COLOR SCHEME FOR BETTER REPRESENTATION OF REGIONAL CHARACTERISTICS IN TOPOGRAPHIC MAPS

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1. MAP AND COLOR

1.1. Significance of Color in Topographic Map

Map is a reduced model of a region of which chracteristics should be represented in appropriate, legible and understandable forms for its users. The topographic map as base map of a country works as a mirror of regional characteristics, a measure of technical level, as well as an agent of preference of people who live in the country.

Color has always been considered important in cartography. In the history of topographic mapping, black and white map has been replaced by multi-colored map finally, while there is still a convention for color use, for instance, hydrography - blue, topographic features - brown, vegetation - green, city - black or red, annotation - black, etc. This convention is usually associated with nature of each object represented in maps, although there are noticed remarkable variations of color coordinates in each country. Variations of color schemes are clearly distinguished one another by means of hue, value and chroma of Munsell's system.

1.2. Color Coordinations in Topographic Maps in Various Countries

The author selected some samples of topographic maps of various countries and examined colors used for them in order to detect differences in color coordinations among those countries, applying a standard color chart based on the Japanese Industrial Standard to identify those colors. However, there was a limit in number of color patches in the chart and names of colors, so that he used the most similar colors in place of the original ones.
The results are, for instance, as follows:
(a) 1:50,000 Topographic Map (6 colored) of Spain
7.5R 5/14 (scarlet), 7.5R 4/3 (cypress bark), 5G 5/10 (malachite green), 10B 7/6 (sky blue), 5PB 5/10 (prussian blue) and N2 (black)
(b) 1:25,000 Topographic Map (5 colored) of U.S.A.

10RP 5/14 (strawberry), 10GY 7/8 (nile green), 5B 6/8 (cyan), 5RP 5/12 (opera) and N2 (black)

(c) 1:25,000 Topographic Map (4 colored) of the former D.D.R. 2.5YR 6/10 (carrot), 10GY 8/6 (spring green), 7.5B 6/8 (turquois blue) and N4 (dark grey)

(d) 1:50,000 Topographic Map (4 colored) of Japan 5YR 5/8 (tan), 10Y 5/6 (moss green), 10B 5/10 (cerulean blue) and N2 (black).

We can make sure those characteristics of color coordinations by means of plotting hue, value and chroma on a hue circle diagram as shown in Figure 1.

2. TOPOGRAPHIC MAPPING PROJECT IN LAOS

2.1 Background of Topographic Mapping Project

The government of Lao People's Democratic Republic requested the government of Japan in July 1992 to carry out technical cooperation work on topographic mapping project of Bolikhamxai Province and its surrounding area in scale of 1:25,000. In response to the request, the government of Japan dispatched an advance mission organized by Japan International Cooperation Agency (JICA) and consisted of members from Geographical Survey Institute (GSI) and other organizations. The mission concluded a scope of works as the result of discussion in detail of the project with staffs of National Geographic Department (NGD), counterpart organization of Laotian side. In accordance with the scope of works, it was decided that 112 sheets of the 1:25,000 Topographic Map with five colors in total covering about 13,000 km² shall be produced, and also technical transfer on topographical mapping for members of NGD by Japanese side shall be carried out.

Bolikhamxai Province area for the project lies to the east of the metropolis Vientiane in the middle of the country and on the left (northeast) bank of the River Mekong which makes a part of national boundary between Thailand. Therefore, the area corresponds to the shortest way for trade from Vientiane to Viet Nam, expected one of the promising area for economical development.

Existing topographic maps in large scale covering whole territory of Laos are both 1:50,000 and 1:100,000 series. The former was compiled on the base of maps have been prepared by American Army in 1960s. While, the latter was prepared in early 1980s in cooperation with Soviet Union. Control points

were also established by Soviet Union for mapping, however, the details of 1:100,000 map series are totally compiled from the above 1;50,000 series in reduction. Both adopt French for annotation. Besides, the 1:25,000 series in five colors were prepared for southern parts of the country in cooperation with Soviet Union, but number of the sheets is only about thirty in total.

The author has been participating in the mapping project as team leader of JICA Survey Team of which main work is preparing of new 1:25,000 Topographic Map series since December 1992 through March 1996, that is, from beginning to end. Among the map making processes of the project, aerial photography, ground control point survey, aerial triangulation, stereo plotting, field identification, and compilation of manuscript have been finished until the end of 1994, so that the following processes, that is, drafting and printing shall be carried out in 1995, and the final printed maps and a report shall be submitted at the end of 1995. Throughout the terms, discussions have been carried out continuously with the staffs of NGD on a legend for the map and a color scheme for printing in order to attain better results.

