

ACTA CARSOLOGICA	34/2	9	439-448	LJUBLJANA 2005
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COBISS: 1.01

**THE MONTELLO HILL: THE “CLASSICAL KARST”
OF THE CONGLOMERATE ROCKS**

**GRIČ MONTELLO – »KLASIČNI KRAS«
V KONGLOMERATNIH KAMNINAH**

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Abstract

UDC: 552.512:551.44(450)

Francesco Ferrarese & Ugo Sauro: The Montello hill: The “Classical Karst” of the conglomerate rocks

The Montello hill is, probably, the most typical morphounit between the karsts developed in conglomerate rocks. It may be considered the classical karst of the conglomerates comparable with the Classical Karst of limestones: the Carso of Trieste. The Montello hill consists in an elliptical plan figure, elongated for about 13 km in a WSW-ENE direction and a width of about 5 km. The rock unit involved is the “Conglomerato del Montello” of late Miocene age (Messinian), mostly composed by carbonate pebbles bound by a calcitic cement, which is 2000 m thick. The Montello is shaped by a complex system of fluvial planation and incision forms in which are distinguishable a main plateau and a stairs of seven planation rock cut terraces. The terraces are cut in the slope of a dead antecedent valley. On the fluvial planation forms, dolines, mostly of the drawdown type but also of the point recharge type, have evolved. In total more than 2000 dolines are present. In the seven rock cut terraces the dolines show different development and dimensions according with the ages of the surfaces. In the first morphogenesis of these dolines and of the caves the control of the plan structures as the bedding surfaces and the fractures seems to have been feeble; on the contrary the porosity of the conglomerate has been a determinant factors for the development of the karst drainage.

Key words: conglomerate karst, karst geomorphology, doline, Montello, Italy.

Izvleček

UDK: 552.512:551.44(450)

Francesco Ferrarese & Ugo Sauro: Grič Montello – »klasični kras« v konglomeratnih kamninah

Grič Montello je najbrž najbolj tipična morfološka enota krasa, razvitega v konglomeratnih kamninah. Lahko ga štejemo za klasični kras v konglomeratu, primerljivim s klasičnim krasom na apnencu, Tržaškim Krasom. Montello je v tlorisu ovalen, dolg približno 13 km v ZJZ – VSV smeri ter širok okoli 5 km. Razvit je v »montelskem konglomeratu« poznomiocenske starosti (mesinij), ki ga gradijo največ karbonatni prodniki zlepljeni s kalcitnim vezivom, debeline do 2 000 m. Montello je oblikovan v cel sistem oblik, nastalih zaradi rečnega uravnavanja in vrezovanja, vidnih na osrednji planoti in sedmih živoskalnih uravnanih teras. Teraso so vrezane v pobočje opuščene antedecedentne doline. Na rečni uravnavi so se razvile vrtače, večinoma iz grezov pa tudi zaradi točkovnega prenikanja. Vsega skupaj jih je preko 2000. Vrtače na sedmih živoskalnih terasah kažejo različen razvoj in različno velikost glede na starost površja. Kaže, da je bil v začetni fazi morfogeneze vrtač vpliv strukture, to je lezika in razpoka, šibak; nasprotno pa je bila poroznost odločujoči dejavnik za razvoj kraškega odtoka.

Ključne besede: kras na konglomeratu, geomorfologija krasa, vrtača, Montello, Italija.

A KARST IN THE CONGLOMERATE

The Montello hill is probably the most typical morphounit between the karsts developed in conglomerate rocks (Toniolo, 1909; Abrami & Massari, 1968). In fact it is for many aspects similar to the classical karst of the limestone: the Carso of Trieste.

The Montello hill is a peculiar morphounit located to the north of Venice at the southern margin of the alpine chain, now emerging from the high Venetian Plain (Fig. 1). For its shape, it may be compared to the back of a whale. The surface area is of about 60 km²; the mean high above the surrounding plain is nearly 100 m, the volume a few more than six billions of cubic meters (Cucchi et alii, 1997; Ferrarese et alii, 1998; B. Castiglioni Ed., 2005).

