LEIDSE GEOLOGISCHE MEDEDELINGEN, Deel 52, Aflevering 2, pp. 185–192, 1-2-1983

UPPER DEVONIAN BLOCK MOVEMENTS AND SEDIMENTATION IN THE ASTURO-LEONESE BASIN (CANTABRIAN MOUNTAINS, SPAIN)

BY

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ABSTRACT

The Upper Devonian shelf of the studied area was divided into two platforms separated by a significant break in the slope, related to the deep-seated fault system of the Sabero-Gordón Line. As differentiated block movements influenced the depositional history of the area, an External Zone, an Intermediate Zone and an Internal Zone can be distinguished. Each zone runs parallel to the east-west striking Upper Devonian coast and has a characteristic sedimentary succession. Due to upheaval, tilting and erosion of the area north of the Sabero-Gordón Line and intermitted subsidence south of this line, related to progradation of the linear shoreline from north to south, three regressive coarsening upward sequences were deposited in the External Zone. The first sequence is capped by a calcareous transgressive unit of minor importance. Based on these sequences the Nocedo Formation is divided into three members. The Gordon Member and the Millar Member are newly introduced in this paper. The Fueyo Member was already officially introduced by Evers (1967). After deposition of the three cycles epeirogenetic movements decreased and a levelling stage occurred in which coastal sands spread out over the whole area forming the transgressive upper part of the Ermita Formation.

INTRODUCTION

The southern slope of the Cantabrian Mountains exposes an almost complete succession of non-metamorphic Palaeozoic strata. The Lower Devonian and Middle Devonian consist mainly of limestone

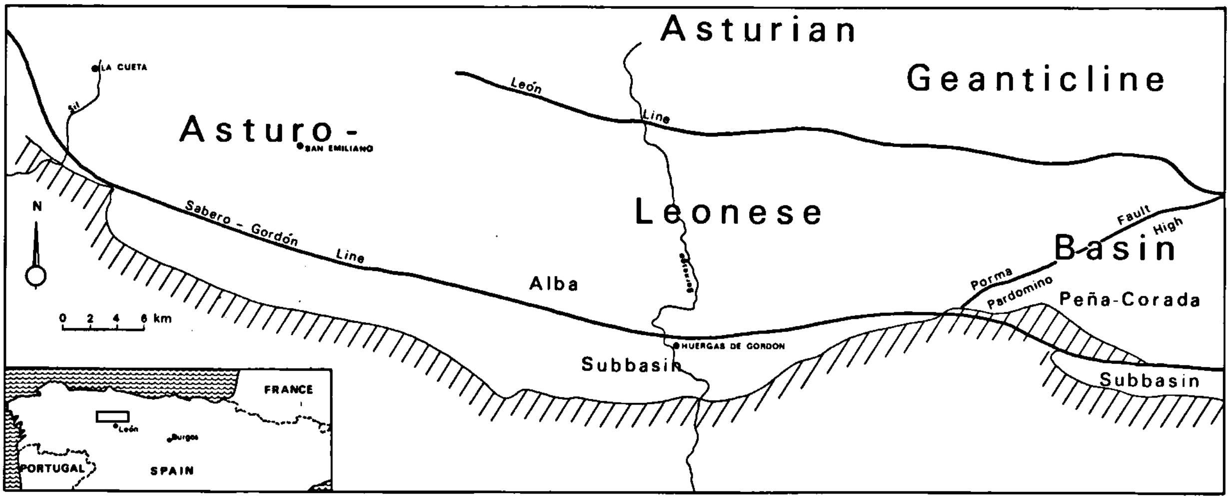

Fig. 1. Map showing the main palaeogeographic elements.

