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GEOMORPHOLOGICAL CARTOGRAPHY AND EVOLUTIONARY ASPECTS OF THE SIERRA DE ALBARRACIN POLJES (EASTERN IBERIAN RANGES, TERUEL, SPAIN)

Abstract: Peña Monne J.L., Jimenez Martinez A. & Echeverria Arnedo M.T., *Geomorphological cartography and evolutionary aspects of the Sierra de Albarracín poljes (Eastern Iberian ranges, Teruel, Spain).* (IT ISSN 0084-8948, 1989).

In The southern Sierra de Albarracín a polye system of structural origin has been formed, whose geomophological cartography demonstrates the existence of five planation surfaces, formed by climatic and tectonic processes throughout the Quaternary period. The intent of this paper is to make a general cartographic correlation of the aforementioned evolutionary phases.

Key-words: Karst; Polje; Planation surfaces, Iberian Range (Spain).

Riassunto: Peña Monne J.L., Jimenez-Martinez A. & Echeverria Arnedo M.T., *Cartografia geomorfologica e aspetti evolutivi dei polje della Sierra de Albarracín (monti Iberici orientali, Teruel, Spagna).* (IT ISSN 0084-8948, 1989).

Nel Sud della Sierra de Albarracín è presente un sistema di polje di origine strutturale, la cui cartografia geomorfologica dimostra l'esistenza di cinque superfici di erosione, generatesi nel Quaternario in seguito a processi climatici e tettonici. In questo articolo si tenta una correlazione cartografica generale delle fasi evolutive.

Termini chiave: Carsismo; Polje; Superfici di erosione, Monti Iberici (Spagna).

Resumen: Peña Monne J.L.; Jimenez Martinez A. & Echeverria Arnedo M.T., *Cartografia geomorfologica y fases evolutivas de un sistema de poljes en la Sierra de Albarracín, Teruel, España* (ISSN 0084-8948, 1989).

En el Sur de la Sierra de Albarracín se ha modelado un sistema de poljes de origen estructural, cuya cartografía geomorfológica nos muestra la existencia de cinco superficies de aplanamiento modeladas a lo largo del Cuaternario por procesos climáticos y tectónicos. En este trabajo se intenta una correlación cartográfica general de dichas fases evolutivas.

Palabras clave: Carso, Polje, Superficies de aplanamiento, Cordillera Ibérica (España).

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INTRODUCTION

The Sierra de Albarracín is situated in the east-central sector of the Iberian Range. The area studied is located in the Montes Universales, bordering on the northeastern edge of the mountainous region know as the Serranía de Cuenca.

From a hydrographic point of view, this sector represents an important watershed between the headwaters of the Turia, Tajo, and Cabriel rivers, with altitudes ranging between 1600 and 1800 m (fig. 1).

The general geomorphological features of this region have recently been studied (Jimenez, 1987), among which the decisive role of karstification and its ties to the lithological and structural characteristics of these mountains stands out, consisting essentially of polje and doline fields. This study focuses on the morphology and evolutionary phases recognizable in the poljes using geomorphological cartography.

THE GEOLOGICAL AND GEOMORPHOLOGICAL CONTEXT

The Sierra de Albarracín is composed of a paleozoic axis, which crops out intermittently, and is bordered by mesozoic and paleogene series. This material is structurally bounded by the tectonic grabens of the Jiloca river and of Alfambra-Teruel, and is full of neogene materials.

The Montes Universales are characterized by the presence of a synclinal structure with periclinal closures as a consequence of north-south folds and faults which transverse the dominant Iberian direction (NW-SE).

The outcropping materials in this meridional sector of the Sierra de Albarracín are of the Jurassic and Cretaceous periods and are contained in the synclinal cores of the Muela de San Juan and Frías de Albarracín, and in the small, transversal, tectonic grabens which exist between them.

