THE STRUCTURE OF THE SOUTHERN SLOPE OF THE CANTABRIAN MOUNTAINS:

explanation of a geological map with sections scale (1 : 100.000) *)

BY

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INTRODUCTION

Since 1952 the Geological Department of the Leiden University has carried out the geological mapping of the southern slopes of the Cantabrian Mountains in the provinces of Palencia and León in northern Spain, slowly progressing from east to west. Our interest has been centred almost exclusively on the Palaeozoic rocks. Untill recently very little was known or published about this part of the Cantabrian Mountains. Quiring, 1939, had given some provisional maps, the 1: 400.000 Spanish maps gave only the broadest of outlines and the survey by Comte dating from before the war was not published until 1959, when our mapping had already covered the same territory.

The stratigraphic sequence of the Paleozoic extends from the earliest Cambrian, resting on some Pre-Cambrian (de Sitter, 1961b), up to the highest Carboniferous. The Lower Palaeozoic, Cambrian to Silurian, crops out only in the western portion of the map and has a rather uniform development, described adequately by Comte, 1959, and further details of the Cambrian by Lotze and Sdzuy, 1961. Devonian outcrops occur scattered over the whole map area, and are of particular interest to stratigraphers because of their rich fauna (Comte, 1959, Kullman, 1960). The Devonian is less uniform than the older formations and shows variations indicating its development in well defined separate areas. Comte (1959) gave an excellent description of the rocks of the Bernesga-Esla zone. The development of the Carboniferous sequence is very variable due to several distinct folding periods of varying intensity (de Sitter, 1961a) and its stratigraphical development is still doubtful in many areas.

From the beginning I want to emphasize the fact that the present outcrop of Palaeozoic rocks in the Cantabric-Asturian mountain chain represents only a more or less fortuitous portion of a much larger Hercynian block, the present outcrop being determined largely by an Alpine deformation.

STRUCTURAL UNITS

A cursory glance at the map shows us at once that there are two main longitudinal units, a northern one containing only Carboniferous and Devonian rocks and a southern one, in particular in the western half of the map where the rocks range from Pre-Cambrian to Upper Carboniferous. The two units have been named the Leonides and Asturides (de Sitter, 1959), differ in many respects, and are separated by a line which could be called the León-line. It runs from west to east roughly along the upper reaches of Bernesga river, crosses the Torio, Curueño and Porma rivers reaching the Esla river near Huelde and

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continues eastwards north of the Camporredondo lake to be cut off by the Mesozoic blanket in the neighbourhood of Cervera de Pisuerga.

The *Leonides*, south of this line, consist of a western portion which we might call the Luna zone, a central Bernesga-Esla zone extending to the east of the Esla river and an eastern portion — the Ruesga zone. On the southern border of the Leonides we find discordant Upper Carboniferous intramontane coal basins, the Magdalena, Matallana, Sabero, Valderuedo or Cea and Guardo-Cervera basins respectively from west to east.

The Luna zone is essentially a complicated synclinorium with Pre-Cambrian in its southern flank and Lower Cambrian in its northern flank and Lower Carboniferous in its centre (section 1). In its northern flank the Cambrian base has been thrust over the Nammurian of the frontal part of the Leonides, which at its northern boundary along the Leon-line again shows up in a long and narrow stretch of Lower Paleozoic with Lower Cambrian at its base.

Just before reaching the Bernesga river this Luna synclinorium splits up into many thrustsheets, the Forcada, Bodón, Gayo, Correcilla, Rozo and Bregon thrustsheets (section 2, 3 and 4) respectively from north to south. Further east the Esla thrustsheet (section 5) has taken over the thrusting movements of the western pile of nappes. Together they form the Bernesga-Esla zone. Still further east follows first the discordant Valderueda or Cea basin and then the Ruesga unit with the Valsurvio dome and the refolded isoclinal folds of the Ruesga region at its most prominent structural feature (section 6).

All these units of the Leonides have some striking stratigraphic features in common. In the first place the almost complete absence of Westphalian (Yuso form.) rocks, except in the Tejerina syncline, and secondly the gradual disappearance of Devonian rocks going from south to north. Just south of the Leon-line the Famennian or the Lower Carboniferous rests directly on the Ordovician or even the Cambrian and in the southernmost outcrops of the Leonides the Devonian sequence is complete. Between these boundaries we find a gradual development of this great stratigraphical hiatus.

