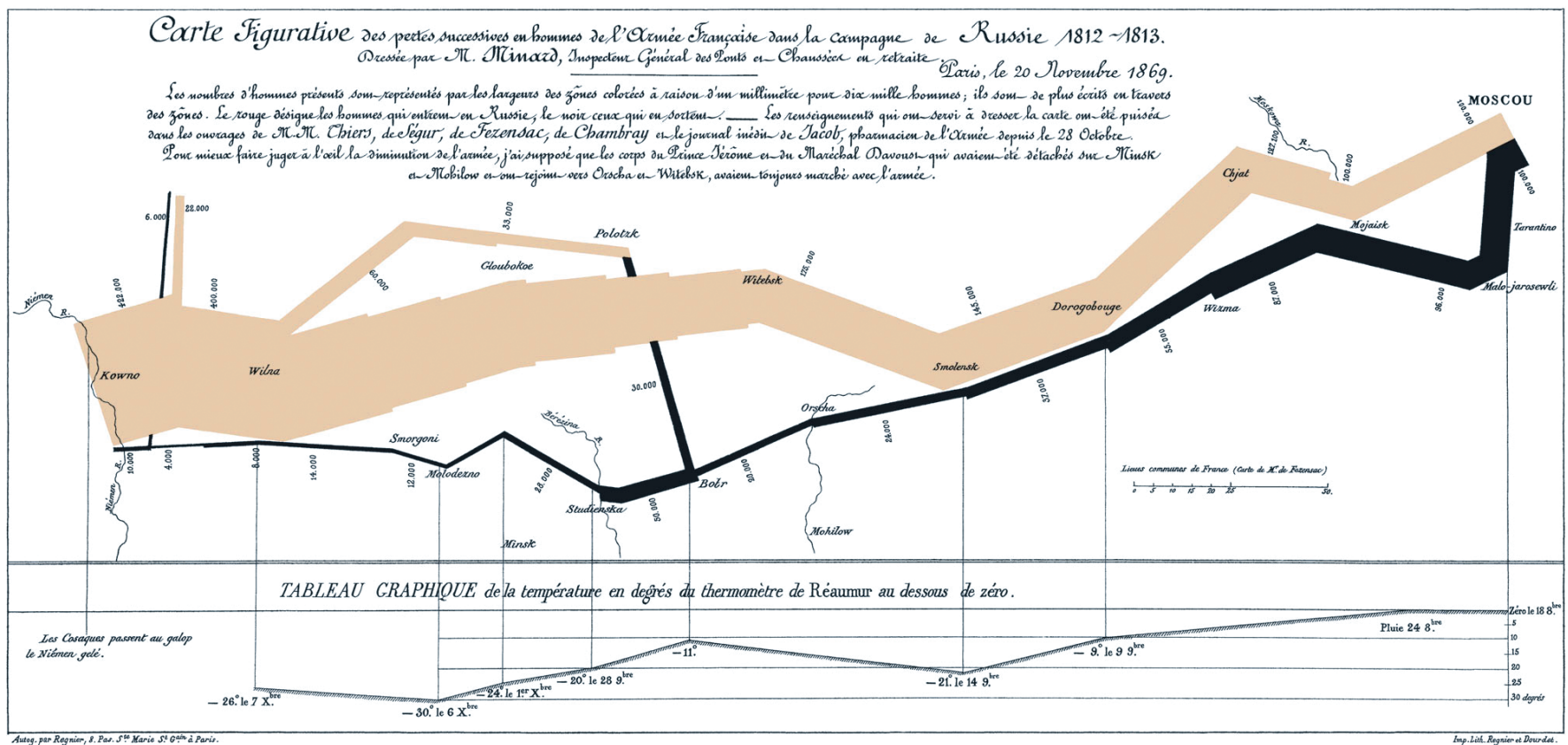


2

Minard's map

This chapter discusses Minard's map in detail, places it in the context of his other works and his times, and compares it with other maps that analyze Napoleon's campaign. Edward Tufte, the noted statistician, regards Minard's map as probably the best statistical graphic ever drawn. What makes this celebrated map so special? The answer requires a closer look. Figures 2-1 and 2-2 display two versions of the map, the original and an adaptation translated into English and redrawn to explain content.

Figure 2-1 The "Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813," translated as: "The Figurative Map of the successive losses of men of the French army during the Russian Campaign 1812-1813."



