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Morphogenesis of the Ourense Plains (NW of Spain)

Morfogénesis de las superficies de Orense (NW de España)

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ABSTRACT

We present a geomorphological analysis of Ourense Province (NW Spain) characterized by: a general narrowing of the fluvial network, highlands with smooth reliefs partially eroded and lowlands with residual reliefs, several extensive plains of erosion frequently limited by fractures -among which Tertiary grabens are inserted-, some "Hollow Surface"-type morphology, absence of sedimentary deposits outside the grabens, and a generalized outcrop of the Hercynian Massif substratum. Traditionally, this "piano's keyboard morphology" has been interpreted as expression of block tectonics in tensile regimen; instead we suggest the existence of: an isostatic upheaval simultaneous to a sequence of tectonic pulses of compressive regimen with activity in favour of transcurrent faults, a General Surface (R_{600}), several plains that present a "Hollow Surface"-type morphology (R_{1600} R_{1400} R_{1000}), a generalized alteration that correspond to a same process of decomposition associated to fluctuating conditions of redox equilibrium, a erosional terraces related principaly to the palaeo-fluvial nets; moreover, we propose the existence of two morphoestructural lineament: the first one represented by the Fault of Vila Real (NE-SW) -a ramification of the "*Basal Pyrenean Overthrust*"-, that would have been active at an early moment of the tectonic sequence with a left transcurrent fault, secondly the lineament represented by the Fault of Maceda (NNW-SSE) that would be related to the "*Fault System NW-SE*" and would have produced a right transcurrent fault during a late tectonic pulse.

Key words: regional geomorphology, planation surfaces, Hesperian Massif, Galicia NW Spain, Plate tectonics.

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INTRODUCTION

The mapping area (figure 1) extends between the provinces of Lugo and Ourense (C.N.I.G. 1994; 1997). Geologically, the area belongs to Galicia-Tras-Os-Montes (BARRERA *et al*. 1989). Only in the NE part, the Asturoccidental-Leonesa area is represented. The main morphological characteristics of the territory are: 1) the deep narrowing of the rivers; 2) the abundance of little contrasted reliefs in the highlands and of residual ones in the lowlands; 3) the regional fractures separate extensive plains of erosion which limit small grabens located between 250-650 m of altitude; 4) outside the grabens the sedimentary deposits are scarce. 5) Geologically, it is an old territory (igneous outcrop, regolith, recent deposits in grabens); but its relief is rejuvenated (widespread incision, dismantlement of the plains, compartmentalization of the territory. On the whole, the territory is a mosaic of block mountains with inserted tectonic basins.

In a traditional way, the previous studies (HERNÁNDEZ-PACHECO 1949; NONN 1966; VILLASANTE & PEDRAZA 1984; MARTIN SERRANO 1989; VERGNOLLE 1990; PÉREZ-ALBERTI 1993) accept the piano's keyboard morphology that has been described (BIROT & SOLÉ 1954), interpreted as the expression of block tectonics in tensile regimen. In this paper, we present some observations which suggest the existence of block tectonics in compressive regimen, with displacements in favour of transcurrent faults. In view of the shortage of deposits; the reconstruction of the morphogeny has not been based on stratigraphic approaches, but on the analysis of: the *topographical plains*, the fluvial network, the fracture, and the alterations, as it has already been carried out in other areas of Galicia (VIDAL ROMANÍ 1996).

THE PLAINS OF EROSION

Eight plains of erosion have been distinguished (figure 1 and table 1), most of which have got associated to them intermediate surfaces of these types: degraded surface, glacis, or ramp. Some of them define gradual and uniform transitions between plains of erosion. The plains of erosion are topographically defined by two topographical heights: the highest one, denoted by the remains of a previous surface, and the lowest one, denoted by the joined degraded areas. The analysis of the spatial extension of the plains (table 2) reveals: a spatial distribution of different area; the main character of the surfaces R_{600} (24.7%) and R_{1000} (10.9%); the respectable extension of the grabens (11.9%); and an advanced state of degradation (slopes and valleys, 40.7%).

The Surface of Serra de Queixa (R_{1600})

This plain is well-preserved in the northern border of the Serra de Queixa-San Mamede (Cabeza de Manzaneda, 1781 m); where it is defined by a net steep (NW-SE), at the N of which only some very degraded remains of the R_{1600} are identified. On the other hand, in the southern border of the mountain range, the plain is very degraded (Altos de Ganzedo, 1330 m). The western border is marked by a NE-SW structural alignment which has

