]GEOREFERENCING OF TOPOGRAPHICAL MAPS USING THE SOFTWARE ARCGIS

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Abstract: *The digital map must be built by using all the resources available based on a rigorous analysis of their content and the costs involved, having the purpose of reaching the necessary quality under conditions of maximum efficiency. Each data source implies the existence of specialized software which will bring that data in a digital map format, starting with insuring the necessary equipment, going through the technological problems and data conversion and ending with the proper training and preparation of the personal. Before using spatial data in Geographical Information System it is necessary to define spatial reference system that can establish with maximum accuracy the corresponding positions from earth. This can be done through a process called georeferencing process that can identify the ellipsoids and cartographical projections simulating the real space. The georeferencing process implies framing of a plan representation into a reference system called location. For georeferencing a map we need at least two pieces of information: a series of points easily identifiable on the map whose location (latitude and longitude, rectangular coordinates) is precise (here the principle is: "the more, the better") and the projection system where the original map on paper was made. The georeferencing process of the topographical maps based on known coordinates represents the most ordinary process of georeferencing a scanned map. This type of georeferencing process is used when we can accurately find the positions of the points on the surface of the map (usually a topographical map). During the time in Romania there have been used more projection systems, and the one used from 1971 until the present is Stereographical Projection 1970 on unique secant plan based on Krasowsy ellipsoid. Before using the georeferencing process, we must define the Romanian National Projection system into a CAD / GIS software. The parameters of this projection which will be used to input in the used software are: Code: Stereo 70; Description: Stereographical Projection 1970; Coordinate System Type: Geodetic; Datum: Pulkovo 1941 Russia (GIS and former USSR Teriritories); Oblique: Stereographic; Northing: 500000, Easting: 500000; Projection Parameters: Origin latitude: 46d , Origin longitude: 25d; Scale reduction: 0.9998.*

Key words: *Maps, Georeferincing process, Coordinates, Scaning, Transformation*

INTRODUCTION

Georeferencing involves image alignment in a coordinate system. Is the stage at which the image becomes a form of spatial data, since they are characterized by reference to a coordinate system defined by parameters such as projection and point of origin (datum). The first consequence of this is that the scale of the map is variable and you can navigate "over" image to different "heights", controlled by the zoom factor.

MATERIAL AND METHODS

In Romania were used over time many projection systems, that applied in 1971 and so far the level in 1970 stereograph projection secant unique elliptical Krasowski.

In a GIS / CAD may be introduced in 1970 stereograph projection these specific parameters such as follows:

- **Code:** Stereo 70
- **Description:** 1970 Stereo Projection System
- **Coordinate System Type:** Geodetic
- **Datum:** Pulkovo 1941 Russia (GIS and former USSR Territories)
- **Oblique:** Stereographic
- **Northing:** 500000 **Easting:** 500000
- **Projection Parameters Origin latitude:** 46d **Origin longitudine:** 25d
- **Scale reduction:** 0,9998

RESULTS AND DISCUSSIONS

Next, we presented the georeferenced style of a scanned map using the software ArcGIS 9.2.

It is open **ArcGIS, ArcMap** application. In the window dialog will choose ***A new empty map***.

Workspace is empty, in this way can provide data that we need as follows: is press the ***Add Data*** with the form of the sign (+) in the toolbar buttons at the top of the screen (figure 1). Then, from the magnetic support is selected the map which is intended to be georeference.