In the *Asturides* we can distinguish a western zone with complicated fold and thrust-structures all in Upper Devonian to Westphalian reaching as far as Riaño, the Pajares-Isidro area, and an eastern zone of more variable structure. First we see a zone in which the Lower Westphalian Curavacas conglomerate, folded in a large syncline and anticline, plays a dominant role — the Yuso area, then we come to a zone of Devonian rocks in the Upper Carrion river — the Carrion area and finally furthest to the east the Pisuerga and Barruelo basins with their Westphalian-Stephanian sequence of coal bearing sediments.

The structural units are summarized in the next table:

Cantabrian Mountains

	southern slope		central zone	
	Leonides	León line	*Asturides*	
west	Luna area			west
|	Bernesga-Esla area		Pajares-Isidro area	|
|	Ruesga area		Yuso area	
|	with discordant		Carrion area	east
east	Upper Carb. basins:		Pisuerga basin	
	Magdalena basin		Barruelo basin	
	Matallana basin			
	Sabero basin			
	Cea basin			
	Guardo basin			

STRATIGRAPHY

The Palaeozoic sequence of the Leonides, apart from the Carboniferous, has been described in detail by Comte, 1959 with complete literature. More recently Lotze and Sdzuy, 1961, published further details of the Cambrian, while Kullman, 1960 has investigated Devonian goniatites. The unconformable contact of Lower Cambrian on Pre-Cambrian was not known to Comte or Lotze but is clearly visible in outcrops along the Luna river and further west (de Sitter, 1961). As far as the Devonian is concerned we will follow Comte, 1959. The Carboniferous stratigraphy has been worked out by Wagner, 1955, 1959, with plants, whereas van Ginkel, 1960, has started with the fusulinids, and Kullmann with goniatites, 1961.

The next table gives the general outline of the stratigraphy.

Stratigraphic Table

		Trias or Cretaceous	
		late Hercynian folding, Saalic phase	
		pronounced unconformity	
Carboniferous		Cea formation [3]	Stephanian — Uppermost Westph. D. intramontane coal basins with congl., sst., sh. coal
		Asturian folding phases varying from Pre-Westph. D to Pre-Steph. B	
		Yuso formation [3]	mostly Westphalian, limest., cgl., sst. sh. with locally thick Curavacas cgl. at base
		Pre- or early Westphalian Sudetic folding phases, great overthrusts in Leonides	
		Ruesga formation [3]	Nam. — Visean limest. — sh.sst., griotte at base (Caliza de Montaña — Culm)
		probable hiatus in the Tournaisian	
Devonian	Upper	Ermitage form. [1]	quartzite (limest.)
		tilting and erosion in Leonides, doubtful folding in Asturides	
	Middle	Nocedo form. [1]	sst. shale
		Portilla form. [1]	limestone
		Huergas form. [1]	shale and sandstone
	Low	Santa Lucia form. [1]	limestone
		La Vid form. [1]	(Lebanza limest.) limest. dolomite, shale
		San Pedro form. [1]	sandst.
Silurian		Formigoso form. [1]	black shales, graptolites
		hiatus?	
Ordovician		Barrios form. [1]	quartzite Tremadoc
Cambrian		Oville form. [1]	Boñar sch. [2]) Luna sch. [2]) — Cerecedo sch.
		Lancara form. [1]	León marl — limestone-dolomites [2])
		Herreria form. [1]	Barrios sch. [2]), Candaño quartzite [2]) (dolomite-slates)
		pronounced unconformity	
Pre-Cambr.		Mora form. [3])	Narcea sch. [2]) slates and sandst.

formation names by: [1]) Comte [2]) Lotze [3]) Leiden

The base of the Oville formation is still Acadian, the boundary with the Ordovician being uncertain. The Barrios quartzite is Ordovician but the boundary with the Silurian is again very uncertain due to the lack of fossils, which is also the case for the Silurian-Devonian boundary, somewhere near the top of the S. Pedro form.

The Lower Palaeozoic has a distinct psammitic facies, poor in fossils except for the Middle Cambrian (see Lotze and Sdzuy, 1961). Its unconformable position overlying the Pre-Cambrian has been ascertained by Lotze in the Narcea

valley further west and reaffirmed by us in the Luna river (de Sitter, 1961).

