4 MAP DESIGN

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4.1 Introduction

Map making is significantly influenced by current information technology that allows the compilation of maps using different software products as a way of displaying individual data layers. The availability of this software allows the compilation of maps by nonprofessional map makers from different occupations. However, without cartographic knowledge, the final products are often artefacts that do not meet one of the main functions of the map—to provide truthful information.

Nevertheless, maps are unique kind of documents that can convey huge amounts of spatial information quickly and accurately.

Map design is the aggregate of all the thought processes that cartographers go through during the abstraction phase of the cartographic process. Map design is a complex activity involving both intellectual and visual, technological and non-technological, and individual and multidisciplinary aspects (Dent, Torgusin and Hodler, 2009).

For map design, it is necessary be knowledgeable about map projections and reference systems (see Chapter 9), types of maps (see Chapters 5, 6 and 7) and geographical names (see Chapter8).

There are different forms of map design—for topographic maps and for thematic maps. The most complex process of map design is for atlases.

The topographic map is an essential reference map product (see Chapter 5). A fundamental aspect of map design for topographic maps is the most accurate recording of planimetric (two-dimensional location) and hypsographic (height above sea level) situations on the scale of a map.

Ideally, thematic maps (see Chapter 6) are the result of creative collaboration of experts from two professions. The first is a thematic content expert, the second is a *cartographer* (a visualization expert). A thematic content expert can be a climatologist, geologist, demographer, urbanist, political scientist, ecologist, botanist, hydrologist, tourist, soldier, economist or other professional who is required to express "his/her thematic information" on a map. A cartographer is responsible for the correct visualization, thus ensuring a process in which the reader gains from the map exactly the same information that the thematic expert was required to insert into the map. Cooperation between the two experts is necessary in most cases—a thematic expert would not display his/her data correctly without a cartographer, and a cartographer would not know without a thematic expert what the map should convey and why.

In order for the map making process to be completed to a high standard (i.e., to produce a map that provides the required information correctly, accurately and quickly), a cartographer must also take into account the process of map use. The beginning of map design must correspond with the end of map use (see Figure 4.1).

Map design passes through three phases—map proposal, map drafting and map compilation (see Figure 4.1).
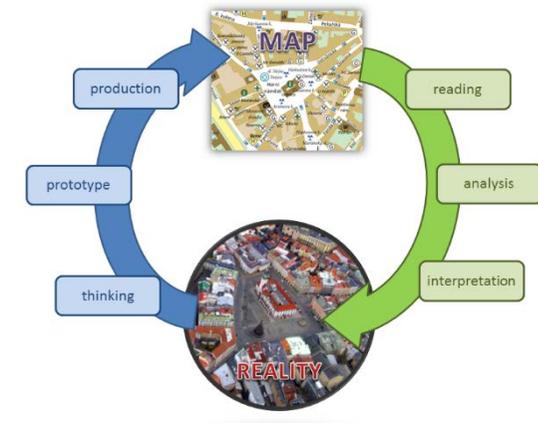

Figure 4.1 Reciprocal influence of map making and map use.

4.2 Map proposal

A mapping assignment is always the beginning of map design. A map assignment is essentially a special type of order. The execution of such a contract requires professional solutions based on the nature of the map project.

A thematic map assignment is formulated by a customer expressing the intention with which each map is to be compiled and published. The map assignment must include a clearly defined objective and purpose for the map, as well as other requirements, such as the volume of the information or the expected map use.

The objective of the map is a key point of the map assignment. The objective of a topographic map is to provide the most accurate display of a topographic and hypsographic situation on the scale of the map. The objective of a thematic map is defined by a thematic expert (or by a contracting authority) in the form of a

statement what is the data provided are about and for whom their visualised portrayal is intended.

According to the map assignment, a cartographer draws up a *project map* and elaborates important items of map design. It consists of two main parts, namely, the objective specification and the project specification (see Figure 4.2).

When the objective of a map is specified, the target group of users, the way of working with the map and the volume of conveyed information are carefully formulated. There are many possible user groups, characterized by age, education, cartographic literacy and previous experience of working with maps:

- school groups (pupils and students) often use school wall maps and atlases;

- professional groups (experts and officers) often use scientific maps with specialized content, including administrative maps, topographic maps and cadastral maps;

- public groups (the general public, including interest groups) often use tourist maps, road maps, maps of wine regions, maps of fishing grounds, etc.

