UNIVERSITY OF LJUBLJANA
FACULTY OF ARTS
DEPARTMENT OF GEOGRAPHY

# DIPLOMA THESIS

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# GEOMORPHOLOGICAL CHARACTERISTICS OF POCKET VALLEYS IN SLOVENIA AND FRANCE

Study programme:
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**STATEMENT**

I declare that this diploma thesis is a result of my authorial work.

Jure Tičar

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*»…Unlike Sisyphus, we don't begin from scratch. Each generation takes over from the previous, pays homage to its predecessors' hard work, insight, and creativity, and pushes up a little further. New theories and more refined measurements are the mark of scientific progress, and such progress builds on what came before, almost never wiping the slate clean. Because this is the case, our task is far from absurd or pointless. In pushing the rock up the mountain, we undertake the most exquisite and noble of tasks: to unveil this place we call home, to revel in the wonders we discover, and to hand off our knowledge to those who follow…«*

Brian Greene, The Fabric of the Cosmos

**GEOMORPHOLOGICAL CHARACTERISTICS OF POCKET VALLEYS IN SLOVENIA AND FRANCE**

***Abstract:***
This diploma thesis examines geomorphological characteristics of pocket valleys in Slovenia and France. Pocket valleys are typical landforms of outflow part of contact karst. Twenty-six typical examples of pocket valleys were identified and geomorphologicaly examined in detail. Existance of linear pocket valleys, which are developing in one cirque and existance of detritical pocket valleys, which are developing in multiple cirques and are highly branched, was confirmed. Identified polygenetic development of pocket valleys led to the typification of pocket valleys on: erosional pocket valleys, phreatic pocket valleys, epiphreatic pocket valleys and glacial pocket valleys. Pocket valleys are sometimes merged with other karstic landforms such as dolines and collapsed dolines. Detailed geomorphological examination and morphogenetic interpretation confirmed the influence of lithology, geological structure, characteristics of waterflow discharge, formation of cave systems in the rim of pocket valley and the level of regional surface landforms above which pocket valleys are situated on the development of pocket valleys.

**Keywords:** geomorphology, karstology, contact karst, pocket valley, morphogenesis, Slovenia, France

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## 4.4. GRAND COYER MASSIF

### Characteristics of the area

Grand Coyer massif is part of the Alps of High Provence in south-east of France that stretches between upper parts of Var and Verdon Rivers and covers an area of about 200 km$^2$. To the south the massif is limited by eastern part of Castellane Subalpine chain and towards the north by Champs mountain pass (d'Antoni-Nobécourt, Audra, 2009). Grand Coyer Massif consists of numerous peaks that are divided by the Valley of Coulomp River and canyons of its tributaries. In opposite of typical alpine ridge orientation in surrounding area, massif has a ridge orientation in north-south and northwest-southeast direction.