2.2 Problems on the Legend and Color Scheme

As above-mentioned, 1:25,000 topographic map of the project is planned in five colors and 112 sheets in total. Outline of specification on the map is prescribed in the scope of works as the result of discussion between both Japanese and Laos sides, in particular, the following items are decided.

- Basic spheroid: Everest (present Krasovskii shall be changed).
- Map projection: Universal Transverse Mercator Projection.
- Annotation: English and Lao - present French shall not be used.
- Legend: depend on the consultation between both sides.

The staffs of NGD were largely educated at the Moscow Engneering Insitute of Geodesy, Photogrammetry and Cartography (MIIGAiK) of which name was changed to MosCartography at present. A specification in a text book has been used at the institute are widely applied to legends of the existing topographic maps in Laos including the 1:25,000 Topographic Map. And, for the 1:25,000 Topographic Map five colors are used: orange, brown, green, blue and black. Among them, brown is applied to topographic features, green to vegetation, blue to hydrography, black to planimetric features and annotation. This application is widely used as usual convention, while the orange is applied

to house block in city or town area as well as national road with coloring tint. It is obvious that topographic maps of Laos are very similar in color scheme to those maps of Soviet Union and affected by its map making system.

However, problems on the legend and color scheme for the new topographic map were anticipated when the scope of works would be applied. First, In case of lettering both annotations in English and Lao on the map, should the both be described in black, or either one, for instance, should Lao be changed to other color? In this case what kind of color should be selected? Secondly, there are few cities and towns and very poor road networks in the mapping area. If we shall adopt the same color scheme as the existing topographic map of Laos and the same orange color shall be applied for the new map, the color shall almost never appear on map surface of the area, except only cases on the legend of each map and in a few number of sheets in which national road shall appear.

Although 1:25,000 topographic maps to be prepared for Bolikhamxai Province and its environs will be directly used for development programs of the region, it is also considered that format and specification designed for these maps should be a prototype for those of maps which shall be prepared in future covering whole territory of Laos. Therefore, considerations should be carefully given to the legend and color scheme of those maps.

As one of five colors, red may be considered instead of orange, which is doubtful in use. Is red useful and effective to represent cities and towns as well as national roads, in addition, how about an idea describing letters of annotations in English by black and in Lao by red?

In fact, the author has ever experimented on represention to distinguish between two kinds of letters in different languages on a map with a manner using two colors, black and red, and succeed with a good result in the case of technical cooperation of the 1:25,000 Topographic Mapping Project in the Kingdom of Morocco.

On the representation of cities and so on by using red color, Rodolfo Núñez de las Cuevas of Spain ever discussed as follows:

"In topographic maps, leaving aside beauty and plastic representation, we use color as a symbol and to make its reading easier. In our National Topo-

graphic Map 1/50,000, black is used to mark the borders, railroads, roads and lettering; red for highways and population centers; blue for hydrography; brown for contour lines and green for vegetation. The symbolic use of red for population centers, red roofs, a strong color, pure and bright, has a great effect on the rest of the colors of the map, above all because on that scale the population centers are not very large and the highways stand out from other colors. Brown, which brings to mind the color of the earth is used for relief; blue, as it is a color that symbolizes water, for hydrography; green for vegetation.

In the military edition of the National Map 1/50,000 black instead of red is used for highways and isolated buildings, and, as a result, the map is more difficult to read.

Very little can be changed in the use of color as a symbol on larger scales. It is possible to debate the use of red or black for highways and urban centers, but it seems to us that red is brighter and psychologically more suitable whereas to avoid using another color is no longer a reason to be considered. The bicolor offset machines that all cartographic centers are equipped with have reduced considerably the cost of printing color maps."

In a case of the 1:25,000 Topographic Map of Morocco above mentioned, red was much used for representation of towns, villages, roads, and the other artifitial facilities. As a result, users who look at the map must be given a remarkable impression by red-colored features which are symbolizing human cultural activities scattered among poor-vegetated vast rocky and barren coastal plain and plateau landscape.

2.3 Drafts of Color Scheme and the Final Decision through Preparing Pilot Sheets

In the planning of color scheme for the 1:25,000 Topographic Map of Laos, it was considered at first that the same five colors as those of the existing topographic map shall be used and in this case orange shall be used for letters of annotations in Lao as one of two languages on the map (Color scheme plan A, Figure 2-(A)). But it was also clear that those annotations by orange are quite illegible for map users.

