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Comparative Study of the Volumetric Methods Calculation Using GNSS Measurements

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Abstract. This paper aims to achieve volumetric calculations for different mineral aggregates using different methods of analysis and also comparison of results. To achieve these comparative studies and presentation were chosen two software licensed, namely TopoLT 11.2 and Surfer 13. TopoLT program is a program dedicated to the development of topographic and cadastral plans. 3D terrain model, level curves and calculation of cut and fill volumes, including georeferencing of images. The program Surfer 13 is produced by Golden Software, in 1983 and is active mainly used in various fields such as agriculture, construction, geophysical, geotechnical engineering, GIS, water resources and others. It is also able to achieve GRID terrain model, to achieve the density maps using the method of isolines, volumetric calculations, 3D maps. Also, it can read different file types, including SHP, DXF and XLSX. In these paper it is presented a comparison in terms of achieving volumetric calculations using TopoLT program by two methods: a method where we choose a 3D model both for surface as well as below the top surface and a 3D model in which we choose a 3D terrain model for the bottom surface and another 3D model for the top surface. The comparison of the two variants will be made with data obtained from the realization of volumetric calculations with the program Surfer 13 generating GRID terrain model. The topographical measurements were performed with equipment from Leica GPS 1200 Series. Measurements were made using Romanian position determination system - ROMPOS which ensures accurate positioning of reference and coordinates ETRS through the National Network of GNSS Permanent Stations. GPS data processing was performed with the program Leica Geo Combined Office. For the volumetric calculating the GPS used point are in 1970 stereographic projection system and for the altitude the reference is 1975 the Black Sea projection system.

1. Introduction

A real progress has been made in the field of terrestrial measurements by introducing spatial measurement techniques who made such determinations extending the areas of land-field measurements type to measurement of land – space type. Currently positioning system ensures the whole area of the globe, while being a unit reference system, named global satellite positioning system, GPS. Anyone with a GPS receiving device can find out speeds and position on the map, both at sea and on land, with superior accuracy. For example, owners of the intelligent watch

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(Smartwatch) can share with other friends' position by sending an automatic invitation via e-mail, Twitter or Facebook, which can be followed in real time. So it can be moved and share pictures and impressions in Live Track mode with friends or family. People passionate for adventure can verify if they are on the correct route and can also to mark important points on the map. Emergency service also uses a GPS device just to be able to see which the fastest route is or report an accident location, so specialized crews to reach there in a short time. Recently this technology has found an important application in terrestrial measurements where modern technologies are used GPS positioning type and global geodetic networks, helping to determine the size and shape of the Earth's gravity field. It is also used in network topography, cartography and surveying to engineering, to study the movement of tectonic plates and also works on general or sporadically survey.

2. Material and methods

The topographical measurement to achieve this topographical works was performed using Leica GPS1200 equipment by RTK method. They were used more reference stations, namely reference station TIM1_2.3 and reference station FAGE_2.3. The GPS reference system is WGS84. After processing of raw data and coordinate transformation into STEREO 1970 system using TransDatRO 4.01 application on to calculate volumes using SURFER [1] and TopoLT [2] programs were passed. Surfer is a very ample informatics product of Golden Software that is specializes in computer graphics. It is a 3D surface mapping. Maps issues with this program can be customized to create the desired map. It is used for land modelling, visualization of their generation 2D maps, profiles automatic measurement of distances and surfaces, creating grids, image georeferencing, digitizing the scanned image export in various file formats and volumetric calculations. TopoLT is a program that works under AutoCAD, being very useful for all those realising topographic and cadastral plans [2]. With this program the measurements can be received directly from the device. Graphic point you can enter, graphical coordinates can be calculated, and coordinates tables can be created. It can create 3D terrain model and contour lines, volumes can be calculated without any restrictions, like the volume obtained by intersecting a 3D surface with a plane or volume between two 3D surfaces of any shape GRID or TIN.

