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STUDY OF THE DEFORMATIONS IN THE SYSTEMS OF CARTOGRAPHIC PROJECTIONS BY THE TECHNOLOGY OF THE GEOGRAPHICAL INFORMATIONAL SYSTEMS

BY

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Abstract. One of the fundamental criteria for adopting a countrywide cartographical projection, in order that our country should be represented in large scales, is represented by the deformations' character, both by the recorded values and their regional distribution.

For Romania, at the same time with passing to a new geodesic datum and to creation of a new supporting geodesic network, there are discussions about establishing the official cartographic projection for drawing up the great-scaled maps and plans, in the field of cadastre and generally, of the terrestrial measu-rements. Given the recommendation of the European Commission regarding adoption of the UTM. projection, a comparative study of the relative deformations is presented in comparison with the actual, Stereographic – 1970, which, by the suggestive results offered by GIS. technology, represents a fundamental landmark in choosing the most advantageous solution.

Key words: cartographic, GIS, projections, cadastre.

1. Introduction

Official cartographic projection in Romania is usually known as *Stereographic projection* – 1970, being effectively applied in geodesy since 1973. The features of the projection define it as an azimuthal, perspective, oblique, consonant projection, on a unique secant plane, relying on the geometrical parameters of the *Krasovski* – 1940 reference ellipsoid. Adoption of this projection took into consideration the clear advantages offered from the point of view of the deformations, for the Romania's approximately circular territory, so that there is a compensation of the relative linear deformations inside the circle of the null deformations with the ones outside it. On the secant plane of the stereographic projection – 1970, the *linear deformations* take negative or positive values depending on the position of the considered point towards "*circle of the null deformations for lengths and surfaces*" and is calculated considering the projection's central point. So, inside the null deformation's circle, linear deformation grows in negative value up to –0,25 m/km *into the central point*, and outside the circle, linear deformation grows positively, up to values of +0,65 m/km (Fig. 1). *Areolar deformations* have the same sign with linear ones, being negative inside the secant circle and positive outside it. Values of the areolar deformations vary depending on the distance from the central point of Stereo-70 projection, between –5 mp/ha in the center of the projection and up to +13 mp/ha towards the extremity of the Romania's eastern border.