2.1 The map

Cartographers classify Minard's work as a flow line map, or flow map for short. These maps overlay lines, typically punctuated by arrowheads, to indicate both the direction and route of movement across a given territory. Origin-destination maps vary slightly from this norm, because they emphasize the connection between locations, rather than the flow from one location to another.

In contrast to flow maps, origin-destination maps' paths are highly structured, and do not use arrowheads to indicate direction. Both types of maps illustrate the volume of flow by varying the thickness of the path line's shaft, some by gradually trimming the thickness of the shaft, others by splitting the shaft into sections and giving each section its own uniform thickness. Minard's map, for example, splits his line into sections to indicate the ever-diminishing size of Napoleon's army. With just a glance, flow line maps give readers an immediate impression of both the direction of something in motion and also the volume of its flow, as Minard did in his studies of transportation, commerce and, in this case, war. True to form, Minard split his line into sections to indicate volume. However, it appears that he did not use arrowheads. At first glance, someone who was not familiar with the topic might not be able to interpret the direction of the movement. However, the text below the map's title explains that color indicates direction: "The red (which appears orange in figure 2-2) designates the men who enter into Russia, the black those who leave it."

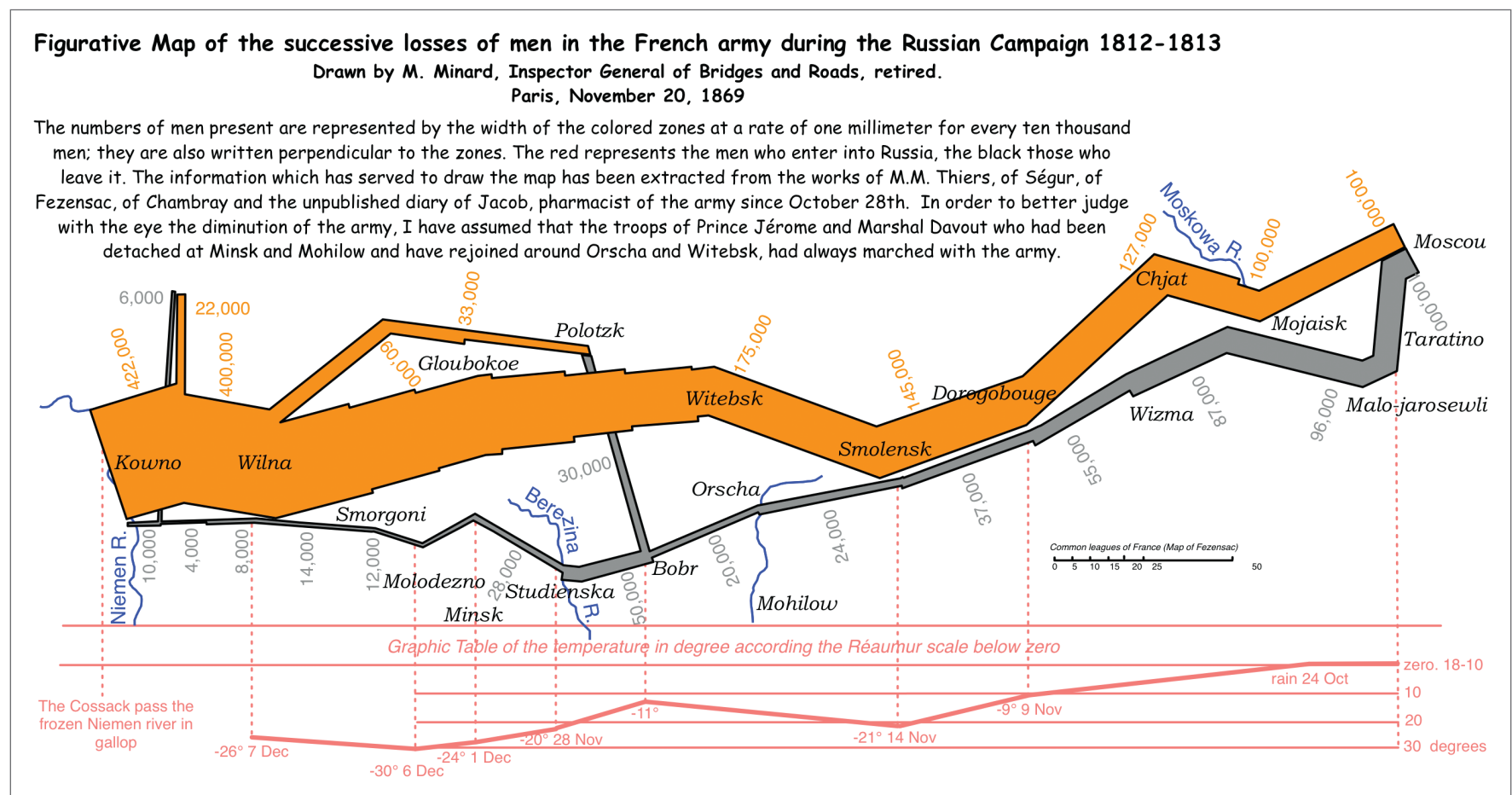
Ideally, good maps should immediately be clear to the reader. To understand their content, however, French cartographer Jacques Bertin argues that readers must adopt a traditional three-step map-reading approach (Bertin 1983 [1967]). First, readers should execute an external identification of the map, asking what the map is about. Reading the title of the map can often answer this question. Minard's title is rather long: "Figurative Map of the successive losses of men of the French army during the Russian campaign 1812-1813."