**Figure 44: Grand Coyer Massif.**

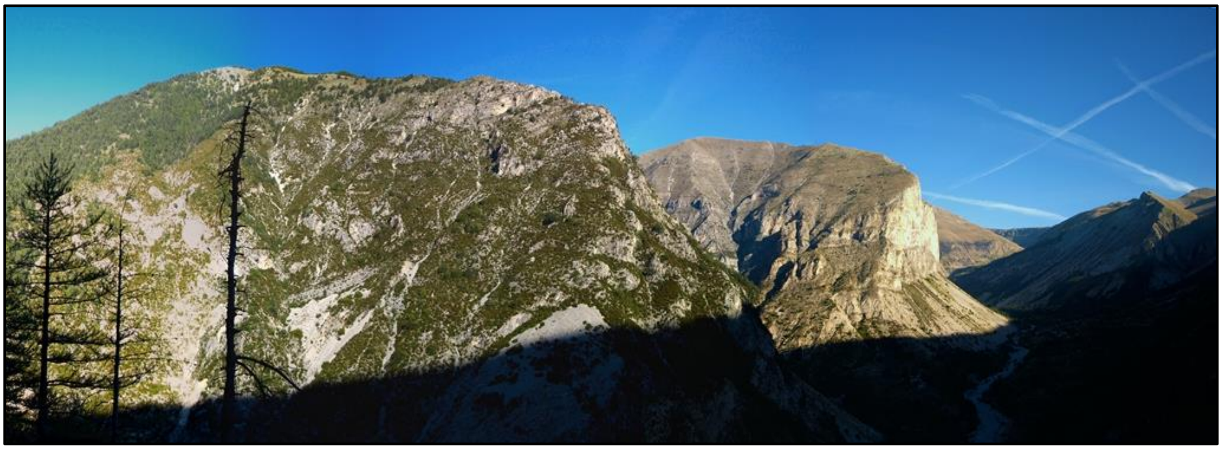
**Author: Jure Tičar, 2011**

The highest part of mountain massif is the peak of Grand Coyer in the north with an elevation of 2.693 m, whereas the examined pocket valley is developed in 2.088 m high mountain of Montagne de Beaussebérard. Most of the surrounding peaks do not exceed the elevation of 2.000 m a.s.l.. Lowest parts of this area are in the valley at the confluence of Coulomp and Ravin de Grande Plane Rivers near the Aurent Village at an elevation of 1.150 m a.s.l.. A distinctive fluvial mountain relief with a certain characteristics of glacial erosion predominates in this area. Due to the lithological conditions only few karst surface features can be distinguished. They are present in form of karst springs, ponors and few horizontal caves. Limestone beddings that are interbedded between layers of marls are forming escarpments on slopes and small karst plateaus. In marls beddings numerous badlands and erosional gullies are formed.

Geological structure of Grand Coyer massif consists of syncline oriented towards south what is also orientation of rock layers (Bertrand, 1914). In the base of massif Cenomanian marls occur. Marls are overlaid with Cretaceous limestone and marly limestone, one top of which lies a thin layer of nummulitic limestone. Furthermore Eocene marls overly limestone beddings. The top of lithology column is represented by sandstone. Due to the overly of impervious and semi-permeable layers over Cretaceous limestone, infiltration into the karst aquifer is mainly diffused. In some areas outcrops of thin bedded marly limestone allow a concentrated recharge of surface water (Audra et al., 2009). Sandstone that overlies all of the strata is very resistible to the erosion and protects the layers below.

In the area of Montagne de Beaussebérard two different directions of faults can be distinguished. Main fault is developed in an N-NE – S-SW direction, its position can also be seen south of the Coulomp Spring on the slopes of Montagne d'Argenton. Due to the main fault on the slopes of Montagne de Beaussebérard a wide zone of fractured and folded rock is present. In the direction of the main fault a cave system of La Grotte des Chamois has developed. The second direction of fault, that can be only observed in this cave system is directed in E-SE – W-NW (d'Antoni-Nobécourt, Audra, 2009).