3. Results and discussion

Volumetric calculations were made with two programs, namely Surfer and TopoLT [1], [2] where they were created 3D models of land, based on TEXT or GRID files. Then we made the comparisons between these models results.

3.1. Generate 3D models and volumetric calculations using the Surfer program

When X and Y have data, you can still create a contour map in Surfer (Figure 1a and Figure 1b).

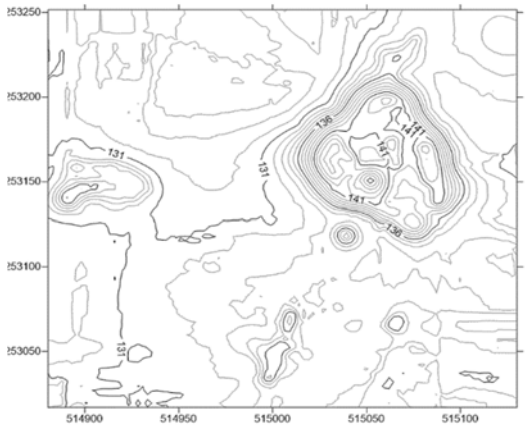

Figure 1a. Raw data contour map

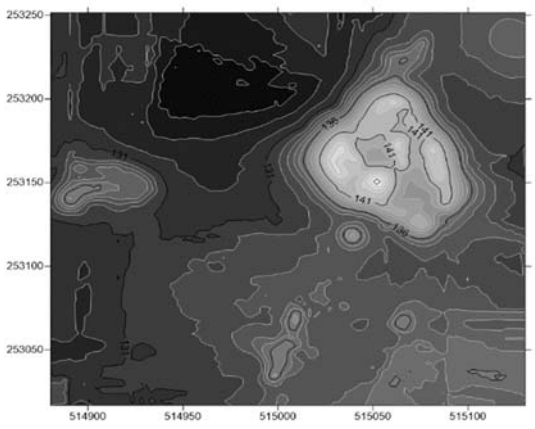

Figure 1b. GrayScale contour map

These contour maps can be edited, thereby producing a contour map that will have colours according to terrain elevation Z (Figure 2) and creating a 3D surface (Figure 3).

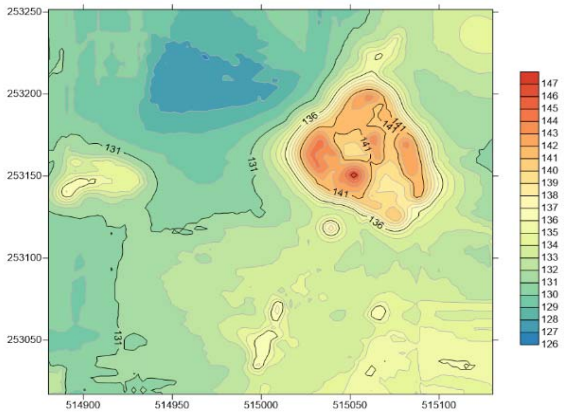

Figure 2. Contour map according to the ground elevation

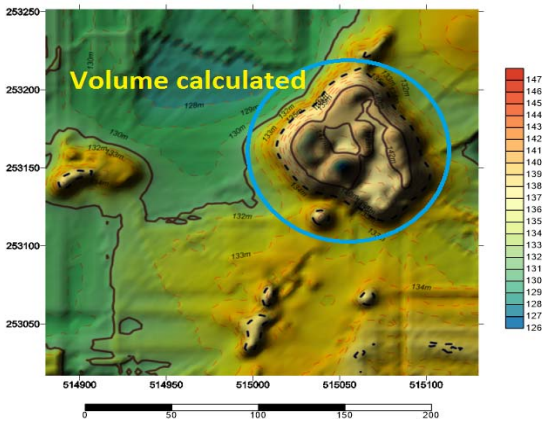

Figure 3. Representation of 3D model

For clearer evidence to the surface measurement a 3D representation using GRID model was made (Figure 4). It was used the specific colour palette for terrain in Surfer program. Also was created a cross section for a better view (Figure 5). The GRID report was carried out to the whole surface of the sand, including the points that are read using the Leica GPS 1200 Series device.