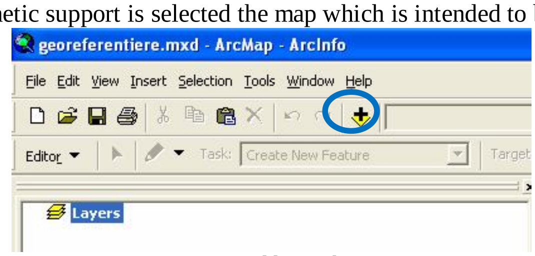

Figure 1. Add Data button

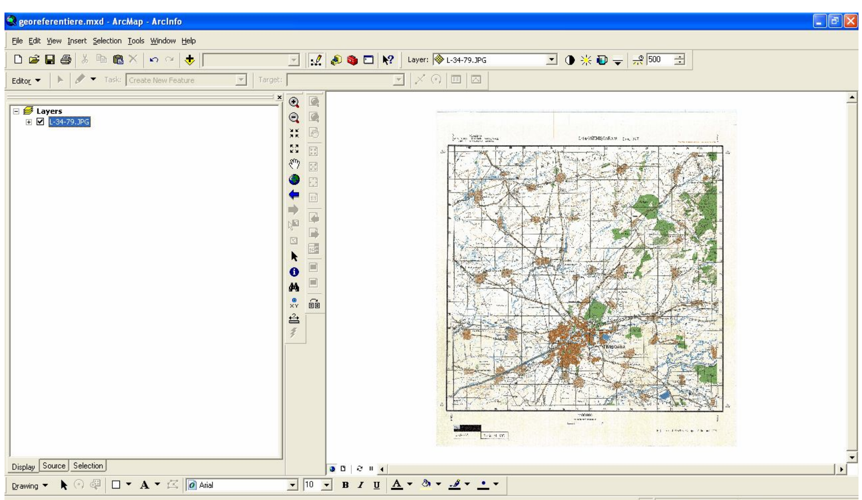

Figure 2. Topographic map L-34-79

A message will warn that the selected image can be displayed, but cannot be designed. It is normal, because we think we just scanned the map (currently for the computer ArcGIS it is just an image) in JPG format.

Clicking OK button, the map will be displayed on the screen (Figure 2).

It is about a topographic map of Romania, 1:100.000 scale, representing sheet (area) Timisoara. The nomenclature of this map is L-34-79.

On this map, we have several indications of the fact that it is not georeferenced. First, if we move the cursor on the area map, especially in the south-west of it, we can read in the right bottom of the screen, coordinates of the cursor tip. In some cases, they have negative values, which are usually avoided in cartography.

Another clue is that, after the coordinate values, follows the text ***Unknown Units*** (units unknown) (Figure 3).

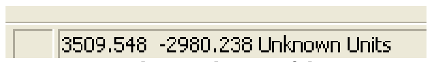

Figure 3. The coordinates of the cursor

To georeference, this map is needed:

1. A series of easily identifiable points, whose position in a coordinate system we know with great precision;

1. Projection system (reference).

These two information are available on the map screen. The second type of information we get it on time easier, using the ***Zoom*** and ***Pan*** to increase the bottom right area of the map where it can be seen a line of text (Figure 4).

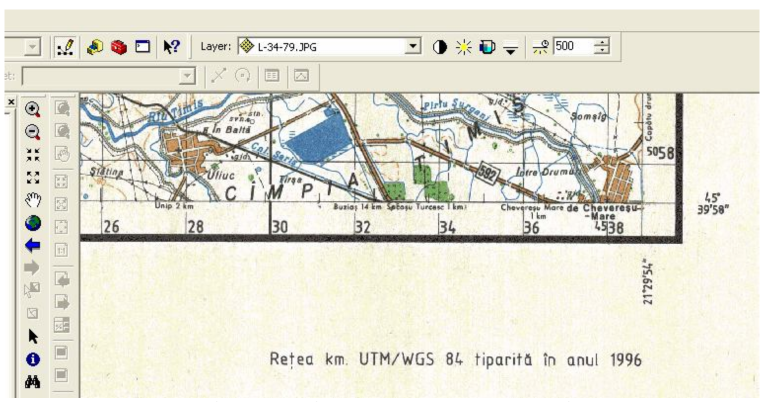

Figure 4. Georeferenced information concerning the reference system

It is noted that **UTM** network (which we will use as a benchmark) is in the UTM system using ellipsoidal WGS84. UTM system consists of several parts (1-60). If we show the whole map and we will ***Zoom*** in the title area at the top of the map, we will find the information ***"Area 34T"*** (Figure 5). We are in the area (strip) 34.

Now it must be identified a series of points of which positions are well known. On the map area, it is noticed a series of vertical and horizontal lines which together form a rectangular grid square. This is the ***kilometric grid square*** of the map. They are not meridian and parallel, but mean the distance in km from an origin point.

The intersections among these lines will be used, as a benchmark for the proposed georeference.

To georeference a map, a plan, we need ***minimum 3 points***, but the rule is: the more, the better, because it can be used a modelling based on a higher degree polynomial.