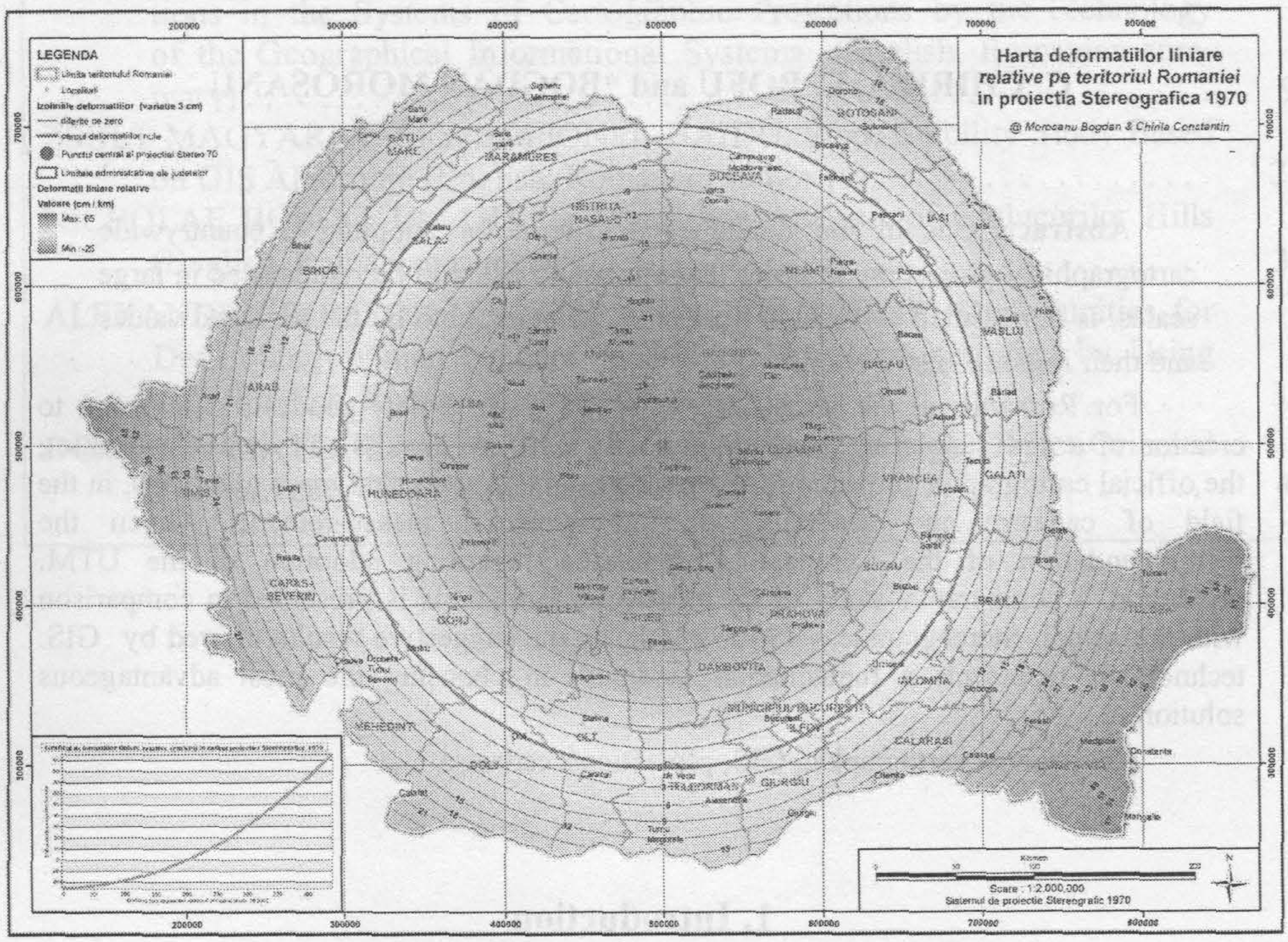

Fig. 1 – Map of the relative linear deformations in the Stereographic – 1970 projection.

The second projection, used also in Romania lately due to accession of our country into the new political and military structures, is UTM projection (Universal Transversal Mercator), a variant of Gauss – Krüger projection which is based on the parameters of WGS–84 international reference ellipsoid.

Romanian territory is mainly included into 34–T, 35–T areas and the part of the northern extremity into 34-U, 35-U areas, with systems of distinct coordinates.

UTM projection is conforming, that is it preserves not distorted the angles, instead, it distorts the distances and, implicitly, the surfaces. The scale of representation on the axial meridian, drawn by a line segment, is not any longer unitary as in Gauss projection, but it has the value of k_0 = 0.9996, expressing the constant ratio between the distances in the plane of UTM projection and Gauss projection. On the *map of the linear deformations* (Fig. 2), two lines of null deformation are to be individuated, symmetric to the axial meridian and approximately parallel to them, at an approximate distance of 180 km. this fact eliminates the necessity of adopting the 3° belt for reducing the deformations in the 6° longitude belt, as it is the case of Gauss projection. The deformations recorded in the 6° longitude belt in UTM projection, are both