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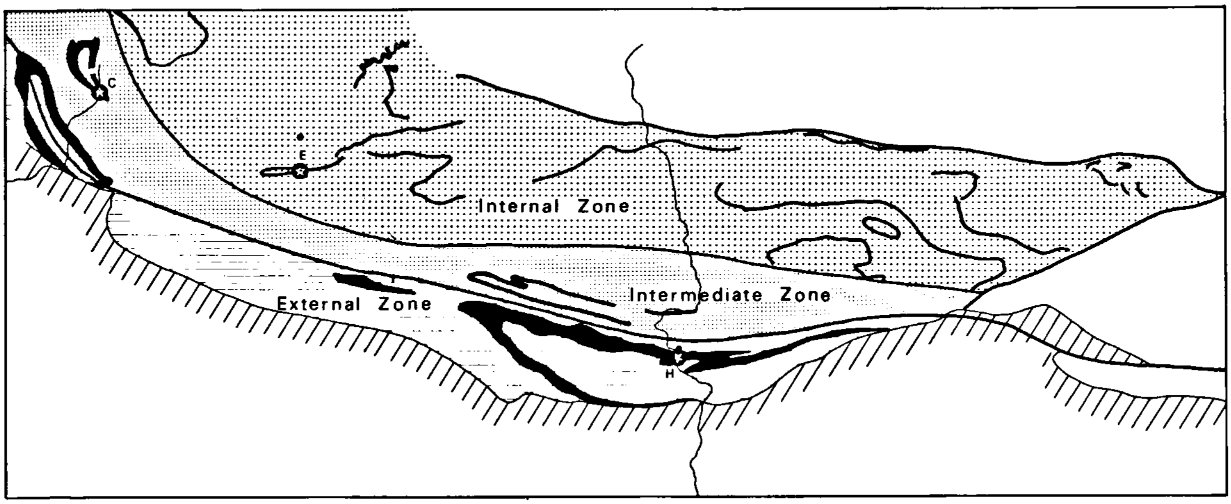


Fig. 2. Outcrop map of the Upper Devonian with the extension of the three zones and the locations of the sections.

deposits interrupted by some siliciclastic intervals. These deposits reflect stable conditions; carbonate masses built out over extensive shallow platforms. Owing to differences in thickness, lithofacies and biofacies, facies belts can be distinguished running parallel to the palaeocoast (de Coo et al., 1971; de Coo, 1974; Méndez-Bedia, 1976; Reyers, 1980). During the Upper Devonian a more pronounced differentiation into positive and negative areas becomes apparent, as a result of epeirogenetic movements of specific blocks, bounded by fundamental fault zones. For the studied area three fault zones appear to be of importance: the León Line (de Sitter, 1962), the Sabero-Gordón Line (Rupke, 1965) and the Porma Fault (Rupke, 1965) (Fig. 1). The León Line acted as a boundary between the Asturo-Leonese Basin in the south and the Asturian Geanticline, which was a positive area during most of the Devonian, in the north. The Asturo-Leonese shelf was divided into two platforms,separated by a sharp break in the slope related to the Sabero-Gordón Line. The platforms were depressed along an axis parallel to the Upper Devonian coast. The Porma Fault bounded the Pardomino Ridge which divided the Asturo-Leonese Basin into an eastern Peña-Corada Subbasin and a western Alba Subbasin (Evers, 1967). The Upper Devonian clastic succession of the Alba Subbasin is the subject of this study.

The Upper Devonian formations

Two formations are distinguished in the upper part of the Devonian. The lower formation, the Nocedo Formation, consists of an alternation of shales, siltstones, sandstones and limestones. The Fueyo shales have been included in the Nocedo Formation as the Fueyo Member (Evers, 1967). The upper formation, the Ermita Formation, consists of siltstones and sandstones, locally capped by a thin limestone.

ZONATION

The strong epeirogenetic movements during the Upper Devonian caused marked differences in thickness and facies. Especially the movements along the Sabero-Gordón Line greatly affected the sedimentation pattern. The area south of this line, characterized by downwarping, corresponds with the External Zone. The area north of the Sabero-Gordón Line is characterized by upheaval and tilting towards the south, causing two different zones. The southern half of this area corresponds with the Intermediate Zone, the northern half with the Internal Zone (Fig. 2). The zones are running parallel to the east-west striking palaeo-coast. Each zone has its own characteristic sedimentary succession. Three sections have been selected, one in each zone, to describe these characters.

