COORDINATE SYSTEMS USED OVRE THE LAST 100 YEARS IN ROMANIA

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Abstract: *The science of mapping has been imposed since ancient times, being generated by the development of other sciences, by military, economic and commercial geo-strategic requirements, and the use of maps and topographical plans can be considered as old as time.*

In our country, starting with the beginning of the twentieth century to the present, the development of reference geodetic systems has directly influenced the scientific issues of cartography.

Thus, as a result of the military artillery of the First World War, our country has switched from equivalent projections to conform projections, after which a need for coordinate transformations from one system to another appeared. This paper aims to present the evolution of the cartographic basis and the reference systems used in Romania for the past 100 years.

Keywords: *topography, expertise, delimitation, plan, georeference.*

1. Introduction

Over the years, mapping the territory of our country has represented a concern starting with Tabula Peutingeriana, which can be seen in Figure 1, and continuing till today's cartographic representations. Thus, this evolution has led to a developmental succession of the geodetic reference systems.

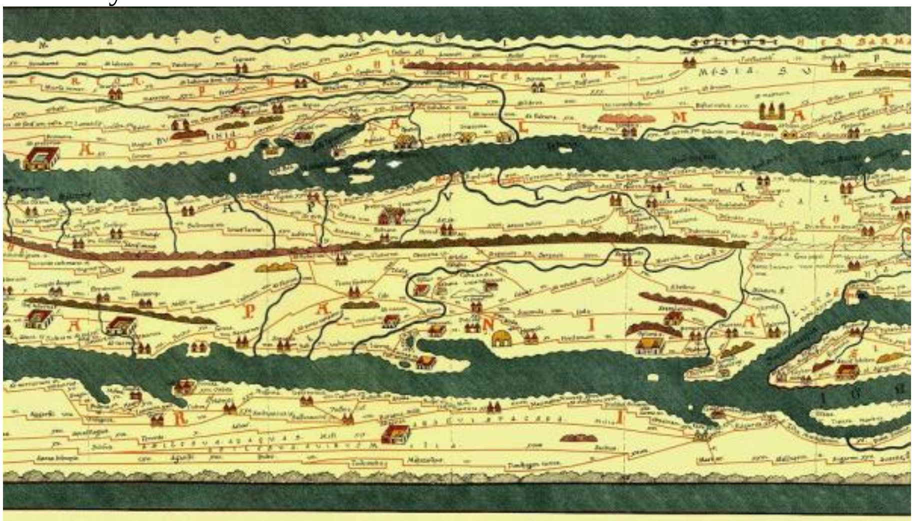

Fig. 1 Extract from the Tabula Peutingeriana.

Today, 100 years after the Great Union of 1918 in Alba Iulia, geodetic reference systems are still evolving, both at a national and at an international level; thus the return to knowledge and the celebration of Romanian centenary is presented in this paper by the exposure of projection systems used on the territory of our country since the realisation of the first cadastral measurements carried out on the territory of our country, before 1918, until now.

2. Projection systems used over the last 100 years in Romania

Our country used a series of projection systems including: the azimuth projection, a stereographic perspective with a tangent plan in Budapest, the azimuth projection - a perspective with a tangent plan in Târgu Mureş, the Bonne equivalent conical projection, the Lambert-Cholesky conical conform projection, the azimuth projection – a stereographic perspective with a secant plan in Braşov, the Gauss-Kruger cross-sectional projection and the stereographic azimuth projection, a 1970 perspective with a secant plan.

2.1 Azimuth projection systems according to a stereographic perspective with tangent plan used on the territory of Romania before 1918, during the old Austro-Hungarian Empire

The first topo-cadastral measurements carried out on the Romanian territory, occupied by the Austro-Hungarian Empire, namely Transylvania, Banat and Bucovina, were started at the order of the Emperor Franz Jozsef I, based on the existent system of measurements and on the Land Registry system.

