic research. Soymonov died in 1780 in Moscow.

ALEXEY V. POSTNIKOV

SEE ALSO: Marine Charting: Russia

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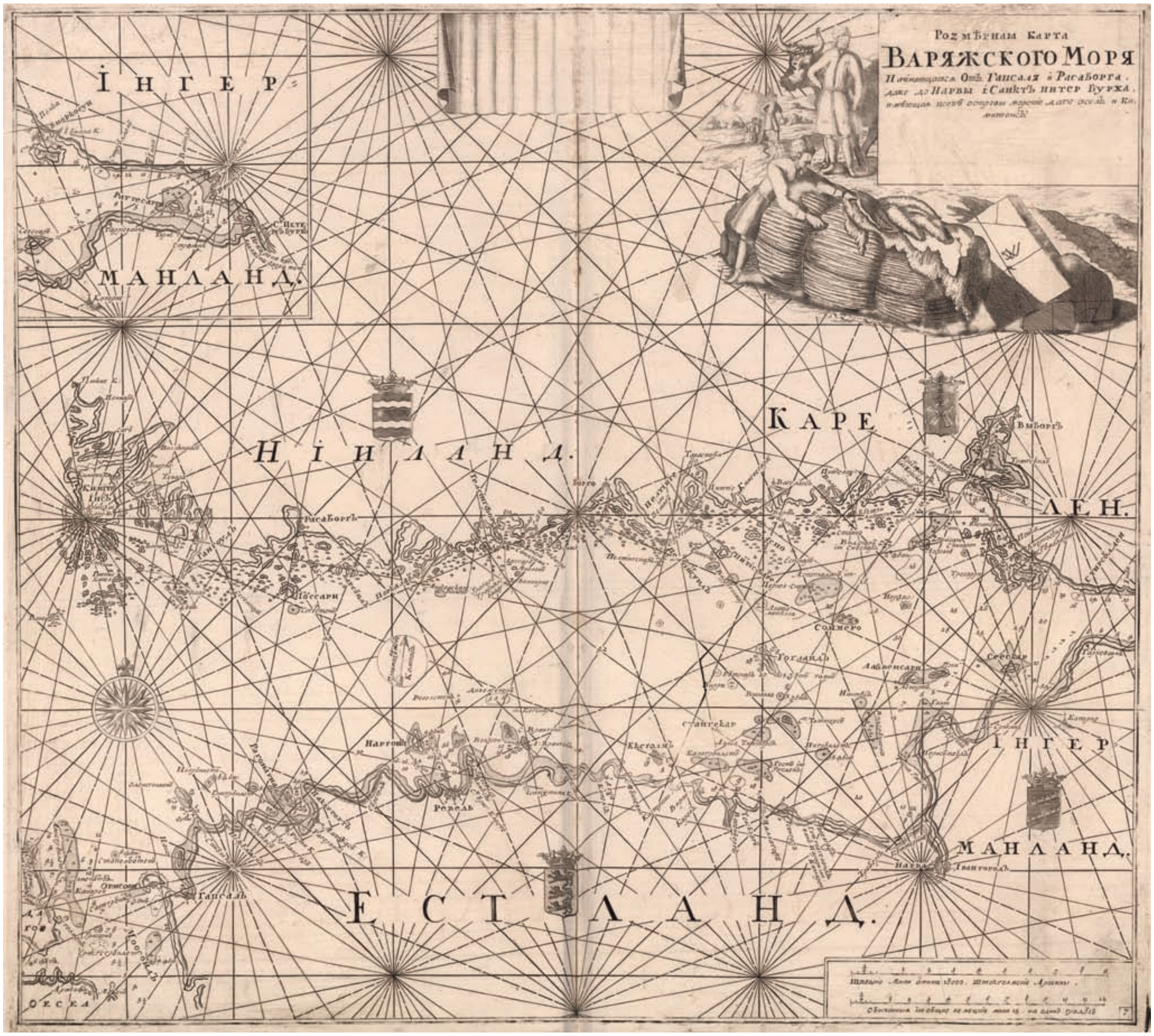

FIG. 763. SOYMONOV'S CHART OF THE GULF OF FINLAND, 1738. *Rozmernaya karta Varyazhkago morya* from Soymonov's *Svetil'nik morya* (also called *Atlas Baltiskago morya*) (1738), map 9.

Image courtesy of the Rossiyskiy gosudarstvennyy arkhiv voyenno-morskogo flota, St. Petersburg (F 1331/4/687).

Istoriya gidrograficheskoy sluzhby Rossiyskogo Flota (k 300-letiyu sozdaniya voyenno-morskogo flota). 1994–97. 4 vols. St. Petersburg: Glavnoye Upravleniye Navigatsii i Okeanografii Ministersva Oborony Rossiyskoy Federatsii.

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Spain. Spain's territory on the Iberian Peninsula remained largely unchanged from the period of the Renaissance (Buisseret 2007, 1070), its borders with France and Portugal firmly determined by treaties in the seventeenth century. In Europe, Spanish hegemony was exercised over the Southern Netherlands and in the Italian peninsula over the Kingdom of Naples, the Kingdom of Sicily, Sardinia, and the State of Milan. The year 1700 marked a profound change for the history of Spain as the Habsburg dynasty ended and the Bourbon dynasty began, bringing with it both the loss of control of the Southern Netherlands and the Italian regions, as well as great political change in the concept of monarchy, rules of government, and cartographic institutions. The famous *Nueva planta* decrees suppressing the local laws, jurisdictions, and institutions from the territories of the Crowns of Aragon, Valencia, Majorca, and Catalonia were instituted between 1707 and 1716. Their purpose was, on the one hand, to create a body of common Spanish laws, and, on the other, to establish a whole new administration.

This new idea of centralized power had long-lasting effects. The old peninsular kingdoms were to be governed in a new way and taxation would not respect local privileges. In order to fix a single tax, a cadastre or inventory of wealth and population was required. Between 1750 and 1754 a great cadastre under the direction of the minister Zenón de Somodevilla y Bengoechea, marqués de la Ensenada, sent a questionnaire with forty inquiries to city councils, villages, and towns in Castile. More than 13,000 different communities responded, producing an enormous body of information, including local and provincial maps. Although Ensenada's fall from power delayed the process, the Catastro de Ensenada was a landmark to which future Spanish cartographic projects would be related.

The second half of the eighteenth century was further influenced by the foundation of a number of academies that affected cartographic production: the Real Academia de Bellas Artes de San Fernando (founded by royal decree of 12 April 1752, and reorganized by ordinances of 1757) offered opportunities to military and civil students to perfect their drawing and measuring skills; one of its graduates was the Spanish geographer Tomás López (fig. 764). Similarly, the Real Academia de Bellas Artes de San Carlos in Valencia (founded in 1768) trained potential architects, surveyors, and military personnel and offered certificates of proficiency. The 1750s and 1760s saw increased interest in architecture and urbanism with specific requirements for maps, an interest that remained important for the remainder of the century, and as with other European monarchies, competition between civil and military institutions, between architects and engineers, was inevitable. The foundations of the Real Academia Militar de Matemáticas de Barcelona (1716, opened 1720) and the Cuerpo de Ingenieros Militares (1711) were noteworthy for providing facilities for students to study topography, geography, and mapping. In 1717 the Academia de Guardiamarinas was established in Cádiz, for which Jorge Juan, a key figure in the modernization of Spanish science and member of the Royal Society of London and the Real Academia de la Historia in Madrid, designed a new syllabus and wrote new books including advanced mathematics.

The result was that cartography based on advanced calculus and nautical astronomy was put into practice from the 1770s in Spain and Spanish America through scientific expeditions and war. For example, José Solano organized a cartography cabinet in his fleet to improve navigation in the Caribbean during the American Revolutionary War (1775–83). Between 1783 and 1788, a Spanish maritime atlas was being prepared by a team of naval officers trained in trigonometry under the direction of Vicente Tofiño de San Miguel. This team mapped the entire Iberian Peninsula and produced maps of ports, cities, and coastal views. The resulting *Atlas marítimo de España* (1789) was celebrated by learned societies and scientific institutions; its success heralded the foundation of the Dirección de Hidrografía in Madrid in 1797, a research institution aimed at publishing maps of the entire world through its extensive network of correspondents in the Americas.

The *Atlas marítimo* was an important step toward the fabrication of an accurate map of Spain, not fulfilled until the nineteenth century. Another logical step toward this objective was the foundation of a corps and a school of civil engineers for roads and canals in 1802 by Agustín de Betancourt y Molina (later founder of Russian civil engineering) and the Mexican-born José María de Lanz. Nevertheless, the lack of a state-supported academy of sciences (the building of the Museo del Prado was planned for that purpose) and the slow development of a civilian cartography took their toll. The policy of royal support for the education of technicians, as in France or England, was replicated only intermittently in Spain; the lack of trained cartographers or engravers and the weakness of professional communities hindered long-term projects. Large-scale topographical mapping was created primarily by military engineers, in concert with civil architects and local land surveyors, focusing especially on hydraulic improvements (e.g., canals, urban water supply).