The manipulation of a map involves specifying the expected time available for viewing the map (a map on the wall permanently or a short map display on TV), the form of the map (paper or digital) and the conditions for viewing the map (for walking, in low light, in a wet environment, etc.).
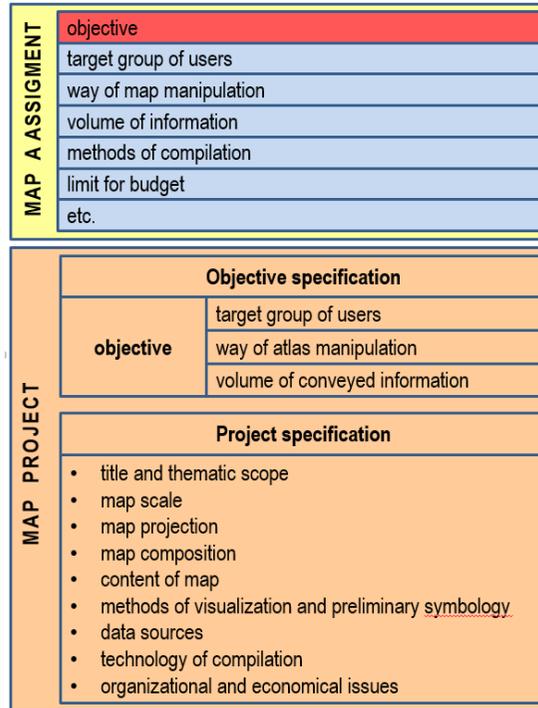

Figure 4.2 A map assignment and a map project.

4.3 Map drafting

4.3.1 Topographic maps

At the beginning of topographic map compilation, astronomical measurements are necessary for determining the exact position of selected points which are used to define coordinate systems. These are followed up by geodetic measurements generating the network of triangulation points with which all objects on the Earth's surface are mapped in the field—buildings, roads, rivers, forests, borders, etc.

Cartographers compile topographic maps according to the rules and regulations set through which all maps in a topographic map series are identical in projection, content, detail, labelling and symbology. Topographic maps are frequently updated and constantly improved.

Topographic maps usually are compiled under the responsibility of national governments and form one of the most important official documents (see Figure 4.3).
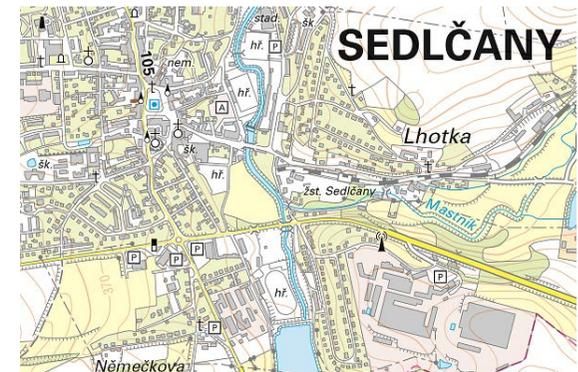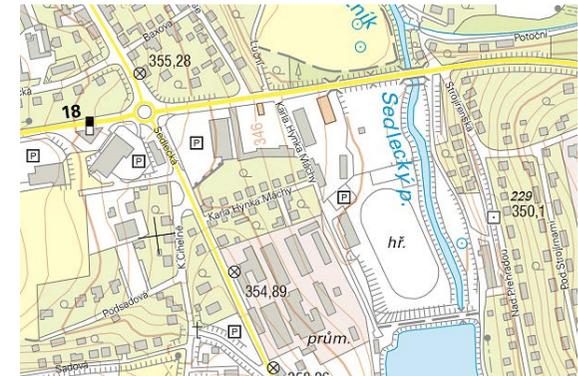
Figure 4.3 Topographic maps of the Czech Republic at different map scales.

4.3.2 Thematic maps

Thematic maps are compiled in a different way. Thematic content (geology, climate, population, transportation, etc.) is drawn on a *base map*, which is most often either a simplified topographic map or a set of data layers. This creates *a working map*. The results of field surveys or other existing thematic data such as statistical data are added to it. In this working map, the cartographic rules (on colours, labelling, etc.) may not be

strictly observed because the working map is only for the author, not for the end users. The cartographer and thematic expert work together to define its content, methods, symbology, etc. If the map is compiled in GIS, the working map is a simple data view (Voženílek 2005) or visualization of the data.

The cartographer and thematic expert can redraw, refine, supplement or generalize this working map several times. The final working map is called the author's original, which is a master for further cartographic processing (see also figure 6.28).