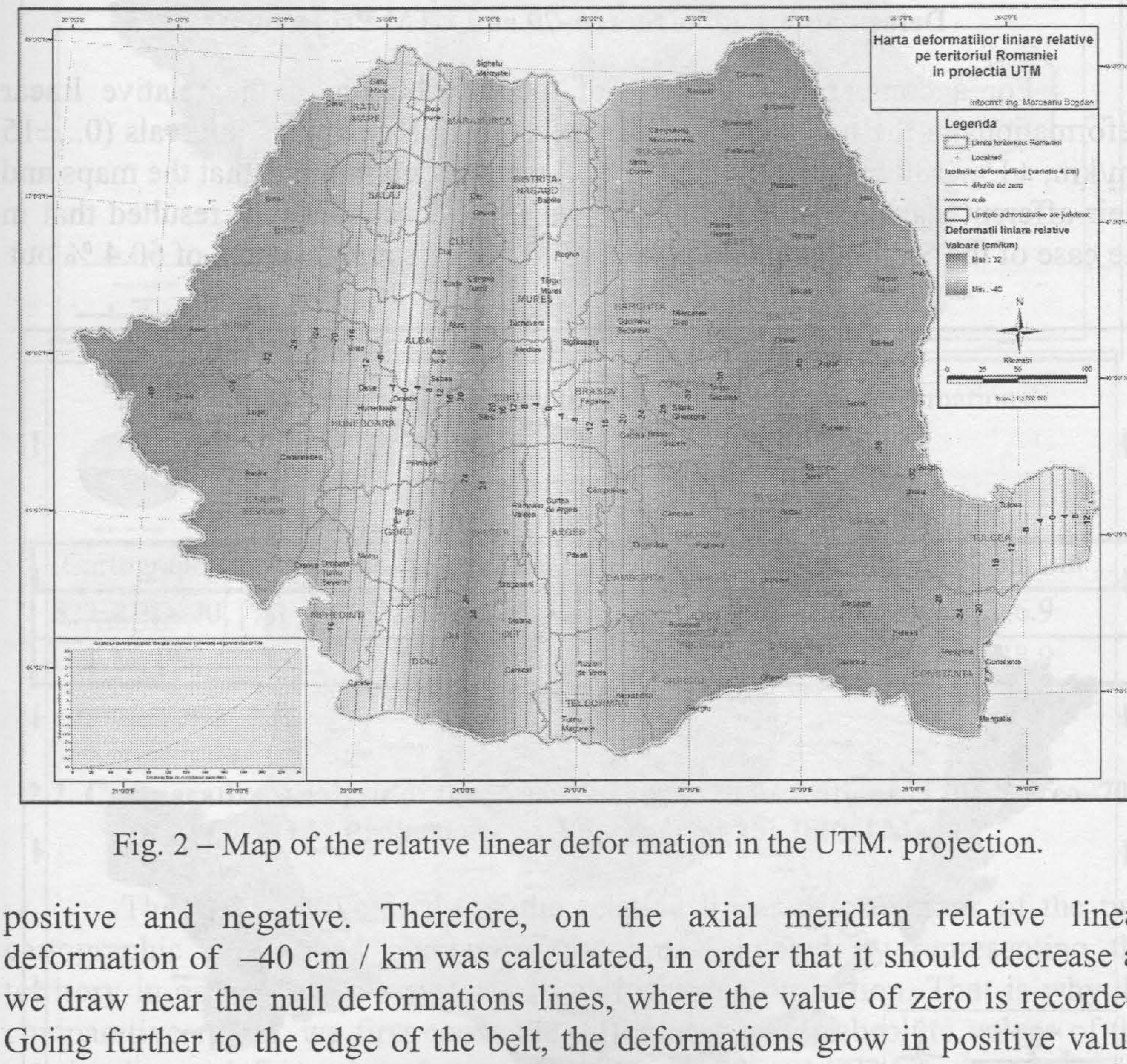

Fig. 2 – Map of the relative linear defor mation in the UTM. projection.

positive and negative. Therefore, on the axial meridian relative linear deformation of –40 cm / km was calculated, in order that it should decrease as we draw near the null deformations lines, where the value of zero is recorded. Going further to the edge of the belt, the deformations grow in positive value, reaching +32 cm/km on the marginal meridian, in the south area. *Areolar deformations* vary in the same sense as the linear ones, having values between –8 mp/ha and +7 mp/ha [1].

2. Comparative Study of the Deformations in the Cartographic Projections, Stereo–70 and UTM, by GIS Technology

In order that the comparative study of the deformations in the two cartographic projections of present interest in Romania, STEREO–70 and UTM, maps of the relative linear deformations were drawn out by means of the technology offered by ArcGIS medium, using color codes reflecting numeric values, calculated on basis of the formulas specific to each projection system (Figs. 1 and 2). Then these maps were used to the comparative analysis of the regional deformations of our entire country's territory and to extracting by reports some real values for certain localities or interest areas [3].

2.1. Statistic Diagrams with Distribution of the Relative Linear Deformations in the Stereo–70 and UTM Projections

For a comparative analysis of the distribution of the relative linear deformations in the two cartographic projections, three values intervals (0...±15 cm/km; ±15...±30 cm/km; ±30 cm/km ...) were set up in order that the maps and their afferent statistic diagrams are drawn up. Consequently, it resulted that in the case of the Stereo–70 projection (Fig. 3), there is a percentage of 60.4 % out