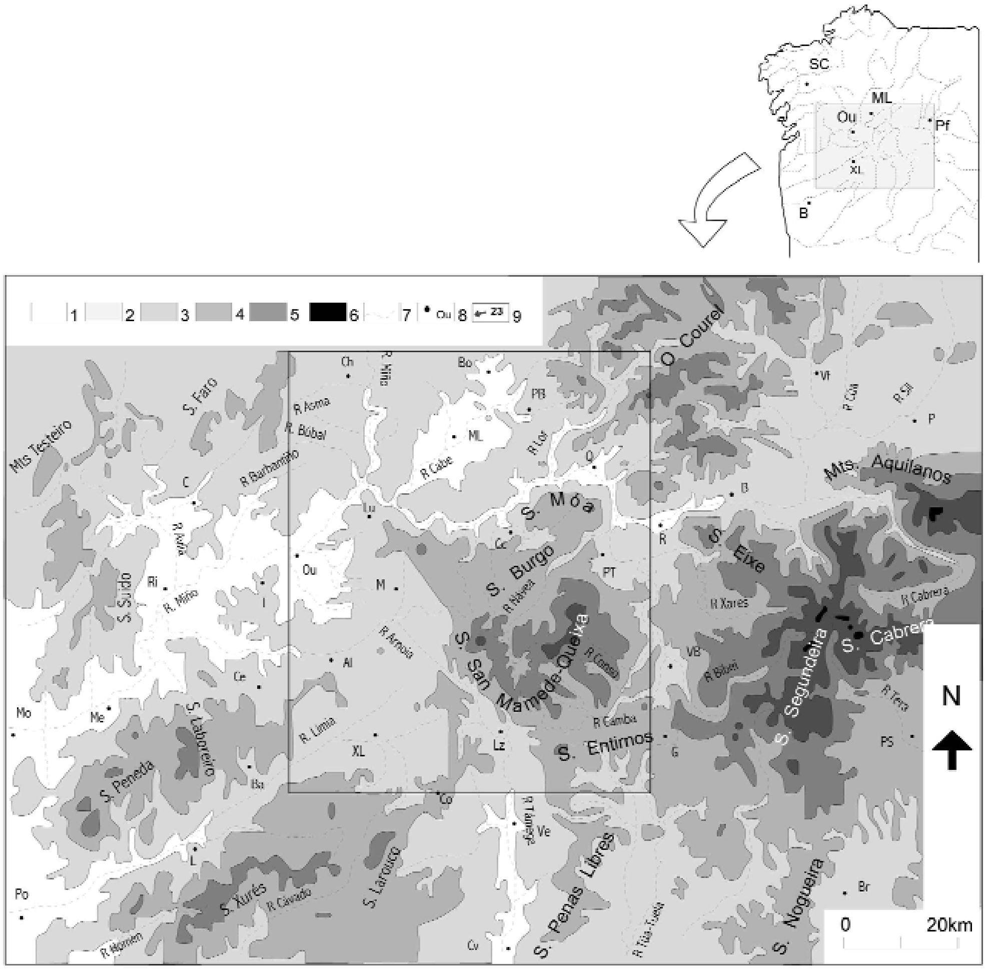


Figure 1. Schematic topography of the SE of Galicia and N of Portugal. Legend: (1) 0-400 m; (2) 400-800 m; (3) 800-1200 m; (4) 1200-1600 m; (5) 1600-2000 m; (6) 2000-2400 m; (7) River; (8) Town; (Al) Allariz; (B) O Barco; (Ba) Bande; (Br) Braga; (C) Carballiño; (Ce) Celanova; (Ch) Chantada; (Co) Cualedro; (Cv) Chaves; (G) La Gudiña; (L) Lobios; (Lu) Luintra; (M) Maceda; (Me) Melgaço; (ML) Monforte de Lemos; (Mo) Monçao; (Ou) Ourense; (Po) Ponte da Barca; (R) La Rúa; (Ri) Ribdavia; (P) Ponferrada; (PB) Puebla de Brollón; (PS) Puebla de Sanabria; (Q) Quiroga; (VB) Viana do Bolo; (Ve) Verín; (Vf) Villafranca del Bierzo; (XL) Xinzo da Limia.

Erosional surfaces in Ourense Province

Toponimical	*Reference*	*Altitude (m)*	*Area(km^2)*	*%*
Serra de Queixa	R_{1600}	1700-1300	18.8	2.38
Chaguazoso	R_{1400}	1500-1300	15.5	1.96
Serra do Burgo	R_{1200}	1300-1100	13.8	1.75
Castro Caldelas	R_{1000}	1000-700	86.6	10.9
Baldriz	R_{800}	900-700	33.3	4.2
Xinzo da Limia	R_{600}	700-600	196.1	24.7
Chantada	R_{500}	600-500	41.6	5.2
Sabadelle	R_{400}	500-300	23.3	2.9
Basins	-	-	94.4	11.9
R_{600}+R_{500}+basins	-	-	279.4	35.2
Slopes + valleys	-	-	-	40.7
TOTAL	-	-	793	100

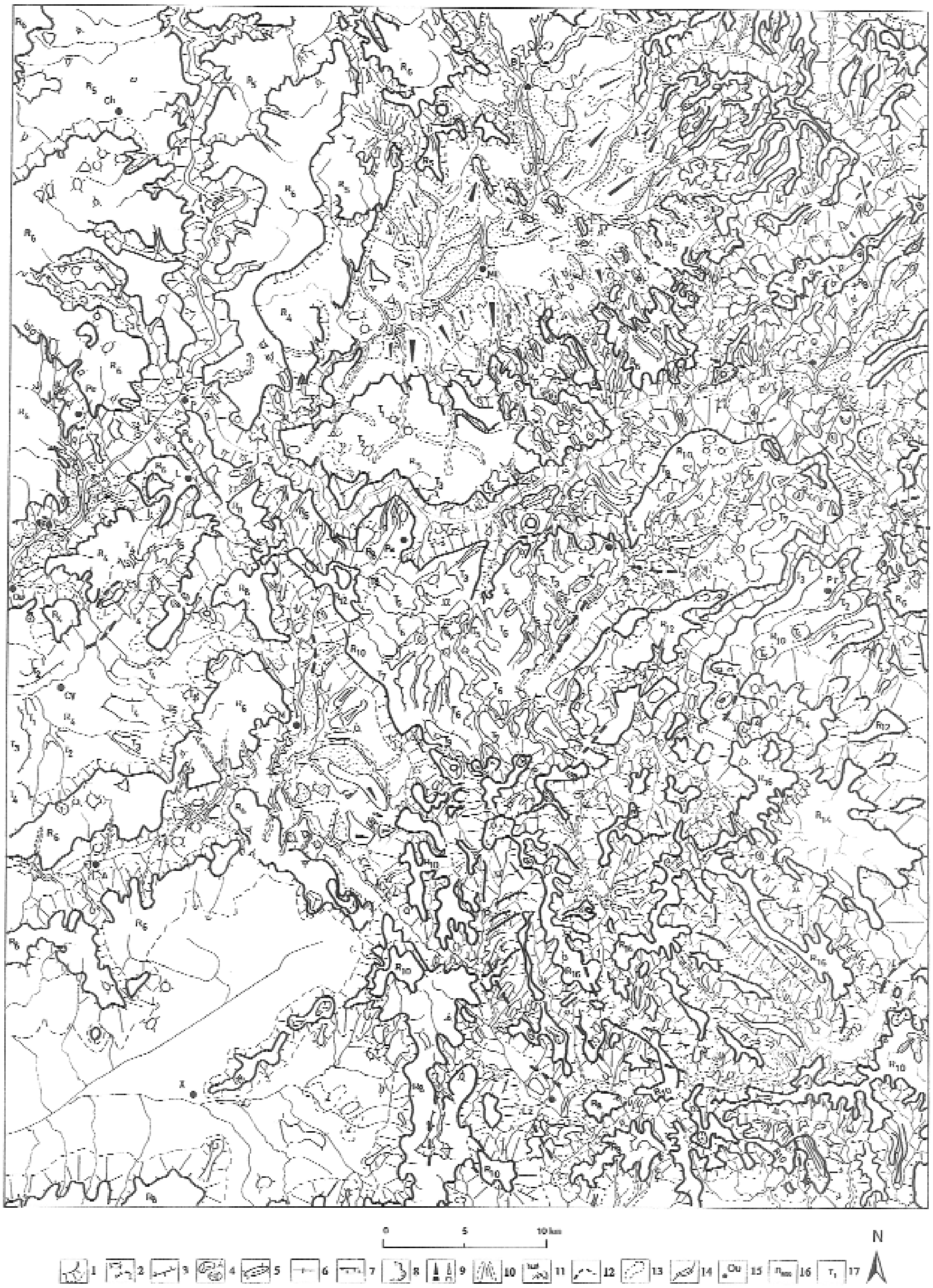
Table 1. Record of plains identified in the studied area. The rank of heights in which they are developed is included, as well as the calculated extension, both for the surfaces and for the grabens and slopes. The calculation of the extension was made from figure 2.