The Romanian territories occupied by the Austro-Hungarian Empire at that time used a series of cartographic projections to establish a map data base, such as: the Mufling polyhedral projection system (1873) which was used to draw up the Austrian map; the Cassini cylindrical projection system (1876) which is an approximate projection having as reference the Zach-Oriani ellipsoid, with the point of origin in relation to the reference surface (Marek, 1875), the values of the geographical coordinates being given the Ferro Meridian origin; the stereographic projection system with the tangent plan in Târgu Mureş – the Marosvásárhely system; the stereographic projection system with the tangent plan in Budapest (centred on Mount Gellért, Budapest), both systems having the reference ellipsoid Bessel ellipsoid (1841).

The following section presents two of the four projection systems used in the elaboration of a cartography data base, under the occupation of the Austro-Hungarian Empire.

The stereographic projection system with the tangent plan in Târgu Mureş – the Marosvásárhely system was mainly used in Transylvania, a province of the Austro-Hungarian Empire, which had the following characteristics [7]: the centre point is located on the Keste-Keszthehegy Hill west of Târgu Mureş, the type of projection was diagonal stereographical, and used as reference the Bessel ellipsoid (1841), the origin of this ellipsoid having the values of the following geographical coordinates: latitude Φ = 46 ° 33'08 ", 8500 and longitude L = 24 ° 23'34", 9350.

Figure 2 shows a map model made using the stereographic projection system with the tangent plan in Târgu Mureş - the Marosvásárhely system for the Sibiu locality, Sibiu County, Romania.

Fig. 2 Extract from the map realized by using the stereographic projection system with the tangent plan in Târgu Mureş - the Marosvásárhely system, Sibiu, Romania

The stereographic projection system with the tangent plan in Budapest was a system mainly used in the regions: Banat, Crişana and Maramureş, regions occupied by the same Austro-Hungarian Empire, which has the following characteristics [7]: the central point is situated on Mount Gellért, near Budapest, the projection type was stereographic oblique, using the reference ellipsoid Bessel (1841), the point of origin of this ellipsoid having the geographical coordinates: latitude Φ = 47 ° 29 '09,6380" and longitude L = 36 ° 42 '53,57".

Figure 3 shows a map model realized with the help of the stereographic projection system with the tangent plane in Budapest, where one can see the nomenclature, the layout of the map sheet and the scale used.