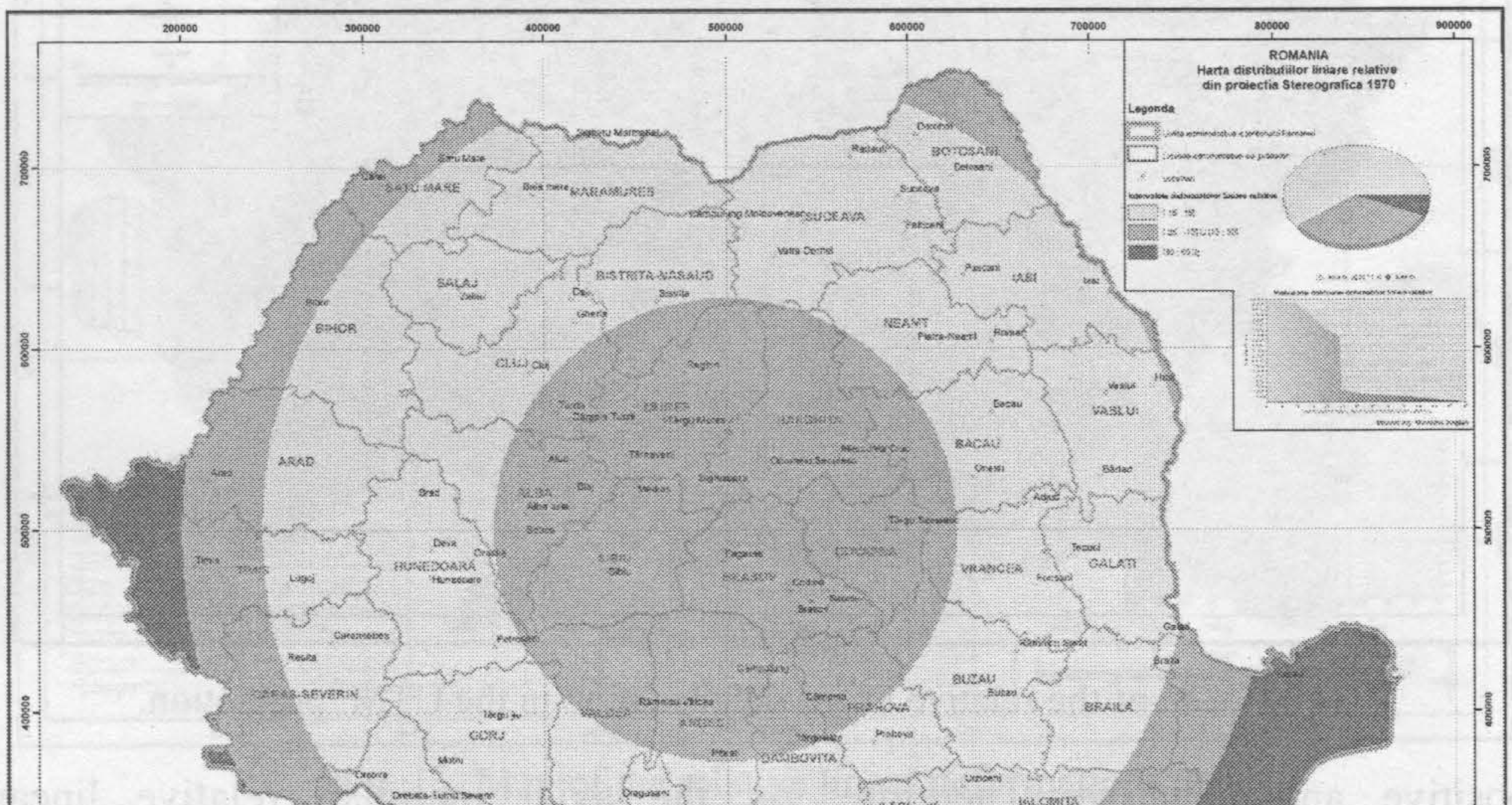

Fig. 3 – Map and statistic diagrams of the relative linear deformations' repartition in the Stereographic – 1970 projection.

of our country's territory where the deformations are in the admissible limit for the geodesic and cadastre works (±15 cm/km), whereas for the UTM. projection (Fig. 4), this percent rises only up to 30.7 % (Table 1).

