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Photographs: above F.P. Michetti, 1911; below M. Sestini, Italian National Police, 2014

# BOOKLET OF ABSTRACTS

# Urban geomorphological heritage: an overview of current research

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Geomorphological research – and geomorphological heritage analyses in particular – has traditionally been carried out in rural or natural areas. For long, geomorphological studies in urban areas have remained less developed. Nevertheless, urban contexts are particularly interesting in a geomorphological point of view for almost three reasons:

- The geomorphological context (site) of some cities is part of their "image" and their fame (e.g. the sugarloaf mountain of Rio de Janeiro);
- Urban sprawl often interacts with geomorphological processes (e.g. landslides) and landforms (e.g. fluvial or coastal forms), which necessitates specific methods to deal with geomorphological processes;
- Cities are often tourist destinations, and there is a potential for a geotourist promotion of their geomorphological heritage.

This communication proposes an overview of current research on urban geomorphological heritage. It is divided in four main parts:

- Definition and characterization of urban geomorphological heritage (urban geomorphosites): in particular we discuss what can be considered as urban geomorphosites (i.e. landforms, former quarries) and what is not part of geomorphological heritage (e.g. stones used in historical buildings, that can be considered as geosites but not geomorphosites);
- Overview of various methods for describing, mapping and assessing urban geomorphological heritage, with a particular focus on the use of historical maps and other "human" medias;
- Main issues in conservation of urban geomorphosites, in particular in a context of rapid urban growth;
- Main issues in the promotion of urban geomorphosites (geotourism), in particular the relationships between geomorphological and cultural or archaeological heritage, and the possible synergies in their tourist promotion.

# The contribution of geology in historic urban landscapes

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During almost the whole of human history, since at least 3 million years ago, mankind has lived by carrying out the two basic activities of hunting (or fishing) and gathering edible items of any kind. We are unusual among animals in combining the two functions, and we have been greatly helped in both by the development of language. But basically, as hunter-gatherers, we have lived by doing what comes naturally. A radical change came roughly 10,000 years ago, after the last glacial age, when people first learned how to cultivate crops and to domesticate animals, what can certainly be considered the most significant development in human history. Beginning with the Age of Agriculture, however, humans began to prosper, and population began to grow intensely. From an anthropological perspective, the convergence of agriculture, a settled existence, and population growth brings a number of significant changes that we identify with the emergence of human civilization.

One of the first changes concerned the process of planning, designing and construction of structures for human settlements. Historical civilizations are often identified with their surviving architectural achievements. Nevertheless, architectural works are not related to construction only. They represent the synthesis of a complex system that, in the different historical ages, is guided by the genius of human beings, but depends mainly from availability and types of construction materials (natural geological resources), is magnified by the available social and economic conditions also in terms of morphological conditions (e.g. defensive settlements on top of cliff), and is also influenced by local meteo-climatic conditions. Before the heavy environmental impact of human growing at worldwide level, concentrating population in a limited number of megalopolis, and also introducing construction techniques that are similar all over the planet, most of urban centres were representing the synthesis of the fore-mentioned four elements and, as a consequence, quite often they constituted unique and spectacular urban landscapes, since they harmonized local architecture based on local natural resources in a given historical climate and socio-economic conditions.

These ancient towns and villages are part of the concept of Historic Urban Landscape (HUL) promoted by UNESCO. In all of the above elements but mainly in availability of natural resources and defensive morphological constrains, Earth sciences are playing a fundamental role. Their integration demonstrates how geology and geomorphology are the real conditioning sciences in the urban town evolution, deeply shaping human settlements. Such geologically dependency ended in the twentieth century when steel and reinforced concrete became a universal building material, together with the new science of construction based on mathematical modelling.

In the present works some case studies highlighting the relationship among geology, architecture, climate and socio-economic factors in the development of the Historic Urban Landscape are discussed starting from HUL concept due to clay based urban settlement, characterized by brick architecture with bricks both sun dried (e.g. adobe) and burnt; soft and hard rock until complex situations, mainly typical of important towns with their stratification during time.

# The toposphere: a conceptual tool for geomorphological analysis in urban environment?(*)

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The concept of critical zone has been defined as the Earth's outer layer from vegetation canopy to the soil and groundwater that sustains human life. This research spans a wide range of disciplines including geosciences, hydrology, microbiology, ecology, soil science, and engineering. Through the Critical Zone Exploration Network (CZEN), researchers can access and integrate data in a way that allows isolation of environmental variables and comparison of environmental effects across gradients of time, lithology, human disturbance, biological activity and topography[1].

However, because most people are actually living in huge cities, with no idea at all of what nature and environment are, the aim of the paper here proposed is to develop the concept of toposphere as a tool for geomorphological analysis in urban environment, where the level of human disturbance is particularly high. The toposphere concept may also be seen as a way to compare urban environments with rural or so-called "natural" (if not pristine) environments, in complement of the critical zone approach. In addition to the group of disciplines cited in the preceding paragraph, many other ones may be concerned with the concept of toposphere, mainly geomorphology, geoarcheology, urban hydrology and urban soil science, *i.e.* artificial (man-made) grounds according to the classification of the British Geological Survey (1999). It must be pointed out that the word "Toposphere" was coined by R.J. Huggett (1995) from the notion of "Relief-Sphere", first developed by German geomorphologist Julius Büdel at the end of the 1970's in his *Klima-Geomorphologie* (Büdel, 1977, 1982).

(*)A tentative draft of this paper has been exposed orally in Lyon during the Vertical City Symposium in November 2015: https://youtu.be/vxhU6MIAzlo (in French).

[1] http://www.czen.org/about [accessed June 3, 2016]

# The urban landscape of Rome: a mixture of geomorphological and cultural heritage

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The last two centuries testify that mankind is radically reshaping the Earth surface; it is deeply evident in the most urbanized areas of the world. In Europe most of the cities are characterized by centuries of urbanization, and millennia in the case of Rome.

Long lasting geomorphological investigations have allowed the geomorphological description of the city centre and the valorization of its geomorphological heritage. Man-made layering over time has modified the original natural setting of the city and the paleogeographical conditions prior to its founding are at present hidden by urbanization. A method aimed at integrating survey data, historical maps, aerial photographs and archaeological and geomorphological literature allowed us to map the geomorphological features of Rome present-day historical centre. The map reconstructs the paleo-geographical conditions prior to the founding of the city and records the stages of landscape evolution. The study area has been affected by continuous man-made changes to the drainage network and to the topographic surface over the last 3000 years. It requested to develop innovative solutions to undertake effective analysis of the urban environment and the legend of the geomorphological map in this peculiar context. The resulting map is useful for urban planning and archaeological research, but also for the inventory of the geosites and geomorphosites.

Rome presents a peculiar mixture of geomorphological features and cultural ones. Lots of sites are at the same time geologically interesting, geomorphologically significative and culturally attractive, for example: Tarpeian Rock, on the south slope of Campidoglio Hill, is a fluvial scarp presenting a stratigraphic interest, and it represents the traitor punishment site during the roman period; Tiberina Island is a fluvial isle in the Tiber River, its genesis is related to the large amount of materials transported by the ancient drainage network of the area, it is a symbol of the city and history and legends tell about the importance of the isle along the centuries; Testaccio Mount is an anthropogenic landform, it is a hill made of shards that have been coming from the ancient fluvial port, and the material accumulation reaches 48m of height.

These geomorphosites are transferred to the proposal for a geotourist itinerary, along which the geomorphosites are joined and related to the historical and cultural features of the city. The valorization of results also includes geotourist map and a mobile application.

**Keywords**: Urban Geomorphology, Classification of Urban Landforms, Geomorphosites, Geotourist itinerary, Rome.

# Urban geomorphosites in the dynamic landscape – The case of the city of Wellington, New Zealand

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The city of Wellington, capital of New Zealand, sits astride the plate boundary, in the geomorphologically highly dynamic setting. Beside tectonic morphology, the physical landscape of Wellington comprises hillslope, fluvial and coastal landforms, all occurring close to one another and influencing one another. The urban development of the city since the mid-19th century has resulted in considerable modifications of natural landscape and the origin of man-made tracts of relief, including long sections of reclaimed land along the Wellington Bay. This diversity favours urban geotourism and examination of various links between geomorphology and human activities, including hazards.