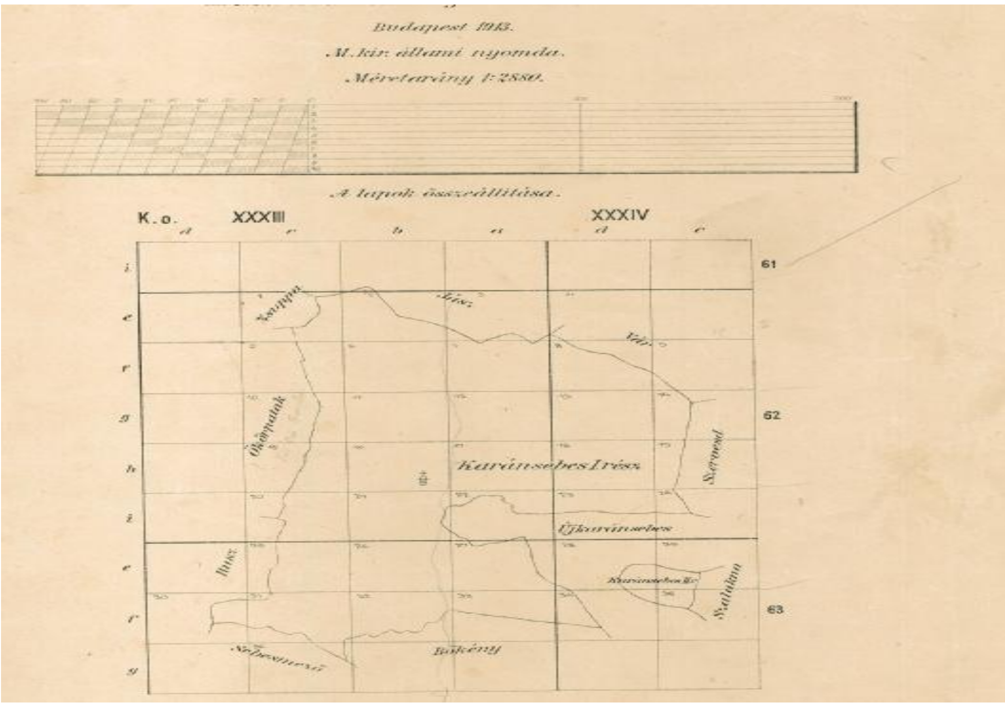

Fig. 3 Extract from the map sheet edited at a 1: 2880 scale from 1913 and realized with the stereographic projection system with the tangent plan in Budapest

2.2. Bonne equivalent pseudo-cone projection system

If for the mapping of the Romanian territory under the rule of the Austro-Hungarian Empire prior to 1918 stereographic projection systems with a tangent plan were used, in the case of the Romanian territory occupied by the regions: Moldova, Muntenia and Oltenia used since 1873 the Bonne pseudo-conical projection was used. This projection has special historical-geodesic significance because it is the first projection applied for the drawing of a topographic map of our country.

In our country, the Bonne pseudo-conical projection was non-uniformly applied, using different reference ellipsoids, different coordinate systems, and so forth [5], as follows:

- for Moldova and Eastern Muntenia up to the Zimnicea meridian [5], the following were used: the Bessel reference ellipsoid (1841), the axis system xOy with the central meridian facing north with the latitude $\Lambda = 25$ ° east of Paris, the representation of the axes system for Moldova and Eastern Muntenia is shown in Figure 4, passing through the proximity of Tecuci and Călăraşi and the tangent axis to the latitude parallel Φ=46° 30', passing through the Roman locality, used as a map sheet frame the geometric model (square shape), which used the sexagesimage gradation and had fieldwork executed for Moldova between (1873-1876, 1884 -1893), and for the Eastern Muntenia up to the Zimnicea meridian, during the period 1893-1902.

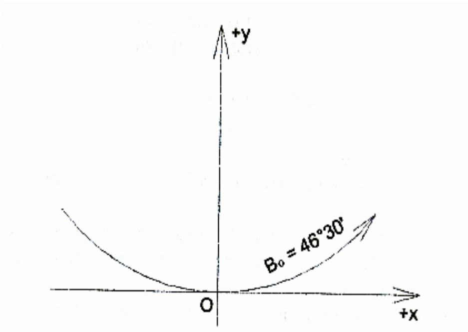

Fig.4. Representation of the axis system for Moldova and eastern Muntenia with L_0 = 25° east of Paris (Tecuci – Călăraşi) [5]

For the western Muntenia of the Zimnicea meridian and Oltenia [5], the reference ellipsoid Clarke 1880 was used, together with the xOy axis system having the meridian of the astronomical observer in Bucharest with the longitude Λ=23° 46' 30" east of Paris, and the axis tangential to the parallel latitude of Φ=45°, the representation of the axis system for West Muntenia and Oltenia is shown in Figure 5, using as a map sheet frame the model of the geographic type (trapezoid curvilinear shape), which used the centesimal gradation and had fieldwork executed during the period 1902 -1 932.

