



4th WLF STUDY TOUR#2 CROATIA AND BOSNIA & HERZEGOVINA

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***Title:* Landslides and World Heritages in Croatia and Bosnia and Herzegovina**

Topic: Landslides in Dinarides and Pannonian Basin – from the biggest historical and recent landslides in Croatia to catastrophic landslides caused by Cyclone Tamara (2014) in Bosnia and Herzegovina

Content: The territory of the Croatia and Bosnia and Herzegovina (BIH) is located in the western mega-geomorphological region of the European Pannonian Basin and in the Dinarides with Northeastern Adriatic Coast on the South. The study tour is planned through various geological and geomorphological settings from the Istrian Peninsula, the largest peninsula in the Adriatic Sea in Croatia, through Inner and Outer Dinarides in BIH, to Pannonian Plane in continental part of Croatia. The topics of the study tour are landslides typical for different geomorphological environments. The tour will visit landslides and badlands erosion phenomena in flysch formation in Istria, very large landslides at the tectonic contact between flysch and carbonate rocks in the Rječina River Valley near Rijeka, catastrophic landslides caused by Cyclone Tamara in 2014 in variety of geological settings in BIH (tectonic contact between carbonate and clastic rocks of Pre-Neogene and Neogene age near Zenica, between ultramafic and flysch rocks near Žepče, between sedimentary and ophiolite rocks near Doboj as well as Neogene sedimentary rocks near Maglaj and Doboj) and very large landslide in the City of Zagreb in sedimentary rocks of the Pannonian Basin. Landslides are mainly caused by extreme hydro-meteorological events (e.g. precipitation). The area of Bosnia and Herzegovina was affected by more than 6,000 landslides in less than two weeks in spring 2014 during the Cyclone Tamara and some of them will be visited in the area between Zenica and Doboj. The landslides in the Rječina River Valley and the Kostanjek landslide are examples of very large landslides of high risks which require risk mitigation based on advanced monitoring. The study tour will also present some of the famous world natural and cultural heritages in Croatia and Bosnia and Herzegovina, such as Roman Amphitheater in Pula, Plitvice Lakes and Jajce, old capital of the Kingdom of Bosnia from 14th century.

TENTATIVE PROGRAMME FOR STUDY TOUR IN CROATIA AND BOSNIA & HERZEGOVINA – 4 DAYS

Saturday, 3 June 2017 (Ljubljana – Pula(HR) – Brus – Učka – Opatija)

Transfer by bus from Ljubljana (Slovenia) to Pula (Croatia), touristic tour through Pula.

First part of day one of the study tour in Croatia takes us to Pula in Istria where we will visit Amphitheatre (<http://www.pulainfo.hr/en/>) popularly called the Arena of Pula. It was built in the 1st century AD during the reign of Emperor Vespasian, at the same time as the magnificent Colosseum in Rome. Local limestone was used for its construction. Today it is the venue for summer performances (the Film Festival, Opera Season, Equestrian Festival, concerts) which can seat about 5,000 spectators. The underground passages, once used by

the gladiators, nowadays host a regular exhibition of viticulture and olive growing in Istria in ancient times. The exhibits include reconstructions of machines once used for the production of olive oil and wine (mills, presses, vessels) and amphorae used for storing and transporting olive oil and wine.
Transfer from Pula to Vodnjan.

Lunch in a local restaurant in Vodnjan.