The External Zone

To describe this zone the section situated just south of the village of Huergas de Gordon has been selected, containing the stratotype of the Nocedo Formation as well as the badly exposed stratotype of the Ermita Formation (Figs. 3 and 4). The Ermita Formation is very well exposed a few hundred meters to the west near the village of Nocedo. Three cycles can be recognized in the 593 m thick succession;

Rocktype	Lithofacies	Biofacies	Depositional environment
	nodular siltstones with bioclastic wackestones strong bioturbation	brachiopods, crinoids, bryozoans and stromatoporoids burrows of suspension-feeders and sediment-feeders	lagoonal
	reddish crossbedded bioclastic packstones and grainstones weak bioturbation	fossil-fragments of brachiopods, crinoids, stromatoporoids and corals burrows of suspension-feeders	bioclastic shoals in agitated water sub- to intertidal
	sandstones with parallel lamination, crossbedding, ripple marks and ferruginous soils moderate bioturbation	off-prints of brachiopods and crinoids burrows of suspension-feeders	coastal sand sub- to supratidal
	siltstones with clay flasers, sporadical channeling sandstone beds strong bioturbation	brachiopods, crinoids and bryozoans burrows of sediment-feeders	transitional
	laminated grey to brown shales striped with graded siltstone and sandstone laminae weak bioturbation	rarely tentaculites and goniatites burrows of sediment-feeders	holomarine

Fig. 3. Facies and depositional environments of the Upper Devonian deposits.

third cycle: holomarine shale - transitional siltstone - coastal sandstone

second cycle: holomarine shale - transitional siltstone - coastal sandstone

first cycle: transitional siltstone - coastal sandstone - bioclastic shoal - lagoonal siltstone and wackestone - coastal sandstone

Each unit begins with shale or siltstone with a sharp base against the underlying deposits and grades upward into more coarse-grained sediments. The Nocedo Formation can be divided into three members: the Gordon Member (named after Huergas de Gordon) representing the first sequence, the Millar Member (named after a small village just west of Huergas de Gordon) representing the second sequence and the Fueyo Member (named after a tributary of the Rio Bernesga) containing the shales of the third sequence. The upper part of the latter sequence belongs to the Ermita Formation.*) Towards the southwest more holomarine deposits are coming in. Towards the east the sections are thinning and the amount of coastal sandstone increases at the cost of transitional siltstone.

The Intermediate Zone

The section in the southern limb of the Quejo syncline just south of the village La Cueta has been selected to describe the depositional history of this zone (Fig. 5). The Nocedo is reduced to a thickness of not more than 45 m. The Millar Member and the Fueyo Member are absent. The lower part of the Gordon Member consists of lagoonal silty wackestone deposits intercalated by a few sandstone layers and bioclastic grainstone layers representing storm-generated washovers. The

*) The Gordon Member and the Millar Member correspond with unit A and unit B respectively of the Nocedo Formation in van Loevezijn & Raven (1983; this issue).