The boundaries of Spain itself remained relatively constant throughout the eighteenth and early nineteenth centuries. The long wars with Britain (1701–13, 1739–42, 1761–63, 1779–83, 1796–1802, 1804–8) and three French invasions with two wars in 1794, 1808, and 1823 caused terrible human losses and mass destruction; while they produced a long and deep political crisis, they hardly changed the national boundaries. The Treaty of Utrecht (1713) confirmed the British capture of Gibraltar, from then a colony on Spanish soil with disputed boundaries. The so-called "natural limit" with France in the Pyrenees was established in 1659; despite significant surveying done by the Comisión Hispano-Francesa de Límites (Caro-d'Ornano Commission) (1784), the interruptions of the French Revolution and following decades of instability meant that the boundary was not set down on the terrain until 1868. Only the so-called War of the Oranges with Portugal in 1801 changed the Extremaduran boundaries in Spain's favor:

FIG. 764. TOMÁS LÓPEZ, *MAPA GENERAL DE ESPAÑA*, 1802. Map in four sheets from the *Atlas geográfico de España*, 2d ed. (Madrid, 1810) by the same author. Size of the original: 82 × 100 cm. Image courtesy of the David Rumsey Map Collection.

Olivenza and two more villages changed hands, and the limit was established once and forever along the Guadiana River.

MANUEL LUCENA GIRALDO

SEE ALSO: Academies of Science; Administrative Cartography; Boundary Surveying; Celestial Mapping; Geodetic Surveying; Geographical Mapping; Map Collecting; Map Trade; Marine Charting; Military Cartography; Property Mapping; Spanish America; Thematic Mapping; Topographical Surveying; Urban Mapping

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Spanish America. Between 1700 and 1800 the Americas underwent a profound transformation, the order and scale of which continue to be a matter of debate, but the independence of the United States, the Haitian revolution, and the consolidation of colonial reforms in Mexico and Brazil were as much the result as the cause of it. Interactions between the two shores of the Atlantic, the growth and mixing of populations, the foundation of scientific institutions and newspapers, and the formation of public opinion on a hemispheric scale all represented the spirit of the age in which both Americas participated.

Similarly, cartography in Spanish America also changed dramatically. Baroque-style, courtier-produced, ecclesiastically oriented, topographically naïve, and pre-Newtonian mapping was replaced by an enlightened, civil, and scientifically oriented Newtonian approach and methodology (fig. 765). The Spanish Empire in the Americas was hardly a dark and isolated confine; rather, it supported commerce in publications of printed books and maps with few restrictions. Scientific instruments, although very expensive and scarce, arrived in remote places, from Louisiana to the Philippines, and in both Americas, from Chile to California. The strong political impulse in Spanish America compared sharply with the stagnation of recent decades, or even centuries, as the minister of the Indies, José del Campillo y Cossío, wrote in his "Nuevo sistema de gobierno económico para la América" (1743; published in 1789). The unification of laws and jurisdictions in the kingdoms of the peninsula was complete, but a push for similar reform programs throughout the empire posed difficult challenges. The Spanish Empire was still a composite monarchy, comprised of aggregate kingdoms of varying customs and manners. Both New Spain and Peru, powerful viceroyalties since the sixteenth century with two capitals and courts in Mexico and Lima, were in essence a network of cities, villages, and towns populated by Spanish, mixed races, African descendants, and natives. Open frontiers were more or less controlled. General captaincies, such as Guatemala, Chile, or Venezuela, roughly situated between viceroyalties, enjoyed great autonomy (see Elliott 2006, 354, for a reference map). Yet in the process of implementing new policies, old kingdoms were converted into new provinces. Each one became an intendancy (*intendencia*), a political institution administered (not governed, because government and administration at least in principle were in the process of separation) by an *intendente*. This all-too-powerful bureaucrat was seen frequently by Spanish American Creoles as ignorant of the true nature of the New World and by those supporting change as a professional devoted to the improvement of taxation and defense in the service of the king. *Intendentes* represented the centralist policies in their most precise form. Most of them came from technical corps of military engineers or the officer corps of the navy or army. They well understood that mapping and the gathering of statistical data were required for the success of their task.

Not surprisingly, the most evident result of the reforms in Spanish America was the foundation of two new viceroyalties, New Granada (1739) and Río de la Plata (1776). Although military reasons dictated the dates of creation—the first at the beginning of the War of Jenkins' Ear between Britain and Spain (1739–48), the second in the middle of a war with Portugal (1775–77) and Great Britain (1779–83)—the political debate concerning reorganization of colonial territories lasted a long time. The Viceroyalty of New Granada, with its capital in Santa Fé de Bogotá, was established first between 1719 and 1721, and then again in 1739, with the aggregation of the governments of Quito, Panama, and Venezuela. The British tried to assault Cartagena, the most important Spanish city in Tierra Firme, in 1741. They were so confident of victory that coins were struck, ready for use when the city surrendered. A dramatic siege of three months ended in British defeat, and Spain learned important lessons. This vital port had to be sustained by updated military and political structures. New Granada was the key to the Indies in the Caribbean and the most important gold producer. From then on, the Real Armada maintained an improved *apostadero* (naval station) with cartographic facilities in Cartagena. After the foundation of the Consulado de Comercio in 1795, a nautical school was established there and important hydrographical expeditions improved the cartography of the region.

In Quito, the foundation of the Viceroyalty of New Granada was received with a mixture of distrust and obedience. This capital city full of lawyers and friars feared, with good reason, that their own captaincy would lose its traditional autonomy, situated between the old decadent Viceroyalty of Peru in the south and the emergent New Granada in the north. A stagnant economy added to their strategic worries, fears that proved correct. In 1802 the government of Mainas was transferred from Quito to Peru on the presumption that control of the region and the frontier war in the Amazon with the Portuguese would be better controlled from Lima.

To the north of New Granada, Panama was a territory in decline, having lost the old monopoly trade and routes. Venezuela, however, was on the rise. In 1777 it became a unified general captaincy, through the addition of Maracaibo, Guiana, and Cumana, and the islands of Trinidad and Margarita to the government of Caracas; the year before, it had become an intendancy. In 1786 it was founded as an *audiencia* or high tribunal, and in 1793 as a consulate of trade. The wealth of Venezuela from cacao and its strategic importance to the Caribbean Windward Islands explain these administrative

FIG. 765. JUAN DE LA CRUZ CANO Y OLMEDILLA, *MAPA GEOGRÁFICO DE AMERICA MERIDIONAL* (MADRID, 1775). Paper, printed, eight sheets, ca. 1:4,000,000. This map was based on the boundary survey work of José Solano and his team in the middle and upper Orinoco River. Cano y Olmedilla not only used the observations and measurements from the survey team, but also indigenous information gleaned by Solano via his friendly relations with the inhabitants of the area. Engraved by Cano y Olmedilla; the letters printed and engraved by Hipólito Ricarte in 1771. The map includes "Notes for the understanding of this map." There was a London edition in 1799, printed by William Faden.

Size of the original: 220 × 162 cm. Image courtesy of the David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

changes. But its geographic location held dangers: the prevailing winds and currents translated into a permanent threat of attack by the British. The Spanish Caribbean was difficult to defend without massively fortified positions and a costly navy. Havana (with an important shipyard and navy depots), Cartagena, Puerto Rico, Maracaibo, and Puerto Cabello in Venezuela all maintained naval stations. Although Spanish support of the American rebels in the American Revolutionary War was organized from the Caribbean with great success, the last decade of the century was a disaster. In 1795 Spain ceded the island of Santo Domingo (Hispaniola) to revolutionary France, after losing the War of the Pyrenees. In 1797 after an attack by a superior British fleet, Trinidad in eastern Venezuela had to be abandoned. The enemy fleet then attacked Puerto Rico but was defeated.

The same entanglement of political and strategic considerations determined territorial changes in the south of the continent. The Viceroyalty of Río de la Plata, its capital in Buenos Aires, was established by Pedro Antonio de Cevallos, the first viceroy, in 1777. His expedition recovered the colony of Sacramento from the Portuguese and other territories in what is now Uruguay, including the governments of Buenos Aires, Paraguay with Uruguay, Tucumán, and Santa Cruz de la Sierra, and the districts of Cuyo and Charcas. The changes in the southern part of the continent reflected the century's trend of transferring power and wealth from the Pacific to the Atlantic. Lima and Panama lost to Buenos Aires, a city of traders and smugglers linked to the Atlantic economy. The key element in the creation of the viceroyalty was the transfer of Charcas, or High Peru, from Lima to Buenos Aires. Although the production from the mines of Potosí and elsewhere was small compared to the previous century, their loss accentuated the sense of isolation and crisis in Peru after 1776. The possession of Charcas symbolized the growing importance of the Viceroyalty of Río de la Plata and its well-situated naval station in Montevideo. From there, the occupation of the Malvinas Islands (Falklands) in 1766 was partly organized, as was the expedition to take possession of Annobón and Fernando Póo in Spanish Guinea, after the preliminary Treaty of San Ildefonso (1777) was signed with the Portuguese.

It can be argued that the General Captaincy of Chile lived in isolation during most of the eighteenth century, but much of the autonomy of this old kingdom also served the new imperial policies. Indian frontiers were more or less respected through agreements (or *parlamentos*) with the natives, especially the fierce Araucanians, who even had their own ambassadors in Santiago. The Spanish never crossed south of the River Bíobío; natives periodically received presents and favors, but no other Europeans were allowed to settle between there and Cape Horn under any circumstances (Levaggi 2002, 103–59).

