The dynamics of the Danube channel over the last 150 years

(Giurgiu – Călărași sector. Preliminary data)

Florina Grecu, Gabriela Ioana-Toroimac, Ștefania
Grigorie (Omrani)
Faculty of Geography
University of Bucharest
Bucharest, Romania
florinagrecu@yahoo.com,
gabriela.toroimac@geo.unibuc.ro,
stefania_grigorie@yahoo.com

Cristina Ghiță
School Inspectorate of Ilfov County
I.S.J. Ilfov
Bucharest, Romania
chrys_geo_2007@yahoo.com

Abstract— The dynamics of a river channel targets the interdependency relations between water, relief and sediments, as well as their effects within the fluvial system. This paper presents the dynamics of some fluvial islands (islets) from the river channel of the Danube between Giurgiu-Russe and Călărași-Siliștea localities, corresponding to a part of the lower sector of the Danube, which constitutes the border between Romania and Bulgaria. The islets are fixed sedimentary deposits, stabilized, with a vegetation cover depending on the soil formation degree. We use the term “ostrov”, as specified on the cartographic materials published in Romanian. The objectives of the study are defined by the main work phases: 1) identification and mapping of islets on maps of 1864, 1910, 1980 and on orthophotoplans of 2009, 2) design of a typology of these islets based on various criteria, 3) determination of the surface evolution of some islets relevant both as position and as morphogenetic environment. The analysis highlights the ascending variation of the surface of the islets both in time and in space, in respect to the sedimentary input of the Danube. A conclusive example is the Kosuy islet, situated upstream of the Argeș-Danube confluence (between kilometers 427-423 on the Danube), with an area which increased over five times in the last 150 years.

Keywords— *dynamics; morphometry; mapping; fluvial island; the Danube; Romania*

I. INTRODUCTION

The Danube crosses Central Europe from West to East and it is the second longest river in Europe. The total length is 2780 km and it has a basin area of 805 300 km².

On Romania's territory (lower sector), it has a length of 1075 km (between localities Baziaș and Sulina) of which 800 km form the border with Serbia, Bulgaria, Moldova, Ukraine, and 275 km are exclusively in Romania, with two large islands transformed into agricultural polders. The Danube drains 93% of the Romanian territory and flows into the Black Sea through a delta, which is a Man and Biosphere reserve. In Romania, the Danube lower course

presents distinctiveness on sectors (major for the economy): the Danube Carpathian Gorge, river sector, river-sea sector, maritime.

The main objectives of this study outcome from the following working stages: understanding the key factors influencing the riverbed dynamics, inventorying, mapping and classifying morphometrically the islands (“ostroave”), as well as assessing the dynamics of large area islands in the last 150 years. Within the study, the Danube sector in Romania is limited by the Romanian Plain in the north, by the Pre-Balkan Plateau in the south and forms the border with Bulgaria.

The geological characteristics are given by the following deposits: alluvial deposits, floodplain and terraces deposits, marsh deposits from Pleistocene and Holocene: sands, silts, loess-like deposits etc. It is part of a plain from southern Romania – the Romanian Plain – with terraces relief, floodplain and river channel (Fig. 1), anthropically transformed by deforestation, diking, construction etc. [1].

The temperate continental climate presents great contrasts between summer and winter and excessive episodes dependent on the circulation of the air masses from Europe. This causes successive episodes of flooding (2006) and / or drought. The natural vegetation covers the islands, depending on the soil formation degree.

II. HYDROGEOMORPHICS FAVOURABILITY FACTOR

The Danube cross-section profile of the river channel (1993-2012) reveals two sectors with different characteristics, located west and east of the Giurgiu city. An erosion tendency can be observed towards the right shore and accumulations on the left side of the river.

At Giurgiu, the cross-section profile asymmetry becomes more noticeable, the maximum depth being on the left side. Downstream, at Chiciu, the asymmetry changes in favour of large depths towards the right shore

(Fig. 2). The river channel indicates minor variations of morphometric parameters (1993-2012) (Table 1).

TABLE I. MAIN MORPHOMETRIC DATA OF THE RIVER CHANNEL

Gauge Station	Cross sectional area (m ²)			Width (m)			The average depth (surface/width) (m)			Maximum depth (m)		
	1993	2003	2012	1993	2003	2012	1993	2003	2012	1993	2003	2012
Giurgiu	4648	4832	4739	761	760	766	6.1	6.3	6.1	10.6	11.2	10.8
Chiciu	4273	4337	4082	744	744	748	5.7	5.8	5.4	8.2	10	9.4

All the values are calculated at low water level.

The longitudinal profile of the riverbed drops below 0 m in some places, reaching -30 m absolute altitude. Depending on the position of the riverbed, the water depth ranges from 4 to 10-11 m [3].

The existence of the bottom silts explains the average and the maximum depth at Chiciu (downstream) lower than at Giurgiu; the situation is reflected by the island forming process (Table 1, Fig. 2). The floodplain has a variable width, from less than a kilometer to over 10 km (the maximum width is 30 km in the ramification sector of Călărași and Brăila). The relative altitude gradually decreases along the river (downstream Oltenița, it exceeds 3 m at the average Danube level) [2]. The meadow is delimited by terraces, whose number decreases from West to East (Fig. 1 and 5).

