# TOPOGRAPHIC STUDY FOR THE INVENTORY AND MANAGEMENT OF MINERAL AGRREGATES DEPOSITS LOCATED ALONG THE TIMIS AND MURES RIVER

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***Abstract:*** *The topographic elevations for this paper were performed along the Timis and Mures Rivers, including the following locations: Timisoara, Covaci, Lugoj, (Timis County), Milova, Arad (Arad County), Caransebes-Jupa (Caras-Severin County). Leica GPS 1200 is a very powerful device with many applications and functions that can satisfy the requirements of users worldwide. GPS1200 can be used either as reference or rover for static or kinematic measurements (RTK); it can be used for topographic elevations, tracing, monitoring, earthquake measurements. GPS1200 receivers are designed to operate under the roughest conditions. They are waterproof up to 1 m water depth, shock, vibration, rain, dust, sand and snowproof, able to operate at temperatures between -40°C and +65°C. Topographic measurements were performed to determine the volumetric quantity of different sorts of ballast mineral aggregates: sand 0-4, gravel 4-8, gravel 8-16, gravel 16-31, sieve oversize. Topographic and land survey measurements were taken with Leica GPS1200, and the data were downloaded and processed with LEICA Geo Office Combined. The data necessary for creating the 3D model of the quantities of the ballast mineral aggregates and the volumetric calculation were processed with Surfer 8.0 software created by Golden Software. The measurements were taken with ROMPOS – the Romanian Position Determination System, a project of the National Agency for Cadastre and Land Registration. This system provides precise reference positioning and ETRS European coordinates through the Network of National Permanent GNSS Stations. ROMPOS is based on Global Navigation Satellite Systems – GNSS (GPS/GLONAS/GALILEO - in the future), providing data for positioning purposes. The system allows for an improved determination of a position with millimetre accuracy. The GNSS permanent stations used for the purpose of this paper are in Timisoara, Faget, Arad and Resita.*

***Key words*****:** *topographic elevations, mineral exploitation, global system positioning (GPS), surfer*

## INTRODUCTION

The emergence of modern total stations is a great step ahead in terrestrial measurements owing to increased precision, work speed and efficiency. The apparition of the GPS technology has been a great step in the same direction. Most likely this is the last stage in the field, as what will follow will be only a reduction in price and receiver dimensions correlated with an increase in autonomy and accuracy. However, as far as the operating principle is concerned, my personal opinion is that no other radically different system will be developed.

The use of GPS equipment has the advantage that it does not require angular and distance measurements and the inconvenience of using total stations is also eliminated. At the same time, it is worth mentioning that with the Stop&Go method (or Real Time Kinematic) it is possible to determine coordinates with an accuracy that is comparable to that of the total stations and in a suitable period of time. One must also take into consideration the necessity to align Romania to the European and international standards by developing a GPS reference geodetic network of high-precision, whose points should be determined and included in the EUREF European GPS geodetic network.

Starting with 2009, the National Network of Permanent GNSS Stations (NN-PGS) has 73 permanent stations. The first permanent GNSS station (BUCU) was installed at the Faculty of Geodesy, Technical University of Civil Engineering Bucharest in 1999, with the help of the Federal Agency for Cartography and Geodesy of Germany (BKG). A rapid development of NN-PGS started in 2004 with the modernisation of the already existing stations and the installation of new ones. The years 2005 – 2008 saw the modernisation of NN-PGS through the acquisition and installation by NACLR (National Agency for Cadastre and Land Registration) of state-of-the-art equipment and software. Starting with 2006, besides the European class (EUREF) permanent GPS station BUCU, which became a permanent station within the IGS (International GNSS Service) network, Romania has been part of the European Reference Frame – European Permanent Network, after the integration of four more permanent GNSS stations: BACA (in Bacau), BAIA (in Baia Mare), COST (in Constanta) and DEVA (in Deva). In June 2008, 48 permanent GNSS stations were installed. In December the same year, their number reached 58, and by 2009, it reached 73. The average distance between the permanent GNSS stations is about 70 km.

