UPPER DEVONIAN TO LOWERMOST CARBONIFEROUS CONCRETION TYPES AND THEIR STRATIGRAPHIC SIGNIFICANCE (CANTABRIAN MOUNTAINS, N SPAIN)

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TRABAJOS DE GEOLOGIA

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Based on their lithology six concretion types are distinguished in the Upper Devonian deposits of the Cantabrian Mountains. Their stratigraphic positions are discussed using conodont biostratigraphy. The concretion types are restricted to certain stratigraphic intervals, thus contributing to a better separation of the Upper Devonian lithostratigraphic units, allowing a more accurate structural mapping.

Key words: Upper Devonian, Lowermost Carboniferous, concretions, stratigraphy, conodonts, Cantabrian Mountains, Spain.

Basándose en la litología se distinguen seis tipos de concreciones en los depósitos del Devónico Superior de la Cordillera Cantábrica. Se discute su posición estratigráfica usando la bioestratigrafía de conodontos. Los tipos de concreciones están restringidos a ciertos intervalos estratigráficos, contribuyendo así a una mejor separación de las unidades litoestratigráficas del Devónico Superior y permitiendo que se hagan los mapas estructurales con más precisión.

Palabras clave: Devónico Superior, Carbonífero Inferior, concreciones, estratigrafía, conodontos, Cordillera Cantábrica, España.

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Since Comte (1959) described the Upper Devonian succession of the southern Cantabrian Mountains, many authors have mentioned concretions as an accessory component of the Upper Devonian succession. Although locally Upper Devonian formation boundaries are based on the occurrence of concretions, no author provides an accurate description of the concretion types, or shows a satisfactory understanding of their stratigraphic value. To fill this gap of information the Upper Devonian concretions are lithologically differentiated, and from each type the stratigraphical position and the fauna is investigated, especially by determination of the conodont assemblages. Some published conodont faunas have been updated and are presented here together with recent collected faunas.

UPPER DEVONIAN STRATIGRAPHY

The thickest and best developed Upper Devonian sequence of the Cantabrian Mountains occurs in the area south of the Intra-Asturo-Leonese facies line in the Alba syncline (van Loevezijn 1986) (Fig. 1), where the Nocedo, Fueyo and Ermita formations form an up to 700 m thick succession. The base of the Nocedo Formation is approximately coincident with the Givetian – Frasnian boundary, and the top with the Frasnian – Famennian boundary. The formation consists of two coarsening upward sequences; the lower one with a limestone unit in the top is included in the Gordón Member and the upper one in the Millar Member. In the western part of the Alba syncline erosive channel – fill conglomerates occur in the top of the Millar Member. The overlying Fueyo Formation consists

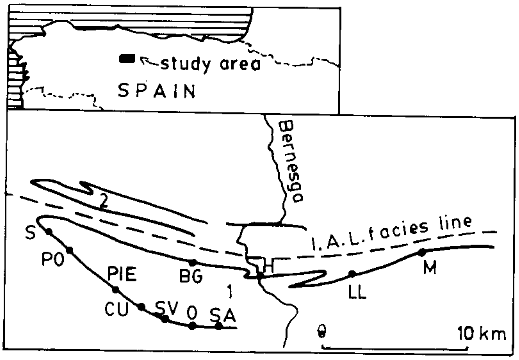


Fig. 1.–Situation map and outcrop map of the river Bernesga area with the positions of the sections; 1 = Alba syncline, 2 = Pedroso syncline, I. A. L. facies line = Intra – Asturo – Leonese facies line.

of a lower shale unit and an upper sandy shale unit. Most of the formation was deposited during the early Famennian, and only in the southernmost part of the Alba syncline sedimentation continued during the late Famennian – earliest Tournaisian. The overlying Ermita Formation was deposited during the late Famennian and earliest Tournaisian, and consists from base to top of a bioturbated siltstone unit, a crossbedded, locally conglomeratic, sandstone unit and a thin bioclastic limestone unit. In the southernmost sections of the Alba syncline most of the siltstones and sandstones of the Millar Member and of the Fueyo and Ermita formations are replaced by shales (Fig. 2).