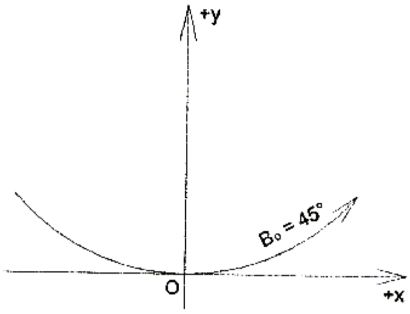

Fig.5. Representation of the axis system for West Muntenia and Oltenia with L_0 =23° 46' 30" east of Paris (Astronomical Observatory Bucharest) [5]

The Bonne pseudo-conical projection is characterized by the fact that all parallels are represented by arcs of conic circles perpendicular to a straight line representing the mean meridian L_0 and the other meridians represented by symmetrical curves relative to the mean meridian L_0. Figure 6 shows the mapping scale of 1: 600,000 in the Bonne equivalent pseudo-conical projection for Romania of 1900. The map was drawn up at the Geographical Institute of the Army in the year 33 of ruling of King Carol I.

Fig. 6 Cartographic representation in Bonne pseudo-conical projection for Romania of 1900

Apart from the primordial property valid for all straight pseudo-conical projections, the Bonne projection fulfilled the following deformation conditions, namely: to be equivalent, linear deformations to be null along any parallel and mid-meridian.

2.3. Lambert-Cholesky modified conic projection system

This projection was applied in our country between the years 1917 and 1930, being a projection adopted for military reasons during the First World War by replacing the Bonne pseudo-conical projection due to non-compliance with its military requirements [5]. This projection includes the following features: uses the Clarke 1880 reference ellipse, the origin of the xOy system has the geographic coordinates: latitude Φ=50° 00’ 00,0000” N and longitude Λ=27° 01’ 38” 843 East Greenwich = L (Râmnicu – Vâlcea), where the Oy axis with a positive north direction and the axis Ox with a positive eastward direction is used to calculations using negative coordinates on the map sheet, and where translations were made on the axis Ox and the axis Oy with the positive value of 500,000, the boundaries of the area represented were: to the south Bs =45°, at the north Bn =55°, at the west - 9° from Râmnicu Vâlcea and for the east side + 5°, from Râmnicu Vâlcea, the representation being confirm on a secant cone at a latitude of con secant Φ=47° and a longitude of Λ=53° , each situated at two degree from the south and the north limits of the projection applicability, L_0 being of 50°, the value of the linear deformation mode, n, on the two extremes, is equal to the inverse value of the linear deformation mode of the mean parallel, latitude B_0=50°, is a projection that uses two constants, and the density with which the mapping network was delimited was of 10 centesimal minutes [5].

Figure 7 shows a directorial military plan made in the Lambert projection for the Timişoara city in our country.

