MASS MOVEMENTS ON THE FRUŠKA GORA MOUNTAIN

Introducing an excellent natural laboratory for slope movement monitoring

Mészáros M\textsuperscript{1}, Marković S.B. \textsuperscript{1}, Pavić D. \textsuperscript{1}, Mezősi G. \textsuperscript{2}, Mucsi L. \textsuperscript{2}, Szatmári J. \textsuperscript{2}, Zorn, M. \textsuperscript{3}, Komac, B. \textsuperscript{3}

Gavrilov B.M. \textsuperscript{1}, Šurlan T. \textsuperscript{3}, Mlađen D. \textsuperscript{3}

\textsuperscript{(1)} Department of Geography, Tourism and Hotel Management, Faculty of Sciences, University of Novi Sad, Serbia
\textsuperscript{(2)} Department of Physical Geography and Geoinformatics, Faculty Science and Informatics, University of Szeged, Hungary
\textsuperscript{(3)} Anton Melik Geographical Institute ZRC SAZU, Ljubljana, Slovenia
\textsuperscript{(4)} Academy of Criminalistic and Police Studies, Serbia
FRUŠKA GORA - SERBIA
DIVERSE GEOLOGICAL STRUCTURE

Toljić et al., 2013
MORE THAN 60 SMALLER STREAM SYSTEMS
<table>
<thead>
<tr>
<th>Landslide type</th>
<th>number</th>
<th>area km²</th>
<th>% of total landslide area</th>
<th>% of research area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – “Danube”</td>
<td>22</td>
<td>13</td>
<td>32</td>
<td>1.3</td>
</tr>
<tr>
<td>2 – concave valley</td>
<td>55</td>
<td>17</td>
<td>41.9</td>
<td>1.7</td>
</tr>
<tr>
<td>3 – steep “V” valley</td>
<td>23</td>
<td>3.8</td>
<td>9.4</td>
<td>0.4</td>
</tr>
<tr>
<td>4 – stream source area</td>
<td>12</td>
<td>4.4</td>
<td>10.8</td>
<td>0.4</td>
</tr>
<tr>
<td>5 – loess scarp</td>
<td>8</td>
<td>2</td>
<td>4.9</td>
<td>0.2</td>
</tr>
<tr>
<td>6 - anthropogenic</td>
<td>2</td>
<td>0.4</td>
<td>1</td>
<td>0.04</td>
</tr>
<tr>
<td>TOTAL</td>
<td>122</td>
<td>40.6</td>
<td>100</td>
<td>4.3</td>
</tr>
</tbody>
</table>
1. "DANUBE TYPE" LANDSLIDES

Schematic geological cross section of typical Danube type deep landslide:

a) in saturated loess (groundwater percolates from the porous bedrock toward loess as clay layer wedges down (left)
b) loess slabs seized by reactivated fossil landslide (right)

1 - phyllite 
2 - gravelly sand (M1) 
3 - sandy clay 
6 - loess with loam layers (Q)

According to Marjanović M. (Marjanović et al., 2011)
1 - The typical form of a “Danube” type landslide, near the village of Banoštor.

2 - Stone jetties constructed to reduce erosion and stabilize slope

3 - Accumulated material contributing to slope stabilization
1. “DANUBE TYPE” LANDSLIDES

Typical deep landslide area beside the Danube near Krčedin (6.4.2005. Photo: Mészáros M.)
Bridge founded on deep landslide on the Belgrade-Budapest motorway

(2008. 9. 10., Mészáros M.)
Riverine island formed in large landslide in 1941
1. “DANUBE TYPE” LANDSLIDES

Another bridge founded on deep seated landslide - Liberty bridge – Novi Sad
1. “DANUBE TYPE” LANDSLIDES

REPAIR OF A ROAD DAMAGED IN SLOPE MOVEMENT NEAR SREMSKI KARLOVCI (2006. 04. 20., Mészáros M.)
2. CONVERGENT, CONCAVE UNSTABLE SLOPES

Schematic cross-section profile of the typical convergent, concave stream valleys affected by landslides (Neštín stream)
2. CONVERGENT, CONCAVE UNSTABLE SLOPES

(Čerević, 2006. 5. 5. photo: Mészáros M.)
2. CONVERGENT, CONCAVE UNSTABLE SLOPES

Schematic geological cross-section, deep seated landslide in clay
1-limestone and marlstone
2-marl
3-sandy clay.

According to Marjanović M. (Marjanović et al., 2011)
3. DIVERGENT, CONVEX, “V” SHAPED VALLEY SIDES

Schematic cross-section profile of the typical convergent, concave stream valleys affected by landslides (Neštín stream)
A typical valley form in the uppermost stream section in the central parts of the mountain. Despite the very steep slope, only minor, shallow landslides form, because of the underlying metamorphic and igneous geologic formations. (3.9.2006. photo: Mészáros M.)
A road damaged by landslide in the vicinity of Rakovac (18. 07. 2006. photo: Mészáros M.)
A number of landslides can be found in the source areas of streams. In the central parts of the mountain, where the oldest metamorphic rocks are uncovered on the surface and the shallow soil layer is under dense forest, conditions are limited for landslide formation. The majority of this type of unstable slopes are located at the contact of the metamorphic and Quaternary zone, or form entirely in loess and loose neogene limnic and marine sediments.
Occur on tectonically or topographically predisposed locations, where the thick loess cover ends in steep walls or vertical scarps. The slumped mass increases the weight on unstable slopes beneath, and in combination with saturated aquifers which often drain on the contact of loess with the neogene clay layers in the base cause movements. The deep cracks formed in the brittle dry loess mass increase infiltration of water in the shear zones and further destabilize the mountainside. Loess covers large parts of the Fruška Gora, and other type of landslides very often form in loess, leaving landslide scars in form of vertical loess scarps („Danube” type landslides as well as all types of mass movements in stream valleys)
SHALLOW LANDSLIDES

Shallow landslide schematic cross section 1- phyllite, green schist (Paleozoic), 2 – deluvial cover (Quaternary) according to Marjanović M.  (Marjanović et al., 2011)
A house damaged by a shallow landslide in the vicinity of Banoštor (21. 04. 2006. photo: Mészáros M.)
A road obstructed by earth flow near the village of Banoštor (21. 04. 2006. photo: Mészáros M.)
LANDSLIDE SUSCEPTIBILITY:

GREEN – low
YELLOW – medium
RED – high
Welcome to INQUA Loess Focus Group

In the honour of Prof. Tungsheng Liu
Beijing, China, 21st October 2013

Wenyong Jiang, (former Ph.D. student of Prof. Liu), vice president Shiling Yang and president of INQUA Loess Focus Group Slodoban Markovic visited the grave of one of the most important loess researchers which world ever had - Prof. Tungsheng Liu.

It is always a great honour to remember our teachers, people who gave us knowledge and an open door to science.

It is just a cycle of the dust...

Archive for the Loess Letters of Dr. Ian Smalley

Read and download all published issues of Loess Letters here:

www.inqua-loess.org
INQUA loess community become quite successful and best recorded unit of this international association

1961-1969 INQUA Sub-Commission
1969-2003 INQUA Commission
2003- INQUA Focus Group

Previous Presidents:
Julius Fink 1961-1977
Marton Pecsi 1977-1991
An ZhiSheng 1991-1999
Ian Smalley 1999-2003
Ludwig Zoeller 2003-2011

www.loessletter.msu.edu
THANK YOU FOR YOUR ATTENTION!

& STAY SAFE 😊