The Silurian, occasionally containing some Upper Silurian graptolites in the Formigoso black shales, is also represented in part by the San Pedro sandstone and the exact limit with the Devonian is in determinable because of the lack of fossils. The Devonian deposition was continuous except that at the end just before the Famennian, when the Ermitage formation was deposited, an important emergence occurred together with regional tilting causing complete denudation down to the Cambrian or Ordovician on the northern border zone of the Leonide block. The Devonian of the Asturides is only known in the Upper Carrion region and west of the Upper Pisuerga region, where it is complete again but in another facies of deeper marine character than the shelf facies of the Leonides.

The Famennian with the overlying Visean is transgressive in the Leonides, but the conditions existing in the Asturides remain unknown because either no rocks older than the Upper Devonian are exposed, as in the Pajares-Isidro zone, or the Carboniferous is no longer present, having been eroded away as in the Carrion zone.

There is probably an hiatus representing emergence between the Ermitage formation (Famennian) and the overlying nodular limestone of Upper Visean age, but in some good sections, in the Camporredondo and Upper Esla regions and elsewhere, there is a black shale with some thin chert layers on the top of the Ermitage formation which in analogy with some Pyrenean sections might represent the Tournaisian.

The base of the Carboniferous with its red nodular limestone (griotte) containing goniatites of Upper Visean age followed by a series of black calcilutites and calcarenites or just massive limestone, is well developed everywhere except in the southwestern corner in the Bernesga-Luna region where shales follow on the griotte. The basal limestones, Caliza de Montaña, is followed by a series of shales, sandstones, conglomerates and limestone of probable Namurian age, known as Culm facies group.

For our purpose we can divide the Carboniferous in three groups terminated by three important tectonic phases, a lower Ruesga formation, followed by the early Hercynian Curavacas phase, a middle Yuso formation followed by the Asturian phase and an upper Cea formation followed by a late Hercynian (Saalic) phase.

The base of the Curavacas conglomerate following on the Curavacas phase has been proved to be Westphalian A in the upper Cardaño valley north of the Camporredondo lake. Elsewhere Westphalian B plants have been found in this conglomerate. There remains a difficulty, however, in the fact that in the Leonides the Westphalian is almost completely missing, and in the western Asturides the unconformable conglomerate of the Westphalian seems to be absent and even an unconformity is no longer discernible. Evidently the Curavacas phase was active only in the Leonides and in the eastern part of the Asturides. After this phase the Leonides were uplifted and the discordant basal conglomerates occur only between the Pisuerga and Esla rivers.

The Yuso formation consists of Westphalian rocks, sometimes with many limestones as in the Riaño-Ciguerga region, sometimes mostly shales and sandstones as in the Yuso region, sometimes as in the Pajares-Isidro unit of the Asturides north of the Bernesga river, very irregular limestones in a shale/sandstone alternation.

A precise age for the Asturian folding phase is difficult to assign with

stratigraphic exactitude. The completely discordant upper Carboniferous intra-montane basins of the southern border sometimes start with beds as young as the upper Stephanian, sometimes lowest Stephanian and sometimes even the upper Westphalian D, always discordant on rocks not younger than the Ruesga formation, except in the Tejerina syncline. Therefore we are not justified in giving a more precise date than somewhere in the Westphalian. In the Pisuerga basin we find at one locality an unconformity between the Stephanian A and the Westphalian and in another locality between Stephanian B and Stephanian A.

The Culm facies of the Ruesga formation is very similar to the general facies of the Yuso and Cea formations. Therefore it is often very difficult or impossible to define in the field which unit one is mapping. The only fossil evidence is formed by foraminifera in the limestones or plants in the coals, and when both kinds of rock are missing the solution to the question of age is difficult to find.

In the region of the Upper Esla valley we are in many localities in doubt as to the distinction between the Cea and Yuso formation, and in the region between the Yuso and Carrion river south of the Curavacas conglomerate as well as that south of the Sierra Coriza in the Pisuerga Basin, between Yuso and Ruesga formations.

The final pre-Triassic Hercynian phase of folding, is demonstrated by the E—W folding of the Cea formation in the intra-montane basins. Compression was quite strong but is often difficult to separate from a possible Alpine folding. This is particularly true for most of the southern border where the possibility of a pre-Upper Cretaceous folding can not be excluded because all the Mesozoic below the basal sandstone followed by Senonian limestone is missing here. Only in the Pisuerga region are the Palaeozoics covered by Triassic strata. As moreover both the Triassic and the Upper Cretaceous are folded, it is difficult to evaluate how far these Tertiary tectonics penetrate into the Palaeozoic. Only in some cases we have definite information, for instance the oblique wrench fault running south eastwards from the Camporredondo lake, which is certainly Tertiary (de Sitter, 1960), and on the southern border of the Cea basin where the Stephanian is thrust over the Cretaceous.