SECTION H
HUERGAS DE GORDON

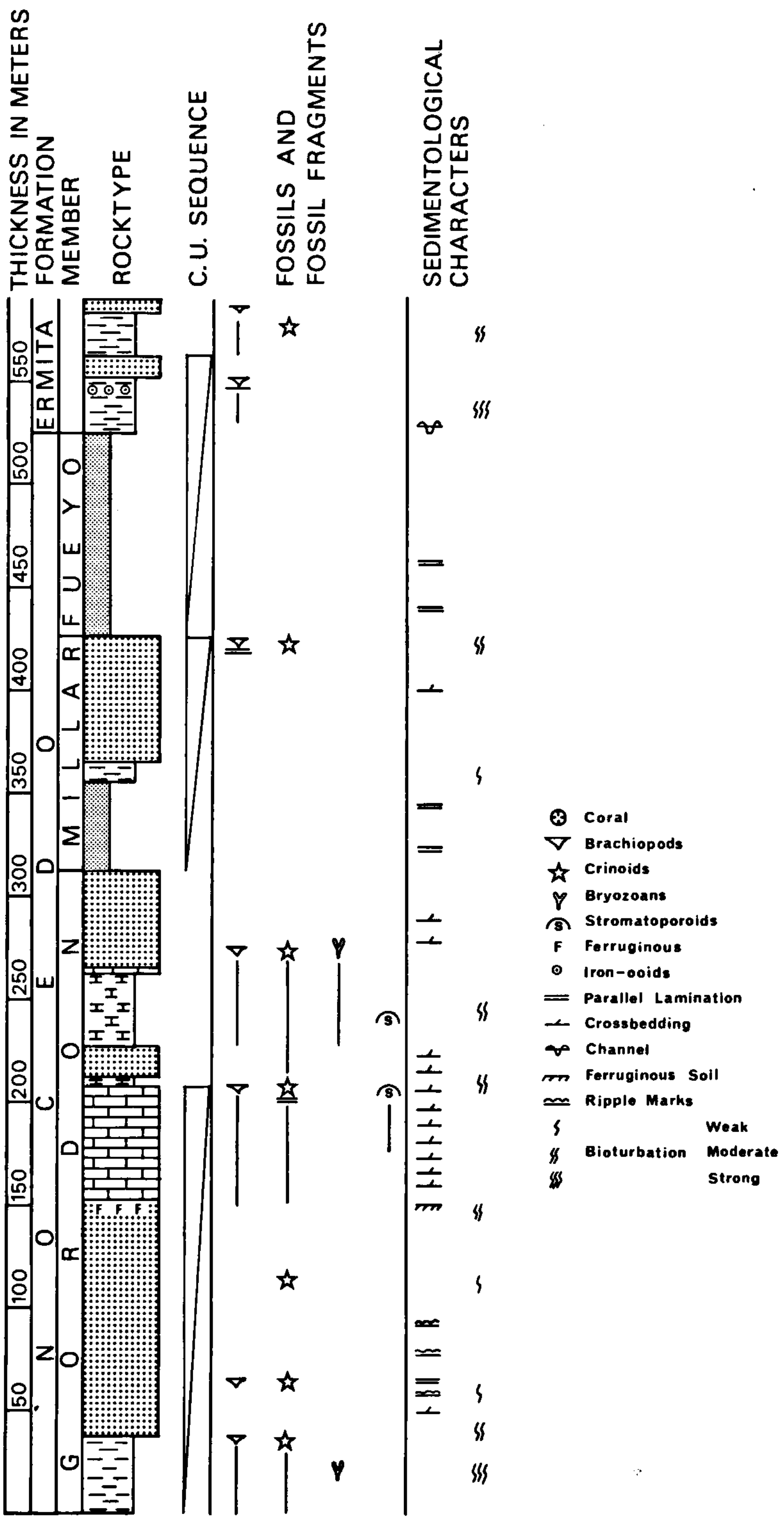


Fig. 4.

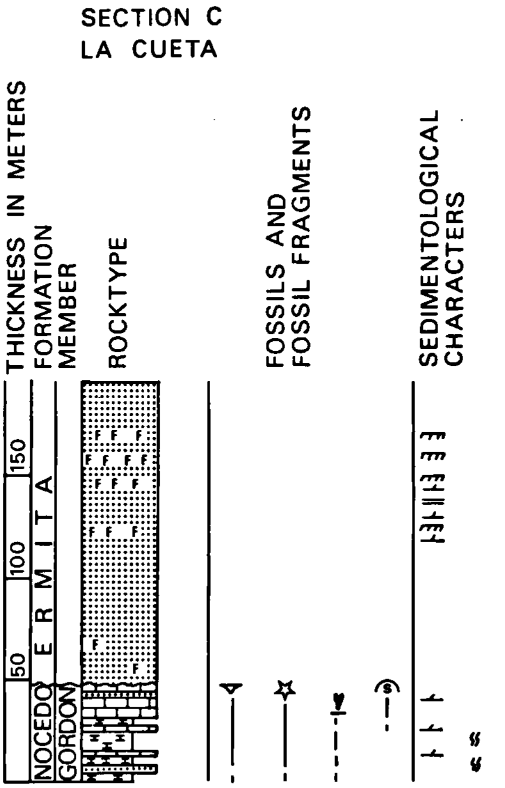


Fig. 5.