The second step calls for internal identification, how the topic is displayed. This requires reading the legend to find out how symbols represent the elements of the topic and what scale is used. It also calls for a study of the map's bibliographic data, which provides information about the map's author, its publisher, and its age. Minard inscribed this information immediately below the title: "Drawn by M. Minard, Inspector General of Bridges and Roads, in retirement. Paris November 20, 1869." However, he relegated the information about the publisher and printer, in small print, to the lower left- and right-hand corners of the map: "Paris: Regnier et Douret."

The map bears no legend that people would generally understand, however, the extensive text below the title takes its place. Explaining the width of the flow line, it states: “The number of men present are represented by the width of the colored zones at a rate of one millimeter for every ten thousand men; they (the numbers) are additionally written across the zones.” In the maps in figures 2-1 and 2-2, this scale is no longer correct, because both have been reduced from their original size (63 × 25 cm), however, the numbers written along the segments mitigate the problem this creates. Moreover, the line’s colors communicate information about direction: “red” (which appears orange in figure 2-2) indicates east into Russia, while black indicates west out of it. Minard also describes his data sources, in the same text block, something that unfortunately doesn’t always appear on today’s maps. He writes: “The information which has served to draw up the map has been extracted from the works of M.M. Thiers, of Ségur, of Fezensac, of Chambray and the unpublished diary of Jacob, pharmacist of the army since October 28th.”

Minard even inserts some of his design decisions: “In order to better judge with the eye the diminution of the army, I have assumed that the troops of Prince Jérôme and Marshal Davout, who had been

Figure 2-2. A translated and redrawn version of Minard’s map of the French invasion of Russia in 1812. At the top of the map, below the title, a body of text explains the data and symbols used. The orange line shows the path of the army’s march to Moskva, while a gray one tracks their retreat. Below, a red diagram links to the gray path in order to relate temperature to the events of Napoleon’s retreat. Blue marks the rivers, which perform a geographic function in the flow map, and black the place names.



detached at Minsk and Mahilyow (today Mogilev) and had rejoined (Napoleon) around Orsha (Orscha) and Vitebsk (Vitsyebesk), had always marched with the army.” This decision certainly must have contributed to Tufte’s admiration: “Graphic elegance is often found in simplicity of design and complexity of data” (Tufte 1983, p. 177). Simplicity may bring elegance but, it also sometimes means that information has been sacrificed. Sometimes, a complex design cannot be avoided, however. Today’s digital environment allows for visualization strategies that help to overcome a reader’s difficulties. A scale bar in the lower right of the map, indicating the map scale, completes the legend (the map measures distance based on the French league, which equals approximately 4 kilometers).

The third step calls on readers to interpret the map itself. As with any thematic map, some basic topographic information is required to orient the theme in space. Here, rivers and place names provide the geographic parameters: Along the western edge is the Neman River, where Napoleon’s campaign began and ended; along the eastern edge, the Moskva River in the east; in the center is the Berezina River, which played a prominent role in the Grand Army’s retreat. East of the Berezina, the map displays but does not label the Dnjepr River. It provides about twenty toponyms—among them Kaunas in the west, Moskva in the east, and Minsk and Smolensk in the center—but adds no symbol to plot their location, leaving their exact location vague. For the map’s theme, Minard reserved the flow lines, inscribing absolute numbers at selected places along the line in order to reinforce the size of Napoleon’s army represented in the flow line.