The Montello hill is a peculiar form in the belt of the subalpine hills. While here most hills consist in articulated and asymmetric homoclinal ridges, the Montello hill is more massive, with an elliptical plan figure, elongated for about 13 km in a WSW-ENE direction and a width of about 5 km.

From the tectonic point of view, it corresponds to a pop up type tectonic wedge uplifting and reshaping by a constrain acting perpendicularly to the alpine chain. The upper part of the wedge is slightly bended to constitute an anticline fold. The rock unit involved consists in a thick series of conglomerate layers interbedded with sandstone, marl and clay lenses, called “Conglomerato del Montello”. This formation, about 2000 m thick and mostly composed by carbonate pebbles bound by a calcitic cement, is of late Miocene age (Messinian). In the south-eastern part of the hill, a more recent conglomerate unit is present, probably of lower Pleistocene age, in contact with the previous one by an unconformity.

From the geomorphological point of view, the Montello hill firstly is an alive tectonic form, a kind of “pop up horst”, which has been shaped by both the fluvial and the karstic process.

It is possible to recognize in it a complex system of fluvial planation and incision forms distinguishable as:

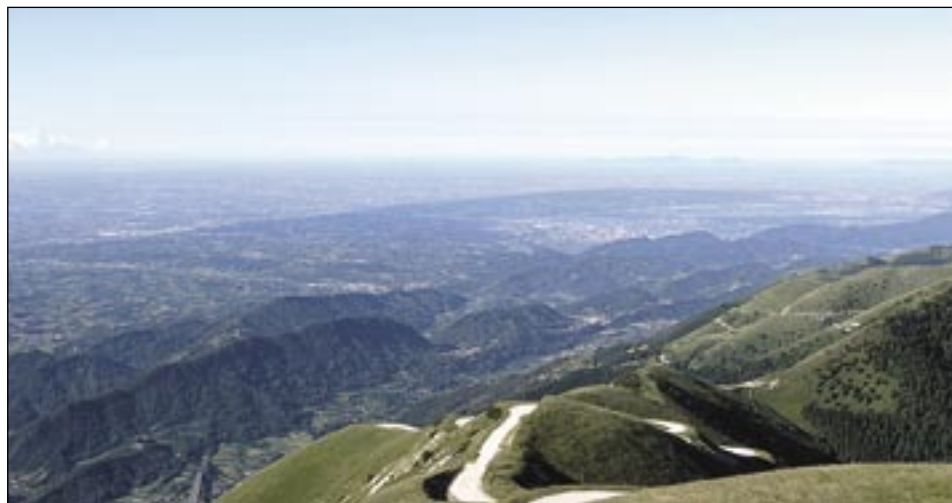


Fig. 1: The Montello as seen from the Prealps (dark elongated ridge in the background) is like the back of a whale emerging from the high Venetian Plain.

- a) planation plateaux,
- b) planation rock cut terraces,
- c) entrenched antecedent valley,
- d) flat bottoms of abandoned valley,
- e) planation surfaces in an active riverbed.

The geomorphological sketch (Fig. 2) evidences that the main plateau may be considered a planation form. In the western part of the hill a stairs of seven planation rock cut terraces represents the right slope of the antecedent dead valley of Biadene, entrenched between the Montello hill and the smaller Montebelluna hill. The Biadene antecedent valley is a relict form, abandoned by the river, strongly asymmetric because the right stairs like slope is about 200 meters high while the steep left slope is only about 60 m high. The flat bottom of the abandoned valley of Biadene is about 1 km width. In the active riverbed of the Piave river to the north of the Montello hill, planation surfaces are present, evolving now in the hard conglomerate. During the floods the river drags large amounts of pebbles acting as rasps for the underlying rock.