Tertiary Basins in Ourense Province

Plain	*Basin*	*Altitude max*	*Altitude min*
R_{800}	Chaves-Verín	550	350
R_{800}	El Bierzo	650	450
R_{600}	Xinzo	680	620
R_{600}	Monforte	750	300
R_{600}	Maceda	750	530
R_{600}	Larouco	550	300
R_{400}	Lañoa	410	390
-	Montefurado	520	-
-	Quiroga	400	260
-	O Barco	550	300
-	La Rúa	550	300

Table 2. Erosion surfaces associated to the main basins of the Galician SE, with indication of the maximum and minimum heights marked by the sedimentary deposits. Legend: (Ri) Surface-Plain; (H Max) Highest altitude; (H min) Lowest altitude.

Figure 2 (next page). Geomorphological map from the SE Galicia where eight plains of erosion have been identified. Legend: (1) Steep of topographical plain. (2) erosional terrace; Residual remmant. (3) Residual relief: Hill of circumdenudation, Castle-kopje. (4) Degradated crest; structural relief on fold axis. (5) Fluvial steep; landslide. (6) Degradated glacis: depositional, erosive. (7) River; sedimentary deposit. (8) Topographical plain. (9) Town. (ML) Monforte de Lemos. (Ou) Ourense. (XL) Xinzo da Limia.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been used by the river Návea to get narrowed and to dismantle the plain. And the eastern border would be characterized by a sequence of reliefs, progressively degraded towards the SE, strongly impacted by the fluvial network (Montes do Invernadoiro, 1550 m; Brotiais, 1532 m). These reliefs are terraced, until connecting with the surface of La Gudiña-Viana do Bolo (R_{1000}). On the whole, it can be supposed that the contour of the plain of erosion would be defined by two systems of fractures: NE-SW, the main one; and NW-SE, subordinate to the first one. Both systems would have dislocated the plain in some moment of the Mesozoic or of the Cenozoic. This hypothesis would be supported by the correlation which is showed by the systems of fractures with the long axis of the Surface of Xinzo and with the steeps of the Serras do Burgo and Paderne-Taboadela.

As for the morphology of the plain, it seems to be related to the lithology. On granite, soft and rounded reliefs are defined. They mark culminating heights (Cabeza de Manzaneda, 1781 m, the Majadales, 1750 m) and they would be the residual of a previous surface, while, on quartzite and slate the relief is more contrasted and the heights are lower (Pereixada, 1501 m). Regarding the morphogeny, the general development of a regolith and the numerous residuals (castle-kopjes on granite and conical hills on quartzite and slate) allow to attribute to this surface an origin by chemical erosion. The preservation of the *vasques* (gnammas), in the castle-kopjes of the Alto de San Mamede and of the original regolith would indicate that, at this point of the massif, the glaciarism would not have been developed during the Quaternary. This fact was already observed in other granite areas of Galicia (VIDAL ROMANÍ *et al.* 1994). Nowadays, the lingering erosion of the river Návea would have dismantled the initial surface until the degree of emptying it, reducing it to the initial contour. So only a residual would have been preserved in the central area (Altos do Acebral, 1606 m). It is what we have called a *hollow surface* morphology

The Surface of Chaguazoso (R_{1400})

This plain can be interpreted as a lower step of the R_{1600}. It is identified both in the area of Queixa (Llanos de Chaguazoso; Portela das Merendas, 1400 m; Serra do Fial das Corzas, 1400 m; y Altos do Gancedo, 1300 m) and in San Mamede (As Donas, 1279 m; Lombo dos Gavianes, 1360 m; y O Marco; 1400 m). Towards the E, it could be correlated with the western slope of the Serra do Eixe (Llanos de Lamalonga, 1445 m; y Serra do Cañizo, 1469 m). Towards the S, with the surface of summits of the Serra de Gerez-Xurés (1556 m). And inside the narrowing of the rivers Návea and Camba, it would be correlated with extensive surface-terrace remnants that would denote an old fluvial network, of a radial geometry to the Serra de Queixa.

Concerning the morphogeny, the partial preservation of the original regolith, would allow assign to the plain an origin by chemical erosion. On the contrary, the dismantlement of the regolith, would be related with a Pleistocene glaciarism, favoured by the preserved position of the plain regarding the dominant winds in two areas: Chaguazoso (HERNÁNDEZ-PACHECO 1958; PÉREZ ALBERTI 1993; VIDAL ROMANÍ 1994), and Dam of San Agustín del river Bibei (SÁENZ RIDRUEJO 1968). Regarding the hollow out of the plain in the area of Chaguazoso, it can be considered a hollow surface, like in the R_{1600}, although in this case the eroding down would have been by the glaciar erosion.

The Surface of the Serra do Burgo (R_{1200})

In the studied area, the R_{1200} is represented by the level of summits of the Serra do Burgo, to the N of the Serra de Queixa-San Mamede. Its western border is defined by a NE-SW morphoestructural steep, and the oriental, by the narrowing of the river Návea. On this plain paleo-valleys of plain bottom are observed; to those ones, remnants of erosive terraces are embedded, partially recovered by an alteration layer. The direction of the paleo-valleys would be SW-NE, concordant with that of the river Návea.

This plain of erosion could be correlated with the surfaces of the Serras de Gerêz-Xurés, Pisco, Pena y Larouco. In almost all the cases it defines narrow blocks, extended in NE-SW direction, among which wide valleys are inserted (rivers Salas, Cábado, Rábago and Porto de Rei), comparable to the plain R_{800}. In the Serra de Gerez-Xurés, the situation of the plain regarding the prevailing winds, allowed the glaciarism development during part of the Quaternary (SCHMIDT-TOME 1978; VIDAL ROMANÍ *et al*., 1990; BRUM *et al*., 1992).

The Surface of Castro Caldelas (R_{1000})

This plain is well-represented in the studied area, being embedded to the Serra de Queixa-San Mamede and O Courel. The Llanos de Puebla de Trives and Llanos de Castro Caldelas are in the N area of Queixa-San Mamede; the S border of Plains of Castro Caldelas is denoted by the Serra do Burgo; the W by the Fault of Maceda; and the N and E, by the narrowing of the river Sil. On these plains, remains of terraces of a SW-NE paleo-network are recognized, nowadays captured by the river Sil. The fluvial erosion has begun to dismantle the plain, conferring it the aspect of a hollow surface similar to the R_{1600} and the R_{1400}. The Llanos de Puebla de Trives constitute a remnant of the R_{1000}, a bit more degraded, which is extended in the N slope of Cabeza de Manzaneda, at the E of the river Návea. The Llanos de La Gudiña-Viana do Bolo are in the E area of Queixa and they define a corridor of meridian direction between La Gudiña and La Rua, enough degraded towards the N; and flanked by Serras de Queixa y Eixe-Secundeira. This plain of erosion would denote an old base level of the rivers paleo-Camba and paleo-Bibei. This same level continues in Serras de Entirnos, Texeiras y Llanos de Carracedo da Serra. In the W area of San Mamede, remnants of the R_{1000} have been mapped, which are very degraded and broken into fragments by the fluvial incision. In the Graben of Maceda they would constitute the southern continuation of the steep of the Fault of Maceda; but more to the S, near Correchouso, Toro and Portocamba, they would correspond to surface-terraces and paleo-courses of an old NW-SE network that later on would have been captured by a S-N network. In the Serra do Courel, the plain R_{1000} defines the eastern end of the graben of Monforte and the general level of summits of the Serras de Peña Redonda, Trapa y Llanos de Maceiras. At a regional range, the R_{1000} would be correlated, because of its altitude, with the Serras de Oribio, in Sarria; Faro, in Chantada; and Faro de Avión, in La Cañiza.