**Figure 45: The Montagne de Beaussebérard in the hinterland of Montagne d'Argenton.**



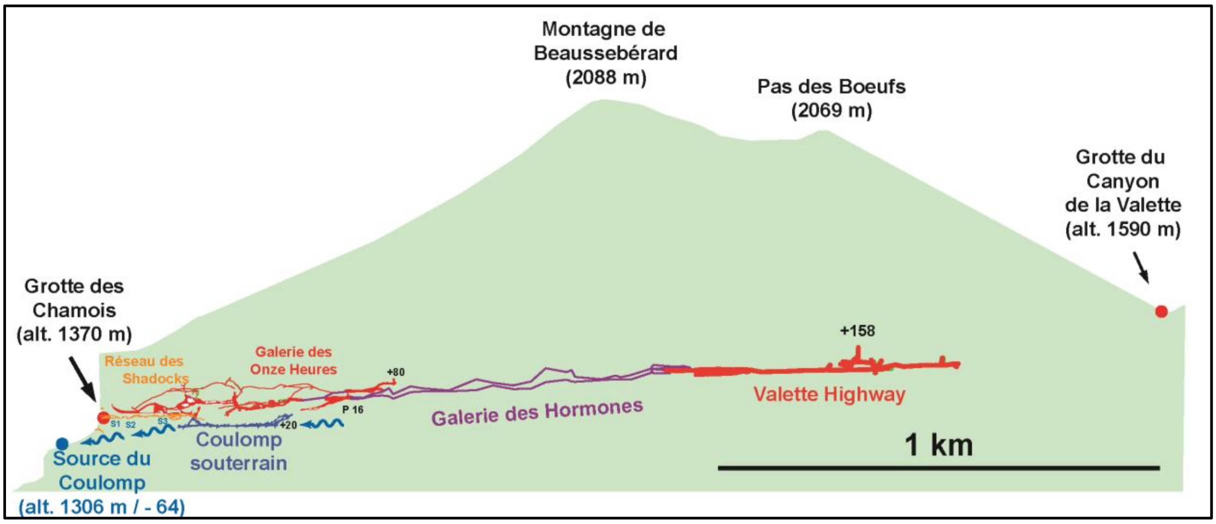
**Author: Jure Tičar, 2011**

Karst aquifer of Coulomp is developed in Cretaceous limestone and extends over an area of 18-37 $km^2$ (Audra et al., 2009). Coulomp Spring is located in the slope of Montagne de Beaussebérard and lies at an elevation of 1.306 m a.s.l.. Spring is followed by a 60 m high waterfall that flows into the Pasqueiret Valley. The most important spring in watershed of Var River has a mean discharge of about 1 $m^3/s$ (Audra et al., 2009). Highest discharge levels of 15-20 $m^3/s$ were measured during the floods in November of 2011 (Audra, 2011). According to lithological characteristics of an aquifer, two different types of infiltration are predicted. Diffused infiltration of precipitation through strata that overlies limestone is the main source of water for an aquifer. On the other hand, high water flows through the cave system have its source in concentrated infiltration of water into karst aquifer from marls and sandstone areas (d'Antoni- Nobécourt, Audra, 2009). During floods, other springs in Coulomp Pocket Valley are active, such as the entrance to the cave system of La Grotte des Chamois (Audra, 2009).

### Speleological characteristics

Only few caves were discovered in this area due to the relatively small outcrops of karst rocks. Some smaller caves are in the Valette Valley on the northern slope of Montagne de Beaussebérard Mountain. The formation of these caves is connected with the speleogenesis of La Grotte des Chamois Cave System that was later cut in smaller segments due to the intensive fluvial erosion of Valette Valley. Smaller caves have large dimensions of cave passages (few meters high and wide) often filled with large amounts of gravels (Audra, 2011).

**Sketch 23: Profile of La Grotte des Chamois Cave System.**




**Author: Philippe Audra, 2011**

Entrance to the La Grotte des Chamois Cave System opens 64 m above Coulomp Spring and 15 m above the bottom of Coulomp Pocket Valley and consists of 4 m wide fossil passage (Audra et al., 2009). In latest explorations, about 10,5 km of cave system was discovered. Main passages follow the fault formation in N-NE – S-SE direction towards the Valette Valley (d'Antoni- Nobécourt, 2011).

### 4.4.1. COULOMP POCKET VALLEY

**Location**

Coulomp Pocket Valley has developed on southwest slope of Montagne de Beaussebérard Mountain, around 1,5 km western from village of Aurent. Its central part is developed in N-NE – S-SE direction (210°), whereas its last part in the vicinity of waterfall follows the N-NE – S-SW direction (145°).

**Figure 46: Coulomp Pocket Valley.**

**Author: Jure Tičar, 2011**

## Geological characteristics

Coulomp Pocket Valley has developed in Upper Cretaceous limestone and marly limestone, which are covered with Eocene marl and sandstone. The main direction of pocket valley is following the main fault in N-NE – S-SW. To the east of fault axis, layers of limestone are uplifted by 40 m, comparing to the west of fault axis. Entrance to the cave and erosional gully above the pocket valley have developed in the direction of main fault. Crosswise to the main fault, smaller fault is directed in N-NW – S-SE. To the west pocket valley is limited by the fault in N-S direction (Geološka karta…, 1980a; Geološka karta, 1980b).

