UNIVERSITY OF SZEGED
Faculty of Science
Doctorate School of Earth Sciences
Department of Physical Geography and Geoinformatics

INVESTIGATION OF PAST AND PRESENT FLUVIAL FORMS AND PROCESSES ALONG THE LOWLAND SECTION OF RIVER MAROS

Theses of Ph.D. dissertation

Orsolya Katona

Supervisor: Dr. György Sipos
Assistant professor

2014, Szeged

1. Introduction

The considerable sediment transport rate of Maros River has been forming the surface of South Great Plain since Pliocen (Pécsi 1969; Borsy 1990). Tectonic activities and climatic factors have played significant role in the evolution of the Maros alluvial fan, influencing on morphology of the area (Timár et al., 2005; Gábris and Nádor 2007; Nádor et al. 2007). All this is well reflected by the abandoned channels on the surface and subsurface fluvial landforms. Based on the pattern, morphology and sediment composition of the alluvial fan's abandoned channels, the evolution conditions in the fluvial system was possible to determine, whereas the sedimentology of islands, bars and paleochannels, refer to level and energy conditions and the fluctuation of fluvial system forming them. Thus, during the investigation of recent paleodrainage and sedimentological features, the recent channel development and its characteristics have to be considered. At the same time, by complex studies on the Maros alluvial fan using shallow geophysical and sedimentological methods, more comprehensive information on the alluvial fan evolution and recent fluvial landforming can be provided.

The major goals of my study are the paleodrainage reconstruction of abandoned channels on the Maros alluvial fan as well as the identification of processes forming recent fluvial landforms on the lowland section of the Maros River. Besides the identification of fluvial landforms by geophysical and sedimentological methods, the reconstruction of former energy conditions using discharge calculations was also aimed. The spatial and temporal investigation of specific stream power and energy conditions opened the way for reconstructing fluvial processes at some river sections. Furthermore, the short-term recent changes in the Maros fluvial landforms of different sizes were also determined via geophysical and geomorphological methods. According to extensive investigations, the formation and the evolution of abandoned channels as well as recent fluvial landforms of the Maros River could be revealed.

2. Research methods and materials

The measurements of paleodrainage reconstruction were realized on seven study sites of the Maros alluvial fan selected in the light of the paleochannel pattern, the location of the alluvial fan as well as the size of formations. Identification of recent fluvial forms and processes was carried out on the sandy river section near the village Apátfalva situated in distal part of the Maros alluvial fan, which as a border region has been slightly impacted by human activities since nineteenth century.

The paleochannels and the recent landforms were examined using sedimentological, electrical profiling as well as morphological, electromagnetic methods, respectively. Based on the analysis of landforms and facies, their forming processes and energy conditions during their evolution could be concluded. Since relatively new (e.g. laser diffraction method) or previously rarely used (use of georadar on water) methods were applied, thus a special emphasis in my research was to test these methods.

2.1. *Examining paleo fluvial forms and processes*

The identification of fluvial landforms and former energy conditions were carried out by the following geophysical, geoelectrical mesurements. After the grain size determination with laser diffraction analysis, comparative measurements of the same fluvial samples were performed using different sample preparation techniques in order to explore relevance and type of preparation. Cross-section of the paleochannel was determined based on the change in the gain sizes of samples originating from paleochannel. The influence of various parameters (moisture content, grain size, depth) on the specific electrical resistivity values was also evaluated by geoelectrical measurements, identifying thereby the location of sandy coarse channel sediment. Cross-sections of paleochannels determined by the sedimentological and electrical measurements were compared. Based on cross-section parameters, the bankfull discharge, the average flow velocity and the specific stream power of paleochannel could be determined alike.

2.2. *Examining recent fluvial forms and processes*

During the investigation of recent fluvial landforms and processes, the development of meso- and macroforms were studied with the help of georadar profiling. In the course of georadar measurements on water, relationship between the water depth and the penetration depth of electromagnetic wave into the channel sediment as well as correlation between the size of river dunes and the hydrological conditions were confirmed. Macroforms were observed three times under various hydrological conditions. In addition to the determination of facies (radar facies) and the investigation of bar structure, the determination of midchannel bar development stages in different energy conditions and the reconstruction of bar development were aimed, as well.

3. Results and Conclusions

3.1. Past forms and processes

1. Based on the tests of the laser diffraction method, sample pretreatment is essential to determine the real grain size distribution provided by elementary grains. The minimum requirements for the effective treatment of fluvial samples are the following: 24 hours etching in 10% HCl and 10 % H_2O_2 to remove carbonates and organic matter and an additional 60 s long ultrasonic bathing just before the measurement.

2. Methodological analysis during the geophysical 2D electrical profiling have shown that the boundaries of the near-surface fluvial units can be determined based on the horizontal and vertical change in electrical resistivity values along the profile. In general three different situations could be identified on the basis of the water content of the sediment and the position of the boundary surface:

- If the boundary of channel and fine grain sediments is situated in the unsaturated zone, then the transition is marked by the relatively sudden increase of specific electrical resistivity values.
- If the boundary of channel and fine grain sediment is situated near the water table, then the transition is marked by the relatively sudden decrease of specific electrical resistivity values.

