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**LARGE COLLAPSE DOLINES IN PUGLIA  
(SOUTHERN ITALY):  
THE CASES OF “DOLINA POZZATINA” IN THE GARGANO  
PLATEAU AND OF “PULI” IN THE MURGE**

VELIKE UDORNE VRTAČE V REGIJI PUGLIA (ITALIJA):  
PRIMERI “DOLINE POZZATINE” NA PLANOTI GARGANO IN  
“PULI” (POKRAJINA MURGE)

BENEDETTA CASTIGLIONI<sup>1</sup> & UGO SAURO<sup>1</sup>

<sup>1</sup> Università degli studi di Padova, Dipartimento di Geografia, Via del Santo 26, IT-35123 PADOVA, ITALY,  
E-mail: sauro@ux1.unipd.it

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**Izvleček**

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**Benedetta Castiglioni & Ugo Sauro: Velike udorne vrtače v regiji Puglia (Italija): primeri “doline Pozzatine” na planoti Gargano in “puli” (pokrajina Murge)**

Prispevek opisuje največjo udornico na planoti Gargano in druge velike udornice (puli) v pokrajini Puglia v južni Italiji. Avtorja predlagata razlago nastanka in razvoja teh vrtač: sovpadanje tektonskih dogodkov, kraških korozijskih procesov ter transgresijskih in regresijskih ciklov.

**Ključne besede:** geomorfologija krasa, udornica, Gargano, Puglia, Italija.

**Abstract**

UDC: 551.435.83(450.75)

**Benedetta Castiglioni & Ugo Sauro: Large collapse dolines in Puglia (southern Italy): the cases of “Dolina Pozzatina” in the Gargano plateau and of “puli” in the Murge**

The paper deals with the description of the largest doline of Gargano and of other large dolines (puli) of Puglia in southern Italy aiming to suggest an interpretation of their origin and development, in relationship with tectonic events, karst corrosion processes, and transgressive and regressive cycles.

**Key words:** karst geomorphology, collapse doline, Gargano, Puglia, Italy.

## INTRODUCTION TO GARGANO LANDSCAPE

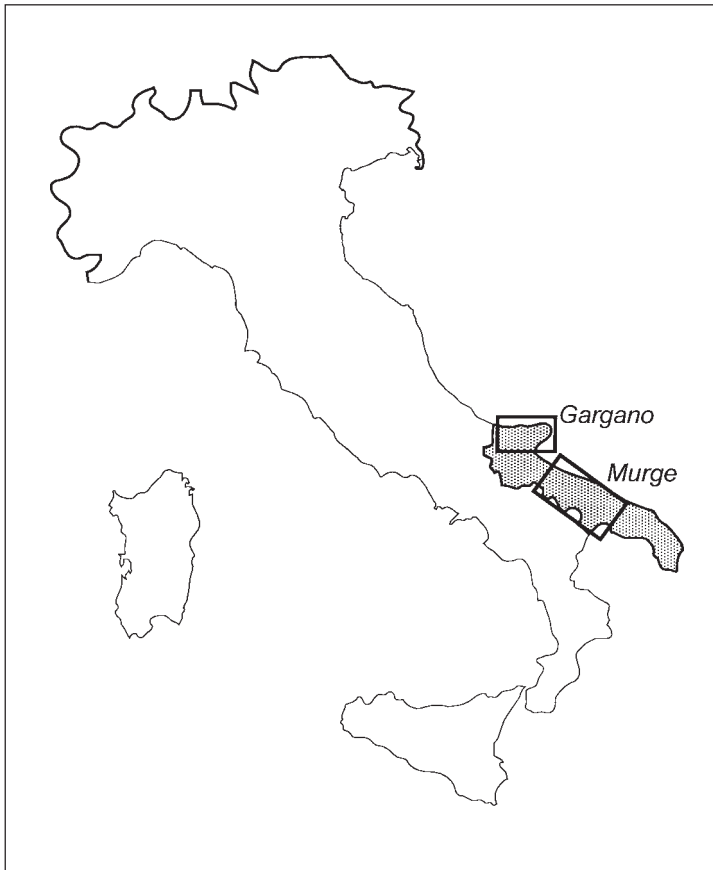
The western part of the Gargano promontory consists of a wide limestone plateau, gently inclined towards the NW, with altitude between 950 m and 400 m. On its surface some ridges rise, corresponding to tectonic blocks delimited by Appenninic faults (SE-NW). A consequent hydrographic relict network is evident, but karst landforms, especially a very large number of dolines, are present on the whole plateau. The alignments of karst depressions follow tectonic directions or they are superimposed upon dry valleys.