Geomorphosites within the boundaries of Wellington can be divided into four groups:

1. natural landforms within the city limits, such as fault-generated escarpments, raised marine platforms and sea stacks;
2. natural landforms significantly modified by humans, such as a natural tombolo that is now partly occupied by the Wellington Airport;
3. evidence of landscape change due to human interventions, such as traces of an old coastline now within a densely built-up city centre or the now infilled lagoon of Basin Reserve;
4. viewing points from which the landscapes of Wellington can be appreciated. Among them is Victoria Peak that offers panoramic view of the entire city and its setting.

While most of interesting places are potential geomorphosites so far, some have already been developed. For example, on the viewing platform on Victoria Peak there are information boards explaining the origin of tectonic relief and effects of the 1855 earthquake, whereas one of walking trails in the city centre follows the old shoreline, now indicated by the curved outline of Lambton Quay street. However, there is scope for the development of further sites of geomorphological interest and addition of geomorphological components to the existing hiking trails. Of particular interest are the trace of the Wellington Fault and various geomorphic features associated with it such as series of triangular facets, longitudinal drainage and straight sections of the coastline. The great earthquake of 1855 focused on this fault caused land uplift and changed the morphology of the area, providing terrain for urban expansion. Tectonic setting of Wellington offers also an opportunity to examine the role of geomorphological hazards directly associated with earthquakes such as landslides, rock falls, and tsunami effects.

# Geomorphology in urban coastal environment: a case study from Rapallo city (Liguria, Italy)

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Rapallo, with 30,000 inhabitants, is an important seaside tourist resort in the Eastern ligurian coast. It is internationally known since the beginning of the 20th century for elite tourism. Following the development of mass tourism, above all during 1960s and 1970s, the whole municipality has been affected by an intense urbanization – mainly due to construction of homes for holiday – which have strongly modified either the former landforms of the flood plain, either the surrounding slopes up to 150-200 m a.s.l. The area covered by urbanization has increased from approximately 45 ha in the early twentieth century, up to 175 ha in 1957, 600 ha in 1978 and 650 ha nowadays.

This research is aimed to reconstruct the morphological transformations in a coastal environment, considering the historical changes due to human interventions and the related impact on geomorphological processes occurred since the 18th century. The study is based on field survey and on the interpretation and comparison among ancient and recent maps, aerial stereographic photos and orthophotos, on historic archive data, on drill analysis by several geotechnical investigations conducted on coastal-flood plain for civil and environmental purposes.

The main significant geomorphological modifications have been caused by river diversion and flow sections reduction of the drainage network (Boate, San Francesco and Tuia streams), by excavations and filling connected with the construction of the railway and the green course, by opening of clay quarries in alluvial plain and limestone quarries on slopes, by embankments along the shoreline for the construction of the marina and the promenade and by overbuilding (cementification/strong reduction of water seepage) in slopes and flood plain areas. These interventions, in addition to the geomorphological and climate features of the catchments (small basins, very steep slopes, high intensity rainfalls), increased flooding hazard and risk conditions that historically affected Rapallo city.

Moreover, geomorphological findings highlighted interesting aspects on coastal plain evolution, which can be usable for geo-environmental and geo-cultural popularization. In fact, boreholes and geotechnical tests, pointing out the morphology of the bedrock and the transition between marine and fluvial domain, showed a notable thickness of clay soils with peat interlayers, which date back to 7000-8000 y BP. Furthermore, several orders of flat surfaces between 15 and 80 m a.s.l. suggest neotectonic activity connected to sea level changes.

At the end, important stream network modifications, also recently conducted for geo-hydrological risk reduction purposes, become a basic component of urban geomorphological landscape of Rapallo.

# Photogrammetric modelling for urban mediaeval site mapping. A case study from Curtea de Argeş, Romania

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The paper proposes the investigation of an old mediaeval town site (Curtea de Argeş, the first Capital of Wallachia, from 13th century), for an accurate 2D and 3D mapping of the historical topographic features together with the elements of the urban landscape. The town was developed on the terrace of the Argeş River on the left slope (450 m altitude, 30-40 m relative altitude) in a strategic point, around the Princerly Court (Curtea Domneasca), surrounded by old systems of walls and canals.

During the last 50-60 years, in the context of industrialization, the urban development of the present-day town, closed the mediaeval core between block of flats and industrial districts, and masked some of the key features of the historical urban site.

First, the study area was identified on historical maps (Specht Map 1796, Satmari Map 1856, Army Shooting map 1914), in order to map its limits. The photogrammetric approach started with the oldest aerial images available.

The approach continued with a photogrammetric workflow integrating the historical aerial photos from 1964 (IGFCOT Bucharest, scale 1: 5000), in order to produce a Digital Elevation Model and ortophoto coverage. After the evaluation of data accuracy, this historical data layer was compared with the orthophotos at the same scale from 2012 (ANCPI Bucharest). The results were partly relevant and focused on the urban landscape change and its correlation with the historical topographic features mapped from the Digital Elevation Model at 0.5 meters.

Another issue was to produce reliable data regarding the historical building superposed on the mapped topography. For this purpose, a special UAV flight was planned and developed. This low altitude flight (150 m) above the study area focused on the detailed mapping of the present-day features. This was planned and developed with a help of special software and a drone with an airborne camera, in natural colours (24 Megapixels). This allowed the production of a 3.0 centimetre resolution photogrammetric coverage of the urban historical core, focusing of topographic features and buildings. The aerial triangulation of the imagery block made possible the creation of an accurate Digital Surface Model/Digital Terrain Model, based on GPS ground control points. This was used for 2D and 3D mapping purposes and GIS analysis, in order to obtain the model of the topography in the historical core as well as with the building coverage by types, ages and function. The photogrammetric data were combined with terrain digital data and imagery.

The morphometric modelling of the elevation data returned useful data and allowed the identification and the analysis of the relationship between topography and the mediaeval configuration of the town. Small sectors of former walls and canals were mapped and correlated with the present-day building. For validation purposes it was necessary to correlate the digital models with some archaeological data and architectural studies within the study area.

# Geomorphological controls on the evolution of Adriatic historical cities (Central Italy), determined using contemporary maps and art

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The geomorphological analysis of historically urbanized areas provides an irreplaceable scientific basis to understand how geomorphological factors conditioned urbanization and it also gives us a baseline for comparison with the modern environment. Recently the mass digitization and resulting online access to old maps and art prints have vastly increased the amount of usable materials available for integrated analysis.

This paper considers three urbanized historical sites on the Adriatic coast (Central Italy): Rimini, Pesaro, and Fano, which owe their urban development to particular geomorphological and environmental conditions modified over the centuries from the Roman age to present time.

The focus here is on the evolution of the shoreline and the geomorphic variables associated with river mouths. These factors are fundamental for determining the development of the city, both as basic boundary elements – and therefore includes defence and protection – and also for development of the harbours.

The studied areas are characterized by very detailed and precise contemporaneous cartographic documentation and artistic representations. The integrated analysis of these sites represents another important tool for urban planning, not to mention a primary data source for historical urban planning. Perhaps a deeper understanding of the rates of geomorphological change in a historical time frame can lead to smarter plans that do not assume a fixed unchanging nature for the physical elements upon which older plans rested.

# Anthropogenic mound growth and the geomorphology of historical cities in the Venetian Plain (Italy)

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Cities with a long settlement history in the low Venetian Plain, such as Padua, Adria, Treviso, and Altinum, are shaped as large mounds that rise several meters above the surrounding alluvial plain. As most European cities of ancient foundation (e.g., Rome, Florence, Paris or London), they are "pluristratified archaeological sites", meaning that the city's space have been occupied continuously over time. The elevated morphology of the historical city centres derives from the accumulation of archaeological deposits and sporadic intercalation of alluvial sediments during the last 3 millennia.