The morphogeny of the R_{1000} is by fluvial erosion. There can be still distinguished on it several incision levels, associate deposits (BARRERA *et al*. 1989; VERGNOLLE 1990), and residuals of older surfaces: Monte Meda (1321 m), Monte Cerengo (1235 m), Monte Legua (1311 m) and Cabeza Grande (1249 m). Nevertheless, some of their borders correspond to morphoestructural steeps: Fault of Maceda, NNW-SSE; river Sil, WSW-ENE; and Serra da Pena Redonda, NW-SE.

The Surface of Baldriz (R_{800})

This surface is represented in Esgos (Altos da Virxe do Monte) and in the graben of Xinzo (by the borders of the graben, except the northern one, and the Serra da Medorra). More to the S of the studied area, it would be correlated with the extensive interfluve of the areas of: Baltar-Cualedro, Chaves-Bragança and Alcañices de Zamora (MARTIN SERRANO 1989).

The morphogeny of the R_{800} is by fluvial erosion. Nowadays, there can be still distinguished on it, some stretches of a paleo-network NW-SE (Baldriz area) and several residuals: Monte Meda (1094 m), Monte Talariño (984 m) and Monte Penamá (927 m). Signs of fluvial touch have also been identified in the small remnants, comparable to the R_{800}. This is the case of: 1) the tailpieces of Penelo (Quiroga) and Serra de Pena Redonda (Monforte); 2) the erosive terraces of the Sil (Parada y Teixeira), Lor, Támega, Riveiriña and Parada; and 3) the glacis-terrace type ramps of the Sil (Castro Caldelas). Nevertheless, as it happened in the R_{1000}, the borders of the R_{800} coincide with structural lines.

The Surface of Xinzo da Limia (R_{600})

This plain is identified along the river Miño, and in the borders of the grabens of Monforte and Maceda. Comparable surface-terraces are also observed, in the river Sil: La Rasa (560 m), confluence of the Cabe; and Peña Grande de Quiroga (613 m). Outside the studied area, the R_{600} would be correlated with the basin of Rábade and Serras da Loba and Montouto (*Dorsal Galaica* or Galician Ridge). The river Miño defines a level of regional devastation among Rábade (Lugo) and Ribadavia (Ourense). In the stretch Rábade-Portomarín, it extends among the *Dorsal Galaica* and Serras del Mirador and Punazo; in total, a strip of 40 km parallel to the river Miño. In the stretch Portomarín-Os Peares, the Graben of Monforte defines the E border of the plain, diminishing the extension of the strip to 20 km. In this stretch, the course of the river Miño is N-S and its narrowing reaches 400 m. In the stretch Os Peares-Monção, the Miño has dismantled great part of the R_{600} to substitute it for a R_{400}. In the W riverbank only some remnants are identified in the head of the river Avia and in La Cañiza; and in the E riverbank, between the lineament Taboadela-Esgos and the Graben of Maceda. In the Graben of Monforte, two remnants of the R_{600} are observed in the southern border. Residuals of the R_{800} have been preserved on them. They coincide with axes of hercynian folds, of NW-SE direction (Barrera *et al.*, 1989). They are the Serras do Marroxo-Monte Vidual (680 m, 816 m) and the Serra de Auga Levada (887 m). These reliefs can be followed towards the S (Serra de Moncai, 531 m; and Serra das Penas, 787 m). The similarity of these residuals with those of the Sierra de la Culebra permits to compare them to the remains of the surface of phinimiocene erosion thet has been described (MARTIN SERRANO 1991), which would have been degraded, according to this author, before the Tertiary. Concerning the residuals identified on granite areas, they have been related to the phinimesozoic surface (MARTÍN SERRANO 1991): Monte Pozu (764 m), in La Peroxa; Monte Cabalo (732 m), in Luintra; Monte Boa (692 m), in Taboadela; and Alto del Portelo (834 m), in Xunqueira de Ambía.

As to its morphogeny, it can be supposed prior to the beginning of the sedimentation in the basins which fossilize it (Xinzo, Monforte and Maceda). The concave profiles that these basins present would reinforce this hypothesis. In the case of Monforte, the scarce deformation of the deposits (DE GROOT 1974), suggests the existence of a paleo-relief in the basin. In the case of Xinzo, the slope of the R_{600} observed at the W of the graben is attributed to the fluvial erosion. This is suggested by the remains of surface-terraces of the river Arnoia found in Allariz and Xunqueira de Ambía. However, to a regional level the distribution of the R_{600} would be partially conditioned by structural factors (figure 3). It makes think so, the existence of steeps in some borders of the plain: 1) in the W border, the steep (N-S) with the Macizo Galaico Portugués; 2) in the E border, the steeps of the Fault of Maceda (NNW-SSE) with the Llanos de Castro Caldelas and the Serra de San Mamede; 3) At the W of Ourense, between Allariz and Esgos, the steep (NE-SW) with the R_{400}; and 4) In Xinzo, the steep (NE-SW) that defines the W border of the graben, which is associated to a diabasis dike (BARRERA *et al.* 1989) fossilized by the basin deposits.

The Surface of Chantada (R_{500})

The remnants of this plain have a small extension. Their distribution is associated to the R_{600} in three points: Maceda, Chantada and Monforte (Puebla de Brollón, Sober and Ferreira de Pantón), and to the narrowing of six rivers: Arnoia (Xunqueira de Ambia, Allariz); Cabe (Lornís); Lor (confluence of the Sil); Miño (Monte Güimil); Támega (Laza); and Sil (La Teixeira). In general, the characteristics of the plain are related with the structure. In Maceda, the E border of the graben is an important steep of fault (30 km of longitude, 400 m of difference and NNW-SSE direction), to which quartz dikes are associated. In Chantada, the N border is a steep (NE-SW), in favour of