4.3.3 Map content

The features on a map are the *map content*. Map content is compiled sequentially to be fully in line with the map objective. Features are displayed in the map content according to one of the following criteria:

- qualitative—the species are expressed (e.g. language map);
- quantitative—the quantifiable properties (e.g. population density map) are displayed;
- topological—the features are represented by their ground nature (the way they relate to the Earth surface) by point, line and areal symbols (e.g. road map);
- developmental—the changes in space and time are displayed (e.g. troop movement map);
- meaning—or significance and the significance of a small settlement in the desert is higher than that of a similar settlement in a well-populated area) and
- structural —the feature as a unit together with its sub-components and interrelationships are represented (e.g. map of the age structure of the population).

In compiling the map contents, the first task is to distinguish primary features (resulting from the map

assignment) from secondary ones (used to supplement the information on the map). A topographic base of the thematic map is created to allow for spatial localization and to find mutual topological relations of the primary features.

4.3.4 Map symbols and cartographic methods

There are a number of methods for map visualization of map contents. The selection of methods is determined by the nature of the displayed features (which can either be related to points, lines or areas) and the objective of the map (see Chapters 4.2 and 4.3.3).

Point map symbols—a simple geometric, figurative or alphanumeric picture (see Figure 4.4)—allow for the expression of feature characteristics at a particular location. Using the shape, size, structure, fill and orientation, both qualitative and quantitative characteristics can be expressed (see Figure 4.5).
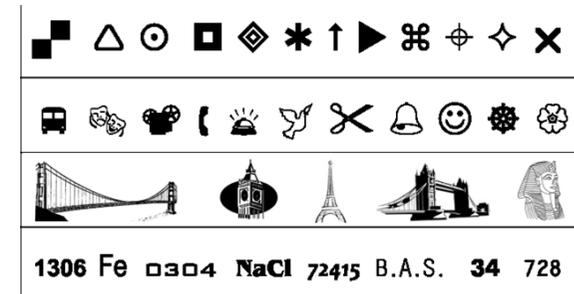
Figure 4.4 Types of point map symbols.

Shape	◯	△	▢
Size	◦ ○ ◯	▵ △ ◭	▫ ▢ ▢
Structure	◉ ◐ ◑	◬ ◮ ◭	▰ ▥ ▫
Fill	◯ ● ◯	△ ▲ △	▢ ▰ ▧
Orientation	◐ ◒ ◓	△ ▽ ▽	▢ ◇

Figure 4.5 Shape, size, structure, fill and orientation—graphic variables of point map symbols.

Qualitative feature characteristics are mostly expressed by the shape of the point symbol. The size of the map symbol is used mainly for expressing amounts, importance or super ordination of the features. The size of a symbol is proportional to the quantity of the feature and is related to the measurable parameter of the symbol—mostly the radius of a circle, the side of a square, the height of a column or picture. The structure (internal graphical breakdown) of the symbol is used to express the internal feature structure, such as the ethnic structure of the population or the sectorial structure of manufacturing. The fill of the symbol by colours or by hatching is used mostly to express the qualitative feature characteristics. The orientation of the symbol (rotation around its centre point) is most commonly used to express the direction of movement, such as wind direction, migration of animals or sight line.
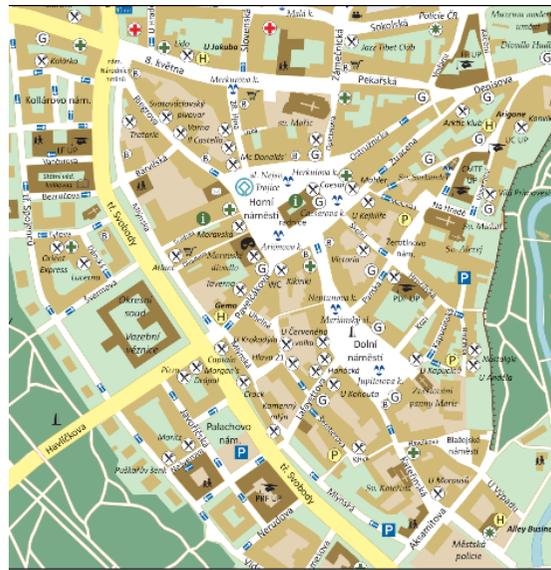
Figure 4.6   Maps with point map symbols.