## MATERIAL AND METHODS

The topographic elevations for this paper were performed with Leica GPS 1200, a very powerful device with many applications and functions that can satisfy the requirements of users worldwide.

GPS1200 can be used either as reference or rover for static or kinematic measurements (RTK); it can be used for topographic elevations, tracing, monitoring, and earthquake measurements. GPS1200 receivers are designed to operate under the roughest weather conditions. They are waterproof up to 1 m water depth, shock, vibration, rain, dust, sand and snowproof, able to operate at temperatures between -40°C and +65°C.

For the purposes of the present paper, the Stop&Go method (or Real Time Kinematic) was applied in the following reference stations: for Timisoara –TIM1_2.3 reference station; for Covaci – TIM1_2.3 reference station; for Lugoj – FAGE_2.3 reference station; for Milova – FAGE_2.3 reference station; for Arad –ARAD_2.3 reference station; for Caransebes - Jupa – RESI_2.3 reference station.

The measurement engine of Leica GPS1200 is a SmartTrack type that acquires satellites within seconds; it is ideal for construction areas where other receivers cannot find a proper position.

The aerial used for this paper is of dual frequency GX1230 type, SmartTrack being designed to support GLONASS, GPS L15 signals, as well as the signals of the future European GPS network GALILEO. Leica GPS1200 uses QWERTY keyboard, with touch screen or non-touchscreen, as requested. The elevation can be viewed directly in the field as well as from the office. ZOOM and PAN functions are also available.

The collected data can be exported directly by the GPS1200 receiver, but for the present paper they were downloaded with the ***Leica Geo Office Combined*** programme.

The GPS reference system is **WGS 84** (World Geodetic System 1984) that, like the ITRF system, is defined by the coordinates of the determined terrestrial points.

The wider and wider use of satellite positioning systems and satellite global mapping systems for geodetic operations may cause serious practical difficulties if the results of these spatial techniques must be related to older maps or digital data. The main difficulty lies in changing data from geocentric datums to local datums that describe older data or viceversa.

The ***TransDatRO 4.01*** software application is a transformation procedure similar to other international procedures. It embeds a spatial data distortion model in order to maintain spatial data integrity and topology in each datum. As a result, points with larger distortions are not eliminated. On the contrary, they are tested and included in the transformation, in order to describe as realistically as possible the characteristics of each area containing new points awaiting transformation.

The transformation process takes place in two stages:

1) Helmert transformation and the determination of distortions in common points;

2) Interpolation of distortions in new points awaiting transformation.

Having processed the data and changed the coordinates from ETRS89 to STEREO70 with the ***TransDatRO 4.01*** application, the volumes were calculated based on the 1970 stereographic coordinates obtained with SURFER 8.0. ***Surfer*** is a very complex product of *Golden Software,* a company that specialises in computer graphics. It is very effective in making digital maps.

The spatial terrain model is based on the points with the X, Z, Y coordinates registered in ASCII-type files with *.DAT* extension. Based on these coordinate points that are disposed on the surface of the whole spatial model that is to be created, a network of points with X, Z, Y coordinates of GRID type is created (it is a grid-type network). The network has a certain point density that is registered in GRID-type files with .GRD extension.

**RESULTS AND DISCUSSIONS**

**Transcalculating coordinates in ’70 Stereographic projection system**

The transcalculation of coordinates from the ETRS’89 reference system in the ’70 Stereographic system was performed with the TransDat 4.01 software produced by NACLR.

The transformation parameters that connect the ETRS89 reference and coordinate system (ellipsoid GRS80) with the national S-42 reference system (ellipsoid Krasovski 1940) are the following:

Helmert transformation parameters from the ETRS89 reference and coordinate system and the national S-42 reference system

| Parameter | Value | Unit |
|---|---|---|
| Tx translation | -2.3283 | m |
| Ty translation | 147.0416 | m |
| Tz translation | 92.0802 | m |
| Sc. dm=(m-1)*1e+6 | -5.68907711 | ppm |
| Rx rotation | -0.30924979 | " |
| Ry rotation | 0.32482188 | " |
| Rz rotation | 0.49730012 | " |

The ellipsoid coordinates that can be transformed with the programme are those obtained through the connection to the class A national geodetic network (NGN). The stationing of the triangulation points is not necessary. Thus the accuracy of the transformation of the new points depends largely on the current number and position of points with common coordinates on the national territory.