The Jurassic series are of marine origin and essentially

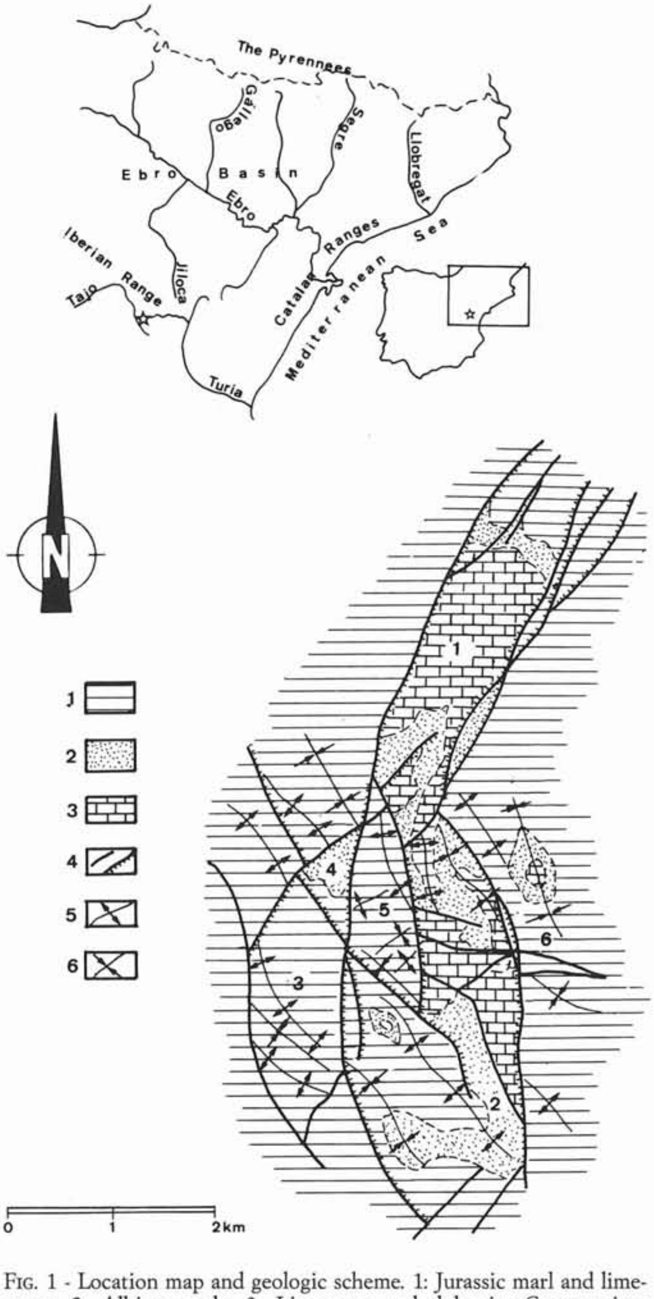

FIG. 1 - Location map and geologic scheme. 1: Jurassic marl and limestone; 2: Albian sands; 3: Limestone and dolomite Cenomanian; 4: Faults; 5: Anticline; 6: Syncline.

of calcareous marl lithology with a very complete stratigraphic succession though the outcropping of the Dogger limestone achieves a much greater expanse. The Cretacic is composed of argillaceous sands of the Albian stage (Utrillas Faces), limestone and dolomite of the Cenomanian; other Cretaceous series appear only in the synclines (PORTERO & *alii,* 1983).

The principal alpine deformations were produced at the end of the Paleogene period, as is evident in the Alto Tajo over-thrusts, generating structures with an Iberian orientation. The following distension phases, especially of the Upper Pliocene, created the small NNE-SSW grabens running parallel to the Alfambra-Teruel Depression.

The most important element of the geomorphological landscape in this area is found in the presence of extensive erosion surfaces which level the Mesozoic and Paleogene structures. These surfaces were deformed by the distensive phases of the Upper Pliocene, which shifted them into sections of differing altitude. In addition, the intense incision of the fluvial network into the calcareous materials has formed deep canyons which reduce the continuity of the above mentioned planation surfaces even further (PEÑA & *alii,* 1984). Karstic formations have been established in these planation calcareous surfaces, favored by the density of discontinuity planes, and by the characteristics of the mountainous climate; precipitation varies between 700 to 1000 mm, partly in the form of snow. Other minor features are the result of the effects of the Pleistocene cold periods, with the characteristic periglacial landforms (*grèzes litées,* solifluction slopes, etc.).

THE POLJES

Between the synclines perched on the Muela de San Juan and Frías de Albarracín, in the sector specified of the Villar del Cobo graben, a polje system has developed which takes advantage of the structural arrangement of the transversal distension faults (fig. 1). In the septentrional sector the system is bordered by parallel, rectilinear faults which create a sole polje with a NNE-SSW orientation and a width of 1,25 km (the Rollo polje), while southwards the structure is complicated by the appearance of a greater number of faults in which the N-S and NE-SW orientation can be discerned. Such circunstances as these determine the existence of six poljes which adapt themselves to these varying directions in a strip of ground whose width is in the area of around 2,6 km. The area as a whole is heavily folded, showing the two principal tectonic directions of this region.