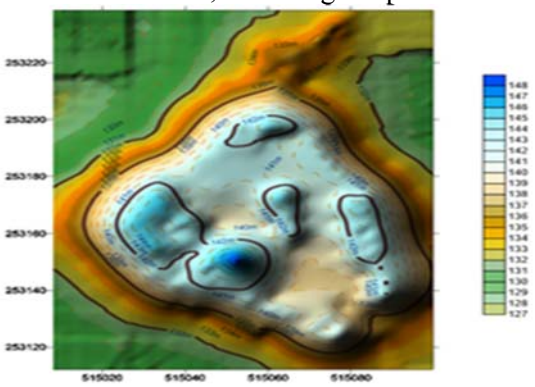

Figure 4. 3D map based on the GRID model

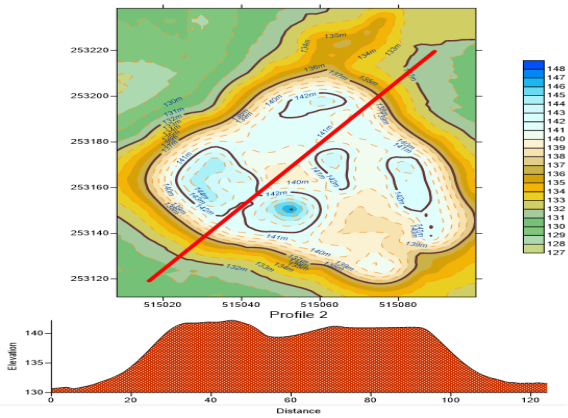

Figure 5. Transverse profile

Next, we opted for making a medium value to the below elevation of the land, resulting in a median value of Z=133,7494m (Figure 6), a value that was used for further calculations to obtain the volume of existing sand.

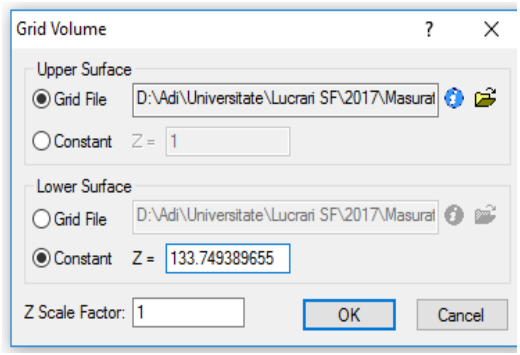

Figure 6. Medium value to the below elevation of the land

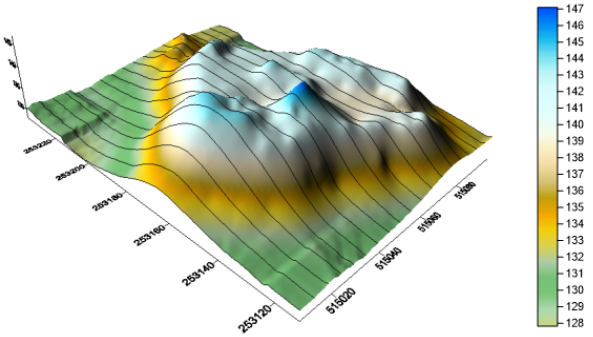

Figure 7. Representing volume

Table 1. Grid Volume Computations, lower and upper points

Upper Surface	
Grid Size	100 rows x 73 columns
X Minimum	515008.2053
X Maximum	515099.738
X Spacing	1.2712875000006
Y Minimum	253112.1132
Y Maximum	253238.4802
Y Spacing	1.2764343434343
Z Minimum	131.50718446486
Z Maximum	147.14239151644
Lower surface	
Level Surface defined by Z	133.7494
Volumes	
Z Scale Factor	1

Table 2. Volumes obtained

Total Volumes by		Cut & Fill Volumes	
Trapezoidal Rule	35458.442718745	Positive Volume [Cut]	35952.320608087
Simpson's Rule	35464.087006104	Negative Volume [Fill]	493.87788934159
Simpson's 3/8 Rule	35464.383167981	Net Volume [Cut-Fill]	35458.442718746