Further north, two new administrative regions were planned by 1760: New Biscay in Mexico with a possible capital in Durango and Guatemala with a capital in Santiago. As with the creation of the Viceroyalty of Río de la Plata, these two helped shape a vision of the Spanish Empire in America with priority placed on the control of frontiers between cities and the reorganization of defense. An interior continental New World was emerging whose geographical maps were no longer filled with serpents or gigantic lakes but with the Provincias Internas. The case of the Viceroyalty of New Spain, simultaneously new and old, exposed the success and the limits of this vision. The Bourbon reformist policies proved to have strategic significance for the Spanish Empire. In 1766, José de Gálvez arrived in Mexico with full powers as *visitador* to organize taxation and militias. In 1767, the expulsion of the Jesuits definitely reduced the power of Creole cities and missionaries. When he returned to Spain and was appointed minister of the Indies, he supported the organization of twelve intendancies, according to the 1786 *ordenanza*: México, Puebla, Veracruz, Oaxaca, Sonora, Guadalajara, Valladolid, Guanajuato, San Luis Potosí, Zacatecas, Durango, and Yucatán. In 1776, the establishment of the Comandancia y Capitanía General de las Provincias Internas, commonly known as the Provincias Internas, its capital in Arizpe, best expressed the territorial power of the Mexican viceroyalty, by encompassing Sonora, New Biscay (Durango), High and Low California, New Mexico, and Texas and surroundings. The foundation of San Blas in 1767 presaged a network of missions in California and a "golden age" of explorations in Northwest America, which concluded after the Nootka crisis in Alaska in 1790. Ten years later more than half of the territory of what is now the United States belonged to the Spanish Empire, mostly in New Spain. Two territories were administered from Cuba: Spanish Louisiana (1763–1803), received from France as a compensation after the French and Indian War, and Florida (Western and Eastern), Spanish territory from 1700 to 1763 and again from 1783 to 1819, when it was finally acquired by the United States. The Captaincy General of the Philippines, a Mexican *entrepôt*, remained the Asian extension of the Viceroyalty of New Spain throughout the century.

Historiographical debate has not settled whether the Spanish Empire was defensive in this last century of its existence or whether it was a new kind of maritime empire, increasingly connected to the interior of the Americas (Elliott 2006). What is indisputable is that from its origins in the 1500s until its decline in the 1800s, its political structure can be properly understood only through its maps and the evolution of its cartographic institutions.

MANUEL LUCENA GIRALDO

SEE ALSO: Administrative Cartography; Boundary Surveying; Geographical Mapping; Madrid, Treaty of (1750); Property Mapping; Topographical Surveying; Urban Mapping

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Statistics and Cartography. The term "statistics" is used here in the modern sense: gathering and using quantitative data to produce insights at a level of abstraction that goes beyond the data themselves. At the very least this process requires an aggregation of data but oftentimes involves additional arithmetic methods. However, the development of advanced mathematical statistics, especially probability calculus, is not considered here because it did not become politically relevant before the nineteenth century and therefore did not have any connection with cartography.

With this modern meaning, the term *statistics* was only used from the end of the eighteenth century, replacing *political arithmetic*. The term *Statistik* originated in Germany, where it had previously denoted descriptions-of-state in textual form that contained little quantification. This has led to the mistaken belief that statistics in the modern sense did not exist in the eighteenth century. This false notion is supported by the fact that statistical bureaus, which produced printed statistics, were not founded until the beginning of the nineteenth century. Although the latter development marks an important caesura for the sources available to economic and social historiography, numbers and calculations had in fact already played an important role in political thought and action during the second half of the eighteenth century. This is especially true for France and Germany, where statistics and cartography became most notably intertwined during this period.

ORIGINS OF STATISTICS IN EUROPE The origins of statistics as an idea and practice of private scholars can be dated with some precision to the 1660s. However, the political implementation and simultaneous wider dissemination of statistics began only a hundred years later. Two factors shaped its theoretical inception as well as its later implementation. They were both based on the increasing domestic consolidation of and competition among European states.

The first factor was the growing registration by governments of their fiscal and military resources in the form of tax lists, tariff registers, conscription lists, and other records. The generation of such information was abetted by the increasing demand for resources and the concomitant desire for a comprehensive and efficient system of taxation. However, such information gathering did not yet constitute statistics in the modern sense of the word since information collected in this way was not aggregated to create new insights and arguments for political designs or strategies. Rather, the data were used for concrete administrational measures in their specific local and factual contexts. Similarly, church registers, created by the confessional churches to monitor parish membership, did not have the quantitative aggregation of their data as a primary objective. Finally, seventeenth-century descriptions-of-state, although they sometimes featured detailed enumerations and descriptions of the resources of a country, generally contained few numbers and no calculations, since their diverse properties were not correlated.

The second factor was the emergence of *political economy*, a new theoretical perspective that conferred the logic of private business onto the state as a system whose economic and demographic factors interacted in both complex and dynamic ways—a system that could and should be managed by the prince. In the second half of the seventeenth century, early economists such as William Petty in England, Sébastien Le Prestre, maréchal de Vauban, and Pierre Le Pesant, sieur de Boisguilbert, in France, and Johann Joachim Becher in Germany all argued that if a country's government were to understand exactly how its demographic-economic system functioned, it could then proceed to make selective interventions that would aid growth and thus increase the state's resources. This idea differed from the concept of mercantilism, which in political practice dominated well into the eighteenth century. According to this idea, only the external balance of trade determined a country's wealth and power, denying the possibility of internal economic growth and focusing only on promoting trade and a few export industries. Therefore, the emergence of *political economy* encouraged a search for a more detailed knowledge of the complexities and dynamics of the domestic economy. *Political economy* was thus directly tied to the emergence of political arithmetic, whose early proponents (John Graunt, Petty, and Vauban), influenced both by seventeenth-century natural sciences putting empiricism and systematic methodology above received wisdom (the Royal Society) and by commercial accounting techniques, which from the early 1660s had attempted to quantify and calculate various demographic and economic factors and their relationships.

The political arithmeticians soon applied their aggregative and arithmetic methods to the aforementioned registers and lists originally created for administrative purposes. However, until the middle of the eighteenth century, this application only occurred as a (mostly private) scholarly practice in England (Gregory King, Charles Davenant, Edmond Halley), in France (Antoine Deparcieux), in Holland (Nicolaas Struyck), and in Germany (Johann Peter Süßmilch). The activities of these early statisticians were often guided by medical motives (smallpox inoculation) or for insurance purposes (life expectancy) (Rusnock 2002). Although a call for official data collection often accompanied these activities, governments hardly ever responded since they paid little attention to the concepts of political economy. Gradually, the Brandenburg-Prussian government began to pave the way by introducing cameralism, the German version of political economy, as a university subject in 1727 while, at the same time, gathering systematic data on population and the economy. Sweden followed with the so-called *Tabellverket*, an exhaustive demographic survey established in 1749. There were also some rudimentary attempts in France as well from around 1730 (*Enquête Orry*).

In the last third of the eighteenth century, triggered to some extent by the fiscal and economic damage of the Seven Years' War (1756–63), the related concepts of political economy and political arithmetic began to be accepted and implemented on a broad scale, especially in France and the German states. Here, systematic compilations and analyses of comprehensive data sets were used to assess economic and demographic resources and to take concrete measures to aid their development (Behrisch 2016a). The registers and lists that had been created earlier for administrative purposes often served as a primary basis for calculations and as starting points for the creation of more comprehensive data collections. In France, nationwide data collections were not feasible due to the sheer size of the country, so methods of collecting spot samples and extrapolation were devised and applied from 1772 (*Enquête Terray*). In England, where state intervention into the economy enjoyed less legitimacy, a population census was rejected by Parliament in the 1750s. However, both the royal government and Parliament did consult tariff registers and other economic data for decision-making purposes, a practice that intensified after the Seven Years' War (Hoppit 1996).

STATISTICS JOINS CARTOGRAPHY The concept of the state as a functional demographic-economic system that could be monitored and steered by the government was closely connected to the concept of a cohesive and homogeneous territorial space. This latter concept in turn underlay the development of state-run cartography projects beginning in the second half of the seventeenth century. Extending beyond context-specific land surveys, they aimed to depict the state as a whole. Therefore, it is not surprising that the development of cartography and surveying techniques were closely linked to the origins of statistics and that a similar chronological development may be observed.

The cases of Petty and Vauban demonstrate how the idea of a demographic-economic system related directly to the idea of a cohesive national space. Both men participated directly in the conception of a cohesive and measurable political space: Petty as conductor of the survey of Ireland after it had been subjugated by Oliver Cromwell (Down Survey, 1655–59), Vauban as intellectual father and founding engineer of the line of military fortifications encircling the perimeter of France after the conquests of Louis XIV. Almost simultaneously, Petty and Vauban developed comprehensive projects for counting and calculating demographic and economic data to serve as the basis for a standardized taxation policy as well as for active economic and population policies.