We reconstructed the buried geomorphic and archaeological surfaces in the 1.55-$km^2$ wide, 7-m thick mound of Padua through the spatial interpolation of 117 elevation points relative to unique archaeological features. Key data were the elevation above sea level of the pre-settlement alluvial plain, flood deposits, roads, floors, hearths, since the late Bronze Age to the Imperial Roman Age. The elevation of the present ground was provided by a LiDAR DEM. Spline interpolation produced general-trend surfaces of the buried alluvial plain, Iron Age ($13^{th}$-$10^{th}$ and $6^{th}$ century BC), and Roman ($1^{st}$ BC and $1^{st}$–$2^{nd}$ centuries AD) levels. Validation of the later Roman surface indicates a decimetre accuracy of interpolation. GIS overlay operations resulted in quantitative estimates of the vertical growth of the mound, the volume of the archaeological deposits, and the depth of burial of the different levels.

This geoarchaeological investigation provided new insights on the geomorphology and development of the ancient city and relations with palaeohydrography, as well as crucial information for the preventive assessment and protection of the buried archaeological heritage.

# Stone quarry in urban landscape: a feature of geoheritage. Examples from Paris and Nantes (France)

*B. Commentale (University of Nantes)*

Stone quarry is a basis of urban landscape, because it provides building materials, and imprints marks in city pattern, even if disused. Progressive integration of quarries in urban landscape also testifies to city growth. For these reasons, one may compare a great city like Paris, holding several limestone and plaster stone quarries, which generally became recreation urban parks, with a medium-range western France city as Nantes, with a little number of quarries linked with a long term slow-rhythm spreading, but where the main granite quarry is poorly integrated in urban landscape even nowadays.

In both cities, which are river cities located in poor relief surroundings, urban quarries are an opportunity to point a non-spectacular geomorphology. The former Paris location is an island and bridge site across Seine River whose large alluvial plain, surrounded by several hills, allowed easy urban growth. Local limestone and gypsum were extracted since Roman times. In the western and southern parts of the city, Lutetian age limestone outcrops were worked from hillslope quarries (Chaillot), and almost from underground quarries, generating a great number of galleries (among them the well-known catacombs). Formerly located in the city suburbs, in a semi-rural landscape, quarrying also extended to the outskirts towns (Arcueil, Châtillon, Clamart). Such disused quarries tend to be considered as geoheritage spots (Meudon quarry). Underlying clay was used too, but there is few evidence of this (*Tuileries* Palace: tile production), because of the cancellation of underground galleries due to clay plasticity. In the northern districts of Paris, Oligocene age gypsum was worked mainly from the slopes of hills, which are the main relief feature of the area (Montmartre and Belleville-Romainville hills). Underground quarries were not so numerous, because of high collapse danger due to gypsum dissolution. For the same reason, building density is lower than in other parts of the city: low-elevation houses blocks, lighter than high buildings (Botzaris, porte de Bagnolet), Buttes-Chaumont recreation park, Père-Lachaise cemetery.

Nantes is located at the widening point of Loire estuary. Slow urban growth, in a city, which was dedicated to overseas trading during a long time, did not require great quantities of building material. The few number of local quarries can also be explained by stone regional trading along Loire River (limestone) and continental roads (slates and tiles for roof covering). Armorican basement rocks were extracted from valley slopes, especially from the Chantenay granite quarry, located near the formerly active, industrial harbour which is disused for 30 years. This forms a low-density quarter, like a parenthesis in the urban landscape for it is not converted into a recreation park. Thanks to a local geoscience association, it is now recognized as a geoheritage spot, but still closed for safety.

In both cases, geomorphologic heritage based on quarrying activity has cultural and historical values. In such cities whose relief is invisible, it has to be recognized as a component of urban memory.

# When Man builds landforms: Artificial landforms and fictive cities as a new urban heritage

*C. Portal (University of Poitiers)*

In a urban context, Man is a physical process, which transforms a natural area (the urban site) in an anthropogenic urban landscape. From a urban geomorphology point of view, geologic and geomorphologic features confer the city initial topography, to which societies have to deal with (Coates, 1976). If the natural urban landforms are often profoundly modified and even destroyed, others are preserved and become vectors of identification and are integrated in urban marketing strategies (the hills of San Francisco, the sugar loafs of Rio de Janeiro etc.). Finally, man is also a creator of landforms. Just like natural ones, artificial landforms arise from varied origins and offer a huge diversity of profiles: industrial and mining (heaps, quarries, troglodytes), ornamental (landscaping integration in parks, gardens and zoos), transport (tunnels, channel), architectural (towers, skyscrapers, landforms buildings), archaeological and historic (*mottes*, grave mounds, embankments, bombing craters, trenches) and "multifunctional" (polders).

Often associated to the history of the city, some of these landforms today emerge as a heritage. This contribution proposes to focus specifically on anthropological landforms in western cities. It follows on from an exploratory inventory of geoheritage of the city of Nantes (France, Kerguillec and Portal, 2015) and widened it. We will see that if the recognition of this anthropogenic heritage is integrated into the history of the city, it is also connected to the natural city, green and mineral, of the 21st century: disappeared landforms as valleys and filled streams are sometimes redrawn; abandoned heaps become green and are recognized as important biodiversity areas; urban quarries faces are rediscovered and sometimes protected. At last, we will discuss the question of imaginary landforms, anthropogenic by definition, as a pattern for a new heritage feature of the city: artificial mountains will be particularly studied, as anthropogenic mirrors of natural mountains but also as constructions of the urban imaginary, between (science)-fiction and reality of the contemporary city. This proceeding will more widely allow approaching the immaterial dimension of geoheritage.

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# A tale of a city, through its urban landscape and cultural heritage in the heart of Europe: The case of Oradea (Romania)

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Oradea is a modern northwest town of Romania, with about 200,000 inhabitants, located at the foot of the Apuseni mountains on the edge of the fluvial plain opening toward Hungary (the border is 12 km westword). The urban landscape of Oradea is still strongly characterized today by the presence of the Crişul Repede River and of the grand pentagonal Renaissance fortress built by Italian architects, even if the cultural links between citizens, river and fortress have almost been forgotten.

Oradea can be a significant example, of both the distant and the recent past, of the development of the relationship between landforms and urbanization, and how the geomorphological heritage and its use could be a tool for the enhancement of urban geotourism, and to increase the awareness of the residents of their own heritage, both geomorphological and cultural.

A particularly dynamic hydrographical network has been the distinguishing and bonding element of the urban landscape of Oradea since the first stages of construction of the fortress (14th century), located on a fluvial ridge between the rivers Crişul Repede and Peţa (the latter born from thermal hot water springs). The fortress is the most antique part of the city centre, but the traces of the old town were destroyed by dense urban planning during the 19th and 20th centuries. The reconstruction and the comprehension of the development of the urban landscape has been possible due to the comparison of cartographical material and documentation from 16th and 17th centuries (maps and prospective views of the town and fortress and chronicles of the same period, mostly unpublished, or never studied from this point of view), complemented by the interpretation of multitemporal aerial photographs and satellite images, and by field surveys. In particular, the study of the abandoned river beds shows that the hydrographical network was subject to constant natural evolution, still on-going, and to human intervention, such as channelization or changes to river courses.

In the past, Oradea was flooded several times by the Crişul Repede River; in order to remind residents of the flood hazard, the water level reached by the river is signed on the walls of historical buildings in the city centre.

Fragments of the architectural and structural elements of the earlier Medieval fortress have been inserted into the red-brick walls of the Renaissance fortress, for decorative purposes; in addition, some sections of the late walls (1600-1700) have been built of white limestone, from the Betfia quarry, near Oradea, these rocks have been used to produce hydraulic lime too.

The study of the evolution of the Oradea urban landscape might represent an effective tool for rediscovering the geomorphological heritage, between the use of resources and environmental conditioning, and the Oradea Fortress can be a chance for developing urban geotourism: in other words, the sustainable development and the active use of the landscape are in fact the foundations for the ethical construction of a collective memory.

Moreover, this case study emphasizes the necessity of studying the urban landscape as a complex system of natural and anthropic interactive elements, through a substantial integration of different disciplinary areas of interest.

