D

Dainville, François de. François Oudot de Dainville was born in Paris, France, on 21 January 1909 to a traditional Catholic family, the oldest of eight children. He reconciled his faith and his thirst for knowledge by joining the Society of Jesus in 1928. He followed the prescribed steps toward ordination and was ordained a priest in 1943. Dainville had a passion for geography and went to Montpellier, where he studied under Jules Sion, a disciple of Paul Vidal de la Blache. Under Sion's guidance he prepared and defended his principal dissertation, *La géographie des humanistes*, in which he examined the geography practiced and taught by the Jesuits during the sixteenth and seventeenth centuries. Antique maps are discussed on multiple occasions in the dissertation, particularly when Dainville addresses the intellectual environment of the Jesuits, their teaching tools, and their sources of descriptive geography, even though these are not the major focus of the work. With the publication of *Cartes anciennes de l'Église de France* in 1956, Dainville emerged as a dominant French scholar in the history of cartography.

Dainville followed historiographical tradition by producing several cartobibliographical studies, including those of the first French atlases of Maurice Bouguereau and of Jean Le Clerc father and son. He also continued the monographic model of the Vidalian geographical tradition by examining the image of the provinces through their successive cartographic representations. At the same time, his research went in several original directions, his main interests diverging from those of his predecessors. Rather than focus on medieval maps of the world and the emergence of portolan charts, he favored cartographic material printed during the modern period, often stored in local archives. He worked tirelessly to uncover unknown maps and little-explored repositories.

Dainville was innovative in his approach. Influenced by the Annales school (of historical writing), he sought to situate maps in their intellectual milieu and socioeconomic context. His monographs explored a broad political and social spectrum, the history of cartographic techniques (engraving, illumination, and printing), and the commercialization and diffusion of documents. Dainville made the language of graphic representation a subject of study in its own right. He retraced the history of the contour line in a 1958 article and analyzed the evolution of cartographic symbols during the modern period in several publications, notably in *Le langage des géographes* (1964). Dainville was also one of the first scholars to take an interest in the history of thematic maps. Religious maps from the sixteenth through eighteenth centuries held his attention, but he also ventured into the nineteenth century and broke new ground with his paper on the early stages of statistical cartography, published posthumously in 1972.

Rather than work in isolation, Dainville maintained close relationships with other researchers as well as with the curators of the Département des cartes et plans at the Bibliothèque nationale de France. He taught at the École des chartes from 1956 and, starting in 1963, at the École pratique des hautes études. Even so, Dainville was a peripheral figure at the university; his work did not greatly interest geographers until the late 1960s. In 1968 Philippe Pinchemel invited him to join the Commission on the History of Geographical Thought of the International Geographical Union. Dainville advised only one student directly, Numa Broc, for a dissertation entitled *La géographie des philosophes* (1972; published 1975).

Dainville died in Paris from leukemia on 15 January 1971. Despite his short academic career, he had a marked influence on contemporary research. In addition to a legacy of several classic syntheses, Dainville opened the history of cartography to new historical questions and to the other social sciences.

GILLES PALSKY

SEE ALSO: Histories of Cartography

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Dasymetric Map. A dasymetric map is a quantitative, thematic map characterized by area symbols similar to those on choropleth maps but with map unit boundaries that represent sharp changes or escarpments in the data surface being represented (McCleary 1969). Dasymetric maps can better represent somewhat stepped data surfaces (such as population density) than can choropleth maps by organizing data into polygonal units of relatively homogeneous data. The shading or coloring of dasymetric maps is also similar to that of choropleth maps, with units of higher data value typically assigned darker colors or shades. Although known by name mostly within academia, dasymetric maps and concepts not only have played a role in the development of modern contemporary thematic mapping but also have become important in using geographic information systems (GIS) to make maps.

George F. McCleary (1969) explored the development of dasymetric mapping in detail and observed that the first dasymetric maps appeared in the first half of the nineteenth century in separate maps produced in Europe—a world population map by George Poulett Scrope (1833, facing the title page) and an 1837 population map of Ireland by Henry Drury Harness (Robinson 1955). In the early twentieth century V. P. (Benjamin) Semënov-Tyan-Shanskiy coined the term "dasymetric" to describe this type of map (Petrov 2008, 134), the Russian term being from the Greek for "measuring of density" (McCleary 1969, 21)—an accurate description of the method he used to produce a detailed national population map series for Russia.

In reviewing the history of the development of dasymetric maps within the context of thematic mapping, McCleary observed that many pre-twentieth-century thematic cartographers had produced maps that were quite dasymetric in nature but never characterized them as such. An important factor in the development of this map type was the parallel advancement of procedures for collecting and analyzing census data. Well into the late nineteenth century, cartographers had much freedom to define their own mapping units and to color or shade these zones based on their own interpretation.

In 1936 John Kirtland Wright published the seminal work on dasymetric mapping when he described the production of two dasymetric population maps of Cape Cod, Massachusetts, and compared them to choropleth maps of the same area (fig. 195). In both methods, he used his knowledge of the local landscape to modify the original choropleth map, which showed population density as homogeneous within township areas. Despite the importance of his work in describing working methodology to produce dasymetric maps, dasymetric mapping never attained the wide popularity of choropleth mapping.

Even so, Wright's influence is strongly felt inasmuch as modern dasymetric maps are typically constructed using methods similar to his. Data available in collection units are overlaid with ancillary data to produce new map zones. For example, land use, slope, or elevation data might be used as ancillary data in population mapping. Attribute data are then reassigned based on map zone geometries and the density limits defined by the cartographer. As a simple example, human population density is constrained to zero in collection unit areas that overlay with water. More complex models exist in which different limits are established for different types of overlay areas. Still other non-density-limiting methods use inferential statistics to establish relationships between one or more independent variables and the data variable being mapped. Regardless of the complexity of the dasymetric estimation method, Waldo R. Tobler's (1979) pycnophylactic property is enforced to ensure that the data count within the original collection areas is the same before and after applying the method.

GIS is an important tool for creating dasymetric maps. By providing relatively easy access to geometric overlay, feature-attribute management, and data manipulation algorithms as well as access to the growing collection of electronic data, GIS can make it easier for cartographers to create dasymetric maps. Indeed, many researchers have used GIS to evaluate and improve dasymetric methods, using both vector and raster data (as has been summarized in Eicher and Brewer 2001; Mennis and Hultgren 2006). Furthermore, examples of GIS-based cartography applied from the 1990s onward demonstrate the usefulness of dasymetric maps for representing population, especially in regions such as the western United States, where maps based on relatively large political units can drastically misrepresent the true nature of the underlying data (Holloway, Schumacher, and Redmond 1999).

Although the twentieth century ended with choropleth maps well entrenched in popular and applied research publications and in commercial GIS and mapping software, dasymetric mapping had a promising future as both a focus for cartographic research and a method for displaying geographic data. Moreover, electronic satellite imagery, which was increasingly available and ever more detailed, had emerged as a promising source of ancillary data for making dasymetric maps, and the growing

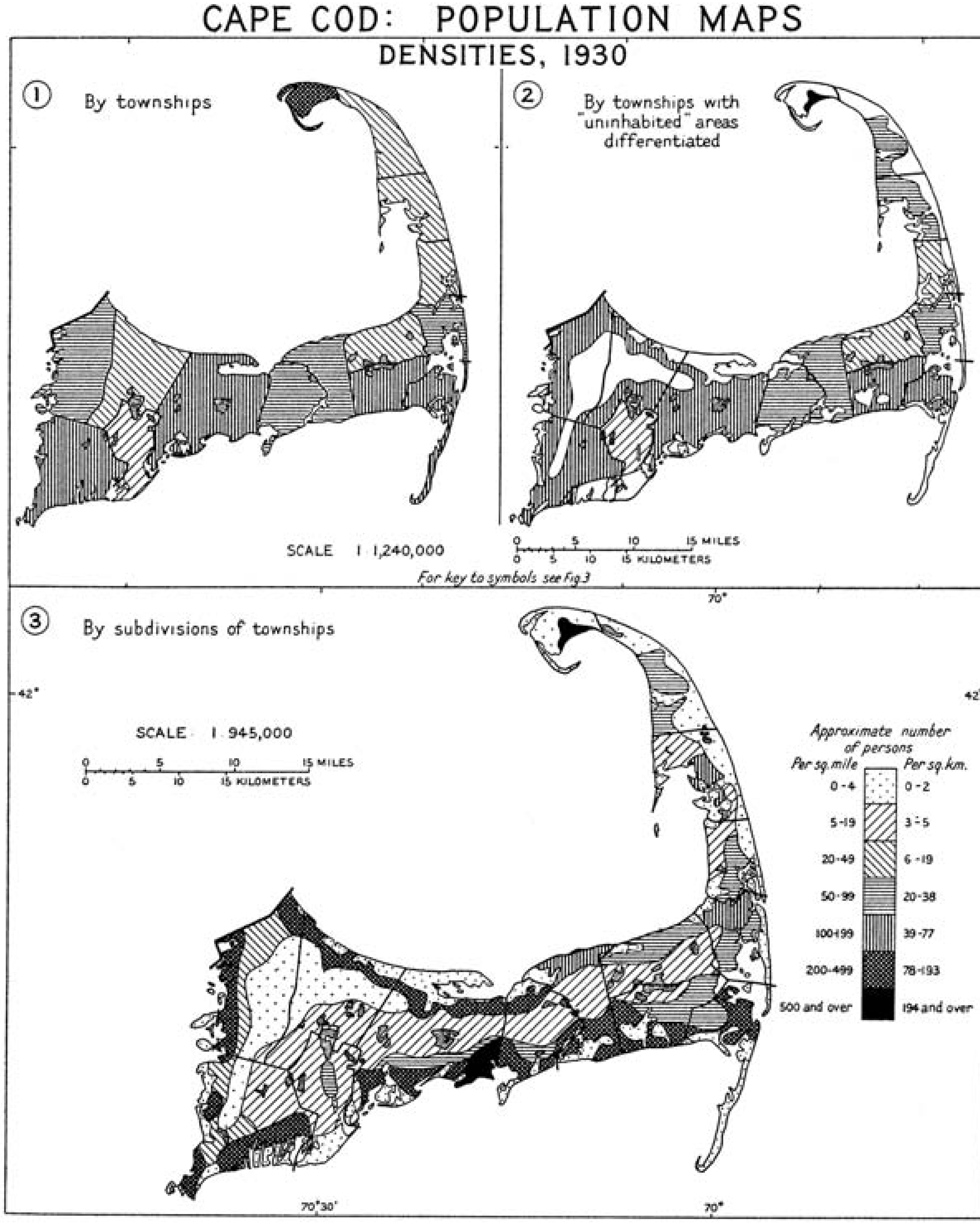

FIG. 195. JOHN KIRTLAND WRIGHT'S CHOROPLETH AND DASYMETRIC MAPS OF THE POPULATION DENSITY OF CAPE COD, MASSACHUSETTS, IN 1930. The first of the three maps is a choropleth map by township, and the second and third are dasymetric maps derived from the original choropleth map. The first dasymetric map was created by removing unpopulated areas (e.g., water) from townships and recalculating densities. The second dasymetric map was created using a more complex method where different density limits were established for different land use categories (e.g., sand, bog), and then densities in the remaining areas were recalculated.

Size of the original: 13.3 × 11 cm. From Wright 1936, 103 (figs. 1–3). Permission courtesy of the American Geographical Society, New York.

penetration of mapping and GIS technology into new application areas was offering an ever-increasing number of users powerful tools for extending the dasymetric tradition to new applications.

CORY L. EICHER

SEE ALSO: Choropleth Map; Statistical Map; Thematic Mapping; Wright, John K(irtland)

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Decolonization and Independence. At the time of the Great War (1914–18), European colonial powers laid claim to more than three-quarters of the world's landmass. A half-century later, this equation had been nearly inverted as anticolonial struggles, domestic agitation in the metropoles, and international pressure brought to bear by the United States and the USSR (both with their own imperial pretensions) fostered the demise of colonial rule in most of Africa, Asia, Oceania, and the circum-Caribbean. The magnitude of change can be conveyed with a few statistics: the continent of Africa contained only one internationally recognized independent state in 1939; by the mid-1960s it had nearly forty (Hobsbawm 1996, 344). The United Nations counted fifty-one member states in 1945; three decades later it had three times that number (Monmonier 1994, 14n52). The change can also be visualized cartographically: by 1962 Britain's colonial empire, upon which the sun had supposedly never set, appeared as little more than an array of lingering outposts on the maps of the annual reports of the British Colonial Office.

Decolonization meant both change and continuity in mapmaking. The first rulers of independent nations, often educated in Europe or by European teachers, used the political systems and technologies associated with Europe to modernize. At the same time they sought to recover or re-create precolonial pasts and cultures, emphasizing national particularity, often through very local and not necessarily representative symbols (Hobsbawm 1996, 202; Cooper 2002, 89). This tension between appeals to modernity and authenticity characterizes much postcolonial cartography.

Decolonization had a limited impact on cartographic methods and technologies in formerly colonized states. This is not surprising: technologies used by colonizing powers did not always develop prior to, or in isolation from, acts of colonization and the activities of the colonized themselves. Self-serving ideologies of technological diffusion, part and parcel of a colonial ideology that emphasized difference to legitimate subjugation, elided the vast realm of interchange, overlap, and reciprocal interaction that often characterized how colonial science functioned and developed on the ground (Raj 2007). Colonial cartographic practices drew upon local practices and mapping operations; colonized peoples, meanwhile, participated in mapping enterprises and populated cartographic bureaucracies (Stone 1995). Moreover, non-European kingdoms, states, and populaces could, and did, appropriate various mapping technologies to their own ends: in some cases to stave off colonial encroachments and expand their own territorial bounds, and in others to defend highly localized forms of land tenure and territorial jurisdiction (Thongchai 1994; Ramaswamy 2000, 588–89). Recognizing such continuities is not intended to dismiss the violence of colonial rule or its imposition of a technology that refused to account for other forms of spatial understanding and practice. Rather, the point is to highlight the complex relationship that existed by the twentieth century between technologies of rule and their uses, and, just as importantly, to suggest from the perspective of cartography that sovereignty was only one of a number of issues confronting colonized populations (Cooper 2003, 26).

Development, to take one example, was of significant importance. In the wake of decolonization, leaders of newly independent countries sought to modernize along European lines, often with European capital, and to ensure national economic development. A comparison of two atlases published the same year (1962), one from a country recently decolonized (Uganda) and the other from a country still under colonial rule (Mozambique), is revealing in this respect. The *Atlas of Uganda*, divided into eight sections, begins with a plate situating Uganda vis-à-vis its transportation and communication links with the rest of Africa, Europe, and the Atlantic and Indian Oceans (fig. 196). It is an atlas that looks to Uganda's future and stresses its situatedness in a broader world of trade and commerce. Historical maps of travelers and encounters only appear, and at that briefly, at the end of the atlas. In contrast, the *Atlas de Moçambique* begins with a map of Vasco da Gama's "discovery" of the country. Centered on the Atlantic Ocean, it shows only the coastlines of the continents, the itinerary of Vasco da Gama's ships, and a portrait of the navigator himself. Subsequent plates outline internal political districts oriented toward colonial governance.

Thus for newly independent nations, technological and methodological continuities in mapmaking existed for quite practical reasons. New forms of state economic planning, an emphasis on "development," concerns with economic independence, and extensive efforts at land reform—nearly half of the planet's population in the late 1940s lived in countries engaged in land reforms—all relied heavily on precise and extensive topographic and cadastral mapping, both of which were aided by the coming of air photography and remote sensing (Hobsbawm 1996, 354–55; Stone 1995). Postcolonial governments took the cadastral, geodetic, and topographic surveys of previous colonial administrations and put them to use for new political, social, and cultural programs. In some cases—Nigeria, Northern Rhodesia/Zambia, and Swaziland, among others—even the personnel changed only slightly as the British Directorate of Overseas Surveys continued working on large-scale topographic surveys even after independence (Stone 1995, 101, 132–33).

Cartographic continuities characterize political borders also. Decolonization led to the dramatic, and still contentious, partition or territorial reconfiguration of some formerly colonized lands, most notably in what had been British India. Yet in many cases it is colonial contours that configure much of the postcolonial globe. While newly independent states would frequently reconfigure internal jurisdictional boundaries, the national political boundaries inscribed by colonial powers often remained intact, despite having been imposed arbitrarily, as a matter of administrative convenience, or based upon flawed and ethnocentric principles. Indeed, colonial boundaries frequently bore little relation to political, social, linguistic, or ecological relationships on the ground. Even so, such spatial abstractions—and the abbreviated history they carried with them—persisted, as both a consequence of and an impetus for modern cartography. As political geographer Matthew Sparke (2005, 12) has aptly noted, "Cartography is part of a reciprocal or, better, a *recursive* social process in which maps shape a world that in turn shapes its maps." Thus it was that the membership of the Organization of African Unity, created in 1966, agreed to abide by the boundaries established by the colonial powers in the years following the Berlin Conference of 1884–85 (fig. 197) (Betts 2004, 2, 55; Stone 1995, 77). Precedent existed in such matters: leaders of the Latin American republics that gained independence in the nineteenth century applied the legal principle of *uti possidetis juris* to ensure, not always successfully, that the colonial administrative boundaries would serve as the international boundaries for their new states (Domínguez et al. 2003, 20–25).

That newly formed states did not escape the boundaries created, or the technologies deployed, by colonial powers does not mean they were somehow inauthentic or, even worse, colonies in postcolonial drag. There is more than a whiff of artifice to all national boundaries, regardless of their longevity. Moreover, while boundaries may be static, their meanings are not. Those created by colonial powers, regardless of how artificial and imposed they may have been at first, and regardless of how dramatically they obscured or overwrote other existing territorialities, could acquire a reality and a meaning over time to the populations within their bounds. Logo-maps that highlighted national boundaries and appeared on everything from stamps to official letterhead may have served to naturalize a cultural and social construction, but they did not remain solely ideological and repressive fictions. Such spaces often constituted the necessary geographies of decolonization, the means through which to link anticolonial politics and identities through geography and history (Fanon 1961; Said 1993).

Within the confines of such boundaries, leaders and intellectuals of independence movements drew upon prevailing cartographic technologies and used existing maps but altered their content. Like novels, art, and music, maps became a means through which to re-present and develop a postcolonial identity liberated from colonial determinations. Maps and atlases thus performed the hard cultural work of decolonizing the land, the past, and (in the famous phrase of Kenyan intellectual Ngũgĩ wa Thiong'o [1986]) the mind itself. Cartographic contributions to this psychological decolonization included the changing of toponyms and the creation of national atlases.