Dolines are more frequent, larger and deeper on the upper part of the plateau (Baboçi et al., 1991; Baboçi et al., 1993), with a density up to 105 dolines/square kilometre.

Baboçi et al. (1993) call the plateau surface Great Top Surface (GSS: Grande Superficie Sommitale), and interpret its genesis and complex development as the result of the different morphogenetic processes, in a long time period and in more that one phase.

They suppose that, before the major raising of the relief, in the period since the Cretaceous to the lower Pliocene, the surface evolved in tropical-subtropical environmental conditions, as a coastal

plain, not very high above sea level. In these conditions "terra rossa" sediments, derived from a first phase of limestone corrosion and karst morphogenesis, evolved in a very thick lateritic crust. In this way the original flat surface was almost preserved, and other morphogenetic processes, included karst ones, have not been able to continue their activity.



*Fig. 1: Location map of Gargano and Murge in Puglia (Italy).*

At the end of the Tertiary, the surface was dislocated in some blocks by different systems of faults, and uplifted by tectonic movements. The current GSS represents the most uplifted block, in the central part of the Gargano relief. Some tilting movements gently inclined it towards the NNW, too. A consequent hydrographic network began to develop and to erode and wash away the lateritic crust. Therefore the rock substratum outcropped and the karst process could intensify its morphogenetic activity, beginning at higher altitudes, where the crust was removed first. At the lower altitudes karst morphogenesis has progressively been less intense. Probably old karst forms developed during the former phase of karst morphogenesis and “buried” by the lateritic crust, had been re-activated in this new phase.

This explanation of the GSS development and evolution suggests a way to understand many of the observed data, first of all the different density of dolines at the various altitudes of the plateau.

### **THE KARST AREA OF DOLINA POZZATINA**

The Dolina Pozzatina is situated on the GSS at 450 m a.s.l., just near the transition zone between the real plateau with high density of dolines and a more sloping area in which karst landforms and fluvial landforms co-exist; fluvial processes were probably active in some periods of rejuvenation of the relief, and are the witness of relatively recent tectonic movements of the plateau.

In this part of the Gargano plateau current karst morphogenesis is made evident by some landscape characteristics: the bottom of the little valleys is often dry and looks like a sequence of aligned dolines; some dolines, situated one following the other, form kinds of tiers, and they seem to be the beginning of the formation of the valley. Moreover some recent soil-hollows and the presence of an open swallow-hole in two-thirds of the dolines indicate that karst morphogenesis is actually active in this zone, and it is possible to suppose the presence of hypogean cavities not very deep below the surface.

A brief morphometric analysis of karst dolines in Dolina Pozzatina surrounding area was made comparing them with the ones of two other zones of the Gargano plateau.

As a result, in this area the dolines (excluding Dolina Pozzatina) have smaller dimensions with respect to the ones of the more elevated parts of the plateau, especially regarding depth. As a matter of fact, doline minimum deepness (average value) is 3.4 m in this area, 3.8 m in the area of altitude around 600 m, and 5.9 m in the area of altitude around 750 m. Average dolines' main diameter is 86 m, while this analysis shows that there are no preferred directions for the elongation of dolines.

An almost complete soil coverage is present in the area surrounding Dolina Pozzatina, probably due not only to the residual of karst dissolution or of the lateritic crust, but also to volcanic ashes, perhaps coming from the Pleistocene activity of Vulture Mountain (100 km from Gargano to the south) and of Campi Flegrei; actually, this soil coverage often has brown colour, different from the reddish “terra rossa”. It has also probably actively contributed in the relief formation, perhaps limiting karst dissolution on the surface.