Time performs an intrinsic function in flow maps, although exact time references rarely occur. Only the diagram at the bottom of the map indicates the time factor in Napoleon’s retreat. It also denotes temperature and links it to both date and location. A quick glance at the study can show, for example, that Napoleon’s army crossed the Berezina River on November 28, when the temperature measured minus 20 degrees Réaumur, equivalent to minus 25 degrees Celsius.

Napoleon crossed the River Neman into Russia with 422,000 troops, and crossed it back into Poland with only 10,000. The flow map expresses this disastrous outcome very clearly. However, it does not explain why the disaster occurred. The temperature diagram tempts readers to conclude that the cold created the calamity. Many paintings of the campaign support this, with their stark depictions of soldiers succumbing to the harsh winter weather (see, for instance, chapter 3, figure 3-1). However, scrutiny of the map reveals that the largest drop in troop numbers occurred on the march *toward* Moskva, which took place during autumn. Did battle, desertion, or illness cause these losses (Talty 2009)? The map does not indicate the most important battles so it is hard to answer this question. Chapter 6,

which describes analytical mapping tools, deals with these kinds of questions in greater depth.

Minard lived in a time when people “invented” many statistical graphics and thematic maps. The next section describes his role in this development.

Figure 2-3 zooms in on some of the map’s details. The section of the map in figure 2-3a displays the Neman River and its surrounding territory where the invasion both started and ended. It is the most dramatic aspect of the map because it shows the big difference between the number of soldiers at the start and end of the campaign. It also demonstrates the problems that a reader might have when faced with the geographical names. Most atlases today apply the so-called local place-name policy, which marks geographical names according to local spelling. Minard’s map, by contrast, uses a combination of French and German names, which can confuse readers unfamiliar with historical toponyms.

In general, this book follows local place policy. In exceptional situations, however, alternative spellings have been allowed if people still widely use it. Take, for example, the city of Tilsit in former East Prussia. Today, it belongs to Russia as Sovetsk. In other cases, places changed their name without changing countries, like the town of Ghat, renamed Gagarin in 1968 in honor of the world’s first man in space. Figure 2-5 lists variations for the most important places listed in the campaign area.

Figure 2-3b shows Moskva. This portion of the map highlights an interesting absence of time, because Minard did not clarify here the fact that Napoleon stayed in Moskva for about a month. This omission is important, because the flow line alone gives readers the misleading impression that the army moved at a uniform rate. Dates could have been added (see examples of this in figures 2-18, 2-20, or 2-21), although other forms of graphic representations might be more expressive (see chapter 5). Minard also makes some curious choices of places to map. The center of this map detail, for example, shows the town of Mozhaysk. Just west of this town, the segment of the flow line that moves toward Moskva shows a reduction of almost 30,000 troops. This happens because the Battle of Borodino, the largest battle of the campaign, occurred here, in the little village 10 kilometers west of Mozhaysk. Adding this name may have improved Minard’s map.

Figure 2-3c displays the losses that the French army suffered while crossing the Berezina River. Napoleon’s troops shrank by almost half (see also chapter 6, figure 6-7). This detail exemplifies how well Minard used geography to communicate his statistics. According to cartographer Arthur H. Robinson (1967), Minard demonstrated “cartographic ingenuity” when it came to using cartographic symbolization to get his message across. The basemap provides needed geographic context

yet can adapt to the theme's constraints. That is why Minard often called his maps "Carte figurative et approximatives." Curiously, he did not add the term "approximatives" to his map's title. Looking at the detailed representation of the rivers, it is easy to understand why. At the same time, the level of thematic data generalization in this map lessens the need for a detailed topography. For example, names loosely indicate the geographic location of towns. This can be misleading. Is Studianka to be found to the east or west of the river? Actually, it is east, though the map does not say. In contrast, Minard has drawn the rivers in his map in great detail, in comparison to the rectangular segments that illustrate the flow of Napoleonic soldiers through Russia.

The detail in figure 2-3d shows the scale bar and part of the temperature diagram used in Minard's map. When he made his map,

France still used its own Réaumur temperature scale. Its zero degree indicates the same temperature as that on the Celsius scale. Measurements compare as follows: -10°R equals -13°C , -20°R equals -25°C , and -30°R equals -38°C . In Fahrenheit, these would equal 9°F , -13°F , and -36°F . Figure 2-4 displays the original map as found in the Library Lasage of the Ecole Nationale des Ponts et Chaussées.