Decolonization at the minimum meant that no longer would colonizers dictate the terms of representation, either politically or poetically. A veritable tide of toponymic change washed much of the globe during the twentieth century. In some cases only the country

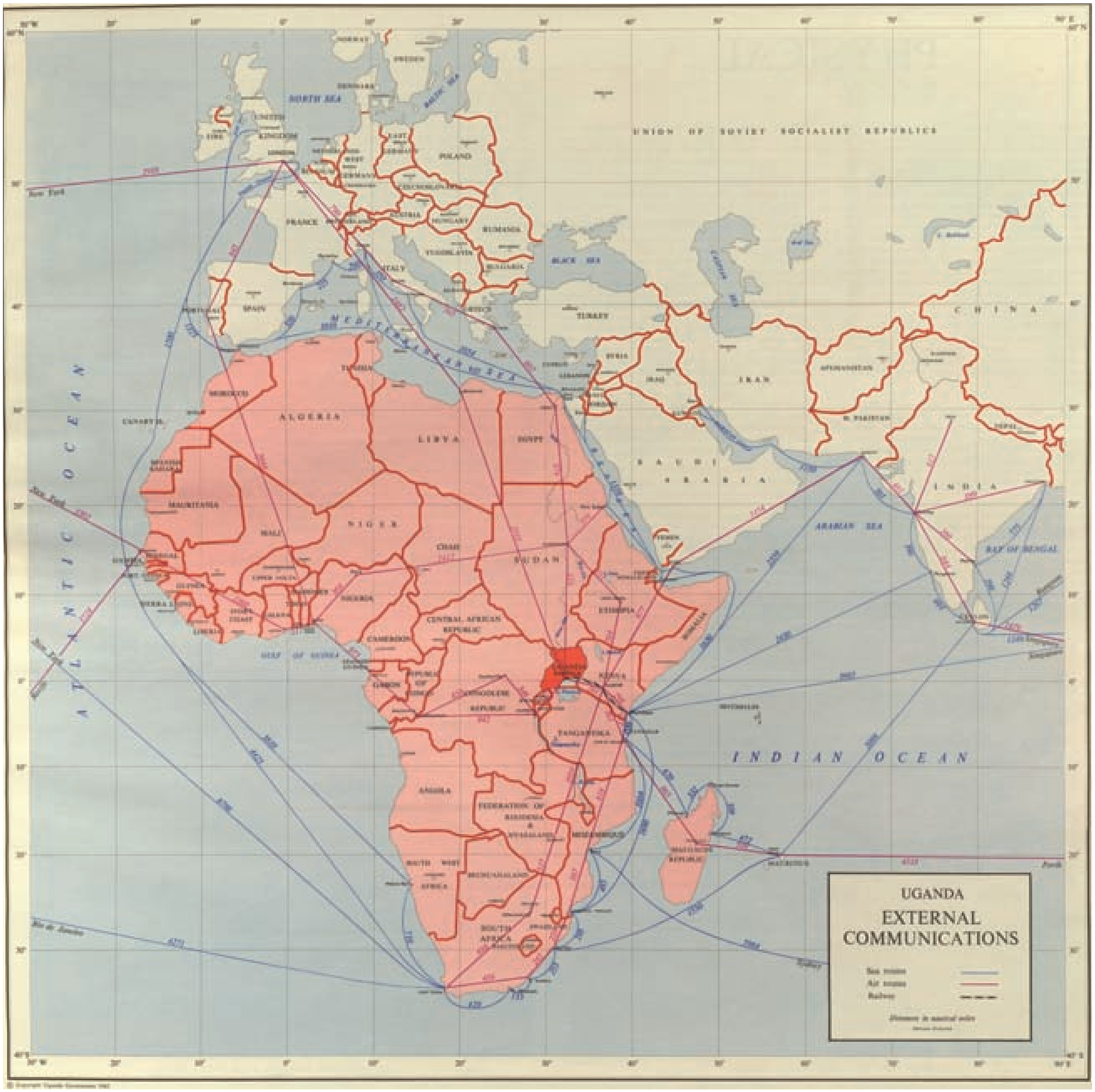

FIG. 196. *UGANDA: EXTERNAL COMMUNICATIONS.* The very first map in Uganda's first postcolonial atlas emphasized the country's hemispheric position, external communications, and lines of commerce, in sharp contrast to the emphasis placed in colonial atlases such as that in figure 197.

Size of the original: 44.2 × 44.7 cm. From *Atlas of Uganda* (Kampala, Uganda: Department of Lands and Surveys, 1962), 5.

name changed: British Honduras may now be Belize, but while there one can still travel through Roaring Creek, Bamboo Camp, and Double Head Cabbage. In other cases, new administrations oversaw name changes not only to their nations but cities, towns, districts, streets, and natural features. New names simultaneously overturned those imposed by colonizers and fostered a renewed interest in, and affirmed the validity of, local languages. Thus in many instances spellings, rather than names per se, changed: whether it be the resuscitation of the hamzah (ʾ) and the macron (ī) in Oceanic place-names or the slight modification to Calcutta (Kolkata), a quintessentially colonial city, the idea was to shift language away from an imposed Europeanization. Names

FIG. 197. *AFRIKA: POLITISCHE ÜBERSICHT*, 1884–85, 1:38,000,000. Produced in the aftermath of the Berlin Congress of European states, this image captures the initial efforts to carve up Africa among the colonial powers, the configuration of which would serve as the basis for postcolonial territorial formations. Size of the original: 25 × 20 cm. From *Meyers kleiner Hand-Atlas* (Leipzig: Verlag des Bibliographischen Instituts, 1892), pl. 82. Image courtesy of the Michigan State University Map Library, East Lansing.

ascribed to particular global "regions" have also come under scrutiny, particularly vis-à-vis the colonialist orientations they evoke. For example, while neither "Pacific Islands" nor "Oceania" is particularly new, each carries with it a host of implications. These are not simple semantic variations, as Epeli Hau'ofa (1994, 152–53) eloquently notes: "There is a world of difference between viewing the Pacific as 'islands in a far sea' and as 'a sea of islands.' The first emphasizes dry surfaces in a vast ocean far from the centers of power. . . . The second is a more holistic perspective in which things are seen in the totality of their relationships." Hau'ofa's cartography is explicitly a decolonial one, rejecting a neocolonial onomastic complicit with a view that dismisses oceanic island states as too small and isolated to achieve economic independence from wealthier nations (Hau'ofa 1994, 150).

Names were frequently deployed by postcolonial administrations as part of a broader effort to connect a place to a past. They helped foster (whether as resurrection or invention) a nationalist historical narrative. Such efforts were not unique to the twentieth century. Cartographers in places as diverse as Mexico and Thailand had similarly inscribed a distant past onto modern maps of the nation in an effort to stress the nation's longevity and coherence (Craib 2004, 19–53; Thongchai 1994). Similarly, Indian intellectuals in turn-of-the-century British India recast the map of the colony as a female adorned with archaic and culturally specific items in order to link history and geography and thereby, in the words of historian Sumathi Ramaswamy (2001, 100, 109), "foster the sentiment of belonging and possession" (fig. 198). By the mid-twentieth century, effectively the zenith of decolonization, such efforts were often pursued through the production of national atlases, the "symbol of national unity, scientific achievement, and political independence" par excellence (Monmonier 1994, 1). Atlases served as a powerful means of cultural and political self-representation. Designed for broad public consumption and reflecting concerted efforts to inculcate a particular image of a place and its past in order to forge collective unity, national atlases combined modern technological forms and formats with attention to cultural specificity and particularity. Thus atlases would often celebrate (or, at times, idealize) pasts that preceded the colonial era, narrating how the country took shape beyond the confines of colonialism. These creations frequently carry with them the specter of invented tradition, purportedly manifestations of what historian Jeremy Black (1997, 186) calls a "habit of seeking to portray the long-term history of states whose territorial extent and ethnic composition were often the work of European conquerors and therefore relatively recent." Be that as it may, there *was* history before the colonials arrived. Rather than anachronistic projections, such atlases might better be seen as simultaneous efforts to account for those neglected pasts and to engage in a dialectical process of "cultural reformulation and recreation" in the wake of generations of colonial rule and cultural and political oppression (Thomas 1997, 9; Jolly 1992).

FIG. 198. *INTIYA*, 1909. An example of gendered geography: India as the mother figure to her colonial subjects.
Size of the original: 14.4 × 9.6 cm. From Rā A. Patmanāpan, *Cittira Pārati*, 2d ed. (Cennai, 1982), 60.

The more troubling aspect of such efforts is not their supposed historical and spatial infidelities but rather their potential for exclusionary politics. Decolonization did not necessarily entail political, social, or cultural equality for all those living within a given state's bounds. For one thing, leaders of independence movements could be more intent on protecting and perpetuating the interests of a particular class than on implementing broad social change, whether it be the Creole elites who garnered independence from Spain in nineteenth-century Latin America or Lat-Dior and his Wolof king-

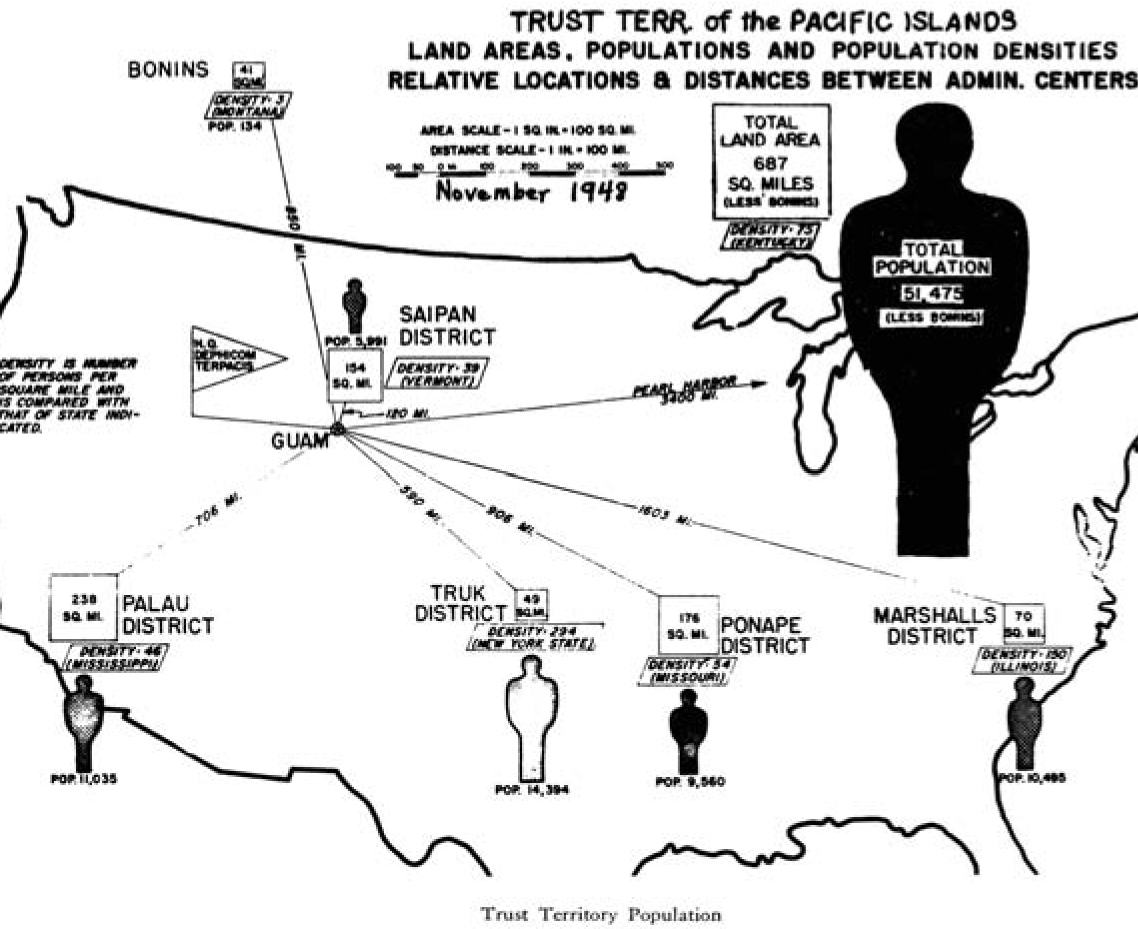

FIG. 199. *TRUST TERR. OF THE PACIFIC ISLANDS: LAND AREAS, POPULATIONS AND POPULATION DENSITIES; RELATIVE LOCATIONS & DISTANCES BETWEEN ADMIN. CENTERS*. "Superimposed" takes on double meaning in maps such as this one of Micronesia, a "trust" territory of the United States after World War II. Such comparative cartographies were also typical of country maps made by the Central Intelligence Agency.
Size of the original: 12 × 16.6 cm. From Dorothy E. Richard, *United States Naval Administration of the Trust Territory of the Pacific Islands*, 3 vols. (Washington, D.C.: U.S. Government Printing Office, 1957–63), 3:414.

dom in Senegal (Klor de Alva 1995; Cooper 2003, 27). In some cases decolonization appeared truncated, such as in various island states in Oceania, like Micronesia, which acquired a kind of loose autonomy proscribed by the strategic needs of the United States (fig. 199). In other cases the transfer of power must have appeared to some as more of the same: the Bougainville Rebellion of 1988 pitted an armed insurgency seeking independence against the military forces of Papua New Guinea, itself only recently liberated from Australian rule in 1975. In Sudan, the three southernmost provinces—home to a missionary-educated elite cultivated by British colonial machinations that sought to racialize and "retribalize" Sudan—"felt so cut off from access to the state" that they rebelled against the Khartoum-based government at the very moment of Sudanese independence (Mamdani 2009, 177). The postcolonial persistence of colonial epistemologies and categories of difference is captured vividly in a 1969 map that took a 1946 colonial map of "tribal" and provincial boundaries and inscribed it thickly with racial categories and boundaries (fig. 200). The southern provinces, still resisting Khartoum, were labeled "Negroid," while all remaining provinces, with one exception, were labeled "Arabic." That one exception was Darfur, a populace categorized as "negroid" but situated within the space deemed Arabic. Meanwhile, in South Africa members of the minority white population created atlases that purported to represent the whole country, giving a cartographic patina of legitimacy to apartheid (Black 1997, 166–67).

These are only two examples of an all-too-frequent occurrence: in maps, as in politics, it is often a particular group that claims to represent—linguistically, culturally—the nation as a whole, frequently to the exclusion

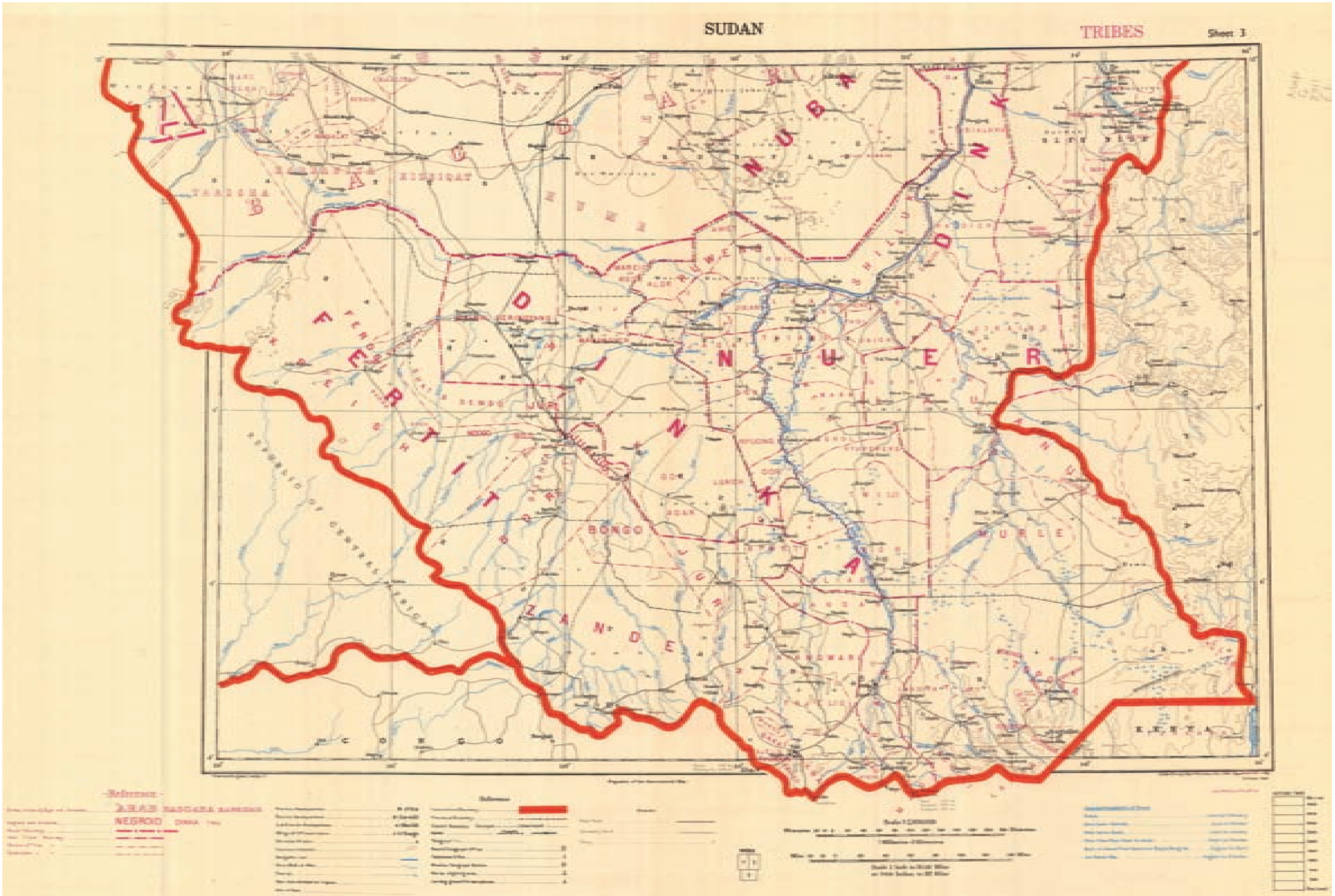

FIG. 200. SUDAN SURVEY DEPT., *SUDAN: TRIBES*, SHEET 3, 1:2,000,000. Khartoum: Sudan Survey Dept., Oct. 1946, corrected 1969. This map, based on a 1946 "tribal" map of Sudan, was reconfigured in 1969 to construct racial, rather than merely tribal, boundaries between "Arabs, Nubians, and Bejans" on the one hand and "Negroids" on the other. Size of the original: 68 × 91 cm. Image courtesy of the Olin Library Map Collection, Cornell University Library, Ithaca.

of other self-defined groups. For the latter, colonialism has hardly receded; it has merely been restructured. At times the very epistemological framework used in postcolonial cartography functions as a form of colonial imposition, with alternative ways of representing the social and political dismissed as unscientific or unreliable. First Nations in the Canadian province of British Columbia brought a case to court in 1987 regarding issues of self-government and territorial jurisdiction using very different conceptualizations and practices of space and cartography than that proffered by the Canadian state (Sparke 2005, 1–2; Brody 1982). They used oral traditions and songs as a means to evoke a historical geography: both in form and content these challenged the standard and imposed criteria for geographical and historical evidence followed by the court (Sparke 2005, 16–29). Their efforts were not successful, revealing the difficulties faced by populations attempting to challenge colonialism's legacies outside of its own epistemological formations.