Table 3. Areas

Planar Areas		Surface Areas	
Positive Planar Area [Cut]	6535.3179816284	Positive Surface Area [Cut]	7331.2115244185
Negative Planar Area [Fill]	715.7841092797	Negative Surface Area [Fill]	756.51691645335
Blanked Planar Area	4315.6106099967		
Total Planar Area	11566.712700905		

It can be seen that by this method of calculation achieved positive volume of 35952.32 mc, where was chosen as the land surface model GRID and as plan, elevation Z value of 133.7494m (Figure 7). Further volumetric calculations will be made using TopoLT program using two methods of calculation.

3.2. Making 3D models and volumetric calculations using the program TopoLT

As I said TopoLT is a program that contains tools for 2D and 3D applications with a number of drawn configuration elements to cadastral and topographic plan realization. It can be used also to the three-dimensional models of the terrain and contour lines achievement, to calculate the excavation and filling volumes, as well as raster image georeferencing, [3].

3.3. Volumetric calculation obtained by a 3D surface with a plane intersecting

When we calculate the volume with TopoLT program, we will report text file in Auto Cad, thus obtaining the 3D position of points (Figure 8). Once the points have been reported in AutoCAd will be achieved TIN terrain model (Figure 9). Based on 3D terrain model we can calculate the volume measurement reported (Figure 10). To calculate the volume it can be selected the top 3D model or a plan elevation Z that represents the top surface of the area for which we calculate the volume. Another mode is to take a bottom surface 3D model or a plan elevation Z that represents the bottom surface (which is calculated by reference to the positive and negative volume). The rule for how forming positive volume sand negative volume is simple, so the top surface from the reference surface is always the positive volume and the volume under this references surface is negative one, whether the reference surface is a constant plan or a 3D surface (Figure 12).