Several scholars have discussed Minard's maps in the context of the history of geography and cartography. In his study of the

Figure 2-3. Details from Minard's map of the French invasion of Russia: (2-3a) The Neman River, the start and end of the campaign; (2-3b) Napoleon in Moskva; (2-3c) the crossing of the Berezina River; (2-3d) the temperature diagram.

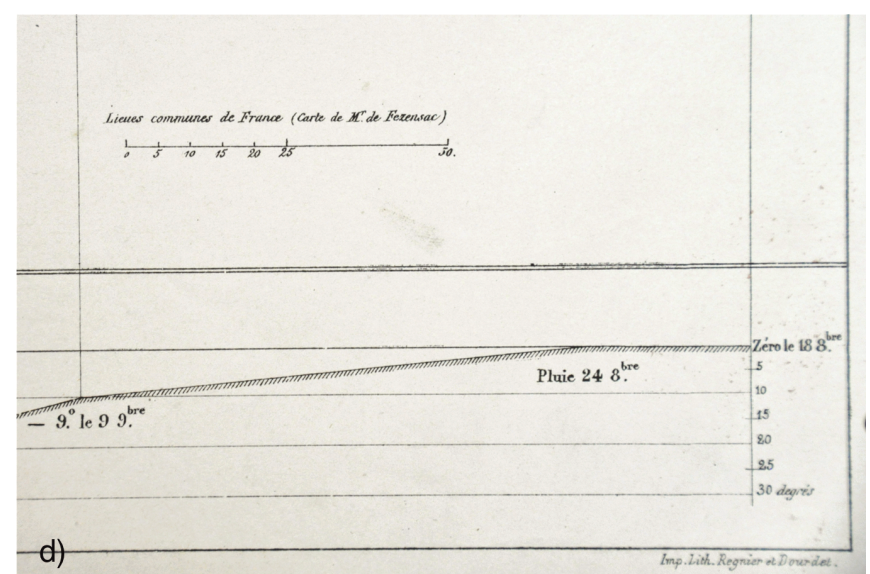
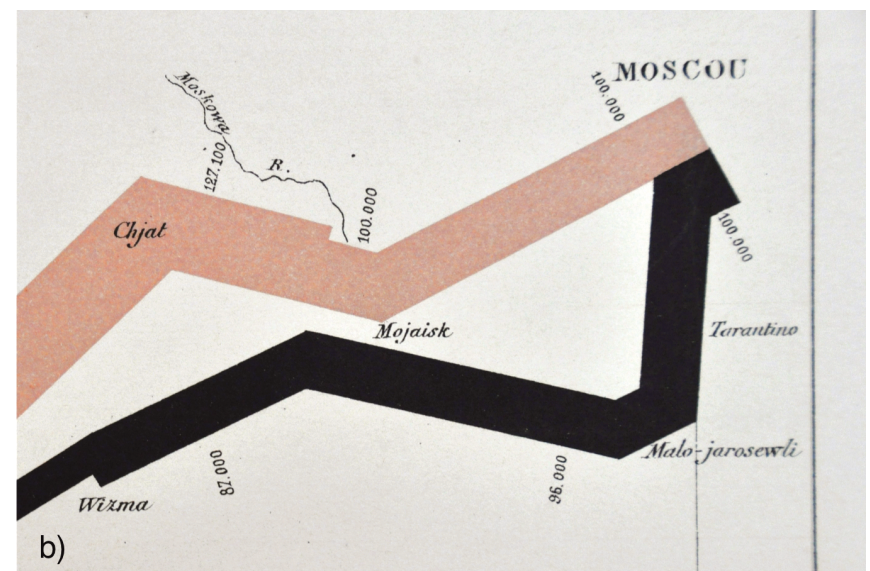
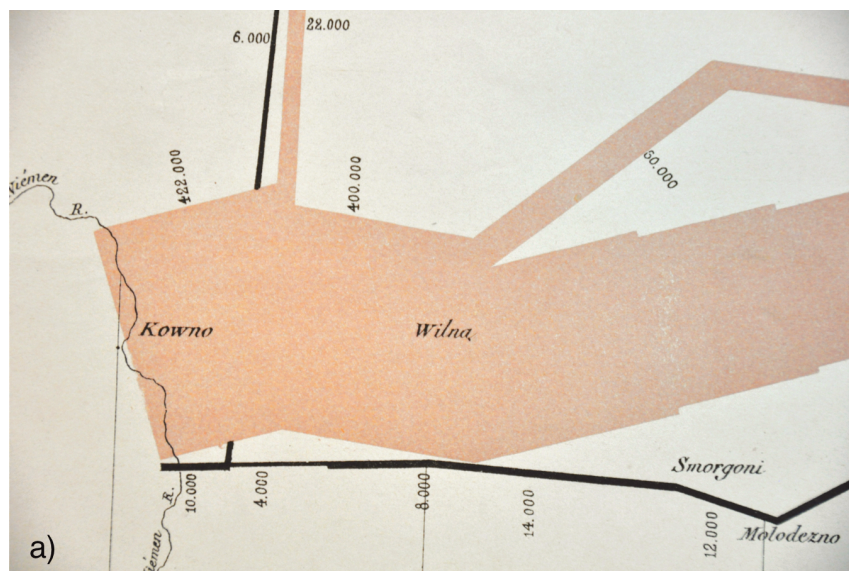
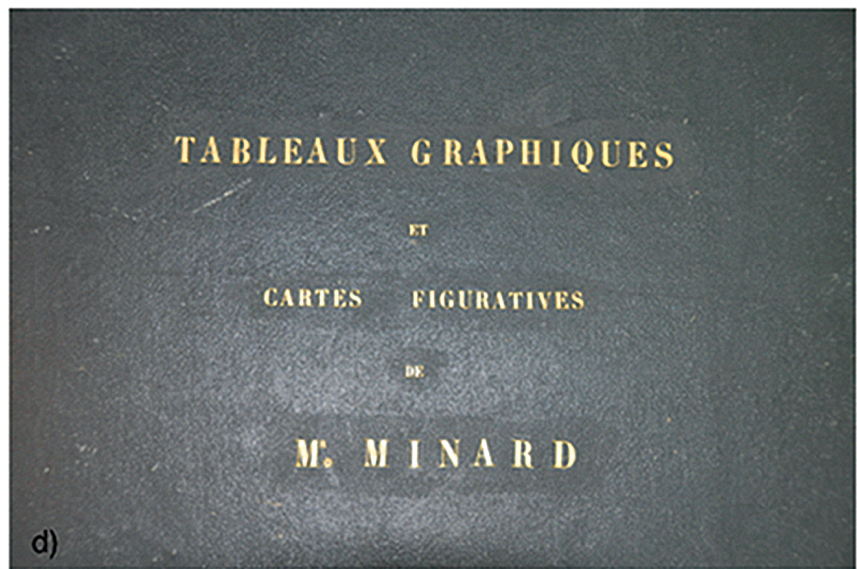
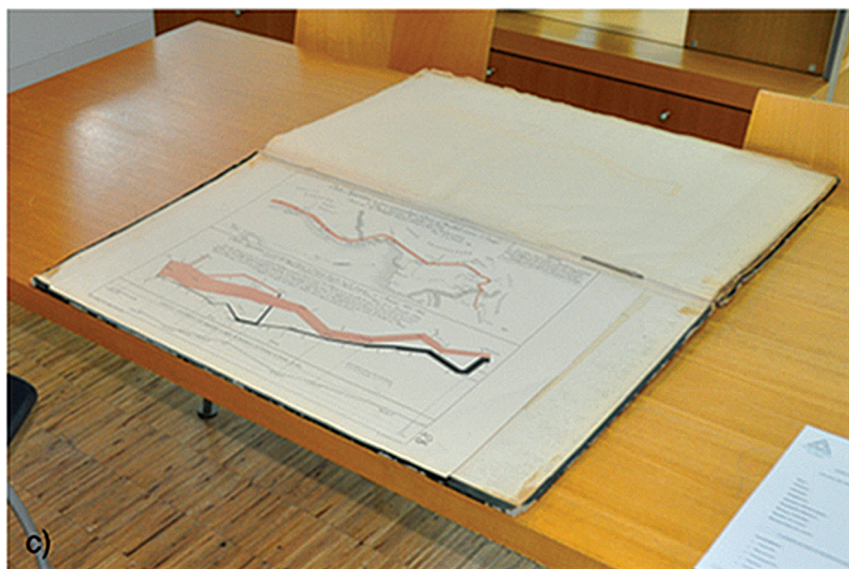