Line map symbols—various forms of lines—express both qualitative and quantitative characteristics of linear features by thickness, structure, colour and orientation (see Figure 4.7). Simple lines (solid, dotted, dashed, dash-and-dot) and complex lines (with various supporting map symbols—crosses, "teeth," ripples, images) are used to express the quality of linear features. The thickness of the line symbol is determined by the relationship to the quantity of the feature (e.g., traffic volume) or importance or super-ordination (e.g., state, provincial, municipal borders). The qualitative characteristics of linear features are mostly expressed through colour (another feature = other colour). The longitudinal orientation of the symbol expresses the direction "forward/backward" such as animal migration or the movement of troops, and the .transverse orientation expresses the fact that boundaries separate areas with different characteristics.

Figure 4.7 The line map symbols in the legends.

Printed map symbols express both qualitative and quantitative characteristics of large-scale features by fill (colours or hatching) and outline. The fill is used more frequently, although outline provides the structure, thickness, colour and orientation (see Figure 4.8).
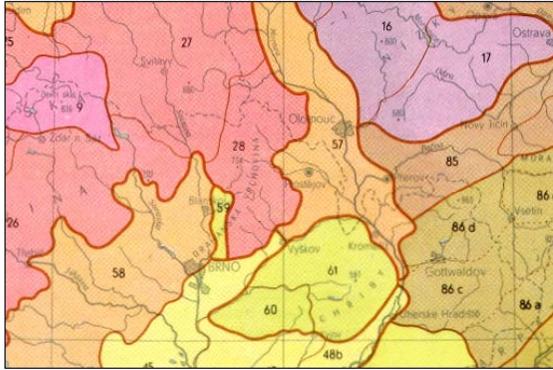
Figure 4.8 Maps with areal map symbols.

4.3.5 Colour

The colour parameters include hue, value and saturation (see Figure 4.9). Hue can be defined as the various colours we perceive (red, blue, green, yellow, orange, etc.). Millions of hues arise by combining various percentages of the primary hues and altering their value and saturation. Value is the lightness or darkness of a hue and is affected by background: the value looks lighter when surrounded by darker shades of grey colour. Saturation means intensity or purity of a colour and ranges from 0% (neutral grey) to 100% (maximum saturation).
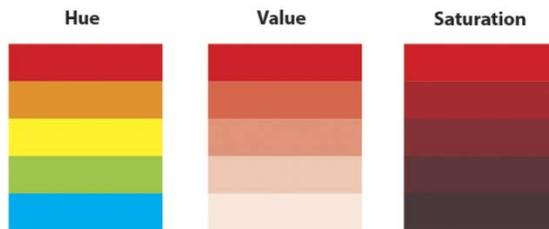
Figure 4.9 Hue, value, saturation.

Finding the right colour combination or colour harmony is not a trivial issue. Colour is used differently for expression of quality (species) and quantity (amount) of the feature characteristics (see Figures 4.10 and 4.11).

When distinguishing the features according to their qualitative characteristics (e.g., countries of the world, soils, language), a cartographer expresses these qualities primarily by differences in hue, then by saturation and value (see Figure 4.10). Lighter colours are applied for larger map areas to be visible and identifiable relative to darker colours. Darker colours appear much more dominant than lighter colours within the same area size. Some colours permit us to perceive less contrast than others (Kraak and Ormeling 2003) because two or more colours interact and influence each other's appearance.
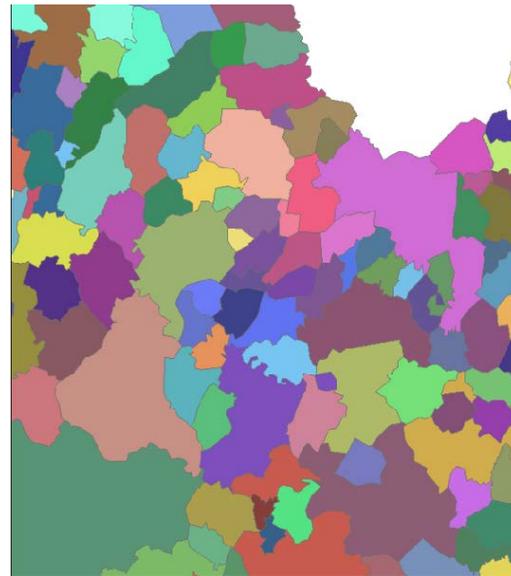
Figure 4.10 A colour used for distinguishing of qualitative feature characteristics in the map.

When using colour to express feature quantities (see Figure 4.11) in the map, cartographers distinguish amounts of features (more—less; most important—unimportant, etc.) by changing the colour intensity, the combination of colour saturation and brightness according to the following rule: the higher the intensity of the feature, the higher the colour intensity.

