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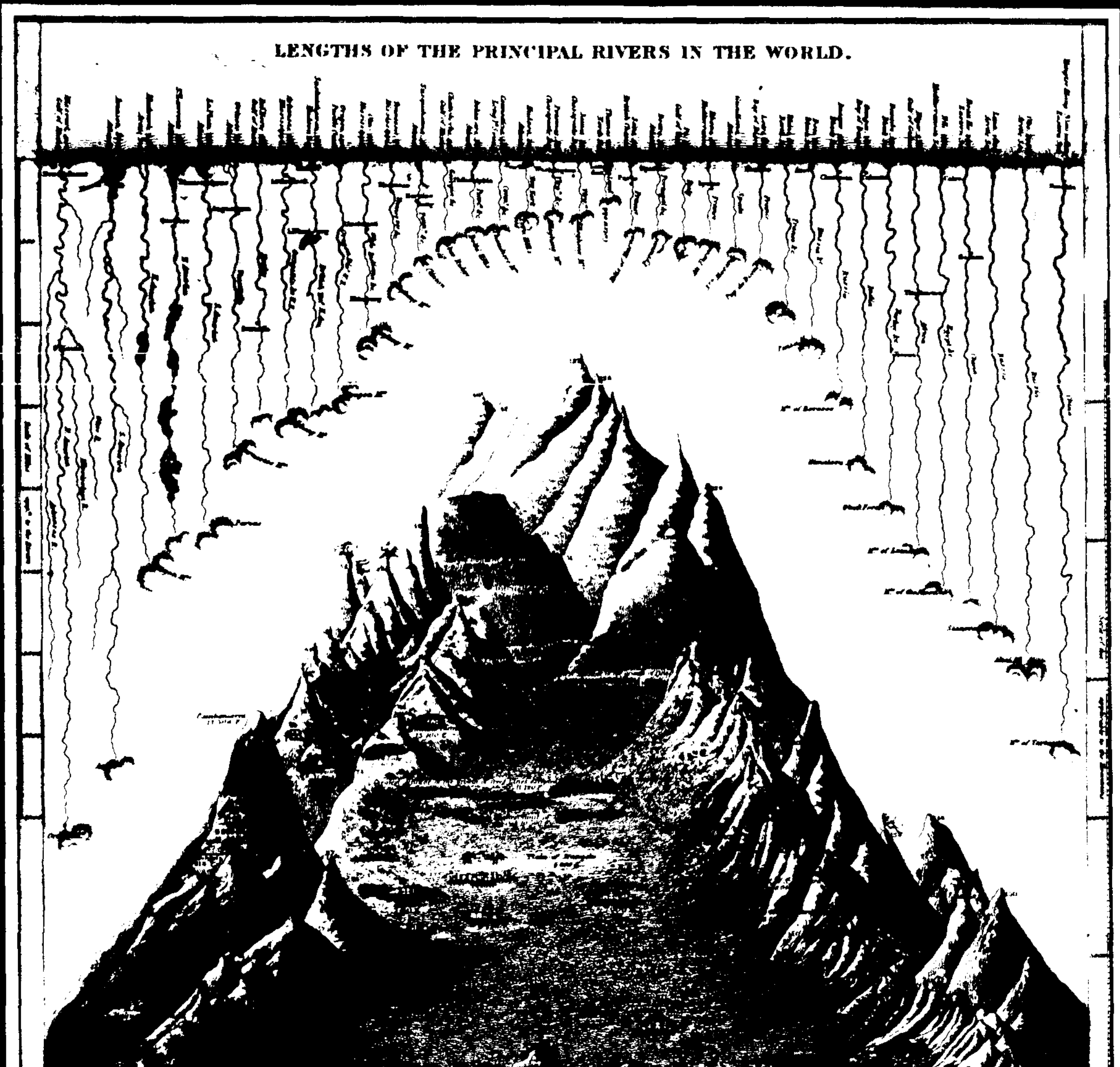

The Heights of Mountains

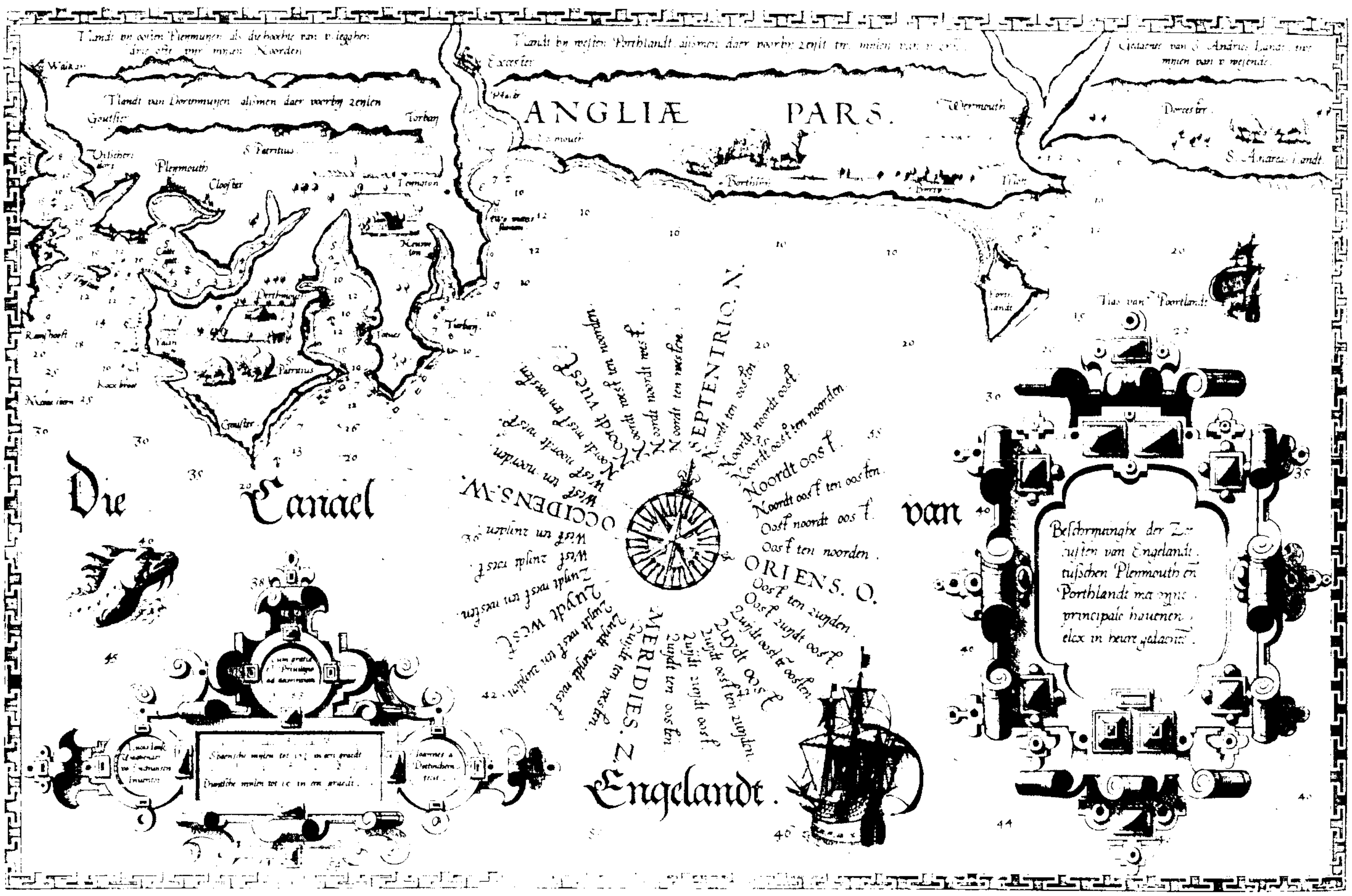

Chart of the English Channel by Lucas Waghenaer. In this "Waggoner" of the late 16th century, landmarks and coastal profiles are indicated to help the navigator determine his position.

and the Lengths of Rivers

by John A. Wolter

The study of the cartographic record, because of the great variety in format and style over the centuries, inevitably leads to speculation regarding the origin and diffusion of a given printing technique or means of cartographic expression. Often this speculation is a natural outgrowth of research which has as its central theme the search for the first cartographic depiction of a place or physical feature. Since earliest recorded history cartographers have used description of relative location, or the direction and distance of a place from other places.[1] Eratosthenes devised a crude earth grid-system as early as 200 B.C., but only in the past few centuries has location been accomplished with increasing accuracy by use of the geographical coordinates of latitude and longitude; John Harrison's invention of the chronometer in the first half of the 18th century has subsequently made the determination of longitude relatively easy. The historical development of these two means of describing spatial location is well documented.

The vertical dimension, that of height or depth, has also been studied, but to a lesser extent. Arthur H. Robinson, François de Dainville, and Norman J. W. Thrower have described in some detail the history and development of different ways of expressing the third dimension in cartographic format, concentrating in particular on the isoline in all its variations.[2] Isolines, according to Robinson, "are the sets of lines (usually on a map) that show by their absolute and relative positions the locations and gradients within a set of numbers, which set may range from temperatures and elevations to population densities or even the blooming dates for flowers." [3]

Little has been written, however, regarding the historical development of the profiling convention—the use of profiles to depict the earth's surface or underwater features, particularly for the purpose of showing relative heights and depths. I have explored both bathymetric and hypsometric measurement as depicted in profile and feel that the latter may very well have given birth to the former (as opposed to current thinking regarding the isoline), but this essay is by no means a definitive statement. It is a history and as such is subject to the continual process of reinterpretation. I hope that my comments will, however, stimulate further research, for the history of 19th-century cartography, particularly American cartography, is relatively unexplored and in that way, perhaps, is analogous to the state of cartographic art at the beginning of that century, when cartographers turned to the use of the profile until something better came along.[4]

The origin of the profiling convention is obscure. Because the concept of end-on viewing is relatively simple, it is certain to have been used in remotest antiquity. The use of profiles in early mining operations and for planning and constructing canals and irrigation works is documented in records dating back to dynastic Egypt.

John A. Wolter is Assistant Chief of the Geography and Map Division. The article is based on a lecture presented at the annual meeting of the Society for the History of Discoveries, at Yale University on November 13, 1971. The author wishes to acknowledge the assistance of Barbara R. Noe in translating the German textual material and in the compilation of tables 1 and 2.