In the south eastern part of the Montello hill the geomorphological style changes in correspondence with the outcrops of a more recent conglomerate unit. Homoclinal features, like small valleys and ridges, are the prevailing forms in this area.

THE EVOLUTION OF THE KARST LANDFORMS

The erosional planation surfaces, once abandoned by the river, are interested by weathering and erosional processes. In the conglomerate rocks a “primary” porosity exist related with the process of water circulation and progressive cementation of the loose fluvial sediments. In the Montello conglomerate there are pores both inside the crystalline cement and in the pebbles, many of which are partly empty (Fig. 3). In the first evolution phases of the karst network, water tends to saturate such pores and its residence time inside the rock is probably long. Beside this, according with the diffuse but not homogeneous pattern of small pores the water does not follow straight but sinuous pathways. In time, the solution process increases the porosity, especially in the outer horizon of the rock, determining the development of both the epikarst (a high porosity zone in the first meters of the rock, just below the topographical surface) and the main drains through the rocky mass toward the springs.

During the wet periods the water hosted inside the epikarstic zone moves toward the most important drain systems. In time, the areas of fastest circulation and solution evolve as dolines.

Most dolines of Montello may be considered as hydro-structures of the epikarst of the type drawdown doline. More than 2000 dolines are present in the Montello hill (Fig. 4, Fig. 5). In the Montello there are also point recharge dolines and small blind valleys.

According with the ages of the surfaces, the degree of development of dolines is unlike. The most evolved forms are in the eastern part, the youngest in the western. In the eastern part there are also large uvalas resulting from the fusion of more dolines.

The seven terraces of the left slope of the Biadene furrow show different degrees of development of dolines. In each terrace, with the exception of the lowest one, is present a peculiar population of dolines.

The relative variability inside each population is large but a general trend to the enlargement of

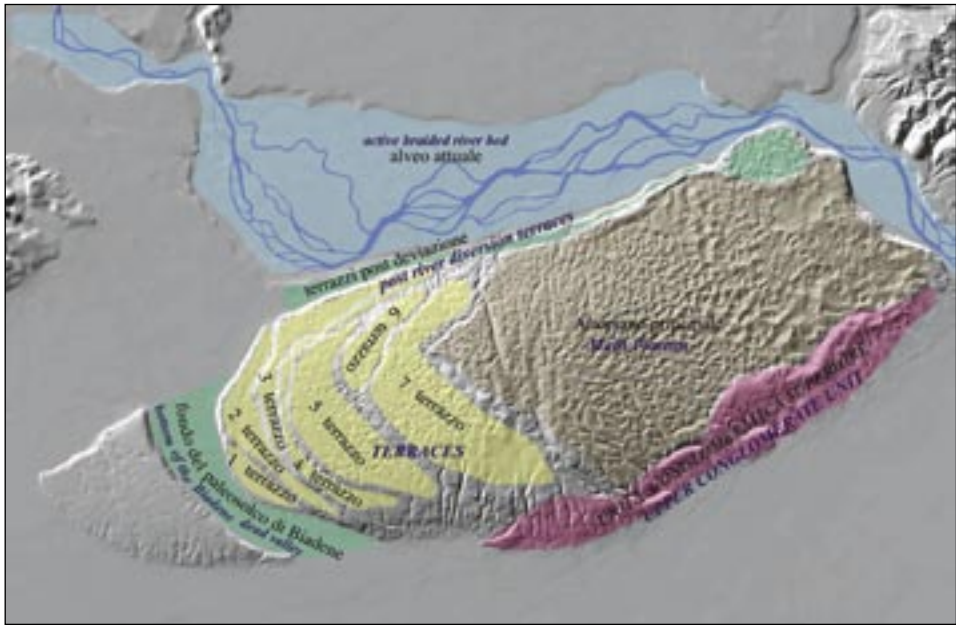


Fig. 2: Digital model of the Montello and of its main geomorphological units.