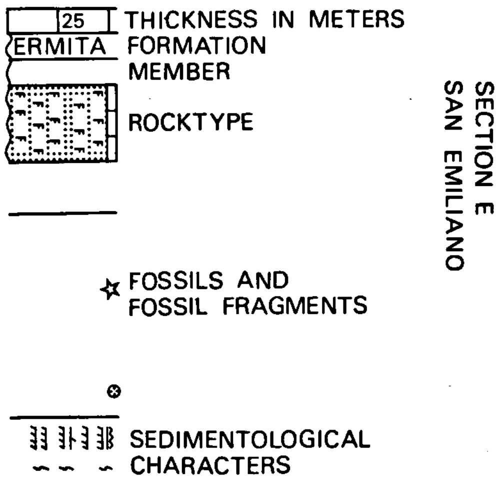


Fig. 6.

grainstone in the upper part of the member represents bioclastic shoals or carbonate sandbars. The Ermita Formation overlies the Nocedo Formation with a paraconformable contact. The coastal sandstone contains a few ferruginous soils. Further eastward the deposits are capped by a grainstone layer.

The Internal Zone

To characterize this zone, the section 2.25 km south of the village of San Emiliano has been selected (Fig. 6). The Nocedo Formation is not present. The Ermita Formation rests with a disconformable contact on the underlying Middle Devonian limestone of the Caldas Formation. More to the northeast progressively older rocks are unconformably overlain by the Ermita Formation. An angularity could not be observed in the field. The most remarkable aspects of this section are the abundant ferruginous soils, indicating subaerial exposure. Laterally of this section karst features in the top of the underlying limestone of the Caldas Formation can be observed (sinkholes, breccias, joints). Table 1 gives a synopsis of the characteristics of each zone.

ISOPACH PATTERNS

The isopach patterns of the members of the Nocedo Formation are largely defined by the Sabero-Gordón Line (Figs. 7a, 7b and 7c). This line separates the southern area with thick deposits from the northern area with limited net sedimentation. The isopachs of the Ermita Formation show a wider pattern and are less controlled by the Sabero-Gordón Line (Fig. 7d). With the isopach patterns a migration of the depocenters to the west can be demonstrated in the Bernesga area.

From the influence of the Sabero-Gordón Line on the isopach patterns and the migration of the depocenters it seems plausible to assign strong tectonic control on the Upper Devonian shelf morphology.

CONCLUSIONS

Especially in the Internal Zone erosion occurred, due to upheaval and canting towards the south of the area north of the Sabero-Gordón Line, resulting in a large supply of clastics in the Intermediate and Internal Zones. Owing to redistribution of terrigenous sediment by marine currents, more or less straight clastic shorelines were formed with bars, beaches and lagoons running parallel to the east-west striking Upper Devonian coast. In the External Zone holomarine sediments were deposited due to strong subsidence. Because of the high production of clastics in the northern area, supply surpassed subsidence and the lithotopes shifted seawards in a southern direction, resulting in a regressive coarsening upward sequence. By intermitted subsidence of the southern area three coarsening upward sequences were formed in the External Zone, corresponding with the lower part of the Gordon Member (the calcareous upper part has a transgressive character), the Millar Member and the Fueyo Member with the lower part of the Ermita Formation (Fig. 8). Subsequently the blockmovements decreased, the area remained stable and a levelling stage followed, during which the whole area was characterized by the deposition of coastal sands, progressively overlying older strata in a northerly direction. Epeirogenetic movements started already in the Upper Silurian with a positive area in the north (Krans, 1982). Therefore a large part of the hiatus was caused by nondeposition and submarine erosion.

Properties	External Zone	Intermediate Zone	Internal Zone
thickness	300 - 730 m	81 - 291 m	0 - 53 m
lithostratigraphic units	Ermita Formation Nocedo Formation: - Fueyo Member - Millar Member - Gordon Member	Ermita Formation Nocedo Formation: - Gordon Member	Ermita Formation Nocedo Formation: - absent
sediments	shales, turbidites siltstones, sandstones, limestones very few ferruginous soils	siltstones, sandstones, limestones few ferruginous soils	sandstones, limestones abundant ferruginous soils
contacts	base of the Ermita Formation conformable	base of the Ermita Formation paraconfor- mable	base of the Ermita Formation disconformable

Table 1. Characteristics of the three zones.