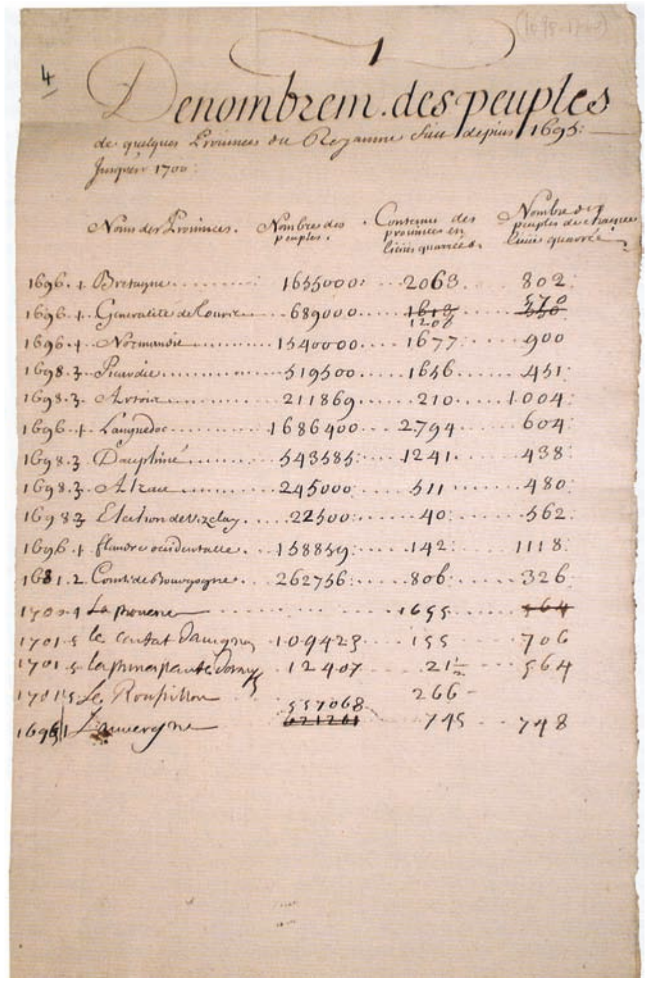
A doctor, mathematician, and economist, Petty coined the term political arithmetic in the title of an essay, written in the 1670s, addressed to the king, and published posthumously in 1690. In this and other publications, Petty advised the king to collect comprehensive quantitative data to provide a (supposedly) precise and objective basis for his taxation, economic, and population policies. Petty argued that in politics "Terms of *Number*, *Weight*, or *Measure*" should replace mere words and "intellectual Arguments" (Petty 1690, preface). As quantitative criteria replaced qualitative assessment, new functional units emerged as objects of governmental action. Hence, the population of Ireland was no longer to be differentiated on the basis of linguistic, religious, or historical criteria, but rather registered according to socioeconomic categories, which would henceforth guide concrete policies (Poovey 1998, 135 ff.). In his program, later refined into a quasi-totalitarian vision to annihilate

Irish identity, the ambivalent political potential of statistics first emerged. On the one hand, they furnished the power to make people more equal, on the other, the power to turn people and objects into predefined functional units, thus allowing and legitimizing outside intervention and control (Scott 1998).

About twenty years after Petty, but apparently independently of him (Reungoat 2008), the French military engineer Vauban, familiar with the art of surveying and mapping, conceptualized France as a cohesive space (the *pré carré*) in military, political, and fiscal as well as economic and demographic terms (Bitterling 2009). He advocated not only the cartographic description of the country, but also a census of the population and data collections on its agrarian productivity. In addition, he tried to accumulate data about the surface area of France and its various regions in order to extrapolate locally collected data for the entire country and to determine the relative population density of individual regions (fig. 766). In correlating geographic space with economic and demographic data, Vauban wanted to acquire detailed and differentiated knowledge allowing for systematic state intervention in the economy as well as an equitable distribution of the tax burden (Vauban 1992; Virol 2003, 139–50; Monsaingeon 2008).

Similar ideas emerged in Germany. As advisor to the dukes of Braunschweig-Lüneburg and later electors of Hannover, mathematician and philosopher Gottfried Wilhelm Leibniz repeatedly, from 1678, proposed surveying and mapping the entire territory as well as gathering data on the number, composition, and productivity of the population. Like Petty and Vauban, Leibniz devised a complex and dynamic demographic-economic system. If the state could collect and analyze various sets of data, it could easily solve numerous fiscal, economic, and infrastructural questions (Leibniz 1923–, I/2 [1927], 74–77, I/3 [1938], 30–33, IV/3 [1986], 340–49). A member of the scientific academies in Paris and London, Leibniz adopted ideas from the English political arithmetic as well as suggestions from France.

Although the comprehensive programs formulated by Petty, Vauban, and Leibniz were seized on by some of their contemporaries, they were not put into practice during the ensuing decades. In the meantime, however, during the first half of the eighteenth century, some countries produced accurately surveyed tax cadastres: starting with Western (Hither) Pomerania, the Swedish province on the German Baltic coast (1691–1709), then the seminal Milan cadastre (1718–33), and finally in Castile and in numerous German territories. Situated at the interface of cartography and tax registers, cadastres incorporated the first concrete fiscal implementation of the concept of a cohesive, homogeneous political space. Cadastral surveys encouraged the creation of accurately



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Denombrem.t des peuples de quelques Provinces du Royaume faits depuis 1695 jusqu'en 1700

Nom des Provinces.	Nombre des peuples.	Contenu des provinces en lieües quarrées.	Nombre des peuples de chaque lieüe quarrée.
1696. 1. Bretagne	1655000	2063	802
1696. 1. Generalité de Rouen	689000	~~1819~~ 1208	~~370~~ 570
1696. 1. Normandie	1540000	1677	900
1698. 3. Picardie	519500	1646	451
1698. 3. Artois	211869	210	1004
1696. 1. Languedoc	1686400	2794	604
1698. 3. Dauphiné	543585	1241	438
1698. 3. Alsace	245000	511	480
1698. 3. Election de Vézelay	22500	40	562
1696. 1. Flandre occidentalle	158859	142	1118
1681. 2. Comté de Bourgogne	262756	806	326
1700. 1. ~~La provence~~		1655	~~764~~
1701. 5. le Contat d'Avignon	109423	155	706
1701. 5. la principauté d'orange	12407	21½	564
1701. 5. Le Roussillon		266	
1695. 1. Auvergne	557068 ~~[illegible]~~	745	748

FIG. 766. "DENOMBREM.T DES PEUPLES," VAUBAN, 1701. Comparative table of population density in France by province from 1696 to 1701.
Archives du Château de Rosanbo, Lanvellec (260 AP 59, dossier 3, pièce 4). Image courtesy of Guillaume Monsaingeon.

surveyed territorial maps, but they also prepared the way for nationwide collections of economic and demographic data, both conceptually and practically. Even where cadastral data remained incomplete, as was often the case, they enhanced the sentiment that collecting comprehensive quantitative data was both necessary and possible.

The oftentimes very direct correlation between cadastres and statistical data collections may be seen in the commentary on a comparison of the tax systems of various European countries, undertaken by the French government and published in 1768. According to this commentary, the Savoy-Piedmont cadastre (1728–38) in particular not only allowed for a more equitable distribution of the tax burden, but also provided precise information on the distribution of the population and its consumption of foodstuffs, which in turn facilitated a better governmental subsistence policy (Bonney 1995, 74).

The relationship between cadastral surveys and data collections became especially apparent in the smaller German states around the middle of the eighteenth century. When the antiquated tax lists of Braunschweig-Wolfenbüttel were due to be improved and put on a more equitable footing in the 1740s, the principality's government first planned to survey all parcels of land. However, it was quickly recognized that this survey could be used for other purposes too; a general map of the territory could be prepared using the uniform and standardized surveying methods of the cadastral plans. Furthermore, quantitative information on natural resources as well as on the population and livestock could be gathered in the process. At the beginning of the 1760s, military engineer Johann Heinrich Daniel Gerlach was commissioned to assemble a general map based on the cadastral plans. By carrying out a few additional surveys, he also collected statistical information on population figures, population structure, and economic development in his desire to produce a quantitative description-of-state that would complete his map. Cartographic and statistical data collections were thus increasingly perceived as going hand in hand, because they could easily be gathered at the same time and the surveyed territory supplied the conceptual and referential framework for the statistical data (Fieseler 2013).

SURFACE AREA AND POPULATION DENSITY Thus, the interest in quantifiable data on population and economy had been closely associated with the idea of a cohesive political space from the start—the collection of such data often went hand in hand with the survey and the cartographic depiction of a state. The next step was to correlate those demographic and economic data with the surface area of the respective territories. In particular, the quantitative relation of surface area to population was increasingly viewed as an indicator of economic prosperity and even of the relative quality of political systems—as Charles-Louis de Secondat, baron de Montesquieu, had argued as early as 1721 in *Lettres persanes*, albeit without any firm data, in favor of "republican" constitutions.

Although Petty and Vauban already worked with surface area data, maps based on comprehensive land surveys were not yet available. Only the data collections, surveys, and cartographic publications that proliferated, especially in France and Germany, in the second half of the eighteenth century facilitated the systematic correlation between surface area and population figures and a broader discussion around them.

As part of his statistical endeavors, Petty (1690) compared the power and developmental potential of various countries on the basis of figures available to him, predominately based on estimates. When he realized that his data concerning surface area and population relegated England to second place behind France, he countered these figures with data on trade and economic activity, which improved England's status and, even more, that of Holland in relation to France (the surface area ratio of Holland to France was 1:8, the tonnage ratio, 9:1). A few decades later, Thomas Templeman (1729) listed the surface area of all European countries and their individual regions in great detail, arguing that it provided the fundamental criterion for the comparison of state power. They shared a desire to prove the superiority of England; however, neither could rely on accurate land surveys or censuses. Thus, Templeman's main source was Herman Moll's *Atlas minor*, a geographical work based on compilation, not actual survey. As the century progressed and no detailed data became available for England, no further development occurred—as indicated by the fact that Templeman's work was republished unaltered as late as 1776.