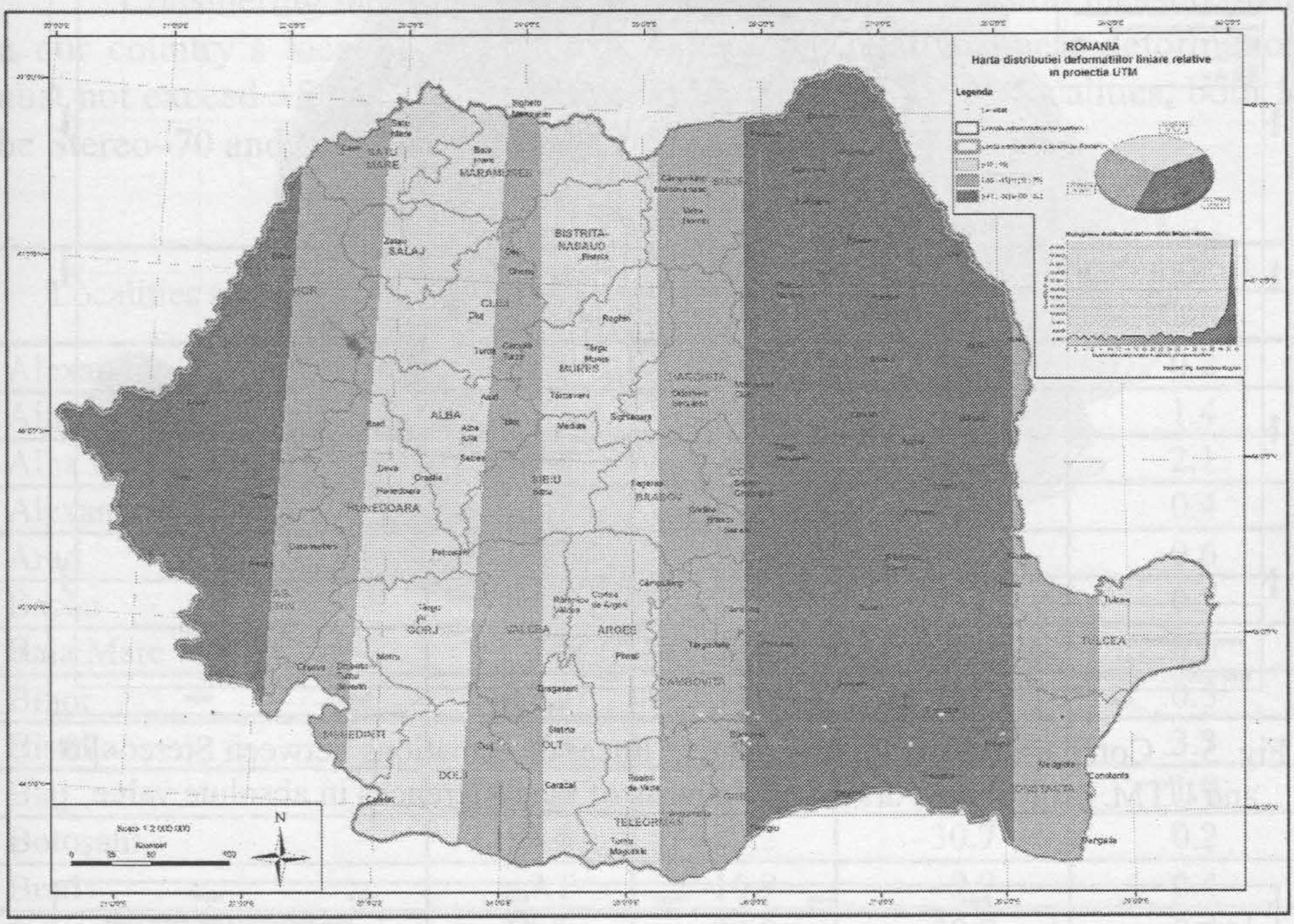

Fig. 4 – Map and statistic diagrams of the relative linear deformations' repartition in the UTM projection.

Table 1

Cartographic projections	0...±15 cm/km	±15...±30 cm/km	±30 cm/km ...
STEREO–70, [%]	60.4	32.7	6.9
U.T.M, [%].	30.7	30.4	38.9

2.2. Comparative Analysis of the Relative Linear Deformations in the Stereo–70 and UTM Projections, by Superposing the Initial Maps

The comparative study of the relative linear deformations of the two cartographic projections points out the areas favored by representing the territory in one of the two systems of cartographic projection. That is why, as comparative etalon, we first chose the differences of the absolute values of the relative linear deformations between the Stereo–70 and UTM projections (Fig. 5) and then, for a more stressed differentiation we chose for the ratio of these deformations' values (Fig. 6).