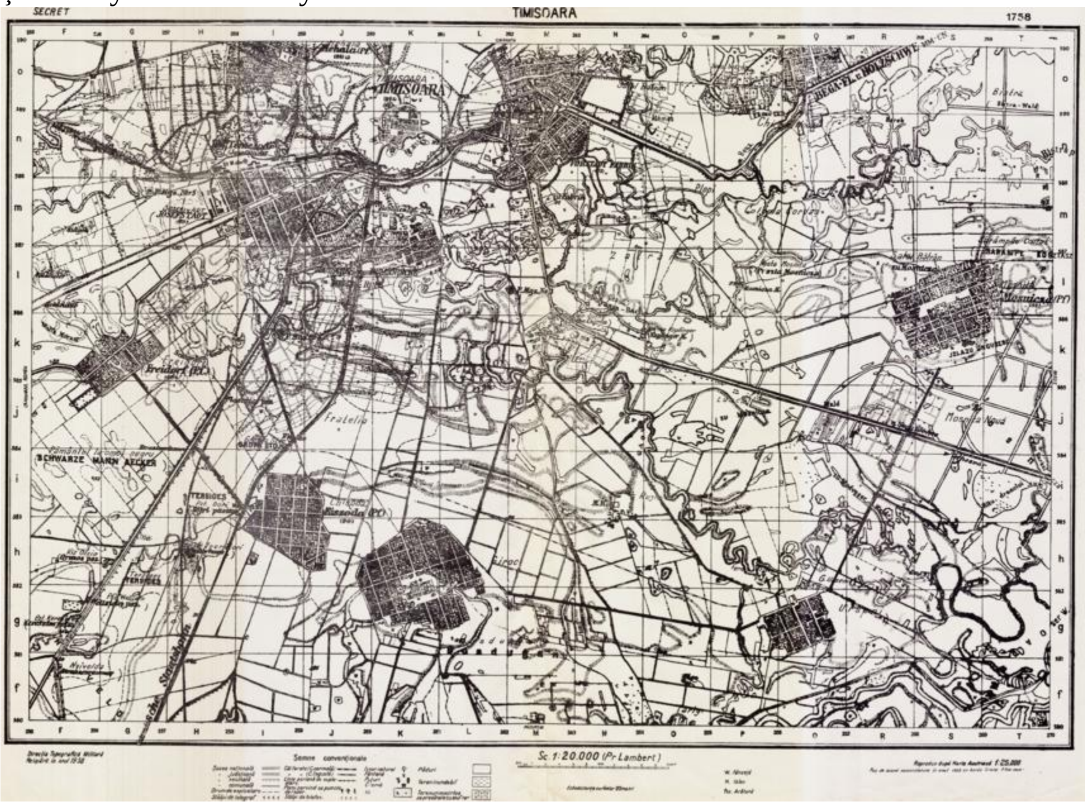

Fig. 7 Military directorial plan made in the Lambert projection for the Timişoara locality in our country

2.4. The stereographic projection system on the single secant plan of Braşov

As a result of conical projections previously presented in this paper, as the official projection was adopted in Romania in 1933, for geodetic and topographic works, the stereographic projection system on the single secant plan of Braşov.

This stereographic projection system marks the beginning of a new era of development in the field of Romanian geodesy at that time, as different projection systems were still used in our country, and the geodetic network requires major development and modernization works.

Through the implementation of this projection system, a single reference system has been adopted, having as reference point a fictional point located about 30 kilometres northwest of Brasov, near Feldioara.

Among the characteristics of the projection system the following are listed: the geographical coordinates of the central point are: latitude Φ=51° 00' 00",0000 north and longitude Λ=28° 21’ 38”, 510 east Greenwich. It uses the Hayford 1910 reference ellipsoid, having as a fundamental point for the orientation of the ellipsoid a concrete pile of the Military Astronomical Observatory in Bucharest, it also uses the coordinates axis system originated in the image of the projection pole, on the Oy axis with the positive northward direction, and on the axis Ox with the positive direction towards the East, the transformation of the geographic coordinates in stereographic coordinates 1930 is done by means of the Roussilhe formulas, and with regard to the deformations in the stereographic projection on the single section of Braşov one can state that this projection distorts the distances and the areas [5].

In Figure 8 the position of the central point can be observed in the stereographic projection at the single secant Braşov section.