STRUCTURE

As was mentioned before we must make a clear distinction between a northern zone, the Asturides, and a southern zone, the Leonides, which show different histories in their Upper Palaeozoic development.

We have already drawn attention to the Leon-line, separating the two units. Its most important characteristic seems to be its function as the divide between distinctive stratigraphic sequences of the Leonide and the Asturide blocs, but this line is also characterized by a broad zone with frequent late-Carboniferous intrusives probably associated with frequent but small low temperature ore deposits, antimonium, mercury and copper. In addition the line itself is accentuated in the Bernesga-Esla zone by a narow stretch of Stephanian rocks.

The Leonides

In the Leonides we have distinguished three structural zones, a western Luna area, west of the Bernesga river, a central one from the Bernesga river to the Esla river, the Bernesga-Esla area, and an eastern one, the Ruesga area round the Carrion and Ruesga rivers.

The *Bernesga-Esla* area is characterized by many flat thrustsheets, each of them consisting of a complete series of Palaeozoic rocks from the Middle Cambrian, Lancara griottes up to the Visean and Namurian. In the Esla region there is only one thrustsheet, the Esla nappe, in the Porma-Torio region there are five of them. There can be little doubt that they all have moved in a northward direction, probable towards the NNE (de Sitter, 1959). The whole set of the Bernesga and Esla thrusts has been refolded most probably with a ENE strike in the Asturian phase before the deposition of the Stephanian intra-montane basins, and probably again, weakly, in the Pre Triassic Saalic phase.

The Asturian refoldings of the thrustsheets is best expressed in the section of the Curueño river where a succession from south to north of an incomplete anticline, a syncline, an anticline and another syncline of the thrust planes is admirably exposed. Detailed mapping proved that in the Correcilla nappe some of the pre-thrusting folds are also preserved. The southern syncline, crossing the Curueño, striking ENE, is the best exposed refolding of the thrust structures and can be followed downwards in the five superposed thrustsheets. It plunges consistently towards the west. A remnant of an anticline is preserved south of it in the Curueño section, but on the whole the south flank of this syncline is cut off by a ENE striking fault, the Porma fault with an uniform Lower Cambrian limb south of it. This Herreria sandstone forms part of the basement on which, further east, the Esla thrustsheet reposes. There can be little doubt that this emergence of the autochtonous basement is partly due to the Asturian folding of the above mentioned syncline, partly to faulting. Because the boundary line of the Cretaceous border lies directly in the continuation of this fault line, there may be some kind of structural relation between the two phenomena. However, it can not be identical structural movements, because they are in opposite senses, the Herreria limb is upthrown and the Cretaceous border zone is downthrown along this zone.

In the front of the thrustsheets there occur two isolated klippes, the Armada and the Pallida klippes, probably belonging originally to the Bodon and/or Forcada thrustsheets. The structure of the frontal part of the Bodon and Forcada thrustsheets still remains an enigma. It looks very probable that the Westphalian of the Asturides rests unconformably on the Cambro-Ordovician of the Forcada sheet and therefore may represent only the uplifted autochtonous front of the Leonide block. But we do not really know whether this is true or whether the most northern frontline is really a thrust. Further west the Forcada sheet disappears below the Westphalian and it is the Bodon sheet which forms the front. Again we are in doubt whether this frontal exposure of Cambrian and Ordovician in the Bernesga region still is a thrust or represents the autochtonous. In this respect it may by important to notice that the Bodon sheet is the only one where the supposed thrustplane is situated far down in the Herreria sandstone, in all the other sheets detachment occurred at the base of the Lancara.

Towards the west the ENE Asturian refolding dies out and the number of thrustsheets diminishes. First the Rozo sheet obliquely cuts off the Correcilla and Gayo thrustsheets very near the Bernesga river section. The Correcilla sheet itself appears to have been a double pre-thrusting fold, somewhat overthrust in the Bernesga river section.

The Rozo sheet also shows in its frontal zone the complication of a double Lancara outcrop, obviously a late feature because Carboniferous shales are exposed between the two Lancara outcrops.

The structure in front of the westward continuation of the Bodon sheet

is still very uncertain; it is partly obscured by narrow unconformable Stephanian basins with coal measures and conglomerates.

In the Bernesga section a syncline followed by an overthrust anticline with Barrios quartzite in its core are developed in the Rozo sheet, a thrust which further towards the west disappears in a whole set of smaller folds and faults.