Vauban, for his part, conducted calculations on population density in France, not so much in order to compare nations but to compare the economic capacity and fiscal resilience of France's various regions. From the 1750s, French physiocrats, following Vauban and the English political arithmetic, correlated data on surface area and agrarian productivity, once again intended less to cast doubt on the economic superiority of England than to demonstrate the deficits of French agriculture and to point toward its possible intensification. Partly because of physiocratic reasoning, the second half of the eighteenth century saw an increased collection of statistical data in France; most prominently, the *Enquête Terray* (from 1772) determined the total population on the basis of local church registers. Population data alone did not yield any fundamental insights, however, as Antoine-Laurent de Lavoisier pointed out in 1772: "I would like to be told that in such and such a province, one square league of terrain has so many inhabitants, and that in another, a square league has only so many, and that the cause of the difference in the one is the kind of crop, in another, the fertility of the soils, . . . in another, the excessive taxes" (quoted in Brian 1994, 258). The successive appearance of sheets from the Cassini *Carte de France* allowed the *Enquête Terray*, from the early 1780s, to correlate population figures with accurate data on surface area and to calculate regional population densities, showing for example that Flanders was almost six times as densely inhabited as the Languedoc (Brian 1994, 286). The scope of such comparisons was restricted, however, since not all the sheets of the Cassini map were completed by the time of the Revolution.

In the German states, data collection on population and economy as well as cartographic surveying were fueled by the ideas and precepts of cameralism and conducted with great intensity during the last third of the century. The discussion about surface area and population data was especially acute. On the one hand, the small size of the German principalities often made it possible to carry out comprehensive data collection and cartographic surveys within just a few years; on the other hand, the proximity of the states led to a permanent exchange of technologies and ideas and increased economic competition and sharp comparisons between the states.

Geographer Anton Friedrich Büsching supplied a pivotal impetus for calculating and comparing data on surface area with his *Neue Erdbeschreibung*, fascicules of which were published from 1754. In this work, he offered detailed descriptions of all the countries of the world along with current cartographic data, which he employed to calculate the surface area of each country and which he updated for every new edition. This extensive and repeatedly published work rapidly became the most important and most highly regarded geographical work of the late eighteenth century both within and beyond the German-speaking world.

August Friedrich Wilhelm Crome took a further step in his 1785 work on the *Staatenverhältnisse* (proportions of states) of Europe (fig. 767). Crome correlated the surface area and population of each country, calling the resulting data on population density the "only true measure of the culture of all nations" (Crome 1785, preface). His work looked beyond the comparison of the sheer power of the states; his "measure," in fact, became an increasingly accepted indicator of the economic capabilities of a state and, consequently, of the relative success of its government. As early as the 1760s, functionaries of various principalities had used this measure to compare the prosperity of their own state to that of their neighbors as well as to determine the status of development of the individual regions of their territories. Apart from population figures, they also correlated data on economic development—the number of looms, for example—with territorial or regional surface areas. Crome's publication lent additional intensity and publicity to this discourse and provided an improved methodological foundation, as he discussed the cartographic sources extensively, assessing and comparing their differing information. Moreover, he always pointed out that the gathering of new data would necessitate repeated revision of his own calculations. Inspired by the publications of Büsching and Crome, scholars and state officials alike discussed these issues across territorial borders in journals and other publications, building further support for conducting surveys and advancing their publicity (Behrisch and Fieseler 2007).

The different development in England and on the Continent shows that the unfolding discussion about numbers depended to a considerable extent on governmental data collection. At the same time, as first shown by the example of Leibniz, statistical discourse during the Enlightenment was also shaped by intensive international exchange. Thus, German and French works in 1789 inspired an anonymous English author to specify the relation between population and surface area in various states and to compare their population density in his *Political Geography* (fig. 768). The author emphasized the preeminence of numbers over other criteria; in this way the comparison of colonial empires, among other things, no longer stemmed "from an imaginary picture traced by the pencil of fancy in all the glare of false colouring, but [is] exhibited in the sober garb of exact statement, backed with the irresistible force of arithmetical demonstration" (Anonymous 1789, 7). More than a hundred years after the invention of political arithmetic, statistical data had succeeded in shaping a new vision of space—a compelling vision, but a vision no more superior to other forms of perception than quantity is to quality.

LARS BEHRISCH AND CHRISTIAN FIESELER

SEE ALSO: Economy, Cartography and the; Irish Plantation Surveys; Thematic Mapping

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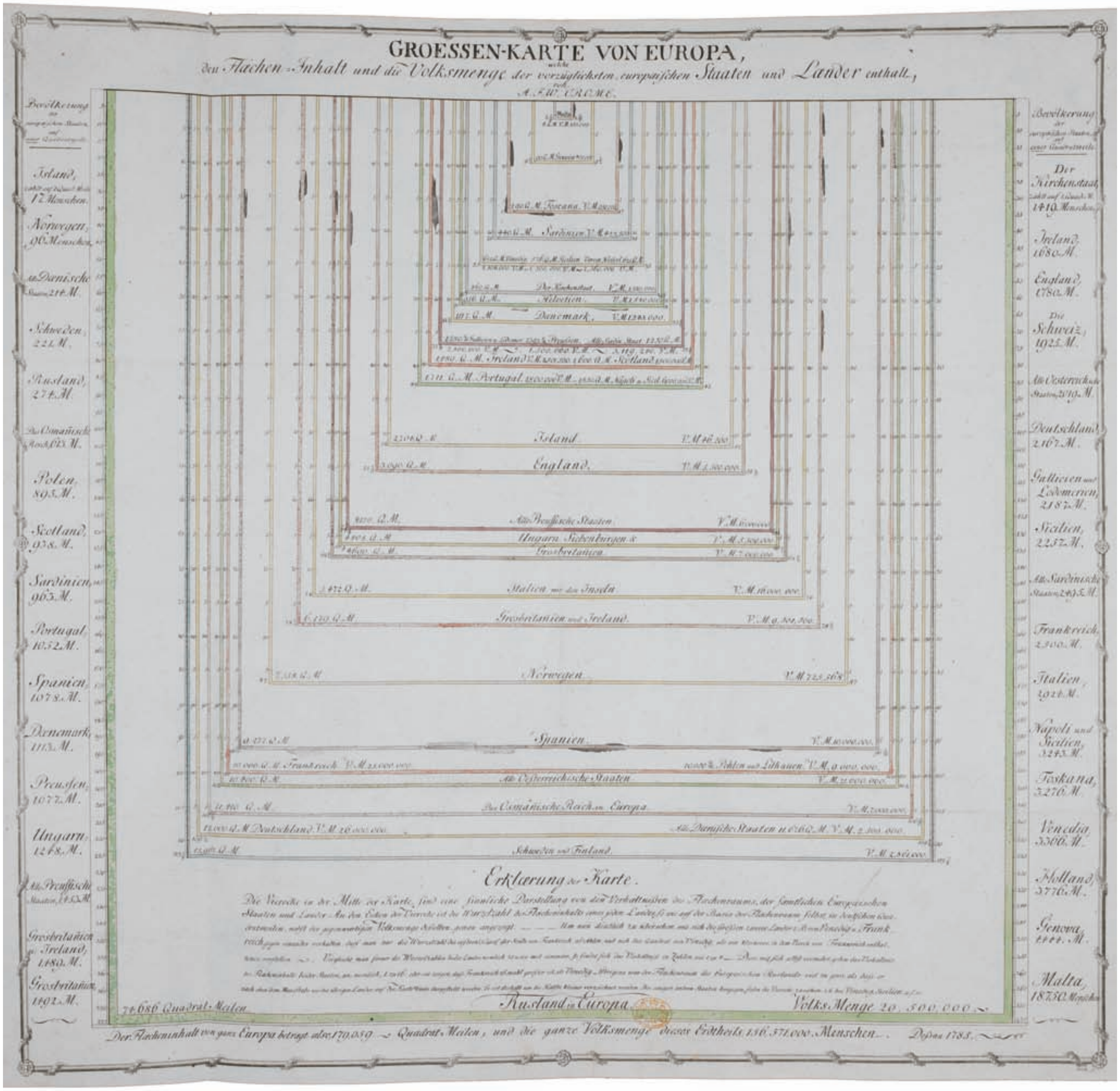

FIG. 767. *GROESSEN-KARTE VON EUROPA*, AUGUST FRIEDRICH WILHELM CROME, 1785. The *Groessen-Karte* is usually added to Crome's *Ueber die Größe und Bevölkerung der sämtlichen europäischen Staaten* (1785). This statistical map compares the states of Europe in proportion by size of land area and by population, from the smallest rectangle (Malta) to the largest (Sweden-Finland).
Size of the original: ca. 41.0 × 42.5 cm. © The British Library Board, London (Cartographic Items Maps K.Top.4.101-1).