- If the boundary of channel and fine grain sediments is situated in the saturated zone, or the entire medium is saturated, then the transition is marked again by the relatively sudden increase of specific electrical resistivity values.

Consequently, simultaneously to electrical profiling, control drilling is essential to determine the position of groundwater table, this way fluvial landforms and units can be more accurately defined.

3. Differences between bankfull discharges determined based on the cross-sectional and planform parameters are very significant (4-5 fold). Possible reason for the differences is that planform parameters are dependent on not only the discharge, but also the channel slope, the sediment of riverbank and its quality. Therefore, ignoring these parameters, the discharges can significantly diverge from real values. Moreover, the width-depth ratio of meandering channels is considerable; thereby planform parameters defined based on determined discharges are higher.

4. No clear correlation between the former calculated discharges and the average grain size could be established in the case of studied paleochannels. In addition to the similar discharges, 2-3 times grain size differences were found, thus the sediment grain size depends on mainly the alluvial fan position as well as the quality of available sediment to be transported in the channel, not on the discharge, in term of studied.

5. According to sediment transport based on the CM diagram three main groups of paleochannels could be identified:

- paleochannels on the proximal part of the alluvial fan, the channel sediment of which (independently from water discharge, channel pattern and slope) contains traction load particles besides the suspended load,
- braided paleochannels on the distal part of the alluvial fan, where bed suspension dominates above the traction load,
- meandering paleochannels on the distal part of the alluvial fan, the bedload of which is characterized by sediment from homogenous suspension.

6. Based on the bivariate scatter plot of mean grain size versus standard deviation (sorting) of sediment, facies boundaries are identified between 3.5-4.2 Φ. On the scatter plot of the investigated channels, sediments of the channel and overbank sediment facies could be well separated. By the determination of the facies type of the samples, fluvial landforms shaped by the investigated paleochannel and the previously existing ones could be differentiated.

7. Based on the investigation of relief, sedimentological data and energy conditions determined by cross section parameters, the abandoned channels located on the central and distal parts of the alluvial fan (H, OH1, OH2, MR) could be incised to former surface. The incision of paleochannels can refer to active neotectonic and intensive avulsion activities on the Maros alluvial fan.

8. Change in channel pattern without significant alteration of the discharge or slope can be observed in case of a paleochannel (OH) located

on the distal part of the alluvial fan. However, the mean grain size of channel sediment has decreased from 150 μm to 51 μm along a 12 km long part of the investigated section. Thus, the alteration of channel pattern in the paleochannel development mainly depends on the change in sediment quality.

9. Aggradation rate of the investigated paleochannels is different in the case of the study sites of the alluvial fan. However, aggradation rate is the highest in the case of the oldest channels (MR, K), whereas it is the lowest in case of the youngest channel (P). Based on number investigated site, can not be established significant correlation between the results of OSL dating (Kiss et al. 2012) and aggradation rate.

10. Bankfull discharge, calculated by the cross section parameters of the abandoned channels, is almost the same as the recent bankfull discharge of River Maros at two meandering channels (H, MR – 300-500 m^3/s), however, in the case of other channels (P, K, OH – 2000-2500 m^3/s) it is equal to the flood discharge. Except of two paleochannels (H, MR) the determined specific stream powers at bankfull discharge (2.91-13.85W/m^2) are similar to the ones at Apátfalva section of the recent Maros channel (10.77 W/m^2), which can refer to processes with similar energy conditions.

3.2. Present forms and processes

11. In general the electromagnetic signal loss (the attenuation of the electromagnetic wave) depends on material composition, moisture content and penetration depth. According to our tests, the presence of water strengthened the signal reflected from the boundary of different media, however, it has significantly reduced the penetration depth by even 25%. In

thalweg position (sandy sediment), determined by morphology and digital elevation models, signal strength decreased to 1-2% at a 2 m depth, while in finer sediments the signal has decreased to 1-2% at a 1.25 m depth.

12. Based on the georadar measurements on water, the georadar is suitable for the high resolution mapping of relatively shallow river channels. The measurement can be carried out at a maximum water depth of 3.5-4 m, Measurements using 50 and 200 MHz antennas confirmed natural logarithmic relationship between water depth and penetration depth in the sediment. Thus, based on the high correlation coefficient ($R^2 > 0.95$), penetration depth in the sediment decreases exponentially with increasing water depth.

13. Linear relationship was identified between the height and length of mesoforms (dunes), but the effect of water depth on these parameters could not be clearly identified. After a higher spring flood, the size of dunes was continuously decreasing at low water periods until the next higher flood, and thereby the dune length and the height values show increasing tendency.

