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A STUDY OF MIGRATION IN TIME OF THE SACALIN ISLAND, DANUBE DELTA, ROMANIA

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Sacalin island is the newest land of Romania. It is located south of the arm and locality Sfantu Gheorhge in Danube Delta area. The faculty of Geology and Geophysics of the University of Bucharest by the Geomatic team of Geophysics Department wanted to study the question of migration of this land. So we took data from existing maps and various studies over time and recent images. So I did a study which covers a period of 32 years, from 1977 to 2009. The data are taken from the 1977 topographic map, from measurements made with the theodolite Theo 020 in 1994 and an ortorectificate image in 2009. The result is a plan which can determine migration distances over time and forecast for future migration.

Key words: sediment, migration, Danube Delta, deposits.

INTRODUCTION

Sacalin island is formed in the south of the mouth Sfantu Gheorghe arm, as a language of sand, with a form and size that ranged over the years. In fact, in time, somewhere between 1977 and 1994, when we performed the measurements, it became as a peninsula united with the north eastern boundary of the Danube mouth (and become joint together). For this reason in the north of the island the vegetation is similar with that in the rest of the delta. However, the remaining part of the island is just sand and low vegetation. Local residents (Sfantu Gheorghe area) used to leave barren animals on the island during the summer, with males. In autumn recover their animals and notes witch one become pregnant. Those that did become pregnant were slaughtered.

Figure 1 shows the north of the island with grazing animals in the distance and an abundant vegetation. Figure 2 shows the south of the island in which, it appears that vegetation is poor.

On the island, since it is uninhabited, a large variety of wild birds, mammals and reptiles can be found. In 1938 Sacalin island was declared a biosphere reserve and populating was banned.

Which may be even more important, is that in terms of evolution these species could be analyzed in order to determine the newest evolutionary changes in the last hundred years.

Perhaps, an interesting morphological and genetic comparison can be made between mammals and reptiles of Sacalin island and Danube Delta.

Currently it is not open to tourists and for the access on the island special approval is needed, and persons receiving such an approval are accompanied by staff from the Danube Delta Biosphere Reserve Administration.

Today, Sacalin Island has a length of about 18.3 km. When first measured, respectively in 1977, had a length of about 14 km. The width of the island is variable. In the north, initially it reached about 830 meters, and roughly a width of 350 to 140 meters. In this moment the width in the north can not be estimated because it is joined with the arm Sfantu Gheorghe, the rest can reach up to 100–150 meters. Also, we can measure these values by directly observing Figure 3B, which represents the island contours superimposed in three versions: 1977, 1994 and 2009.

Fig. 1. Abundant vegetation in the North of the island

Fig. 2. Poor vegetation in the South of the island.

MATERIAL AND METHODS

Position of an object can be determined by several methods: photogrammetric, topographic, remote sensing, GNSS, etc.

Topographic methods. An area like the size of the Sacalin island requires completion of a topographic surveying from points of a geodetic network or a poligonation. The geodetic network constrain is based on the idea that we have a number of points with known coordinates and a number of points whose coordinates we want to determine. For this we determine directions, distances and measurements with GNSS technology. After measurements, data is processed with the method of least squares indirect measurements. The algorithm for calculations is known from the theory of errors.

$$v = Ax + l \qquad (2.1)$$

M^0 measurements made are erroneous:

$$M = M^0 + v \qquad (2.2)$$

Coordinates to be determined are calculated from the provisional values:

$$X = X' + x \qquad (2.3)$$

– M^0 – measurements of direction, distance or GNSS;
– M – corrected measurements;
– v – correction of the measurements;
– X^0 – provisional coordinates of points to be determined;
– X – corrected coordinates of points to be determined;
– x – corrections of the provisional coordinate (unknown);
– A – matrix of unknowns coefficients;
– l – matrix of the free terms.

The formulas by which we determine the values are:

$$N = A^{tr} PA \qquad (2.4)$$

$$L = A^{tr} Pl \qquad (2.5)$$

$$x = -N^{-1} L \qquad (2.6)$$

Of course, we can calculate and determine the accuracies of each unknown variable and each measurement, according to the average unit weight error.

$$S_0 = \sqrt{\frac{[pvv]}{m-n}} \qquad (2.7)$$

$$S_{xi} = S_0 \sqrt{Q_{xx}} \qquad (2.8)$$

$$S_{M_i^0} = \frac{s_0}{\sqrt{p_i}} \qquad (2.9)$$

Where:
– m – is the number of measurements (equations);
– n – is the number of unknowns;
– s_0 – the average error of unit weight;
– S_{xi} – accuracy of determination of each unknown;
– Q_{xx} – diagonal N^{-1} matrix;
– $S_{M_i^0}$ – accuracy of determination of each measurement;
– p_i – the weight of each measurement.