# Geoheritage assessment of relief forms in a modern city – The case of Ljubljana

*J. Tičar, B. Komac, M. Zorn, M. Ferk, M. Hrvatin, R. Ciglič (Slovenian Academy of Sciences and Arts)*

The city of Ljubljana lies on the contact of different geomorphological features. Position of the sediments (gravel, clay, conglomerate etc.) and relief forms (river channels and terraces) strongly influenced the spatial organization of the city. Most of the city was built on sediments of the Alpine rivers (e.g., Sava River), while its southern part was built on the sediments from the Dinaric region (e.g., Ljubljanica River).

Through history the inhabitants of the city used different relief forms and materials to build the city and develop urban space.

The settlement centre was positioned on different locations in different time periods. Prehistoric settlements were built on marshland (Ljubljansko barje), the Roman city was built on the first river terrace of the Sava River, while the Middle-Ages city was built on a strategic position between a Ljubljanica River and a castle hill. The modern city absorbed all usable space between the nearby hills.

The paper presents the relief analysis in Ljubljana city, its influence on city spatial development, and urban geoheritage. The geoheritage value of relief forms in urban environment of Ljubljana city was assessed using 1x1m LIDAR data, geological map, and data on natural heritage. The results indicate new possibilities for urban geoheritage tourism in the Slovenian capital.

# The Stones of Perugia: the art of photography and the geological assessment of a city

*L. Melelli (University of Perugia)*

Perugia is the capital city of Umbria region (Central Italy) and is located on a gentle hill (493 m a.s.l., area 27 $km^2$) with a triangular shape where four narrow and elongated ridges spread out from the historical centre (in the highest and northern apex) decreasing in altitude and reaching the Tiber River valley.

The drainage network shows a radial pattern flowing from the apex downward to the valley. The morphology and the morphometry of the hill reflect the structural factors and the shaping by geomorphological processes. Fluvial lacustrine deposits (Pleistocene – Holocene) deposits are present on the hill, included in a sandstone-marly formation (*Marnoso Arenacea*, Miocene). The deposits are the result of the infilling of the Tiber Basin, the largest of the intermountain basins in the Umbria region, due to the extensional tectonic phase started in the Pliocene. Pebbles, sands and clays are all present in the Perugia hill with a general coarsening upward sequence from the bottom to the top. Moreover the extensional tectonic phase, still active, is responsible for the tilting and faulting of the relief.

The main aim of this study is the updated and complete knowledge of the geological and geomorphological assessment of the Perugia hill. Moreover a geotouristic network is provided linking the subsurface geology to the building stones of the most important historical buildings in the old town. The lithological and mineralogical nature of the stone, the origin of the mining areas and the meaning of the use of a particular kind of lithotypes are provided. Furthermore, in the main stops of the touristic route, the connection between the geological assessment of the hill and the setting of the main historical buildings is specified in order to provide a complete vision of the urban geology of the entire area.

# Existing and proposed urban geosites in Poznań (Poland) – Town in the river valley and on the Pleistocene morainic plateau

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Poznan is one of the largest cities in Poland. Geological, geomorphological and hydrological conditions favoured location of Poznan and influenced its further spatial development. It has a good recognition in the field of geomorphology, i.e. landforms, natural and anthropogenic deposits and ancient and present-day morphogenetic processes.

The city is situated at the postglacial morainic plateau in the Poznan' phase of the Vistulian glaciation, dating to approx. 18,400 years BP. The city is surrounded by morainic plateaus on the east and west areas. The main morphological axis of the city is a gap valley of the Warta River. Along the valley there are seven levels of uneven-aged river terraces. Holocene discharges of the Warta River have shaped the very rich contemporary river landscape on the bottom of the valley and floodplain, too. Within the city river channel is partially straightened and partially concreted. The Warta River has become the settlement structure of the city. The areas bordering the river valley or directly in the valley were the earliest inhabited and transformed by man through the centuries. Because of the natural character of the valley and long period of its use, surfaces of river terraces were lifted and leveled. In that zone, we can observe the greatest thickness of anthropogenic layers. After many years of neglect, today the valley floor is managed in accordance with the concept of sustainable development.

Summed land used for agricultural and fallow and green spaces (including forests, parks and lawns, green the estate gardens) represent over 50% of the city. Undeveloped areas represent 4.5% and the surfaces of open water cover 3% of the city area. The remaining areas are the surfaces that are to a greater or lesser extent modified and developed by Man. This paper will present the following issues: 1) the progress in understanding the geomorphology of the city, along with urban sprawl from the beginning of its foundation, 2) geoarcheological sites evidenced stages of the city development and the associated transformation of natural landforms into anthropogenic ones, 3) evidences of weathering processes on historical buildings, 4) the metamorphosis of the river channel pattern changing morphological landscape of the valley floor in the city.

Until now there are five geosites in the city: erratic boulders in the Botanical Garden and Millennium Park, petrographic lapidarium, impact crater (reserve Meteorite), moraine hills Morasko Mt. The proposed new geosites are: the bog Żurawiniec, Genius Loci and the Warta River valley, which runs through the city from south to north.

# Application of geohazard assessment methods to test the security of Svalbard's coastal infrastructure

*M. W. Jaskólski, M. C. Strzelecki, Ł. Pawłowski (University of Wrocław)*

The rapid changes of Arctic environment affect the security of local communities (IASC 2015). Increased temperatures and the continuing loss of sea ice cover, glacier retreat and thawing permafrost conditions are responsible for acceleration of geomorphological processes and triggering of geohazards such as landslides, land destabilization, coastal erosion or even tsunamis (e.g. Prno et al. 2011, Lantuit et al. 2012, Jones et al. 2013, Buchwal et al. 2015). The observed changes are particularly important for the functioning of Arctic coastal zone, the interface where severe environmental processes (e.g. storms and erosion), have the direct impact on Arctic human activity including modern and historical infrastructure (Forbes et al. 2011).

In this paper we present the results of a project focusing on the impact of coastal changes on community and scientific infrastructure in Svalbard. Svalbard has one of the longest periods of human activity (exploration, mining, military, tourism, research) among High Arctic archipelagos. Majority of scientific, industrial, touristic and community infrastructure has been developed along fjord coastlines and is threatened not only by changes of sea-ice cover but also by changes in glacier, river and slope systems associated with accelerated climate warming. In the project we have applied the combination of spatial planning methods, geomorphological mapping remote sensing techniques together with environmental assessment techniques to design a complex hazard and risk assessment of urban infrastructure in Longyearbyen, Piramiden, Barentsburg and Svea – major towns and settlements of Svalbard.

**Acknowledgments**

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# The Macro-tidal Rance Estuary (Britanny, France): morphogenesis and assessment of a "Man-shaped" coastal geomorphosite?

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As urban geomorphology offers a privileged framework to discuss the way that Man increasingly "shapes the Earth", this communication aims at presenting the Rance Estuary as a very original urban part of the French coastline (Manche area). Despite the absence of classical urban features (an imposing skyline or an impressive urban sprawl) many arguments can be put forward to underline the urban character of this area. Actually, this 20-km long ria, turned into a totally artificial waterway due to industry and tourism, may be considered as an archetypal cultural landscape. The Rance ria, which connects two main seaside cities, Saint-Malo and Dinard, has undergone scattered urbanisation since the beginning of the Modern Ages, with the edification of industrial buildings (shipyards and tide mills) and the construction of many mansions (locally known as "malouinières") built with the money of the privateers. More recently, little towns along the estuary have known a rapid development. Last but not least, in 1966, the first tidal power plant of the world was achieved largely influencing the estuarial geosystem in various aspects of its physical and societal dimensions.

First, we discuss the geomorphological issues raised by this very specific part of a "man–made estuary", specifically emphasizing the many significant landscape changes which occurred during the last century. Predominantly anthropogenic, these changes, which can be created (built landforms) or induced (morphological consequences of built landforms) imply the development of a "geomorphological and architectural" approach of coastline geomorphology that breaks the classical opposition between natural and artificial landforms. For this purpose we have used a large corpus of iconographic artistic representations of the ria (paintings, engravings and postcards) in order to identify the entire bank transformation that has occurred. The points of view of the different representations have been located and current photos have been taken, trying to reproduce the exact same frame in order to precisely compare diachronic couples of images. An interactive on-line map allows us to locate the places of study and to access the associated observations and comments.