All of this calls into question the very notion of decolonization itself. Indeed, at the very height of decolonization, intellectuals in African and Latin American countries (most of which had long been decolonized) began to write of *neo*colonialism, questioning the determinations of what constituted the end of colonial rule through the lens of international political economy. Was it purely an issue of political self-determination and formal structures of political power? Had colonial rule collapsed simply by the flight of the colonial powers? To what degree had national autonomy truly severed the unequal relationship of dependency between metropole and periphery, or north and south, or colonizer and colonized? How could, for example, the promise of democracy and self-determination be fulfilled if confronted with the strategic threat of capital flight? Critics of capitalism had long stressed its deeply implicated relationship with colonialism. In the 1960s intellectuals implied that the demise of the latter might be called into question by the persistence of the former, suggesting a new cartography of the globe in which metropolitan powers continued to exercise their might through more subtle means.

Indeed, cartography was not immune or removed from such questions. Cartographers provided readers with atlases that mapped infant mortality rates, literacy rates, gross domestic product, and pollution levels, oftentimes implicitly reaffirming metropolitan superiority through cartographic comparison. After World War II, former geographic frameworks premised upon colonial empires and continental divisions ceded to new structures shaped by Cold War geopolitics and by the recognition that flight and the threat of nuclear annihilation had dramatically compacted the world (Lewis and Wigen 1997). Area studies paradigms, which compartmentalized the world according to world regions of strategic importance with a certain amount of supposed cultural coherence, and the three-worlds paradigm, first used in 1952 and which organized the globe according to political ideologies and presumed stages of development, both achieved institutional and political validity and shaped subsequent mappings of the world (Lewis and Wigen 1997; Hobsbawm 1996, 357). These paradigms did not go unchallenged as intellectuals from both the global north and the global south offered alternative, and implicitly decolonial, images of their own. Joaquín Torres-García's 1943 inverted sketch of the map of South America that derived from his broader project to forge a universal artistic aesthetic that neither rejected nor privileged European models (fig. 201); Arno Peters' alternative global projection that critiqued standard cartographic projections on the grounds of Eurocentrism; the situationists' efforts to expose the practices of capitalist space through alternative mappings (Debord 1967)—all reveal that dominant cartographic and geographic frameworks were never simply hegemonic. At

FIG. 201. JOAQUÍN TORRES-GARCÍA, UNTITLED DRAWING. Art and cartography meet in this black-and-white 1943 perspective on South America by Uruguayan artist and theorist Joaquín Torres-García, who sought to forge a universal aesthetic that would in effect overturn the hegemony of European aesthetics without rejecting them entirely.
Size of the original: 8.7 × 7.9 cm. From Joaquín Torres-García, *Universalismo Constructivo* (Buenos Aires: Editorial Poseidón, 1944), 218.

the same time, intellectual figures such as Andre Gunder Frank (1967), Eduardo H. Galeano (1971), and Fernando Henrique Cardoso and Enzo Faletto (1969) generated new intellectual maps of a world still divided along colonial lines by tracing historical networks and spatial grids of dependency and underdevelopment.

As global geopolitics and international economic structures shift, so too does the language and idea of decolonization. For example, in recent decades residents in postsocialist Eastern and Southern Europe see themselves as engaged in a process of "institutional, disciplinary and psychological decolonization" from state socialism, one that involves various remappings (Pickles 2005, 359–60). In other cases, perhaps taking a cue from the situationists, mapmakers use cartography in an effort to decolonize quotidian spaces or certain perspectives and visions of space generated by powerful entities. While such efforts may stretch the meaning of "decolonial," they serve as a reminder of the encompassing reality and persistence of colonialism itself as something more than merely a system of (over)extended political rule.

It is worth concluding by briefly observing the broader impact decolonization movements have had on intellectual life, in particular the history of cartography itself. Anticolonial writers and thinkers—C. L. R. James, Amilcar Cabral, Walter Rodney, Edward W. Said, and Ngũgĩ wa Thiong'o, among others—sought intellectual and cultural, not just political, liberation. Their writings and critiques of colonial epistemologies were mirrored by metropolitan intellectuals. This proved particularly the case in France, where prominent philosophers and critics—Michel Foucault, Jacques Derrida, Roland Barthes, and Louis Althusser—were decisively shaped by the liberation struggles in French North Africa and Vietnam. Said's *Orientalism* (1978) and Barthes's *Mythologies* (1957) each took on specific mental cartographies of the world, a world profoundly shaken by decolonization, but also trenchantly critiqued the very idea of pursuing emancipation through methods and epistemologies associated with colonial powers. Such critiques of empiricist epistemologies resonated, albeit with some delay, within the discipline of the history of cartography, most notably with J. B. Harley. While Harley's oeuvre defies easy summation, it would be fair to say that he, more than any other scholar, pulled the history of cartography and map analysis into the light (some might say the glare) of critical theory. Harley's eclectic appropriation of poststructuralist arguments regarding language and power and their application to the analysis of maps signaled a sharp turn in the history of cartography, one that has itself shaped the collection in which this essay appears and the author writing it. It may be a protracted line that one traces from, say, Fanon to Said to Harley, but the line is there nonetheless. Decolonization—as both a historical process and a continuing endeavor—has dramatically marked both cartography and the writing of its history.

RAYMOND B. CRAIB

SEE ALSO: Atlas: National Atlas; Colonial and Imperial Cartography; Directorate of Overseas Surveys (U.K.); Geopolitics and Cartography; International Cartographic Association; International Institute for Geo-information Science and Earth Observation (ITC; Netherlands); Nation-State Formation and Cartography

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Decoration, Maps as. The use of maps and globes for decoration has a long history that is not confined to the twentieth century. By maps as decoration, we mean that the map is used as an object whose primary function is not to represent spatial relationships but to serve as an ornament, to embellish or beautify. While closely tied to maps in art and advertising, decorative maps are a subset of curiosities or "cartifacts," a term coined by J. B. Post (2001) to describe an object on which the mapping elements are not designed primarily to convey spatial data. This can be expanded to any object that has map elements or a map image, but whose primary function is symbolic, decorative, commemorative, or intended to amuse or entertain. The objects discussed here consist of either decorative objects that contain map elements or conventional maps and globes that are used as items of decoration.

The ways in which maps and globes are used for decoration are myriad. These range from actual flat maps and globes used purely for their decorative value to maps on clothing, household items, jewelry, mosaics, and coins (table 12). Why are maps used in these ways? While this major question is largely unanswered in the literature, one simple reason is that people see maps as inherently decorative. This is more common for antique maps with their elegant lettering, vignettes, and ornamental cartouches than for contemporary maps. A second reason is that the maps are used metaphorically or symbolically. Richard V. Francaviglia examined this use in a study of the map of Texas as an icon: "On one level it simply stands for Texas; but on other, deeper levels, it also symbolizes the values—such as independence, loyalty, and sacrifice—that remain a part of the mystique of Texas identity to Texans and the world" (1995, 104).

Interior decorators have become fond of using framed antique maps or reproductions in an office or study to project an image of scholarliness, tradition, or solidarity. Globes are also used in this manner, and manufacturers create modern globes with antique coloring to give an old appearance. Examples exist of antique-appearing globes with liquor cabinets concealed inside.

Old maps are used to ornament non-map objects such as clothing, furniture, coffee mugs, and teapots. When a copy of an antique map is printed on a mug, for example, the sole purpose of the map would appear to be

TABLE 12. Objects on which maps are used as decoration

Furniture	Clothing	Jewelry	Stationery	Souvenirs	Household	China
Room screens	Neckties	Earrings	Paper	Magnets	Tablecloths	Dishes
Table tops	T-shirts	Brooches	Pens	Mugs	Placemats	Cups and mugs
Clocks	Shirts	Charms	Pencils	T-shirts	Coasters	Teapots
Liquor cabinets	Shoes	Lapel pins	Calendars	Spoons	Pillows	Coffee carafes
Decorative globes	Scarves	Belt buckles	Journals	Lapel pins	Lampshades	Candle holders
Framed maps	Handkerchiefs	Watches	Sticky notes	Postcards	Shower curtains	Sugar bowls
Mosaic maps and globes	Caps/hats	Necklaces	Greeting cards	Handkerchiefs	Rugs	Cream pitchers
	Jacket linings		Gift wrap	Neckties	Jewelry boxes	
	Jackets		Bookends		Needlework patterns and kits	
	Bicycle jerseys		Paperweights		Needlework maps	
			Note pads		Bed linens	
			Stress balls		Tea towels	
			Desk sets		Beach towels	
			Postcards			

its decorative value. A close examination of such mugs reveals that often only a part of the map is used, and the detail is often not legible owing to the great reduction of the map. Coffee tables, end tables, and room screens with maps imprinted are other ways in which old maps are used as decorative elements.

Modern maps are also used to decorate common objects. The perceived inherent beauty of maps is often combined with precious or semiprecious stones or exotic woods to create mosaic maps and globes. Wooden maps of the United States or of counties in a single state designed to be hung on a wall have been created using a different wood for each state or county. The capitol building in Ohio has a room-size mosaic map embedded in the floor that shows counties with different types of stone. At the end of the twentieth century, mosaic globes with different semiprecious stones and mother of pearl representing countries and oceans were fashionable; sizes ranged from 8 to 40 centimeters. The popularity of these globes resulted in copies with printed plastic pieces rather than real stones. Globe paperweights in glass are common and range from etched glass to Waterford cut crystal. Flat maps are also used in rectangular glass paperweights. Stationery supplies form one of the largest groups of decorative maps: pens, pencils, and note pads are all adorned with maps, antique or modern (fig. 202). An unusual example is note paper and envelopes created from recycled, surplus modern maps.

FIG. 202. A SELECTION OF STATIONERY ITEMS WITH MAPS OR GLOBES AS DECORATION.
Image courtesy of Judith A. Tyner.

Maps are used to commemorate travels. The rise of this type of cartifact is more closely tied to the rise in automobile travel after World War II than to technological changes in map production. Souvenirs with maps range from cheap plastic refrigerator magnets in the shape of states or countries through T-shirts, teaspoons, and lapel pins. The maps may be simple outline maps or detailed road maps and are designed to say "I was there" or to commemorate some event. The sixty-sixth anniversary of U.S. Route 66 spawned hordes of map-related memorabilia showing the highway.

Textile maps are a large category of decorative maps and include a variety of clothing items, including T-shirts, bandannas, scarves, and ties. Many of these also fall into the travel souvenir category. T-shirts were considered underwear until after World War II and generally did not contain graphics until about the 1960s. In 1959 a durable and stretchable ink was invented that could be used in screen printing T-shirts, and at about the same time advertisers saw the potential for turning people into walking advertisements. One of the most common types of T-shirt map is a state map that advertises the wearer's travels; others show routes for bicycle tours, give the locations of rock music tours, or commemorate events such as the above-mentioned Route 66 anniversary.

Bandannas have been popular since the nineteenth century and have been used to advertise, campaign, and commemorate. Maps on bandannas and silk scarves have been a part of this tradition. Head scarves with state maps became popular in America in the 1950s as a part of the travel souvenir tradition. Although head scarves fell out of fashion, bandannas and neck scarves remained popular. These may also serve practical map functions. Maps of recreational areas, national parks, and cities are printed on cotton bandannas or silk scarves and are advertised as accessories that can be removed and used as working maps.

Because decorative items were not considered "real" maps, they were ignored or marginalized in serious study until the end of the twentieth century, when interest in maps as popular culture developed. Although there have been scattered papers and conferences, a definitive analysis of maps as decoration remains to be done.

JUDITH A. TYNER

SEE ALSO: Art and Cartography; Cartogram; Cloth, Maps on; Color and Cartogaphy

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Demographic Map. Demographic maps show geographic distributions of people, their conditions, and their activities. The demographic map is a subset of the broader concepts thematic map and statistical map, being a "tool for exploring the spatial aspects of population" (Monmonier and Schnell 1988, 163). "Population map" is an earlier term with a longer history of use in the geographic literature.

The common denominator in demographic mapping is people, whether total population or a segment of population, e.g., registered voters or the foreign born. Such data are obtained from fieldwork, private surveys, or government registration systems that produce vital statistics but most often from national censuses. Therefore a big driver for increased demographic mapping was the emergence of national censuses in the early- to mid-1800s. National statistical atlases date from the same century. (For a history of pre-twentieth-century population mapping within thematic mapping, see Robinson 1982.)

Throughout the twentieth century, both maps of the physical landscape and reference maps noticeably outnumbered population maps; see the Map Supplement series to the *Annals of the Association of American Geographers* and National Geographic Society flagship publications. Some reference atlases had token population maps—as in the *Times* atlases of the world editions beginning in 1895 (at that time, simply "*The Times" Atlas*). However, in total, there is only a scattered, but meaningful, selection of population maps in general-purpose publications and in pedagogical materials.

In the first half of the twentieth century, geographers published population map topics in the *Geographical Review* and *Geographical Journal* and in the regular and irregular publications of the American Geographical Society. The 1930s produced a spate of scholarly interest in population mapping such as *Notes on Statistical Mapping* (Wright et al. 1938). A discussion on population maps at a meeting of the Royal Geographical Society (RGS) gave the flavor of the issues of the day, particularly the obsession with precise population mapping: "No population map or population-density map which does not enable one to take off some figures from it, without elaborate calculation, can be considered as anything of a success" (Arthur R. Hinks in Fawcett 1935, 153). Amateurs and nonscientific geographers also were active in the population mapping debates (Trewartha 1953; Fawcett 1935).

The thrust of publications on population mapping post–World War II was toward scientific research on symbolization and improved technology for producing maps (Klawe 1973; Dixon 1972). Among cartography textbooks, the second edition of Erwin Raisz's *General Cartography* (1948) incorporated advances in remote sensing and other mapping technologies but added little to the short section on population mapping in the first edition, and its successor, Arthur H. Robinson's *Elements of Cartography* (1953), gave thorough coverage to thematic mapping in general with respectable coverage of population mapping.

Midcentury, cultural and regional geographers demonstrated mapping solutions to particular population data representation problems. Peirce F. Lewis (1965) used choropleth and isopleth symbolization on individual maps (with the latter overlaid on the former) and maps alone and in time series to analyze neighborhoods and voting precincts in Flint, Michigan. The methodological means and benefits of cartographic analysis are important points of his article. Lewis used data for election precincts in his detailed analysis; at about the same time geographers were discovering small-areas data made available as part of national censuses.

Uniform grid-cell maps had their moment when a subset of the 1971 British census data was tallied to a one-kilometer National Grid (University of Durham 1980). The *Atlas till folk-och bostadsräkningen = A Census Atlas of Sweden* (Szegö 1984) also included maps with grid-cell bases for overlays of other population data symbolization such as proportional circles.

The 1980s produced a wave of special-purpose thematic atlases on population such as *The State of the World Atlas* (Kidron and Segal 1981), where the human condition is featured. Eugene Turner and James P. Allen's *An Atlas of Population Patterns in Metropolitan Los Angeles and Orange Counties, 1990* (1991) is an early example of demographic maps from the desktop computer. The twentieth century transitioned into the twenty-first with experiments in technology-driven means of mapping, including demographic mapping—interactive, animated, hypermedia, and multimedia applications (Cartwright, Peterson, and Gartner 1999).

The crux of the demographic mapping problem is to best represent the uneven distribution of the phenomenon, i.e., to portray the extreme range of population numbers and densities. The iconic map of the Stockholm area by Sten De Geer (1922) used a hybrid design to overcome the weaknesses of various symbolization schemes. He used dots in the sparsest population areas, ordered groups of dots to show rural population, and proportional spheres gridded to facilitate counting to show densest population areas. With his peers, De Geer advocated descriptive population mapping—where description was quantitative representation. He promoted the idea of a world population map at the 1:1,000,000 scale to complement the physical world map then in progress at the same scale. The idea received intermittent attention during the midcentury decades. In 1956, a Commission on a World Population Map was formed by the International Geographic Union to develop standards for mapping the results of the 1960 censuses. Seven years later, the commission's final report dealt at length with testing symbolization, gave guidelines for marginalia, conceded to variations in scale, and finessed language issues (William-Olsson et al. 1963). Also, De Geer's passion for counting population from the map survived into the commission's final report. Norman J. W. Thrower (1966) used the guiding principles from the commission work, with his own enhancements, on a sheet map of California population that used one dot per fifty people in rural areas, proportional plus areal symbols for city population, and relief to help explain population distribution.

Demographic or population mapping has enduring interest to social scientists but in addition has a practical value. C. B. Fawcett (1935) asserted the importance of the population map in advancing human geography and as a starting point in community planning. John Kirtland Wright (1938) thought population mapping was necessary for scholars who needed maps of actual conditions to properly study population problems—and to business interests and government officials. The case for the relevance of contemporary demographic mapping variously includes its utility to public administration, planning local services infrastructure, and federal and local emergency management. With the advent of small-areas data from national censuses, marketing research firms repackaged public data with data they collected themselves. Demographic mapping was integrated into such companies' products in the 1980s. The initial practice was to make maps for clients. By the early 1990s such companies sold or licensed mapping tools along with demographic and spatial data to other companies.

Demographic map topics start with population distribution and density. Topics include age, birth and death rates, commuting patterns, educational attainment, electoral behavior, ethnicity, fertility, housing, income and poverty, living conditions, migration, nationality, occupation, race, religion, sex, and state of health. Mark Monmonier and George A. Schnell (1988, 165) classified characteristics as ascribed (e.g., age, sex, race) and achieved, the latter further classified as social (e.g., citizenship, educational attainment) and economic (e.g., income, occupation). Janusz J. Klawe (1973) discussed the mapping of physical characteristics (sex, age, race, state of health), social characteristics (education, income, occupation, political affiliation), and cultural characteristics (religion, ethnicity, nationality). Robinson (1982, 155–70) noted that in the nineteenth century some topics would have been characterized as moral statistics (ignorance, pauperism, improvident marriage).