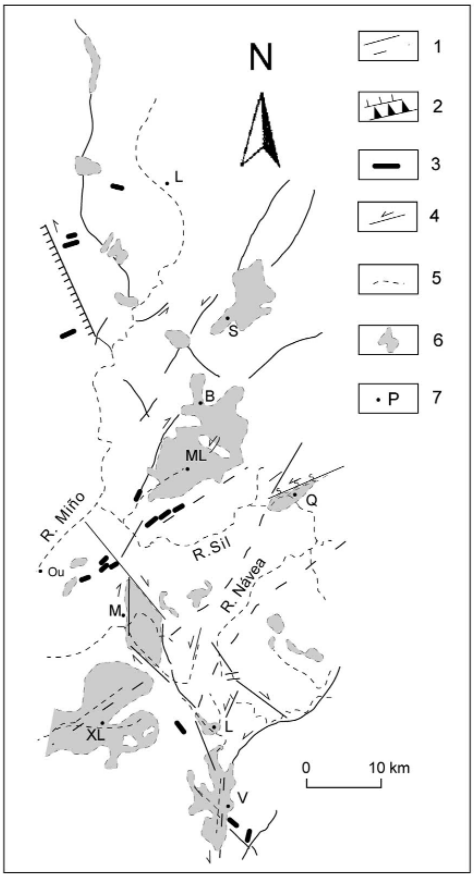

Figure 3. Morphostructural outline of the Tertiary basins from the SE Galicia. Legend: (1) Fracture; Fracture supposed. (2) Fracture with sign of dowcast side; Overthrust. (3) End Hercynic vein. (4) Alpine displacement supposed. (5) River. (6) Sedimentary deposit. (7) Town. (B) Bóveda. (L) Laza. (Lu) Lugo. (M) Maceda. (Mo) Monforte de Lemos. (Ou) Ourense. (Q) Quiroga. (V) Verín. (X) Xinzo de Limia.

which the river Asma is narrowed; the S border is the steep (ENE-WSW) of the mounts S. Cristóbal (826 m) and Rego (756 m). The courses that cut it (Sardiñeira-Portiño and brook Saviñao) are captured by the river Miño. In Monforte, the W border (Ferreira de Pantón) is marked by two fractures (NNE-SSW) which define an intermediate step, and which are associated to quartz dikes (BARRERA *et al*. 1989) and to fluvial elbows that could be expression of a dextral directional movement. Moreover, the courses that cut the plain (arroyo Regueiro-Rexidoira), are captured by the river Cabe near the fracture. Regarding the S border (Sober-Puebla de Brollón), it has a network of dikes associated (SW-NE) of porphyry and porfidic microgranite (BARRERA *et al*., 1989). And the courses which cut the plain (brook Lama-Santé and Monretán) are captured by a centripetal network.

Regarding the morphogeny of the plain, the short differences of heights it has with the R_{600} (<100 m), made suppose the existence of a *General Surface*, divided in two peneplanes (BIROT & SOLÉ 1954; MARTIN SERRANO 1989; 1994a). However, the R_{500} could be interpreted as a group of sunken blocks of the R_{600} and, in some cases, apparently tilted. In fact, in Monforte the R_{500} seems to form a topographical unit with Serras de Marroxo-Vidual and Auga Levada. On the other hand, the fact that the large fluvial courses don't interfere with the formation and development of the grabens of Maceda, Monforte and Xinzo, would permit to attribute the R_{500} an age prior to these three grabens. This background would already have been mentioned (MARTIN SERRANO 1989; 1994a; 1994b), when assigning a pre-Miocene age to the course of the rivers.

The Surface of Sabadelle (R_{400})

This plain is observed near Bóveda, in the city of Ourense and in the narrowing of the Miño (Os Peares, Barra), the Sil (Mounte Furado, La Teixeira), and the Támega (Valle de Laza). Under the R_{400}, only levels of erosive terrace and Quiroga's Graben are identified (280 m), in which was observed (VERGNOLLE 1990) evidences of an Alpine synsedimentary tectonic. In Bóveda (Graben of Monforte) the plain defines the general level of the topography of the subbasin. Around the city of Ourense (basins of the Barra, Loña and Barbaña) the surface is very degraded and it presents abundant inselberg type residuals (*conical hills*, *castle-kopje* and *tors*), boulders of weathering and alteration alveoli (San Ciprián das Viñas and Faramontaos-Lañoa). So only in the higher borders (La Peroxa, Paderne, Llanos de Sabadelle and Monte Alegre) the original surface seems to have been preserved. To be precise, deposits of the paleo-Loña have been preserved in San Ciprián das Viñas. It would flows in NE-SW direction before being captured by the Miño in the dam of Cachamuiña.

All these observations indicate an origin of the R_{400} by chemical erosion (etched), to which there would have been imposed a fluvial network that would alter the surface and would have dismantled it partially. In broad outline, the R_{400} is equal to the *Surface of Substitution* S_2 (VILLASANTE & PEDRAZA 1984), although some characteristics of the R_{400} seem to indicate a bigger influence of the structure: the capture of the paleo-Loña; the subparallel network of the basin of the Barra; and the morphoestructural steeps (NE-SW and NW-SE) that R_{400} and R_{600} articulate.

DISCUSSION

Reactivation of relief

As it has already been said, in the studied area the geology is characteristic of an old territory and, however, the relief is rejuvenated. Before this fact, some tectonic pulses in compressive regimen that elevate the relief could be supposed. Nevertheless, there are some pitfalls: 1) the compressive structures are difficult to recognize and the associate deposits hardly exist; 2) the fractures should be closed and should not favour the escape of the network towards them. However, the course of the network seems to be related with the structure; 3) the absence of deposits could be due to an antiquity of the pulses, bigger than what had habitually been thought, all the above-mentioned suggest the existence of an isostatic rebounding, simultaneous to the tectonic pulses, which would justify the continuous waste away of sedimentary cover. An outline of the sequence of the supposed events appears in table 3.