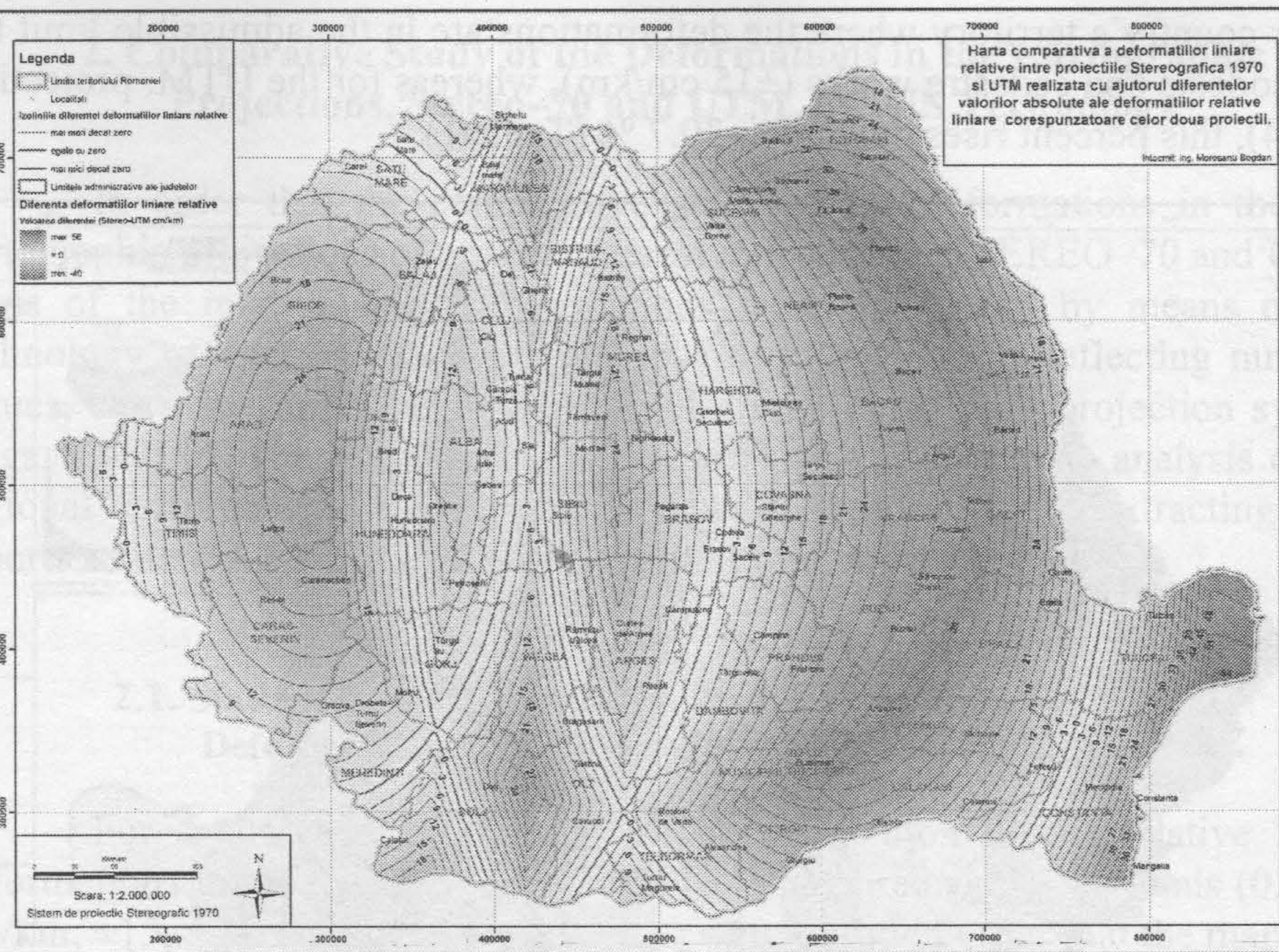

Fig. 5 – Comparative map of the relative linear deformations between Stereo–70 and UTM. projections, drawn up on basis of the differences in absolute value

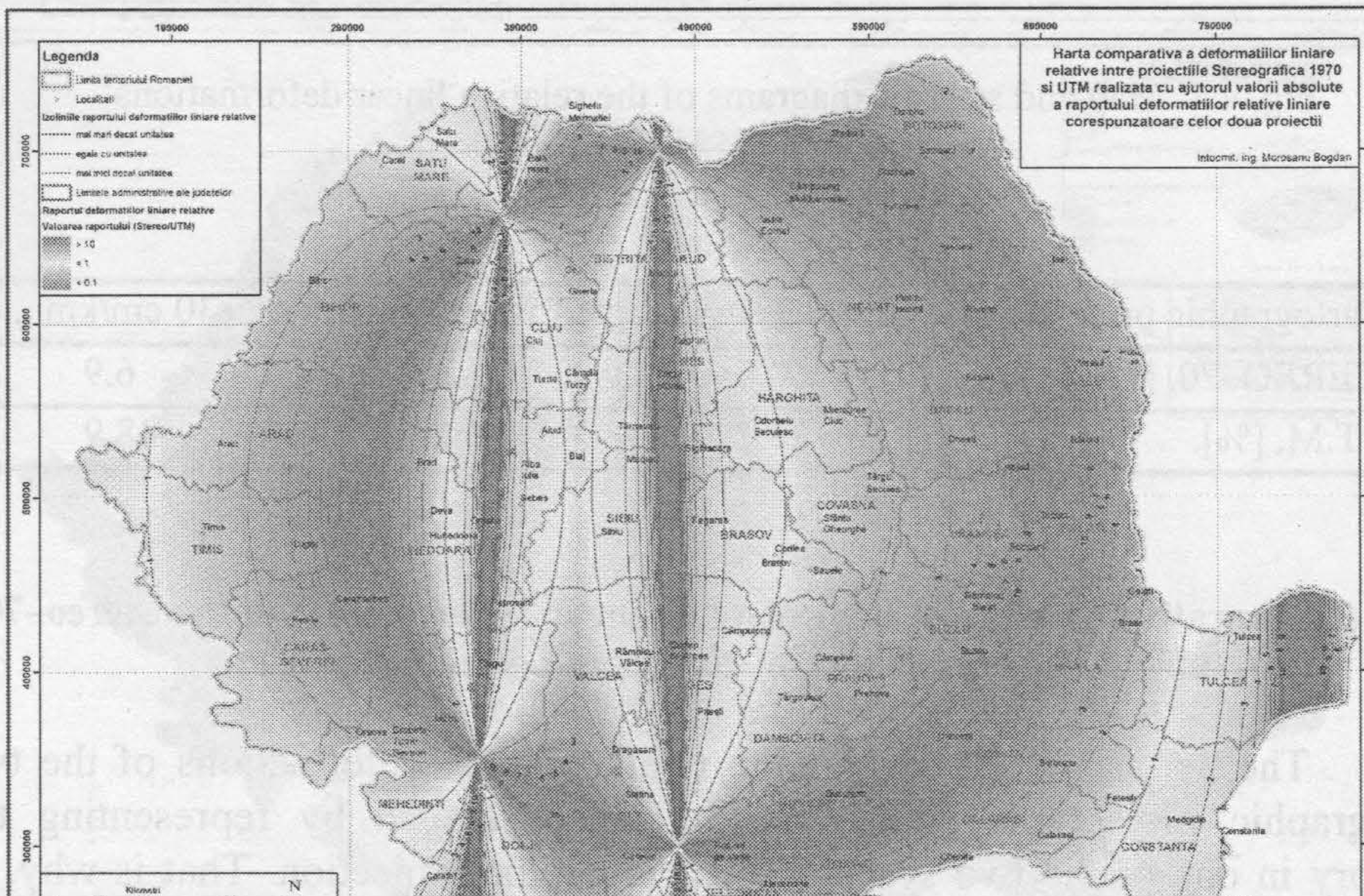

Fig. 6 – Comparative map of the relative linear deformations between Stereo–70 and UTM projections, drawn up on basis of the ratio of absolute value.