In the Rollo polje only Cretacic materials of the Albian and Cenomanian periods crop out, with a practically horizontal structure. In the meridional poljes, differences are apparent between the oucropping materials of the western sector consisting, basically, of Jurassic limestone and marl- and the sandier Cretacic levels of the eastern sector. These differences are reflected in the composition of the bottom levels of the poljes.

The edges are composed of principally Dogger calcareous materials, leveled by an erosion surface at altitudes of around 1600-1700 m, above which can be found an occasional residual rise such as the Cerro del Pú (1763 m) and the Cañada (1783 m).

At the present time, within this structural framework, the surface drainage is divided between the Guadalaviar basin, towards which the Rollo polje runs, and that of the Tajo into which the meridional streams flow. This fluvial network has taken in the depressions, converting them into open poljes with the exception of the small La Cañada polje which remains closed.

The poljes' limits perfectly reflect their structural

TABLE 1
BASIC DATA OF THE VILLAR DEL COBO POLJES

Poljes	Longitude	Max. width	Bottom Alt.	Grade	Direction
El Rollo	2,3 km	0,650 km	1620-1580 m	1,3%	NNE-SSO
Navaseca					
long. sector	4 km	0,520 km	1600-1580 m	0,5%	N-S
trans. sector	1,5 km	0,260 km	1600-1580 m	1,3%	NO-SE
La Melchora	2 km	0,260 km	1660-1620 m	2 %	NNO-SSE
La Cañada	0,5 km	0,5 km	1620 m	—	NE-SO
La Capitana	1 km	0,390 km	1620-1600 m	2 %	NO-SE
El Navazo	0,8 km	0,390 km	1620-1610 m	1,2%	E-O

genesis, evidenced by rectilinear outlines which follow the dominant tectonic directions (tab. 1). Furthermore, the important shifts in level between the rises along the edges and the depths of the depressions are also consequences of the tectonic deformation which must have experienced very recent reactivation.

The entire polje system is characterized by the symetry of its edges, which agrees with its origin in tectonic grabens, in contrast with other poljes in nearby areas, such as the Sierra de Javalambre (GUTIERREZ, PEÑA & SIMON, 1983), the Barracas-Alcotas (PEÑA , GUTIERREZ & SIMON, 1987), the Sierras de Gúdar-Maestrazgo (GUTIERREZ, PEÑA & SIMON, 1982; LOZANO, 1988) and the Serranía de Cuenca (ALONSO, GONZALEZ & UGARTE, 1987) all of which are of structural origin but with marked disymetries in their edges, having been determined by dense fracture networks, as a result of the existence of a main fault or of folded structures.

The bottom of the poljes presents a large flat surface, given that its grade never exceeds 2% (tab. 1). The greater part of its area is occupied by a detrital cover of varying thickness, composed of residual clays of limestone discalcification and of the erosion of the clay — marl sectors of the depressions, and calcareous stones dragged by the force of the water that flows through the bottom. In addition, the lateral gorges have deposited small alluvial cones, especially along the eastern border of the Navaseca polje, which contribute thicker detrital deposits. Outcroppings of bare rock (calcareous and marl) levelled by the effects of dissolution also appear, whose surface connects with the detrital packing of the bottom, and which are found, at the edges of the poljes, placed back to back, or again, in the central part of the depressions, in the form of residual rises (hums). These planation surfaces are affected by the crypto-karstic corrosion process (NICOD, 1975) in the form of kluftkarren and kavernösenkarren, generated beneath a groundcover, now exposed, with significant biochemical action (FABRE & NICOD, 1982).

Despite its flatness, the surface drainage occurs with relative ease at the bottom of the polje, though temporal flooding does occur in some sectors where concentrations of marl are to be found. Streams are occasionally trapped within the depression packing, creating a narrow canal where normally a meandering layout is found.