Fig. 1. Cross-section through the Danube valley (Greaca, Chirmogi, Ulmeni).

The lower terrace is spreading along the river between Baziaș and Brăila; its altitude varies from 5-6 m to 12-13

m being occupied by towns and villages, which have expanded into the meadow, being exposed to flood risk.

Fig. 2. Cross-sections through the river channel of the Danube at Giurgiu (A) and Chiciu (Călărași) gauging stations (B) (based on data from A.N.A.R – Administrația Națională Apele Române).

Solid flow – sediments: the decreasing trend of sediments amount after completing upstream hydraulic structures (dams and reservoirs of Iron Gates I and II) seriously affects the material source for islands (Fig. 3) [3].

Fig. 3. Solid flow evolution – Oltenița and Călărași gauging stations (1840-2006) (based on data from A.N.A.R).

The case studies target the islands located downstream confluences, where the influx of sediments is high (Ostrov Kosuy - Argeş, Ciocăneşti island - Mostiştea).

III. METHODS AND CARTOGRAPHIC MATERIALS USED

Programs used: QGIS 2.2, ArcGIS 10.1. Global Mapper 15. Methods: geomorphological mapping, hydrology, hydrogeomorphic, observation, analysis, investigation and aerospace instrumental method, diachronic research (Table 2) etc.

TABLE II. DATA SOURCES

Type	Scale / Resolution	Year	Data source
Historical maps			
Szatmary Map	1 : 57600	1864	http://www.charta1864.ro/charta.html
Austrian Empire map	1 : 200000	1910	http://www.earth.unibuc.ro
The Gauss – Krüger Topographic map	1: 25000	1980	http://opengis.unibuc.ro
Aerial image uses in GIS			
Orthophotoplas	5 m resolution	2009	Optical spectral bands SC BLOM ROMANIA SRL
SRTM (Shuttle Radar Topography Mission)	1: 100 000	2000	Raster, http://www.earth.unibuc.ro

IV. ISLANDS INVENTORY

There are differences between the two sectors in terms of area of the islands, which can be explained by morphometric particularities of the river channel and the floodplain. In the Giurgiu-Oltenița sector there are 18 islands, generally with large surfaces, four of them exceeding 5 km² and they are located immediately downstream from Giurgiu (probably tectonic factors) (Table 3). In the Oltenița and Călărași sector, the small size surface makes many of the 11 islands to be submerged during floods [1].

TABLE III. ISLANDS: GIURGIU – CĂLĂRAȘI SECTOR

No.	Island name	Danube km
1.	MOKAN	489 - 482
2.	MARTEN	480 - 477
3.	ALEKO	478 - 472
4.	GOSTIN	475 - 474
5.	LUNGU	469 - 464
6.	MISHKA	460 - 458
7.	TUTRAKAN	434 - 433
8.	KOSUY	428 - 424
9.	MALAK KOSUY	425 - 422
10.	ALBINA	414 - 411
11.	GARVANOVI	411 - 408
12.	VĂRĂȘTI	403 - 401
13.	CIOCĂNEȘTI	397 - 393
14.	DEVNYA	396 - 394
15.	OSTROV	388 - 387
16.	PESCĂRUȘUL 1	387 - 386
17.	CHAYKA	388
18.	PASTRAMAGIU	379 - 375
19.	HOPA	378 - 371
20.	JIANU	376 - 373

V. RESULTS AND CONCLUSIONS

The number, the density and the size of the islands are relying on the contribution of sediments. The islands surfaces registered a general increasing trend. A rise in the surface of the islands was observed during the period between 1910 and 1950, followed by a stagnation, reduction or a very low growth (Table 4). The large islands have continued to expand but with reduced average rates. Topographically, the islands change their appearance depending on the water dynamics and the position to the shoreline. A conclusive example is the Kosuy islet, situated upstream the Argeş-Danube confluence (between kilometers 427-423 on the Danube), with an area that increased over five times in the last 150 years (Fig. 4).

The alluvial terrace has a lower altitude downstream from 20 km at Giurgiu to 15-17 km at Greaca, 10-13 km at Oltenița and less than 10 km at Ulmeni (Fig. 1) [7].

The dynamics of the river channel is limited by diking. According to the system theory, the water flow through a channel maintains a relatively stable geomorphometry at a constant discharge [5, 6]. Diking affects the relations between the flow and the floodplain (Fig. 5) [7], the systemic connection existing only at high flow levels. Thus, sediments are deposited laterally or axially on the bottom of the riverbed, reducing the water depth and creating islets of various sizes and/or lateral deposits.

TABLE IV. CHANGES / YEAR RECORDED AT HE SURFACE OF THE ISLAND (KM²) [4]

Islands	1864	1910	1942-1950	1980	2009	Changes/year		
						1864-1910	1910-1950	1980-2009
Albina	2.19	5.0	4.8	0.72	0.51	+2.81	-4.08	-0.21
Garnovari	1.2	0.83	0.56	1.7	1.4	-0.37	+1.14	-0.3
Ciocănești	0.29	0.41	0.58	1.83	2.19	+0.12	+1.25	+0.36
Hopa	1.16	2.4	1.8	2.55	5.05	+1.24	+0.75	+2.5

Fig. 4. Kosuy island in the last 150 years.

Fig. 5. Danube Terraces downstream of the Olt confluence (after [7]).

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