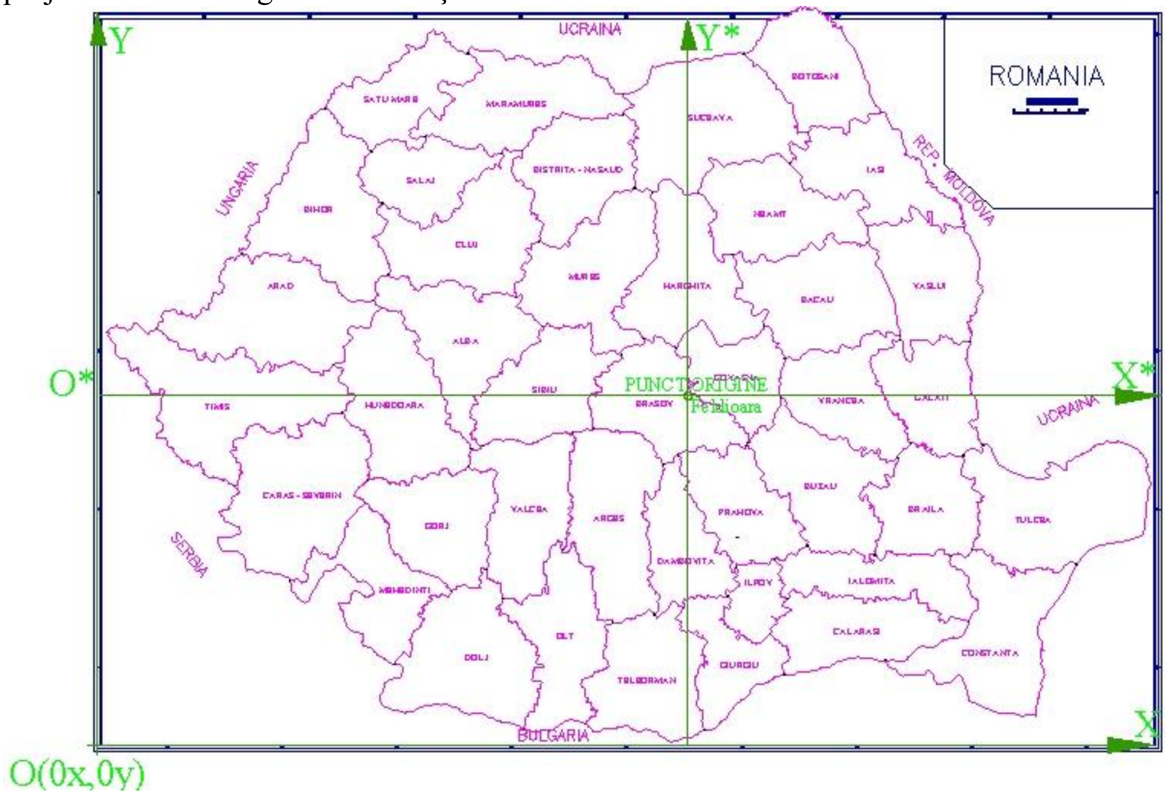

Fig. 8 The position of the central point in the stereographic projection on the single secant section Braşov

2.5. The Gauss-Kruger cylindrical transverse projection system

With the beginning of the year 1951, the Gauss projection system was introduced for the first time in the drawing of maps, the foundations of this projection being situated in time between the years 1825 and 1830 by the mathematician Karl Fr. Gauss, which some theories claim to have been started with Lambert transversal Mercator projection (1772) by altering the ellipsoid.

In our country, this projection was the basis of the creation of important series of topographic maps of Romania, which is sometimes used even today, being considered by some specialists, identical to the Universal Transversal Mercator (UTM) projection.

This projection performs the design of the surface of the Earth ellipsoid directly on the cartographic support, without intermediate passage on the sphere. Figure 7 shows a cartographic material using the Universal Transversal Mercator projection.