The formulas for determining the position of points of detail is shown below:

$$x_B = x_A + D_{pprAB} \cos\theta_{AB} \qquad (2.10)$$

$$y_B = y_A + D_{pprAB} \sin\theta_{AB} \qquad (2.11)$$

Distances are reduced to Stereographic 1970 projection plane used in Romania.

Photogrammetric methods

Topographic maps and plans on large surfaces are prepared by photogrammetric methods. Basically, a flight over the area of interest was made. In other words, it determines the position of points on the ground in a coordinate system plan, as well as determinations of altitudes. With these common points in both coordinate systems, other parameters can be determined, such as translations, the rotations and the scale factor for each photogram in part or even other photogrammetric couplings. The method that uses points from which the reference parameters can be determined is called photogrammetric transformation. These points are very important because if they are not properly chosen or mistakenly selected, they can lead to serious errors in determination of parameters.

Thus, we can determine: the contours of certain areas (buildings, plots, lakes, etc.) or certain objects (antennas, high voltage pylons, sewers, drains, etc.), the planimetric position and the height (altitude).

Remote sensing offers images whose pixels incorporate a certain size on the real surface. Images can be made in natural colors or color combinations depending on the purpose for which they were made.

GNSS methods. Global Positioning System has developed exponentially in recent years, opportunities for position determination is made easy. The accuracy of position determination is very precise and can be done quickly. To determine a large area such as Sacalin island, real-time determination LRK (RTK) type or ROMPOS can be used (given the opening sky and phone signal). LRK method requires two receivers: one is located at known point coordinates and the second one is a moving object determining the contour. Basically, it provides a radio link between the two receivers, the receiver with known coordinate is sending corrections to the other satellite receiver. ROMPOS is using only a single receptor that binds the permanent stations and gives the receiver the position with centimeter precision (of course, in such a system one must consider the GSM signal area).

RESULTS AND DISCUSSION

The faculty of Geology and Geophysics of the University of Bucharest by the Geomatic team of Geophysics Department wanted to study the question of migration of this land. Also, within our Faculty, island perimeter measurements were made in 1992, 1993 and 1994. But the study was needed on a wider time period. Basically I found three sources of information (three versions).

The topographic map 1:25,000 scale (Figure 3A) **prepared in 1977 (version 1)** by photogrammetric methods and coordinate Gauss - Kruger. The topographic map was scanned and the data was entered into the computer. Corners of the topographic map were over the geographical coordinates. I converted the geographical coordinates in Stereographic 1970 coordinate system in order to have the same system for all three sources. I imported the file in AutoCAD programs and brought the picture in Stereographic 1970 coordinates on the four corner points. By superimposing the digitized images of the island, the first contour of the coast was obtained. In Figure 3B, the island is represented with a red line and the coast with a green line.

Topographical survey 1994 (version 2). On the island there were two points of geodetic triangulation network, respectively Sacalinul Mic in north and Sacalinul Mare in the South (and marked on Figure 3, respectively 1:25,000 map).

These two points were marked on the ground with a triangulation tower of three feet, made of metal. Also, the whole island was still visible from the village lighthouse (the network triangulation point) in Sfantu Gheorghe. In North, Sfantu Gheorghe church was also visible and in the rest of the island - Ciotica point, flagged with triangulation tower floor of metal, both from the national geodetic network. These points were sufficient to achieve a geodetic network in the Stereographic 1970 coordinate system.

From these points we made a survey with theodolite Theo 020 and rod of 4 meters. Thus, this survey has captured the whole contour of the island. The contour was overlaid on contour map made in 1977 and marked with magenta (Figure 3A).

In 2009 a **photogrammetric flight** was made **(version 3)** for Agricultural Payments Agency. The image was georeferenced in Stereographic 1970 coordinate system (and was digitized). Thus, the obtained contour was superimposed on the other two variants and marked with blue color (Figure 3B).

On the overlay image we marked 8 points. In Table 1 we calculated the movements that these points have suffered between version 1 and version 2, between version 2 and version 3 and between version 1 and version 3. Movements marked with (+) are from east to west, and those with (–) are from west to east. The results are shown further in Figure 3C.

CONCLUSIONS AND FUTURE PROSPECTS

As can be seen from the three overlapping contours, the island has a large movement in a short period of time. The northern part remained in principle unchanged. As we go south, the movement between the three determinations is greater. The first part is moving from east to west, then, the most southern part of the island is longer and the movement is from west to east. In the north of the island we observe how the sea side has come together with the island and now is becoming a peninsula. So far the movement seems to lead to the formation of a lake, queue of the island to reach the sea side.