Fig. 3: Detail of the conglomerate including empty pebbles.

the forms with the increasing of the terrace order is evident. Even if the dolines characters present a large variability, the karst volume (the volume of the closed depressions) for surface unit of each terrace grows linearly from the second to the seventh terrace.

A preliminary model of the standard doline of each terrace based on the available data has been sketched. From these models, and in particular that of the standard doline of the second terrace, it is possible to see how a doline begins to develop as a relatively large form in its plan size. This behaviour is probably linked with the diffuse porosity of the conglomerate, which influences the evolution of the epikarst. When the water hosted inside the epikarst begins to find a fast underground drainage way, a relatively large area is dragged, the residence time of the porosity water is reduced and the quantity of circulating solution is increased especially in the proximity of the main drains. In this way accelerated solution takes place and a surface depression begins to evolve.

The large presence of dolines in the Montello karst, beside with the solubility of the rock, is due to the gently sloping surfaces, to the relaxation of the rock near the surface also related with the changes in the stress conditions from the tectonic constrain in the depth to the tension in the upper part of the tectonic wedge. Anyway it is evident that, in comparison with most of the limestone karsts, here the diffuse porosity is more important than the fracture network. This is evident also because the pattern of the dolines reflects the influence of morphological elements (position near a base of a terrace scarp, presence of old channels in the planation surfaces, etc) much more than those of the fractures network.

In the Montello there are many caves, mostly with horizontal development (about 90, one of which, the Busa di Castel Sotterra, is about 7 km in development) (Mietto & Sauro, 2000; Gasparetto & Talamanca, 2003). The geomorphological features show that they have evolved in the zone of saturation or at the water table (Fig. 6). The fractures have had a limited influence in their development. More important is the presence inside the conglomerate of sandstone and clay lenses.

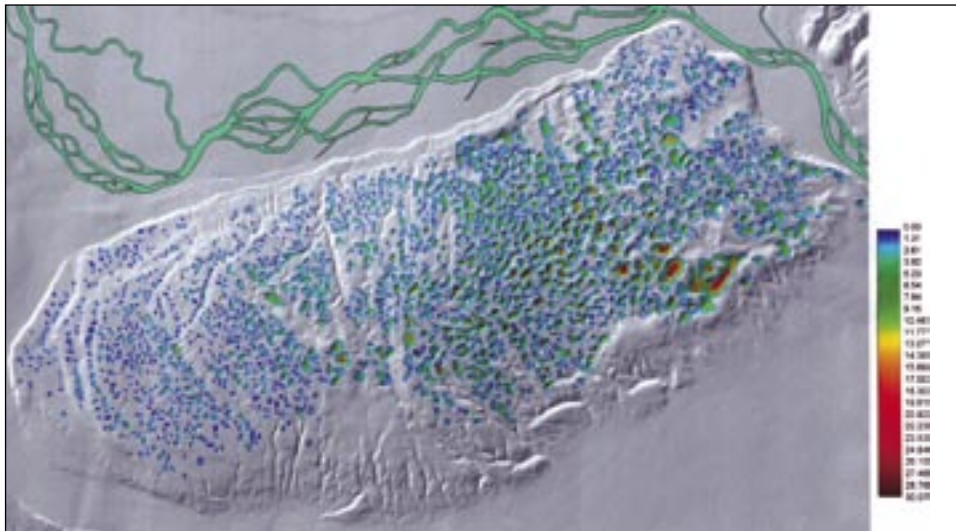


Fig. 4: Map of the dolines of Montello evidenced with a scale of colours indicating the depths of the closed depressions.

SOME CONCLUSIVE REMARKS

In the Montello conglomerate karst there are very clear inter-relations between the main tectonic form, the fluvial planation forms and the karst forms.