The representation of quantitative features on maps involves the use of a single hue or a limited number of hues to unify a feature. For example, with an air temperature map, the hue progression (colour ramp) represents air temperature, and varied values and saturation within the hue creates a graded series from light to dark showing degrees of Celsius. With such a scheme it is easy to associate the feature with the hue and the different quantities with the lightness or darkness of the hue. Lighter hues normally represent lower quantities while darker hues are for higher quantities. The reverse may be applied, however, when it is desirable to emphasize the lower quantities (e.g., to highlight areas of extreme poverty [low income] with the strongest colour in the graded series).

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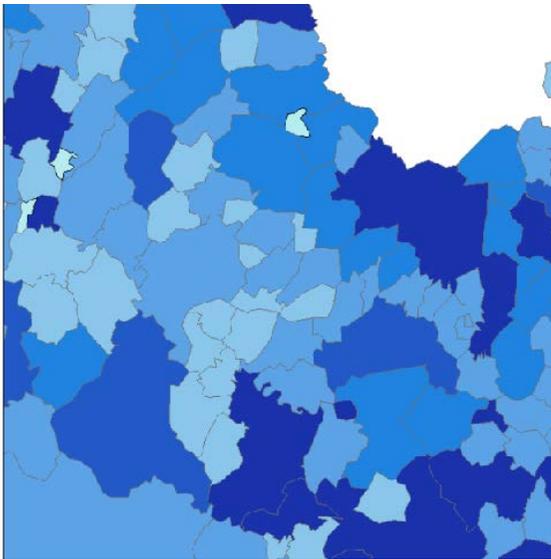
Figure 4.11 A colour ramp used for distinguishing quantitative feature characteristics in the map.

While some colour combinations can adversely affect map interpretation, there are other combinations that create positive effects, which are complementary and pleasant to look at, or accentuate figures and subdue backgrounds.

4.3.6 Labelling or map text

All maps but orienteering maps contain text. Place names must be easy to read and be placed at the right location also when you zoom in or out on your computer screen. The first thing that catches the eye is that there are so many printing typefaces. The development of typefaces has a long history; its main purpose has been to create texts easy to read in books and newspapers. The typefaces used in advertising have other characteristics, chosen in order to convey an impression

of the objects the advertisement deals with.

In this section we will handle typography and how to print the text on the map. However, only Roman writing will be dealt with, hoping that in translations of this book into Russian or Arabic the typography of Cyrillic or Arabic scripts will be dealt with.

The typeface or font of the text is very important in a map. Different typefaces are used to label different types of map objects, and of course texts are also used the title, legend, imprint and text boxes. By changing type parameters (see Figure 4.12), we can distinguish features by labelling the map content and thus improve the map readability and attractiveness. The readability and clarity of each letter symbol or character are provided by the basic parameters of type—family, size, colour, etc.

Figure 4.12 Typography used in maps.

Map typography includes all the letters (regardless of language or writing system) and numbers on the map sheet that are classified according to the features to which they are related .The labelling must always be formally and linguistically correct. For the spelling of the names see chapter 8 on toponymy.

Each type is created in four forms. Firstly, the normal form in uppercase and lowercase letters, and secondly the italic form also in uppercase and lowercase letters. The size of the letters is measured in points. The Anglo-Saxon point is 0.375 millimetre, and the American pica point 0.351 millimetre. The latter one is mostly used in computer graphics. Text in five points is readable, but six points is the smallest recommended.
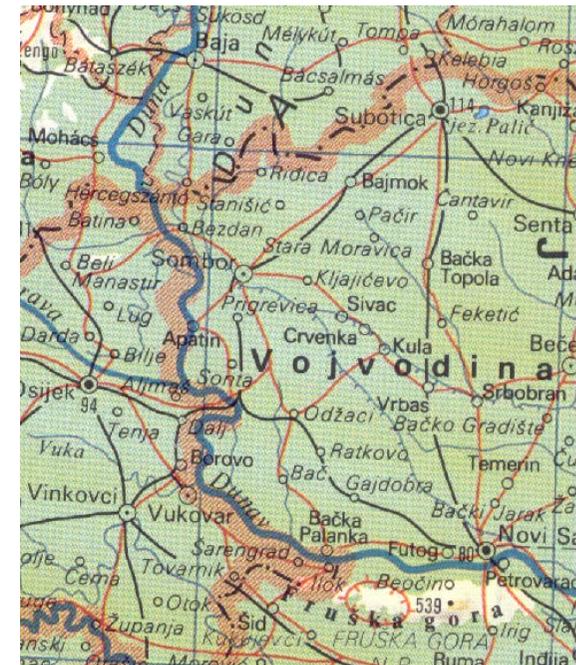
Figure 4.13 Various types of map labelling.