Second, it is proposed to consider here this Man-shaped ria as a urban coastal geomorphosite. Many arguments do converge: the natural configuration (the fractal cutting of the shores and macro-tidal range) and its exploitation and transformation by former tidal mills and the modern power station constitute a strong part of the scientific values of the site. Sedimentation and sediment cell processes are totally controlled on a distinct scale (the whole ria and its subsection). Moreover a large range of man-made additional values (tourism, archaeological sites, environmental aspects, dramatic landscapes, heritage promotion, innovative architectural propositions, land art experimentation and so on…) can also be considered. We believe that the recognition of the site as a coastal "anthropogenic" geomorphosite may help efficiently in the controversial creation of a Natural Regional Park.

**Keywords**: Cultural landscape - Coastal changes – Geomorphosite

# Integrating the geomorphological heritage. A case study in Tata Province, Southern Morocco

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To discover a region through its geological heritage is learning to read a landscape through its relief, rocks, vegetation, architecture and to decrypt the imprint of its history features, which makes its specificity. Scientific and educational mediation permits us to promote geological heritage while discovering the cultural identity and heritage of this region of Morocco. Intended for a wide audience (hikers, tourists, teachers, students...), this approach can be carried out in collaboration with local partners, and can take the form of walking routes of geological discovery and fact sheets on cultural identity in the region.

Such an approach is now about to be carried out to Tata. Tata is a tourist area renowned domestically and for its geology. Unknown to the general public it can address many topics of geosciences: sedimentology, tectonics, hydrogeology, geomorphology, geological hazards, etc. Throughout our approach, the public will discover an original link between history, human settlement and geological determinism. Located south of Morocco, the landscapes of the Tata region is the conjugate result of geological evolution over hundreds of millions of years and the recent action of Man. The area is inhabited by Berbers, although rooted in history, with a strong cultural identity still maintaining ancient traditions.

This original approach of geological heritage also helps to raise public awareness of geological hazards and environmental respect (water resources management, materials) of such heritage.

**Keywords**: Geotourism, geo-education, scientific mediation, geomorphological heritage, Tata province, Morocco.

# City of Kielce – "The largest museum of geology under the open sky in Europe" (Holy Cross Mountains, central Poland)

*M. Górska-Zabielska (Jan Kochanowski University)*

Kielce, a medium-sized city (ca. 200,000 inh., 2015), is situated in the Holy Cross Mountains, in central Poland. It is the only city in Europe having within its boundaries a great variety of geological formations protected by law. There are rocks of the Paleozoic, Mesozoic (Triassic) and Cenozoic (Tertiary and Quaternary) eras here (Filonowicz 1980a, b; Jarosz et al. 2010). Therefore Kielce has been called "the largest museum of geology under the open sky in Europe" (Nita, Myga-Piątek 2010).

As many as five inanimate nature reserves located within Kielce (Wróblewski 2008; Urban, Gągol 2008) are real geotourist attractions. The visitors are attracted by:

1. Kadzielnia - a nature reserve of inanimate nature, located in the centre of the city, founded in the Devonian limestone. The effects of a number of tectonic and karst processes and sedimentation (e.g. the remains of corals) can be seen there. Reserve represents the largest concentration of caves (about 20) in the Kielce district,
2. Biesak quarry in the south part of the city, which shows sandstones and siltstones of the Lower Cambrian and Lower Ordovician,
3. Traces of the 15$^{th}$-18$^{th}$ century lead ore mining in Devonian limestone in the landscape reserve Karczówka. The unique sculpture of St. Barbara, carved out of solid galena excavated in 1646, is to be seen in the adjacent church,
4. Śluchowice quarry, where unique tectonic mesostructures developed due to Variscan tectonic movements in the Upper Devonian bedded limestones is visible; the main outcropped structure is a recumbent flexure fold (turned to the south) with subordinate foldings in its wide axial zone. Characteristic elements of these forms enable detailed studies of the mechanism of folding (Czarnocki 1949; Konon 2006, 2007),
5. Abandoned Wietrznia quarry with exposed Middle to Upper Devonian carbonates, as well Permian, Triassic and Cenozoic paleokarst (Urban, Gągol 2008) and Permian-Triassic hydrothermal veins of calcite-barite-galena mineralization (Rubinowski 1971). The diversity of forms and fills suggests several phases of erosion and terrestrial deposition related to the tectonic events in Permian-Triassic time (Skompski 1995; Urban 2007).

The idea of public geoeducation has had long tradition in Kielce and Holy Cross Mountains region. Some years ago (2003) it evolved to the concept of the Centre of Geological Education in Kielce, which recently was done in form of the Kielce Geopark (www.geopark-kielce.pl). The Kielce Geopark Centre promotes the geoheritage of the nature reserves (old quarries) situated within the Kielce town and manages these reserves.

Apart from the Geopark Kielce Centre, the Holy Cross Mts. Branch of the Polish Geological Institute (http://www.pgi.gov.pl/pgi_en/) is located in the town. This is also the site of the Chair of Geotourism and Environmental Geology in the Institute of Geography at Jan Kochanowski University. All these institutions have rich geological collections of regional rocks, which are accessible for public. They also offer help in preparation and organization of geotourist trips and students' field trips.

# Mapping geomorphological and cultural heritage for geotourism development, case study: Tessaout valley in central High-Atlas (Morocco)

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Geotouristic maps are produced to promote geological, geomorphological and cultural heritage of the territory; they are useful for tourists who are passionate with the nature, more particularly geodiversity and geomorphosites. The valley of Tessaout is among the three main valleys of the central High-Atlas. It is located in the Moroccan High-Atlas, of which the height is 4068 m in Ighil M'goun Mountain. It possesses a geological, geomorphological and cultural heritage, which is very rich and much diversified. And it has exceptional high-mountain landscapes. The valley attracts a number of tourists every year. However, this number remains restricted because of the lack of tools of promotion, valuation and mediation of the geoheritage. Moreover, the touristic infrastructure is modest.

Regarding this situation, the geotouristic map appears as a tool of promotion of the geotourism and diversification of the regional and national touristic product. This work aims at elaborating new maps of geomorphosites and geomonuments, tangible cultural sites and high-mountain landscapes of the valley, proposed in geotourism circuits. The first results reveal the low exploitation of the geodiversity of this valley-oasis: natural bridge, canyons, dinosaur footprints, spectacular waterfalls, large area of scree, rocky spurs, arid peaks and cliffs of central High-Atlas and the geological history from the Precambrian to the present. In addition, the valley has cultural heritage such as the architecture of the villages, terraced agriculture, geomonuments (Atlas Kasbah, old cooperative storage and the traditional water mills). It has also an intangible cultural heritage: folklore, songs of Tessaout Berbers. This cultural heritage remains poorly valued. This richness was the object of four geotouristic trails and itineraries suggested on a geotouristic map that will be proposed at the end of this work.

**Keywords:** Cultural sites, geoheritage, geomorphosites, geotouristic map, Tessaout valley, High-Atlas

# Urban geomorphological heritage in Cagliari City (Italy): Preliminary results

*R. T. Melis, F. Montis (University of Cagliari)*

The city is an anthropogenic landscape where it is possible to evaluate the geoheritage, despite the impact of urbanisation on landforms. A urban geomorphosite has both natural and anthropogenic origin and it represents a possibility of development for urban geotourism, which allows us to emphasize the relationship between the scientific aspects of a landscape and the culture that characterizes it (Del Monte et al. 2013).

The city of Cagliari, located in the wide Gulf of Cagliari at the centre of the western Mediterranean, develops over an articulated geomorphological context in which the hilly landscape is wrapped up with the coastal one. This particular geomorphological context, characterized by ten limestone hills surrounded by lagoons, the sea and the plain of the Campidano, has influenced the urban development.

In the city, there are still evident traces of the anthropogenic impact of Punic and Roman domination but it is the urbanisation after the World War II that has strongly changed the original conformation of the city. However it is still possible to recognize the characteristic landforms that have guided the urban expansion of the city from its origins until today.