In the first morphogenesis of the dolines of Montello the role of the plan structures as the bedding surfaces and the fractures is probably feeble; on the contrary both the intra-cement porosity and the presence of cavities inside the pebbles are determinant factors for the penetration of the water inside the rocky mass and the slow circulation preparing the epikarst to develop dolines.

In the speleogenesis the control of the fractures seems to have been feeble; on the contrary that of the bedding plains between the conglomerate beds and sandstone, marls and clay lenses has been important in the development of some galleries.

The Montello karst may be considered a sort of “classical karst of the conglomerate”. The table evidences the main analogies and differences of this conglomerate karst and the classical karst of limestone: the Carso of Trieste.

<i>KARST UNITS</i>	<i>CARSO OF TRIESTE</i>	<i>MONTELLO KARST</i>
Type of morphotectonic unit	complex partly folded horst	popup “horst”
State of tectonic activity	alive	alive
Main rocks	shelf limestone	conglomerate
Other rocks	dolomite and flysch	sandstone, marls and clay
Main topographical character	plateau	plateau
Main geomorphological features	planation surfaces	planation surfaces
Most common surface forms	dolines	dolines
Main hydrological type of doline	drawdown	drawdown
Features mainly affecting primary porosity	fracture network	porosity of the conglomerate
Main types of caves	both phreatic and vadose	mainly phreatic or water table (also of perched aquifers)

In comparison with the Carso of Trieste, in the Montello there are more clear evidences of alive tectonic which are given both by the sequence of rock cut terraces and by the progressive deformations of their surfaces. In fact the terrace surfaces are more or less bended upward in agreement with the evolution of the anticline and according with the relative age of the forms.

From the point of view of the morphogenesis of the dolines, in the Montello karst beside the drawdown dolines, also the point recharge dolines are well represented; in the Carso of Trieste there are several intersection dolines (in the sense of Sauro, 2004; roofless caves in the sense of Mihevc, 2001).

In the conglomerate karst of Montello the processes of filling of the dolines by local weathered material seem to be more effective than in the Classical Carso. The loose pebbles and the fine grained materials of different origin accumulate in the bottoms of the depressions, which evolve as a small inner plains.

From the point of view of the vulnerability of the karst aquifers, the conglomerate shows a different behaviour than the limestone (Boccalon et alii, 1987; AA. VV., 2002; Fileccia, 1999). In the



Fig. 5: Dolines of the V terrace. Terra rossa soils are evidenced by agricultural works.



Fig. 6: A cave gallery developed in the conglomerate in phreatic conditions.

limestone of the Classical Carso a pollutant may reach the springs very fast through the system of drains developed along the main fractures, but also the auto-depuration of the system by the circulating waters occurs in relatively a short time. In the conglomerate of Montello the filtering capacity is higher but a pollutants may reside in the karst system for a long time span. In fact, the water of the main spring of Montello, the Forame spring, 25 years after a pollution event occurred in 1973 was still contaminated (Fileccia, 1995, 1998).

The comparison between types of karsts developed in different rocks is very stimulating and it is also important to establish reference and comparison terms. The Montello karst represents a very good reference and comparison term for the other conglomerate karsts. It constitutes also a very good natural laboratory very useful for the understanding of the evolution of a karst geo-systems.

NOTE

This paper is partly the result of a research work carried on inside a European Community supported program "Cultura 2000" with the title: "3KCL - Karstic Cultural Landscapes. Architecture of a unique relationship people-territory". The project has been promoted by the Museum of Montebelluna (Treviso, Italy) with the cooperation of the University of Padova and the participation of the University of Nice and of the Karst Research Institute, Postojna. Three volumes have been produced about the conglomerate karsts:

- Montello (B. Castiglioni Ed.) Museo di Storia Naturale e Archeologia di Montebelluna, (TV).
- Méailles – (P. Audra Ed.) Museo di Storia Naturale e Archeologia di Montebelluna, (TV).
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