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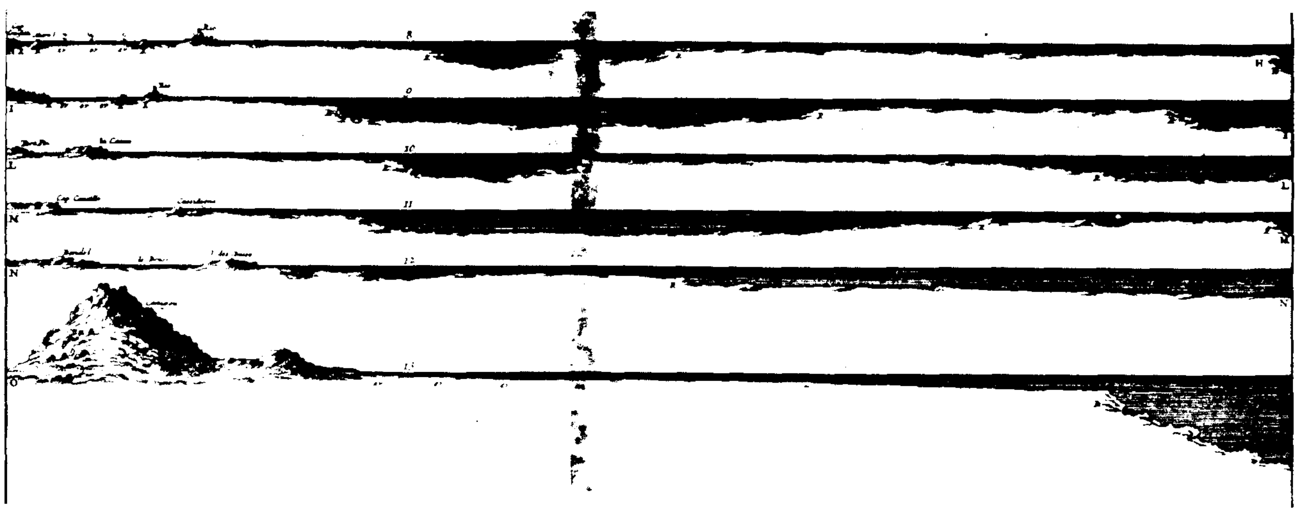
The technique seems to have been revived in the late Renaissance and has passed with modification, particularly in accuracy of measurement, into our own time.

As early as the second half of the 15th century, rutters of the sea, or pilot books, were illustrated by rough coastal profiles or views of prominent landmarks as seen from seaward and oriented by compass direction. Coastal profiles were included either with or on sea charts, particularly those published in the sea atlases or "Waggoners" of the early 17th century. An interesting description of the use and worth of coastal profiling is contained in *A Regiment for the Sea and Other Writings on Navigation*, by William Bourne, a 16th-century English gunner and sailor:

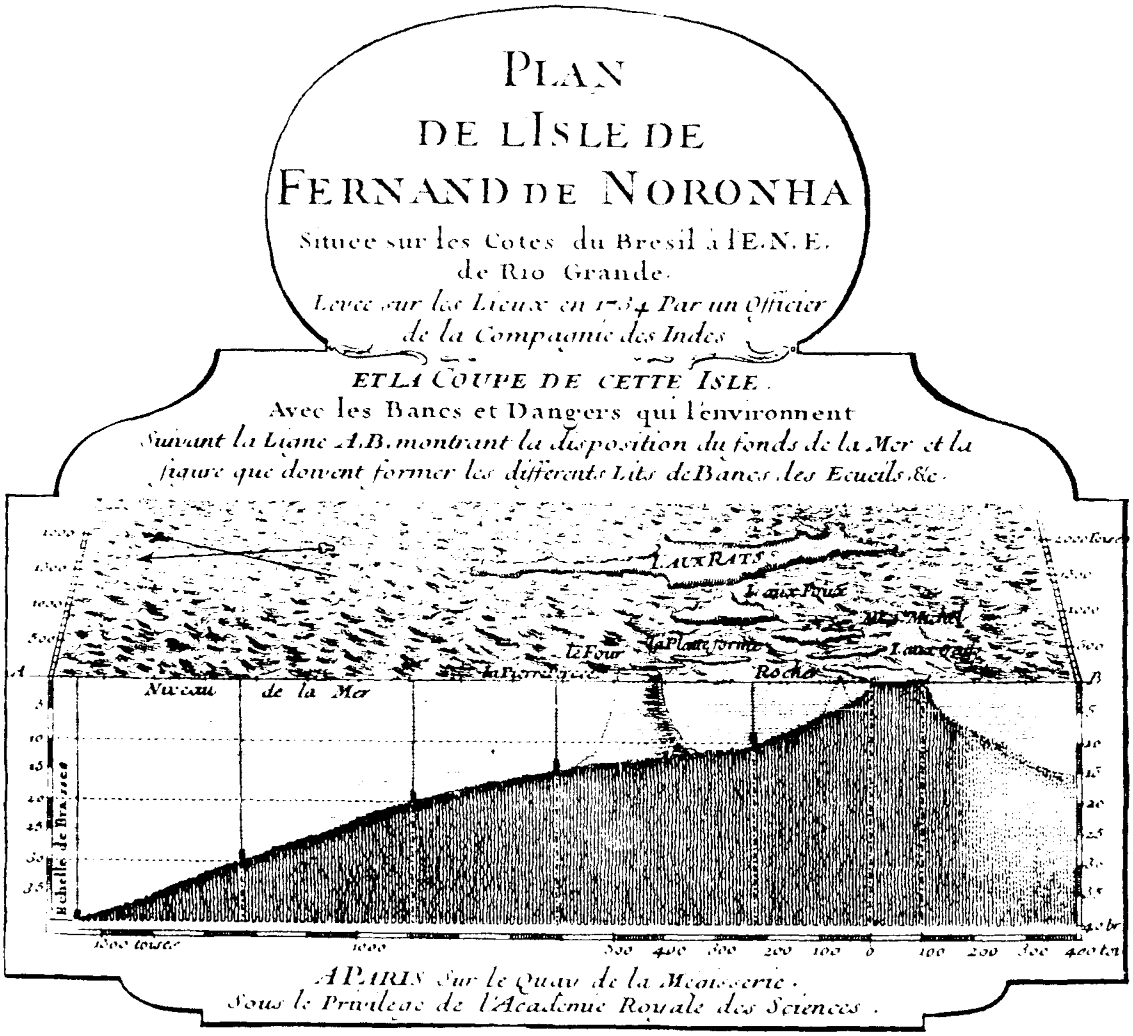
> This also is very necessarie to be done to furnishe vp all the vacant places of the plat or carde, to drawe the shape or fashion of euery headland or high lande alongst euery coast that is needefull to be knowne, and at what poynte of the compasse the lande is of that fashion: at howe farre off the lande ryseth in that fashion: and so to make the fashion of the lande as often as the lande altereth the forme and fashion: and last of all, at what poynte of the compasse the lande hathe that shape or fashion: for being vpon one side, the lande ryseth of one fashion, and on the other side of another forme or fashion: Also being neare the lande it will be in one fashion, and being far off in an other fashion . . . for there is nothing more needefull and necessarie for a Seaman, than this: to knowe the lande when he seeth it, and there is no way better to make him remember it, than to haue notes howe the lande dothe rise vpon euery side: and what greater inconuenience may there growe by any meanes, than there may by mistaking of a place: for it were twentie times better to be throughly persuaded that he knoweth it not, than to thinke he doth knowe it not being that place. For whereas he doth thinke to preuent the dangers, he may willingly runne vpon the dangers not known of him. Therefore in my opinion they can do no better than to furnish their vacant places in their plats and cards with this matter: for there can be nothing better.[5]

Similar profiles are used in conjunction with modern charts and good examples appear in the sailing directions and admiralty pilots published by most of the national hydrographic bureaus.[6] The landscape surrounding fortifications constructed during the late 17th and early 18th centuries is also illustrated in profile in military treatises and atlases of the period.

The beginning of scientific, or measured, precision in graphic presentation and the first extensive use of the bathymetric profile appears in Luigi Ferdinando Marsigli's *Histoire physique de la mer*,[7] published in Amsterdam in 1725. The several transects shown on the profiles in *Carte du Golfe de Lion*, drawn seaward from the coasts of Roussillon, Languedoc, and Provence, are lines of soundings taken in the Gulf. In *Profiles ou coupes du bassin de la mer*, individual



Profile of the ocean bottom as measured along different transects. From Marsigli's Histoire physique de la mer, *1725.*



Block-diagram detail from Philippe Buache's Carte de l'ocean vers l'équateur.

depths are marked in brasses (fathoms) along the transects and illustrated in profile. Each horizontal line appears to equal five brasses, but the absence of a vertical scale on the plate makes this estimate conjectural. De Dainville has noted that Marsigli's *Carte du Golfe de Lion* also contains one of the first underwater depth contours.[8]

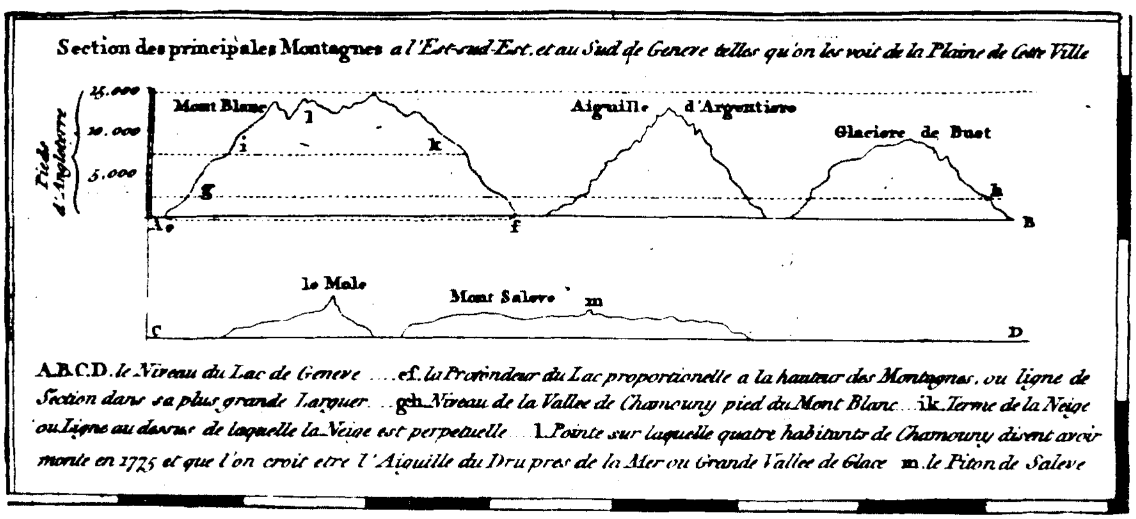
In 1757 Philippe Buache, a French geographer, included two charts of interest in his *Cartes et tables de la géographie physique ou naturelle.*[9] The first chart, entitled *Carte de l'ocean vers l'équateur,* originally published in 1737, contains two profiles, one of which, a plan of the area surrounding the island of Fernando de Noronha (1734), includes both vertical and horizontal measurements, in brasses and toises (6 pieds or 2.1315 yards) respectively. It could be considered an early forerunner of the block-diagram, a measured perspective drawing which gives a three-dimensional impression of landform.