Wright (1938) characterized information for a demographic map as quantitative or qualitative, static or dynamic—showing change or movement. The data may be categorical or counts, ratios, densities, measures around an average or other benchmark, or measures of change. Demographic mapping uses all symbolization types common in thematic mapping. The gentlemanly but pointed debate on the best method for depicting population density at the 1934 RGS meeting showed that shading method (choropleth), dots, and contours (isopleths) each had their advocates. H. S. L. Winterbotham opined that dot symbolization of population was better suited to maps for experts, while choropleth symbolization was better suited to the public, who wanted only broad conclusions from the map (in Fawcett 1935, 147–48).

Dot maps rely on visual density; for population mapping, Fawcett (1935, 146) characterized this as inhabitants "dotted about" the surface. Dots may be of different sizes for different numbers on a map, progressing to proportional symbols. Wilbur Zelinsky (1961) published twenty-six maps in an analysis of spatial patterns of religious groups and used range-graded dots plus continuously scaled proportional cubes on the maps. In the Swedish census atlas, Janos Szegö used proportional point symbols of rural population working in urban places, with internal segmentation—pie charts—of occupation (1984, 118–19). Elsewhere in the atlas, Szegö used proportional rings with color segments for occupations.

Choropleth symbolization is associated closely with demographic maps. Since choropleth maps are defined as using enumeration units, national censuses are a major source of data. Further, choropleth symbolization has been prevalent in population mapping because choropleth maps were relatively quick to make even in pre–computer mapping days (fig. 203). In the late twentieth century, geographic information systems clinched the ubiquity of choropleth maps by making demographic mapping easy for noncartographers.

Dasymetric mapping is a modification of the choropleth method. The cartographer makes corrections and recalculations based on another data source or their local knowledge to further divide the administrative units; see, for example, Wright's (1936) much-reproduced map of Cape Cod (fig. 195 above).

An isopleth map shows a population surface with lines of equal value similar to elevation contours on a topographic map. The symbols are constructed from density values (or other derived measures) that are distilled to points at enumeration-area centroids. Isopleths are interpolated among these points. B. C. Wallis (1916) used the method to map nationalities in Hungary. Wallis's paper is noteworthy for his interest in representing mixed ethnic areas. William Warntz (1964) promoted a method to create isolines of population potential, a distance relationship between a place and its surrounding

FIG. 203. *DENSITY OF POPULATION IN CHINA: CENSUS, 1902*. Choropleth map published with a brief assessment of reliability of the Chinese government numbers compared with foreign population estimates for China. Size of the original: 20.2 × 20.2 cm. From Anonymous, "The Population of China in 1902," *Bulletin of the American Geographical Society* 34 (1902): 440–41.

population; Daniel Dorling mapped population potential of Britain (1995, 2–3).

Other symbolization styles for demographic mapping include: applying a graph or diagram in locations (Lewis 1965, 21, illustrating graphs leader-lined into voting precincts); using pictorial symbols in lieu of dots (McEvedy and Jones 1978, 22, with a person-shaped icon per million people on a map of Europe in the second century); using scaled pictorial symbols (such as *USA Today*); and printing numbers directly on the map (Wallis 1916, map D, showing percents of nationalities).

The cartogram has been used with demographic data, but it is in a class by itself as a symbolization type. On a population cartogram the areas are scaled to repre-

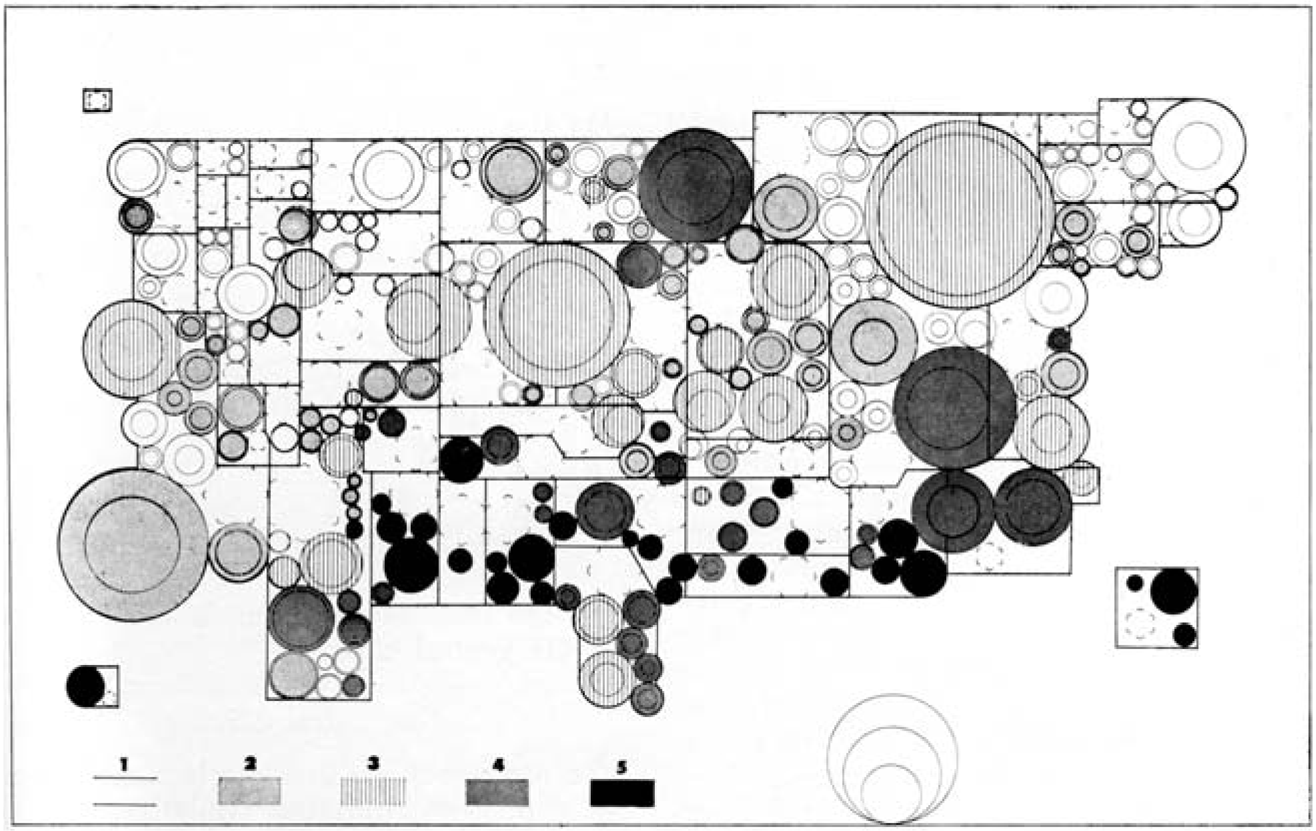

FIG. 204. EXAMPLE OF POPULATION SYMBOLIZATION METHODS. A value-by-area cartogram overlaid with proportional symbols shaded with a third population variable. Map shows U.S. nonwhite population by percentage: (1) less than 5 percent, (2) 5–9.9 percent, (3) 10–14.9 percent, (4) 15–24.9 percent, and (5) 25 percent and over.

Size of the original: 9.2 × 14.6 cm. From A. Sakari Härö, "Area Cartogram of the SMSA Population of the United States," *Annals of the Association of American Geographers* 58 (1968): 452–60, esp. 459 (fig. 9). Reproduced by permission of Taylor & Francis.

sent the population data. A. Sakari Härö presented a schematic with a value-by-area cartogram of states as a base for proportional symbols of city and suburb sizes, the latter shaded by percentage range (fig. 204). Dorling (1993) produced a fine array of cartograms illustrating transformations of both data and geographic units to minimize representational bias.

Population mapping varies considerably in level of abstraction. Charles Booth's *Map Descriptive of London Poverty, 1898–9* (1902–3; twelve sheets), gives a graphic inventory, street by street and in some places structure by structure, of living conditions and social class. Early dot maps were inventories of individual entities at specific locations. Choropleth maps present summary or aggregate data, but the reference still is to the specific units of geography with specific boundaries. Isopleth maps blur the boundary lines, generalizing data into contours suggesting a continuous distribution of density. Raisz championed value-by-area cartograms—but his designs were so abstract that he considered them diagrams rather than maps. At the highest level of abstraction is the centrogram, where the entire geographic distribution of the population is reduced to a single balance point. A series of center-of-population markers on one map for progressive time points is visually spare yet has distilled a great deal of data to graphically communicate geographic shifts in population (fig. 205).

Maps showing change or movement are another aspect of population mapping. In the Swedish census atlas (Szegö 1984, 114–17), a large-scale map shows commuter flows into a given urban area through an array of hundreds of wind-arrow style symbols, one for each ten people. Colin McEvedy and Richard Jones (1978, 215–16) use scaled arrows showing slave exports from Africa 1500 to 1810 and 1810 to 1880. Time is collapsed in a single qualitative choropleth map of the aboriginal population in the *Atlas of Canada* (1957, pl. 52). The extent of each group is shown as it existed at the time of European contact, with the date of contact progressing from east (earliest) to west (latest).

With increasing use of electronic technology as the century progressed, the phrase "dynamic maps" changed in meaning from static maps in multiples or maps with symbolization showing change or movement to maps with animation or interactive capabilities. There were a few early exceptions. Andrew Charles O'Dell (in Fawcett 1935, 153) experimented with filming a series using maps at seventeen time points, musing on showing change with 4,000 maps in series. By the 1990s, digital images and hyperlinking were used to advantage for demographic maps, whether population was the focus of the product or whether demographic maps were part of a larger reference work. Products were distributed on compact discs (CDs). For example, the U.S. Department of Housing and Urban Development (HUD) tool Community 2020, which helped communities determine eligibility for HUD assistance programs, was produced and distributed on CD and included demographic data and a basic mapping utility. At the same time, the U.S. Census Bureau included a then state-of-the-art interactive mapping function in its online data dissemination tool, American FactFinder. The digital material for the printed *Atlas of Oregon* (Loy 2001) was reused in the *Atlas of Oregon CD-ROM* (2002), a compendium of content from the hard copy with interactive capabilities added (fig. 206).

At the end of the century, historical map collections were brought online, including population maps, making them available to potentially huge numbers of people. The U.S. Library of Congress posted to its website the U.S. Census Bureau statistical atlases from 1874 forward. The London School of Economics and Political Science published Booth's *Map Descriptive of London Poverty, 1898–9* with a large-scale modern map for

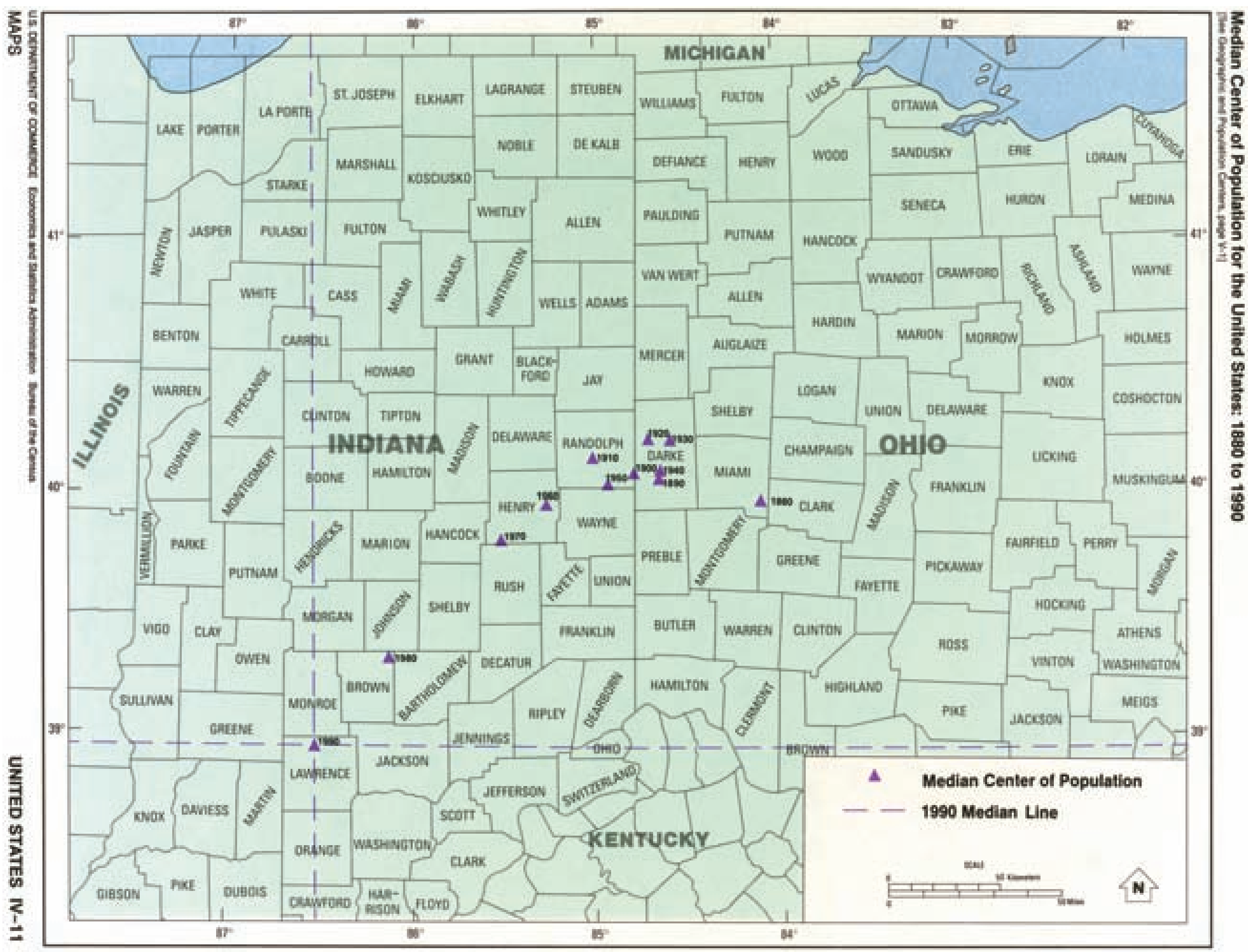

FIG. 205. CENTROGRAM, *MEDIAN CENTER OF POPULATION FOR THE UNITED STATES: 1880 TO 1990.* Size of the original: 19 × 25.3 cm. From U.S. Census Bureau, *1990 Census of Population and Housing*: *Population and Housing Unit Counts, United States*, 1990 CPH-2-1 (Washington, D.C.: U.S. Government Printing Office, 1993), IV-11.

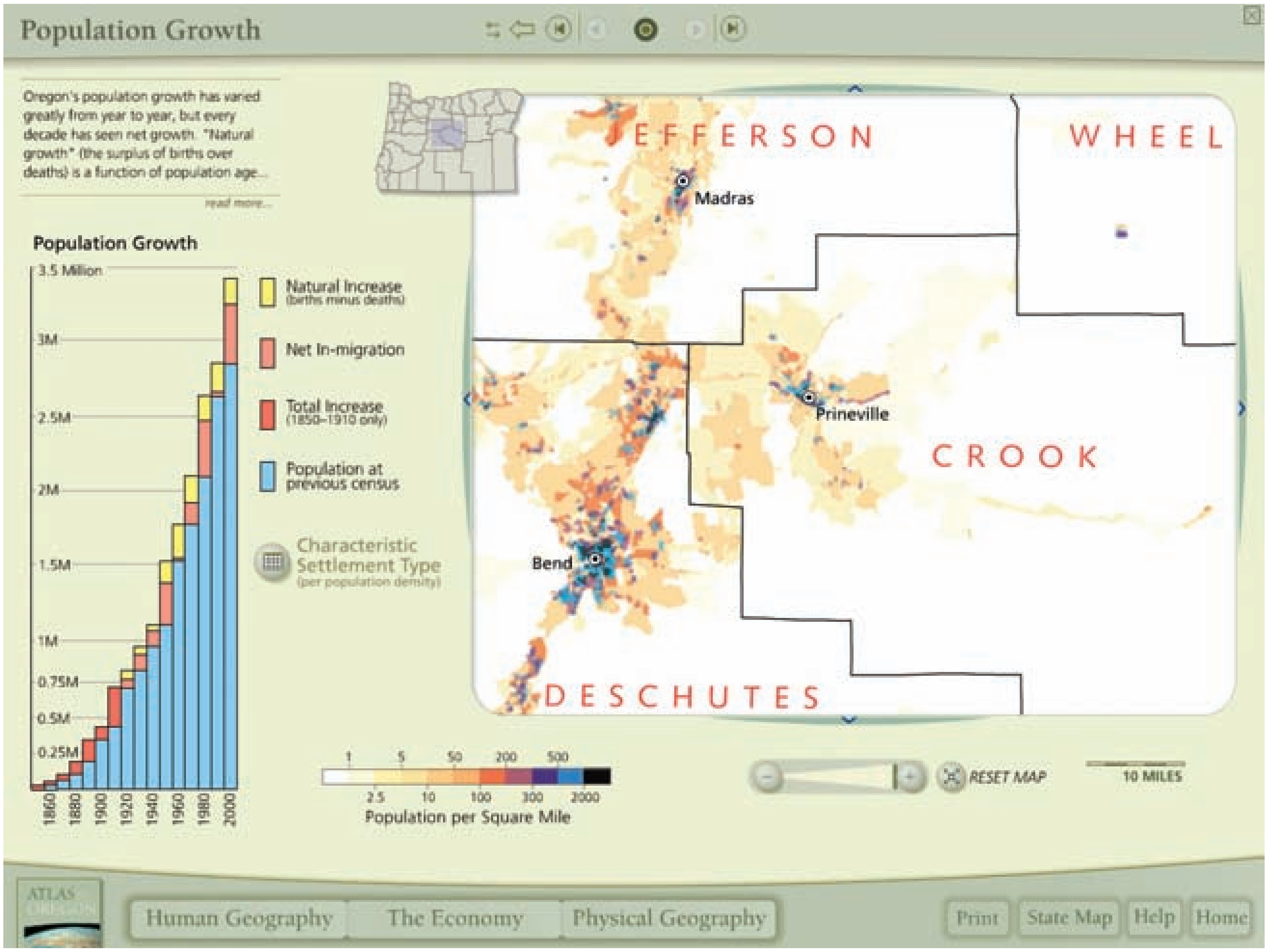

FIG. 206. *POPULATION GROWTH*, CD-ROM MAP. Enhanced treatment of population growth maps and other content from the *Atlas of Oregon*, 2d ed., with interactive controls. From James E. Meacham and Erik B. Steiner, eds., *Atlas of Oregon CD-ROM* (Eugene: University of Oregon, 2002). Permission courtesy of the University of Oregon, Eugene.

comparison. It is a neat circle that brings these historical maps 100-plus years later to anyone with a computer and an interest in the human condition.