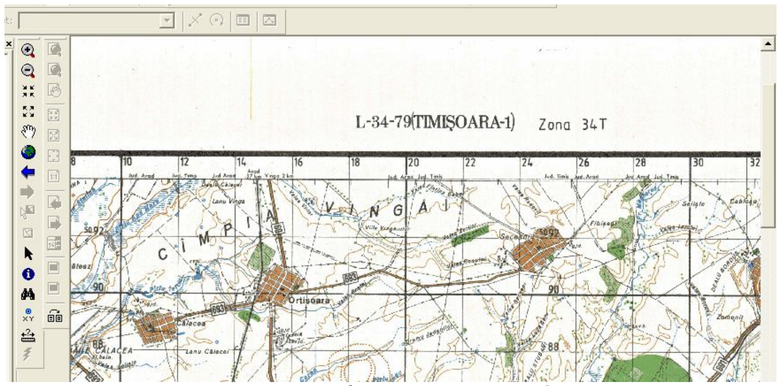

Figure 5. Information concerning location

However, for our example we will use 4 points. They will be chosen as far apart and will avoid that they will be on the same line. Will be chosen points located on the edges (corners) of the map to make sure that most of the map is properly georeferenced.

As a first benchmark we will choose the lower right corner of the square where the text *DL. WHITE EARTH* is included (Figure 6).

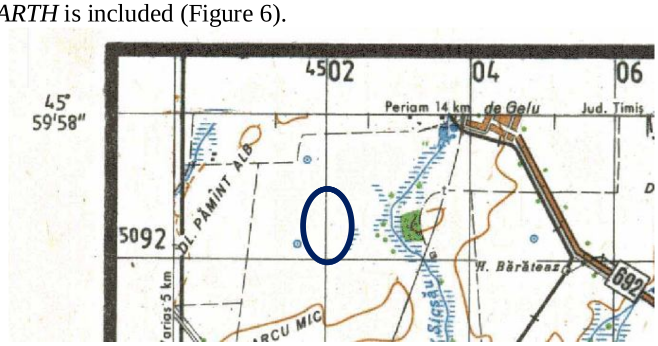

Figure 6. Position of the first landmark

Its coordinates are:

x = 502.000 m

y = 509.2000 m

These are read on the top side respectively on the left.

Follow suit for the 2, 3 and 4 points.

In the following table are given the four landmarks and their coordinates.

Table 1

Landmarks and their coordinates

NO. ITEM	X	Y
1	502.000	509.2000
2	538.000	509.2000
3	538.000	505.8000
4	502.000	505.8000

Next it can be pass at the properly georeference.

Georeferencing will be made on a map with edge removed. The edge may be extinguished in different ways using either software imaging or CAD software. It was exemplified in this application the edge elimination using Adobe Photoshop software.

The map cut out in ArcGis will be then loaded with the button ***Add Data***, the map L-34-79.jpg, which is the borderless version of the previous map (Figure 7).

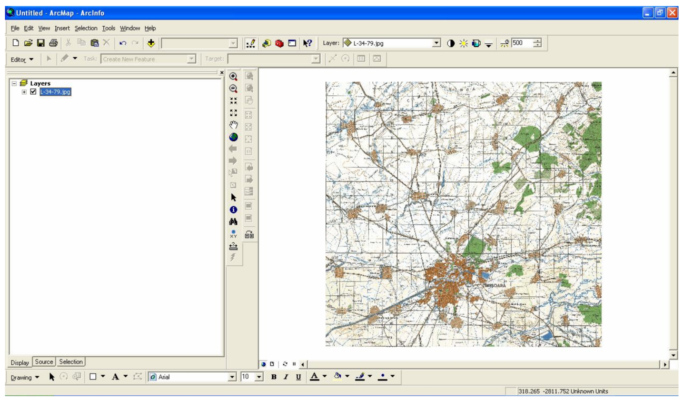

Figure 7. Map L-34-79.jpg

From the View → Toolbars menu, will be check for display ***Georeferencing*** toolbar. It contains a set of functions with which we can georeference the map on the screen (Figure 8).