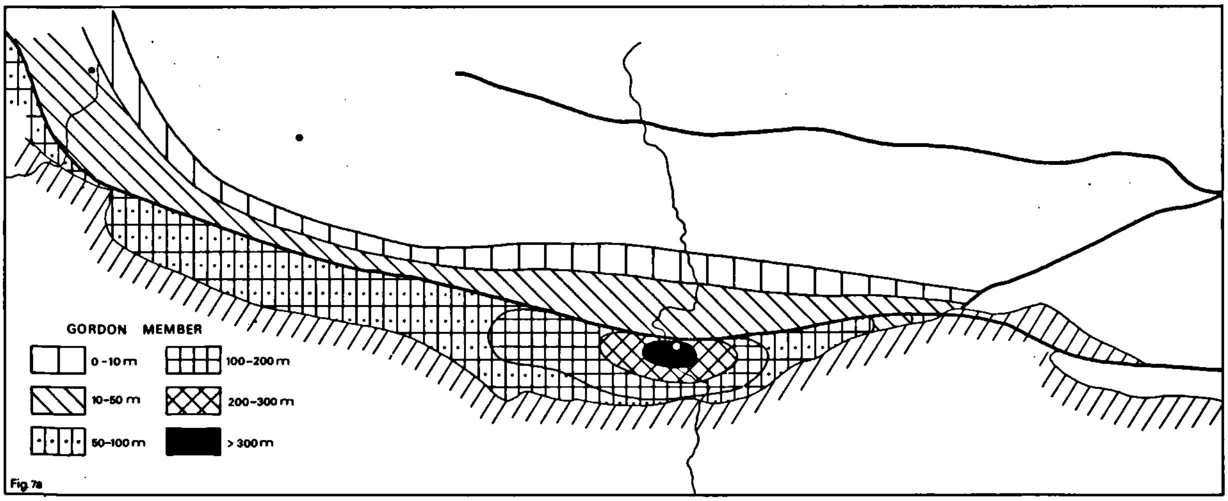
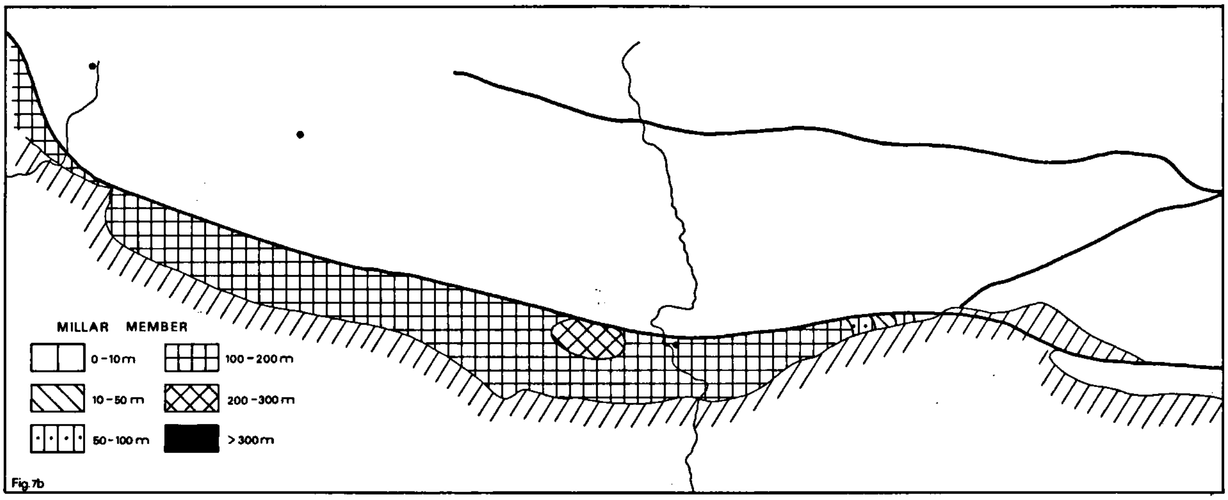