***a. GPS topographic elevations for volumetric calculation, Timisoara, Timis County***

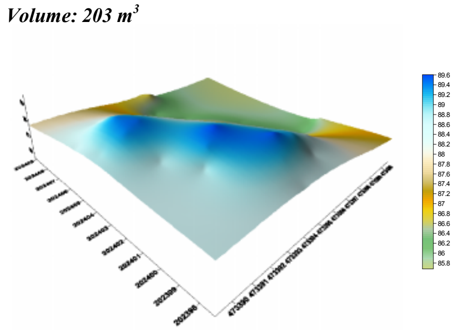
Spatial terrain model created with Surfer 8.0 and the volumetric calculation for the types of measured ballast mineral aggregates, Figure 1.

Permanent GNSS station used:

| GEOCENTRIC CARTESIAN COORDINATES | | | | |
|---|---|---|---|---|
| Name of permanent station | Class | Xc | Yc | Zc |
| Timisoara (TIM1_2.3) | A | 4153556,883 | 1613641.291 | 4548330.869 |
| ELLIPSOID COORDINATES | | | | |
| Name of permanent station | Class | B[m] | L[m] | He[m] |
| Timisoara (TIM1_2.3) | A | 45°46'47.65271"N | 21°13'51.46281"E | 154,7278 |
| 1970 STEREOGRAPHIC COORDINATES | | | | |
| Name of permanent station | Class | X(m) | Y(m) | Z(m) |
| Timisoara (TIM1_2.3) | A | 482495.124 | 207132.249 | 111.641 |

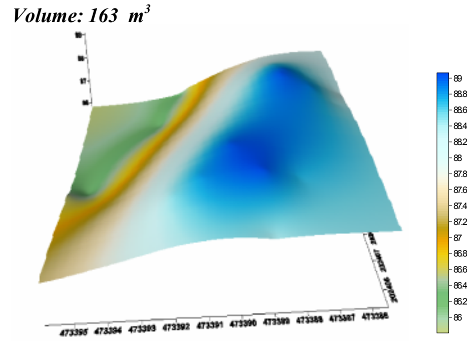
**PADDOCK 1 – Timisoara (Calea Sagului), TIMIS County**

***SAND 0÷4***
***Volume: 203 $m^3$***



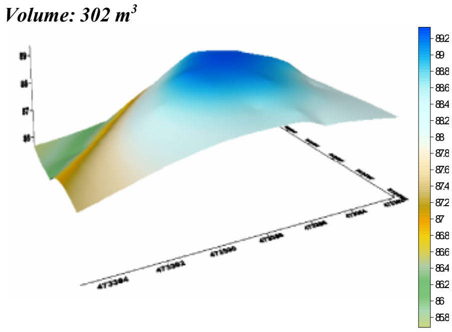
**PADDOCK 2 – Timisoara (Calea Sagului), TIMIS County**

***GRAVEL 4÷8***
***Volume: 163 $m^3$***



**PADDOCK 3 – Timisoara (Calea Sagului), TIMIS County**

***GRAVEL 16÷32***
***Volume: 302 $m^3$***



**PADDOCK 4 – Timisoara (Calea Sagului), TIMIS County**

***GRAVEL 8÷16***
***Volume: 134 $m^3$***

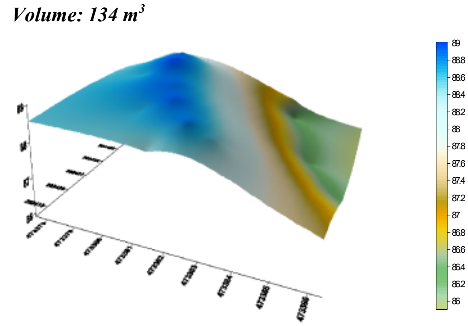


Figure 1 – Spatial terrain model and volumetric calculation, Timisoara, Timis County