The second profile, entitled *Coupe de fonds de la mer entre d'Afrique et l'Amerique* (1734) and also measured in brasses, is of a transect from West Africa to Brazil. Buache's second chart, first published in 1752, is the very interesting and important *Cartes et coupes du Canal de la Manche*.[10] This plate contains a much more sophisticated profile of the middle of the English Channel, with Dover as mid- or zero-point from which distances are measured north and south, and northeast and southwest, in marine leagues. The latter chart is also generally recognized as one of the first printed charts to show the depth contour line, or isobath. It is interesting to note that Thomas Jefferys evidently copied Buache's English Channel chart, naming it the *3d Chart of the Coast of France, Including the British Channel*, which he published in *A Description of the Maritime Parts of France* (London, 1774). The relative positions of the profile and contour are reversed on the plate, and the northern transect inset is omitted, but in all other respects it is essentially the same chart.

The earliest measured representation of a topographic relief profile that I have so far unearthed appears in La Condamine's *Journal du voyage fait . . . a l'équateur*[11] and portrays the result of his measurement of the arc of the meridian of Quito, accomplished under extreme hardships during the period 1735–45. La Condamine and his companions Bouguer and Godin used barometric pressure to determine the absolute height of several South American mountains above the mean sea level of Porto Bello, Guayaquil, and Callao. Geometric measurements were used for heights and locations between the mountains. Measurement of this equatorial arc and similar arcs in the high latitudes of Lapland and the middle latitudes of France helped to determine the length of the degree at various latitudes, providing the first tentative steps toward accurate measurement of the general oblate spheroidal shape of the earth. Although quite primitive in graphic form when compared to later representations, La Condamine's resulting profile does indicate that some thought was being given to the importance of comparative heights in any physical description of the earth's surface.

William Faden, the 18th-century English cartographer and successor to Thomas Jefferys, was among the first to use the profile frequently, particularly on his canal plans during the latter part of the century. The examples in his *Nouvelle Carte de la Suisse*,[12] published in London in 1778 and reprinted and republished until 1799, are the most important to our discussion. Inside the lower right hand margin there is an outline profile—a transect through Mt. Blanc—measured with the level of Lake Geneva as base line and drawn to scale, in English feet, with notes on prominent landmarks. This is certainly one of the earliest scientifically determined hypsometric profiles to appear on a separately published map, antedating by several years some other maps be-

Detail from Faden's Nouvelle Carte de la Suisse, *a hypsometric profile of Mt. Blanc and other mountains around Lake Geneva.*



lieved to represent the introduction of this technique. After Faden the use of this graphic means of representing comparative heights seems to have been gradually accepted.

In 1783 the French scientist Pasumot pictured the Andean, Pyrenean, and Alpine peaks in Rozier's *Observations sur la physique*. The peaks are drawn in profile and resemble the teeth of a saw. Dupain-Triel's profile of elevations across France, on his map *La France considerée dans les differentes hauteurs de ses plaines,* published in Paris in 1791,[13] is believed to be the first of an entire country. Because there were only some 200 recorded heights, it is grossly generalized. Nevertheless, this profile probably represents the general acceptance of the technique as one way to show the vertical dimension, particularly at a small scale and in a manner which allows for close comparison, whether of height or of some other feature, such as vegetation.

Alexander von Humboldt is of primary importance in this discussion, for in his work one can see the beginning of a more formal and scientific means of expressing the vertical dimension. Although all Humboldt's contributions to the study of geography cannot be enumerated here, his emphasis on the use of illustrative techniques is evident in the scores of maps, charts, and diagrams he published over a period of many years. His training in biology and geology and his travels in Europe with Georg Forster, the botanist who had accompanied Cook on his second world voyage, had a great effect on Humboldt's subsequent interests. His use of the profile to show a wide range of geographical distributions may also have had its origins during the geographer's early experience as an inspector of mines in the Prussian civil service: subsurface mineral exploitation can be effectively depicted through the cross-section.

Humboldt's Andean profile, *Geographie der Pflanzen in den Tropenländern, ein Naturgemälde der Anden,*[14] published in Tübingen in 1805, is his earliest and perhaps his most interesting. As Robert Dickinson notes of Humboldt's travel in Brazil and Peru:

> In a matter of days he traversed from the equatorial forest to the tundra, the equivalent [in environmental change] of some 5,000 miles from the equator to the Arctic Circle. He noted, measured, and mapped changes in relief, plant life, crops, tree and snow lines, in a way that had never been done before. To generalize these features (particularly important since no maps were available) he used the cross section or profile. . . . In Paris, in 1804, he had a Viennese landscape painter draw the cross section . . . to give pictorial representation to the generalized altitudinal zones between latitudes 10° north and south [of the equator].

The object of this was "to bring out the ways in which the great variety of observable phenomena of the landscape are associated and interconnected with each other at different places." [15]

His famous *Profil du chemin d'Acapulco à Mexico, et de Mexico à Veracruz*, which appears in the *Atlas géographique et physique du royaume de la Nouvelle-Espagne,*[16] first published in 1811, was designed according to barometric and trigonometric measurements obtained in 1804. In addition to the data for the Mexican transect, it contains comparative heights from other continents. Mont Blanc in the Swiss Alps and Mt. Canigou in the Pyrenees, for example, are recorded on the vertical scale and appear on the plates in profile. This particular profile was often copied and apparently served as an example of the technique for a large number of cartographers and map and atlas publishers during the first half of the 19th century. Max Eckert notes:

> With the depiction of heights, maps became more useful. At first [map] construction aids were still necessary. One of the most important is the profile or vertical section which is imagined to be drawn through the plane. . . . Just as one did not [immediately] recognize the true value of the contour maps to geography so it was with profiles. First A. v. Humboldt had to draw his profiles, which he used to illustrate his discussions on hypsometry, before we could recognize the significance of the profile for the estimation of the orography of a country or continent.[17]

Oskar Peschel has written that "looking at the gigantic gives us a certain satisfaction; that is why we have the desire to know the tallest peaks of the earth. . . . But the name and location of these highest peaks is only an object of curiosity because, much more important, since A. v. Humboldt founded the comparative science of heights, are the differences in pass heights, and the ridge lines of a mountain chain. The pictorial representation alone gives us the possibility of comparing these relationships." [18]

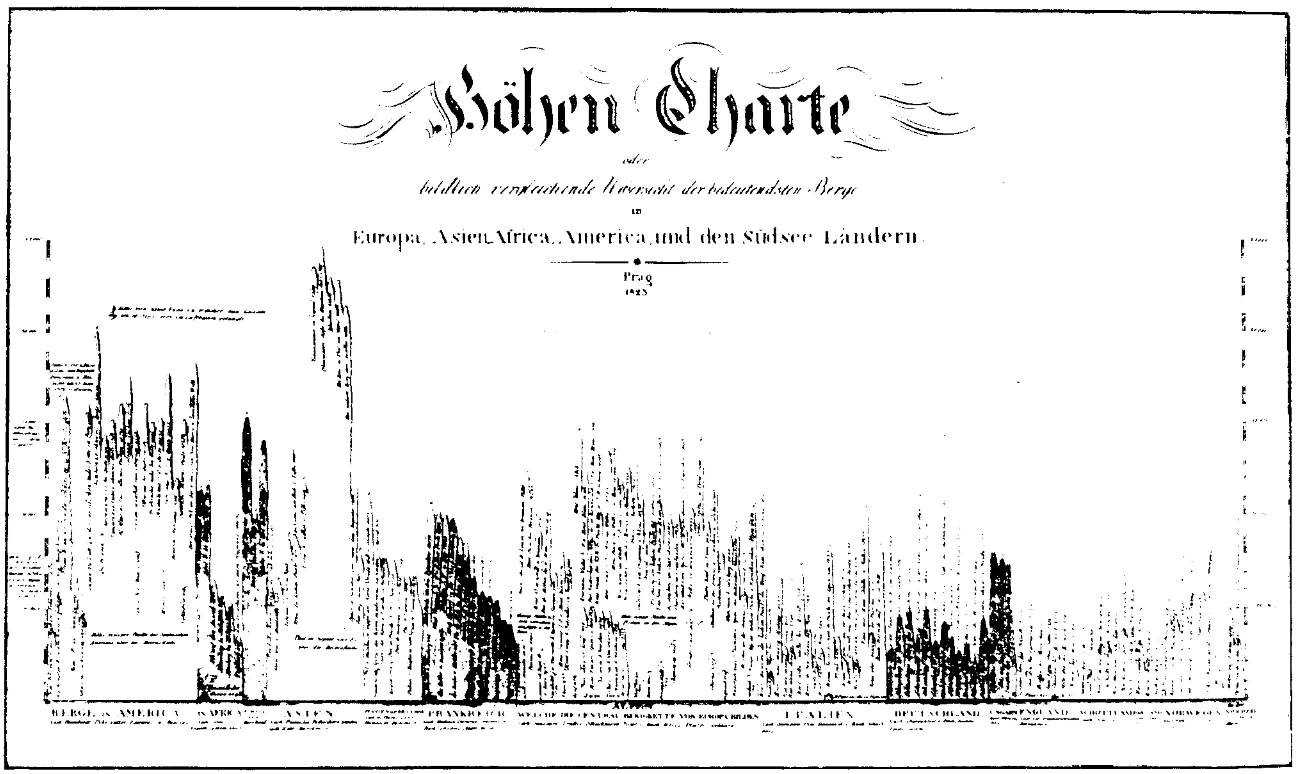
After Humboldt and during the 19th century, atlas and map publishers gradually began to adopt the profile as a most useful pictorial technique. In the early years of the century, numerical lists or tables of comparative heights and lengths had predominated, but with the 1817 and 1821 publications of *A New General Atlas of the World*, by John Thomson,[19] we begin to see a change. His introductory "Summary of Physical Geography" in the 1817 edition contains a tabular description of the principal rivers' lengths and a "Table of the Snow Line or Lower Limit of Congealation of Different Latitudes. . . ." In the 1821 edition the snow line table remains the same, but the river length table has evolved into a pictorial representation of the comparative lengths of major rivers throughout the world.[20] The 1817 edition, however, also contains a double-page *Comparative View of the Heights of the Principal Mountains and Other Elevations in the World*. This plate, by W. and D. Lizar of Edinburgh, includes an ingenious locational device and, with minor variations, is found in many different atlases published from about 1817 to 1840.