The Bregon thrustsheet, covered by the Stephanian of the Matallana basin further east, is clearly developed in the Bernesga section, but soon disappears as a distinct thrust further to the west.

The result is that west of the Bernesga river this multitude of thrustsheets has transformed itself into a set of complicated folds with Lower Palaeozoic exposed only in the fronts of the Rozo and the Bodon sheets. The zone of folds north of the Pedroso syncline has been called the Aralla zone.

The Luna area has now become a vast synclinorium with an ESE strike, consisting of two very complicated synclines and one anticline in the centre. The Pedroso syncline and the Alba syncline appraoch one another when they reach the Luna river and further west they unite together with the Mirantes anticline into one complicated synclinal structure, the Abelgas syncline, which disappears gradually due to its eastward plunge.

In the southern flank the Lower Paleozoic comes to the surface, the Barrios quartzite forming the foundation for the dam of the Barrios de Luna reservoir, and a little further south we find for the first time the base of the Herreria formation lying unconformably on the Precambrian. To the north on the other side of the synclinorium the Lower Palaeozoic comes also to the surface, here as the front of the Rozo thrustsheet, thrust over the Namurian of the now probably autochtonous Bodon unit.

The amount of thrusting of this Rozo nappe forming this synclinorium is difficult to ascertain. Personally I think it is not more than two or three kilometres. We see in the northern flank of the synclinorium a very sharp line representing the first outcrop of the St. Lucia limestone, indicating a sudden drop of the block south of it. North of this line all the folds are exposed in the La Vid and San Pedro formations, south of this line they are all formed by La Vid-St. Lucia up to Carboniferous rocks. This surface feature probably represents the sudden rise of the thrustplane at depth, cutting through the autochtonous Lower Palaeozoic as drawn in section 1.

On the other hand the frontal Lower Palaeozoic outcrop of the Rozo thrustsheet makes an enormous curve in the NW corner of our map and reappears as the western limit of the San Emeliano Namurian basin. If this continuation of the Cambrian-Ordovician is really the same unit, it would perhaps indicate that the thrustsheet has an enormous extension of well over 30—50 km thrustmovement. Further mapping will have to be done to solve this question.

The frontal Cambro-Ordovician outcrop of the Leonides in the Upper Bernesga river makes the same enormous curve further west, now east of the San Emiliano basin, but here I think we may rest assured that it represents simply the autochtonous with Westphalian strata of the Asturian basin unconformable on top.

If the interpretation of a mere 2—3 km thrust movement in the Luna unit is correct, we obtain the interesting picture of the thrusting movement increasing eastwards, first by simplifying the folds and multiplying the thrusts and then simplification of the thrusts by concentrating all movement in one thrustsheet, the Esla nappe of perhaps 15—20 km thrustmovement.

Going further to the east, we are confronted again by a great difficulty in

following the development of the thrusting because the large unconformable blanket of Stephanian rocks of the Cea basin covers the Esla sheet completely. The front of Esla thrustsheet must bend southwards below this basin because in the Rio Grande and Carrion rivers no great thrustmovements can be discerned anymore. We have left all Lower Paleozoic outcrops behind us. It looks as if we might regard the curve of the Visean limestone crossing these rivers as the autochtonous in front of the Esla thrustsheet.

Eastwards from the Las Salas anticline in the Esla river, where the Lower Carboniferous limestone rests directly on the Barrios quartzite, the position and presence of the León line becomes less distinct. However, it can be followed eastward, north of the Valsurvio dome and further, north of Ruesga lake in the presence of the stratigraphic hiatus in the Devonian beneath the Famennian.

A detailed survey has shown that in both the Valsurvio dome and the isoclinal folds of the Ruesga region we find the same kind of intense refolding of the originally south dipping thrust and isoclinal folds as in the Bernesga thrustsheet pile, only here the older folds and thrusts are of much smaller size and the refolding is more intense (Koopmans, in press). In the Devonian of the Upper Carrion river the folding structure is of a completely different style so that here also the León line separates two structural units of different type. The line runs south of the large development of the Curavacas conglomerate and thus separates the Pisuerga basin with its Westphalian strata from the Leonides.