14. According to the three-year-long measurement of a bar at Apátfalva section of River Maros, four radar facies were identified. The differentiation of the radar facies was carried out based on the shape, incline, their relationship, length and amplitude of reflection surfaces. Among four radar-facies, dune facies of hummocky structure and bar facies of oblique stratification can be found near the bar surface. At deeper parts of the bar channel facies of horizontal stratification can be found, and the

bottom of the bar is separated by a stratification-free facies indicating the riverbed.

15. According to the georadar cross-sections, water level within the bar, the depth of riverbed and the height of sediment could be identified. The radar facies show that small and medium floods between 2011 and 2012 significantly formed the channel sediment, since the mean accumulation was 2 meters. However, bar facies forming typically at small-medium energy conditions was changed to dune facies forming at smaller water depth and lower energy conditions, which constituted the upper 1 metre of the bar in 2012. Later, bar and dune facies were also formed near the bar surface after a medium flood event between 2012 and 2013 in continuously decreasing water level conditions.

16. Based on the three-year-long measurement, relationship was identified between the separated facies and their hydrological position. Lower and long-lasting inundations characterized by slower changes in water level contribute to the formation of bar facies. Medium- and shorter-term water inundation causing quicker alteration of water level results in the advance of dune facies.

17. Based on the incline of bar facies the direction of bar lope advance could be identified in the study period. In 2011, in the case of the bar located in front of the fluvial island, the direction of bar formation is equal to the flow direction at luv site and directly in front of the island it takes right by 40°. This direction was also detected in 2012. The water flow turning right is likely to confirm the existence of a side branch, which was located in front of the island. For 2013, this side-branch was blocked and

the position of the bar changed compared to the island, the direction of bar formation was equal to the flow direction.

The complex approach in the investigation of the former and recent fluvial landform allows the detailed and more comprehensive understanding of fluvial processes. Future research on methodology and reconstruction of further abandoned and recent channels and channel forms should be required applying the revealed interrelations, since they would greatly contribute to more knowledge on the development of Maros alluvial fan.

The measurement series on the Maros alluvial fan can be applied on other alluvial fans to reveal the size and energy conditions of paleochannels, regardless of sediment quality during formation, climatic conditions and vegetation influence. By the analysis of channel formation in different climate conditions, character and intensity of future geomorphological processes can be concluded.

Furthermore, the investigations of recent meso- and macroforms can be carried out on other rivers, thus fluvial landform size and facies of rivers with different discharge and sediment quality could be compared. By continuous monitoring measurements sediment dynamics of River Maros can be revealed, sediment transport and the volume of bedload reallocation can be estimated, which is an important question in river regulation, economic and ecological viewpoints as well.

Publication in relation with the dissertation

Katona O., Sipos Gy., Nagy Z. 2012: The hydromorphological and hydrodynamic characteristics of abandoned channels on the Maros Alluvial Fan. Conference on Hungarian Geography, Szeged. Abstract volume, 1140-1150, *(in Hungarian).*

Katona O., Sipos Gy., Onaca A., Ardelean F. 2012: Reconstruction of paleo-hydrology and fluvial architecture at the Orosháza paleo-channel of River Maros, Hungary. Journal of Environmental Geography 5(1–2), 29-38.

Kun Á., Barta K., Katona O. 2012: Impact of inland excess water to soil characteristics induced by the M43 motorway between 2010-2011. Conference on Hungarian Geography, Szeged. Abstract volume, 483-494, *(in Hungarian).*

Kiss T., Urdea P., Sipos Gy., Sümeghy B., Katona O., Tóth O., Onaca A., Ardelean F., Timofte F., Ardelean C., Kovacs A. 2012: The past of the river. In Sipos Gy. (ed) 2012: Past, Present, Future of the Maros/Mures River. Szegedi Tudományegyetem, Természeti Földrajzi és Geoinformatikai Tanszék, 33-64

Sipos Gy., Pravetz T., Katona O., Ardelean F., Timofte F., Onaca A., Kiss T., Kovacs F., Tobak Z. 2012: The ever changing river. In Sipos Gy. (ed) 2012: Past, Present, Future of the Maros/Mures River. Szegedi Tudományegyetem, Termeszeti Földrajzi és Geoinformatikai Tanszék, 65-106

Preotease L., Vespremeanu-Stroe A., Hanganu D., Katona O., Timar-Gabor A., 2013. Coastal change from open coastal to present lagoon system in Histria region (Danube delta), Journal of Coastal Research, Special Issue 65, 564-569

Katona O., Sipos Gy., Fiala K., Rakonczai J., Mezősi G., 2013: Working principle of georadar and application fields, with special emphasis on the water management problems. Hidrológiai Közlemények 93 (4), 55-60, *(in Hungarian).*

Kun Á., Katona O., Sipos Gy., Barta K. 2013: Comparison of Pipette and Laser Diffraction Methods in Determining the Granulometric Content of Fluvial Sediment Samples. Journal of Environmental Geography 6(3-4), 49-54.