Although I have, of necessity, confined the major part of my research to comparative plates in atlases, comparative views were also published separately and many fine examples are extant. The *American Journal of Science, and Arts* in 1821, for example, contained this advertisement:

> Map of Mountains.
>
> Cummings and Hilliard of Boston, have just published an engraving presenting at one view, the comparative heights of the principal mountains in the world, with corrections, and upwards of one hundred additions of the principal American mountains. We have a copy of this map and think it well worthy of being possessed, both for geographical and geological purposes, as it produces, at a *coup d'oeil*, an impression, for which no description can be an adequate substitute. The annexed heights, latitudes and names, give the most important particular information, and the map neatly mounted, coloured and varnished, forms a handsome parlour picture.[21]

European publishers were also producing scores of comparative views on both large and small scales. German cartographers coined the terms

Franz Pluth's Höhen Charte *represents one of the many styles of comparative plates.*



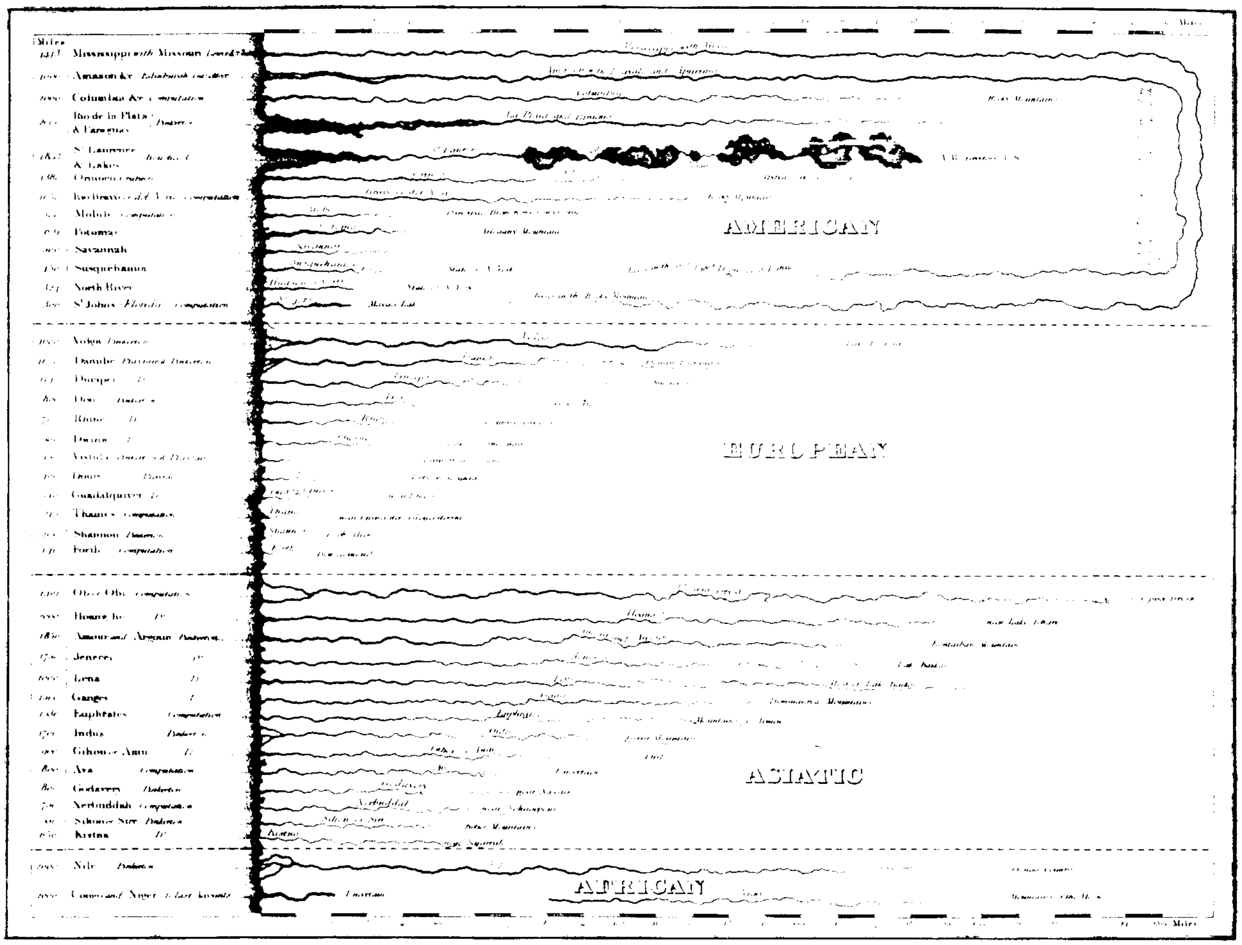
"Comparative Height of the Principal Mountains and Other Elevations in the World," published in 1823 by Fielding Lucas, Jr., in A General Atlas.

"Höhentableau" and "Höhenbilder" to describe them. "Höhentafeln" was also used to describe those views which covered smaller areas.

Henry S. Tanner's *New American Atlas*, published in Philadelphia in 1823, has a small comparative inset on his *Map of North America*. In the 1825 edition of the *Atlas*, a much more elaborate representation of heights and lengths appears on the *Map of South America*.[22] Mountains are shaded to give the appearance of depth, and river lengths are depicted in a highly stylized form which is not often found in other atlases of the period.

There are several ways of portraying mountain heights pictorially, all of which seem to have been introduced during the first part of the 19th century. Franz Pluth's *Höhen Charte*,[23] published in Prague in 1823, is an example of a style current in Germany and Central Europe and a direct descendent of Pasumot's 1783 saw-tooth profile. Max Eckert refers to it as "generally resembling long and pointed icicles" and complains that such "pictures are . . . monsters" [24] with too much vertical exaggeration. They do lack the visual appeal of the more pictorial profiles.

Much more pleasing to the eye are the comparative mountain height plates from *A General Atlas*,[25] by Fielding Lucas, Jr., published in Baltimore in 1823 and perhaps the first Ameri-



Pictorial representations of different river lengths were also popular in the 19th century. This example is from Lucas' 1823 General Atlas.

can atlas to contain a comparative plate derived from the Lizar view mentioned earlier. Vandermaelen's *Atlas universel de géographie,*[26] published in 1827 in Brussels, contains a colorful *Tableau comparatif des principales hauteurs du globe.* Shown on the plate are a balloon symbol for Gay-Lussac's 1804 balloon ascent, the limit of vegetation (in this case 6,977 meters), the heights reached by Humboldt and Bonpland in the South American Andes, and the maximum altitude which the Andean condor attains in flight.

Illustrative depiction of comparative river lengths kept pace with those of mountain heights. As new geographical knowledge became available, this was reflected in increasingly sophisticated pictorial representations of the major rivers of the world. Particularly noteworthy is the expedient curving of the American rivers on the comparative plate from Lucas' previously mentioned 1823 *General Atlas.* A map of the principal rivers throughout the world, in Tanner's 1836 *Universal Atlas,*[27] adds textual material to the same pictorial representation. It should be noted that all the river lengths in these maps are selective, with only the major rivers for each continent shown.

Atlas plates which combine worldwide comparisons of both selected mountain heights and river lengths began to appear about 1826. We

Bulla's Tableau comparatif, *one of the most comprehensive and detailed comparative plates, encompassing cities, balloons, snow lines, waterfalls, and the Egyptian pyramids as well as rivers and mountains.*

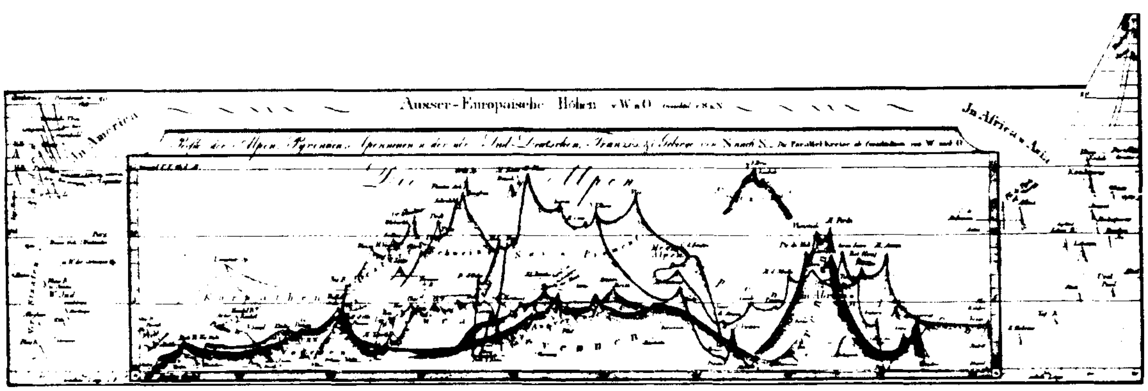
have already noted Tanner's *Map of South America*, which contains an early example of this trend. With these new atlas plates, what could be called the "illustrative," or pictorial, way of expressing comparative relationships reaches its finest representation. They show a marked advance in the imaginative use of color and symbols and in the manner of depicting heights and lengths.