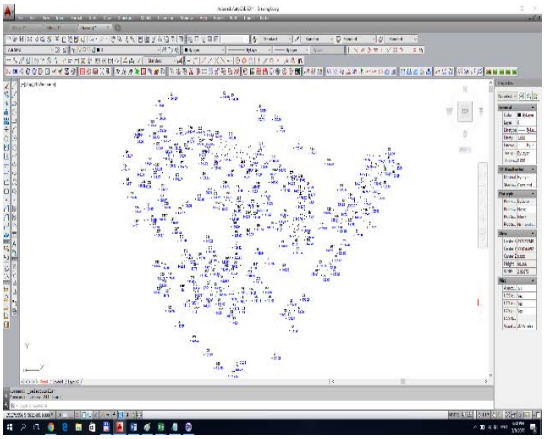

Figure 8. 3D point representation

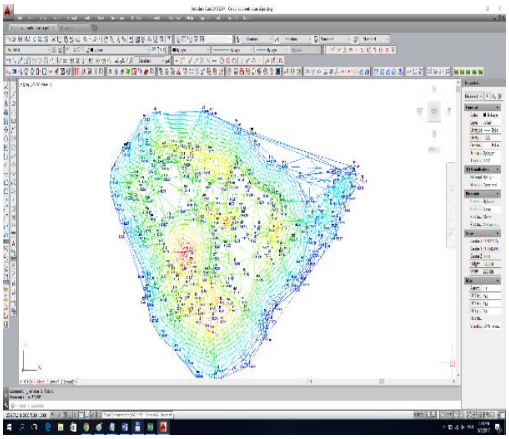

Figure 9.TIN terrain model

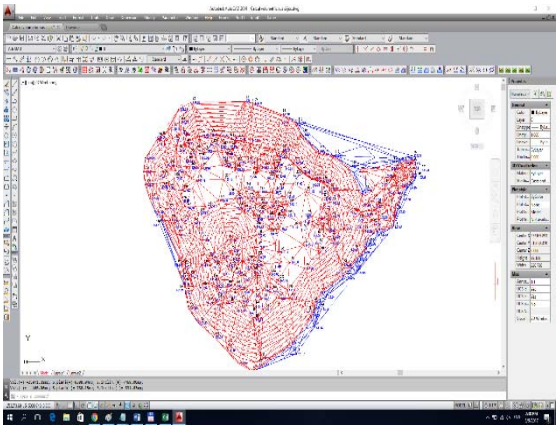

Figure 10. 3D model representation (red) to volumetric calculation

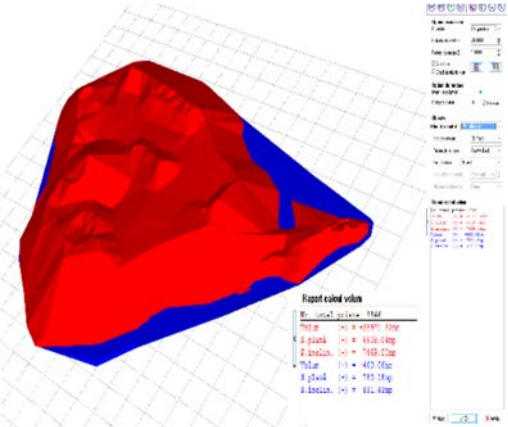

Figure 11. 3D representation of volumetric calculation in TopoLT

Other than positive and negative volume, we calculated the plan area and sloping area (developed) that corresponding with the areas that form these volumes. To understand what the sloping area is, an example would be the area of a thin layer of snow which covered a mountain. If we calculated the volume between two 3 D surface, we are calculated the sloping area for the top and bottom, to positive and negative volume [4], [5].

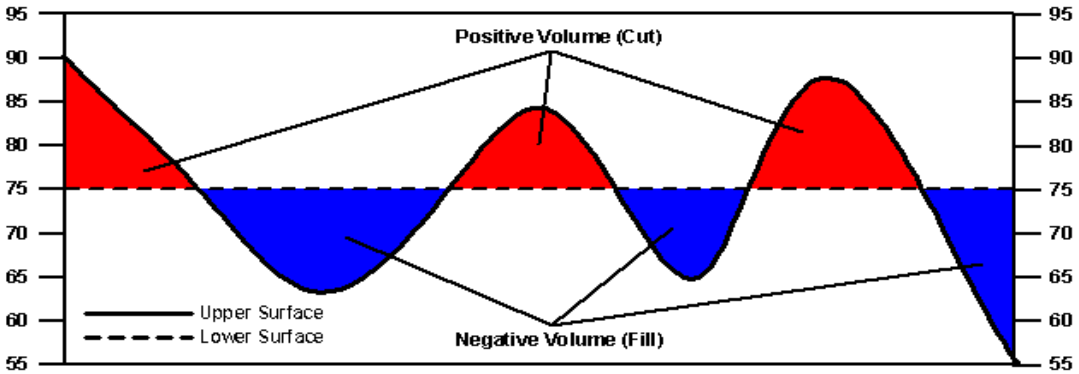

Figure 12. Cross section to represents positive and negative volume

Volume plotting positive and negative in our work can be seen in Figure 12. It can be seen from these results that achieved positive volume is 35971.82 mc with a plan surface of 6608.04 mp and a sloping surface of 7469.00 mp. The negative volume of -460 mc has a plan surface of 780.16 mp and an inclined surface of 831.63 mp as awe shown in Figure 13 (3D representation).