## Hydrological characteristics

Spring of Coulomp River has developed around 120 m below the cirque. Its mean discharge reaches around 1 $m^3/s$ (Audra et al., 2009), whereas in flood season the discharge can rise up to 20 $m^3/s$. About 10 m below the spring, Coulomp River flows through 60 m high waterfall into the Pasqueiret Valley, where the last part of pocket valley is developed. In the flood season smaller springs are active below the cirque, at the foot of western scree and at the entrance to the La Grotte des Chamois Cave System. Due to the heavy rainfall, smaller streams in erosional gully above the pocket valley are active and flowing in waterfall to the bottom of pocket valley (Audra, 2011).

**Figure 47: Sixty meters high waterfall of Coulomp River.**

**Author: Catherine Frison, 2011**

**Morphographic and morphometric characteristics**

The length between the cirque and end of the pocket valley is 470 m, whereas its width varies from 160 m at the end and 230 m in a cirque. Floor of pocket valley is with 20 m widest at the cirque and narrowest below Coulomp Spring with only 5 m of river bed. Coulomp River emerges from the karst aquifer at the elevation of 1.306 m a.s.l.. Above the spring there is a 164 m high cirque, above which 170 m high erosion gully continues. Highest point of the pocket valley is at the top of erosion gully at the elevation of 1.640 m. End of pocket valley lies at the elevation of 1.225 m below the Coulomp Waterfall.

Cirque of the Coulomp Pocket Valley lies at northern side and consists of 164 m high wall, which has developed along the fault in direction N-NW- S-SE. In the wall we can distinguish a large fault, among which La Grotte des Chamois Cave System and Coulomp Pocket Valley had developed. Above the cirque lies a larger erosion gully, whereas below the cirque extensive screes and river-bed of intermittent stream are developed.

**Figure 48: Scree on the western slope of Coulomp Pocket Valley.**

**Author: Jure Tičar, 2011**

Eastern slopes of cirque consist of walls, which are gradually lowering towards the Spring of Coulomp River. In the high walls a cuesta with small scree has developed. Below the walls are screes and rock-fall material.

Western slopes of cirque have 30-40 m high walls with extensive screes below, which are stretching to the floor of pocket valley. The top part of northwestern scree is balanced by the vegetation and small escarpment has formed. In western part of slope two deformed and unstable rotational blocks of rock are present.

**Figure 49: Entrance to the La Grotte des Chamois Cave System is located in high walls of cirque.**

**Author: Jure Tičar, 2011**

The floor of pocket valley consist of intermittent river bed in cirque and active river bed of Coulomp River, which descends down the waterfall towards Pasqueiret Valley. Floor of pocket valley is located below the eastern walls, west from the floor scree slopes ascend.