In Figure 4.13 it can be seen that different text is used for labelling different kinds of objects. For built-up areas, a larger size letter is used for more populous areas. For small areas and cultural buildings the text is in italic. Names of waters are blue and in italic. It is also common to let the names of rivers follow the form of the river. For a great area like an ocean the name may be given a curved structure. The designer of the map has many possibilities to give the map a personal style. Furthermore, the typefaces either can have serifs (these are the small projecting features at the end of letter strokes), then they are called antique or they can be without serifs, then they are called sans serif or linear typefaces. Both these forms may be used. Figure 4.14 shows examples of different typefaces and sizes.

This text is in Calibri 11 points.
This text is in Calibri 9 points.
This text is in Times New Roman 9 points.
This text is in Arial 11 points.
This text is italic in Arial 9 points.

Figure 4.14 shows text in different typefaces and sizes. Times New Roman is an antique typeface while Calibri and Arial are linear.

Placement of Text

After the typography has been chosen it is time to place the name in the map. For a settlement or a single object six locations can be considered. Place a rectangle around the object and consider the four corners, and above and under. The text with a corner as a reference point should end or start close to the reference point. The text above or under should have the reference point in the middle.

For large cities the text can cover some of the area. Names of populated settlements are normally in black colour. Name placement also involves work with reduction of part of other elements but not more than necessary to make the letters free. The text placement is computerized and needs good cartographic software.
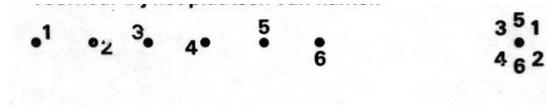

Figure 4.15 Preferential locations for name labels of point features: the best location is to the upper right (1).

There are many rules for text placement. The name of a river should follow the river line and be placed north of the river (see figure 4.16b). If the river is broad enough the name can be placed in the river. The river name can also be placed on many locations and especially at the end of the river. Names of settlements along the river should be placed on the same side as the settlement is located. A harbour city may have its name in the Sea (or in the lake). An inland city may have its name on land. Name labels may not be placed upside down. The only text that can be placed upside down is the height figures of elevation lines (see Figure 2.3). The labelling is mainly positioned horizontally, only the line and area features are labelled along geographic grids or along their axes (see figure 4-16a). The labelling is always placed so that it is clear to which feature it belongs.
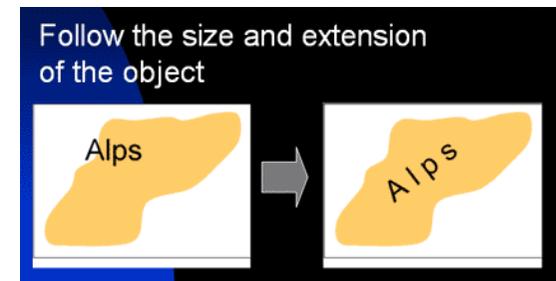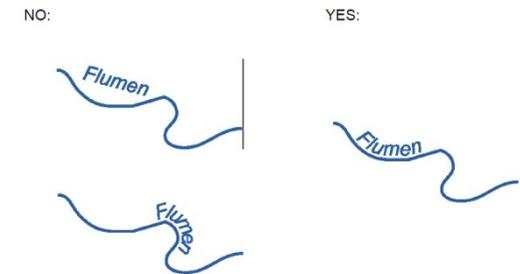
Figure 4.16 incorrect and correct name placement for areal (a) and linear (b) map objects

The labelling is mainly positioned horizontally, only the line and area features are labelled along geographic grids or along their axes. The labelling is always placed so that it is clear to which feature it belongs. More on labelling is to be found in section 13.6.