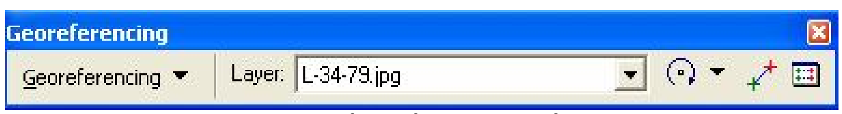

Figure 8. Bar of georeference - Georeferencing

In the following will be identify the points from the corners considered as benchmark.

We amplify the north-west area (upper left) until will be see the square in which is situated DL WHITE EARTH and especially the lower right corner of the square, chosen by us as a landmark.

On the Georeferencing toolbar button is pressed - Add Control Points (penultimate button) (Figure 9). Cursor shape changes in a little cross.

Figure 9. The Add Control Points

Function called by the button is applied as follows: is made a first click right on the landmark (in our case the bottom right corner of the square), then is made a second click in the point with real coordinates (those noted by us). Given, however, that they are very distant from the actual coordinates, we perform the second click at a distance of approx. 3-4 cm from the first point, anywhere on the map and will subsequently associate coordinates. It is therefore a first click on the landmark and a second click at a small distance from the first (Figure 10).

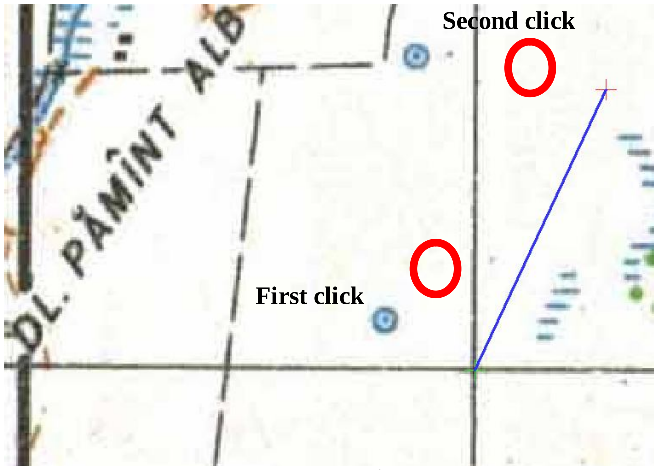

Figure 10. Marking the first landmark

For points, 2, 3 and 4 (Figure 11 - a,b,c) is acting identical. For each will make a click right on the landmark and a second click at some distance from the first. The order in which items were introduced **must be retained**. If the order is changed, or the correspondence between point and coordinates is not stored, the map will be geo-referenced incorrectly, or more, will be distorted.

a ***b*** ***c***

Figure 11. Marking control points 2, 3 and 4

Once points marked, it can pass to introduce the new coordinates. On the ***Georeferencing*** toolbar is press the button ***View Linked Table*** (last button) (Figure 12).

Fig. 12. View Link Table button

Is open a table with connection points (Figure 13).

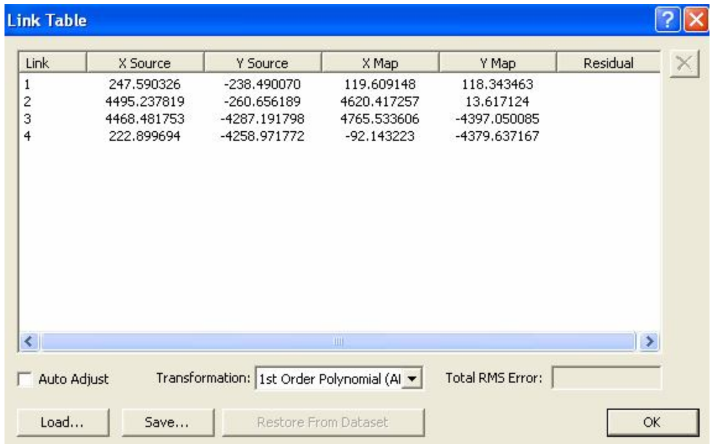

Figure 13. Table with connection points

Table structure is as follows:

- In the first column are numbered points, in the introduced order;
- Columns 2 and 3 gives the coordinates x, y of the first click;
- Columns 4 and 5 represent the location (coordinates) where it should be this landmark in our georeference; currently describes the second click made by us for each point.

It will change for every point columns 4 and 5. It is make click on row 1 and then again click on the value in column 4. Hereby this will thread the X and Y values, noted in Table 1 for all 4 points (Figure 14).