***b. GPS topographic elevations for volumetric calculation, Covaci, Timis County***

Permanent GNSS station used:

| GEOCENTRIC CARTESIAN COORDINATES – ETRS89 | | | | |
|---|---|---|---|---|
| Name of permanent station | Class | Xc | Yc | Zc |
| Timisoara (TIM1_2.3) | A | 4153556.883 | 1613641.291 | 4548330.869 |
| ELLIPSOID COORDINATES – ETRS89 | | | | |
| Name of permanent station | Class | B[m] | L[m] | He[m] |
| Timisoara (TIM1_2.3) | A | 45°46'47.65271"N | 21°13'51.46281"E | 154,7278 |
| 1970 STEREOGRAPHIC COORDINATES | | | | |
| Name of permanent station | Class | X(m) | Y(m) | Z(m) |
| Timisoara (TIM1_2.3) | A | 482495.124 | 207132.249 | 111.641 |

Spatial terrain model created with Surfer 8.0 and the volumetric calculation for the types of measured ballast mineral aggregates. Figure 2.

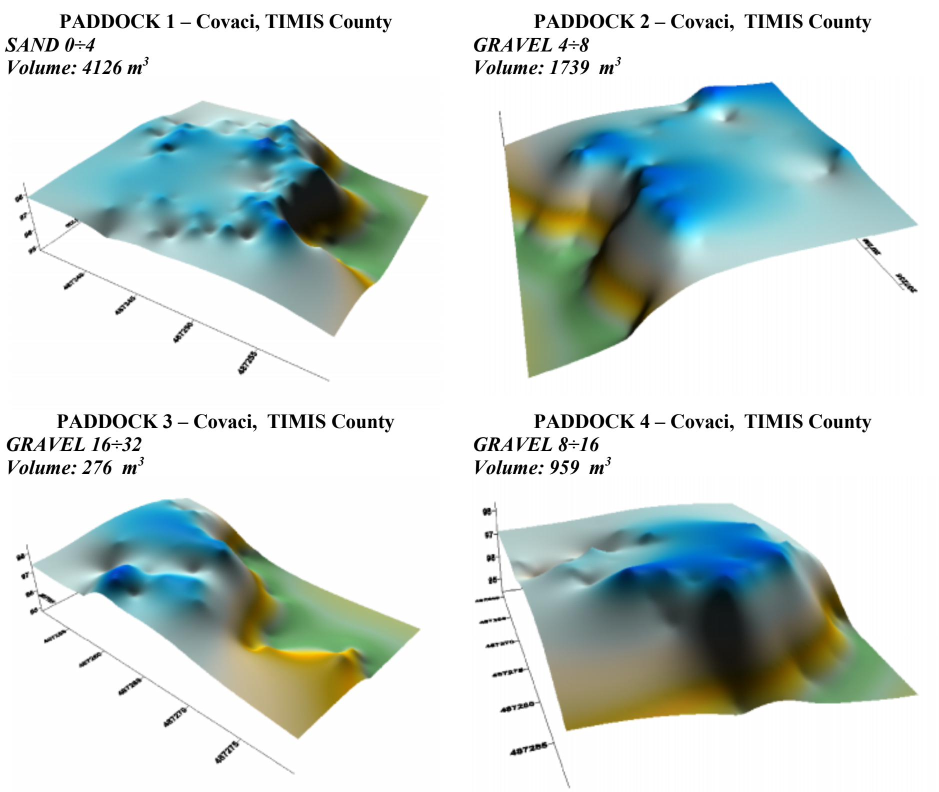



Figure 2 – Spatial terrain model and volumetric calculation, Covaci, Timis County