2.3. Extracting Reports Containing the Values of the Relative Linear Deformations for the Main Romanian Localities, in the Stereo–70 and UTM Projections

Considering the importance of the topographic–cadastral measurements in our country's localities and towns, where the relative linear deformations must not exceed ±5 cm/km, we extracted their values for 91 localities, both for the Stereo–70 and UTM projections (Table 2).

Table 2

Localities and towns	Values of the relative linear deformation, [cm/km]			
	Stereo–70	UTM	Differences	Ratio
Alexandria	–7.1	-39.8	–32.7	0.2
Aiud	–18.3	13.2	5.1	1.4
Alba Iulia	–17.4	8.2	9.2	2.1
Alexandria	6.3	–17.9	–11.6	0.4
Arad	25.1	-39.4	–14.3	0.6
Bacău	–9.0	-39.9	-31.0	0.2
Baia Mare	3.2	5.3	–2.1	0.6
Bihor	17.2	–34.0	–16.7	0.5
Bistriţa	–14.3	4.4	9.9	3.3
Blaj	–20.6	21.7	–1.1	1.0
Botoşani	8.5	-39.2	–30.7	0.2
Brad	–7.1	–16.9	–9.9	0.4
Brăila	12.2	–32.9	–20.7	0.4
Braşov	-22.8	-25.1	–2.3	0.9
Bucureşti	–1.9	–33.6	–31.8	0.1
Buzău	–7.2	-39.8	–32.5	0.2
Bârlad	1.9	–36.8	–34.9	0.1
Călăraşi	20.3	–39.1	–18.8	0.5
Caracal	3.2	15.8	–12.6	0.2
Caransebeş	6.5	–29.1	–22.7	0.2
Carei	19.9	–25.7	–5.8	0.8
Cluj–Napoca	–13.5	7.2	6.2	1.9
Codlea	–23.6	–22.0	1.6	1.1
Constanţa	50.8	–18.9	31.9	2.7
Curtea de Argeş	–19.2	1.2	18.1	16.7
Câmpia Turzii	–18.2	19.5	–1.2	0.9
Câmpina	–17.4	–27.7	–10.3	0.6
Câmpulung	–21.1	–11.2	9.8	1.9
Câmpulung Moldovenesc	–5.7	–25.4	–19.7	0.2
Dej	–10.4	17.3	–6.9	0.6
Deva	–8.8	–13.8	–5.0	0.6
Dolj	1.7	20.0	–18.3	0.1

Table 2
(Continuations)

Localities and towns	Values of the relative linear deformation, [cm/km]			
	Stereo–70	UTM	Differences	Ratio
Dorohoi	11.7	–37.5	–25.9	0.3
Drăgăşani	–9.5	17.9	–8.3	0.5
Drobeta–Turnu Severin	9.5	–19.2	–9.7	0.5
Făgăraş	–24.8	–9.3	15.5	2.7
Fălticeni	–2.6	–36.5	–34.0	0.1
Feteşti	26.2	–34.5	–8.3	0.8
Focşani	–6.7	–39.8	–33.1	0.2
Galaţi	12.4	–31.7	–19.3	0.4
Gherla	–12.6	18.9	–6.3	0.7
Giurgiu	12.2	–31.5	–19.3	0.4
Hunedoara	–8.5	–13.8	–5.3	0.6
Huşi	12.7	–31.9	–19.3	0.4
Iaşi	9.7	–37.6	–27.9	0.3
Lugoj	11.2	–34.2	–23.0	0.3
Medgidia	38.8	–27.5	11.4	1.4
Mediaş	–23.3	11.1	12.2	2.1
Miercurea–Ciuc	–21.5	–29.6	–8.1	0.7
Motru	1.0	–10.9	–9.9	0.1
Odorheiu–Secuiesc	–23.9	–18.9	4.9	1.3
Olteniţa	13.0	–39.0	–26.0	0.3
Oneşti	–12.9	–39.6	–26.7	0.3
Orăştie	–13.0	–4.5	8.5	2.9
Orşova	12.8	–25.4	–12.6	0.5
Paşcani	–2.2	–39.5	–37.2	0.1
Petroşani	–12.7	1.6	11.0	7.9
Piatra–Neamţ	–11.5	–37.2	–25.7	0.3
Piteşti	–15.4	–5.3	10.0	2.9
Prahova	–12.8	–32.7	–19.9	0.4
Rădăuţi	4.3	–31.9	–27.7	0.1
Reghin	–20.1	–1.9	18.1	10.4
Reşiţa	14.7	–34.2	–19.5	0.4
Roman	–4.8	–40.0	–35.1	0.1
Roşiori de Vede	2.1	–8.1	–0.6	0.3
Râmnicu Sărat	–6.3	–40.0	–33.7	0.2
Râmnicu Vâlcea	–17.6	12.7	5.0	1.4
Săcele	–22.0	–27.5	–5.5	0.8
Satu–Mare	15.2	–16.3	–1.1	0.9
Sebeş	–17.4	8.2	9.2	2.1
Sfântu–Gheorghe	–22.4	–29.1	–6.7	0.8