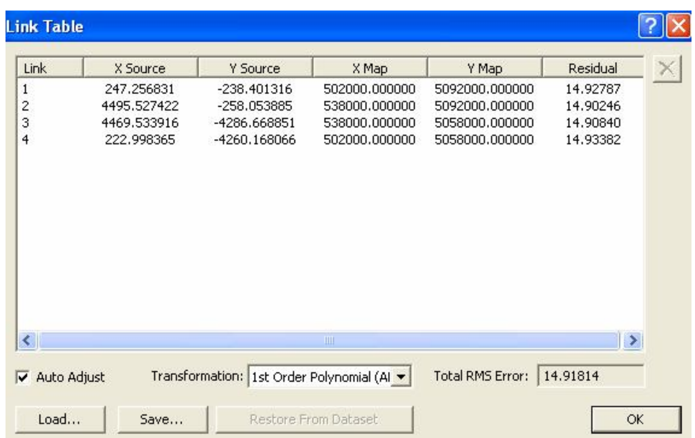

Figure 14. Filling table link

Tick the Auto Adjust from the left corner of the window. The map on the screen will disappear in fact is rotated, enhanced and scaled on the new coordinates.

Full Extent button is pressed (Figure 15) and the map reappears, but when the cursor is moved around the screen, you can read in the bottom-right, the coordinates of the order of which you just entered.

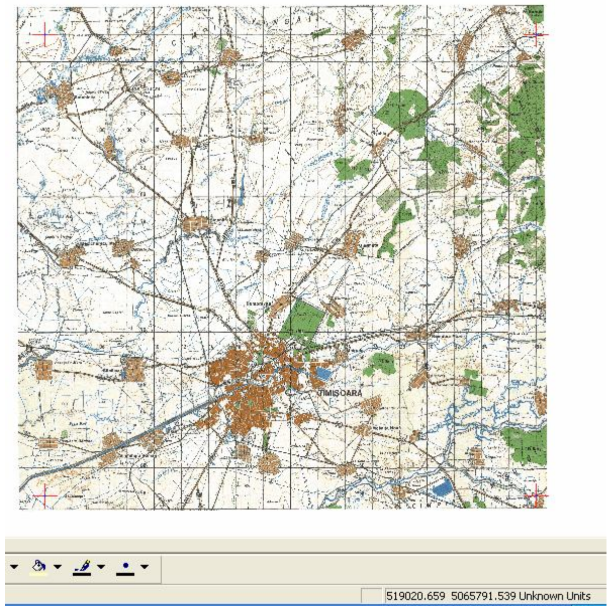

Figure 15. View map with new coordinates

For obtaining a permanent map, it must be corrected. The ***Georeferencing*** button is press and then it is choosing ***Rectify*** function (Figure 16).

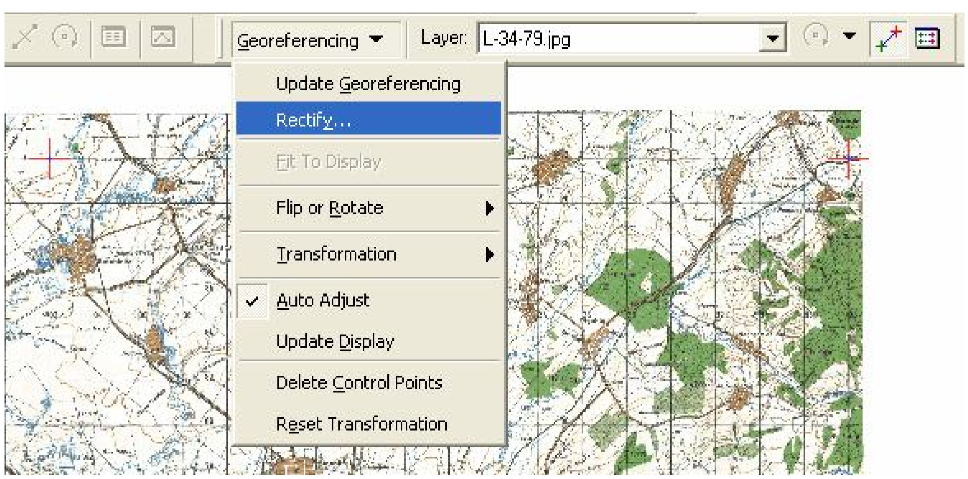

Figure 16. Calling function Rectify

A window will be open stating the size of each pixel (***Cell Size)*** in units introduced, is allow the choice of conversion method (leave the default one) and also allows you to save the new map in our chosen location, and with the name chosen by us. In addition, we can choose its format (TIFF, BMP, JPEG) (Figure 17). The Save button is pressed, and after a few seconds the map is corrected and saved on hard disk in the location specified by us. It is not displayed.