The Asturides

The structure of the northern stretch on our map is less clearly understood than that of the Leonides, only one map by Llopis Llado, 1955, is available, those of two of his collaboraters Martinez and Julivert, are still unpublished. In the whole region west of the Esla river the only rocks exposed are Upper Devonian-Visean-Westphalian and some Stephanian. The proven Stephanian is a very narrow and often interrupted band lying directly along the León line, from the Bernesga river crossing the Torio, Curueño and Porma and Esla rivers (Huelda) to join up in the Tejerina syncline with the Cea basin. The age of the rocks filling the Upper Esla basin is somewhat doubtful, they begin with a unconformable basal conglomerate exposed near Uña and west of Riaño. No fossils have been found yet in this shale-sandstone-conglomerate sequence but as it is unconformable on Westphalian strata, it is either of Upper Yuso or of Cea group age.

The folds in the Westphalian-limestone-shale-graywacke sequence in the western part of the Asturidas, the Pajares-Isidro unit, are very complex, almost isoclinal, with north dipping axial planes. They are difficult to map because the limestones have a very irregular development. In the region between Piedafrita on the Torio river and Riaño we find that the Visean limestone and Upper Devonian beds take part in numerous large folds. It appears to be certain that there occur folded thrustplanes in these structures but we do not yet know the scale of the thrusting that took place. A very clear example of the thrusting is to be seen in the two superposed Peña Cruz sheets north of Lois, each consisting of Upper Devonian-Visean and some Namurian. North and west of the Upper Esla valley several of these thrusts are also exposed but it is still not certain whether such overthrust blocks represent independent structures or have to be combined in a few thrustsheets of large dimensions or in one very large thrust-

sheet. Neither have we been able yet to define the exact date of thrusting and of the later refolding. There can be no doubt that there are at least two phases and the later phase is certainly post Westphalian, but whether it is Asturian or Saalic is still in doubt.

In the Yuso unit a large anticline, the Vallines anticline flanked in the south by the large Lechada syncline has developed. The southern flank of the Lechada syncline in the Barniedo-Cardaño-Triollo zone is complicated by small folds and thrusts.

The Devonian of the upper Carion unit is folded in a set of E—W trending anticlines and synclines with occasional thrustplanes.

Further east we find the Pisuerga basin with its NNW—SSE striking folds of probable Asturian age, extending into the Barruelo basin. The two basins are separated by the San Julian hill with its E—W striking folds in Lower-Devonian rocks, probably sticking up through an unconformable cover of Lower Carboniferous rocks, which does not seem to follow the folds of the Devonian. This E—W trend of the Devonian in the Carrion and S. Julian region suggests that here, and perhaps in the Asturides as a whole, there was a pre-Famennian folding phase with this strike, which did not fold the Leonides but only tilted it.

Apparently the next phase, the pre-Westphalian Curavacas phase affected only the Leonides with great thrustsheets and isoclinal folds and left the Asturides alone. The late or post-Westphalian phase was active in the Pisuerga region, with NNW—SSE strike, elsewhere with a NE—SW strike affecting the whole region.

After denudation and the subsidence of the upper Westphalian-Stephanian intramontane basins, probably related to normal faulting (Henkes, 1961) the post-Stephanian folding affected the whole region now with a normal concentric folding having an E—W strike.

Tertiary folding probably affected the region hardly at all except along its present southern border. The whole of the Asturian-Cantabrian mountains were uplifted and a few wrench faults, cut into it from the southern border. There is some evidence in the west that besides the steep but narrow southern border zone, exposed in the Triassic rocks, flat and large-amplitude folds of Tertiary age did penetrate to some extent into the Palaeozoic (de Sitter, 1957; Nederlof & de Sitter, 1957).

The *Cantabrian Mountain chain* as it is now exposed at the surface is rather an incongruous structure. The Leonide thrustsheets have moved towards the present crestal zone, in which not the older but the younger sequence of rocks is exposed. There is no trace of any regional metamorphic core of the mountain chain, and the oldest rocks, Pre Cambrian, crop out only on its southernmost boundary.

Without doubt it is the Mesozoic and Cenozoic history of this part of earth's crust which has caused such an unusual picture of a Hercynian orogene: Mesozoic emergences, denudations and blanketing and finally Tertiary emergence and sedimentation have defined the present outcrop of the Paleozoic rocks, events which were to a large degree independent of the original structure.

When we try to reconstruct the Hercynian orogene it looks very probable that the core of that orogene lies further south below the Tertiary cover, perhaps regionally metamorphosed, so that the external zone with the Helvetian type thrustsheets is represented by the northern Leonide zone. The marginal trough, filled with Carboniferous sediments, would be represented by the Central Asturian basin, our Asturides, to complete an orogene analogous with the alpine type.

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