Figure 2-4. Minard's maps and diagrams in the Library Lasage, Ecole Nationale des Ponts et Chaussées: (2-4a) the library entrance; (2-4b) the author and the map; (2-4c) Folio 28 of the collection with the combined Hannibal and Napoleon campaign maps (45 × 87 cm); (2-4d) the cover of the collection.



history of thematic maps, Robinson (1982) revealed that the Irishman Henry Drury Harness published the first flow map in 1837. In it, Drury shows “the relative quantities of traffic in different directions.” Minard’s flow map appeared only a few years later, at about the same time that Alfred Belpaire, a Belgian railway engineer, produced his transportation maps in flow line style. It remains unclear whether Minard or Belpaire knew about Harness’ work, or whether the engineers influenced each other. Robinson describes Minard’s maps as more varied and sophisticated than the other two. In another article, “Visions and re-visions of Charles Joseph Minard,” Michael Friendly pays special attention to how others have used the Frenchman’s map to explain some of today’s interactive situations. His website archive contains copies of most of Minard’s maps and provides links to other

examples <http://www.math.yorku.ca/SCS/Gallery/re-minard.html>. In his most recent book *Beautiful Evidence* (2006), Tufte revisits the map in a chapter about the “fundamental principles of analytical design” (see also chapter 6).

Minard worked at a time when innovations in both statistical graphics and thematic mapping flourished. Gilles Palsky (1996), Robinson (1982), and Friendly (2008) describe this burst of invention in detail. Noteworthy diagrams of the nineteenth century include William Playfair’s time series line graph, the bar graph, the circle diagram pie chart, and Florence Nightengale’s polar area diagram; maps include the choropleth map, dot map, flow map, and isoline map. Minard played an important role in stimulating the rise of visual thinking and explanation during this formative period. Friendly, in his Milestones website <http://www.datavis.ca/milestones/>, uses several of Minard’s own maps to explain how the French engineer influenced the development of statistical mapping. Minard reported in a number of his pamphlets that he had published over ten thousand copies of his maps, most of them distributed within his Ministry of Public Works. Outside France, his work attracted less attention, although he did participate in international statistical conferences to discuss his work with others and learn from them. His work grew obscure and then experienced a revival of interest at the

ABOUT MINARD

Charles Joseph Minard was born in Dijon, France, on March 24, 1781. He studied to become an engineer in Paris at the École Polytechnique and the École Nationale des Pont et Chaussées. During his early career, he was posted to several locations in France and the Low Countries in order to work on canals and ports. In 1832, he accepted a teaching and administrative position at the École Nationale des Pont et Chaussées. From 1841 on, he became the superintendent of a district in the southwestern part of Paris. In 1846, he was promoted to Inspecteur Général des Pont et Chaussées, and became a member of its directive council. He retired five years later, in 1851, at the age of seventy.

Minard’s (carto)graphic career began just before he retired as an engineer. Or, as Friendly (2002) put it: “Minard had moved from work as a civil engineer (designing canals and railways) to work as a visual engineer (designing informative visual data displays).” The engineer published his first graphic, “Tableaux figurative de la circulation de quelques chemins de fer,” in 1844 (see figure 2-6). It represents the number of passengers that traveled on several railroad lines. In 1845, he published his first map,

“Carte de la circulation des voyageurs par voitures publique,” to support the planning process of a new railroad. The map illustrates the intensity of traffic that circulated between Dijon and Mulhouse. Minard published a number of maps over the course of his second career. His last known map, the combined Hannibal and Napoleon map shown in figure I-1, was published in 1869. He died in Bordeaux on October 24, 1870. An English translation of his bibliographic obituary appears on Edward Tufte’s website <http://www.edwardtufte.com/tufte/minard-obit>.