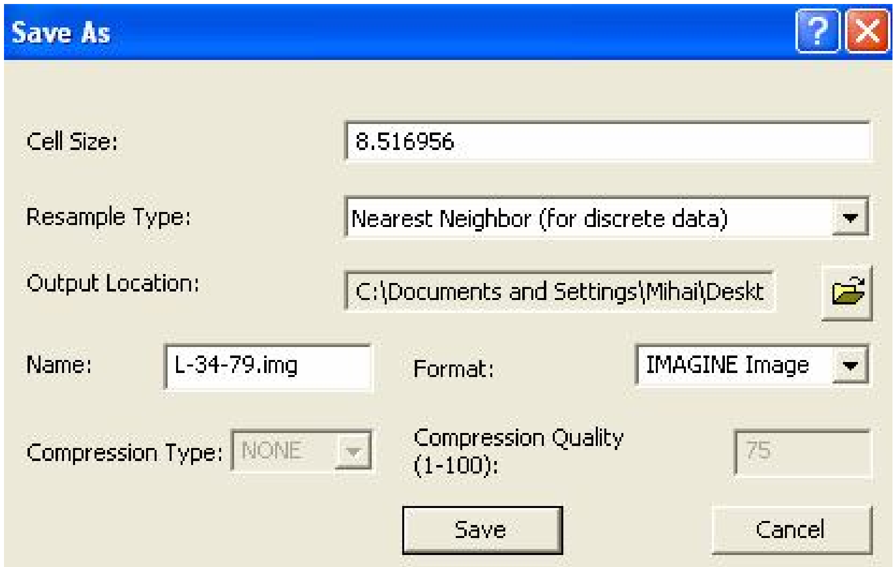

Figure 17. Correction of map L-34-79

At this time, we have the map with the new coordinates. We must associate to it **a coordinate system.**

As noted at the outset, it is **UTM WGS84 Zone 34**. This is done in **ArcCatalog** application.

Then opens the Start / Programs / ArcGIS ArcCatalog application. This application is a file manager, as Windows Explorer but it can handle files of which are made maps. We surf in the place where we saved the new map L-34-79 (Figure 18).

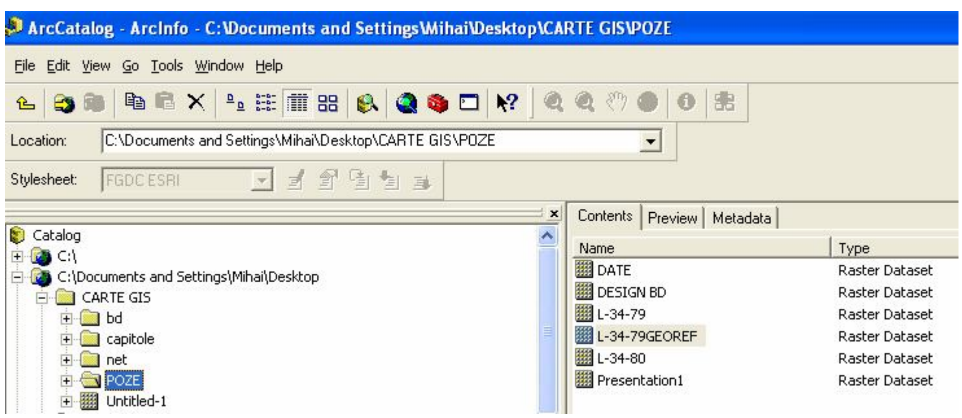

Figure 18. ArcCatalog application and navigating to the map L-34-79

Runs right-click on the new map L-34-79 and is chosen the last option Properties. Now, Properties box is opens (Figure 19).