	Geomorphological Events in the Ourense Province			
	Erosional Surfaces	*Fluvial Terraces*	*Fluvial Networks*	*Grabens*
1	Pregeomorphologic Phase (Vidal Romaní, 1996)			Overthrust the continental platform in a paleozoical convergent margin
2	R_{1600} (etching)			
3	R_{1600} (1. Striping away; 2. Hollowing in Sªof Queixa)		Traces of radial network in Sª Queixa: SW-NE (Návea); NW-SE (Camba, Ribeira, Conso).	
4	R_{1400} (fluvial eroding)		Fluvial radial network narrow in Sª of Queixa	
5	R_{1400} (Striping away)	Návea, Bibei, Camba, Ribeira Grande, Ribeira Pequeña, Conso, Xares	Návea valley: 1) capture of the palaeo-Camba. 2) Individualize of the palaeo-Mao Bibei valley: 1) the river Sil capture the headwater of rivers Bibei and Cabrera	
6	R_{1200} (fluvial eroding)			
7	R_{1200} (striping away)	Návea, Bibei, Camba, Ribeira Grande, Xares Paleo-Mao (Sª do Burgo)	Bibei valley: 1) the river Xares it is captured. 2) narrow of the network NW-SE (Camba, Ribeira, Conso, Cenza) Návea valley: 1) general narrowing. 2) the river Mao it is capturated by the Sil and define a bend for the NW	Tectonical activity in the fractures NE-SW and ENE-WSW Opening-up of the Sil grabens and Xinzo Basin?
8	R_{1000} (fluvial eroding)	Llanos of Castro Caldelas, Puebla of Trives, La Gudiña	Sil valley: 1) the palaeo-Sil break through the Llanos of Castro Caldelas heading for WSW direction. Bibei valley: 1) the palaeo-Bibei break through the Llanos of Puebla of Trives heading for NW direction. Támega valley: 1) the Palaeo-Támega flows heading for NW-SE direction	
10	R_{1000} (Fracturing)		Sil valley: 1) the palaeo-Sil define a bend in Montefurado and surround the Llanos of Castro Caldelas by the N side. Bibei valley: 1) the network NW-SE it is captured in Cenza-Conso 2) the network NW-SE it is captured in Ribeira Grande-Cenza	Tectonical activity in the fractures NNW-SSE to NW-SE
11	R_{1000} (1. Striping away; 2. Hollowing in the Llanos of Castro Caldelas)	Návea, Bibei, Camba, Ribeira Grande, Xares	Sil valley: 1) lateral migration for the N while the course is narrowing Bibei valley: 1) lateral displacement of the Bibei-Návea confluence for the E side. Návea valley: 1) the fossil course of the palaeo-Mao is capturated by the Návea. Támega valley: 1) the Támega it is narrowing on the Llanos of La Gudiña Túa-Tuela valley: 1) the Parada is captured by the Douro, that narrow it course in La Gudiña	

Table 3. Sequence of events proposed for the Galician SE during the Alpine cycle.

	Geomorphological Events in the Ourense Province (continuation)			
	Erosional Surfaces	*Fluvial Terraces*	*Fluvial Networks*	*Grabens*
12	R_{800} (etching)		Sil valley: 1) narrowing continuously of the Sil course. Támega valley: 1) the Palaeo-Baldriz flows heading for NW-SE direction. Bibei valley: 1) general narrowing in the Llanos of Puebla de Trives and lateral displacement of the course for the NE. 2) lateral displacement of the Návea-Bibei confluence for the NE. 3) the Llanos of Puebla de Trives it is striped away by the secundary network SW-NE	Sedimentation in the Sil Graben and Xinzo Basin?
13	R_{800} (1. Striping away; 2. Exhuming structural reliefs in Monforte)	Miño (Ribadavia Melgaço), Sil, Lor, Támega. Glacis in Sil valley	Miño valley: 1) narrowing continuously of the Miño course between Melgaço and Ribadavia. Sil valley: 1) the Lor it is captured. 2) the actual course it is defined. 3) lateral displacement of the Miño-Sil confluence for the W. Támega valley: 1) general narrowing. 2) the Tamega it is captured by the Arnoia. 3) the Correchouso, Trez and Parada are captured by the Támega. 4) the Palaeo-Baldriz it is captured reversing it direction Túa-Tuela valley: 1) the Parada define it actual course. Bibei valley: 1) the Camba, Ribeira and Conso are captured. 2) it is defined the actual Návea-Bibei confluence.	Opening-up of the Maceda Basin. Xinzo Basin disconnect from the sedimentary source area. Consecutives bending of the Arnoia and tectonical activity in a transcurrent fault.
14	R_{600} (fluvial eroding)			
15	R_{600} (Striping away	Miño (Ribadavia Melgaço), Sil and Támega.	Miño valley: 1) it is defined the actual course between Chantada-Peares and Ribadavia-Melgaço. Sil valey: 1) definition of the actual course and the Miño-Sil-Búbal confluence. Támega valley: 1) it is practicaly defined the actual course of the Támega. Bibei valley: 1) the Xares it is captured by the Bibei in Larouco Arnoia valley: 1) the Arnoia and Tioira define a bending for the W Cabe valley: 1) sediment discharge for the NW-SE direction. 2) inversion of the fluvial network (NE-SW)	Opening-up of the Monforte Basin?
16	R_{600} (fracturing in Monforte and Chantada?) R_{500} (fluvial eroding)	Miño (altitude 550 m), Sil, Búbal, Arnoia, Támega	Miño valley: 1) Sardiñeira and Saviñao are captured. 2) progresive narrow. Sil valley: 1) definition of the actual Sil-Lor confluence. Cabe valley: 1) start the glyptogenesis of Monforte's Basin by the fluvial network NE-SW. Arnoia valley: 1) traces of exorheism in the Maceda's Basin.	
17	R_{400} (etching)	Miño (section Peares-Ribadavia)		Sedimentation in Lañoa and S. Ciprián das Viñas Basins.
18	R_{400} (striping away)	Barra, Lonia, Barbaña, Miño	Miño valley: 1) it is defined the actual course between Os Peares-Ribadavia. 2) the river Miño capture the headwater of the Lonia and Barbanha and the final stretch of the Arnoia	

Table 3. Continuation.

Surfaces and fractures

Almost all the plains define some of their borders with steeps which in some cases (R_{1000} to R_{1600}) coincide with directions of alpine fracture (NNW-SSE and WSW-ENE). This seems to indicate a certain relationship between surfaces and alpine fracture. On the other hand, the degradation of the tectonic steps, as well as the appearance of transition ramps among surfaces, support the thesis of the antiquity of the tectonic pulse. This would be the case of the steeps: R_{400}-R_{600}, in Ourense-Os Peares; R_{1600}-R_{1000} and R_{1600}-R_{1200} in the Serra de Burgo-San Mamede.

Origin of the surfaces

If it were necessary to specify the phase of dismantlement of a surface of erosion, the following ones could be distinguished: 1) well-preserved regolith; 2) appearance of the altered rocky substratum; 3) appearance of the engraving shapes; 4) appearance of the *hollow surface*, where only the contour of the initial surface is preserved; and 5) disappearance of the surface. In the case of the surfaces R_{1600}, R_{1400} and R_{1000}, they all have regoliths, etche forms and hollow surfaces associated; this is why they could be set in the 4th stage. However, it would be necessary to point out that the hollow out of the R_{1600} is bigger than in the R_{1000} which is bigger than in the R_{1400}. This would indicate a bigger dismantlement of the R_{1600}. The fact that the R_{1000} in the *Llanos de Castro Caldelas* appears covered by alluvial deposits, would permit to attribute its dismantlement to the fluvial erosion. Something similar would happen with the R_{1400} in the Llanos de Chaguazoso, regarding the glacial erosion.