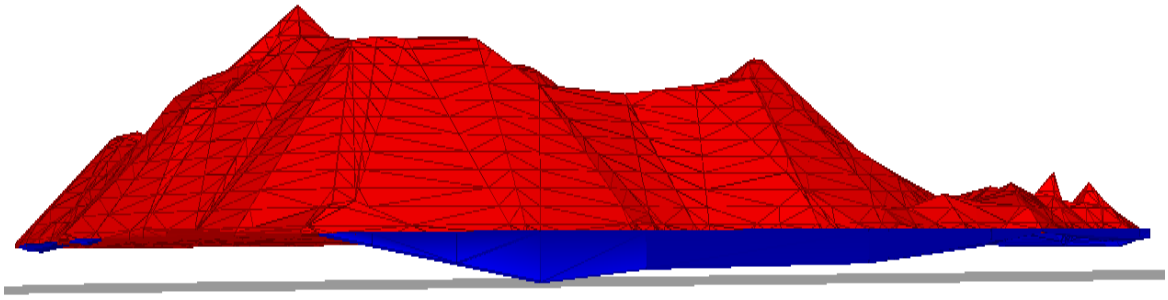

Figure 13. 3D Representation of positive and negative volume through the intersection of a surface with a plan, elevation Z = 133.7494 m

3.4. 3D volumetric calculation between two surfaces of any shape, TIN or GRID

The volume is calculated as a sum of 3D solids (prism trunks) [6] that are obtained by spatial intersection between the 3D model and constant data plan or by spatial intersection of two 3D models. The calculation methods are purely geometric; approximation methods neither are nor used [7]. For these, the 3D models that we use is better to describe the terrain as accurately is possible.

In this case we have achieved reporting for below the ground plan points (Figure 14) and the upper plan (see Figure 16). A 3D terrain model for each plan separately was performed (Figure 15 and 17).

It has been realized volumetric calculation and we choose as the reference plane to the bottom - the first model and for the upper plane, the second model obtained (Figure 18). So we calculated the total volume (Figure 19). As is evident from the 3D representation of the type of sand taken into account, it can be seen that the total volume of sand is 36020.11 mc, with a plan surface of 5503.56 mp. The inclined up surface is 6767.24 mp and the inclined down surface is 5508.65 mp.