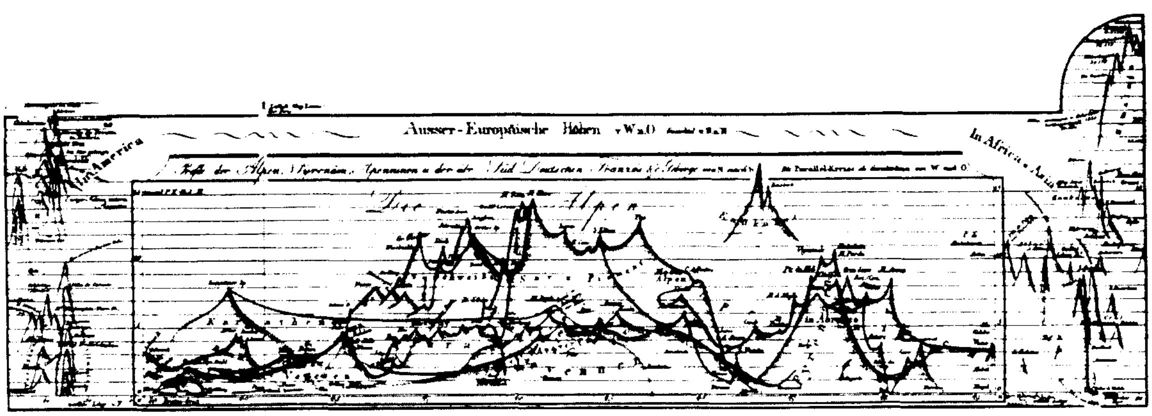
Sometime after 1826 Bulla produced the *Tableau comparatif*,[28] another one of the first to show both heights and lengths. The plate also includes, for comparison, illustrations of waterfall heights and the heights of the Egyptian pyramids and selected European buildings. The latitude and longitude of river sources and the general direction of their major trends by compass direction is also indicated. The heights which the balloonists Gay-Lussac (21,474 pieds in 1804) and M. Brioschi (25,445 pieds) attained is shown. Also included is the altitudinal limit of perpetual snow and the tree line for both deciduous and coniferous trees, and color is used to differentiate the continents. It is one of the finest and most comprehensive representations that I have considered. A detail of the waterfalls section of the plate illustrates the use of symbols for vegetation types. Smith's *New General Atlas*,[29] published in London in 1836, contains a plate that is similar in appearance, but not quite as detailed as Bulla's. These two comparative plates and one from Joseph H. Colton's 1852 *General Atlas*[30] represent what could be called the "diagonal style"; the mountains are arranged by height in ascending order from left to right, and the river lengths are likewise arrayed across the top of the plate, from right to left. This kind of plate was still used in G. W. and C. W. Colton's 1888 *General Atlas*,[31] but appears in few atlases after that date.

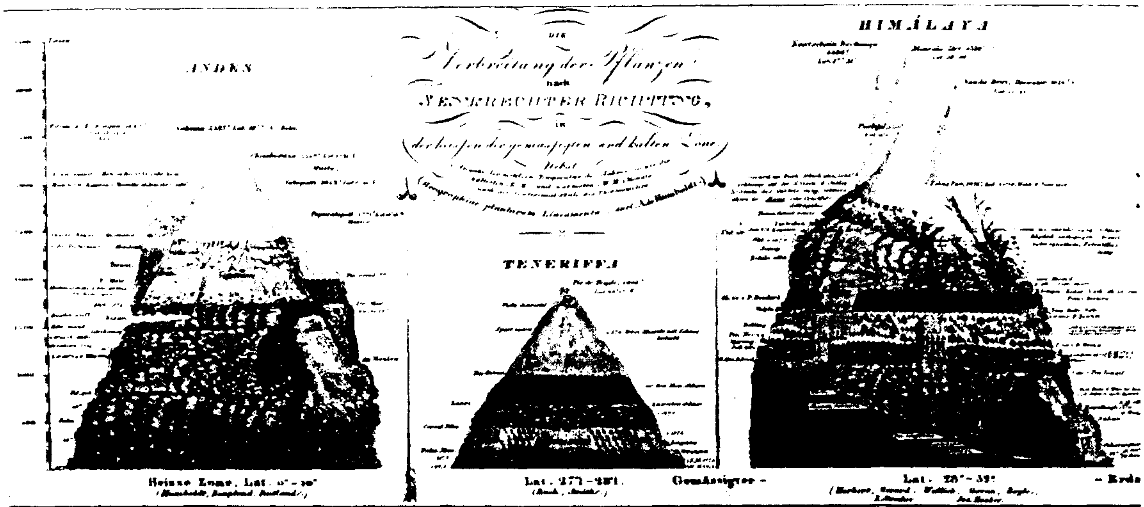
A different technique for depicting comparative heights and lengths is found in *A New Universal Atlas*, published in 1846 by S. A. Mitchell.[32] This plate is an example of what I will call the "center peak style," with the mountains clustered in the middle and the rivers shown on either side. Not nearly as comprehensive as the "diagonal style" but still as pictorially appealing, it is included with minor variations in many different atlases for a period of some 20 years or more. As late as 1866, Johnson's *New Illustrated Family Atlas*[33] includes a similar plate, but the style has clearly deteriorated.

There are many other variations in style which were introduced about midcentury. The highly stylized "double hemisphere style," in which the two hemispheres of the globe are shown with the comparative mountain heights arranged below and the river lengths above, is exhibited in Lange's *Geographischer Handatlas über alle Theile der Erde* of 1866.[34] Another plate, in Taintor and Merrill's *American Household and Commercial Atlas*, published in 1874,[35] is also stylized but to a point of diminishing effectiveness. The "single hemisphere style" can be seen in a plate in Traugott Bromme's *Atlas zu A. v. Humboldt's Kosmos*, 1851–54.[36] These styles have continued to find expression in one way or

The same chart as it appeared in the 1823 and the 1861 editions of Adolf Stieler's Hand-Atlas. *The later edition (below) reflects the knowledge gained through explorations in Africa, Asia, and America.*







A chart from Berghaus' Physikalischer Atlas *(1852) showing the distribution of vegetation in various mountain ranges.*

another up to the present time.

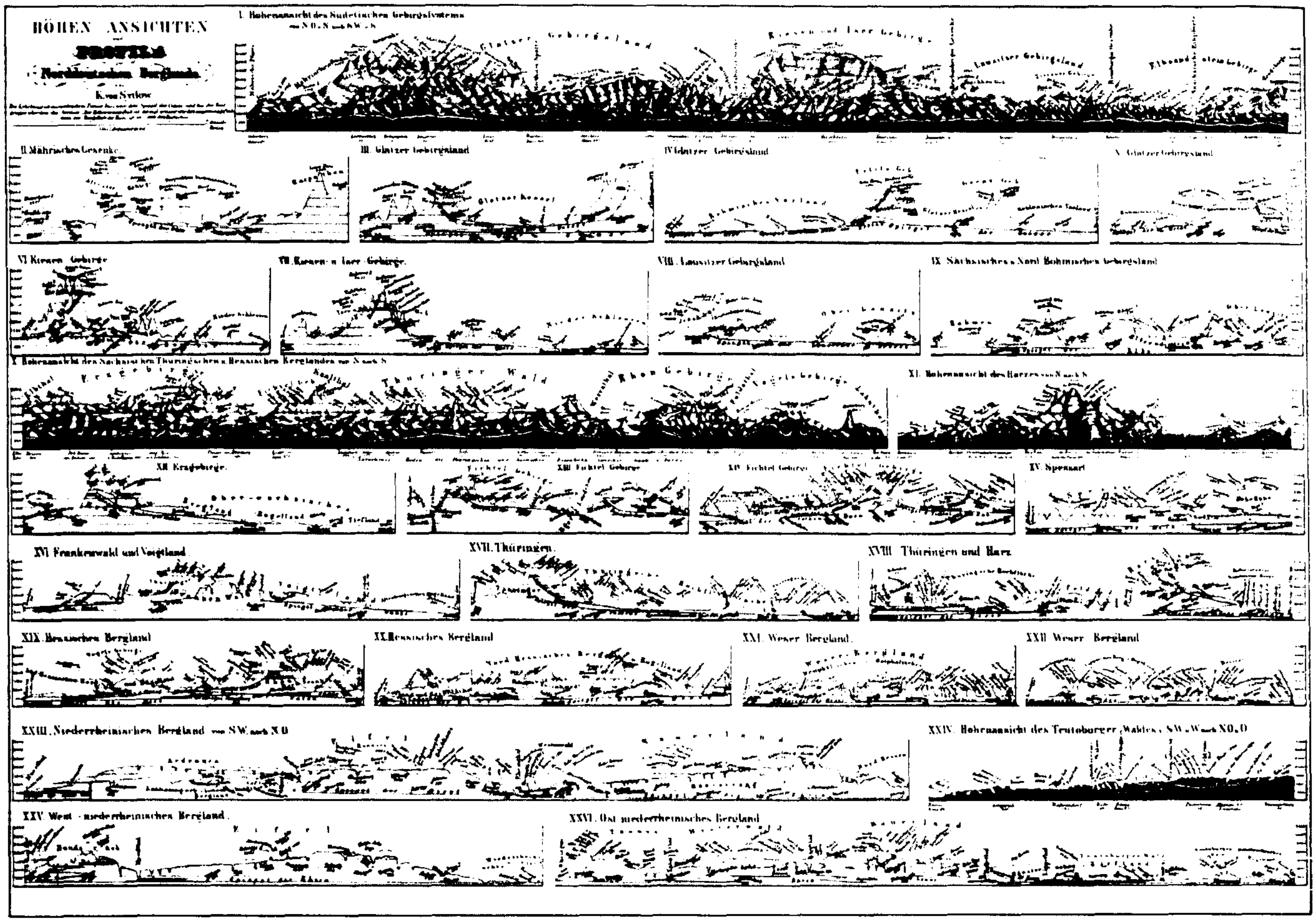
I would like to examine briefly another somewhat different way of expressing vertical dimension. We have seen the general manner in which the illustrative technique of height and length depiction developed. The "scientific" technique of representation, as I will call it for lack of a more appropriate term, is less pictorial than the illustrative method and tends to resemble graphs, although the comparative profile idea is retained. This style also had its origin in Humboldt's early work, beginning with the *Geographie der Pflanzen.*

One of the earliest scientific profiles is found in Adolf Stieler's *Hand-Atlas* of 1823.[37] The *Höhen über der Meeresfläche in transparenten profilen* appears in increasingly updated form in almost every edition of this magnificent atlas from 1823 to 1861; for example, there is an increase in the number of recorded mountain heights in Asia and Africa during this period. Bromme's *Atlas zu A. v. Humboldt's Kosmos,* mentioned above, also contains a similar plate. Both atlases, however, are selective in the new additions they show from year to year.