Travel through the central area of the Istrian Peninsula called “Grey Istria” according to grey color of Paleogene flysch sediments to the Brus Village on the local road Boljun-Cerovlje. Field visit is planned to the Brus landslide and badlands erosion phenomena in flysch of Istria. The Brus landslide occurred in 2005 as a typical translational block slide with landslide body which mainly consists of massive block of flysch rock, 10 m thick. Sliding occurred abruptly, without previous indicators of possible instability. Landslide body is composed of flysch rock mass with alternating layers of siltstones, marls and sandstones and sliding surface is formed through bedding planes of siltstone layers. The sliding was caused by the unfavorable dip orientation of flysch strata, and additionally by the river erosion in the toe in combination with unfavorable hydrogeological conditions. Slope movements in “Grey Istria” are also caused by erosion phenomena which include badlands formed in flysch deposits. Istrian badlands are isolated phenomena covering 2% of the area composed of flysch and associated rocks; badlands density is approx. 11 phenomena/km². Denudation of flysch rock, which ranges 1-4 cm per year, cause formation of relief prone to erosional processes (gully erosion) as well as sliding processes (rock falls and rotational slides).

Travel from Brus landslide to Učka Mt. Park of Nature. Coffee break at the top of Učka Mt. with panoramic view to Kvarner Bay. Travel from Učka Mt. to Opatija.

Opatija (<http://visitopatija.com/en/opatija/>), this elegant tourist destination, lies at the center of the Riviera with the longest tradition of tourism in Croatia. The very attractive geographic position, enabling to be quickly reached from many cities in Central Europe (only about 500 km from Milan, Vienna and Munich), lush green scenery and a pleasant climate (45° 20' north latitude) were some of the main reasons for its beginning and the quick development of its tourism at the end of the 19th century. Built mainly at the turn of the 20th century, Opatija has remained in complete harmony with Nature right up until the present day. Well-maintained public gardens, the illuminated 12-km-long coastal promenade known as the "Lungomare", well-kept beaches and fountains provide a stunning backdrop for the villas and hotels that cater comfortably for up to 6,000 guests. The contrasts of sea and mountains, green parks and blue ocean, old buildings and modern comforts, noisy entertainment venues and quiet destinations for excursions all combine to make Opatija and its surroundings a very attractive tourist resort at any time of the year.

Free time and overnight stay in Opatija.

Sunday, 4 June 2017 (Opatija – Grohovo – Grobničko Polje – Plitvice Lakes – Bihać (BIH))

Transfer by bus from Opatija to the Rječina River Valley and the Grohovo landslide, field visit of the Grohovo landslide.

The Rječina River Valley extends northwest from the center of the City of Rijeka. It belongs to the large morphostructural unit characterized by elongated structure composed of flysch deposit and limestones in fault contact. The Rječina River Valley has the most hazardous slopes in the flysch deposits in Croatia, with one deadly landslide which buried the Grohovo Village in 1885. The percentage of landslide area in the southeastern part of the Rječina River Valley (valley area of 10 km²) is more than 50%. There are moderate deep to deep relict landslides (landslide area of 36-44 ha) and numerous active or reactivated shallow landslides. The Grohovo landslide, reactivated in 1996 in the form of moderate large and moderate shallow translational sliding of colluvial deposits (predominantly coarse fragments and limestone blocks) over the flysch bedrock, was equipped with integrated monitoring system in the framework of the SATREPS FY2008 project. This is the largest active landslide phenomena in the Croatian coastal zone of the Adriatic Sea. The most significant risk with further movement of the recent Grohovo landslide is potential direct damage to the channel of the Rječina River and the Valići Dam and potential indirect risk of flooding of the City of Rijeka by collapse of landslide dam. Another large landslide occurred in February 2014 after long period of heavy rain. The toe of the landslide reached the bank of the Valići Reservoir 250 m upstream from the Valići Dam. The landslide movement of approximately 12 to 15 m down the slope caused the complete damage of the local road over the landslide body. The estimated landslide area is 4.7 ha and depth to the slip surface is approx. 20-30 m. Filling of the Valići Reservoir, forming a

landslide dam and overflow of the dam were identified as a main hazard of further movement of this slow-moving landslide.

Transfer from Grohovo landslide to Grobničko Polje.

Lunch in a local restaurant in Grobničko Polje.