Remains of old fluvial networks and erosion surfaces

Of the mapping plains, some have been interpreted as remains of erosive terraces or paleo-channels. The cases in which deposits have been preserved are scarce (Llanos de Castro Caldelas, Puebla de Trives, Baldriz and Amandi and Valle de Allariz). This shortage could be justified because: 1) they are erosive levels, and 2) the general meteorization involves the edafization of the deposit, except for the case of quartz-containing materials or of well-drained deposits. On the other hand, the orientation of these remnants of fossil networks is different in each plain: 1) SW-NE in Serra do Burgo (R_{1200}) and Llanos de Puebla de Trives (R_{1000}), where they would be related with the paleo-Návea; 2) NW-SE in the Surface of Baldriz (R_{800}), where they would be related with the paleo-Arnoia-Támega; and 3) SE-NW in the Surface of Amandi (R_{500}), where the paleo-course is parallel to the Sil. Lastly, it could be added that some fossil networks do not correspond to *consequen*t rivers, but to *resequent* ones. This would be the case of the arroyo Santé, in the Surface of Amandi (R_{500}), whose fossil stretch is at a height (460-440 m) lower than the one that defines the upper border of the narrowing of the River Sil in this area (540-520 m). The existence of the topographical beginning among both networks, makes us think of the development of the channel in favour of an area of structural weakness (a fracture corridor), more degradable to the erosion. The course of the streams would be explained in this way: Portizo and Camilo (NW-SE), in Amandi (R_{500}); of the headwaters of the Edo, Vaus and Alenza (SW-NE), in *Llanos de Castro Caldelas* (R_{1000}); and of the arroyo Muiños (NE-SW), in Xunqueira de Ambía.

The grabens and the tectonic activity

In the grabens of the studied area, two significant morphoestructural directions are distinguished: 1) NE-SW which determines the orientation of the River Návea and the sedimentation in the Graben of Xinzo de Limia; and 2) NNW-SSE to NW-SE which would be represented in the Fault of Maceda.

The NE-SW direction could be associated to one of the western terminations of the *Basal Pyrenean Thrus*t defined (SANTANACH 1994). Its activity would have been of sinistral direction, and in the case of the graben of Xinzo, its geometry on surface and its stratigraphy (Division of Geology of As Pontes Lignite Mine, c.p.), would make suppose an pull-apart type operation. This family of fractures would have defined a block (Serra of Queixa-San Mamede, Llanos de Chaguazoso and Serra do Burgo) that would move in a solidary way after the R_{1000} and before the R_{800}.

The NNW-SSE direction would be represented in the Fault of Maceda that worked (figure 4) like a dextral directional fracture, in a similar way to what the fracture corridors of As Pontes and Meirama did (MONGE 1987; FERRUS 1994). The fact that the R_{1000} is observed exclusively at the E of Maceda and at the S of the River Sil, would denote the N and W limits of an area which would reach the Surface of La Gudiña-Viana do Bolo, and which would have corresponded, as a single block, to the movement of the Fault of Maceda. The existence of this unitary movement would be based on several facts: 1) between the W and E borders of the Graben of Verín, there is a discontinuity that affects to the structures of Phase I and III of the Grupo Santabaia and to the Zona de Cizalla Dúctil del Rodicio (figure 5); this discontinuity has been interpreted as dextral break-up for which (ROEL & TOYOS 1993) estimate a displacement of 8 km; 2) the existence of a combined system of Faults NNW-SSE (Maceda)-NE-SW (Vila Real and Xinzo); and 3) the existence of hydrothermal signs (SOUTO 1996) in several points near the Fault of Maceda (Baños de Molgas, Verín and Chaves).

Therefore, the combination of efforts in those two combined directions would show the fragmentation of a very old surface, may be finiMesozoic, and its later levelling down in several stages. The absence of slope deposits with mapping magnitudes supports the idea of a very old event. The sequence of the tectonic risings would be related, in a first moment, with the NE-SW fracture and later on with the NNW-SSE one. The relative dating is based on two observations: 1) that the N border of the graben of Xinzo de Limia is truncated by the Graben of Maceda, which indicates more antiquity of the graben of Xinzo in relation to that of Maceda; and 2) that the steep of the Fault of Maceda is evened in Luintra by the R_{600} (Serra do

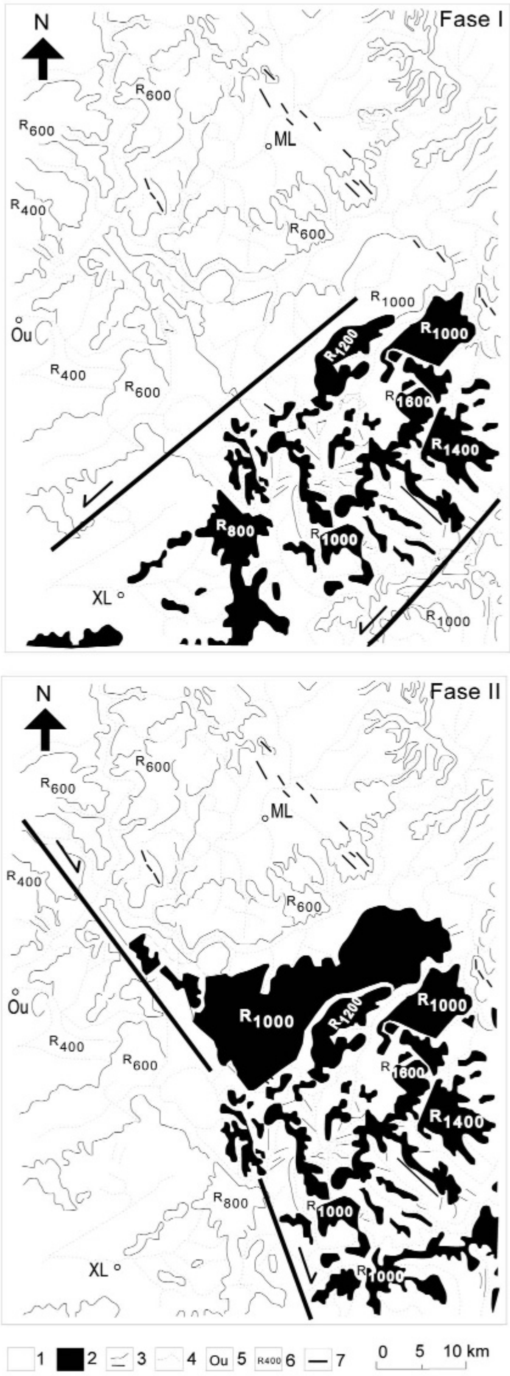

Figure 4. Hypothesis about the possible work of blocks in the SE of Galicia during the Alpine Orogeny. The grabens-tectonic activity relationship is not evident, in view of the advanced degradation of the morphostructural steeps; however, two significant structural lineaments are distinguished: the first one (NE-SW) would be associated to the "Basal Pyrenean Overthrust" and would have worked as a transcurrent fault with left movement in a first phase (Phase I), defining a Pull-Apart basin in Xinzo; the second lineament (NW-SE) would be related to the "Fault System NW-SE" and would have worked in a second phase (Phase II) as a transcurrent fault with right movement, defining the E border from the Graben of Maceda. The old age of the tectonic activity would come supported by the absence of significant slope deposits and the levelling down of the steep of the Fault of Maceda by the plains R800 y R600; the preceding of the NE-SW fracture in relation to the NW-SE direction comes pointed by the fact that the N border of the Graben of Xinzo is cut short by the Graben of Maceda. Legend: (look at figure 2).