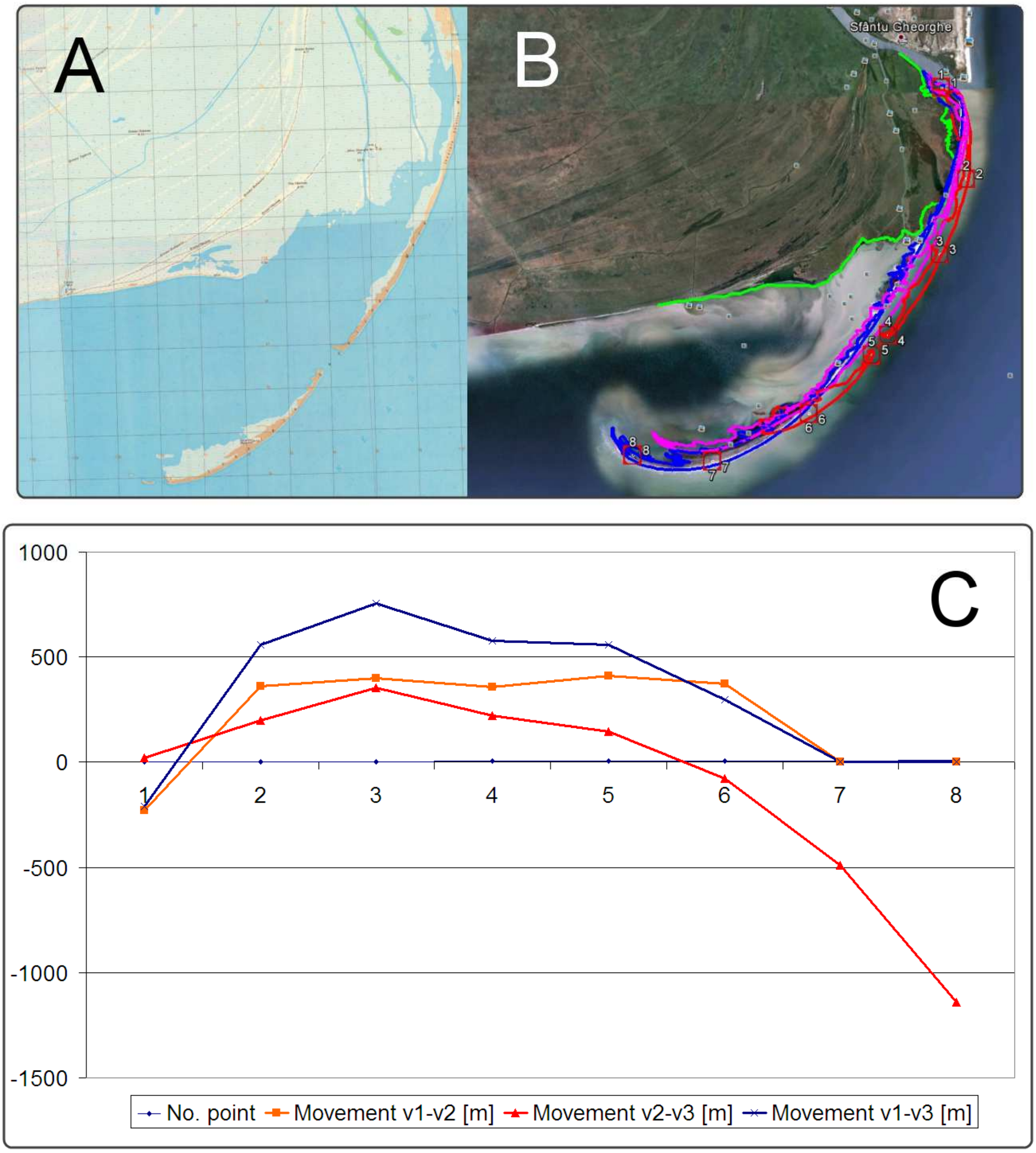

Fig. 3. Sacalin island migration: (**A**) topographic map 1:25,000 scale prepared in 1977, (**B**) a photogrammetric flight made for Romanian Agricultural Payments Agency in 2009.

Table 1

Sacalin island movements

No. point	Movement v1-v2 [m]	Movement v2-v3 [m]	Movement v1-v3 [m]
1	- 230	+ 20	- 210
2	+ 360	+ 198	+ 558
3	+ 398	+ 355	+ 753
4	+ 356	+ 222	+ 578
5	+ 410	+ 146	+ 556
6	+ 374	- 78	+ 296
7	-	- 490	-
8	-	- 1140	-

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