TRUDY A. SUCHAN

SEE ALSO: Cartogram; Census Mapping; Choropleth Map; Ethnographic Map; Statistical Map; Thematic Mapping

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Design of Maps. See Reproduction: Reproduction, Design, and Aesthetics

Development. See Planning, Urban and Regional

Dictionary, Cartographic. During the twentieth century, the centuries-old craft of mapmaking practiced by draftsmen became an independent scientific discipline. Cartographic technical literature originated as manuals (handbooks) and specialized periodicals and was followed, especially in German-speaking Europe, by cartographic dictionaries.

Basic terms (*cartographer*, *cartography*, *map*, *map projection*, etc.) had already appeared in general encyclopedias. The first cartographic books containing indexes of technical terms were *Die Kartenwissenschaft* (1921–25), Max Eckert's comprehensive two-volume handbook, and *General Cartography* (1938), Erwin Raisz's textbook.

Forerunners of cartographic dictionaries included the Deutsche Gesellschaft für Photogrammetrie's *Mehrsprachiges Wörterbuch für Photogrammetrie* in five languages (1934) and the *Lexikon der Vermessungskunde* (1943) compiled by Paul Werkmeister et al. Cartographic entries also appeared in some geographic dictionaries, such as Ewald Banse's two-volume *Lexikon der Geographie* (1923) and *Das Gesicht der Erde*, compiled by Ernst Neef (1956; 5th ed., 1981).

Publication of specialized cartographic dictionaries began after World War II. The most important cartographic dictionaries of the 1960s were Herbert Wilhelmy, *Kartographie in Stichworten* (1966; 7th ed., 2002); Wilhelm Bonacker, *Kartenmacher aller Länder und Zeiten* (1966); G. L. Galperin, comp., *Anglo-russkiy slovar' po kartografii, geodezii i aerofototopografii* (1958; 2d ed.,1968); and the Comité français de cartographie, *Glossaire français de cartographie* (1970; 2d ed., 1990).

The International Cartographic Association (ICA), founded in 1961, sponsored publication of the *Multilingual Dictionary of Technical Terms in Cartography* (1973) edited by Emil Meynen. Containing short definitions of all terms in five languages, it also translated the terms into nine additional languages. Derivatives appeared in Croatian, *Visejezicni kartografski rjecnik*, edited by Branko Borcic et al. (1977), and Dutch, *Kartografisch Woordenboek*, by E. S. Bos et al. (1991). The second edition, the *Enzyklopädisches Wörterbuch Kartographie in 25 Sprachen* (1977), was compiled by Joachim Neumann.

Although akin to Bonacker's *Kartenmacher* in its biographical-historical focus, *Tooley`s Dictionary of Mapmakers* (1979; supp. 1985) by R. V. Tooley covered more mapmakers (21,450) with a brevity later ameliorated by expanding the revised edition into four volumes (1999–2004). Robert W. Karrow's *Mapmakers of the Sixteenth Century and Their Maps* (1993) was a scholarly biobibliographical study.

In Vienna in 1975 Erik Arnberger began publishing *Die Kartographie und ihre Randgebiete*, an encyclopedia that would include two cartographic dictionaries. The *Lexikon der Kartographie* by Werner Witt (1979) covered all aspects of cartography and included a chronological table of the history of cartography with special commentary and an index. The *Lexikon zur Geschichte der Kartographie* (1986), written by 150 international experts and edited by Ingrid Kretschmer, Johannes Dörflinger, and Franz Wawrik, was the only twentieth-century cartographic dictionary exclusively dedicated to the history of cartography covering all types of cartographic representations in all cultural regions of the world from their beginnings up to World War II.

Rudi Ogrissek and fifteen coauthors were responsible for another type of cartographic dictionary, the *Brockhaus ABC Kartenkunde* (1983). It demonstrated a unified understanding of cartography and neighboring fields.

A new dictionary series was initiated in Germany at the end of the twentieth century by Spektrum Akademischer Verlag. First to appear was the *Lexikon der Geowissenschaften* (6 vols. including index, 2000–2002), to which more than 200 authors contributed. This was the first dictionary to contain cartographic entries interfiled alphabetically with entries for other geosciences (excluding geography). The *Lexikon der Kartographie und Geomatik* (2 vols., 2001–2002) was compiled by eighty authors, mainly from the universities of Dresden and Trier. It covered cartography and the geoinformation sciences, as well as geodesy, photogrammetry and remote sensing, geostatistics, and scientific visualization. It set the standard for dictionaries of cartography and related fields at the beginning of the twenty-first century and was also available on CD-ROM and in an online version. The parallel *Lexikon der Geographie* (4 vols., 2001–2) contained about eigthy entries on cartography. The *Lexikon der Geoinformatik* (2001) included about 4,500 entries, among them new terms from the field of geographic information technology in German and English.

Altogether these dictionaries show how cartography changed during the twentieth century as it shifted from manual to digital technology. Although a few cartographic dictionaries were devoted to the earlier history of cartography, the larger number of dictionaries focused on the cartography of their day have also gained historical value as records of the development of cartography from the 1960s into the twenty-first century.

INGRID KRETSCHMER

SEE ALSO: Sources of Cartographic Information

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Digital Cartography. See Electronic Cartography

Digital Library. In contrast to a traditional library with physical collections housed in a building, a digital library makes locally or remotely stored digital content available to users who access it by computer. The digital library, a name newly coined in the late 1980s, progressed rapidly from experimentation to implementation and specialization. Digital geospatial libraries (DGL) not only began to provide Internet-accessible searching of materials containing information about geographical locations but also played a leading role in the early overall development of digital libraries.

By 2005 a user of a full-featured DGL could click on a map or input the name or coordinates of a geographic place to search an online catalog of metadata (catalog) records and downloadable digital geospatial data, often from more than one data source. For example, the downloadable portions of the Center for Earth Resources Observation and Science (EROS) EarthExplorer constituted a full-featured DGL with local holdings, while the U.S. Geological Survey (USGS) Geospatial One-Stop redirected users to other web locations. Only a few institutions maintained large data inventories locally, an example being the National Geospatial Digital Archive (NGDA), which used the Alexandria Digital Library middleware to access metadata and to display results.

DGLs were revolutionary because of their innovative search-and-management dimension. Examples of geospatial information were maps and aerial images, while georeferenced information, a broader information type, included geospatial data and documents mentioning a geographic area. Addition of a place-name or a point or polygon of latitude-longitude coordinates to the metadata meant that a DGL enabled users to search by pointing to a location on a map. The advantage was item-level retrieval for data that had been hard to find using traditional library catalogs.

Digital libraries benefited from the transition from printed to digital publication facilitated by cheaper digital storage and faster networks. Although digital content became less and less expensive to ingest, maintain, and obtain, continuing management problems for online collections of digital geospatial data included the large size of files, which thus required more time for network downloading and more disk storage space. Also, creating metadata and populating the data archive were labor-intensive tasks. A geospatial data search interface that users would perceive to be intuitive to use was a difficult computer-programming task requiring skilled computer-technical staff to work on DGL operations.

The advent of environmental and other laws affecting property and land use increased the demand for library services to support spatial searching. Digital libraries of geospatial data gained in popularity as substantial portions of cartographic resources became available in digital form. The transition from analog maps to digital cartographic products in the last thirty years of the twentieth century can be traced in the research literature, such as the proceedings of the series of international symposia on computer-assisted cartography, known as "Auto-Carto," first held in Reston, Virginia, in 1974 (ACSM 1974–).

In the late 1980s the development of web services was just starting, and few tools were available for building and archiving persistent digital content. This was followed in about 1989 by the emergence and instant success of the Internet and easy-to-use browsers. U.S. federal government agencies soon began to serve out digital geospatial data that they had produced, and an early adopter was the U.S. Fish and Wildlife Service, which began serving out wetlands digital geospatial data in 1994 (Robinson and Wilen 1997). The September 1993 release of the web browser Mosaic was an advance that allowed users to browse graphically.

DGLs first became part of the nation's research agenda in 1994, with the inception of the U.S. National Science Foundation's (NSF) Digital Library Initiative (DLI) grant program. Six universities received DLI grants, with one grant being expressly for building a digital library of geospatial data, the Alexandria Digital Library (ADL), received by the University of California, Santa Barbara (UCSB) (Lipkin 1995). A group of library staff, computer scientists, and geographers collaborated to design and implement a geospatial digital library based on an earlier external design developed in 1985 under a grant from the Keck Foundation. The objective was to spatially organize, graphically search, and deliver via the Internet information objects containing at least one component represented by an earth location. By late 1995 there was a web prototype (Buttenfield and Larsen 1997), and by the end of the grant (September 1998), there was a working digital library. A place-name index, the ADL Gazetteer, was constructed using databases from the U.S. Board of Geographic Names (place-names for non-U.S. countries) and the U.S. Geological Survey (U.S. place-names) to make geospatial searching easier for those unfamiliar with geographical coordinates.

By the end of 1999, what began as the research-oriented ADL project had become an operational digital library, part of the library services of the Davidson Library, UCSB. The transition required modifications to technical components, as well as development of core ingest services. In order to move the ADL smoothly into the regular library operations, some ADL programming staff were integrated into the library's expanding technology team. As shown in the chronological diagram (fig. 207), the NGDA was in operation by 2005.

Well-thought-out technical architecture and middleware, as well as carefully designed user-friendly interfaces, proved to be essential for sustainable information services. At the heart of ADL architecture was a loosely coupled, layered, distributed, metadata-agnostic middleware that utilized extended library semantics to enable spatial discovery of information. ADL software accepted queries defined using standard library semantics, such as controlled vocabularies with hierarchical relationships, text, numeric identifiers, dates, and extended semantic

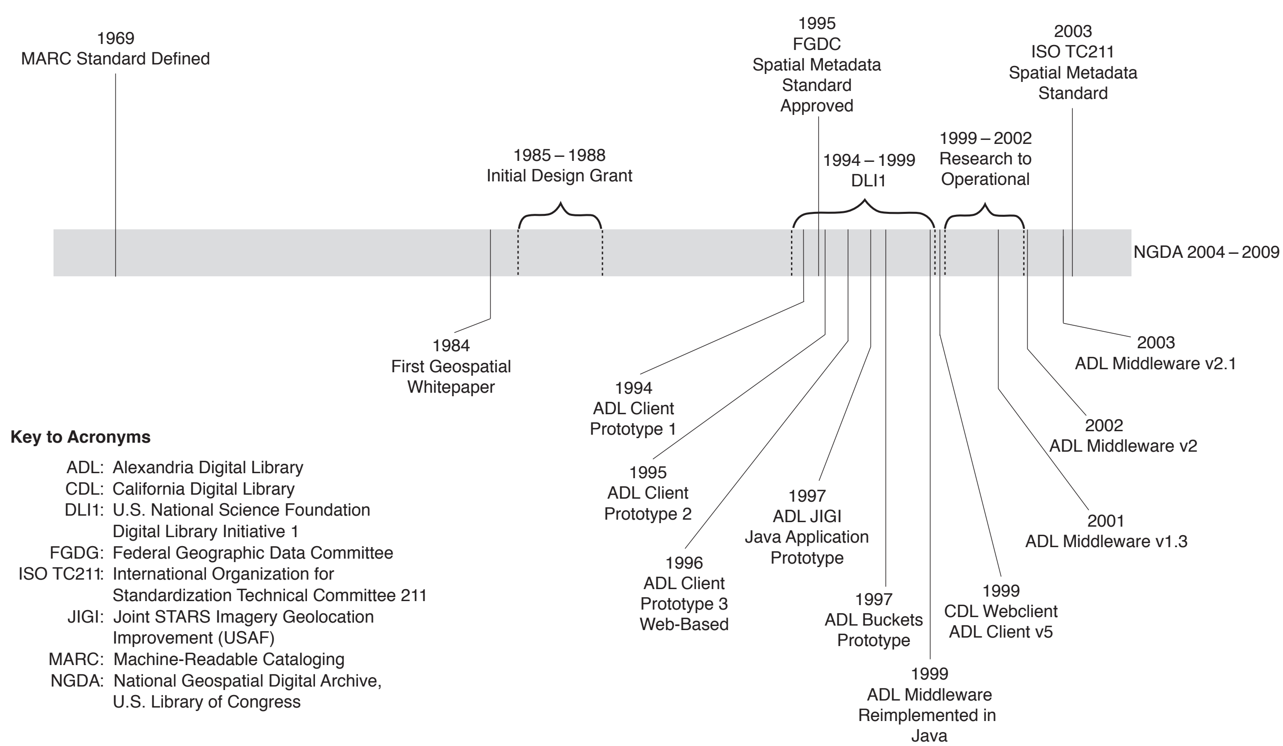

FIG. 207. A BRIEF CHRONOLOGY OF THE ALEXANDRIA DIGITAL LIBRARY (ADL) BASED AT UCSB.
Illustration adapted from a paper delivered by Larry Carver at an International Digital Libraries meeting in Beijing, China, September 2004.

objects, such as geospatial constraints. Such queries could be sent to multiple ADL middleware servers, each of which might contain catalog records in one or more metadata standards. ADL middleware differed from other library search protocols in that query construction was not only a textual constraint but also a set of specific semantics.

Both government agencies and the library world realized that users wanted to obtain geospatial data in digital form over the web. U.S. government agencies found they could reach many more users more efficiently by serving out more data in digital form than they ever distributed as paper maps. A prominent example was the U.S. National Wetlands Inventory: "Over a period of 13 years before Internet, NWI sold 37,996 digital wetland data files through USGS's 1-800-USA-MAPS. . . . The average cost per map file was $9.20. . . . During the first two years 163,570 digital wetland map files were downloaded. At the average cost of $9.20 per map file, users have saved over $1.5 million dollars" (Robinson and Wilen 1997).

It became common for state-based centers to serve out or point to digital geospatial data for a given state. Of the many in existence, two representative examples were the California Spatial Information Library and the North Carolina Geographic Data Clearinghouse.

Among American libraries, serving out digital geospatial data became part of every major map library's web presence. In addition to the ADL, some other major servers were the Geography and Map Division of the Library of Congress, the Map Division of the New York Public Library, the Pennsylvania State University Maps Library, and the Map and Geographic Information Center at the University of Connecticut (McGlammery 1995). Their success rested upon their ability to incorporate online delivery of geospatial data into ongoing library services for all types of digital data and to integrate digital library operations with traditional library collections and services. The presence of these innovative digital library projects stimulated digital projects in other fields, such as the digitization of audio files. Successful geospatial digital library projects also enhanced the position of university libraries as partners in the technological and academic curricular initiatives of larger organizations.

LARRY CARVER

SEE ALSO: Computer, Digital; Geographic Information System (GIS): Metadata; Libraries, Map; Libraries and Map Collections, National; Map: Electronic Map; Public Access to Cartographic Information; Web Cartography

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Digital Worldwide Mapping Projects. Interest in general-purpose world maps continued into the digital age. The U.S. Central Intelligence Agency's World Data Bank II, a data set of national boundaries and world coastlines introduced in mid-1970, is an early example of a digital world map (Estes et al. 2001). Increasingly sophisticated application software developed soon after and demanded more comprehensive, consistent, and detailed information (Mounsey and Tomlinson 1988). The three international projects examined here addressed these new demands.

The Digital Chart of the World (DCW) began in 1989 as a cooperative research and development project led by the U.S. Defense Mapping Agency (DMA), with the military mapping agencies of the United Kingdom, Canada, and Australia as partners and ESRI (Environmental Systems Research Institute) as the principal contractor. The goal was a distribution format—the Vector Product Format (VPF)—and an initial data set to attract users. Compilation was based on 270 1:1,000,000 Operational Navigation Charts, an aeronautical product produced by the participating nations. Sources also included the 1:2,000,000 Jet Navigation Charts (covering Antarctica), DMA's Digital Aeronautical Flight Information File (world airports), and the National Aeronautics and Space Administration's (NASA) Advanced Very High Resolution Radiometer data (vegetation covering North America). The result was 1.7 gigabytes of vector data on four CD-ROMs, each covering one quarter of the world for sixteen thematic layers, which included transportation, drainage, hypsographic, utility, cultural, political boundary, and populated place information (Danko 1991). Original development was completed in 1992. Later known as VMap Level 0, the DCW has been used widely throughout the world for military, scientific, and educational purposes.

The General Bathymetric Chart of the Oceans (GEBCO) digital atlas evolved from the *Carte générale bathymétrique des océans*, published in Paris in 1905 by a commission of the Seventh International Geographic

Congress. The fifth edition (1982) of the paper version, which covered the world's oceans at 1:10,000,000, was a joint endeavor of the International Hydrographic Organization and the Intergovernmental Oceanographic Commission of UNESCO (United Nations Educational, Scientific, and Cultural Organization). Work on the *GEBCO Digital Atlas* was started in 1984, and an initial version, completed in 1994, was followed by an updated version in 1997 and a centenary edition in 2003 (Scott 2003).

The Global Map Project is rooted in the 1992 Earth Summit—the United Nations Conference on Environment and Development—and the International Steering Committee for Global Mapping, formed in 1994 with support from the Japanese Ministry of Land, Infrastructure and Transport. The project's specifications called for whole earth coverage at an equivalent resolution of 1 kilometer for eight thematic layers: boundaries, drainage, transportation, population centers, elevation, land cover, land use, and vegetation. Initial data sources included the Global 30 Arc-Second Elevation Data Set for elevation data (provided by the U.S. Geological Survey's National Center for Earth Resources Observation and Science [EROS]); the Global Land Cover Characteristics Data Base for land cover, land use, and vegetation (from U.S. Geological Survey, the University of Nebraska-Lincoln, and the European Commission's Joint Research Centre); and VMap Level 0 data. Production continued into the twenty-first century as more nations produced country-specific data sets. Global Map Project data sets have been available on the Internet since November 2000, and worldwide coverage was complete in 2007.

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SEE ALSO: General Bathymetric Chart of the Oceans (GEBCO); International Map of the World; Kokudo chiriin (Geographical Survey Institute; Japan); Military Mapping by Major Powers: United States

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Directorate of Overseas Surveys (U.K.). The Directorate of Colonial (Geodetic and Topographical) Surveys was established on 1 March 1946 as a centrally administered organization of the Colonial Office to undertake surveys and mapping in British colonial dependencies. It opened in southwest London on 11 March 1946 with Brigadier Martin Hotine, a wartime director of Military Survey seconded from the War Office, as the director. In 1957 it was renamed the Directorate of Overseas (Geodetic and Topographical) Surveys, with the name shortened to Directorate of Overseas Surveys in 1968. The Directorate was closed in 1984. "Directorate" and the acronym "DOS" will be used in this article.