This area (in spite of the general rural exodus from southern Italy mountains), is still partly used for agriculture and grazing. The signs of a more intensive land use in the recent past are evident in the landscape, for example abandoned farms and old terraces on the doline slopes now covered by brushwood.

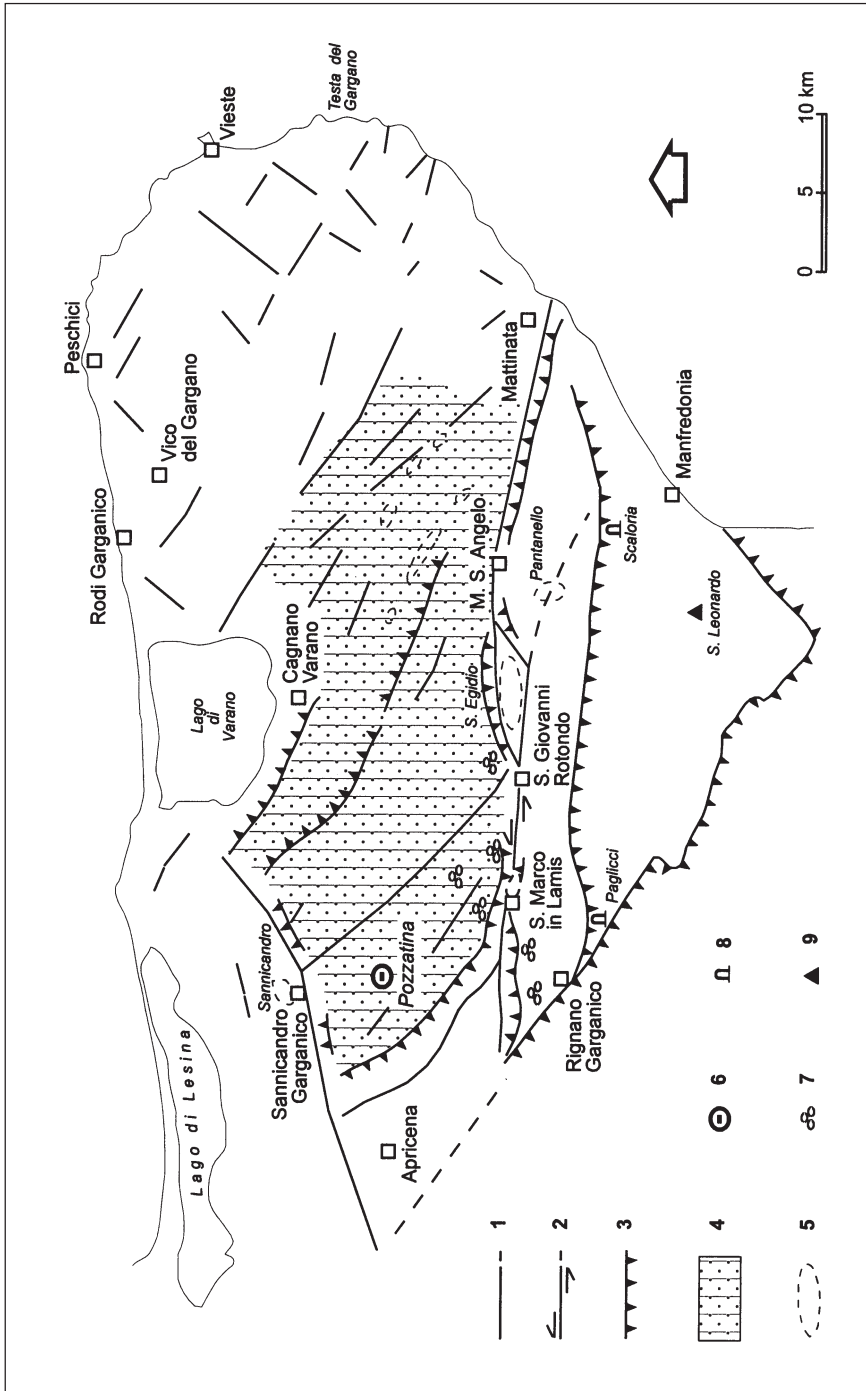


Fig. 2: Morphotectonic map of Gargano Promontory (da Caldara e Palmentola, 1991).  
 1. Normal fault, 2. Transcurrent fault, 3. Fault line scarp, 4. Central karst plateau, 5. Polje, 6. Doline, 7. Doline field, 8. Cave, 9. Grave.