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[1] Rodolfo Núñez de las Cuevas: Color in Topographic Maps; International Yearbook of Cartography, VII · 1967, pp.43-49.

Then, applying the experience above mentioned, the author proposed the use of red for orange on the map. However, there are many variations among what is called red. In a hue circle of the Munsell's system, ranges from about 5RP to 2YR centering around 5R may be called "red" in a broad sense. And, for instance, red as a basic (pure) color is shown by 5R 4/14, magenta is by 6RP 4/14, and a color of paint prepared from dry powder of loess is by 2.5YR 5/8.5. What is a color of red the most popular for Laotian people ? The answer is easy, the red of the national flag!

The national flag of Laos is three-colored, red, blue and white. It is very interesting thing that the same combination of three colors is used also for national flags of the neighbor countries of Laos, that is, Thailand, Myanmar and Cambodia. It seemed a nice idea to adopt colors of the national flag for the topographic maps since these were basic maps of the country, moreover, perhaps to meet preference for color of people in the country. Then, the author proposed the staffs of NGD to adopt the same red and blue of the national flag of Laos as two colors among five colors for topographic maps and obtained their favor. As to brown and green, a color chart of the Visual Design Institute of Japan was used for selection of their favorite ones, adding black, then five colors were selected in a basic color scheme (Color scheme plan B).

When applying the three attributes of the Munsell's system, hue, value and chroma, to the five colors selected, we get the following results: red - 5R 4/14; brown - 5YR 5/8; green - 10GY 5/10; blue - 10B 5/10; and black - N2. Each hue of these colors is placed on a hue circle as shown in Figure 2-(B), while black is centered on the circle with white of printing paper as both are achromatic colors. Looking at step of each hue on the circle and assuming the circumference of the circle to be 100 and using n for the position of red, then brown is n+10, green is n+35, and blue is n+65 (or n-35), after all these three colors of red, green and blue consist in harmonious relationship upon a theory of color harmony, forming an equilateral triangle close to a regular triangle, and, the brown is in harmony of similar color with red and in harmony of different color with green as well as in harmony of complementary color with blue. In this case, the red which is at the highest grade among others in chroma becomes a principal color in the color scheme.

The author felt, however, uneasy a little. The red and blue of the national

flag of Laos are colors which make very strong impression on eyes as both are at high grades in chroma, namely, vivid or strong colors in tone. Might he fail of holding a balance of those red and blue with other colors when he shall apply them to the topographic map?

A degree of color harmony among various kinds of colors changes according to differences of hue, value and chroma of those colors as well as a proportion of area occupied by each color. In a case of color scheme of multi-colored map, one of the important things to be considered is the proportion of area which each color occupy in the map. If we suppose to compile any sheet of topographic map of Laos conforming to a legend should be applied, and also considering characteristics of the topographic features and land use/land cover of the country, we shall get, in general, such a map in which a large number of area occupied by green with half tone screen to be mainly used for a representation of vegetation covers, following brown for contour lines and black for line features and annotations. Proportion of area occupied by red and blue mainly for point or line symbols is rather small, except some cases which the latter explains such large rivers as the Mekong and its big tributaries or lakes and reservoirs. Therefore, it is necessary to consider such proportion of area occupied by each color and to modulate properly each hue, value and chroma of the color.

There was a discussion by A.H.Robinson on psychological aspects of color in cartography. He analysed characteristics of three attributes of color based on psychological aspects.

It is said that a good harmonious color scheme among several colors could be, in general, obtained such a manner as if a step between two colors in a hue circle is narrow, then grades in value of the two colors should be far apart, and if the step is enough large, the grades might be closed. In the case of the color scheme plan B, steps among each color are generally large so that it is not necessary to give large differences of grades in value, although only the red and brown consist of harmony in similar color relation-

[2] Shoichi Hoshino: Color Harmony and Color Scheme (in Japanese), Maruzen Co. Ltd. 1957.

[3] Arthur H.Robinson: Psychological Aspects of *Color in Cartography*; International Yearbook of Cartography, VII · 1967, pp.50-61.

ship as the step between both colors is relatively narrow.

In order that a color moduration may be effective, such manners as giving a moderate change to tone of color or as reforming a color coordination when areal proportions of each color on a map are widely different, are generally chosen. For instance, the larger area occupied by a color, the lower grade in chroma of the color, and in contrary, the smaller area, the higher grade, or, the larger difference in areal proportions, the less contrast in chroma. Therefore, it is reasonable that the grade in chroma of the red (=14) occupies only small area is higher than both grades of the green (=10) and the brown (=8) in the color scheme plan B. However, the red in this case is 5R 4/14 and a very vivid color so that the author schemed an alternative plan, that is, the red shall be changed with a color closed to magenta (=6RP 4/14) in hue and graded down both in value and chroma, then, starting at this red he selected two kinds of complementary color pairs of red - green and brown - blue, considering that these colors should not be different too much from those colors had been used conventionally in the existing topographic maps.