Travel from Grobničko Polje to Plitvice Lakes National Park, guided tour through Plitvice Lakes National Park. Plitvice Lake National Park (<http://www.np-plitvicka-jezera.hr/en/>), (Croatian: Nacionalni park Plitvička jezera, colloquial Plitvice, pronounced [plítvitse]) is one of the oldest national parks in Southeast Europe and the largest national park in Croatia. In 1979, Plitvice Lakes National Park was added to the UNESCO World Heritage register. The national park was founded in 1949 and is situated in the mountainous karst area of central Croatia, at the border to Bosnia and Herzegovina. The important north-south road connection, which passes through the national park area, connects the Croatian inland with the Adriatic coastal region. The protected area extends over 296.85 square kilometers (73,350 acres). Each year, more than 1.1 million visitors are recorded.

Travel from Plitvice Lakes to Bihać (Bosnia and Herzegovina).

Free time and overnight stay in Bihać.

Monday, 5 June 2017 (Bihać – Jajce – Zenica – Maglaj - Doboj)

Transfer by bus from Bihać to Jajce, touristic tour through Jajce.

Jajce (<https://en.wikipedia.org/wiki/Jajce>) is a city and municipality located in the central part of Bosnia and Herzegovina. It is part of the Central Bosnia Canton of the Federation of Bosnia and Herzegovina entity. Jajce was first built in the 14th century and served as the capital of the independent Kingdom of Bosnia during its time. The town has gates as fortifications, as well as a castle with walls which lead to the various gates around the town. Jajce was a popular tourist destination in Yugoslav times, mostly due to the historical importance of the AVNOJ session; on 29 November 1943 it hosted the second convention of the Anti-Fascist Council of National Liberation of Yugoslavia (AVNOJ). Tourism has restarted, and its numbers (20-55,000 tourists in 2012-2013) are relevant in relation with the municipality's population (25,000). Tourists from across former Yugoslavia still make up most of tourism in Jajce, but middle-eastern tourists have also increased since the early 2000s. The town is famous for its beautiful waterfall where the Pliva River meets the Vrbas River. It was 30 meters high, but during the Bosnian war, the area was flooded and the waterfall is now 20 meters high. The flooding may have been due to an earthquake and/or attacks on the hydroelectric power plant further up the river. UNESCO has started to renovate the historical parts of the city together with Kulturarvutangränsar (Cultural Heritage without Borders), a Swedish organization. The main project of the company was to renovate the old traditional houses which symbolized the panoramic view of the city and the waterfall. As of 2006, most of the houses were rebuilt.

Lunch in a local restaurant.

Travel from Jajce to Doboj, field visit of landslides from Zenica to Doboj: Talami landslide, Mjestova Ravan landslide, Suljakovići landslide and Kosova landslide.

Landslide Talami in Zenica is moderate shallow (10 m deep sliding surface) landslide activated in May 2014 by Cyclone Tamara. The landslide is formed in Neogene clayey soils (with coal strata) overlying fault contact between Cretaceous marls and Triassic limestones. Landslide area is 17.5 ha with about 130 private houses is monitored by piezometers and inclinometers. Design of remedial measures is already finished.

Landslide Mjestova Ravan in Žepče (Željezno Polje) is another example of moderate shallow (7 m deep sliding surface) landslide activated in May 2014 by Cyclone Tamara. Landslide body is formed of debris and sandy clays in the zone of thrust fault of Jurassic- Cretaceous mélange and ultrabasic rocks.

Landslide Suljakovići in Maglaj is old moderate shallow (8 m deep sliding surface) landslide reactivated in 2010. At the landslide area of 12 ha, 14 private houses were completely destroyed or damaged. Landslide is formed of Neogene clayey soils and marls overlying Jurassic-Cretaceous sandstone. Partial remedial measures were undertaken and most of the citizens were displaced.

Landslide Kosova is also moderate shallow (10 m deep sliding surface) activated in in May 2014 by Cyclone Tamara. Landslide activation caused damages of large number of private houses and road between Zenica and Doboj. Landslide body is composed of sandy clays, weathered marls and conglomerates overlying fault belonging to Ophiolite zone.