Old planation surfaces, formed either by dissolution or by karstic denudation (SWEETING, 1972; GAMS, 1978), can be found bordering the depression bottoms. These surfaces correspond to the different evolutionary stages of the poljes' formation. The problem lies in the disperse, residual remnants between the various depressions whose general correlation presents difficulties. The cartography of these remnants has been achieved through the use of aerial photogrammetry to the scale of 1:18.000, given that field identification was not able to provide satisfactory results, due to slight topographical contrast between the surfaces. Five levels of planation surfaces can be differentiated (fig. 2), which only appear all together in the meridional sector of the Navaseca polje (tab. 2). Some poljes, such as the La Cañada and the Navazo, have two levels of planation surfaces, others, such as La Capitana have three, and still others, the Rollo for example, four. While the lowest level of the planation surfaces, which connects with the present bottom packing, only appears in the two largest poljes (Rollo and Navaseca), the three intermediary levels are located in the majority of the depressions. The second level in the southern part of the Navaseca polje juts out markedly. The upper level of the central şector in the meridional poljes consists of residual rises.

Altitude separation between the levels is slight, oscillating between 10 to 20 m as can be seen in tab. 2, and all of them are formed, just as in the lowest level, as fields of kluftkarren and kavernösenkarren. These planation surfaces should be interpreted as testimonial remains of successive water entrapment by the poljes.

With the existing data on two nearby poljes, La Rambla (Guadalaviar) and Los Corrales (Frías de Albarracín), both with and E-W direction, the possibility of an initial connection between the three systems, beginning with the upper and intermediate planation surfaces, can be drawn. Thus, the Navaseca polje bould be lengthened to reach the