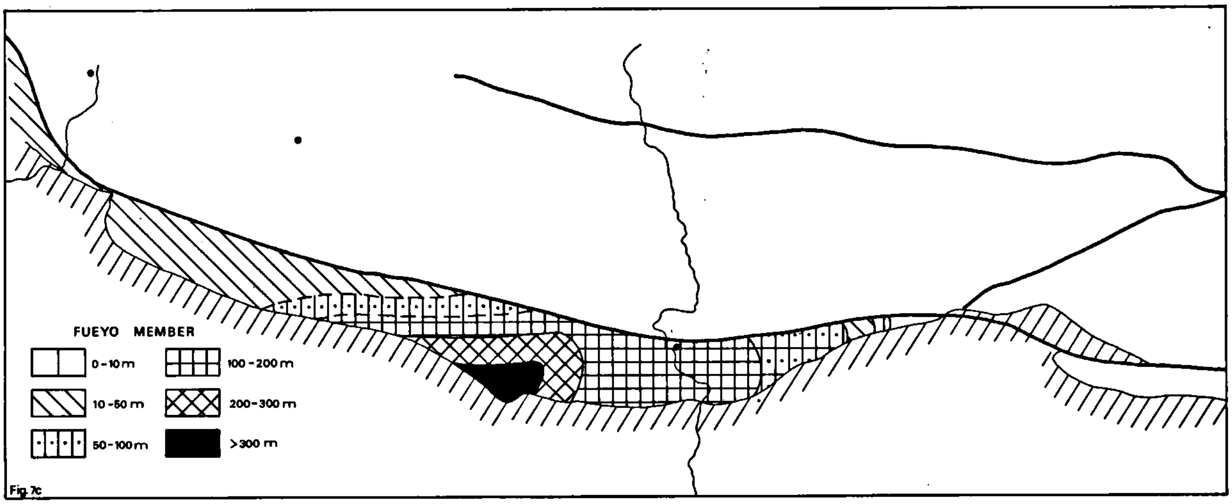
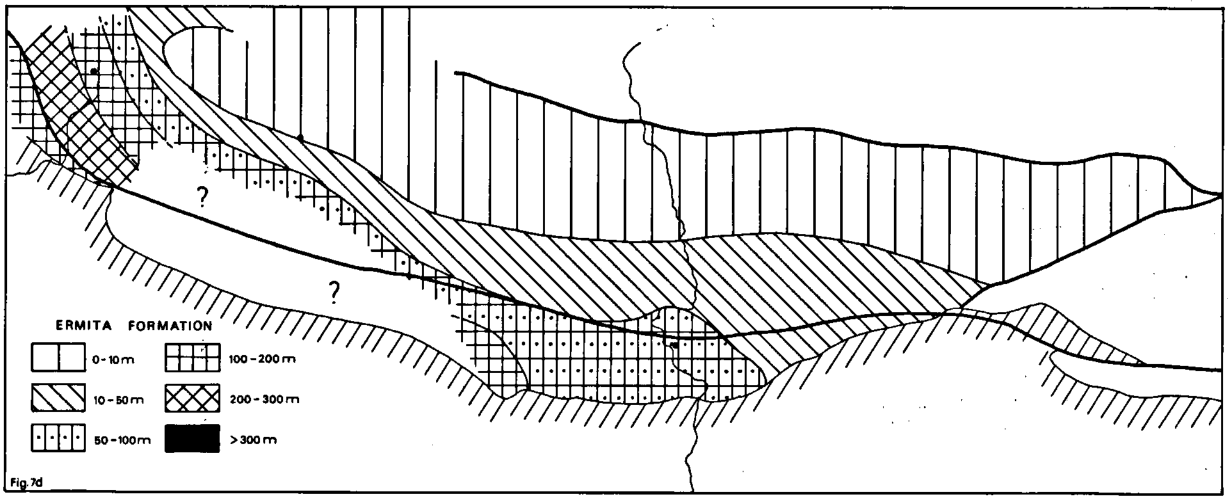