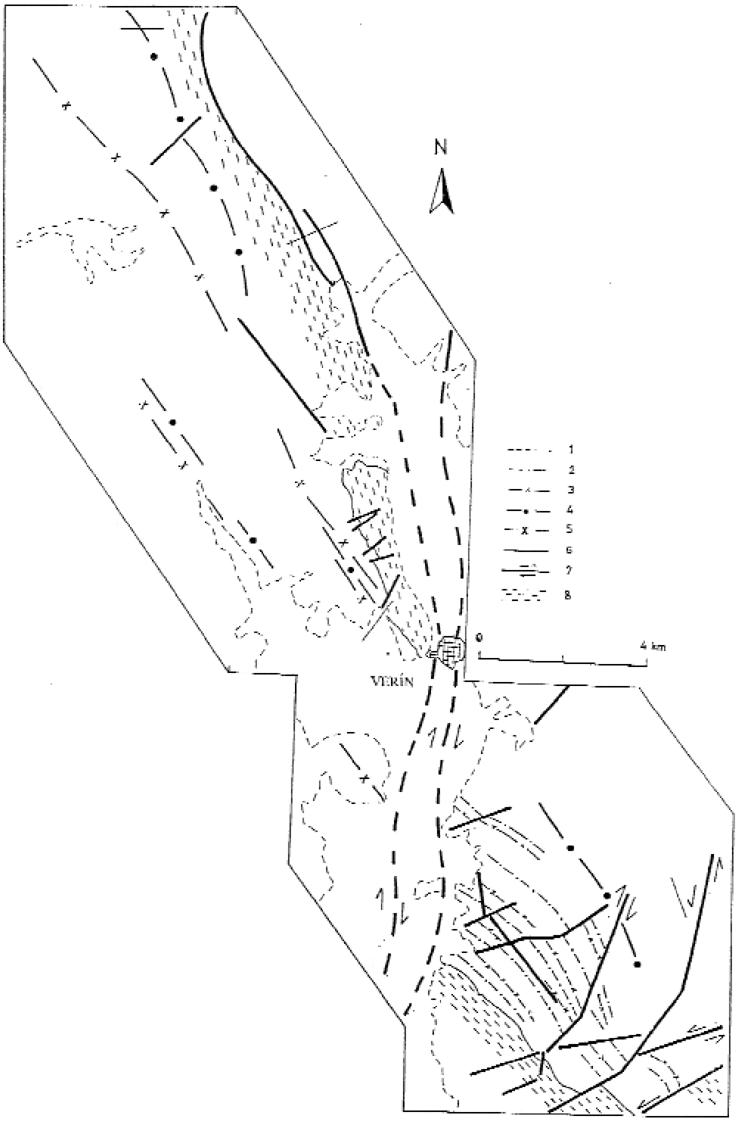

Figure 5. Tectonic scheme from the Fault of Maceda in the Graben of Verín; simplified from the Map nº 3 in (ROEL & TOYOS 1993). This fault, of NNW-SSE to NW-SE direction, would be related to the "Fault System NW-SE" which is observed round La Coruña and would have worked as a transcurrent fault with right movement defining the E border from the Graben of Maceda during the Alpine Orogeny; the supposed displacement in favour of this structural lineament would come supported by the observation of a combined fault network (NW-SE / NE-SW), associated to hydrothermal expressions (SOUTO 1996), which would have affected with right transcurrent fault (ROEL & TOYOS 1993) the structures of the Hercynian Phase III. Legend: (1) Stratigraphic unit. (2) Anticlinal of Fase I. (3) Synclinal of Fase I. (4) Antiform of Fase III. (5) Synform of Fase III. (6) Fault. (7) Direction of fault displacement. (8) The Rodicio's Cizalla Ductile Zone.

Cabalo and Llanos de Monteverde), and in Esgos by the R_{800} (Serra da Virxen do Monte and *Llanos de Cortacadela*). All this would indicate the precedence of the steep of Maceda, in relation to the surfaces R_{800} and R_{600}.

CONCLUSIONS

a) Eight different plains have been recognized between the heights 1800 m and 100 m. Its distribution has neither equivalent areas, nor proportion to the height. The most extensive plain would be the R_{600}, a *General Surface* in the sense used by Martin Serrano (1989). Two types of surfaces have been distinguished for its origin: those of fluvial erosion (R_{1400}, R_{1200}, R_{1000} and R_{600}) and the etching or of chemical erosion (R_{1600}, R_{800} and R_{400}). Two types of surfaces have been distinguished for their morphology: the *Ramp Surfaces* (Llanos de Puebla de Trives and the R_{400}); and the *Hollow Surfaces* (Llanos de Chaguazoso, Llanos de Castro Caldelas and the Serra de Queixa-S. Mamede). These morphologies would express different stages in the dismantlement of the plains of erosion. The *Ramp Surfaces* would show the initial stage, with prevalence of the areolar erosion; and the *Hollow Surfaces* would show a more advanced stage, with prevalence of the linear erosion by an organized network. The importance of the hollow out would indicate the advance of the dismantlement.

b) The general alteration would be a consequence of an arenization process, associated to fluctuating redox conditions. The variations observed would be due to the substratum: the granite would be kaolinized and the metamorphic lithologies would show an argilic covering of motley colours. The preservation of the basins and remains of the regolith in the R_{1600} would indicate that at these points of the massif the glaciar erosion was not very strong.

c) The remains of erosive terraces would correspond to old networks, nowadays hung and dismantled, which would be associated to the elaboration and/or the dismantlement of the plains; and in some cases, they would be related to areas of structural weakness, more changeable and therefore more subject to erosion.

d) Two significant morphoestructural directions are observed: NE-SW and NNW-SSE. The NE-SW direction would be a ramification of the Pyrenean Basal Thrust, represented by the Fault of Vila Real. The NNW-SSE direction would be represented by the Fault of Maceda, a dextral directional fault. The sequence of tectonic pulses would be related, in a first moment, to the NE-SW fracture and later on to the NNW-SSE one. The NE-SW direction would have conditioned the orientation of the river Návea and the tectonic regimen in the Graben of Xinzo. This is why the pattern of pull-apart type basin is proposed, with a left directional activity and certain inverse component. During the activity of the NE-SW fractures a solidary behaviour is supposed to the block formed by the Serra of Queixa-San Mamede, Surface of Chaguazoso and Serra do Burgo.

e) The Graben of Xinzo is supposed to be prior to that of Maceda, because its borders are truncated by those of Maceda. Concerning the activity of the Fault of Maceda, it is synchronous or prior to the plains R_{600} and R_{800}, which even the Fault steep in two points (Esgos and Luintra).

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