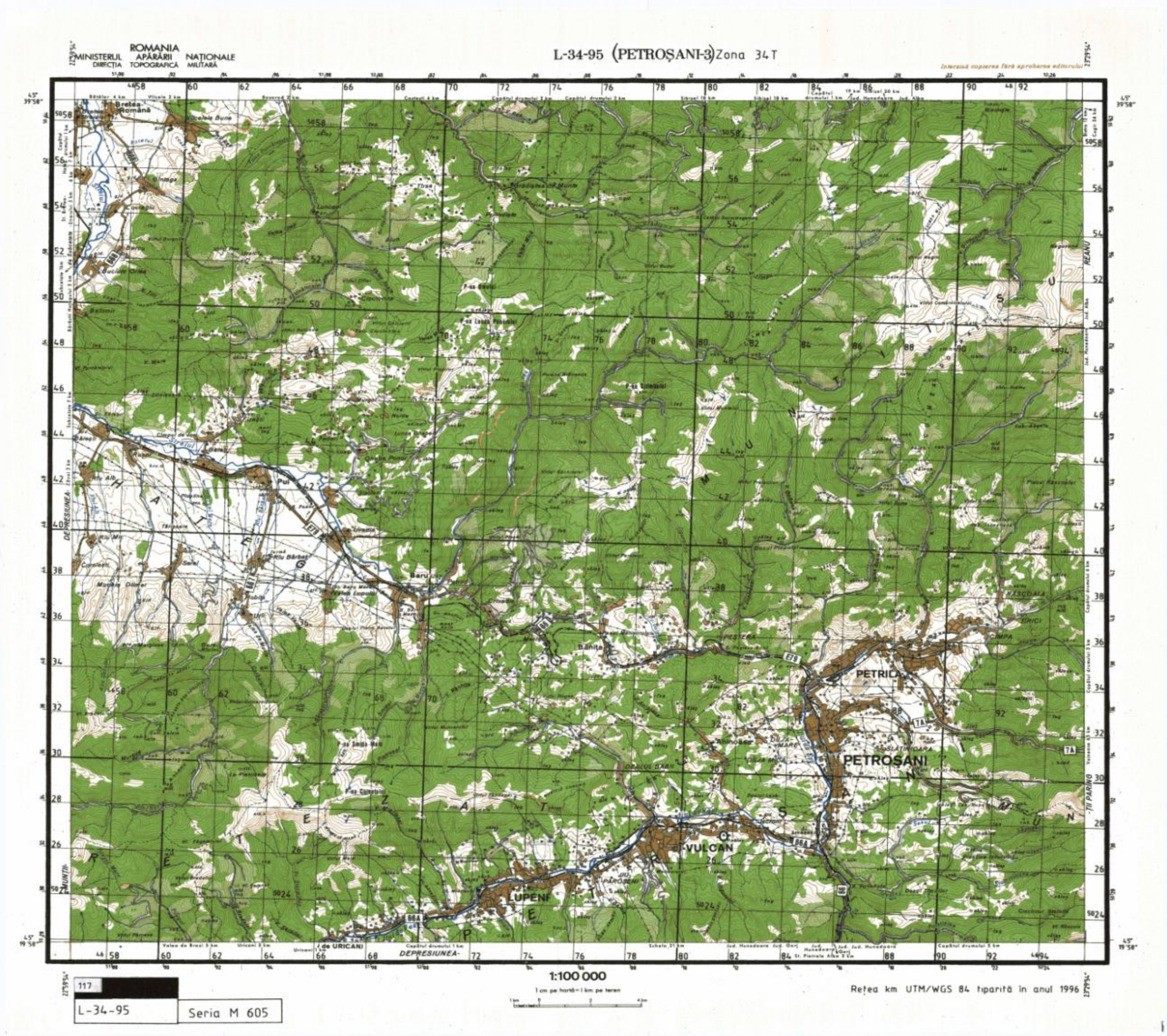

Fig. 7 Map realized with the Universal Transversal Mercator projection.

In this projection, the Earth's surface is divided into 60 spherical 6 ° long spherical axes so as not to exceed the deformation limit of the lengths (1 / 2,500), Romania being covered by axes 34 and 35.

The meridian of a 6 ° axis is represented by a straight line, and the other meridian and parallel are symmetrical curves with respect to the axial and equatorial meridian.

The axes of the rectangular coordinates are Ox that coincide with the projection of the central meridian and Oy that coincide with the projection of the equator.

The rectangular coordinates for each sphere are not the origin of the intersection point of the central meridian with the equator (as normal), but a point located on the equator's axis at 500 km west, so that the abscissa y are positive. Therefore, the origin of the axle system will have the coordinates x = 0 km and y = 500 km (false coordinates).

This projection ensures compliance but deforms surfaces and lengths.