***c. GPS topographic elevations for volumetric calculation, Lugoj, Timis County***

Permanent GNSS station used:

| GEOCENTRIC CARTESIAN COORDINATES – ETRS89 | | | | |
|---|---|---|---|---|
| Name of permanent station | Class | Xc | Yc | Zc |
| Faget (FAGE_2.3) | A | 4120872.648 | 1679781.156 | 4554158.791 |
| ELLIPSOID COORDINATES – ETRS89 | | | | |
| Name of permanent station | Class | B[m] | L[m] | He[m] |
| Faget (FAGE_2.3) | A | 45°51'16.42753"N | 22°10' 37.78289"E | 216,4898 |
| 1970 STEREOGRAPHIC COORDINATES | | | | |
| Name of permanent station | Class | X(m) | Y(m) | Z(m) |
| Faget (FAGE_2.3) | A | 487749.641 | 280960.451 | 173.080 |

Spatial terrain model created with Surfer 8.0 and the volumetric calculation for the types of measured ballast mineral aggregates. Figure 3.

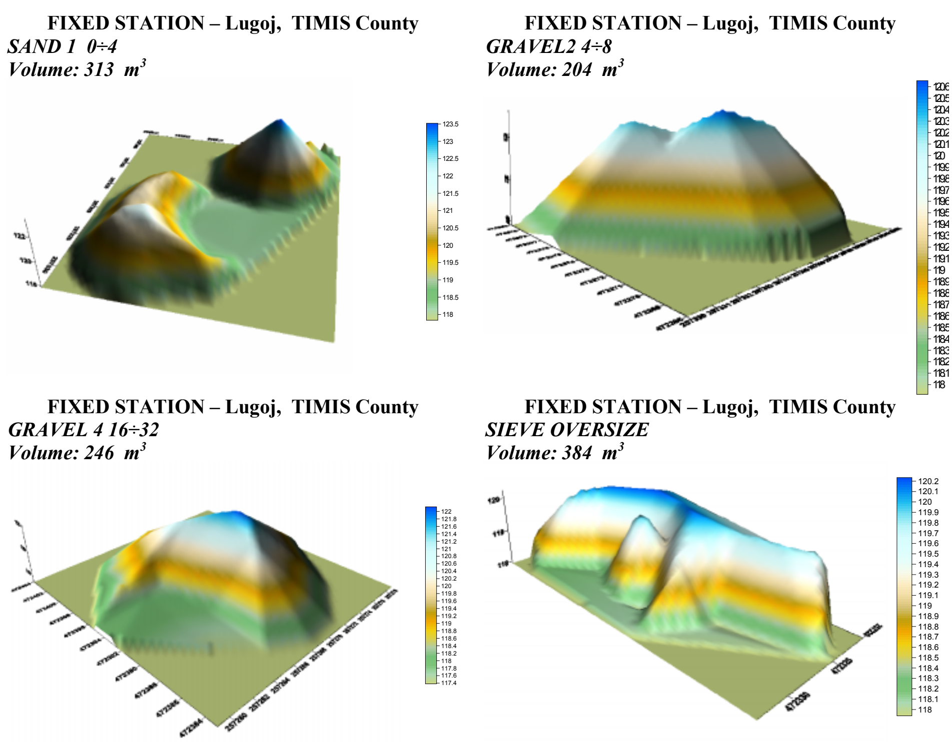



Figure 3 – Spatial terrain model created and volumetric calculation, Lugoj, Timis County

***d. GPS topographic elevations for volumetric calculation, Milova, Arad County***

Permanent GNSS station used:

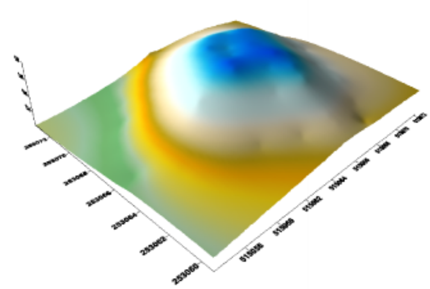
| GEOCENTRIC CARTESIAN COORDINATES – ETRS89 | | | | |
|---|---|---|---|---|
| Name of permanent station | Class | Xc | Yc | Zc |
| Arad (ARAD_2.3) | A | 4121078.991 | 1610437.09 | 4578720.705 |
| ELLIPSOID COORDINATES – ETRS89 | | | | |
| Name of permanent station | Class | B[m] | L[m] | He[m] |
| Arad (ARAD_2.3) | A | 46°10'23.51004"N | 21°13'51.46281"E | 154,7278 |
| 1970 STEREOGRAPHIC COORDINATES | | | | |
| Name of permanent station | Class | X(m) | Y(m) | Z(m) |
| Arad (ARAD_2.3) | A | 415119.935 | 203955.371 | 110.831 |

Spatial terrain model created with Surfer 8.0 and the volumetric calculation for the types of measured ballast mineral aggregates. Figure 4.

**PADDOCK 1 – Milova, ARAD County**

***SAND 0÷4***

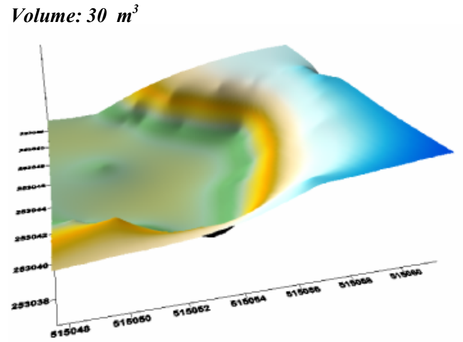
***Volume: 260 m³***



**PADDOCK 2 – Milova, ARAD County**

***GRAVEL 4÷8***

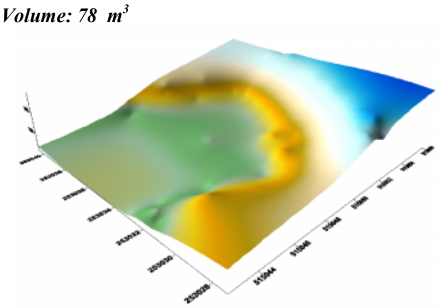
***Volume: 30 m³***



**PADDOCK 3 – Milova, ARAD County**

***GRAVEL 8÷16***

***Volume: 78 m³***



**PADDOCK 4 – Milova, ARAD County**

***GRAVEL 16÷32***

***Volume: 30 m³***

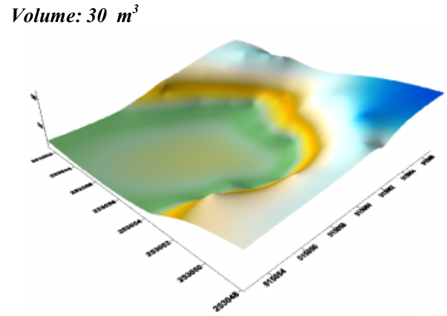


Figure 4 – Spatial terrain model created and volumetric calculation, Milova, Arad County

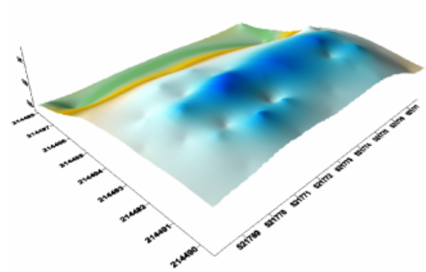
***e. GPS topographic elevations for volumetric calculation, Arad, Arad County***

Permanent GNSS station used:

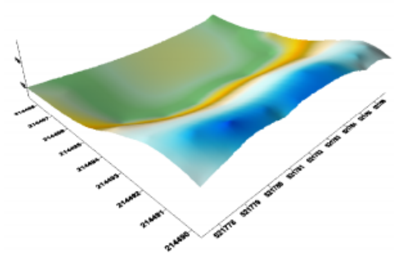
| GEOCENTRIC CARTESIAN COORDINATES – ETRS89 | | | | |
|---|---|---|---|---|
| Name of permanent station | Class | Xc | Yc | Zc |
| Arad (ARAD_2.3) | A | 4121078.991 | 1610437.09 | 4578720.705 |
| ELLIPSOID COORDINATES – ETRS89 | | | | |
| Name of permanent station | Class | B[m] | L[m] | He[m] |
| Arad (ARAD_2.3) | A | 46°10'23.51004"N | 21°13'51.46281"E | 154,7278 |
| 1970 STEREOGRAPHIC COORDINATES | | | | |
| Name of permanent station | Class | X(m) | Y(m) | Z(m) |
| Arad (ARAD_2.3) | A | 415119.935 | 203955.371 | 110.831 |

Spatial terrain model created with Surfer 8.0 and the volumetric calculation for the types of measured ballast mineral aggregates. Figure 5.

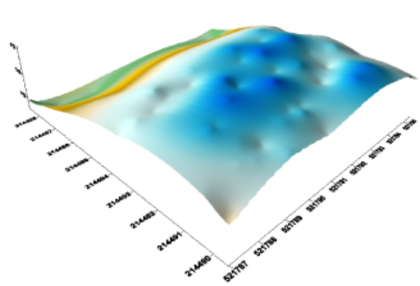
**PADDOCK 1 – Arad, ARAD County**
***SAND 0÷4***
***Volume: 116 $m^3$***



**PADDOCK 2 – Arad, ARAD County**
***GRAVEL 4÷8***
***Volume: 52 $m^3$***



**PADDOCK 3 – Arad, ARAD County**
***GRAVEL 8÷16***
***Volume: 117 $m^3$***



**PADDOCK 4 – Arad, ARAD County**
***GRAVEL 16÷32***
***Volume: 110 $m^3$***

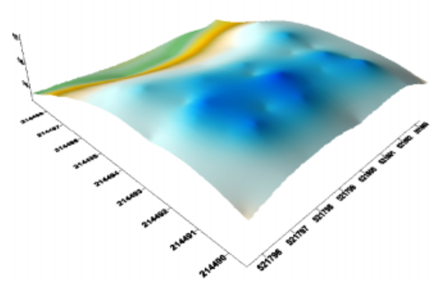


Figure 5 – Spatial terrain model created and volumetric calculation, Arad, Arad County

***f. GPS topographic elevations for volumetric calculation, Caransebes-Jupa, Caras-Severin County***

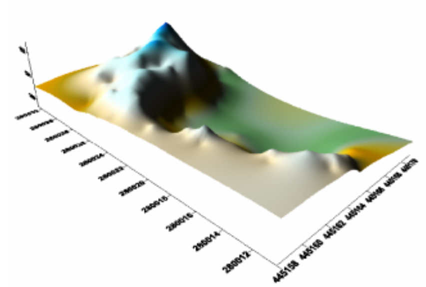
Permanent GNSS station used:

| GEOCENTRIC CARTESIAN COORDINATES – ETRS89 | | | | |
|---|---|---|---|---|
| Name of permanent station | Class | Xc | Yc | Zc |
| Resita (RESI_2.3) | A | | | |
| ELLIPSOID COORDINATES – ETRS89 | | | | |
| Name of permanent station | Class | B[m] | L[m] | He[m] |
| Resita (RESI_2.3) | A | 45°17'34.45921"N | 21°53'54.54481"E | 300.2380 m |
| 1970 STEREOGRAPHIC COORDINATES | | | | |
| Name of permanent station | Class | X(m) | Y(m) | Z(m) |
| Resita (RESI_2.3) | A | 426168.097 | 256908.054 | 256.075 |

Spatial terrain model created with Surfer 8.0 and the volumetric calculation for the types of measured ballast mineral aggregates, Figure 6.