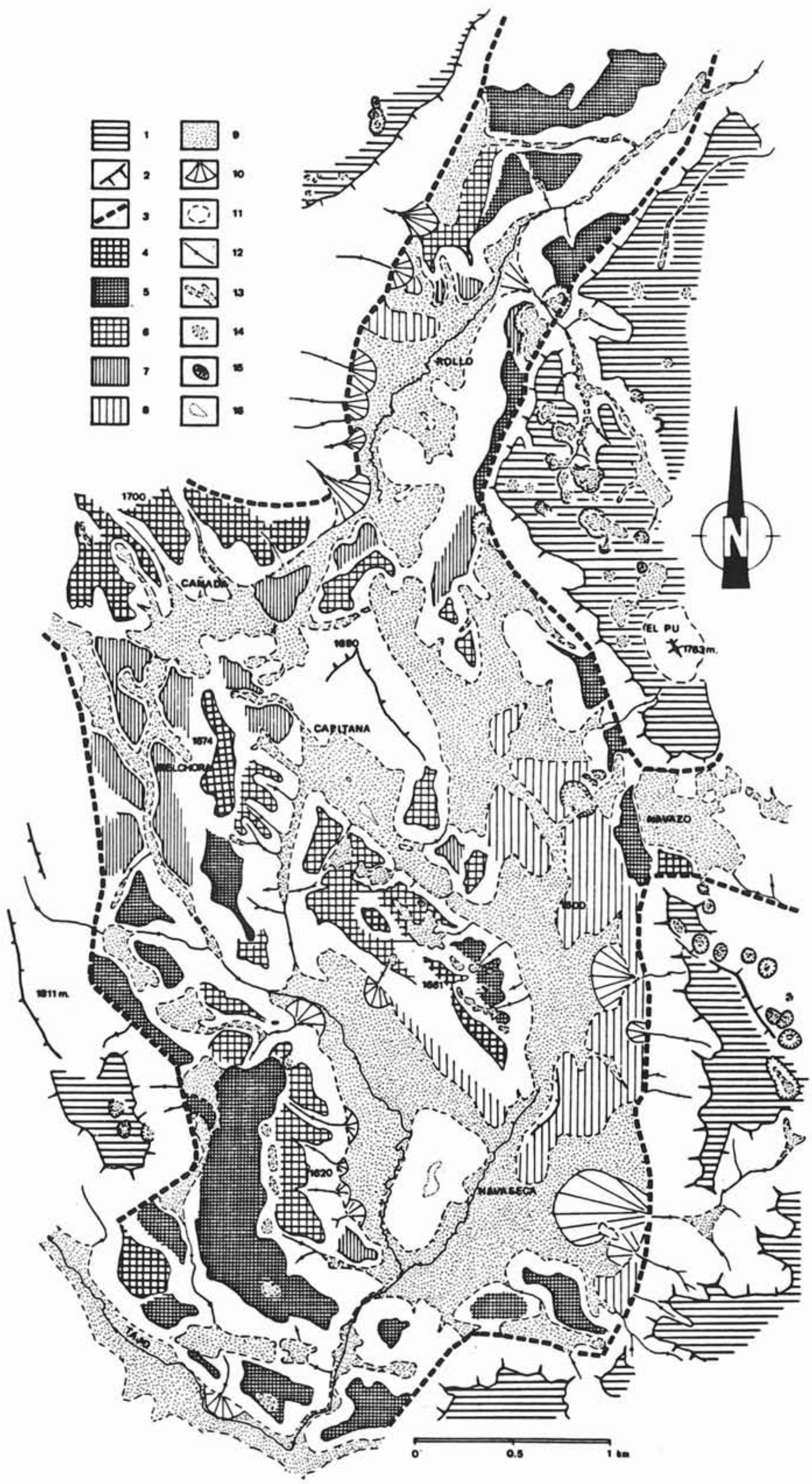

FIG. 2 - Geomorphological map of the Villar del Cobo poljes. 1: Late-Pliocene erosion surface; 2: Structural scarps; 3: Edge of the poljes system; 4: Level 1 of the planation surface; 5: Level 2; 6: Level 3; 7: Level 4; 6: Level 5; 9: Recent filling; 10: Alluvial cones; 11: Residual rises; 12: Downcutting; 13: Flat bottomed valleys; 14: Deposit dolines; 15: Dolines; 16: Marsh zones.