In this work, we present the results of a geomorphological analysis within Cagliari city that led to the production of a geomorphological sketch and an inventory of the geomorphosites in the urban area. The aims of this paper are to divulgate and to promote the geomorphological heritage, and to contribute to the growth of the urban geotourism.

The analysis of the landforms was performed by means of a geomorphological survey through aerial photographs and satellite imagery, the study of cores, historical maps, old historical and archaeological books.

The survey has highlighted some geomorphological (geomorphosites) and cultural sites such as the Tuvixeddu Hill, heavily modified from the Phoenician-Punic necropolis and quarries activity, and Castello-Buoncammino Hill that, for its morphological characteristics, was a natural fortress under the Spanish domination. Moreover, two tourist itineraries are proposed: one that shows the influence of geomorphology in the development of the four historic districts of the city; another, underground, through the numerous cavities, not only places of worship, but evidence of anthropic landforms.

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# From Brocchi to Ponzi and Verri: A century about the mapping soil geology of Rome

*L. Laureti, (University of Pavia)*

The purpose of this paper is to review, together with the evolution of the geological knowledge about the site of Rome, also the carrying out of the cartographic production, mainly during the 19th century, from the field observations made by G. B. Brocchi, with his well-known *Physical map of the soil of Rome* (1820), till to the great *Geological map of Rome* by the Gen. A. Verri (1915) upon a topographic map with contour lines.

After an initial period of still fragmentary knowledge with relatively modest geological mapping, also owing to the lack of reliable topographical basis, a period of concentrated researches follows up, and the leader of which is mainly G. Ponzi, first holder of the chair of Geology in the Roman University. To him is due the just recognition of the Brocchi work about the Roman soil, also by the widen his researches to the Latium region and to the Central Italian Apennine. With aimed excavations (also as tireless fossils collector) into all the Roman hills, he was persuaded about the usefulness of the detail's knowledge. By this point of view it seems possible, in our opinion, to compare the work carried out by Ponzi with the figure and work of T. Taramelli (active mainly in the second half of the 19th century), both joined by the method of the so called "total geology".

Besides to the works of many others, as S. Borkowsky (1816), F. C. Sickler (1821), J. D. Forbes (1828), F. Degli Abbati (1865), P. Mantovani (1874-78), an important contribution was yet given by F. Giordano who, though engaged in the realization of the great geological map of Italy at topographic scale, devoted large part of his time to the study of the physical conditions of the Roman soil (1871-78).

**Keywords**: *Geological Mapping, Roman Geology, Italian Geologists*

# Interpretation and popularization of urban geomorphosites

*M. Taabni, (University of Poitiers)*

The city of Constantine in Algeria shares with Ronda in Spain the fact of occupying spectacular sites, acropolis, rocky plateaus limited by cliffs, steep slopes and deep gorges crossings. The historic centre of Constantine (the old Casbah and the colonial centre) is built on limestone plateau 649 meters above sea level. This site easy to defend explained its choice by the Numidian Berber and then the Romans to build the former city Cirta. It remained up to the 13th century and began to extend outside the "Rock" (name given after the conquest by the French to the original site) after this period while keeping until 1837.

The limestone of the "Rock" has a wide variety of shapes and karst cavities. The canyon through the town, and where flows the river Rhummel is 1800m long, 135m deep at its beginning and 200m at exit Sidi Mcid. The explanation for the formation of these landforms has resulted during the colonial period debates between geologists, geographers and archaeologists. The characteristics of this geomorphosite confer it a real geoheritage value. Along its route we can observe vaults, and arches, basins bleachers with travertines.

It represents a remarkable interest for its geological and geomorphological history (scientific value, cultural interest by the values attached to landscapes and the links with the urbanization of the site that has induced in particular the construction of many structures (the bridges). These urban geomorphosites of Constantine, widely recognized by locals and visitors, are a heritage that deserves to be protected and transmitted; they have received no development program nowadays.

In collaboration with academics from the University of Constantine (geologists, geographers and architects), I initiated discussions since January 2016 on the subject of urban geomorphosites in Constantine through several approaches and goals. The systematic inventory of the sites, their characterization as markers of geomorphic evolution, selection argued for geomorphosites protection, tools, development means and materials according to targeted audiences.

The formalization of the project is being finalized at the end of this working paper and it will be forwarded to the directions of the culture of the municipality and the Wilaya (Department) for its feasibility in collaboration.

This contribution will present the project and the progress of the reflection state about it.

**Keywords**: Urban geomorphosites, Constantine, heritage landscapes, karst, interpretation, conservation.

# Urban geomorphological heritage of an Alpine town: Sion (Valais, Switzerland)

*E. Reynard (University of Lausanne)*

Sion is a small Alpine town situated in the Western Swiss Alps, along the Rhone River. With 30,000 inhabitants, Sion is the administrative capital of the canton of Valais and proposes numerous working places, in particular in the tertiary sector. Situated originally on the alluvial fan of the Sionne River, a tributary of the Rhone River, the town has grown rapidly during the 20th century and occupies now the whole surface of the Sionne River alluvial fan, and large parts of the Rhone River alluvial plain. Occupied since prehistoric times, the town has been the capital of the Bishop of Valais for centuries since the Middle Ages. It presents therefore a very rich archaeological and historical heritage that constitutes the original offer for tourism. Recently, Sion has also developed new tourist services based on the concept of "urban terroir", trying to combine cultural urban and rural heritage.

This poster aims at studying the relationships between the geomorphological forms, processes and heritage, and the urban development. The analysis combines four main methods:

- a simplified geomorphological map is created;
- a geohistorical analysis of the landscape evolution, in particular fluvial landscapes, combining historical maps of the two last centuries, is carried out;
- an inventory of regional geomorphosites is carried out using the method of the University of Lausanne (Reynard et al., 2016);
- a concept for the development of urban geotourism is proposed.

**Reference**

Reynard E., Perret A., Bussard J., Grangier L., Martin S. (2015) Integrated approach for the inventory and management of geomorphological heritage at the regional scale, *Geoheritage*, 8(1), 43-60. DOI: 10.1007/s12371-015-0153-0

# Urban Geoheritage and Geotourism: a neglected value to conserve and promote

*M. L. Rodrigues (University of Lisbon)*

The concept of geotourism is inseparable of the geoheritage one, because there is not geotourism without geosites. So, the differences we can found in research and applied papers are those related to the definition of geoheritage and geosites. For most of the classical geologists (those that only deal with geological issues), the geoheritage concept is equivalent to geological heritage and the geosites are geological sites. If we follow this idea geotourism is a type of tourism with a geological purpose. This is, at least, a very narrow definition that does not include every aspect of the Earth sciences. That is why some surveys of urban geosites are only formed by geologic exposures not totally destroyed by the urbanization plans. In Lisbon there is such a survey, the so-called geomonuments, that does not include other valuable abiotic elements such as the landscapes and the geomorphological or hydrological sites.

Another point of view about geoheritage has been developed by other Earth scientists like geomorphologists with different background formations (including geologists that are concerned with landscapes or with geomorphologic issues). For them the geoheritage is formed by any valuable abiotic element that should be preserved due to its heritage value. So, geoheritage includes not only the geological geosites but also the geomorphological geosites, the valuable soils (like paleo-soils) and the hydrological geosites (neglected by researchers that subdivided them in the geohydrology, normally studied by geologists and some hydrologists, in the hydro-geography approaches or in the strict sense of the hydrologic processes). Due to the minor importance conferred to the non-geological sites some geomorphologists adopted the term geomorphosites to name those linked with geomorphic forms and processes. This wider point of view of the geoheritage concept includes a lot of the Earth non-biological values and points to a different definition of geotourism, as a type of tourism focused on the sustainable usufruct (by geotourists and local communities) of all types of geoheritage, with the aim (in what concerns local or regional communities) of providing a sustainable development of those areas. That is why most of the applied work in this field are normally devoted to rural areas or simply mountainous areas, because they have a richer preserved geoheritage and, at the same time, the population that lived there needs more support for its development. The result of the above mentioned ideas is the neglect of works in the field of geoheritage and geotourism in urban areas. This is also linked with the prejudice that the rural and mountainous areas have the most beautiful landscapes. However, nowadays a large number of tourists choose to visit cities with the objective to admire the cultural heritage and to experience different ways of living (merging with the locals). They are not interested to see urban geoheritage simply because they do not know that there is urban geoheritage. To illustrate this idea some examples of Lisbon geoheritage will be given.