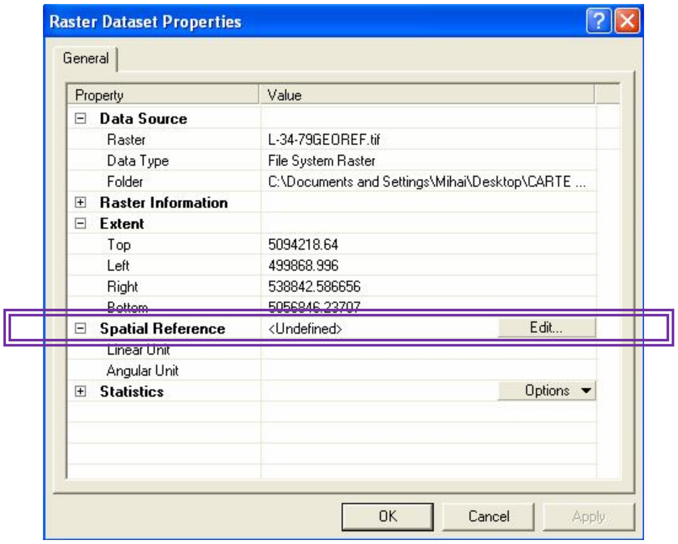

Figure 19. Box Properties

At the middle of the page is found the information about georeferencing, which is currently not defined. Press the **Edit** button...

A box is opens (Figure 20), of where it can be pick and select a reference system if want, it can be import one from a map previously created, or it may be create a new one.

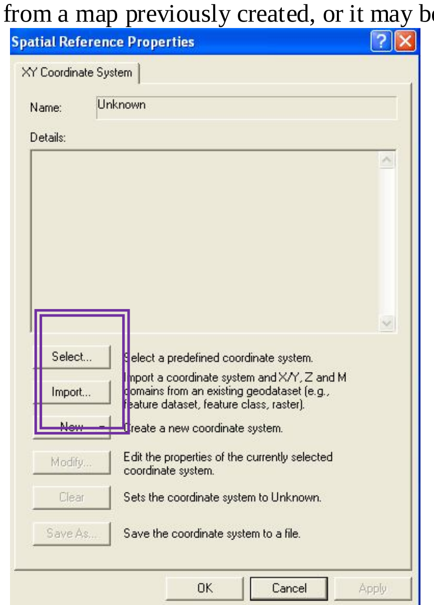

Figure 20. Space Reference Properties box

In this case, will be **selected** a coordinate system. This will open a navigation and selection box. At this point, we choose a **Projected Coordinate System** (Figure 21).

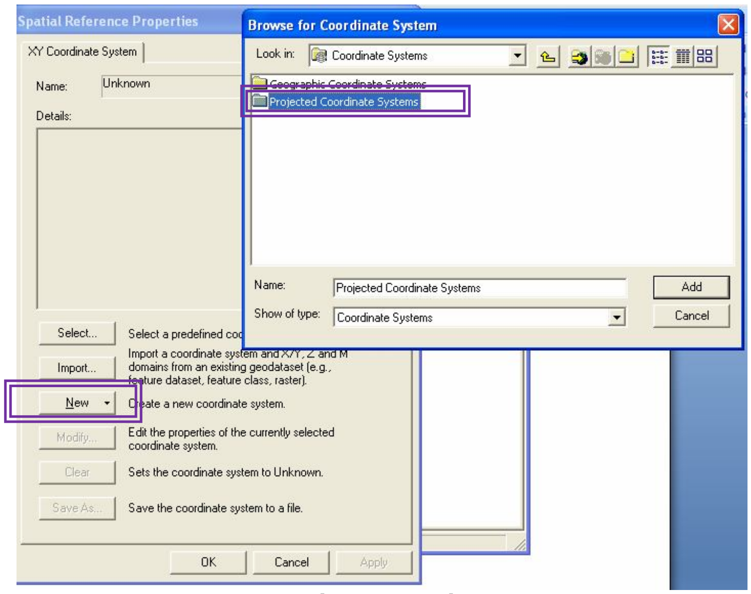

Figure 21. Selecting a coordinate system

Then we will follow the path UTM →WGS84 → ***WGS 1984 UTM Zone 34N.prj*** (Figure 22).