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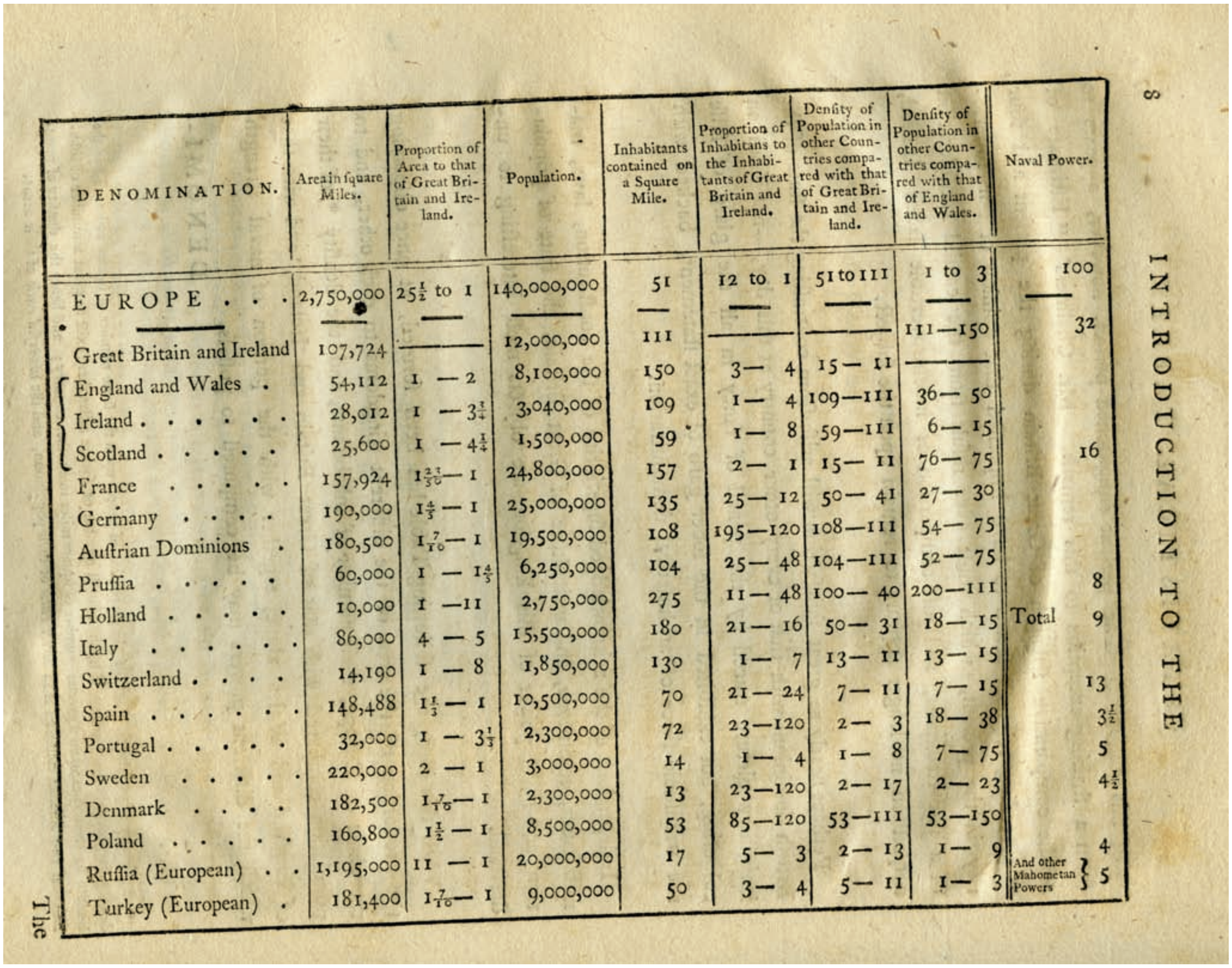

INTRODUCTION TO THE 8

DENOMINATION.	Area in ſquare Miles.	Proportion of Area to that of Great Britain and Ireland.	Population.	Inhabitants contained on a Square Mile.	Proportion of Inhabitans to the Inhabitants of Great Britain and Ireland.	Denſity of Population in other Countries compared with that of Great Britain and Ireland.	Denſity of Population in other Countries compared with that of England and Wales.	Naval Power.
EUROPE . . .	2,750,000	25½ to 1	140,000,000	51	12 to 1	51 to 111	1 to 3	100
Great Britain and Ireland	107,724		12,000,000	111			111—150	32
England and Wales .	54,112	1 — 2	8,100,000	150	3— 4	15— 11		
Ireland	28,012	1 — 3$\frac{1}{4}$	3,040,000	109	1— 4	109—111	36— 50	
Scotland	25,600	1 — 4$\frac{1}{4}$	1,500,000	59	1— 8	59—111	6— 15	
France	157,924	1$\frac{23}{50}$— 1	24,800,000	157	2— 1	15— 11	76— 75	16
Germany	190,000	1$\frac{4}{5}$ — 1	25,000,000	135	25— 12	50— 41	27— 30	
Auſtrian Dominions .	180,500	1$\frac{7}{10}$— 1	19,500,000	108	195—120	108—111	54— 75	
Pruſſia	60,000	1 — 1$\frac{4}{5}$	6,250,000	104	25— 48	104—111	52— 75	
Holland	10,000	1 —11	2,750,000	275	11— 48	100— 40	200—111	8
Italy	86,000	4 — 5	15,500,000	180	21— 16	50— 31	18— 15	Total 9
Switzerland	14,190	1 — 8	1,850,000	130	1— 7	13— 11	13— 15	
Spain	148,488	1$\frac{1}{3}$ — 1	10,500,000	70	21— 24	7— 11	7— 15	13
Portugal	32,000	1 — 3$\frac{1}{3}$	2,300,000	72	23—120	2— 3	18— 38	3½
Sweden	220,000	2 — 1	3,000,000	14	1— 4	1— 8	7— 75	5
Denmark	182,500	1$\frac{7}{10}$— 1	2,300,000	13	23—120	2— 17	2— 23	4½
Poland	160,800	1½ — 1	8,500,000	53	85—120	53—111	53—150	
Ruſſia (European) . .	1,195,000	11 — 1	20,000,000	17	5— 3	2— 13	1— 9	4
Turkey (European) .	181,400	1$\frac{7}{10}$— 1	9,000,000	50	3— 4	5— 11	1— 3	And other Mahometan Powers 5

The

FIG. 768. TABLE DISPLAYING THE PROPORTION OF THE AREA TO THE POPULATION OF DIFFERENT KINGDOMS. From the anonymous *Political Geography* (1789), 8. The table displays the proportions in relation to Great Britain and Ireland, and vice versa.
Image courtesy of the Library of Congress, Washington, D.C.

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Sveriges Lantmäteriet (Swedish Land Survey). During the so-called era of Sweden's greatness, 1620–1720, Sweden was geographically extensive but poor and sparsely populated and lacking in administrative resources, which caused difficulties for mapping and surveying. It did nevertheless create an effective national surveying organization, one of the first of its kind in Europe.

The Swedish land survey, Sveriges Lantmäteriet, which had become an organizational unit separate from Kammarkollegiet (treasury) by the 1650s, achieved some significant results in cartography in the seventeenth century, in particular, in 1643 it began the use of geometrical land books (*geometriska jordeböcker*) for improving taxation and geographic mapping (*geografiska mätningar*). In addition, surveyors made private surveys for the nobility (*frälse*). By the late seventeenth century there were about sixty surveyors in the realm of Sweden. This was not many, considering that Swedish Lantmäteriet covered not only Sweden and Finland but also the Baltic provinces and Swedish Pomerania. The difficulty of dealing with long distances was partly eliminated when the first county land survey offices (*länslantmäterikontor*) were founded in the early eighteenth century. The central survey office in Stockholm had by then become known as Generallantmäterikontoret (general land survey office).

Generallantmäterikontoret was, in comparison with its predecessor, a quite independent administrative unit. The introduction of a new remuneration system for the military and the civil service known as the allotment (the arrangement of paying wages in the form of land revenues) meant that surveying and mapping were a crucial element in this system (*indelningsverket*), as well as for the confiscation of land properties granted to the nobility known as the great reduction (*stora reduktionen*). Carl Gripenhielm was appointed as the first director of the national land survey in 1683, and he started an ambitious development project to give the survey a proper identity as a government office.