4.3.7 Map generalization

Map generalization is the process that simplifies visualization to produce a map at a certain scale with a defined and readable legend. To be readable at a smaller scale, some objects are removed, enlarged, aggregated, displaced or simplified. During generalization, map information can be globally simplified but has to stay readable and understandable (see Figure 4.14).
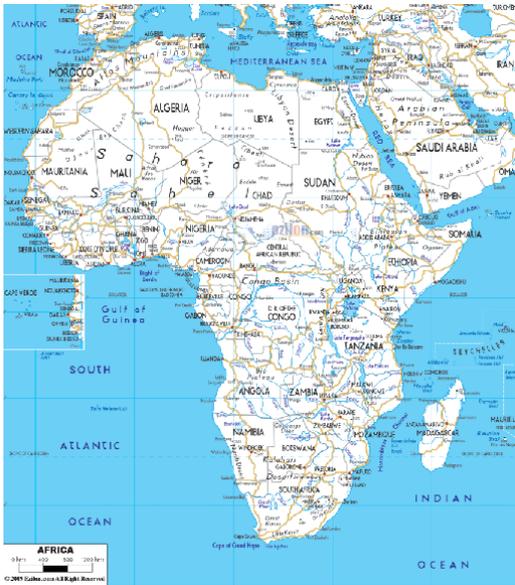
Figure 4.17 Two maps with different levels of map generalization.

The smaller the scale, the less information is given per square kilometre. Conversely, the larger the scale, the more detailed information is given for the same map size.

Map generalization includes several methods for reducing the complexity of the real world by strategically reducing unnecessary details (see Figure 4.14):

- Selection—the most important features stand out while lesser ones are left out entirely. For example, a directional map between two points may have lesser and untraveled roadways omitted so as not to confuse the map reader. The selection of the most direct and uncomplicated route between the two points is the most important data, and the cartographer may choose to emphasize this;

- Simplification—the shapes of retained features are altered to enhance visibility and reduce complexity. Smaller scale maps have more simplified features than larger scale maps because they simply exhibit more area;

- Combination—the features are combined when their separation is irrelevant to the objective of the map. A mountain chain may be isolated into several smaller ridges and peaks with intermittent forest in the natural environment, but shown as a continuous chain on the map, as determined by scale;

- Smoothing—is reducing the angularity of line work to exhibit it in a much less complicated and less visually disruptive way. An example is the smoothing of a meandering river so that the generalized line of the river contains less bends, is less curved and follows the main flow direction; and
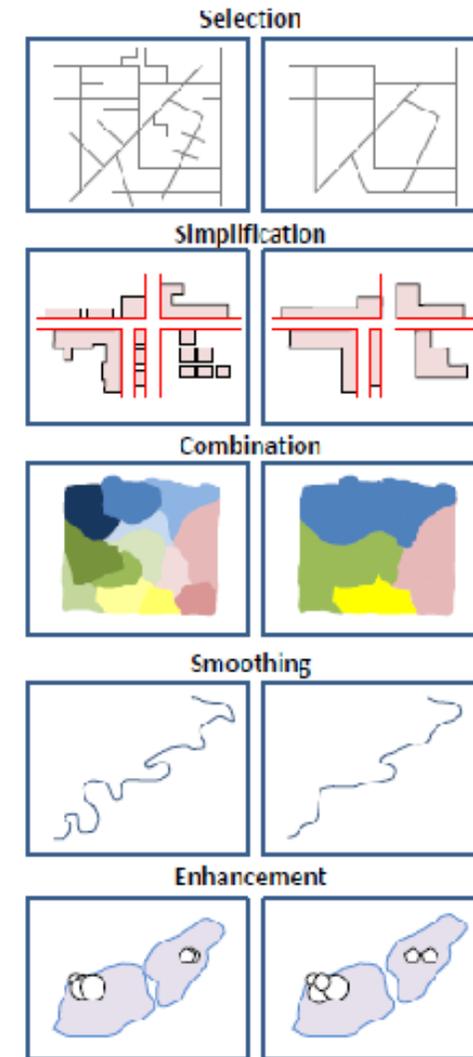

Figure 4.18 The methods of map generalization.

8

- Enhancement—is used to show the primary nature of features and to highlight specific details that would otherwise be left out.

4.3.8 Map composition

Map composition is the first image the reader sees on the map. Map composition means the distribution of the graphic elements on the map sheet. It depends primarily on the objective and scale of the map, map projection, the shape and size of the mapped area and the format of the map sheet. The map composition of the thematic maps is very varied and diverse, unlike the topographic maps with uniform map composition based on official rules and regulations.

Map composition must meet three basic requirements:

- to include all the basic composition elements;

- to be balanced, without empty or overfilled areas; and

- to present aesthetically pleasant conditions for map reading.

The basic elements of composition are:

- map area;
- map title;
- map legend;
- map scale (graphical, verbal); and
- imprint.