## THE DOLINA POZZATINA

A detailed description of this very large karst form was given by Bissanti in 1966 (Bissanti, 1966). This cavity has a coarsely elliptical shape, 675 m long in SSW-NNE direction and 440 m wide. The heights between the bottom and the lowest and the highest point of the edge are respectively 104 m (minimum depth) and 130 m (maximum depth).

The slopes are all very steep, with concave profile: in the upper part some rock walls outcrop (especially on the northern and western slopes), while in the lower part the inclination is more gentle because of the drifts coming from the erosion of the slope. Some terraces were made in the lowest part of the slopes, for farming use, but by now they are completely covered by brushwood and wood, as well as the whole slopes themselves.

On the other hand the large bottom is still cultivated (wheat, oats), thanks to its flat shape, its large dimension (225 m long, 128 m wide), and the deep soil. Near the centre of the bottom there is a shaft that, according to Bissanti notes, is active because of a little water-bearing stratum in the bottom deposits (terra rossa soil, limestone sands and detritus).

On the higher part of the western slope a cave (Grotta Pozzatina) is situated, this feature described by Bissanti too. It consists of a short tunnel, a small hall, a fusiform cavity 7 m high, and a very narrow passage 10 m long; it is no longer possible to explore it.

On the eastern slope some speleothems were found; they indicate the presence of hypogean cavities in some phases of the development of this large form.

Bissanti explains this form as a normal solution doline; he excludes the hypothesis of a large collapse because he does not recognise evident signs of it, although it is possible that at the beginning a small collapse would have determined an accelerated karstic corrosion.

On the other hand, the doline would be a solution form, and some collapses would have enlarged it in a second time.

## THE MURGE PLATEAU

The Murge plateau in central Puglia (southern Italy) is a planation surface cut on Cretaceous limestones during Paleogene and Neogene. It consists in a main ridge, the so called Murge Alte plateau, and in a step of marine terraces developed on the north-eastern side; on the south-western side, a main morphotectonic scarp marks the transition to the Fossa Bradanica basin.

The maximum elevations are Torre Disperata and Mt. Caccia (686 and 680 m a.s.l.); the minimum correspond to the Adriatic coast.

The limestones are part of a sedimentary sequence of carbonatic platform some thousands of meters thick. The main rock units consist in calcilutites (Calcare di Bari, Calcare di Mola, Calcari grigi a Rudiste). Inside the sequence and also corresponding to the erosional surface there are cavities filled by bauxite and "terra rossa" deposits, expression of phases of karst morphogenesis and pedogenesis in a subtropical environment during episodes of emersion of the platform. Transgressive carbonate deposits have sealed pockets of these deposits inside large fossilised paleokarstic depressions. Some bauxite ore deposits have been exploited until about 1981.

During a large part of the Neogene the area was uplifted and affected by karst morphogenesis. During Pliocene and the early Pleistocene the sea submerged most of the region and the upper part



*Fig. 3: The dolina Pozzatina on the Gargano Plateau.*



*Fig. 4: The Pulo di Altamura in the Alte Murge Plateau.*



*Fig. 5: Spongework caves inside the cliff of the Pulo di Molfetta.*



of Murge Alte became an isle. Some calcarenitic rock units (Calcareniti di Gravina) fossilised the erosional surfaces on the limestones.

During the Pleistocene several important episodes of fallout of volcanic ashes occurred, connected with the volcanism of southern Italy (Vulture, Campi Flegrei, etc.).

So the different karst morphogenetical phases have been influenced by different factors as:

- a) presence of pockets of "terra rossa", that, after the exhumation of these paleokarstic structures, influenced the landform evolution;
- b) role of marine abrasion and deposition during the Pliocene transgression and Pleistocene regression;
- c) role of volcanic ash cover on the water circulation.