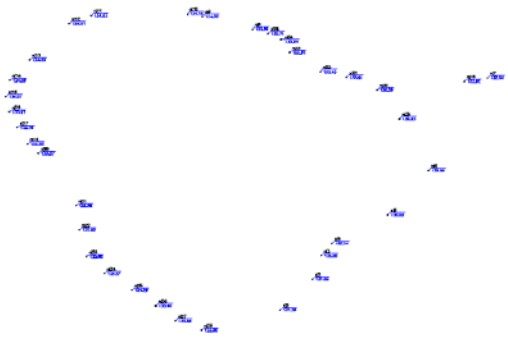

Figure 14. Reporting points lower surface

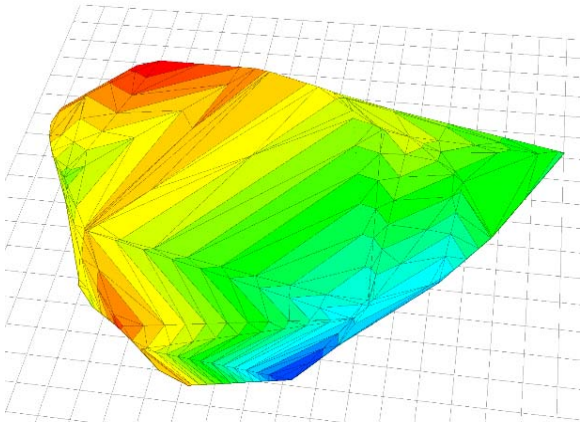

Figure 15. 3D lower surface representation

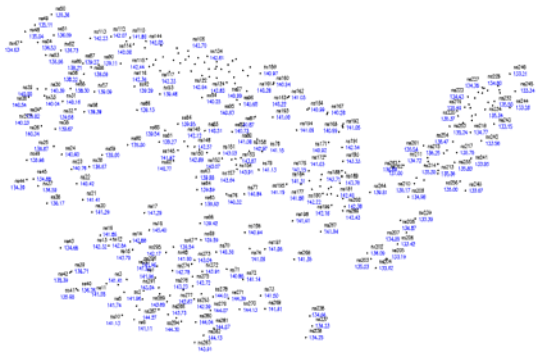

Figure 16. Reporting points upper surface

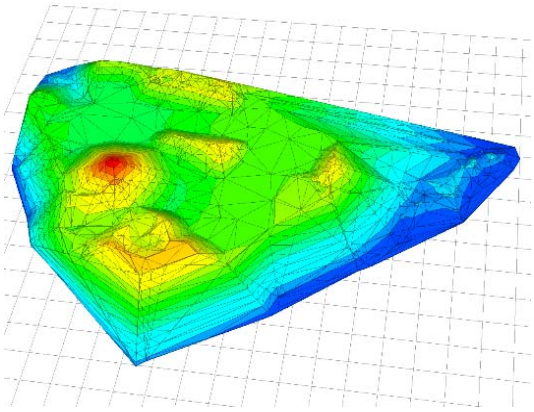

Figure17. 3D upper surface representation

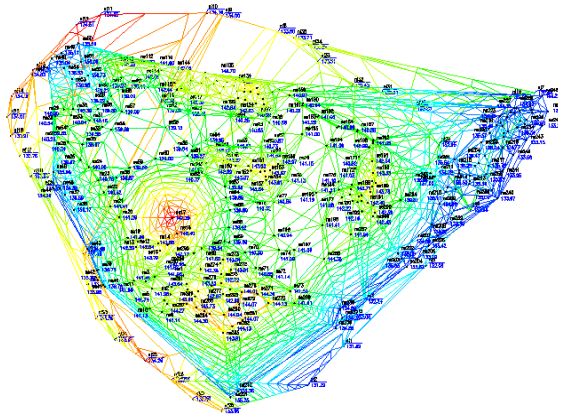

Figure 18. Reporting points lower surface

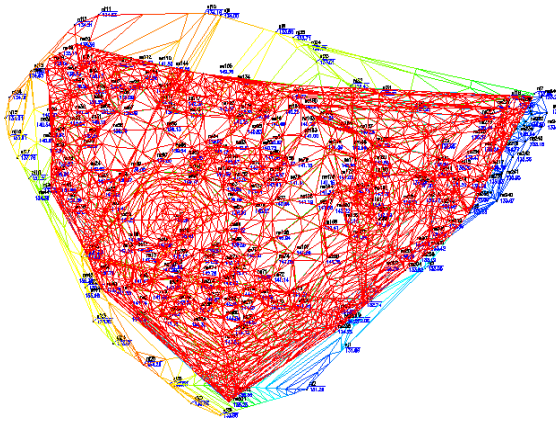

Figure 19. 3D lower surface representation

4. Conclusion

Volumetric calculation achievement is necessary. Every year or twice a year the companies engaged in the production of mortar and concrete, needs various types of special activity for mapping and monitoring of mineral aggregate deposits.

In the present paper we choose for volumetric calculations with two programs, namely: Surfer program and TopoLT program.

Following the volumetric calculation shows the next conclusion:

✓ When we used Surfer programme, we find that the use of a reference plane and a 3D model with elevation Z = 133.7494 m we achieved a positive volume of 35952.32mc and negative volume is 493.88mc.

✓ The results from TopoLT program when we used like reference a plane and a 3D model, it was found that using the same reference plane elevation Z = 133.7494 m we have a positive volume of 35971.82 mc and a negative volume of - 460mc.

✓ In the case of the second method, where we used two 3D surfaces of any shape GRID or TIN is found that the total positive volume is 36020.11 mc.

✓ If we compare Surfer program and TopoLT program when we used a 3D top model and a reference plane for the bottom, we find that the differences are very small, about 20mc.

✓ The reference plan elevation was achieved by averaging all the points below, which has been also verified by the Surfer program.

✓ However we can say that for the volumetric calculations the Surfer program is dedicated to those needs, using superb graphics, with multiple editing, including their presentation in

Google Earth, the possibility of overlapping patterns and a great view. Also performed statistical calculations and more.

✓ Regarding TopoLT program, this is a very good program based on AutoCad options. But this program has no graphics program that has Surfer, statistical calculations are not visible and not too many edits can be makes to the 3D model.

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