The map title contains the main textual information on the map. The theme of the map, which the cartographer receives from the map assignment, should be briefly but clearly expressed in the map title. It is then placed on the top of the map legend. The map title must contain thematic, spatial and temporal determinations of the main theme of the map. If the map title is too long, part of the title is given as the subtitle. The title usually contains the thematic determination of the feature and it is always written in uppercase letters. The subtitle contains the spatial and temporal determinations of the features and it is always written under the title and in lowercase and smaller letters than the title.

The map legend is an overview of the symbology used on the map in easily readable and understandable form, from which the map reader correctly decodes information stored in the map. The map legend is placed near the map area. The map legend must be:

- Complete —"what is in the map is then in the legend." The map legend must contain all map symbols that are in the map. The map legend does not contain information on construction elements (map projection, geographic grid, etc.). The legend of thematic maps does not include the symbols of the topographical base;

- Independent —one feature has only one symbol in the map legend;

- Ordered —the map legend map must be arranged in a logical structure, usually by hierarchy of the features;

- In accordance with the symbol appearance in the map—the symbols in the legend and in the map must be rendered identically (the same shade of colour, the same size, the same thickness, the same width, etc.); and

- Understandable—the explanation of all symbols must be clear and easy to understand.

An imprint always contains the author's name, publisher, place and year of publication. It may also contain information on the map's projection, edition, reviewers' names, copyright, etc.

In addition to basic composition elements, a map can contain other additional composition elements to increase the information value of the map and its attractiveness, such as a north arrow, insets, charts, profiles, explanatory texts, tables, etc.

4.4 Map compilation

Once a cartographer generalizes the map content and interprets it in the map at the scale of issue, this results in an *editorial original*. The content of the editorial original is drawn with the prescribed graphical accuracy in all details in accordance with a map project.

The thematic content of the editorial original is taken from the authors' originals, which are compiled by thematic experts rather than cartographers. The compilation of the thematic map requires a skilled cartographer, who addresses a number of cartographic tasks in accordance with the map project, especially map composition, generalization, map content maps and symbology. A cartographer is fully responsible for the quality of visualization of the editorial original, which is the final form of the map design.

The editorial original is first elaborated in the areas with the richest map content in order to determine the optimal graphic complexity of these areas and their readability. Symbology and level of generalization are adjusted according to these areas. Other features of the map content are then drawn according to their importance. Finally, the labelling and additional composition elements are drawn. The thematic expert is involved in the compilation of the editorial original primarily as a consultant on the map content and symbology.

Printing is the last phase of the map. The result is a perfect map copy, which is then to be faithfully reproduced and published (see Chapter 13). The resultant map must comply in accuracy, completeness and topicality of all features from the map content and all aesthetic demands. Print quality is checked at the first test prints.

4.5 Think before you draw

In map design, all the above knowledge must be respected. In order for a cartographer to work effectively and successfully, everything has to be carefully thought out and plotted. The following principles must be observed:

… each map should be elaborated at least twice

First, a working map should be drawn. On the working map, the thematic expert compiles thematic contents of the map ("the first" map), which does not change during further processing. Then when compiling "the second" map, the cartographer collaborates his/her activities with the thematic expert, in relation to generalization and symbology.

… pay the same attention to each part of the map

All features have to be treated with the same attention on the entire map area. Each map has three aspects—subject (related to content), technical (related to design) and aesthetic (related to appearance)—which need to be processed uniformly and with the same thoroughness.

… from the theme to the legend

It is necessary to follow the sequence: main theme—map title—the most noticeable symbols—map legend. This means that the main theme of the map must be uniquely determined in the map title, then expressed by the most noticeable symbols and located at the top of the map legend.

… the best legend is an unnecessary legend

The easier it is to read the symbols and the clearer the "map language," the better the map. The problem is author blindness and branch blindness. In *author blindness*, the author of the map thinks that if he does understands the map other readers will understand it too. Maps affected by author blindness occur when the thematic expert compiles the map without the cartographer and without cartographic skills. In *branch blindness*, the members of one branch of science or discipline argue that they all easily understand the map and so everybody will understand it. However, the map will be read by people from other scientific disciplines as well, with varying levels of knowledge of the themes, even with visual impairments or specific colour sense. The map must be understood by all these people.

… a map is read from two distances

From a longer distance, the reader first reads the map composition (especially the map title that tells what the map is about) and the basic spatial pattern of the primary features. All details (particularly map symbols and labelling) are read from a short distance (such as text in book).

… sometimes less is more

A map that is too full graphically is difficult to read and remember.

… no map is useless, the worst-case scenario serves as a deterrent.

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