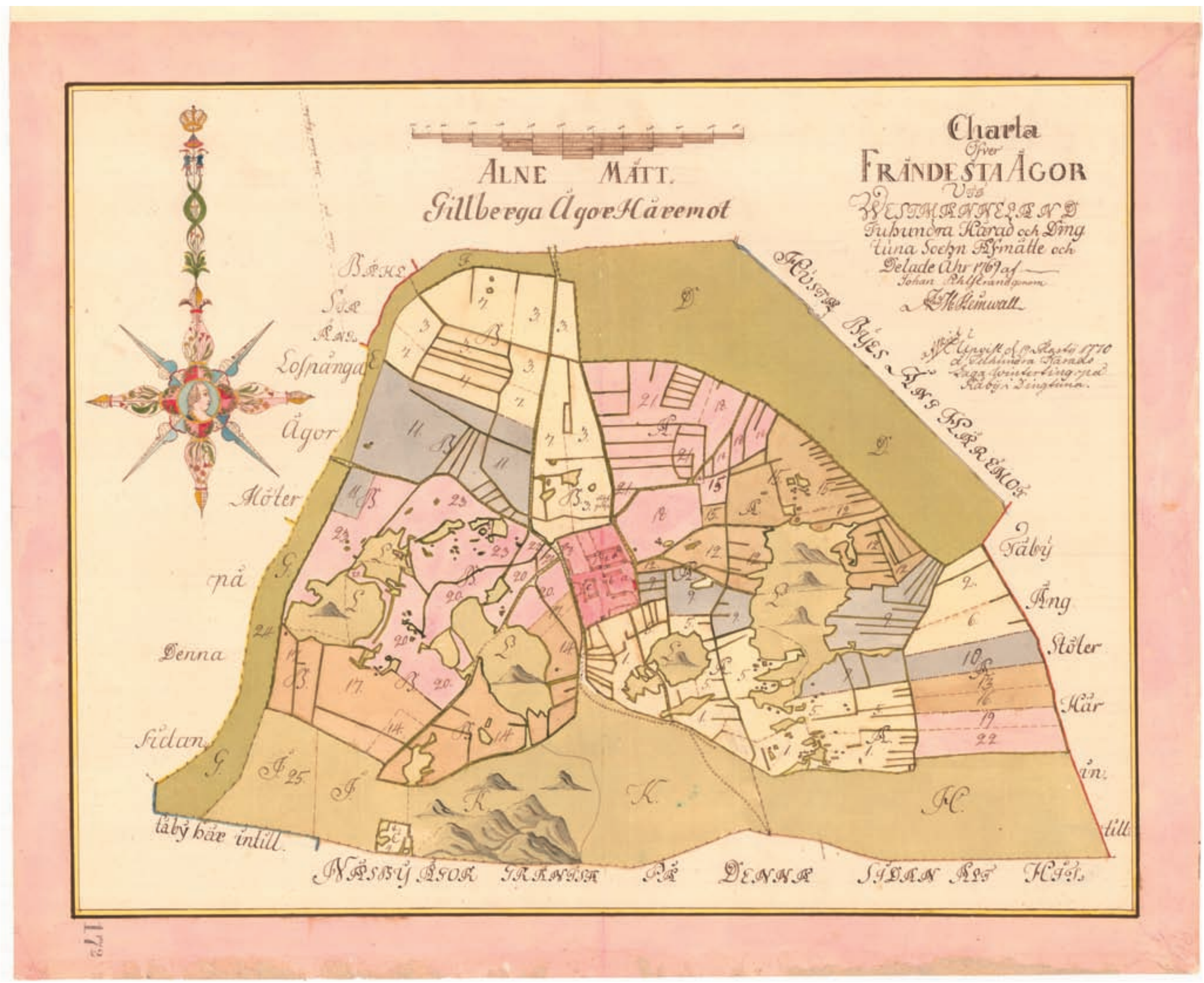

FIG. 769. "CHARTA ÖFVER FRÄNDESTA ÄGOR," BY ANDERS MAGNUS STEINWALL. At a scale of ca. 1:4,000, the map was drawn for the *storskifte* of 1769 following survey instructions of 1766. A different color is used for each of six farms; the areas of pasture and meadow surrounding the fields was not divided.
Size of the original: ca. 41.0 × 62.5 cm. © Lantmäteriet, Gävle (Dingtuna socken Frändesta nr 1-5).

Mapping and surveying work connected to the *indelningsverket* system and the *reduktion* became the focus of activities. The mapping of coastal waters to improve trade connections also increased. Gripenhielm produced a seminal map of the realm of Sweden in 1688 (see fig. 811), the first since Andreas Bureus's map of 1626. Surveying commissions were introduced, with dozens of authorized district surveyors, to carry out extensive legal surveys (*reduktion* and cadastral surveys in the Baltic and Swedish Pomerania). In addition, the corps of surveyors consisted of ordinary surveyors (*ordinarie lantmätare*) and, in their respective counties, extraordinary surveyors (*extra ordinarie lantmätare*). Only the ordinary surveyors were paid a regular salary. In the 1690s there were approximately eighty surveyors in Sweden (Bagger-Jörgensen 1928, 7–8; Huhtamies 2008, 115). The Great Northern War between Sweden and its neighboring countries (1700–1721) interrupted Gripenhielm's reform work: the surveying stopped, and the number of surveyors declined.

After the turbulent years of war, a significant connection between Swedish geodesy and the field of international science was forged by the Frenchman Pierre Louis Moreau de Maupertuis, whose survey expedition visited Lapland in 1736 and 1737. Swedish Lantmäteriet started to measure locations using new sophisticated methods (triangulations) and instruments (pendulum clock, zenith sector, and quadrant with telescope) donated by the French. The focus moved to geographical mapping near the Russian border. In the mid-eighteenth century, Finland obtained its own provincial land survey office.

A significant new era in the survey began in 1747, when Jacob Faggot, who had formerly worked as an inspector at Generallantmäterikontoret in Stockholm, was appointed director, and he recruited more staff. Faggot is best known as a fervent supporter of land consolidation, where jointly owned fields in an open field system (*tegskifte*) were consolidated into contiguous parcels of land (*storskifte*), giving the peasants full ownership of their land (Örback 1990, 131–32) (fig. 769). The process was therefore the opposite of the enclosure process elsewhere, as, for example, in England. The implementation of land consolidation was the most important task of the survey until the end of the eighteenth century; it transferred the focus from geographic surveys to cadastral surveys.

Privately financed geographic mapping started in the late eighteenth century (e.g., the Hermelin atlas [1799] included the first accurate maps of Sweden and Finland; see fig. 325). There were also military reconnaissance surveys commissioned by the Crown. There were approximately three hundred surveyors in Sweden at the end of the period.

MIKKO HUHTAMIES

SEE ALSO: Administrative Cartography: Sweden-Finland; Geodetic Surveying: Sweden-Finland; Property Mapping: Sweden-Finland; Sweden-Finland; Topographical Mapping and the State

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Sweden-Finland. Between 1650 and 1800, the Nordic countries were divided into an Atlantic realm and a Baltic one. The united kingdoms of Denmark and Norway faced west, increasingly so as they lost sole control in 1645–60 of the entryways into the Baltic: the Kattegat, Skagerrak, and the Sound (Swedish Öresund, Danish Øresund). Sweden and Finland had been linked since the mid-twelfth century, and in the early seventeenth century comprised the four provinces of Götaland, Svealand, Finland, and Norrland. Denmark and Norway ceded portions of what is now southern and western Sweden in a series of peace treaties in 1645, 1658, and 1660, although the northern frontiers remained undefined and were the subject of conflicts between Denmark, Sweden, and Muscovy; a precise delimitation of boundaries in the far north had to wait until the eighteenth century (Mead 2007, 1781–82).

During the seventeenth century, Sweden expanded at a speed that amazed the empires of Europe. As early as 1561, Sweden had gained a foothold in Estonia at Reval (Tallinn), laying the first stone of its Baltic empire. To stem the advance of the Muscovites to the sea, the Swedes fought back and concluded two successful treaties in 1595 and 1617. By adding Kexholms län and Ingria to the Swedish dominion, Russia was shut off from the Finnish Gulf. The dynastic quarrel within the Vasa family in Poland provoked the Swedes to go further on into Livonia, and in 1621 the important granary of Riga was seized. Sweden thus obtained control of the Düna (Daugava; Dvina) River and its outlet and in the following years the whole of northern Livonia. The conquests in the eastern Baltic were finally confirmed by the Peace of Oliva (with Poland) in 1660 and the Peace of Kardis (with Russia) in 1661. Sweden's participation from 1630 in the Thirty Years' War (1618–48) meant further additions of land. In the Peace of Westphalia in 1648, Sweden received Western Pomerania (Vorpommern) and a part of Farther Pomerania (Hinterpommern) with the city of Stettin (Szczecin), the islands of Rügen and Usedom, and the city of Wismar as enfeoffments under the Holy Roman Empire. This meant that Sweden had a seat and vote in the German parliament, together with the political possibilities that such participation might bring. The Swedish realm had realized its early goal of entering the war: to secure a strong presence on the Baltic coast, as seen in Carl Gripenhielm's manuscript map of Sueciae and Gothia of 1688 (see fig. 811). The Swedes could in that way confront an enemy in Germany instead of awaiting an attack on its long, and difficult to defend, coast. The customs receipts at the mouths of the rivers meant good income as well. Further west, Sweden received the areas of Bremen (except the city of Bremen) and Verden.

Denmark had originally held the leading position among the Nordic countries, but by the end of the sixteenth century, Sweden had become a formidable rival. The two kingdoms were more or less equal as maritime powers. But in 1637 the Danish king increased the customs fee for sailing into the Baltic through the Sound. This caused great resentment not only in Sweden but also in the Netherlands, and it resulted in these two countries entering into an alliance in 1640 with the goal of upholding free sailing and trade in the Baltic. In October 1644, a combined Dutch-Swedish fleet prevailed at the Battle of Fehmarn, thus demonstrating that the Danish fleet no longer ruled the Baltic. The following year the Danes were forced into peace negotiations, and the Swedes received Gotland and Ösel (Saaremaa) from the Danes and Jämtland and Härjedalen from the Norwegians. The two islands gave the Swedes harbors on their crossing to Livonia, and the two Norwegian provinces provided Sweden with a natural border to the west. Neither party thought this peace would last.

The Great Northern War (1700–1721) pitted Denmark-Norway, Prussia, and Russia against Sweden in an effort to end the Swedish *dominium maris baltici*, which had prevailed for half a century. Under the leadership of their young king Karl XII, Sweden initially knocked both Denmark-Norway and Russia out of the war, then moved vigorously across the Baltic to occupy most of the Polish-Lithuanian Commonwealth. Karl's armies battled Peter I far into Ukraine only to be defeated in the Battle of Poltava (1709), where they were heavily outnumbered and also victims of starvation and the Russian winter. After his army's surrender, Karl, a small number of his troops, and some allied Cossack troops managed to take refuge in Moldova in the Ottoman Empire, which was also at war with Russia. Karl spent five years among the Turks, attempting to form an alliance with the sultan but was eventually arrested by him and did not return to Sweden until 1714. Meanwhile, the Swedish army in Poland-Lithuania had retreated to the confines of Swedish Pomerania. Karl resumed the offensive against Denmark-Norway and was killed during the siege of Fredriksten in 1718. Battles continued on the eastern front, and the Swedish-Finnish mainland was repeatedly attacked by Russian ships. Peace finally came with the Treaty of Nystad (1721), which resulted in Sweden's loss of Ingria, Estonia, Livonia, and most of Karelia. In treaties in 1719 and 1720, most of the possessions in Germany were lost. A further war with Russia in 1741–43 resulted in Sweden's loss of yet more territory in southeastern Finland.