2.6. The 1970 stereographic projection system

In order to reliably respond to practical needs, as a result of the Decree No. 305 of September 1971, the stereographic projection system 1970 was developed. The features of this projection system are: this projection system uses the Krasovski 1940 reference ellipsoid with the geographic coordinates of the point central: latitude Φ=45° 00’ 00”,0000 Nord north and longitude Λ=25° 00’ 00” , 0000 east Greenwich using the Pulkovo-oriented astronomical fundamental point, the coordinate axis system originates in the image of the pointer on the axis Ox with the north-positive direction, and on the axis Oy with the positive eastward direction, it also uses a centesimal angular system and a fictitious coordinate system.

This stereographic projection keeps undisturbed angles, and due to the use of the secant plane, the deformations of the lengths are smaller than with other projection systems.

Figure 8 shows an extract from the cadastral plan performed in the 1970 Stereographic Projection System.

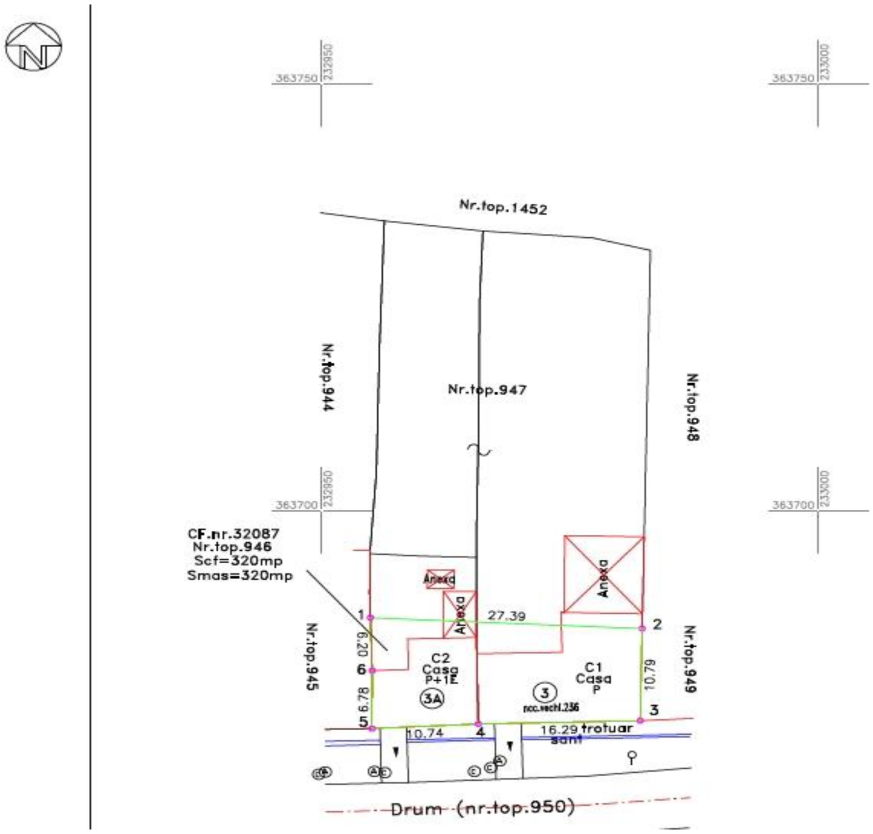

Fig. 8 Extract from the cadastral plan carried out in the 1970 Stereographic Projection System

The 1970 Stereographic Projection is specifically designed for large scale topographic and cadastral maps, being created as an alternative to the Gauss-Kruger projection to overcome the deficiencies generated by it.

3. Conclusions

The coordinate systems used over the past 100 years in Romania have been in constant evolution since ancient times.

The coordinate systems used in our country have different peculiarities, both in terms of their applicability in mapping and topographic plans, as well as corrections and transformations from one system to another.

One could say that the coordinate systems used in the last 100 years in Romania have a centennial history connected to the existing geo-policy, being in continuous development even today.

The cartographic basis made during the last century in our country is of an inestimable value, being used mainly by specialists in the field of measurement sciences and the representation of the terrestrial surface and not only through the transformation from one system to the other, serving its applicability in the various ways being a lingering source of information.

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