**Keywords**: Geoheritage and Geotourism concepts, Urban Geoheritage, Lisbon

# The cliff of Monastir (Sahel region, Eastern coast of Tunisia): example of urban planning destroying geomorphosites

*T. Ben Fraj, F. Brahim (University of Sousse)*

The coast of Monastir is a part of the oriental coast of Tunisia, which extends over approximately 900 km between the region of El Haouaira and the Tunisian-Libyan borders. Characterized mainly by the extension of the sandy beaches and the maritime marshes, this coast includes also some rare sectors with little spread cliffs such as the cliff of Monastir. It characterizes the coast of the cape of Monastir, which separates the bay of Skanes on the West from that of Khenis in the East. The length of the cliff is about 7,3 km. Its command varies between 4 and 25 m and is outstripped by five islets.

The oriental part of the cliff and the islets are shaped in fossiliferous stonewares of the Pliocene overlain by a calcareous crust. Several segments of this cliff hold Roman quarries that have exploited these sandstones. The northern part is shaped in the Miocene series of clay, sand and stoneware oblique layers. These series are surmounted, in angular unconformity, by 1 to 2 m thick transgressive marine deposits of the Tyrrhenian made of biodetritic sands characterized by the abundance of *Stombus bubonius* fauna having lived in the Mediterranean Sea during this period of the Quaternary. Finally, comes a 0,5 to 2 m thick brown sandy-silt soil deposit of Holocene to historical ages. At the foot of the cliff are present several hectometric creeks shelter beaches 2 to 5 m wide where settle down the summer vacationers.

This whole morpho-sedimentary scheme allows us to reconstitute an important part of the geologic and geomorphological history of the region between the Miocene and the Tyrrhenian. Indeed, after their deposition, the Miocene series were affected by tectonics, which strongly inclined them. The dip varies between 20 and 45 ° and can be subvertical by places. During the Tyrrhenian, marine deposits truncated the Miocene series and came to cover them according to an angular unconformity. The altitude position of marine Tyrrhenian deposits raises a problem. How to explain that it is at height of 25 m while on all the Tunisian coast the height of this fossil beach does not exceed 15 m? The solution was found in the effects of the Saknes fault, which lifted, since the Tyrrhenian, the plateau of Monastir at a maximal height of 31 m dominating at the West, by a talus, the subsided Sebkha of Sahline.

In addition to this reconstruction, the cliff of Monastir presents very pedagogical examples of the dynamic evolution of these types of coasts, in particular landslides, slips and gullies. It presents a complex and fast evolution.

Many interventions interested an important part of the cliff between the 1960s and 1980s. In the South was installed the fishing port. Near the City centre was built an esplanade and close to it a marina on the surface subtracted from the sea by linking the cliff with two of the islets. To the West of the marina, 900 m of the cliff were built by ripraps and reprofiling its slope. The rest of the cliff knew only light and localized interventions since the 1960 s. There were reforestation actions and construction of dry stone thresholds for the stabilization of slopes and gullies.

Today, this urban geomorphosite is partially destroyed following heavy intervention under the pretext of stabilizing the cliff, protecting the road, which lines it as well as

the close constructions, creating recreation areas and an artificial beach. However, even if the evolution of the cliff can be considered fast, it does not justify intervention by these heavy methods. Already the light interventions of reforestation and construction of dry stones thresholds, although badly maintained, showed efficiency. Heavy interventions present ripraps surrounding the base of the cliff and the reprofiling of the front and the summit of the cliff by making four terraces buried by concrete. These actions have widely disfigured the landscape and destroyed the Tyrrhenian deposits and the Miocene series depriving forever the City of Monastir of its coastal geomorphosite.

The part of the cliff, which escapes up to now to these interventions does not exceed 1 km. Its protection is essential to not deprive such touristic town of this important geomorphosite. Calls to declare the cliff of Monastir as *non aedificandi* zone began in the 1990s to protect this geoheritage and to opt for light interventions but in vain.

**Keywords:** Tunisia, Oriental coast, Cliff of Monastir, urban geomorphosite, destruction.

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# Geotouristic itineraries in Bucharest city (Romania)

*L. Comănescu, A. Nedelea (University of Bucharest)*

The present paper aims at inventorying and evaluating the geomophosites in Bucharest and its metropolitan area as well as introducing geotouristic itineraries that take into account the long-time developed high value cultural heritage of the area.

The process included several stages: studying Bucharest's relief from existing bibliography, cartographic methods (aerial photos and different editions of topographic maps), as well as the information gathered from field investigations; identifying and inventorying geomorphosites, evaluating geomorphosites mainly based on their cultural value; creating geotouristic itineraries and later promoting them.

Bucharest's relief is mainly represented by Bucharest Plain with its subunits (Băneasa Field, Colentina Field, Cotroceni Field, Colentina Valley, Dâmboviței Valley), the altitudes vary between 50 and 120m, fragmentation density between 0 and 1,5km/km$^2$, a low general slope (1-3˚). The Bucharest Plain formed through the gradual retreat of the Getic lake and then silt accumulating, followed by loess and loess deposits during Late Pleistocene. The Plain has completely rose above sea level at the beginning of the Holocene era, and was later sculptured by multiple generations of valleys and transformed by anthropic activity.

The most valuable and representative geomorphosites identified at this point in time in the study are: on Colentina Valley: the Plumbuita, Dobreşti, and Pantelimon hills; on Dâmboviței Valley: Cotroceni terrace; Uranus - Mihai Vodă, Mitropoliei, Spirii, Movila Mare, Radu Vodă, Cişmigiu, and Filaret hills.

The authors suggest two geotouristic itineraries that emphasize the relationship between the scientific, cultural, and historic elements as well as the human-nature report within the urban area.

The first itinerary is: Cotroceni Hill (Cotroceni Palace, Botanical Garden) – Romanian Opera – Dâmbovița Valley - Cişmigiu (Kretzulescu Palace) - Spirii Hill (Palace of Parliament) - Filaret Hill (Carol Park including the Mausoleum and Suter Palace).

The second itinerary is: Dâmbovița Valley (Palace of Justice, Antim Ivireanul Church - Mitropoliei Hill (Patriarchal Palace) - Saint Ecaterina Chruch - Saint Spridon Chruch – Curtea Veche Museum and Church – National History Museum – Stravopoleos Church – National Bank Museum – Bucharest University.

# Geoheritage is fun! Gamification in smartphone application for geoheritage promotion

*L. Grangier, C. Kaiser (University of Lausanne)*

For more than 10 years, the Institute of Geography and Sustainability (IGD) of the University of Lausanne (UNIL) works on geoheritage assessment, protection and promotion. An assessment method for geosites has been developed that is used by several other universities in the world (Reynard et al., 2009). Recently, the research focus has shifted towards scientific mediation and tourism promotion of geoheritage, widely for nature tourism. We developed a smartphone-based interactive guide for educational itineraries covering several environmental topics and we have conducted user tests comparing different versions of the app (Reynard et al. 2015).

Currently, research is done to develop methods that can improve user experience, knowledge acquisition and create a fun learning and knowledge exploration environment. Methods and concepts of gamification – the use of game elements in a serious context – are studied in this context. Insights from gamification for education and for business can apply in the case of the GeoGuide application where the product is free and users have to be motivated to learn scientific facts on a voluntary basis outside of a scholar environment. Generally, studies on gamification for education are based on classroom experiments with students and teachers (Cheong et al. 2013; Denny 2013; Sousa Borges et al. 2014; Dicheva et al. 2015). While these studies certainly apply to our case, the additional dimension of motivation and voluntary knowledge acquisition needs to be taken care of in a leisure context.