Shorn of her southern and eastern possessions, Sweden was much reduced, and would reach her current borders with the loss of Finland to Russia in 1809 and the remaining part of Pomerania in 1814. But her expansive years left a remarkable cartographic legacy, still to be seen in the archives, where thousands of manuscript maps of Sweden-Finland, the eastern Baltic, northern Germany, and Poland, and as far as the Black Sea testify to her imperial ambitions until the mid-eighteenth century.

ULLA EHRENSVÄRD

SEE ALSO: Administrative Cartography; Boundary Surveying; Celestial Mapping; Geodetic Surveying; Geographical Mapping; Map Collecting; Map Trade; Marine Charting; Military Cartography; Property Mapping; Thematic Mapping; Topographical Surveying; Urban Mapping

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Switzerland. Switzerland became independent from the German Reich de facto in 1499 after the Swabian War and de jure in 1648 by the Peace of Münster after the Thirty Years' War. The size of its territory did not change again between 1650 and 1798. Even today's borders deviate from those of 1798 only in a few cases. Before 1798, Valtellina, which is now part of Italy, was part of Switzerland. After 1798 the territory of the present-day cantons of Jura, Fricktal, and parts of the canton of Geneva were added to it. The Swiss Confederation (*Eidgenossenschaft*) was a union of states, whose only collective body was the Swiss Diet, an assembly of envoys from the thirteen fully entitled cantons and the associate cantons. The so-called collective dominions (or condominiums; *Gemeine Herrschaften*) were subordinate territories whose administration was shared by between two and thirteen cantons. In addition, there were small protectorates. After the Thirty Years' War, which chiefly affected Grisons, Switzerland was spared nondomestic

FIG. 770. HANS CONRAD GYGER, SECOND MANUSCRIPT MAP OF SWITZERLAND, BEFORE 1657. Colored pen-and-ink drawing on paper, no title, ca. 1:350,000. The map was last mentioned in 1893 by Johann Heinrich Graf in "Die Karte von Gyger und Haller aus dem Jahre 1620," *Jahresbericht der Geographischen Gesellschaft von Bern* 11:250–64, and then was missing until it was rediscovered; it was published in facsimile in 2012 (Feldmann and Wyder).
Size of the original: 83.0 × 105.5 cm. Image courtesy of the Staatsarchiv des Kantons Zürich (PLAN G 16).

wars until the French invasion. Only three civil wars afflicted the country: the Peasant War (1653) and the First and Second Villmergen Wars (1656 and 1712). The French invasion of 1798 led to the collapse of the old Confederation, which was superseded by a centralized state body subordinate to France (the Helvetic Republic).

Geographical maps were created in the seventeenth century by a variety of authors (e.g., pastors, painters, city officials) for reasons ranging from legal disputes and border control to urban expansion. The maps of the following territories offer a representative though not exhaustive list (most can be found in Blumer 1957, 163–69): Lucerne (Hans Heinrich Wägmann, 1613, manuscript), Grisons (Fortunat Sprecher von Bernegg, *Alpinæ seu fœderatæ Rhaetiae*, 1618), Thurgovia (Johannes Murer, 1628/29, manuscript, preserved only in copy), Lake Lucerne (Johann Leopold Cysat, *Wahre Abbildung der 4 Waldstätten See*, 1645), Fribourg (Franz Peter von der Weid, *Incliti cantonis Fribvrgensis tabula*, 1668), Principality of Neuchâtel (*Neuchâtel et Vallangin*, Claude Bonjour, 1673, and David-François de Merveilleux, 1694), Solothurn (Mauritz Grimm, 1680, manuscript), Valais (Anton Lambien, 1682, printed in 1706), and Schaffhausen (Heinrich Peyer, *Schaffhauser Gebiet*, 1685). Georg Friedrich Meyer created large-scale manuscript maps of the Basel region from 1680 to 1690, which formed the basis of published maps by Christoph Brunner (*Territorium Basileense*, 1729) and

Daniel Bruckner (*Canton Basel*, 1766). The maps of the canton of Bern by Joseph Plepp (*Noua et compendiosa inclÿtæ vrbis et agri Bernensis descriptio geographica*, 1638) and Albrecht Zollinger (*Inclytæ urbis et ditionis Bernensis*, 1684) were based on the earlier maps by Thomas Schöpf of 1578. The *grosse Landtafel* of the Zurich region by Hans Conrad Gyger (1664/67), a colored manuscript drawing on a scale of about 1:32,000, was a high point in cartography of the region in the seventeenth century, especially for its rendering of relief employing a hill-shading effect that emphasized the contiguous nature of the mountain ranges. This map was printed in a smaller version in 1685 (*Nova descriptio ditionis Tigurinæ*) by his son Johann Georg Gyger.

Hans Conrad Gyger also created the most important general maps of Switzerland of the seventeenth century. He compiled information from available regional maps and employed an innovative mountain representation using a bird's-eye perspective (fig. 770). His most skilled printed map of Switzerland (*Helvetiæ Rhætiæ et Valesiæ*, 1657) was long used domestically and abroad as a reference point, even by Johann Jakob Scheuchzer for his *Nova Helvetiae tabula geographica* (engraved and dated 1712; printed in 1713), the most well-known map of Switzerland of the eighteenth century (fig. 771).

FIG. 771. JOHANN JAKOB SCHEUCHZER, *NOVA HELVETIAE TABULA GEOGRAPHICA* (ZURICH, 1713). Scheuchzer's large map on four sheets is embellished with rich imagery of Swiss life and resources. Its wide distribution was ensured by the copy published by Petrus II Schenk in Amsterdam. Scheuchzer was trained as a doctor; he also received an advanced degree in mathematics. His strong interest in natural history led him to travel extensively around Switzerland; his map was based on his observations and measurements and drawn at a scale of ca. 1:230,000. See figure 274 for a distortion diagram indicating the map's geometrical accuracy.
Size of the original: 110 × 148 cm. Image courtesy of the Universität Bern, Zentralbibliothek, Sammlung Ryhiner (MUE Kart 395:11).

An atlas of all Switzerland was published by Homann Heirs under the title *Atlas novus Reipublicae Helvetiae* (1769). Fifteen of its eighteen maps were authored by Gabriel Walser, a pastor and geographer who compiled maps of various cantons in a style reminiscent of an earlier period of mapmaking.

The influence of the natural sciences became apparent in the eighteenth century. Regional maps reflected French survey methods that were based on more precise measurements. In western Switzerland, the carefully surveyed map of Lake Geneva by Antoine Chopy (*Carte du Lac de Geneve*, 1730) used measurements made by Jean-Christophe Fatio and Isaac Gamaliel de Rovéréa, who as director of the saltworks of Bex surveyed the region of Aigle between 1734 and 1744 for the *Carte du gouvernement d'Aigle* (ca. 1788), with its mineralogical key. Henri Mallet precisely measured maps of Geneva in 1776 (*Carte des environs de Genève*) and of Vaud in 1781 (*Carte de la Suisse Romande*). The map of Sottoceneri by Hans Conrad Finsler (*Die schweizerischen Landvogteyen Lauis und Mendris*, 1786) is a reduction of a manuscript map by Pietro Neurone, an engineer from Lugano, which is based on precise border measurements made 1754 by Gaudenzo Portigliotti and Giuseppe Caresana. The *Specialcharte des Rheinthals* (1796) by Johannes Feer was based on trigonometric and astronomical calculations.

The eighteenth century witnessed early baseline and altitude measurements. The first barometric altitude measurements were made by Scheuchzer in Zurich from 1705 to 1707, by the Geneva polymath Jacques-Barthélemy Micheli du Crest in 1755, and by the Alpine naturalist Horace-Bénédict de Saussure in Geneva in 1787. Johann Georg Tralles made the first careful baseline measurements in 1788 in Thun, 1791 in Aarau, and in 1791 and 1797 in the Grosses Moos. Ferdinand Rudolf Hassler elaborated the oldest preserved coordinate and altitude index of Switzerland in 1797 (Cajori 1929, 506–7, 509; Feldmann 1997, 206).

Because of the spread of authority across many cantons and administrative divisions, the production of a uniform atlas of the country waited until the end of the eighteenth century. Johann Rudolf Meyer had a relief model constructed of all Switzerland, on the basis of which he made a topographical map. Johann Heinrich Weiss started the measurement work in 1786 and Joachim Eugen Müller began the topographical recordings in 1788. Their work led to the compilation of the *Atlas Suisse*, which appeared from 1796–1802 in sixteen sheets on a scale of ca. 1:120,000 (see fig. 861). The Alps are shown with great verisimilitude through the use of uniform hachures and northwestern lighting.

HANS-ULI FELDMANN AND HANS-PETER HÖHENER

SEE ALSO: Administrative Cartography; Boundary Surveying; Geodetic Surveying; Height Measurement: Altimetry; Heights and Depths, Mapping of: Relief Map; Map Collecting; Map Trade; Military Cartography; Property Mapping; Thematic Mapping; Topographical Surveying; Urban Mapping

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