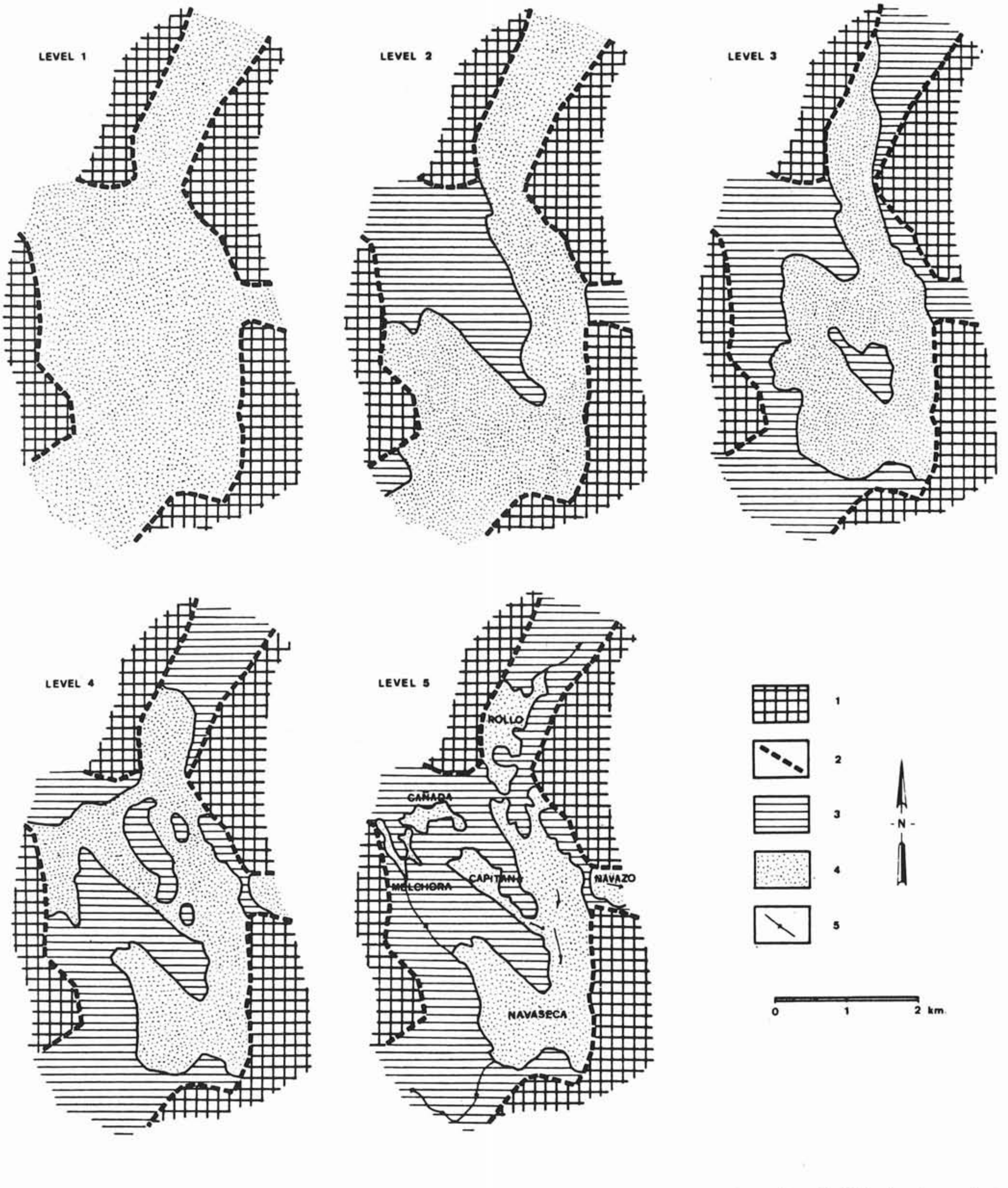

FIG. 3 - Hypothetical evolution of the Villar del Cobo poljes system. 1: Marginal landscape; 2: Poljes outline; 3: Old planation surfaces; 4: Poljes bottom; 5: Valleys.

TABLE 2
PLANATION SURFACE LEVELS RESULTING FROM DISSOLUTION IN THE VILLAR DEL COBO POLJES

Poljes	Level 1 (1640-1660 m)	Level 2 (1620-1640 m)	Level 3 (1610-1620 m)	Level 4 (1600-1610 m)	Level 5 (1590-1600 m)
El Rollo		*	*	*	*
Navaseca					
long. sector		*			*
trans. sector	*	*	*	*	*
La Melchora	*	*		*	
La Cañada			*	*	
La Capitana			*	*	
El Navazo	*	*			

southern part of the Tajo valley via residual surfaces of the intermediate level (level 4), in such a way that the original extension would be conceived to have been much greater than is presently observed. Throughout the evolution of this wide system, and due to the successive water entrapments, progressively individualized depressions, continually reduced in size, would be formed, in which the lateral progression of the planation surfaces would never manage to completely uncover the oldest levels which remained to form the dividers between the different poljes (fig. 3).

EVOLUTION

The evolutionary history of the poljes begins with the deformation of the erosion surface of the Upper Pliocene period by the distensive late-Pliocene phases, which produced normal faults running in an approximately N-S direction, and coupled together as tectonic grabens. Making use of this structural device, initial fluvio-karstic depressions were formed, whose function as open or closed poljes remains unknown. Other authors also point to this origin's link to the Pliocene-Pleistocene transition in nearby areas (GUTIERREZ, PEÑA & SIMON, 1982, 1983; PEÑA , GUTIERREZ & SIMON, 1987; LOZANO, 1988) as well as in the entire mediterranean area (NICOD, 1972; GAMS, 1978).

Throughout the Quaternary, and up to the present time, the system has suffered a series of modifications related to neotectonic activity, climatic changes, and the reparative action of the fluvial network. The climatic changes have been the causal agents in the succession of phases with significant karstic dissolution, which have laterally widened the poljes and created planation surfaces, alternating with moments of incision by flowing water along the depression bottoms. As indicated by NICOD (1967), these surfaces would be created in humid phases, and the fluvial entrapment in drier conditions.

The neotectonic reactivation, as in other poljes in the eastern Iberian Range, may also have played an important role in the deepening of the poljes, through readjustments in their rectilinear edges, as evidence by the presence of escarpments clearly seen between the planation surfaces and widely developed alluvial cones, like those of the eastern Navaseca polje.

The presence of the poljes in a watershed sector has permitted a relative conservation of these morphologies, despite having been taken in by the Guadalaviar and Tajo network, rivers which flow deeply trapped in the extreme north and south of this polje system. It is important to add to these fluvial effects, the general beatings, especially on the slopes, by the periglacial processes dictated by the region's altitude, which is manifested in cumulative forms and in regularization (*grezès litées*, solifluction etc.). At the present time, though they act as open valleys, the flatness of their bottoms, as well as the existence of impermeable sectors, favors a slow drainage. The resulting tendency is towards the persistence of subcutaneous dissolution at the bottom and the edges of the poljes.

Because of these characteristics, and because of the type or evolution evidenced, one can only draw resemblance to the «dinaric type» defined by LEHMANN (1959) (in: BÖGLI, 1980), even though a few particular traits, such as the multiplication of levels and the tendency to progressively subdivide the poljes into smaller and smaller units (aspects also observed in the Javalambre and Gúdar-Maestrazgo mountains), permit us to define them as an «iberian type».

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