Heinrich Berghaus' *Atlas von Asia,* 1828–56,[38] contains an interesting early profile on the *Karte von Assam,* published in 1834. Like illustrative profiles in coloration and style of presentation, shaded to present a conical or rounded appearance with snow line shown, it is also similar to many of the scientific genre. This style is found in several of the midcentury and later thematic atlases which depicted in detail different features of the landscape. Tanner's 1825 South American map profile, although classed with the illustrative school, may very well be an antecedent of this profile.

Berghaus' *Physikalischer Atlas* of 1845 and 1852,[39] and A. K. Johnston's *Physical Atlas of Natural Phenomena,* published in Edinburgh in 1848 and in Philadelphia in 1850, both exhibit the same sophisticated scientific pictorial technique which has so many variations; for example, each atlas contains a plate representing the distribution of world vegetation types in both vertical and spatial dimensions. Almost every plate in the early thematic atlases carries some form of vertical expression.[40] Max von Sydow's *Methodischer Hand-Atlas* of 1853 contains many colorful diagrams which illustrate the relief of various smaller regions. There are several other variations of this profile type which could be described; however, either illustrative or scientific comparisons were made in virtually all atlases published during this period, and some atlases used variations of both.

The comparative plates depicting mountain heights and river lengths, from the 19th-century "heyday" of the technique, could be considered the visual expression of a methodological era in



Max von Sydow used both pictorial and scientific profiles in this plate from his Methodischer Hand-Atlas, *published in 1853.*

the development of geographic thought. Systematic description, comparison, and classification in geography had their origins during the lifetimes of Humboldt and his contemporary Carl Ritter. Both men made major contributions to the development of geography and it is from this period that we date modern scientific geography.

At the beginning of the century there were few accurate maps of any scale available for most areas. There was no better way of comparing relations or connections between sets of phenomena in the same area and from one place to another than the comparative profile. The decline in its use is directly due to the increase in large-scale topographic mapping for most areas of the world.

Environmental perception also seems certain to have played an important part in the creation and development of these very elaborate and exaggerated styles of graphic presentation. Objects seemed larger, distances greater, heights higher, and lengths longer in the early part of the century. Geographical and physical dimensions became more manageable—and less exaggerated—as the century drew to a close. Discoveries of mountain heights and river sources and lengths proliferated and the blank places on maps were gradually filled in.

As a measure of geographical exploration and discovery, both the profile and river comparisons are certainly of some value, even though most representations are highly selective regarding

Mountains	1971 World Almanac*	1899 Un-rivaled Atlas†	1874 Colton	1852 Colton	1851 Humboldt (Bromme) in pieds	1850 Johnston	1836 Tanner	1830 Smith	1817 Thomson
EUROPE									
Mt. Blanc	15, 781	15, 760	15, 750	15, 730	14, 766	15, 810	15, 781	15, 735	15, 665
Mt. Etna	11, 122	10, 876	10, 874	.....	11, 400	.....	10, 963	10, 963	10, 955
Mt. Vesuvius	3, 842	3, 800	3, 932	3, 932	3, 636	.....	3, 800	3, 978	3, 935
Mt. Snowdon	3, 560	3, 554	3, 571	3, 571	3, 500	3, 571	3, 568	3, 571	3, 517
Mt. Elbrus	18, 481	18, 526	18, 493	.....	16, 698	17, 796	16, 411	.....	.....
Pico	7, 615	.....	.....	8, 057	7, 428	.....	8, 000	7, 223	.....
ASIA									
Dhaulagiri	26, 810	26, 820	28, 073	26, 862	26, 345	28, 000	26, 262	26, 462	27, 677
Lebanon	10, 131	.....	11, 050	11, 050	10, 000	11, 030	9, 500	9, 520	.....
Mt. Ararat	17, 011	17, 200	17, 112	17, 265	16, 200	.....	9, 500	9, 500	.....
AFRICA									
High Atlas	13, 665	.....	.....	.....	12, 500	.....	12, 500	12, 500	.....
Tenerife	12, 192	.....	12, 236	12, 236	11, 454	.....	12, 171	12, 358	12, 176
AMERICAS									
Chimborazo	20, 561	21, 424	21, 424	21, 440	20, 100	.....	21, 441	21, 464	.....
Long's Peak	14, 256	.....	13, 575	.....	.....	.....	15, 000	.....	.....
Mt. Washington, N.H.	6, 288	6, 288	6, 428	6, 428	6, 240	6, 620	6, 634	.....	.....
Popocatipetl	17, 887	17, 800	17, 884	.....	16, 696	17, 720	17, 710	17, 674	.....
Sorata	.....	.....	21, 286	25, 400	.....	.....	25, 250	.....	.....

**World Almanac and Book of Facts*, published by the Newspaper Enterprise Association, Inc., New York.
†*The Unrivaled Atlas*, published by the *Philadelphia Public Ledger*.

Table 1. Comparative mountain heights, as recorded in various atlases from 1817 to 1971. Measurement is in feet, except where noted.

what they include. These plates did record advances in scientific and technical knowledge, and heights and lengths changed from time to time as new and better measuring instruments were made available. A comparison of the measures recorded from 1817 through 1899 with those of 1971 (see tables 1 and 2) reveals several differences, particularly outside the European continent. Delays in showing new information may be due in part to the atlas publisher, who was probably reluctant to make small changes on his plates. Some direct copying, such as between Smith (1830) and Colton (1852), can also be seen. Changing printing techniques, the gradual transition from engraving to lithography, and the introduction of cerography (wax engraving) were also reflected on the plates as the century wore on.

The technique of profiling, as an illustrative method for comparisons of heights between and among continents and mountain systems, is seldom seen today. River lengths have, for the most part, been consigned once again to tabular form. A few school atlases—usually the last holdout of any cartographic format—still contain a few comparative examples. Perhaps, as Carl Troll, an eminent European geographer, has said:

> One could say that modern relief presentation on physical maps gives sufficient indication of elevations. But the distribution of certain features, e.g. vegetation, settlements, the snow line, etc., cannot be determined from these maps, not even ones with larger scales. . . . It is worth noting that those graphic means of portrayal of a third dimension created under Humboldt greatly excel over our modern products. . . . It would be greatly appreciated if the lost tradition is taken up again in the preparation of a national atlas.[41]

If Troll's recommendations are followed we may see the reintroduction of this excellent

Rivers	1971 World Almanac	1899 Unrivaled Atlas	1874 Colton	1852 Colton	1850 Johnston	1844 Maps, S.D.U.K.*	1836 Tanner	1830 Smith	1826 Lucas	1817 Thomson
EUROPE										
Danube	1, 770	1, 725	1, 630	1, 833	1, 496	1, 630	2, 100	1, 833	1, 600	1, 300
Dnieper	1, 420	.....	1, 200	1, 390	1, 080	1, 050	1, 300	1, 390	1, 140	1, 000
Don	1, 224	1, 300	1, 000	980	960	860	1, 100	980	800	800
Loire	625	600	570	.....	520	620	600	520	.....	.....
Po	418	.....	340	430	352	380	470	430	.....	.....
Rhine	820	600	960	820	600	830	840	840	700	600
Rhone	504	580	490	442	560	540	480	510	.....	.....
Thames	209	220	215	215	.....	240	220	215	215	200
Volga	2, 293	2, 400	2, 200	2, 190	2, 400	1, 900	.....	2, 190	1, 600	2, 600
ASIA										
Brahmaputra	1, 800	1, 400	1, 500	2, 200	.....	1, 500	.....	2, 200	.....	.....
Euphrates	1, 675	1, 750	1, 780	1, 840	1, 492	1, 360	.....	1, 840	1, 530	1, 200
Ganges	1, 550	1, 600	1, 960	1, 850	1, 680	1, 350	1, 800	1, 850	1, 500	1, 400
Hwang-ho	2, 903	2, 700	3, 040	3, 040	2, 280	2, 400	2, 700	3, 040	2, 000	2, 000
Indus	1, 980	2, 000	1, 700	1, 700	1, 960	1, 700	.....	1, 700	1, 700	1, 000
Lena	2, 653	.....	2, 400	.....	2, 400	2, 500	2, 800	2, 374	2, 000	1, 570
Ob	3, 461	3, 000	2, 890	2, 890	2, 320	2, 800	3, 000	2, 890	2, 401	2, 300
AFRICA										
Congo	2, 900	2, 900	1, 700	.....	.....	1, 400	.....	.....	?	?
Niger	2, 590	3, 000	2, 500	2, 000	.....	2, 300	2, 350	2, 670	?	?
Nile	4, 132	4, 100	3, 200	3, 200	2, 240	2, 750	2, 600	3, 000	2, 000	2, 000
AMERICAS										
Amazon	3, 900	4, 000	3, 900	3, 795	.....	3, 200	3, 700	3, 350	4, 000	3, 100
Colorado	840	.....	690	.....	800	700	.....	.....	.....	.....
Mackenzie	2, 635	2, 300	2, 500	2, 350	2, 120	1, 600	2, 450	.....	.....	.....
Mississippi/Missouri	3, 860	4, 650	3, 160	4, 490	3, 560	3, 500	4, 100	3, 760	4, 443	2, 000
Ohio	981	.....	950	.....	.....	.....	1, 050	1, 050	.....	.....
Orinoco	1, 800	1, 570	1, 600	1, 600	1, 352	1, 150	1, 750	1, 600	1, 380	1, 380
Rio de la Plata	2, 300	2, 500	.....	2, 250	1, 920	2, 130	2, 200	.....	2, 000	1, 900
Rio Grande	1, 885	1, 800	1, 800	1, 800	.....	.....	.....	.....	.....	.....
St. Lawrence	1, 900	2, 200	2, 200	2, 050	1, 800	1, 930	2, 300	1, 180	1, 853	700

**Maps of the Society for the Diffusion of Useful Knowledge* (London).

Table 2. Comparative river lengths, as recorded in various atlases from 1817 to 1971. Measurement is in miles.

and easily understood scientific means of comparing heights and lengths. We will, however, probably never again see the elaborate, exuberant, and colorful illustrative plates that were so popular a hundred or more years ago. We can lament their passing, for they are certainly fascinating to peruse and a pleasure to view—perhaps the next best thing to viewing the mountains and rivers themselves.

