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EIGTH INTERNATIONAL CARTOGRAPHIC CONFERENCE
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INVESTIGATION OF THE DEFORMATION IN THE SCHOOL-RELIEF MAPS

Paper submitted
by
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1. Introduction

For more than two hundred years cartography has made use of and perfected various methods of presenting the relief which have met not only the requirements for accuracy but also for plasticity.

It has been found that only the relief maps, as a physical model of the represented territory, give direct information about the relief of the Earth's surface. We have reason enough to assume that the mutual supplementation of two-dimensional and three dimensional (relief) maps creates new possibilities for the development of cartographic methods and research in the field of education.

One of the basic problems in the construction of relief maps is the problem of determining the character and degree of the arising deformations and of elaborating the methods aimed at removing the lack of correspondence between the cartographic content and the relief model.

2. Character of the Deformations in Relief Maps

The school relief maps have their own peculiarities connected with the conditions in which they are used (distance from which they are looked at, angle of observation and character of the lighting) as well as with the age group of students who in the initial course of study have an insufficiently developed spatial vision.

The relief in relief maps has to be represented with maximum expressivness and truth to reality. The requirements for maximum expressiveness call for a considerable enlargement of the relief in representing its third dimension. These specific peculiarities of the relief school maps are connected with considerable linear and area deformations.

We shall stop and discuss the most important factors which exert influence on the deformation, and will also show the results of the investigation on the magnitude of the deformation.

2.1. Factors Influencing the Deformation

The deformation is caused by many factors but of decisive influence are the following:

- the altitude of the represented relief
- the inclination angle and degree of the horizontal and vertical differentiation of the relief
- the amount of the vertical scale
- the thickness of the plastic material and its quality
- the intensity and time of heating the plastic material
- the vacuum pressure, number and distribution of the sucking channels
- the method of vacuum molding

The influence of the first three factors shows that the deformation is the larger, the greater the height of the relief model and the greater the horizontal and vertical differentiation of the represented relief.

Best suited for the production of relief maps for the time being have proved the polyvinylchloride thermoplastic folios.

The heating of the plastic material should not exceed the so-called

"elastic diapason" - 80 to 130 ^{o} C. The temperature regime depends upon the capacity of the heat source, upon the distance between this source and the plastic material, upon the height of the relief matrix and the vaccuum-forming apparatus. The best time for heating can be set at 10 to 15 seconds depending upon the concrete case.

Depending upon the conditions of moulding a pressure of 400 to 600 atmospheres can be accepted as normal.

The selection of the method of vaccuum moulding depends upon the concrete case: if the relief is that of a plain and the valleys are those that have to be properly represented, preferance should be given to the negative method, and if the relief is high-mountainous, or it is required to represent with greater stress the high formations, preference should be given to the positive method.

2.2. Linear Deformations

The investigations carried out are based on positive moulding in the experiments a truncated pyramid has been used with a base of 15/15 cm, height 5 cm and incline of the sides 45^{o} (Fig. 1).

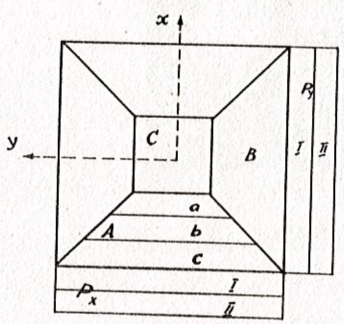

Fig 1

The obtained deformations are shown in Table 1.

Table 1

Sides	A			B			C	P_x		Py	
Zones	a	b	c	a	b	c	-	I	II	I	II
Mean linear deformation of zone in %	11.8	18.0	20.8	14.5	22.2	23.6	0	6.5	3.3	7.3	4.0
Mean linear deformation of side in %	16.8			20.1				5.0		5.7	

2.3. Area Deformations

The investigation of area deformations was made on an experimental model shown in Fig. 2.

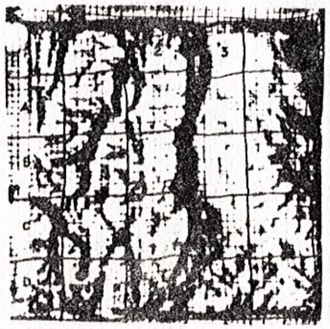

Fig. 2

The model performs a plastic folio on which a millimetre set is printed off. The millimetre set lines are thicken at every 50 mm and they mark out squares with sides a, b, c, d, which have lengths accordingly

$L_a = L_b = L_c = L_d = 50$ mm. The plastic folio has been vaccuum molded on a suitable relief model and the deformed lengths of the sides L'_a, L'_b, L'_c, L'_d arė measured.