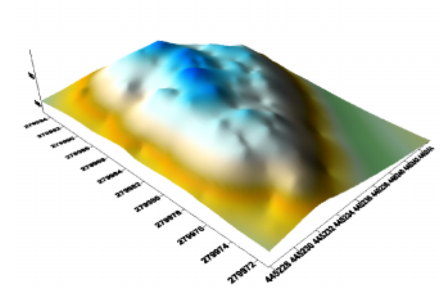
**PADDOCK 1– Caransebes-Jupa,**
**CARAS-SEVERIN County**

***SAND 0÷4***
***Volume: 298 mc***



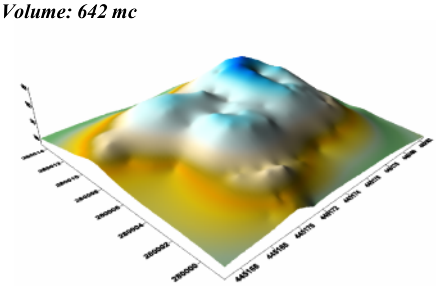
**PADDOCK 1– Caransebes - Jupa,**
**CARAS-SEVERIN County**

***GRAVEL 4÷8***
***Volume: 493 mc***



**PADDOCK 1– Caransebes-Jupa**
**CARAS-SEVERIN County**

***SAND 8÷16***
***Volume: 642 mc***



**PADDOCK 1– Caransebes-Jupa,**
**CARAS-SEVERIN County**

**PADDOCK *16÷32***
***Volume: 309 mc***

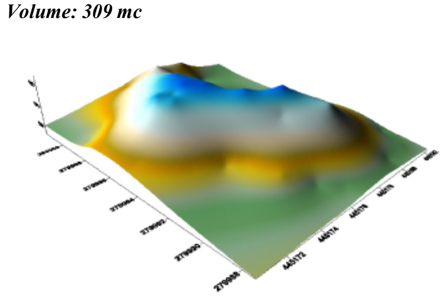


Figure 6 – Spatial terrain model created and volumetric calculation, Caransebes-Jupa, Caras-Severin County

## CONCLUSIONS

The topographic elevations for this paper were performed along the Timis and Mures Rivers, including the following locations: Timisoara, Covaci, Lugoj, (Timis County), Milova, Arad (Arad County), Caransebes-Jupa (Caras-Severin County). Leica GPS1200 was used, the point determination method was Stop&Go (or Real Time Kinematic) and the following reference stations were used: for Timisoara – reference station TIM1_2.3; for Covaci – reference station TIM1_2.3; for Lugoj – reference station FAGE_2.3; for Milova – reference station FAGE_2.3; for Arad – reference station ARAD_2.3; and for Caransebes - Jupa – reference station RESI_2.3.

The topographic measurements were taken for the calculation of the volumetric quantity of different types of ballast mineral aggregates: sand 0-4, gravel 4-8, gravel 8-16, gravel 16-31, sieve oversize.

The transcalculation of the coordinates from the ETRS'89 reference system to the STEREO70 reference system was made with TransDat 4.01 software made by NACLR.

Data processing and coordinate changing from ETRS89 in STEREO70 was done with *TransDatRO 4.01*. Next the volumes were calculated based on the 1970 stereographic coordinates obtained with SURFER 8.0, a very complex product of *Golden Software* company that specialises in computer graphics. It is very effective in creating digital maps.

The spatial terrain model is based on the points with the X, Z, Y coordinates registered in ASCII-type files with *.DAT* extension. Based on these coordinate points that are disposed on the surface of the whole spatial model that is to be created, a network of points with X, Z, Y coordinates of GRID type is created (it is a grid-type network). The network has a certain point density that is registered in GRID-type files with .GRD extension.

## BIBLIOGRAPHY

1. BALOTĂ O. NEUNER J., Program de gestionare a datelor GPS şi a transformării 3D, 2D şi 1D pe teritoriul României, Simpozion „50 de ani de la înfiinţarea Facultăţii de Geodezie şi 180 de ani de la prima promoţie de ingineri hotarnici" – U.T.C.B. Bucuresti , 1998
2. NEUNER J., Sisteme de pozitionare globala, Ed. Matrix Rom, Bucuresti, 2000
3. *** WWW.ROMPOS.RO
4. *** WWW. ANCPI.RO