NOTES

[1] For an excellent summary of the accomplishments of the classical Greek geographers see F. Lukermann's "The Concept of Location in Classical Geography," *Annals of the Association of American Geographers,* 51:194–210 (June 1961). He points out that location was the central concern of the Greek geographers, as it is of modern geographers, and that the Greeks developed the science of geographical description.

[2] Arthur H. Robinson, "The Genealogy of the Isopleth," *Cartographic Journal,* 8:49–53 (June 1971). See especially the diagram on p. 50 depicting "the family tree of the isopleth."

François de Dainville, "De la Profondeur à l'Altitude," *International Yearbook of Cartography,* 2:150–160 (1962). Translated by A. H. Robinson as "From the Depths to the Heights," *Surveying and Mapping,* 30:389–403 (September 1970).

Norman J. W. Thrower, "Edmond Halley as a Thematic Geo-cartographer," *Annals of the Association of American Geographers,* 59:652–676 (December 1969).

[3] Robinson, p. 49.

[4] The late John Kirtland Wright's *Human Nature in Geography: Fourteen Papers, 1925–1965* (Cambridge, Mass., 1966) contains three essays of particular interest. "On Medievalism and Watersheds in the History of American Geography" has a Lizar comparative plate for illustration in figure 5 (the dust jacket uses the same plate). "The Heights of Mountains: 'An Historical Notice' " is a short history of mountain measuring, and "Notes on Measuring and Counting in Early American Geography" contains a plea for a history of the development of what he calls vertical geomensuration.

[5] *A Regiment for the Sea and Other Writings on Navigation,* by William Bourne of Gravesend, a gunner (c1535–1582), edited by E. G. R. Taylor (Cambridge, England, 1963), p. 250–251 (Hakluyt Society Second Series No. CXXI).

[6] For illustrations comparing 16th- and 20th-century coastal profiles as depicted in pilots of the periods, see *The Haven-Finding Art,* by Eva G. R. Taylor (New York, 1957), p. 169.

[7] Luigi Ferdinando Marsigli, *Histoire physique de la mer* (Amsterdam, 1725). The first section of this book, which deals with the profile, was published in Venice in 1711, thus predating La Condamine by some 20 years or more.

[8] De Dainville, p. 392. According to Cornelius Koeman, a leading Dutch historian of cartography, Peter Bruinss compiled a manuscript map of the Het Spaarne River in 1584 which showed a contour line in midchannel. In 1696, Pierre Ancelin produced a chart of the Meuse River in which depths are shown by a system of equidistant curves.

See also Margaret Deacon's *Scientists and the Sea, 1650–1900: A Study of Marine Science* (London, New York, 1971). For a short biographical sketch of Marsigli, see F. C. W. Olson and Mary Ann Olson's "Luigi Ferdinando Marsigli, the Lost Father of Oceanography," *Quarterly Journal of the Florida Academy of Science,* 21:227–234 (1958).

[9] Philippe Buache, *Cartes et tables de la géographie physique ou naturelle* (Paris, 1757). This interesting atlas of 14 plates illustrates Buache's theory that the earth was divided into several "natural" regions or basins by mountain ranges, both on land and under the sea.

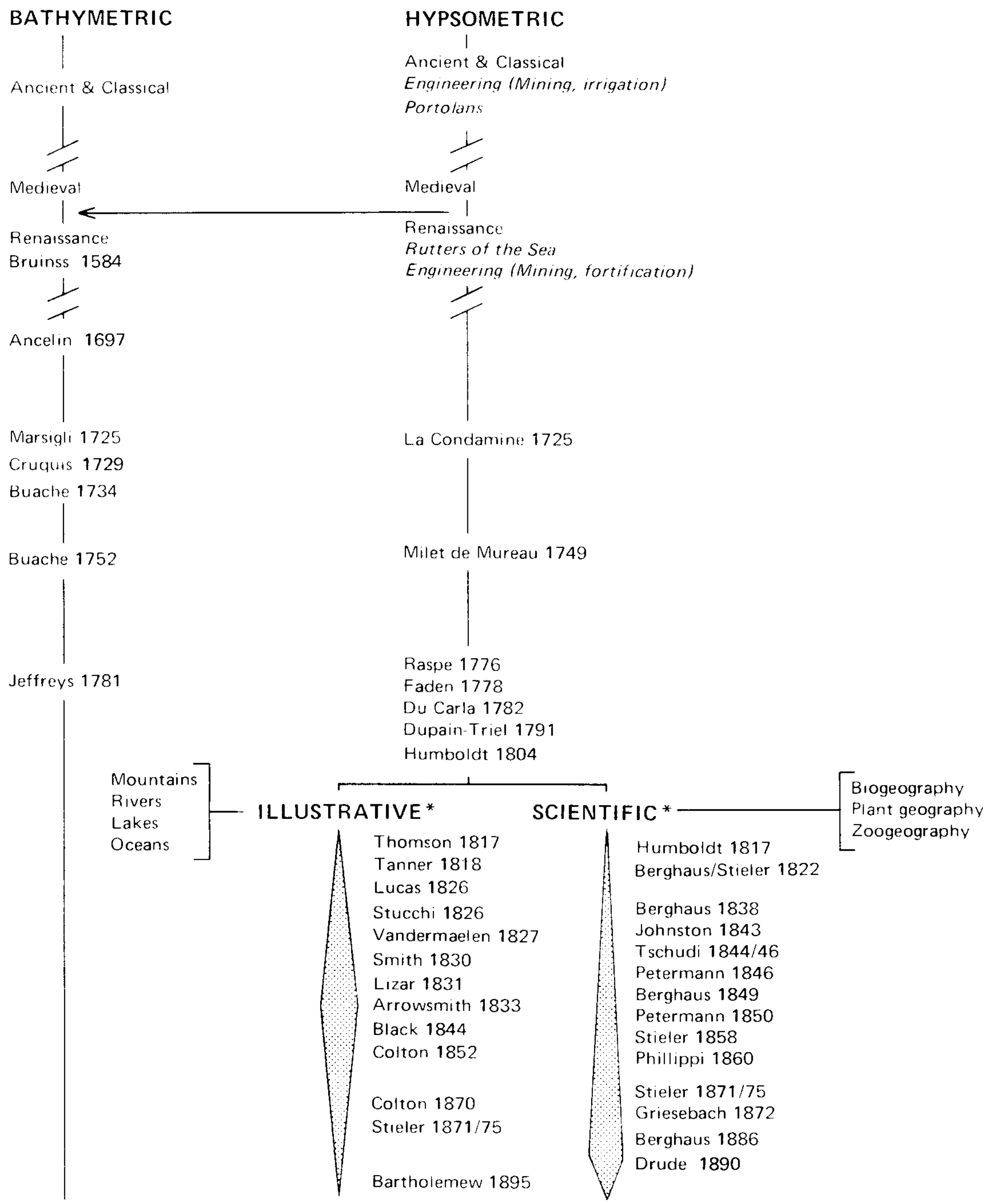
[10] *Cartes et coupes du Canal de la Manche et d'une partie de la Mer d'Allemagne qui présentent par une nouvelle méthod la peute du fonds de ces deux mers.* The plate contains two insets, a *Profil ou coupe des differens fonds du Canal* and a small enlarged scale chart (Sec. de Carte (B)) which shows the transect extending northward to the latitude of Yarmouth, England.

[11] Charles M. de La Condamine, *Journal du voyage fait par ordre du roi, a l'équateur, servant d'introduction historique a la mesure des trois premiers degrés du méridien* (Paris, 1751). To accompany the *Histoire de l'Academie Royale des Sciences* for 1751.

[12] *Nouvelle Carte de la Suisse, dans laquelle sont exactement distingués les treize cantons, leurs allies et leurs sujets, dressée sur les mémoires les plus corrects assujettie aux observations astronomiques* (Londre, chez W. Faden, 1778). In *A Catalogue of Maps, Charts, and Plans Printed for William Faden, Successor to the late T. Jefferys, Geographer to the King* (negative photostat copy in G&M Division pamphlet file), the map is listed as one sheet, Grand Eagle, 1778. I have not located an English-language version, but a German edition was published in 1789 and included in *Allegemeiner Grosser Schrämblisher Atlas* (Wien, 1800).