The influence of the War Office on colonial surveys and mapping can be traced to boundary delimitation and demarcation surveys undertaken in Africa during the period 1890 to 1914 (McGrath 1976). Learned societies demonstrated interest in the need for systematic topographic mapping, especially the Royal Geographical Society and the Royal Colonial Institute. In 1901 the former provided an estimate of the cost of topographic mapping of the African dependencies prepared by Colonel Thomas Hungerford Holdich based on his experience in India. The director of Military Intelligence in the War Office was also concerned over the state of mapping in the African dependencies after the Anglo-Boer War. This led to a proposal by Major E. H. Hills in 1903 for a Department for African Mapping that should be independent of the War Office, though this was not implemented. The creation of the Colonial Survey Committee (CSC) in 1905, with initial membership from the Colonial Office, War Office, and Ordnance Survey, proved to be of long-standing significance. It was a critical mechanism for drafting specifications for colonial topographic mapping, coordinating colonial geodetic and topographic surveys, and arranging for military survey parties to be sent to colonial possessions for specific tasks. The War Office supplied Royal Engineers field parties that undertook control surveys and mapping in the West and East African dependencies prior to 1914, and during the interwar years in Nigeria (Anderson 2004), on the 30th Arc geodetic triangulation in Tanganyika (Hotine 1934a, 1934b, 1935a, 1935b), and in Jamaica (McGrath 1983).

Lord William Malcolm Hailey's comprehensive and unprecedented study of Africa (Hailey 1938) and Dr. E. Barton Worthington's complementary review of the state of surveying and mapping in Africa with particular discussion of the use of loan funds (Worthington 1938) influenced the colonial secretary to refer the subject of coordination of surveys to the CSC in 1939. In 1941 Hailey was appointed chairman of the Colonial Office Committee on Post-war Problems and in 1942 chairman of the Colonial Research Committee. Both turned their attention quickly to the control survey framework and the need for centralized direction and control of colonial surveys. The War Office and Ordnance Survey submitted a joint memorandum that favored a central organization. By December 1943 a planning section had drafted a detailed ten-year plan for such an organization. Aerial photography was to play a crucial role in topographic mapping. The map scales envisaged were 1:125,000 for full coverage of a dependency, 1:50,000 for the more developed areas, and 1:25,000 for areas of special economic importance. The draft plan was reviewed by the CSC and the Colonial Research Committee in 1944 and in September of that year was circulated by the colonial secretary to colonial governments. Most responses favored the proposed central organization (McGrath 1983, 2–4). There was one strenuous objection, several offered comments, and several indicated they would not require its services.

Financing colonial surveys and mapping was assisted to a small extent by passage of the 1929 Colonial Development Act and the creation of the Colonial Development Fund (CDF). Both Tanganyika and Northern Rhodesia received grants from the CDF in partial support of geodetic and topographic surveys, the balance being funded by the respective governments. The 1940 Colonial Development and Welfare Act represented a significant change in British government policy. However, its impact upon colonial surveys and mapping was minimal due to wartime preoccupation with meeting military requirements and shortages of staff, equipment, and materials in the survey departments of individual dependencies. In contrast the 1945 Colonial Development and Welfare Act (CDW) was of the utmost importance. It recognized the need for centrally administered schemes and provided capital and operating funds on which the Directorate was fully dependent from its creation in 1946 until 1961, and to a reduced extent thereafter.

The Directorate began work with mathematical adjustment of the portion of the 30th Arc between Southern Rhodesia and Uganda; and with the completion of mapping begun by military units in 1944–45. The latter included 1:50,000 multicolor topographic sheets of Jamaica; 1:25,000 of Antigua; 1:10,000 maps of Bridgetown, Barbados; and parts of the Freetown Peninsula, Sierra Leone. Gambia was an early recipient of Directorate 1:50,000 mapping as well as 1:10,000 sheets of the Kombo Peninsula.

The years 1948 to 1953 were mainly committed to substantial colonial development projects that required large areas of 1:30,000 panchromatic aerial photography for 1:50,000 mapping; to meet the urgent mapping needs of the security forces in Malaya and Kenya after the declarations of an emergency in 1948 and 1952 respectively; and to 1:50,000 mapping of the Kenya-Ethiopia boundary. The photography was exposed from Royal Air Force (RAF) aircraft equipped with Gee-H radar, which usually flew in concentric circles at fixed radial distances from a single ground radar station. Only small areas were photographed under visual navigation, and most of that was undertaken by commercial air survey companies in the Caribbean, British Guiana, the Gold Coast, Bechuanaland, and Fiji.

Between 1946 and 1953 the RAF achieved slightly more than one million square miles of photography, albeit of variable quality, from Fairchild K-17 and later Williamson F49 cameras. The development projects were in the Gold Coast (the proposed Volta River dam and future reservoir); Nigeria (Niger Agricultural Project and part of the north); Uganda (the desiccated area of Karamoja); Kenya (African agriculture between Mount Kenya and the Aberdare Mountains), Southern and Northern Rhodesia (the proposed Kariba Dam and Reservoir on the Zambezi River); Tanganyika (East African Groundnuts Scheme); and Tanganyika–Northern Rhodesia (the proposed Central African Rail Link). Most ground control was surveyed by Directorate surveyors, Nigeria being an exception, while a number of sheets in Tanganyika had to be compiled without ground control. Slotted-template assemblies were laid down at the Directorate, and 1:50,000 planimetric maps were compiled by graphical techniques preparatory to fair drawing for monochrome reproduction. Only a very small proportion could be contoured on multiplex plotters in the time available. Usually the Preliminary Plots were not field-completed and thus carried few names. Exceptions to the monochrome 1:50,000 sheets were a planned block of nine five-color, contoured 1:62,500 sheets of the central highlands of Kenya and some in the Gold Coast and Nigeria (monochrome), the choice of scale being influenced by existing maps. Only one multicolored 1:62,500 sheet of Kenya was published in 1949.

The pressure of postwar demand for medium-scale mapping simply excluded the luxury of contouring and color separations. Priorities changed with little warning. Thus the so-called 1:50,000 Preliminary Plot entered the cartographic vocabulary. It continued until 1955–56. The Directorate expected that the Plots would be replaced by standard multicolor topographical series "as and when time allows, and when full control has been fixed" (McGrath 1983, 102). Hotine accepted early in 1946 that the proposed 1:125,000 scale was too small for general coverage, though it was used for monochrome mapping of the Somaliland Protectorate in 1952 and parts of Bechuanaland. Printing of the Directorate's map sheets was undertaken by the Survey Production Centre of the Royal Engineers with the exception of Nigerian sheets, which were printed in Lagos. Printing by the military became a long-standing arrangement despite an unsuccessful DOS proposal in 1958 for the purchase of printing presses and associated photomechanical equipment. Printing of DOS maps was also done by the Ordnance Survey for many years and, occasionally, by the Hydrographic Department of the Admiralty.

Between 1950 and 1958 the Directorate completed observations of numerous chains of triangulation in East and Central Africa. These were computed, adjusted, and, where appropriate, connected to the 30th Arc. A profound change in scaling triangulation occurred in 1957 when the new electromagnetic distance measurement (EDM) instrument, the Tellurometer, was used to remeasure a baseline in Kenya that had recently been measured with invar wires. Its potential in first-order traversing was recognized and tested the same year in Kenya. The Directorate became one of the first survey organizations to adopt EDM traversing rather than triangulation as the means of providing first- and lower-order control (Macdonald 1996).

Photogrammetric compilation of large-scale maps on a Wild A5 plotter commenced in 1950 for the production of four-colored, contoured 1:10,000 mapping of the whole of Barbados. A Zeiss C6 plotter was added in 1953, and gradually other British islands in the Caribbean were mapped. The absence of contours or form lines from the 1:50,000 Preliminary Plots of the African dependencies prompted strong demand from map users for topography to be shown. Several interim solutions were adopted: point elevations; stylized relief utilizing hachures or hachure-like symbols together with textual descriptions; and finally hill shading, which was used in 1:50,000 mapping of Nyasaland, Southern Cameroons, Sierra Leone, Kenya, and Sarawak. However, there was continued pressure for contoured or form-lined sheets, and by the late 1950s multiplex long- and short-bar plotters became the workhorses for contouring medium-scale maps. The emergency in Kenya (1952–60) led to a crash program in which the Directorate of Military Survey superimposed the East African 5° transverse Mercator reference grid on the Preliminary Plots, and field completion was incorporated by the Survey of Kenya. These steps necessitated multicolor reproduction and, in conjunction with neighboring Tanganyika and Uganda, the subsequent development of a common East African 1:50,000 map specification by 1962.

Electronic computing for the conversion of geographical to grid coordinates was undertaken first in 1955. This was followed by the production of provisional coordinates and heights for mapping. The Directorate arranged with the Directorate of Military Survey for part-time use of the latter's mainframe computer, and electronic adjustments of chains of triangulation and traversing in East and Central Africa were begun in 1960. Use of a military mainframe computer continued after the Directorate acquired its HP 9100B desktop computer and peripherals in 1970.

After satisfying the mapping requirements of major infrastructure and development projects, the Directorate accepted requests for new blocks of medium-scale mapping directly from the survey departments in the dependencies. These requests were based on consultations between the overseas directors and their counterparts in agriculture, forestry, mineral and natural resources, veterinary services, and water supply. The Directorate assessed the requests, assigned relative priorities, and financed map production with the CDW funds that sustained its operations. Thus in a given dependency there could be areas mapped previously for a development project or security requirement, new areas of mapping completed or in progress, and areas not yet mapped. The last would prompt further requests to the Directorate with the ultimate goal being full medium-scale map coverage of the dependency. The system relied on at least annual consultations between Hotine and his counterparts overseas.

Independence was granted to the Gold Coast (Ghana) in 1957. By 1964 nine other dependencies, and several island states of the former West Indian Federation, had also been granted independence. This profound change in political status, and the resulting ineligibility for CDW funds, prompted successive British governments to introduce new administrative arrangements, policies, and practices to regulate the delivery of aid. These changes had gradual but significant impact on the programs of work and funding of the Directorate. There was closer scrutiny and tighter control of the organization by the Treasury, the Department of Technical Cooperation (DTC), created in 1961, and the Overseas Development Ministry (ODM), created in 1964. An early decision required an application for technical assistance from the Directorate to be submitted directly to the DTC, which also required the Directorate to submit a five-year forecast of work so that staffing could be regulated. Increasing emphasis was placed by ODM on the justification and evaluation of proposed aid projects so that their "aid worthiness" could be determined. To a large extent this relied on a Project Assessment Committee established in 1967. The Norwood Working Party reported on the Directorate in 1968. It recommended that an Overseas Advisory Committee be created for discussion of the annual program of work and future proposals, and that new surveys and mapping projects be justified. Advice should be sought from ODM geographical departments, and the Directorate should have a long-term scheme for the replacement of technical equipment.

There were several significant additions to the Directorate's roles in the early 1960s. Independence led to the loss of experienced expatriate officers from the newly independent states and to the secondment of Directorate staff to overseas governments, the first being Ghana and Nigeria, to assist in training schemes, the provision of mapping control, survey administration, and later land administration. Assistance with first-order leveling was provided to Bermuda, Gibraltar, Uganda, and Kenya. The first overseas staff to undergo practical training in a production setting at the Directorate arrived in 1951–52. Capacity was increased after 1960 to reflect the growing requirements of newly independent states, the maximum enrollment in a single year rising to thirty-nine students. The variety of subjects was expanded to cover photogrammetry, cartography, photography, and photomechanical methods.

Large-scale mapping of urban and project areas became a major commitment for the Directorate affecting all departments. This was in response to requests from overseas governments for mapping needed for urban planning, property valuation, engineering assessment and design, farm planning, and land registration schemes. The case of Cyprus, before independence, illustrates the mapping of a small territory with a single compilation and drawing scale for two map series. The 1:10,000 photogrammetric compilations were field-completed, scribed, color-separated, and reproduced at the scales of 1:10,000 and 1:25,000. Similar dual-scale mapping was applied to Tobago and gradually to other West Indian islands. The method of Aerotriangulation of Independent Models (AIM) was developed by the Directorate for observations on an A8 plotter and adjustment on the Pegasus computer of the Military Survey. Compilation and contouring were undertaken separately on first-order plotters and were followed by field completion, fair drawing, and color reproduction. The islands of Gozo and Comino (at 1:2,500 scale); Nassau in the Bahamas (1:2,500); the peri-urban area of Lagos (1:1,200) and Enugu (1:2,400), Nigeria; and Bathurst in Gambia (1:2,500) illustrate the growing importance of large-scale mapping.

The Directorate also undertook medium-scale mapping projects at the request of United Nations (UN) agencies in North Borneo (Sabah), Northern Rhodesia (Zambia), and Kenya. The provision of survey control for cadastral surveys was accepted as a task in Mauritius, the Solomon Islands, Trinidad, and Kenya, where the Directorate's contribution to the massive land reform and registration program was begun in 1965 and lasted thirteen years. The Directorate adjusted large blocks of secondary and lower-order triangulation and traverses for Kenya, Uganda, Malawi, and Sierra Leone, projects that would previously have been undertaken by the respective governments. It also performed numerous transformations of coordinates from one system to another.

The Directorate provided workspace for the secretary of the Committee on the Aerial Survey of Forests from 1949. Eventually the Photo Forestry Section was formed that drew upon the Directorate's growing expertise in panchromatic aerial photography, photographic processing, and topographic mapping. The section investigated the use of black-and-white infrared photography for rice surveys, forestry, and vegetation applications and produced the drafts of thematic maps that were fair-drawn by the Directorate's cartographers. A land utilization officer was appointed in 1956, and land evaluation for particular uses was added to field and office investigations. The two interests were merged in 1958, and additional staff were appointed. From this stemmed the Land Resources Division (LRD) of the Directorate, created in 1964. It was responsible for reconnaissance-level land resource surveys to evaluate development potential and to indicate areas worthy of more detailed attention. The Pool of Soil Surveyors was incorporated several years later. Normal and infrared color photography was first commissioned for land resource investigations in Ghana during 1965. LRD staff worked in many locations and on varied topics. For example, in 1964 there were projects in Basutoland (landform analysis and soil survey), Bechuanaland (irrigation), the Solomon Islands (forest inventory), Christmas Island (coconut production), Kenya (ecological survey), New Hebrides (forestry), northern Nigeria (land analysis), Sudan (vegetation mapping), and Tanzania (land resources). A rich stream of thematic maps, small-scale report maps, block diagrams, and graphs was produced to illustrate the results of field investigations. Even after the division was separated from the Directorate in 1971, production of cartographic products for the LRD continued.

The Directorate achieved wide recognition and won several national awards for its recreational and tourist mapping. This began with a 1:25,000 hill-shaded map of Mount Kenya published in 1958, which showed tracks and mountain huts. A similar sheet for the Central Ruwenzori followed in 1962 and subsequently smaller-scale sheets of Mount Kenya, Kilimanjaro, and the Aberdares. Tourist mapping opened with a request from the Barbados Development Board in 1959 for a single 1:50,000 sheet of the island. A similar map was produced later for each of the larger islands in the Windward group, the Seychelles, Bermuda, and Victoria Falls.

Photomaps were one of the Directorate's major cartographic contributions during the 1970s. Experiments were begun in 1967 using unsharp masking, but this technique was replaced in 1968 by combinations of line screens and colors that would reflect the nature of the terrain being mapped. The early photomaps were produced for part of the Okavango Swamp in Botswana, Tonga, and Aldabra. Refinements during the 1970s introduced appropriate line symbols and resulted in a reduced number of printing plates. Large blocks of photomapping were produced for Botswana, Gambia, Lake Chad, and the Middle Tana River in Kenya, in some cases as substitutes for older line mapping. Photomaps were also produced of small islands in the Pacific and the Caribbean.

The Directorate first produced 1:63,360 derived mapping for Zanzibar in 1946, and for Jamaica (1:250,000) in 1954. Due to its preoccupation with urgent medium-scale mapping from 1948 to 1960, and the growing capability of some local survey departments to produce their own, production of first edition derived mapping was not resumed until the early 1960s for Fiji, the Falkland Islands, Lesotho, and Botswana. Interesting innovations were introduced into the production of derived million-scale mapping to the 1962 International Map of the World specification for parts of Tanzania, Malawi, and Zambia, and on locally determined sheetlines for Kenya and Malawi.

A Civil Service Department review of the Directorate in 1971 recommended that the Directorate's staff be reduced by about 25 percent within two years and that photogrammetric plotting and drawing beyond the Directorate's capacity be contracted to private sector companies. This was modified in 1974 to contracting being an occasional rather than a permanent feature. The first contract was let in November 1972, and the final (forty-fifth) in April 1979. Contract mapping scales ranged from 1:1,000 (Maldives) to 1:50,000 (43 percent of contracts), with the largest block comprising 102 sheets. The supervision of contracts and quality control became significant new responsibilities for the Directorate. Another important innovation of the 1970s was the Joint Project. Either the DOS and the client country worked together on most aspects of a mapping project so that the client's domestic capacity and capability were strengthened, or the DOS undertook those functions for which the client was not equipped or had insufficient capacity. Ethiopia (1970–77) illustrated the first and Cyprus the second.

The 1971 review also led to the government decision that the DOS should remain a viable organization until 1979, with a further review in 1975. However, the Directorate was threatened with relocation consistent with the government's regional policies. Manchester and Glasgow were proposed in 1973, though other locations were considered. Staff morale was affected, and a steady drain of staff to other organizations began. The 1975 review of the Directorate concluded that it was sound in principle for government to provide direct aid in surveys and mapping, and that the Directorate should continue beyond 1979 without major change. This was confirmed by the minister in 1976, which brought some relief to the beleaguered organization. Then in 1977 the Labour government announced that the Directorate should be relocated to Glasgow, a decision that was revoked two years later by the incoming Conservative government. The latter embarked upon an in-depth scrutiny of all government departments, the so-called Rayner reviews. In 1980, the review focused upon the Directorate—its services, costs, and benefits—and a comparison of productivity and costs with private sector mapping. As a result of the review, the minister decided in mid-1981 that many of the Directorate's functions should be transferred to the private sector with a consequential 60 percent reduction in staff. The remaining staff would be relocated to Southampton as an Overseas Directorate of the Ordnance Survey. That move took place in 1984.