Fig. 7. Thickness distribution of the Gordon Member (Fig. 7a), the Millar Member (Fig. 7b), the Fueyo Member (Fig. 7c) and the Ermita Formation (Fig. 7d).


MILLAR MEMBER
0-10m
100-200m
10-50m
200-300m
50-100m
>300m
Fig.7b


FUEYO MEMBER
0-10m
100-200m
10-50m
200-300m
50-100m
>300m
Fig.7c


?
?
ERMITA FORMATION
0-10m
100-200m
10-50m
200-300m
50-100m
>300m
Fig.7d

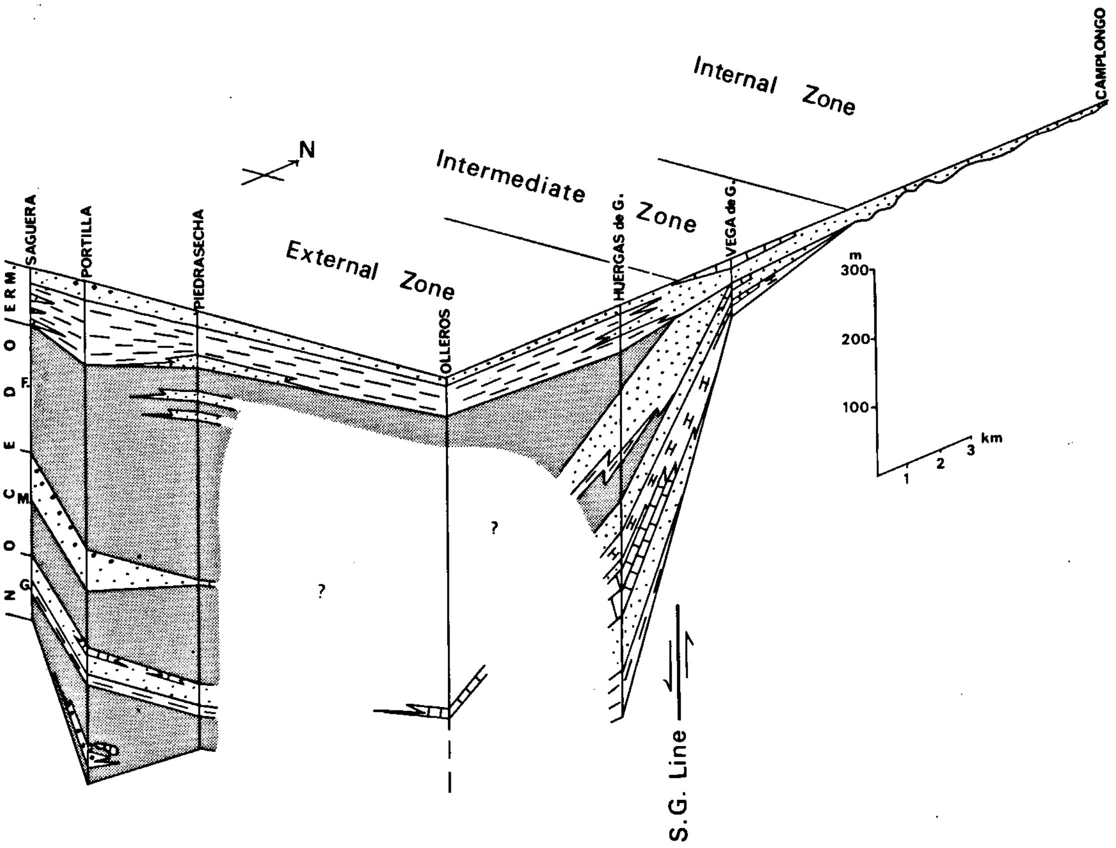


Fig. 8. Block diagram showing the facies distribution of the Nocedo Formation and the Ermita Formation in the Bernesga area. No palinspastic corrections were made.

ACKNOWLEDGEMENT

The fieldwork was carried out in the summers of 1979, 1980 and 1981 when data were obtained for a M.Sc. thesis (van Loevezijn, 1982). Thanks are due to the staff members of the Department of Stratigraphy and Palaeontology of Leiden University for their assistance and valuable discussions.

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