**Figure 50: Morphology of Valette Highway Passage that is covered with gravel.**

**Author: Jean-Yves Bigot, 2011**

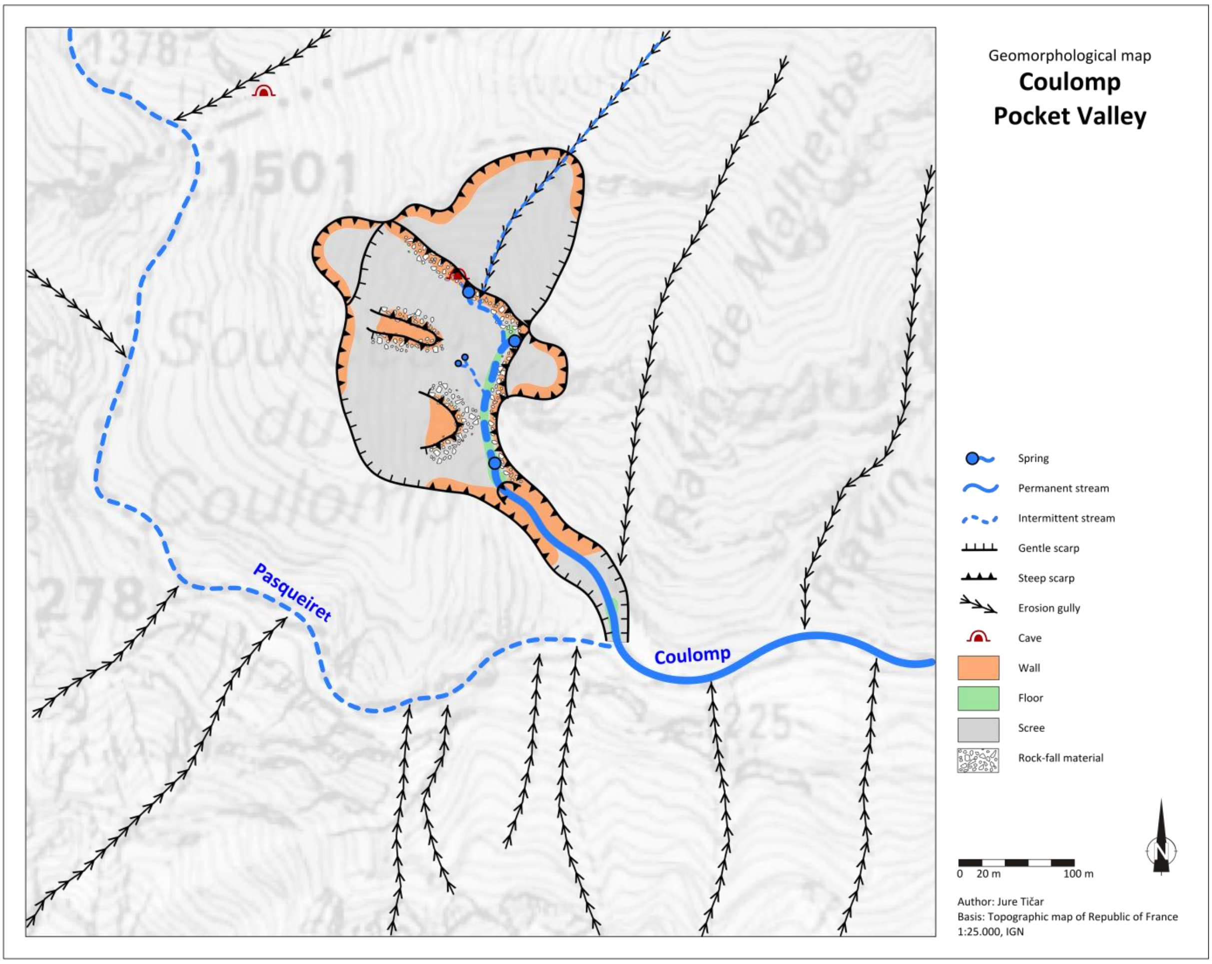
## Morphogenetic characteristics

Coulomp Pocket Valley has developed along the main fault in N-NE – S-SW direction, above the present spring of Coulomp River such as the upper levels of La Grotte des Chamois Cave System. Floors of these passages are partly filled with large quantities of gravel (10 x 10 cm), thereby a large underground flow from the northern part of Montagne de Beaussebérard Mountain created and later deposited material in cave. In the Ravin la Valette Valley on the northern face of mountain small segments of large cave systems that are filled with large quantities of gravel were also discovered. In the past, a lot of passages on the southern side above the Pasqueiret Valley that are now covered with scree material in cirque were still active. The period of relative stability ended with a fast down cutting of valleys in this area that could be connected with a period of Pleistocene glaciation. Due to the fast down cutting, hydrological conditions in cave and pocket valley consequently changed dramatically. The bottom of pocket valley has deepened and hydrological changes in cave system resulted in activation of present Coulomp Spring. In the last period, accumulation of material from the slopes has enlarged and extensive screes that covered old cave passages were developed. In the time of floods some of these older channels below the screes are still hydrological active. At that time fluvial erosion of scree material in the Coulomp Pocket Valley is a dominant process.

**Figure 51: Underground Coulomp River.**

**Author: Jean-Yves Bigot, 2011**

**Map 16: Geomorphological map of Coulomp Pocket Valley.**




**Author: Jure Tičar, 2011**

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