Since 1946 the Directorate had assisted eighty countries, produced maps of over two million square miles, trained more than 600 overseas staff in London and countless others abroad, and achieved professional distinction for its innovative methods and cartographic excellence. Its collective accomplishments were a unique contribution to the accelerated development of British dependencies and then of independent countries.

GERALD MCGRATH

SEE ALSO: Decolonization and Independence; Hotine, Martin; Military Mapping of Geographic Areas: Southeast Asia; Topographic Mapping: Africa by the British

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Distance Measurement. See Electromagnetic Distance Measurement; Property Mapping Practices

Drafting of Maps.

DRAWING INSTRUMENTS
DRAWING MEDIA
PEN-AND-INK DRAFTING

Drawing Instruments. For most of the twentieth century, drawing instruments used to apply pencil or ink to a surface were staples in the cartographer's toolkit. Rather than discuss each drawing instrument separately, this essay explains how the ensemble changed over time, as described in mapmaking textbooks.

Drawing instruments were exported worldwide from European countries, leaders in drawing technology, where similar trends were evident. Drawing tools were produced by companies specializing in precision engineering. Manufacturers of surveying instruments often used their expertise to make drafting and drawing instruments. In turn, producers of drawing instruments made contributions to surveying equipment. One company, Kern & Co. AG of Aarau, Switzerland, founded in 1819, expanded the market for its drawing instruments through international subsidiaries until taken over by the Wild Leitz Gruppe in Heerbrugg, Switzerland, in 1988.

Since the advent of photomechanical reproduction in the late 1800s, drawing maps for photography soon supplanted manual production of the printing image. Frank T. Daniels included a chapter on photographic methods in his 1907 topographical drawing textbook, as did Henry A. Reed in his 1903 book on drawing and sketching, by then in its fourth edition. The list in Reed's book of essential drawing instruments (1903, 1:1–3), includes lead pencils in hardnesses from HB to 6H (fig. 208), common drawing pens (Gillott's 303 and 404 nibs), and finer crow-quill metal-nib pens used for freehand drawing and lettering (fig. 209), and the drawing or right-line pen for ruled lines (fig. 210).

While the Romans had used ruling pens (Hambly 1988, 57–58), steel-nibbed common pens did not replace quill pens until the mid-1800s, when the first nib factories appeared in England and Germany. Nibs favored by mapmakers were marketed for decades by manufacturers in Germany: Heintze & Blanckertz, Brause & Co., and F. Soennecken; in Austria: Carl Kuhn & Co.; and in England: Joseph Gillott, C. Brandauer and Co., and A. Sommerville and Co.

Early twentieth-century compilations of drawing accessories (Reed 1903, 1:3–8; Daniels 1907, 1–17; Spooner 1908, 4–22) also included: penknife, file and emery paper or sandpaper for sharpening pencils; whetstone (or oilstone, grindstone) for sharpening ruling pens (ruling pens that were too sharp would cause cuts in the paper, which would cause bleeding lines). In addition to wood-covered graphite pencils, leads could be inserted into ever-pointed pencils (an early name for mechanical, clutch, or propelling pencils) useful for skilled draftsmen. The straightedge or ruler, triangle, T-square, and parallel rulers guided the drawing of straight lines. Marking and drawing regular curved lines involved dividers, ordinary compasses, bow-pens (or bow compasses) for small circles and beam compasses for large circles. A horn or metal disk protected the paper from the compass point. French curves guided pencil drawing of irregular curves before inking with a curve pen, a swiveling ruling pen. Distances and angles were measured and marked with a triangular scale, spacing divid-

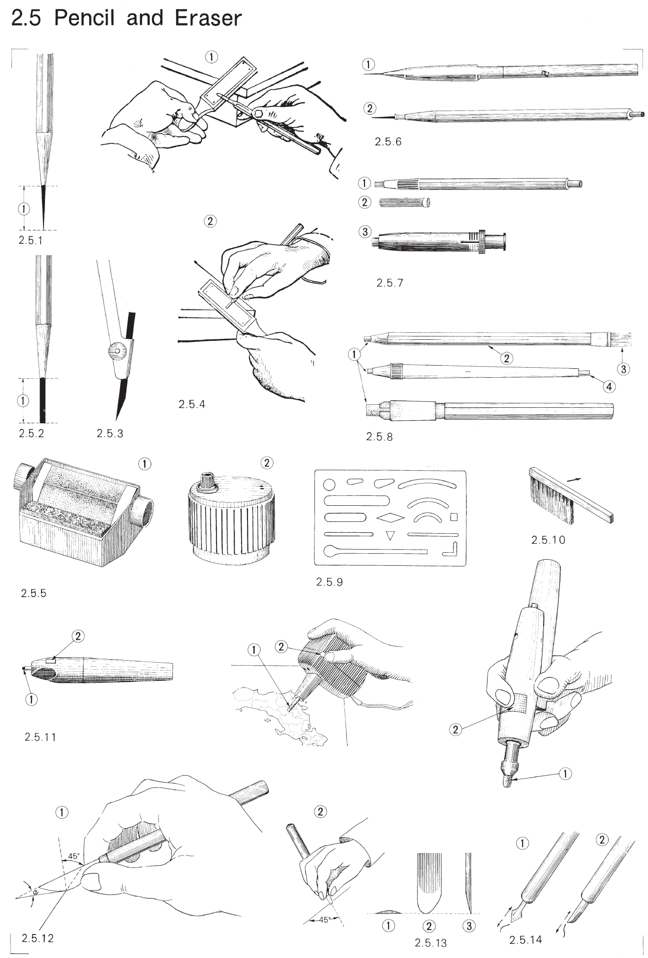

FIG. 208. *PENCIL AND ERASER*. Improvements in devices for holding, sharpening, and erasing leads increased the functionality of the pencil in map drawing during the twentieth century. Depicted are: examples of sharpening lead (2.5.1–2.5.4); lead sharpeners (2.5.5); clutch pencils (2.5.6); fiberglass erasers (2.5.7); India rubber (2.5.8); template for erasing (2.5.9); brush (2.5.10); types of electric rubber erasers (2.5.11); erasing knives (2.5.12); views of eraser points (2.5.13); and erasers for a small area (2.5.14).
Size of the original: 24.8 × 16.8 cm. From Kanazawa 1984, 129. Permission courtesy of the International Cartographic Association.

ers, and various protractors. Also essential were drawing pins (or thumbtacks), sponges, blotting paper, erasers, and a drawing board. Walter G. Stephan (1908, 40) also praised the Universal brand drafting machine for freeing the draftsman from tedious repositioning of T-square and triangles. Other labor-saving devices included ruling pens with graduated thumbscrews for resetting blades to particular line widths (62), double-nib railroad pens (74–75), erasing stencils (or templates for erasing), lead weights holding flexible splines to guide curve drawing (81), and Alteneder's one-handed pen-filling inkstand (71). Wheel-driven pens for dotting lines had been invented but worked poorly (63).

2.6 Drawing Pen

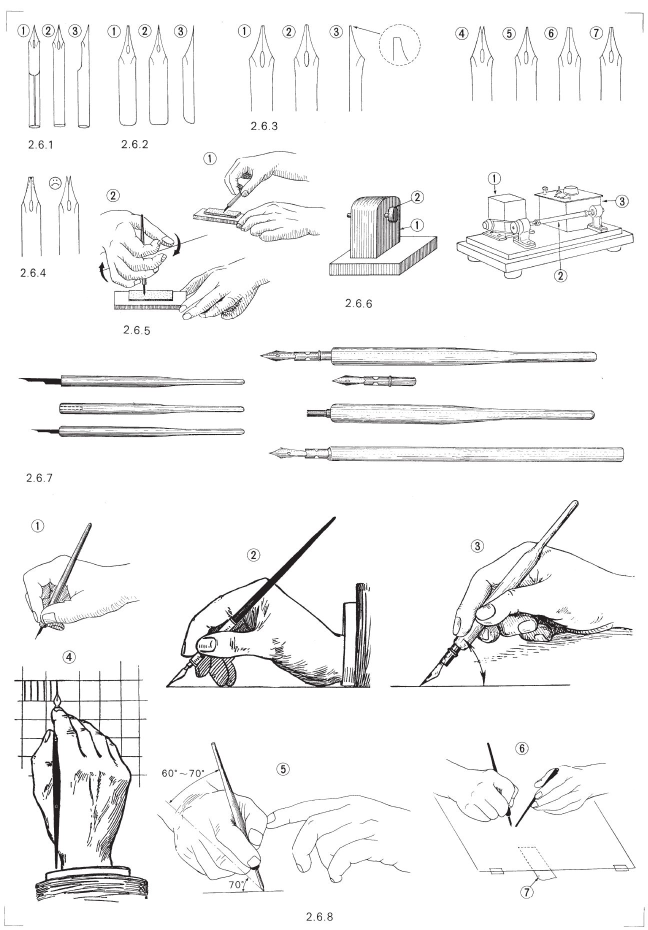

FIG. 209. *DRAWING PEN*. The drawing pen remained in use in map drawing for most of the twentieth century but became less important after the introduction of ink-reservoir technical pens midcentury. Depicted are: different pens and nibs (2.6.1–2.6.3); shaping a nib (2.6.4); grinding a nib (2.6.5); electric motor driven grinders (2.6.6); penholders (2.6.7); and holding a drawing pen (2.6.8).
Size of the original: 24.8 × 16.7 cm. From Kanazawa 1984, 131. Permission courtesy of the International Cartographic Association.

Cartographic textbooks of the second quarter of the century ranged from production manuals, like Malcolm Lloyd's *Practical Treatise on Mapping and Lettering* (1930), to academic textbooks broader in scope, like Erwin Raisz's *General Cartography* (1938, 1948). While Lloyd's list of instruments was traditional, except for Wrico lettering templates (5), Raisz compared old and new drawing instruments, the goal being to choose the best. He noted that some mapmakers preferred mechanical pencils but objected that the lead needed con-

2.7 Ruling Pen

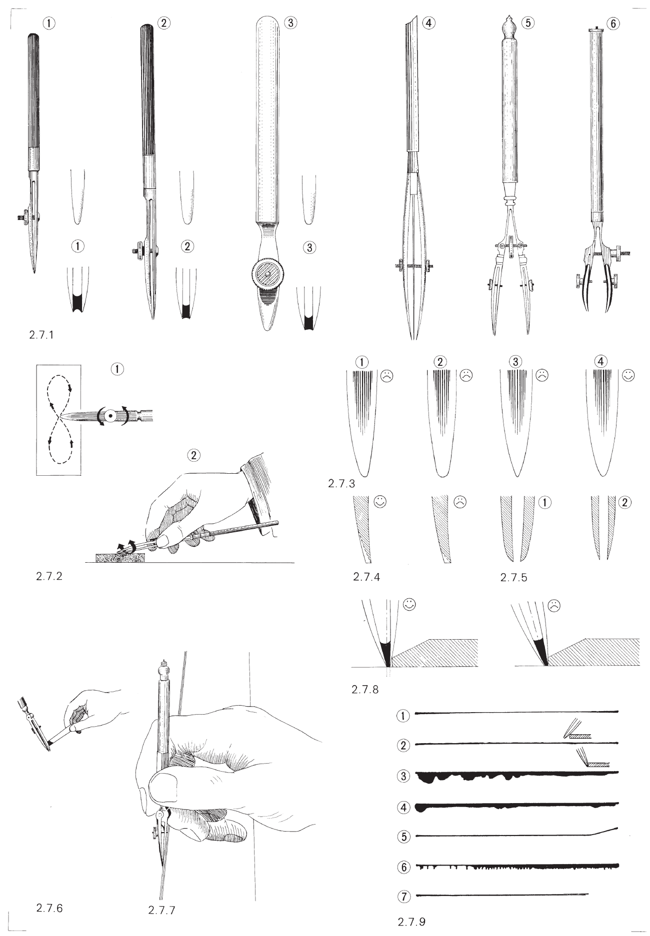

FIG. 210. *RULING PEN*. Like the drawing pen, the ruling pen saw less use in map drawing after the introduction of ink-reservoir technical pens and was regarded as a technology of the past by 1970. Depicted are: ruling pens (2.7.1); grinding tips (2.7.2); shapes of tips (2.7.3); correct and incorrect grinding (2.7.4); shapes of tips, sideviews (2.7.5); filling pen with ink using a strip of paper (2.7.6); correct vertical alignment of pen to drawing surface (2.7.7); correct and incorrect alignment of pen blade to ruler (2.7.8); and failures in drawing lines (2.7.9).
Size of the original: 24.8 × 16.7 cm. From Kanazawa 1984, 133. Permission courtesy of the International Cartographic Association.

stant sharpening (1938, 174; 1948, 149). Although the best mechanical sharpeners were adequate, he preferred traditional hand sharpening. By 1938 thumbtacks had been replaced by dry-sticking Scotch tape (or sellotape or cellophane tape), over which a ruler slid more easily (Raisz 1938, 177). Raisz recommended kneading or powdered erasers for cleaning pencil off maps after inking and process or reproduction white-out paint for correcting (1938, 171, 176) but failed to mention electric erasers, on the market by 1932 (Anonymous 1932). By 1938 layout notes to the printer were being written on artwork with nonphotographic blue wax crayons (Raisz 1938, 174), and in the second half of the century nonphotographic blue pencils became standard equipment.

In 1938 Raisz dismissed mechanical lettering templates and stencils as no easier than freehand lettering (174–75), although others disagreed (Saunders and Ives 1931, 107–8). By 1948, though, Raisz felt obliged to add one page (140) about mechanical lettering for geographers and other occasional mapmakers, noting that professional cartographers would seldom use them (140–41). Another addition was the comment that special mechanical-lettering pens, such as Leroy, were useful for drawing heavier lines. Although Raisz still preferred common pens for lettering and freehand drawing, he recommended inserting a small piece of copper wire or a strip cut from a tin can to retain ink and improve flow (1938, 175). A set of good-quality ruling pens and other instruments for measuring, marking, and ruling lines was still essential. Raisz did not mention the Pelikan Graphos, the first modern technical pen with an internal reservoir, introduced in Germany in 1932 (Hambly 1988, 64) (fig. 211).

The third quarter of the twentieth century was a period of transition as new types of pens replaced traditional ones. Although early 1960s textbooks still recommended ruling pens (Robinson 1960, 34–37; Raisz 1962, 13–14), by 1970 they were a technology of the past (Robinson and Sale 1969, 316; Hodgkiss 1970, 60–62). British textbook authors preceded American authors in recommending both Pelikan Graphos and other fountain-style (or reservoir) pens, such as Rotring Variant, Rapidograph, and Mars, whose tubular points in standard widths has a central pin regulating ink flow and do not require cleaning after use (Hodgkiss 1970, 63–67; Lawrence 1971, 117–18; Monkhouse and Wilkinson 1971, 3). However, new plastic drawing media caused pens to wear down faster and required special inks, which could corrode pens (Robinson 1960, 43; Raisz 1962, 15). The airbrush, invented in the late 1800s, was used mainly for terrain shading (Robinson 1960, 204). In addition to preprinted adhesive-backed lettering, point symbols, and area patterns, various brands of tape pens (such as

2.10 Special Drawing Pen and Drawing Ink

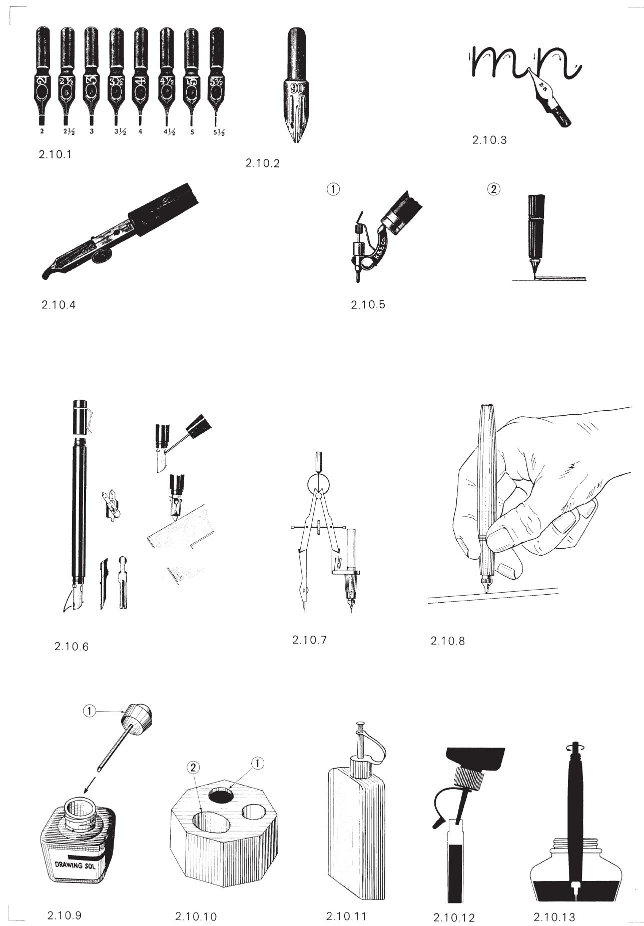

FIG. 211. *SPECIAL DRAWING PEN AND DRAWING INK.* The introduction of special nibs for drawing and lettering, available in standard sizes and combined with ink-reservoir pen holders, facilitated map design and drawing during the twentieth century. Depicted are: flat, double, and round nibs (2.10.1–2.10.3); Payzant lettering pen (2.10.4); tubular point (2.10.5); Pelikan Graphos pen (2.10.6); ink compass with tubular point and ink reservoir (2.10.7); tubular point pen with ruler (2.10.8); commercial drawing ink (2.10.9); ink bottle used on drawing desk (2.10.10); commercial ink dropper bottle (2.10.11); filling ink into cartridge-type reservoir (2.10.12); and tubular point pen with built-in piston mechanism (2.10.13).
Size of the original: 24.8 × 16.7 cm. From Kanazawa 1984, 139. Permission courtesy of the International Cartographic Association.

Chart-Pak or Brady Quick-Line) enabled penless application of adhesive-backed line symbols to maps (Hodgkiss 1970, 72–74). Drafting tape, less sticky than Scotch tape, was preferred in 1960 for keeping drawing media in place (Robinson 1960, 32), but by 1969 registry pins were also standard for holding multiple layers of artwork in register (Robinson and Sale 1969, 321–22). Increasing textbook space about direct negative scribing indicated the diminishing importance of ink drawing for photomechanical reproduction.