The mean area deformations N of the squares have been computed by the formula:

$$N = \frac{m_a + m_c}{2} \cdot \frac{m_b + m_d}{2}$$

where

$$m_a = \frac{L'a}{L_a}$$

$$m_b = \frac{L'b}{L_b}$$

$$m_c = \frac{L'c}{L_c}$$ - ratio between the measured and actual lengths of the sides

$$m_d = \frac{L'd}{L_d}$$

The results obtained are shown in Table 2.

Table 2

№ of the squer		1 a	1 b	1 c	1 d	2 a	2 b	2 c	2 d
A	L	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0
	L'	49,5	51,0	49,5	51,0	51,5	50,5	43,0	51,0
	m	0,99	1,02	0,99	1,02	1,03	1,01	0,86	1,02
	N	1,020				0,959			
B	L	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0
	L'	49,5	51,0	50,0	50,0	43,0	50,5	45,5	51,0
	m	0,99	1,02	1,00	1,00	0,86	1,01	0,91	1,02
	N	1,006				0,868			
C	L	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0
	L'	50,0	51,0	51,0	50,0	45,5	50,0	47,5	51,0
	m	1,00	1,02	1,02	1,00	0,91	1,00	0,95	1,02
	N	1,020				0,939			
D	L	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0
	L'	51,0	49,0	51,0	51,5	47,5	52,0	47,5	49,0
	m	1,02	0,98	1,02	1,03	0,95	1,04	0,95	0,98
	N	1,026				0,960			

№ of the squer		3 a	3 b	3 c	3 d	4 a	4 b	4 c	4 d
A	L	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0
	L'	45,0	49,0	51,5	50,5	51,0	50,5	51,0	49,0
	m	0,90	0,98	1,03	1,01	1,02	1,01	1,02	0,98
	N	0,960				1,015			
B	L	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0
	L'	51,5	50,5	51,0	50,5	51,0	49,5	51,0	50,5
	m	1,03	1,01	1,02	1,01	1,02	0,99	1,02	1,01
	N	1,035				1,020			
C	L	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0
	L'	51,0	51,5	52,0	50,0	51,0	50,0	52,0	51,5
	m	1,02	1,03	1,04	1,00	1,02	1,00	1,04	1,03
	N	1,045				1,045			
D	L	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0
	L'	52,0	49,0	51,0	52,0	52,0	48,5	51,0	49,0
	m	1,04	0,98	1,02	1,04	1,04	0,97	1,02	0,98
	N	1,040				1,004			

The results shown the dependences between the relief complexity and the degree of area deformations. The deformations are the biggest within the squares B-2 and C-2, where the relief has the biggest vertical differentiations. The mean area deformations have their extreme values in squares B-2 (13.2%) and D-4 (0.4%), where they are expected. If we examine the relief model, we will be convinced, that the relief in B-2 has the highest absolute altitude, the largest angle of slope and the biggest relative deference in level, while the relief in D-4 has the weakest expressed horizontal and vertical differentiation.

On Fig. 3 the mean area deformations are referred to the middle of the squares, after which, through interpolation, isolines of the plain area deformations (isoforms) have been drawn. The isoforms give a visual idea of the distribution of area deformations.

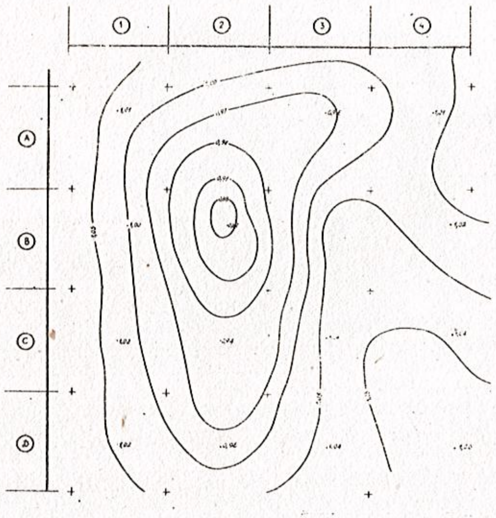

Fig. 3

3. Inferences

- the deformation in the direction of the moulding of the plastic material (the axis X) is greater compared with the transversal deformation (the axis Y).
- the deformation is the greater, the greater the altitude of the relief model
- the deformation is the greater, the greater the horizontal and vertical differentiation of the represented model
- the deformation has a zonal spread. In positive molding the highest zone have a deformation of zero.
- the deformations increase in the direction of the lowering of the relief
- the deformations diminish as they move away from the slope.

4. Conclusion

As a result of the complex character of the deformations in the relief maps it is impossible in advance to prevent their appearance or in advance to determine their magnitude. It is possible, however, to study the character of the deformations and the law-governed regularities in their manifestation with a view to securing a maximum conformity to reality of the cartographic works in the process of constructing and publishing the school relief maps.

A method has been elaborated by us to express the non-coincidence between the cartographic representation and the relief model in a mechanical way. The method is based on the reverse elastic properties of the of the plastic folio and is the subject of a separate treatment.

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