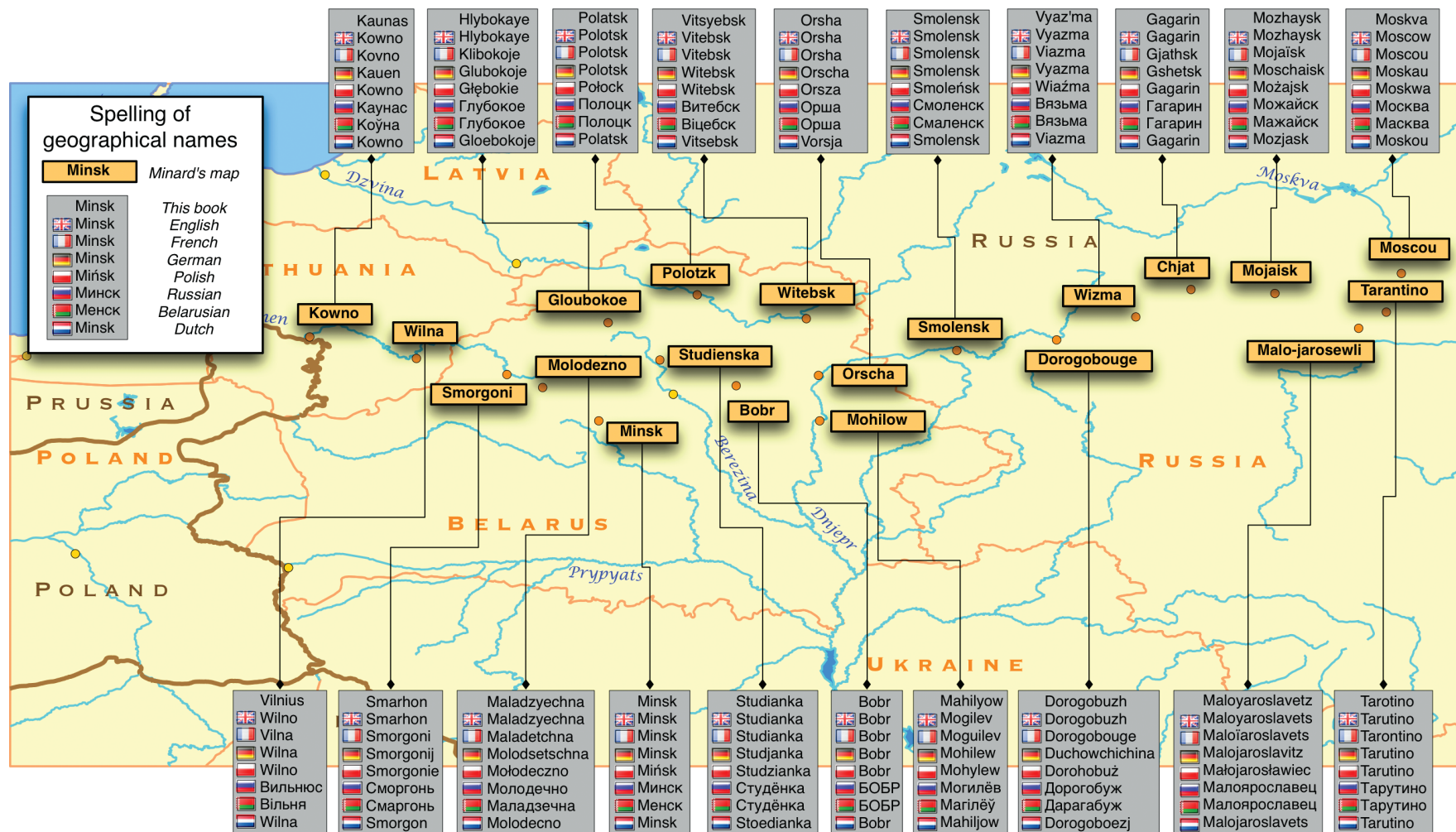
Charles Minard’s signature

beginning of the twentieth century; Funkhouser, for example, called him “the French Playfair.”

2.2 Minard’s work

Although Minard remains best known for his map of Napoleon’s march to Moskva, he previously had produced other interesting and innovative work. His first diagram (figure 2-6) which he published in 1844, displays the number of passengers who traveled along selected railroads in France and Belgium. Ingeniously, the diagram incorporates geography. The horizontal axes, for example, represent trajectories, as illustrated in the upper right diagram,

Figure 2-5. The spelling of geographic names can vary depending upon the sources used. This map displays toponyms in six different languages.



which represents the railroad from Kortrijk (left) to Brussels (right). The width of each individual diagram indicates the total distance between the two final stations. The width of each bar in the diagram marks the distance between stations along that line, while the height measures the number of passengers.

Figure 2-6. One of Minard's early diagrams (1844), measuring traffic volume on selected railroads. (Tableaux figuratifs de la circulation de quelques chemins de fer. 1844).