Table 2
(*Continuations*)

Localities and towns	Values of the relative linear deformation, [cm/km]			
	Stereo–70	UTM	Differences	Ratio
Sibiu	–22.1	20.6	1.5	1.1
Sighetu–Marmaţiei	7.5	16.8	–9.3	0.5
Sighişoara	–24.5	–4.1	20.4	6.0
Slatina	–5.0	14.7	–9.7	0.3
Slobozia	11.9	–39.0	–27.1	0.3
Suceava	1.5	–36.1	–34.7	0.0
Tecuci	–2.9	–38.7	–35.7	0.1
Timiş	27.7	–39.6	–12.0	0.7
Tulcea	34.7	–15.6	19.1	2.2
Turda	–17.2	14.7	2.5	1.2
Turnu–Măgurele	13.2	–3.6	9.5	3.6
Târgovişte	–15.7	–21.7	–6.0	0.7
Târgu–Jiu	–7.0	–1.5	5.5	4.7
Târgu–Mureş	–21.9	3.0	10.0	7.4
Târgu–Secuiesc	–20.0	–34.5	–14.5	0.6
Târnăveni	–22.3	13.7	8.6	1.6
Urziceni	–2.4	–39.0	–36.6	0.1
Vaslui	5.3	–36.1	–30.8	0.2
Vatra–Dornei	–10.5	–21.1	–10.6	0.5
Zalău	–0.7	–10.9	–10.2	01

By comparing the obtained data, we calculated (for the whole localities) a value of 71.4% favorable cases for the Stereo–70 projection in regard to only 28.6% for the UTM projection. On basis of these values of the relative linear deformations in the two presented cartographic projections we were also able to render evident the statistic repartition percents, on the values' intervals of the deformations, adapted to the urban requirements (Table 3).

Table 3

Cartographic projections	0…±5 cm/km	±5…±15 cm/km	±15 cm/km…
Steroe–70, [%]	16.5	42.9	39.6
UTM, [%]	9.9	19.8	70.3

The percentage ratio for the first two values' intervals, with an important significance for the urban cadastre and topological–geodesic measurements, is 62.5% to 37.5% (interval 0...± 5 cm/km), respectively 68.4% to 31.6 % (interval ±5...±15 cm/km), in favor of the official Stereo–70 projection.

3. Conclusions

As a result of the complex analysis with the help of GIS technology and of the deformations appeared in the Stereo–70 and UTM cartographic projections, both on the entire territory of Romania and the main localities of our country, we can conclude that the Stereo–70 projection is superior from the point of view of the deformations' character. Taking also into consideration one of the major disadvantages of the UTM projection, that is representation of our country's territory in different coordinate systems, the idea of the continuity in using the Stereographic – 1970 projection as the official projection for Romania, but redefined on an international geocentric ellipsoid specific to the satellite measurements (WGS–84 or GRS–80) should remain in use.

Although in the military field the applications continue in the UTM projection and, probably, this one will also be valid in other fields of the European interests, operating with these two cartographic projections raise no problems because the fast conversion of the coordinates by the method of the formulas with constant coefficients, determined for the whole Romanian territory is a rapid and efficient means of transferring the geodesic and cartographic information [2].

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STUDIUL DEFORMAŢIILOR ÎN SISTEMELE DE PROIECŢII CARTOGRAFICE, PRIN TEHNOLOGIA SISTEMELOR INFORMAŢIONALE GEOGRAFICE

(Rezumat)

Unul dintre criteriile de bază pentru adoptarea unei proiecţii cartografice la nivel naţional, în scopul reprezentării teritoriului ţării la scări mari, îl constituie caracterul deformaţiilor, atât prin valorile înregistrate, cât şi prin distribuţia lor regională.

În cazul României, odată cu trecerea la un nou datum geodezic şi la crearea unei noi reţele geodezice de sprijin, se pune problema stabilirii proiecţiei cartografice oficiale pentru întocmirea hărţilor şi planurilor la scări mari, în domeniul cadastrului şi a măsurătorilor terestre, în general. Dată fiind recomandarea Comisiei europene privind adoptarea proiecţiei UTM, se prezintă un studiu comparativ al deformaţiilor relative în raport cu proiecţia actuală, Stereografică – 1970, care prin rezultatele sugestive oferite de tehnologia GIS, să constituie un reper de bază în alegerea celei mai avantajoase soluţii