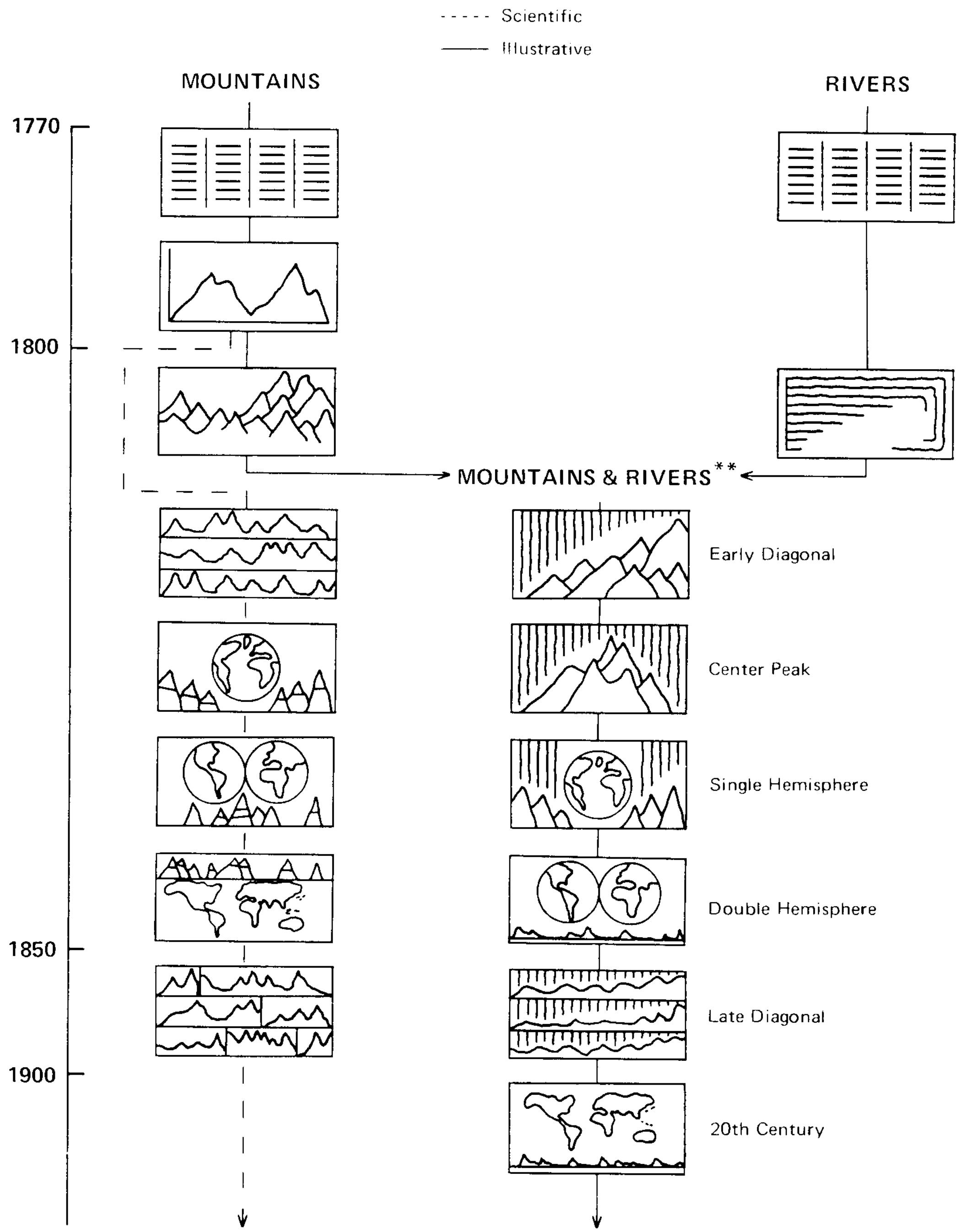
[13] In J. J. Dupain-Triel's *Recherches géographiques*

Chronology of the Profile to 1900



*Shading implies increasingly heavy use in "illustrative" column to mid-century with decline thereafter, general increase to end of century in "scientific" column.

Comparative Atlas Plates: Evolution of Style*



*Based on examination of approximately 250 atlases. Conclusions are tentative

**Lakes and seas were also included on some plates.

sur les hauteurs des plaines du royaume (Paris, 1791). The profile very effectively complements the map, the first contour map of an entire country.

[14] The plate is in Alexander von Humboldt's *Ideen zu einer Geographie der Pflanzen nebst einem Naturgemälde der Tropenländer* (Tübingen, 1807).

[15] Robert E. Dickinson, *The Makers of Modern Geography* (New York, Washington, 1969), p. 27–28.

[16] Humboldt, *Atlas géographique et physique du royaume de la Nouvelle-Espagne* (Paris, 1811). Four plates are of particular interest: 12. Tableau physique; 13. Tableau occidentale; 14. Tableau central; and 15. Profil du canal de Huehuetoca.

[17] Max Eckert, *Die Kartenwissenschaft; Forschungen und Grundlagen zu einer Kartographie als Wissenschaft* (Berlin, 1921), vol. 1, p. 450–451. In this landmark cartographic text, Eckert cautions the reader against being misled by vertical exaggeration on the plates, sometimes as much as 200:1.

[18] Oskar Peschel, *Geschichte der Erdkunde: bis auf Alexander von Humboldt und Carl Ritter* (Munich, 1877), p. 697, 699. It should also be noted that the first profile which Humboldt designed was of Colombia's Magdalena River Valley. This was engraved and published according to his drawing, but without his permission, in Madrid in 1801.

[19] John Thomson, *A New General Atlas, Consisting of a Series of Geographical Designs, on Various Projections, Exhibiting the Form and Component Parts of the Globe; and a Collection of Maps and Charts, Delineating the Natural and Political Divisions of the Empires, Kingdoms, and States in the World. . . . With a Memoir of the Progress of Geography, a Summary of Physical Geography, and a Consulting Index to Facilitate the Finding Out of Places* (Edinburgh, London, 1817).

[20] Thomson, *A New General Atlas . . .*, 1821 ed. See also Thomson's excellent *Atlas of Scotland* (1832) for examples of plates using smaller geographical areas for comparison. This atlas contains an imaginatively styled waterfall plate and a river plate which indicates bridges by illustration.

[21] *American Journal of Science, and Arts,* 3:364 (1821).

[22] The plate carries the date 1818. In other Tanner atlases—*Atlas of the United States* (1835), profile of Erie Canal on a *New Map of New York* (plate 9), and *Tanner's New Universal Atlas* (1833 and 1836)—profiles of lengths of rivers and heights of mountains show the gradual increase in elaborate pictorial expression.

[23] Franz Pluth, *Höhen Charte: oder bildlich vergleichende Übersicht der bedeutendsten Berge in Europa, Asien, Africa, America und den südsee Ländern* (Prag, 1823).

[24] Eckert, p. 449.

[25] Fielding Lucas, Jr., *A General Atlas Containing Distinct Maps of All the Known Countries in the World* (Baltimore [1823]). See plate entitled *Comparative Height of Principal Mountains and Other Elevations in the World.* The copy examined contained two similar plates, one uncolored and numbered to correspond to name and height tables and the other colored and unnumbered.

[26] Philippe Marie Guillaume van der Maelen, *Atlas universel de géographie, physique, politique, statistique et minéralogique, sur l'échelle de 1:1,641,836 ou d'une ligne par 1900 toises, dressé par Ph. Vandermaelen, d'apres les meilleures cartes, observations astronomiques et voyages dans les divers pays de la terre* (Bruxelles, 1827). This six-volume compilation is the first atlas to use the recently discovered process of lithography and is a landmark work in the history of cartographic expression.

[27] Tanner, *A New Universal Atlas, Containing Maps of the Various Empires, Kingdoms, States and Republics of the World* (Philadelphia, 1836).

[28] Bulla, *Tableau comparatif des principales montagnes, des principaux fleuves et cataractes de la terre* (18—). In color and published sometime after Perrot's 1826 *Atlas,* and probably before 1837.

[29] Charles Smith, *Smith's New General Atlas, Containing Distinct Maps of All the Principal Empires, Kingdoms, & States Throughout the World, Arranged According to the General Treaty Signed in Congress at Vienna, With Considerable Additions* (London, 1836). Copies of editions published in 1826, 1830, and 1836 are in the G&M Division atlas collection. The 1826 edition includes in plate 1 a *Table of Heights and Lengths of Some of the Principal Mountains and Rivers in the World.* In the 1836 edition appears *A Comparative Picture of the Waterfalls of the World,* from which Bulla may have received his inspiration.

[30] Joseph H. Colton, *General Atlas . . .* (New York, 1852). In this plate the rivers have been straightened out and the true direction of flow indicated. Distance between points is also indicated. The balloonists are gone but active volcanoes are shown with smoke and fire issuing from their high points.

[31] George Woolworth Colton, *General Atlas . . . .* Letterpress Descriptions, Geographical, Statistical, and Historical, by Richard Swainson Fisher (New York, 1874). Editions of 1855 (sepia plates), 1874, 1884, and 1888 (all in color) were examined. Plate 5 includes *Principal Rivers and Lakes of the World* and, on the verso, *Principal Mountains of the World.* Plate 6, *Comparative Size of Lakes and Islands,* is similar to plates in several atlases of the period.

[32] Samuel Augustus Mitchell, *A New Universal Atlas Containing Maps of the Various Empires, Kingdoms, States and Republics of the World, With a Special*

Map of Each of the United States, Plans of Cities, &c. . . . (Philadelphia, 1846).

[33] Alvin Jewett Johnson, *New Illustrated Family Atlas of the World, With Physical Geography, and With Descriptions Geographical, Statistical, and Historical, Including the Latest Federal Census, and the Existing Religious Denominations in the World.* Text by Richard Swainson Fisher (New York, 1866).

[34] Henry Lange, *Geographischer Handatlas über alle Theile der Erde* (Leipzig, 1866).

[35] Taintor Bros. and Merrill, *The American Household and Commercial Atlas of the World. Carefully Prepared and Drawn From the Coast Survey Reports, and Other Official Surveys and Authorities of the United States and Other Governments* (New York, 1874).

[36] *Atlas zu Alex. v. Humboldt's Kosmos in zweiundvierzig Tafeln mit erläuterndem Texte.* Herausgegeben von Traugott Bromme (Stuttgart [1851–54]).

[37] Adolf Stieler, *Hand-Atlas über alle Theile der Erde, nach dem neuesten Zustande, und über das Weltgebäude;* hrsg. von Adolf Stieler . . . (Gotha [1834]). Plates are dated from 1816 to 1834.

[38] Heinrich Berghaus, *Atlas von Asia* (Gotha, 1828–56). See also the profiles on plates 5, 9, 11, and 12.

[39] Berghaus, *Physikalischer Atlas: oder, Sammlung von Karten, auf denen die hauptsächlichsten Erscheinungen der anorganischen und organischen Natur nach ihrer geographischen Verbreitung und Vertheilung bildlich dargestellt sind* (Gotha, 1845). 1852 edition in two volumes.

[40] The two atlases are similar, Johnston's atlas being "based on the Physikalischer Atlas of Professor H. Berghaus." For an excellent history of these physical atlases, their publication history, plates, etc., see Gerhard Engelmann's "Der Physikalische Atlas des Heinrich Berghaus und Alexander Keith Johnstons Physical Atlas," *Petermanns Geographische Mitteilungen,* 108:133–149 (1964).

[41] Carl Troll, introduction to *Die tropischen Gebirge: ihre dreidimensionale klimatische und pflanzengeographische Zonierung* (Bonn, 1959). See also "Die dreidimensionale Landschaftsgleiderung der Erde," in *Hermann von Wissman-Festschrift* (Tübingen, 1962), p. 54–80.