The five colors selected in this way are as follows: red - 7.5RP 5/12, brown - 7.5YR 5/6, green - 7.5G 6/10, blue - 7.5B 5/8, black - N2 (Color scheme plan C). In a hue circle, if use n for red, brown is n+20, green is n+50, and blue is n+70 (n-30), then, these colors make a biased four color harmony similar to the golden section (Figure 2-(C)). As to chroma, red - 14, green = blue - 10 and brown - 8 in the plan B, but, red -12, green - 10, blue - 8 and brown - 6 in the plan C. These differences between grades in chroma of each color in the plan C from the plan B were decided after consideration on details shall be represented by those colors and on areal proportions shall be occupied by each color on the map.

After discussions with staff of NGD, a plan was decided that three kinds of pilot sheets shall be printed according to the three color scheme plans A, B and C above mentioned respectively, and two topographic maps were selected for printing: (1) a map including a city and its environs, and (2) a map including mountainious area especially karst topography which is dominant in the mapping area. Accordingly, six pilot sheets were printed in Japan as A-(1), A-(2), B-(1), B-(2), C-(1) and C-(2). These sheets were brought to Laos for consultation with the staff of NGD.

At the result of the consultation, B-(1) and B-(2) were selected as the most favorite sheets in color for Laotian people, but, C-(2) was also appraised on its representation of mountanious region. Finally, the plan B was adopted in principal for the final printing of the topographic maps, except brown which shall be closed with the brown in the plan C as follows: red - 5R 4/14, brown - 5YR 5/6, green - 10GY 5/10, blue - 10B 5/10, and black - N2.

In consequence, the red in the plan B is not so much stimulative visually as the authour has been anxious at first, but rather acts on the enhancement of legibility for villages and annotations in Lao scattered on a map surface as it is in high grade in value. It may be quite all right to consider that an impression of the printed topographic map is bright and light in total, and reflects a general preference of Laotian people.

This result reminds the author of a past similar experience in Thailand. On the technical cooperation project for the topographic mapping of the Bangkok Metropolitan Administration, there was also a plan to prepare pilot sheets. The author proposed two kinds of color scheme. At that time, all of colors selected by Thai people were those of in high grades in value and chroma without exception, that is, the same tendency as in the case of Laos was observed. These cases were very interesting matters which reflecting a sort of color preference peculiar to each nation and should be considered on a planning of color scheme for any kind of map.

Furhtermore, control of colors in map printing is a very important issue, especially, reproduction of the same colors as once decided and printed on the pilot sheet is always a big source of trouble in mapping process. In the case of topographic mapping in Laos, from the first stage of preparing pilot sheets the author and his staff tried to identify a brand of printing ink and paper, and to record a proportion of each volume of ink used for colors decided, then expected to reproduce the same colors as those of the final pilot sheet when the final printing shall be carried out.

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Fig.1 Various color coodinations in topographic maps of different countries

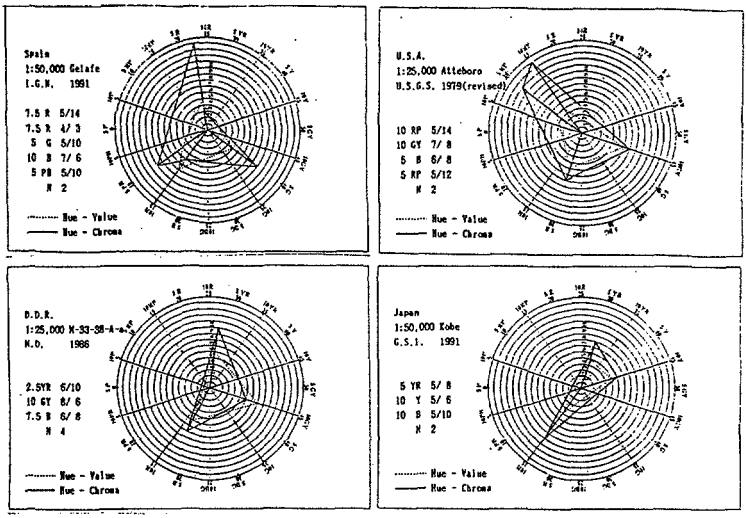

Fig.2 Color schemes for the 1:25,000 topographic map of Laos