For the 10th anniversary of the Faculty of Geosciences and Environment (FGSE) of UNIL we developed a free smartphone application available for iOS, Android and a desktop version (http://igd.unil.ch/geoguide[1]). GeoGuide offers an itinerary of 30 stops through the city of Lausanne to the campus of the University. The aim of the application is to present to the public the different research works of the faculty related to the field. The user gets to know the city from the perspective of hydrology, geology, geomorphology, urban planning, archaeology and history. Every stop shows one topic with texts, pictures, and movies.

To improve the interest, the use of the app and the user experience and in order to understand what is the best way to communicate about science, we are working on a gamified version of GeoGuide. In this version you go in a treasure hunt in the city. You have the choice between three map representation modes: path only, stops only, stops and path. While walking, if the user is near to a stop, he receives a notification on his smartphone that describes the exact position of the point of interest. From that, the user can launch other actions related to the stop. After the presentation there is always a multiple-choice quiz or something to do – like puzzle – in order to anchor the new knowledge.

We aim to understand what are the benefits of gamification in geotourism promotion. It is now established that gamification can increase the motivation and the involvement of a product (Hamari et al. 2014). But as far as we know, these results are based on qualitative studies and physiological answer of gamification was never assessed. We will present during the workshop some results of our actual studies.

[1]The GeoGuide Lausanne V.1 is the actual public version available on the web. The gamified V.2 experimental version is not online yet.

**Keywords**: GeoGuide, geoheritage, gamification, smartphone application.

# The possibilities of geotourism development in a small Polish town (Pruszków, central Masovia)

*M. Górska-Zabielska (Jan Kochanowski University), R. Zabielski (Polish Geological Institute)*

Pruszków, a district town on the south-western Mazovia, is the largest city, outside Warsaw, in the Warsaw agglomeration. The city is growing very rapidly. In addition to its primary role – the bedroom of the capital – it also provides an interesting cultural offer for its inhabitants. The natural biotic and abiotic background of the small town is not appreciated at all. Georesources of Pruszków and its immediate surroundings are now in the urban landscape hard to see because of increasing human pressure. Hence the lack of awareness among Pruszków residents about presence of natural objects at their fingertips can be noted.

The purpose of this contribution is to prove that each, even small, town (for instance from Poland), has abiotic resources which may transform into geotouristic values. The key initiatives belong to local self-government institutions, landscape interpretators, local patriots and geography teachers who are obliged to disseminate their knowledge and experience among town inhabitants and, possibly, (geo)tourists.

All the abiotic resources of Pruszków are the wealth of the local geological heritage. They are intertwined with the topography, history, folklores and the local economy. The objects are valuable incentives motivating to explore the sources of identity of the inhabitants. There are also storage media for further and closer history of this part of Poland.

Geological resources of Pruszków and the outskirts consist of:

- glacial weathered landscape, whose origin dates back to the Wartian Glaciation (185-130 ka BP; Mojski 2005),
- vast areas of open Błońsko-Łowicka Plain, developed as meadows and cultivated fields, are the foreground for the palaces, manor houses and parks, exposing their architectural and compositional qualities (Bielawski 2009),
- glacial till of poor permeability, a feature especially valuable in agriculture,
- excavation voids and artificial ponds in places of former Neogene clays mines for prosperous brickyard companies in 19$^{th}$-20$^{th}$ century (Kaleta 2010),
- bog ore, which in the period 200 BC to 400 AD, became the basis for the development of a large centre in Barbarian Europe of production and processing of iron (Skwara 2002; Woyda 2006); the archeological artifacts are to see in the Museum of Prehistoric Metallurgy,
- water – underestimated natural resource by the inhabitants of Mazovia – appears in rivers, left tributaries of Vistula, vintage hydraulic engineering systems in the former land properties (Skwara 2002; Lewin & Root 2008; Jakubowski 2009) and as city groundwater resources, operated for the needs of the residents,
- stones – hardly noted by the inhabitants – with their cognitive, educational, conservation, aesthetic and, finally, geotouristic sense (Reynard 2004; Migoń 2012; Górska-Zabielska 2010, 2015); they appear as big glacial boulders, aesthetic ornaments in churches, parks and private properties and stony walls (Ital. - *gabbione*) in a city open area.

# Volcanic necks in the area W of Lisbon city – A geoheritage resource for the implementation of Geotourism

*M. L. Rodrigues (University of Lisbon)*[1]

The CVL (Volcanic Complex of Lisbon) testifies the last volcanic event in the Portuguese mainland (excluding the volcanic islands of Madeira and Azores). The volcanic materials (lava flows mainly basaltic, tephra and volcanic ashes), covering around 200km$^2$, cover the pure and massif limestone beds from the lower part of the Upper Cenomanian (Turonian) and so the volcanic episode occured from the Upper Cenomanian (around 72 M.A. ago) till the lower and medium Paleogene period.

The main volcanic cones were located in the area North of Lisbon (mainly in the municipality of Mafra and in its contact with the one of Loures), but smaller volcanic apparatus are scattered in the present urban area W of the Lisbon city, from the base of Sintra mountain almost till the Tagus right bank and occupying areas within the municipality of Lisbon (like those of the Monsanto Forestall Park and of the western part of the built area). This paper is about the remains of those smaller volcanic apparatus near and within the city of Lisbon.

The detailed fieldwork survey, with the filling of inventory sheets for each volcanic neck and the construction of geomorphologic maps, allows us to identify, classify and evaluate the remains of those volcanic necks (the volcanic necks themselves are already very eroded and only correspond to the basal part of the original necks). Although the consolidated lava that supports the necks is quite hard, some necks were completely destroyed by men to construct buildings or industrial and road infrastructures.

However, due to the extreme difficulty to flatten and build upon the basaltic necks (and due to the expenses linked to this type of works), most of those remains stand out in the landscape.

The inventory, classification and evaluation will be discussed in the presentation as well as the problems linked to the accesses, human occupation (vulnerability) and geotourism potential. A geotourism map was done including the potential itineraries and the tourism infrastructures. Some guidelines to the municipalities involved are presented in order to rehabilitate and revitalize these geoheritage resources and promote them to the local population and the potential tourists.

**Keywords**: Lisbon, volcanic necks, urban geoheritage, geotourism.

[1] With the collaboration of Bogdan Jaranovic, Joana Coutinho, Raquel Fernandes and Irene Marrafa.

# Secondary geodiversity and its potential for urban geotourism: a case study from Brno city

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Secondary geodiversity or man-made/anthropogenic geodiversity (represented by the anthropogenic landforms as quarries, pits, communication cuttings or underground spaces) represents a considerable resource for geotourism and geoeducational activities within urban areas.

Brno (the second largest city of the Czech Republic, situated in the region of South Moravia) is rich in these landforms. Some of them (especially old quarries) are already used for recreation and leisure or they serve as excursion localities for the university students, some of them are unique from the geoscience point of view and they have also certain added values (historical, archaeological or ecological), however, in some cases, their potential is not fully recognized.

The most important sites within Brno (which are already used both for recreation and education) are the limestone quarry of Hády on the north-east of the city, the Červený kopec (Red hill) with small conglomerate quarries and loess profile (which displays the sequence of the soils during the last 2 Ma years), active sand pit of Černovice (where the marine sediments can be found and it is also an important palaeontological site) and Stránská skála where the palaeontologically rich crinoid limestone can be found and there are also significant underground spaces. From the tourist point of view, the most remarkable is probably the Brno underground – the system of cellars under the Zelný trh and Ossuary under the St. James Church. Nevertheless, there are other anthropogenic landforms, where the tourist, recreational and educational potential has not still been developed, e.g. abrasion cliffs on the Brno dam or communication cuttings in the various parts of the city. These landforms uncover the features, which would normally remain hidden, so they increase the overall geodiversity of the urban area. As they show the various geological issues or geomorphological processes, they can serve as a resource for urban geotourism and from the geoeducational point of view, they can be used as a terrain handbook for Earth sciences.

**Keywords:** anthropogenic landforms; urban geosites and geomorphosites; excursion localities; geotourist and geoeducational activities