That trend accelerated with the rise of computer cartography during the last quarter of the century. Although Claude Z. Westfall (1984) emphasized manual map drawing and mentioned innovations, such as the slide compass for precise circle sizing (23), special plastic pencil leads for smear-free drawing on polyester films (25), and the ultrasonic pen cleaner (35), he also discussed scribing and computer-assisted cartography. The pace of change varied in different fields; in 1989 Lesley Adkins and Roy Adkins noted in *Archaeological Illustration* that cartographic establishments had adopted scribing but that pen drawing was still the mainstay of archeological mapmaking (14), although they included a chapter on computer graphics (215–37). By 1995 the sixth edition of *Elements of Cartography* noted that most map production was by computer (Robinson et al. 1995, 586), while hand drawing and scribing were fast fading from the mapping scene (651–52). The shift to computer production of graphic images was widespread in the graphic arts, as in the 2005 fifth edition of *Technical Drawing*, which included two chapters on manual drawing with instruments, but only for historical purposes (Goetsch et al. 2005, 43).

HANS-ULI FELDMANN

SEE ALSO: Airbrush; Scribing

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Drawing Media. Over time the development of different media, on whose surfaces map drawing was done, was associated with innovations in drawing techniques and instruments. By 1900 paper, introduced to Europe from China via Muslim trade routes in the tenth century, had long been the staple writing and drawing medium of Europe. Hand papermaking involved beating cloth rags mixed with water into a pulp into which a paper mold (a type of sieve) was dipped to remove a mat of fibers that formed a sheet of paper when pressed and dried. The parallel wires of the paper mold formed ribs in the paper surface, a disadvantage for map drawing and fine printing. In the 1780s, however, smoother wove paper (using a woven sieve), introduced several decades earlier by English papermaker James Whatman, spread to Europe, where it was called *vélin*. By 1850, production of machine-made wove paper in continuous rolls had increased in response to growing demand for printing. Rags for papermaking became scarce, inspiring attempts to make paper from wood pulp in the early 1800s. Even though it was adopted for printing newspapers and cheap books, wood pulp paper was inferior and tended to discolor.

During the early 1900s, a range of machine- and handmade papers were used for map drawing, each suitable for certain steps in and types of mapmaking: tracing paper, graph paper, transfer paper, cartridge paper, manila paper, Bristol board, and drawing paper. Tracing paper was thin and transparent but tended to tear and alter size with varying humidity, limiting it to ephemeral uses. Heavier tracing paper was convenient for plane table sheets in topographical survey work, because its transparency allowed direct copying of lines and control points on the projection sheet and of connecting topography on adjacent sheets (Stuart 1917, 20–21). When direct tracing was not feasible, the alternative was to interpose transfer paper, made by rubbing the back of thin paper with soft pencil, between the drawing and a blank sheet of paper and use a pointed instrument to transfer outlines lightly (Daniels 1907, 15–16).

Graph paper with precisely ruled lines (also called cross-section, profile, sectional, squared, or quadrille paper) served for preliminary sketching and drawing to scale. Cartridge and manila papers, often brownish or yellowish in color but strong, smooth, and able to withstand erasing, were employed for compilation and preliminary pencil drawing.

Whatman paper, handmade in a range of finishes and thicknesses, was generally recognized as best for the final stage of map production. It met all the requirements for drawing paper: strength, uniform thickness and surface, ability to withstand moisture but accept ink, retention of flexibility and whiteness with aging, hardness sufficient to keep pencil lines from forming grooves, and ability to withstand erasing (Stephan 1908, 18). Unlike machine-made paper, handmade paper fibers were aligned randomly, so the paper expanded or contracted evenly when humidity changed (Daniels 1907, 13). Sometimes drawing paper was mounted on backing sheets to improve its dimensional stability. Hot-pressed paper with a smooth finish worked best for pencil and fine ink drawings intended for photomechanical reproduction, while paper not hot-pressed had a grained surface suitable for maps drawn in ink and then hand-colored with watercolors. The smoother side on which the watermark was right-reading was the preferred drawing side (Reed 1903, 1:10). Other paper brands used for map drawing in America included Leonine, Weston's Linen Record, and Keuffel & Esser's Normal (Daniels 1907, 14). Smaller maps intended for reproduction by photoengraving, a photomechanical relief printing process often used for book illustrations, were drawn on Bristol board, a smooth-finished card that took ink well.

Some large-format maps for inventorying and planning were maintained as master copies and duplicated on-demand as single copies using, for example, the blueprinting process. They were usually drawn on durable, starched tracing cloth. Its dull side was preferred for pencil, while the shiny side was better for pen drawing after being prepared to receive ink by rubbing with powdered chalk or pumice (Daniels 1907, 16; Stephan 1908, 21). Tracing cloth was transparent, but its tendency to stretch when damp and become soiled were disadvantages. One strategy was to cover the tracing cloth with sheets of heavy paper or celluloid and draw through a small opening (Stuart 1917, 21). Lettering and lines for blueprinting had to be drawn larger and thicker than for photographic reproduction.

Although celluloid sheets with a ground-glass (i.e., matte) finish were recommended for field sketching of topography with pencil in 1918 (Stuart 1918, 97), the usual medium for map drawing was paper. When his *General Cartography* appeared in 1938, Erwin Raisz emphasized traditional paper for drawing except for a few innovations under "special papers." One with graphic potential for map illustration was Ross board, a paper with a grained enamel surface on which crayon terrain shading formed a pattern of dots, similar to halftone photography but simpler and cheaper to reproduce. Raisz also recommended cellophane and a product called Tracilin for tracing details from aerial photographs when perfect transparency was needed. Although celluloid sheets, either transparent or opaque, took fine lines in pen and pencil well and were washable and reusable, they were not dimensionally stable (Raisz 1938, 173, 187–88). Sheets of cellulose acetate, another mid-nineteenth-century invention, were also used for drawing maps in ink, but it was necessary to mix acetone with regular drawing ink to enable it to adhere (LeRoy and Low 1954, 28).

In 1954, however, cartographic publications from opposite sides of the world, Germany and Australia, were excitedly reporting the application of new polyvinyl chloride (PVC) plastic drawing media. Astralon (a German product) and Astrafoil (a U.K. product) were used for producing multiple pin- or punch-registered overlays, forming image layers that were then transformed into line and open-window negatives and positives by photographic copying and composited, in combination with reproduction screens, to form printing plates for multicolor lithographic map printing (Ashbolt 1954; Bosse 1954–55, 1:95–98). More dimensionally stable than Kodatrace and Ethulon (Braithwaite et al. 1954, 26) and able to take ink well, Astrafoil suffered from brittleness, a disadvantage later overcome by bonding it to a base layer of more flexible polyester film (Loxton 1980, 69). There were other well-known brands of polyester drawing films: Cronar, Duratrace, Folarex, Hostaphan, Kimoto, Permatrace, Herculene, and Stabilene (fig. 212). The development of plastic drawing media, stimulated by the World War II, led to a postwar revolution in map production, but the central role played in the 1950s by ink drawing for photography was soon usurped by direct scribing of negatives, also employing new plastic media (Holland 1980, 214).

Even so, the need for particular drawing media varied with the type and stage of mapmaking. Field topographic surveys, for example, required dimensionally stable drawing media usable under field conditions. The state of the art since the 1930s was to draw plane surveys on drawing paper mounted on both sides of aluminum sheets 0.5 to 2 millimeters thick, thus achieving maximum dimensional stability. Swiss, German, and Dutch industries excelled in manufacturing that drawing medium (Koeman 1958, 6).

Original topographical drawing was also done on

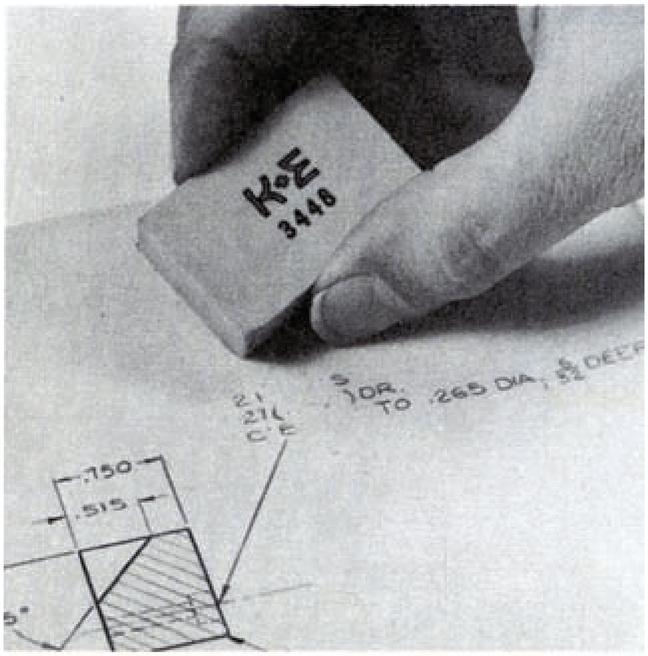

FIG. 212. HERCULENE STATIC-FREE DRAFTING FILM. This matte polyvinyl film bonded to a base layer of polyester not only took ink well but also could be erased completely clean with a dampened, soft vinyl eraser, as this Keuffel & Esser advertisement showed.
Size of the original: 5.1 × 5.1 cm. From *Drafting Media, Catalog 1* (Hoboken: Keuffel & Esser, 1966), 14. Permission courtesy of National/AZON, Troy, Michigan.

paper. Initial sketching, mostly in soft pencil, was later finished with black ink and watercolors. Traces of the original pencil sketch were removed at the end using an eraser. For especially high-quality artwork, base information was copied by the photographic process onto silver bromide paper, providing a drawing medium with a guide image until ink sketching was complete, after which the base information was bleached away.

As mentioned above, large-scale maps and plans, such as for property or land management or for road and railway construction and maintenance, took the form of a frequently revised master map duplicated as needed by a one-off process. A decided improvement over tracing cloth, plastic drawing media were correctible, as well as dimensionally stable. Although some countries adopted scribing for such maps and plans, pen-and-ink drawing techniques remained in use near the end of the twentieth century, when CAD (computer-aided drafting) technology took over.

As the twentieth century closed, manual drawing and scribing of map overlays for photomechanical reproduction of multicolor maps gave way to electronic technology (Robinson et al. 1995, 651). In a first phase, the linear elements of the original drawings were scanned and digitized automatically or interactively into vector files. In a later phase, those graphically generated data, no longer adequate, were replaced through stereo image analysis with more accurate and more sophisticated databases. By the early twenty-first century, maps not produced by CAD, geographic information systems (GIS), or computer-graphics software had become the exception, dinosaur-like fossils of the precomputer era.

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SEE ALSO: Paper; Scribing

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Pen-and-Ink Drafting. From the 1500s onward in Europe map printing increasingly relegated hand copying of maps with pen-and-ink to preparatory drawing (figs. 213 and 214). Not until 1800 did the invention of lithography enable printing of pen-and-ink maps drawn directly on or transferred to lithographic stone. After 1860 photomechanical processes emerged, able to copy pen-and-ink drawings from any medium onto lithographic, relief, or intaglio printing surfaces.

In Britain, for example, staff of the Royal Geographical Society's Drawing Office, established in 1878, at

FIG. 213. DETAIL FROM PLANE TABLE SURVEY SHEET *SIMPLON* (SHEET 501), 1886/87. Multicolored manuscript drawing at the original scale of 1:50,000 by Xaver Imfeld for the national topographic map series of Switzerland (called the Siegfriedkarte). The extract depicts the Fletschhorn and the southern part of the Simplon Pass and shows the subtleties of ink drawing.
Size of the entire original: 28.1 × 37.8 cm; size of detail: 11.6 × 17.3 cm. © swisstopo. Reproduced by permission of swisstopo (BA13119).

first compiled maps but left finishing to the lithographic draftsman, who redrew them on stone for printing. In 1914, though, the Drawing Office began producing fair drawings for photolithography and soon had to hire art school–trained staff able to letter quickly in pen and ink (Holland 1980, 211–13).

Military engineering and topographical survey establishments also hired and trained draftsmen, a resource especially valued during the two world wars, when military needs called for increased map production. During World War I, while French aviation units of former engineers, architects, and artists applied their skills in compiling maps from a new source, air photographs, the British Royal Flying Corps trained lower ranks to perform "exceedingly well" the work of interpreting air photographs onto maps (Jerrold 1917, 475–76).

Content and symbolization guidelines ensured uniform output in large mapping organizations but also reached the public sector via map drawing manuals. For example, Edwin R. Stuart, a professor of drawing at the U.S. Military Academy, used the standard symbols adopted by the U.S. Geographic Board in 1912 for all mapmaking departments of the government (Stuart 1917, v). Emphasizing pen-and-ink drafting techniques and equipment, such manuals barely mentioned other stages of mapmaking.

However, escalating government and commercial mapping between the world wars inspired New Orleans mapmaker William E. Boesch to expand the scope of his 1930 textbook on drawing and lettering. Following 100 pages about pen-and-ink drafting and lettering, he added 70 pages about map compilation, aerial mapping, and map reproduction. Boesch extolled map drawing as a career and hoped his textbook would remedy the lack of academic map drawing courses (1930, v, 173). Despite such aspirations, his approach to drafting on paper

FIG. 214. DETAIL OF MODEL FOR ROCK SYMBOLS FOR THE NATIONAL TOPOGRAPHIC MAP SERIES OF SWITZERLAND. *Anzeindaz* (sheet 480) by Charles Jacot-Guillarmod, ca. 1906. Manuscript drawing in ink at original scale of 1:25,000 on transparent paper for further processing. © swisstopo. Reproduced by permission of swisstopo (BA13119).

with ruling and nib pens was traditional, apart from his praise of new Speedball lettering pens (68).

Soon Erwin Raisz's *General Cartography* (1938) entered the American university classroom. While covering pen-and-ink drafting, Raisz increased space for other stages of the cartographic process, and later cartographic textbooks continued the trend. Chapters on map production also reflected advances in mapmaking.

Innovations in ink were one example of the interdependent development of pen-and-ink drafting instruments, techniques, media, and materials. Cartographic drawing required ink to flow easily from the pen for lengthy periods, form sharp lines without running or smearing, be opaque, dry quickly, adhere without flaking or wearing off, and work in drawing instruments without corroding them. Those desiderata remained constant, even while advances in drawing instruments and media affected the ability to maintain them, and necessitated changes in ink composition.

In 1900 most maps were drafted for photomechanical reproduction on handmade drawing paper, such as Whatman (the premier English brand). If kept clean of dirt and grease, good paper took ink well, better than thin starched tracing cloth, whose semitransparency aided one-off copying processes, such as blueprint, but had to be abraded before it would take ink (Reed 1903, 1:10–11). India ink was imported from India, China, or Japan in the form of a stick that the draftsman rubbed up daily with distilled water. Its blackness was tested by drawing a line and checking it with a magnifier. Although such ink was usually waterproof after drying, poorer qualities sold premixed were not (Reed 1903, 1:11–12).

By the 1930s preference had shifted toward commercial predissolved waterproof inks, Higgins India ink being favored by American authors (Lloyd 1930, 4). The carbon particles (lampblack) coloring the ink were suspended in a liquid (water, glycerin, oil, alcohol, etc.) of the same specific gravity (Raisz 1938, 176). In addition to Whatman paper, authors began to recommend Bristol and Strathmore board, smooth machine-made papers available in various thicknesses (Lloyd 1930, 6; Raisz 1938, 172). Cellophane and celluloid, new for pen-and-ink drafting in the 1930s, were transparent and took ink well but were not dimensionally stable (Raisz 1938, 173).

Following World War II the search for dimensionally stable drawing media intensified, each new medium gaining favor in turn. Raisz updated *General Cartography* in 1948, noting that "shapeproof drawings" could be made on zinc or aluminum sheets painted white, vellum paper mounted on glass, or on sheets of special plastics (149). In 1946 vinylite (vinyl chloride-acetate resin) was touted at the American Congress on Surveying and Mapping (Littlepage 1946, 274–76) but by 1954 was being criticized for poor ink adherence and a tendency to shatter in Australia, where Astralon and Astrafoil were in favor (Braithwaite et al. 1954, 26). Over several decades a succession of PVC (polyvinyl chloride) and polyester films presented ink manufacturers with new challenges, such as ink flaking, spread, and slow drying.

Aqueous inks, containing water-soluble binders, did not bond firmly with the drawing medium but were relatively water and eraser resistant after drying and found use on all types of paper and even polyester film. Other inks contained solvents that etched into PVC film, adhering so well that they allowed information to be added to existing maps on smooth films. Rotring, Hausleiter, Pelikan, Higgins, and Leroy marketed a variety of aqueous and lacquer-type etching inks. New products for cleaning drawing films to help them take ink were introduced, but the traditional method of rubbing the drawing surface with an eraser before drafting persisted. Correction methods were expanded to include electric erasers and special solvents as well as scraping with a blade, the latter requiring resurfacing the scraped area with an eraser or a matte solution before re-inking.

While pen-and-ink drafting techniques, media, tools, and materials were becoming more sophisticated, their foothold in map production was diminishing. When the twentieth century began, it was standard practice to work entirely with pen and ink, drafting an oversized fair drawing for reduction to final size (thus minimizing imperfections) by photography, but the options soon multiplied. Even before 1900 Ben Day tints could be added mechanically by the printer to fill in area symbols. By the 1930s the draftsman could cut out and apply patterns preprinted on adhesive-backed cellophane. A process using filters with halftone screens to separate full color originals into cyan, yellow, magenta, and black negatives was perfected during the early 1900s, although the screened point and line symbols and letters were sometimes too pixillated for high-quality map reproduction. For areas printed in color, like blue lakes or green forests, the drafted line features of the map were photographed and printed in light (nonphotographing) blue to form a guide for drafting the separate color overlays in opaque ink for later screening. By World War II, though, the increasing use of stick-up and rub-on lettering and point symbols was reducing the role of pen-and-ink drafting in creating the map image. After the war the replacement of paper by transparent, dimensionally stable plastic drafting film meant that the map artwork ranging from small to large formats was being produced as two or more overlays. In the 1970s direct negative scribing, executed with greater precision at final size, effectively replaced pen-and-ink linework. In 1986 Gary R. Brannon wrote a scribing-based cartography textbook in which the words "pen" and "ink" did not even appear in the index. Combined with innovations including punch registration, open-window negatives, and tint and pattern photographic screens, scribing accelerated the trend to produce maps on separate overlays, combined into a unified whole only during the proofing and printing stage. The era of pen-and-ink drafting was over. Its last gasp, the use of technical pens in automatic plotters to generate vector-based computer print-outs, ended in 1995, when Hewlett-Packard discontinued its last pen plotter in favor of inkjet plotters (Anonymous 1995).

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SEE ALSO: Education and Cartography: Educating Mapmakers; Labeling of Maps: Labeling Techniques

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