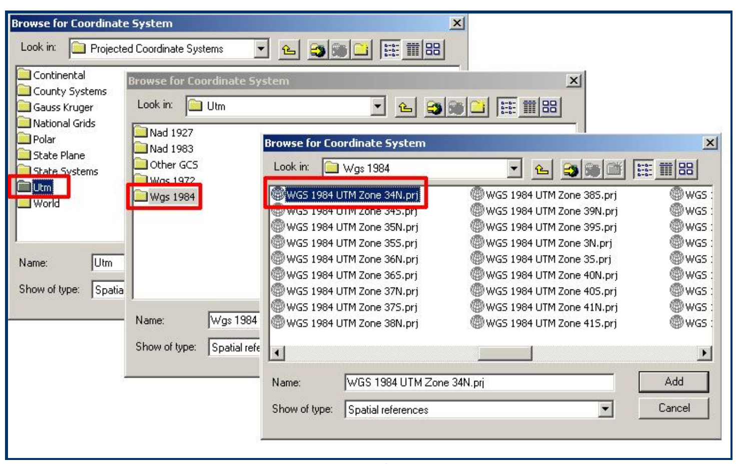

Figure 22. Selection of coordinate system

Press the **Add** button. **OK** will then validate the two open boxes. Then close **ArcCatalog.**

In this moment, we have the map L-34-79 geo-referenced.

ArcMap opens and with the **Add Data** button and we bring the geo-referenced map on the desktop. It may be noted that no warning message appears on the reference system. In addition, in the bottom right corner, coordinate values are followed by the **Meters** text (Figure 23).

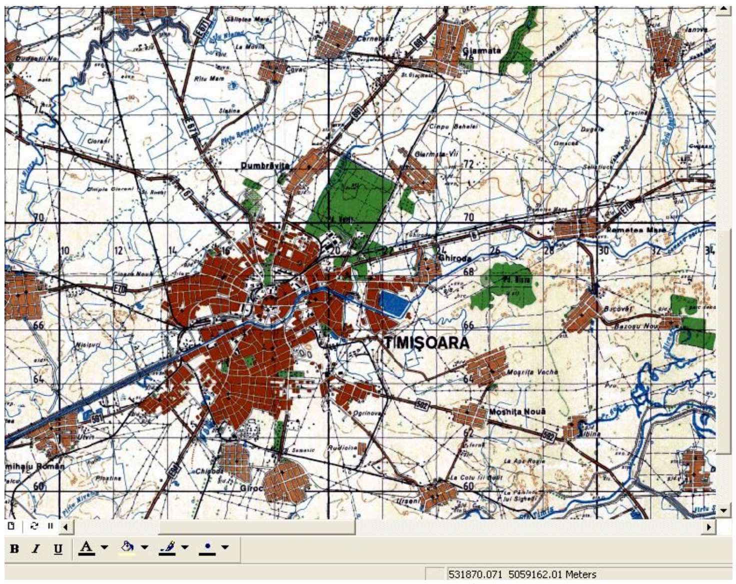

Figure 23. Map L-34-79 georeferenced

CONCLUSIONS

Although there are currently many methods of acquiring field data, existing analog cartographic material is the main source of data needed for a Geographic Information System. This material, which exists in analog format, must be brought to a digital format to can be interpreted and analyzed using computer and specialized software. A georeferenced process immediately follows the scanning process of this analog material. By georeferencing, to the digital map are associated the real coordinates (geographic or rectangular); the new coordinates must be associated with a particular cartographic projection. This process is particularly important because an inaccurate georeferencing will generate errors throughout the project. As a result, the process of georeferencing must be treated with special attention so that, the data brought from analogue to digital format to provide high accuracy to can be used in the best conditions.

BIBLIOGRAPHY

1. DIMA, N., HERBEI, O., et. al. - “General topography and elements of mining topography”, Universitas Publishing, Petrosani, 2005
2. DAVIS, D., - „GIS for Everyone”, ESRI, 1999
3. HERBEI, M., - “Performing a geographic information system into the areas affected by the mining exploitations by using modern techniques and technologies” - Doctorate thesis, Petrosani, 2009
4. MITCHELL, A., - “The ESRI Guide to GIS Analysis”, ESRI Press