Tuesday, 6 June 2017 (Doboj (BA) – Zagreb (HR))

Transfer by bus from Doboj to Zagreb (Croatia).

Lunch in a local restaurant in Zagreb.

Presentation of the Kostanjek Landslide Observatory, field visit to the Kostanjek landslide.

The Kostanjek landslide is a reactivated deep-seated large translational landslide that formed in soft rock-hard soil, i.e., Pannonian and Sarmatian marls. The landslide presents a risk for approximately 300 buildings (mostly residential houses) in an area of 1 square kilometer in the urban part of the City of Zagreb. Its landslide velocities have been changing over the last 50 years from landslide activation (in 1963) until the present day, ranging from extremely slow to very slow. An integrated automated monitoring system of the Kostanjek landslide (the Kostanjek Landslide Observatory) was established from 2011 to 2013 in the framework of the Japanese-Croatian SATREPS FY2008 project. The objective of the monitoring system was to continuously observe the parameters of landslide movement in real-time and monitor the landslide's causal factors, i.e., processes that trigger landslide reactivations, such as precipitation, groundwater changes and earthquakes. The automated continuous monitoring sensor network provided good quality data for the establishment of relationships between landslide movement parameters and the triggering causal factor parameters to predict faster movements, accelerated movement and/or large displacements. The monitoring sensors at the Kostanjek landslide recorded multiple landslide reactivations from external triggers, such as during the winter of 2012/2013 and the spring of 2013.

Part of field trip to the Kostanjek landslide is planned to the abandoned open pit mine of marls and the cement factory 'Sloboda' in the middle and the lower part of the landslide, where destroyed factory buildings and risky slope cuts are visible even after more than 50 years of landslide activation. The tour will visit the Kostanjek Landslide Observatory with the sensor network that encompasses approximately 40 sensors for the monitoring of landslide movement and landslide causal factors. The monitoring system consists of multiple sensor networks for the measurement of (1) external triggers (a rain gauge, a meteorological station and 7 accelerometers), (2) displacement/deformation/activity (15 GNSS sensors, 7 extensometers, 4 borehole extensometers and an inclinometer), and (3) hydrological properties (3 pore pressure gauges and 5 water level sensors in boreholes and domestic wells, and 2 water level sensors at outflow weirs).

Transfer to Zagreb center.

Zagreb (<http://www.infozagreb.hr/&lang=en>), Zagreb is the capital and the largest city of the Republic of Croatia, located in the northwest of the country, along the Sava River, at the southern slopes of the Medvednica Mt. It is the biggest metropolitan area in Croatia with a population of over 1 million. Zagreb is a city with a rich history dating from the Roman times to the present day. The oldest settlement located in the vicinity of the city was the Roman Andautonia, in today's Šćitarjevo. The name "Zagreb" is mentioned for the first time in 1094 at the founding of the Zagreb diocese of Kaptol, and Zagreb became a free royal town in 1242, whereas the origin of the name still remains a mystery in spite of several theories. In 1851 Zagreb had its first mayor, Janko Kamauf, and in 1945 it was made the capital of Croatia when the demographic boom and the urban sprawl made the city as it is known today. The transport connections, concentration of industry, scientific and research institutions and industrial tradition underlie its leading economic position in Croatia. Zagreb is the most important transport hub in Croatia where Central Europe, the Mediterranean and Southeast Europe meet, making the Zagreb area the center of the road, rail and air networks of Croatia.

At the end of the tour participants have the following options:

- transfer to Ljubljana (SI) by bus or train
- transfer from Zagreb airport to major European airports
- stay in Zagreb (hotel accommodation can be arranged by request).

Number of participants: minimum 30, up to 40.

Travel: By bus (maximum 40 seats).

Field trip cost: 550 EUR. The cost includes overnight costs, lunches, tickets and travel guides.

Field-guide: The tour organizers are willing to prepare the field-guide text to be printed by the Conference Organization.

Requirements for participants: -