The landscape of Alte Murge, the area that was an island in the Pliocene sea, is now characterised by a honeycomb system of very large karst depressions, with diameters between some hundreds meters and some kilometres (average of 1619 m), average area of 2,65 km<sup>2</sup>, and with little depths (average of the maximum depths of 52 m of the minimum depth of 10 m. These landforms may be classified as low relief cockpits, probably relicts of a morphogenetical phase that took place during late Tertiary (late Miocene?) (Sauro, 1991).

The curious hydrographic network both inside the closed depressions and in the external areas is explainable as the morphogenetical consequence of the volcanic ash cover.

In the Murge there are also few smaller and relatively deeper depressions, a kind of large doline, locally called "puli". The best known among these closed depressions are indicated in the table.

NAME	maximum diameter	minimum diameter	maximum depth
Pulo di Altamura	500	450	75
Pulicchio	710	550	99
Pulo di Molfetta	170	130	30

## MODELS OF EVOLUTION

These forms have been interpreted by some authors as collapse dolines, even if some debate on the correct model has still been kept open (Colamonico, 1916).

In these depressions it is possible to recognise the presence of a high density of karst hollows, some of which are large caves or remnants of caves. So it is evident that their development has been favoured by the presence of pre-existing underground cavities.

In our opinion these few relatively large and deep karst basins could result from two possible type of evolution:

- 1) exhumation and re-elaboration of old paleokarstic features of Cretaceous and of Tertiary age,
- 2) karst development inside sponge-like rock volumes, previously affected by accelerated corrosion induced by the mixing of salt and fresh water during the transgressive and regressive cycles of the late Tertiary and Quaternary.

In particular the dolina Pozzatina, the Pulo di Altamura and the Pulicchio seem to fit better with the first model, even if the oscillation of the karst water table linked with the relative changes

of the marine levels during the Pliocene and Pleistocene could have favoured the “piping” of the filling sediments of old paleokarstic structures.

On the contrary the Pulo di Mofetta could be considered a relict “cenotes” type depression, evolved by the activity of brackish waters. The sponge-work system of cavities present on its sides supports such an interpretation. The primitive form could have been enlarged by collapse phenomena.

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(POKRAJINA MURGE)**

**Povzetek**

Zahodni del polotoka Gargano je obsežna apnenčeva planota v nadmorski višini 400 - 950 m. Vrtače so številnejše v zgornjem delu planote, do 105 vrtač/km<sup>2</sup>. Že na robu planote (450 m n.m.) je največja vrtača, Pozzatina, 675 m dolga, 440 m široka in 104 - 130 m globoka. Ima strma, deloma skalnata pobočja ter obsežno plosko dno (225 x 128 m). Raziskovalci domnevajo, da gre za korozijsko vrtačo, ki je bila kasneje povečana z udornimi procesi.

Planota Murge je uravnano površje v krednih apnencih, nastalo tekom paleogena in neogena, ki se spušča z višin 680 m do gladine Jadranskega morja. Tekom neogena je bila dvignjena in podvržena zakrasevanju, v pliocenu in pleistocenu pa jo je zalilo morje. O različnih morfogenetskih fazah pričajo žepi "terre rosse", sledovi morske abrazije in pokrov iz vulkanskega pepela. Na najvišjem delu planote je mreža velikih kraških depresij, s povprečnim premerom 1619 m in 2,65 km<sup>2</sup> tlorisne površine, a razmeroma plitvih (10 - 52 m). To bi bil lahko plitvi relief tipa cockpit.

Na planoti Murge pa je tudi nekaj manjših, a globljih depresij, imenovanih "puli". Največja meri 710 x 550 m in je 99 m globoka.

Avtorja predlagata dva možna načina razvoja teh depresij:

- ekshumacija in preoblikovanje paleokraških oblik iz krede in terciarja,
- razvoj krasa v "gobasti" kamnini, k čemur je pripomogla pospešena korozija mešanja sladke in slane vode ob transgresijskih in regresijskih ciklih.

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