PREVIOUS WORK ON CONCRETIONS

Comte (1959) was the first who mentioned concretions from the Upper Devonian in the Cantabrian Mountains. He found these nodules in the Fueyo Formation and described them as «nodules argilo - siliceux». Based on this work Rodríguez Fernández *et al.* (1985) consider the uppermost part of the underlying Nocedo Formation sensu van Loevezijn (1986), which contains similar nodules, as the basal part of the Fueyo Formation.

Frankenfeld (1981) mentioned «geoden Horizonten» from the Upper Devonian shales in the southern limb of the Alba syncline (section Piedrasecha). From the same area he also mentioned «Ton – Gerolle» from the

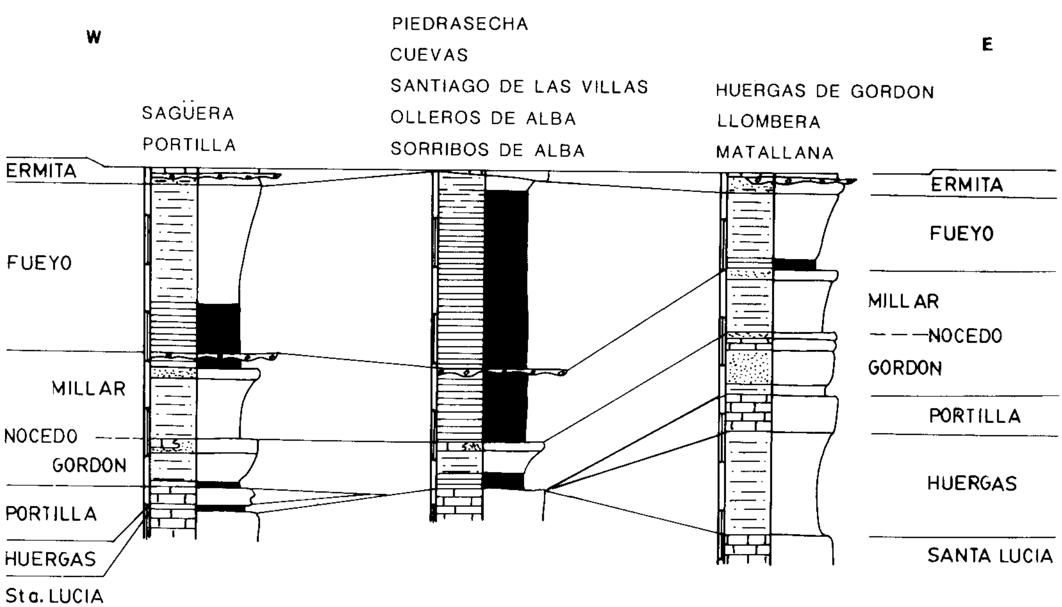


Fig. 2.–Middle and Upper Devonian correlations in the Alba syncline; in the southernmost sections the Huergas and Portilla formations are tectonically eroded and most of the Upper Devonian siltstones and sandstones are replaced by shales (after van Loevezijn 1986); the scale bars indicate units of 100 m.

uppermost part of the Ermita Formation and from the overlying Vegamián Formation, which are synonymous with the «black shale pebbles» of Raven (1983).

Van Loevezijn (1986) mentioned septaria nodules from the base of the Fueyo Formation (Piedrasecha section). Limestone concretions and lenticles were found in laminated dark shales in the uppermost part of the Upper Devonian sequence in the southern limb of the Alba syncline (Rodríguez Fernández *et al.* 1985; van Loevezijn 1986).

CONCRETION TYPES

In the Upper Devonian of the Alba syncline six concretion types are recognized with different stratigraphic positions: burrowed mud nodules, concentric silt nodules, laminated argillaceous silt nodules, calcareous silt lenticles, limestone lenticles, and black shale nodules.

BURROWED MUD NODULES (Fig. 3a)

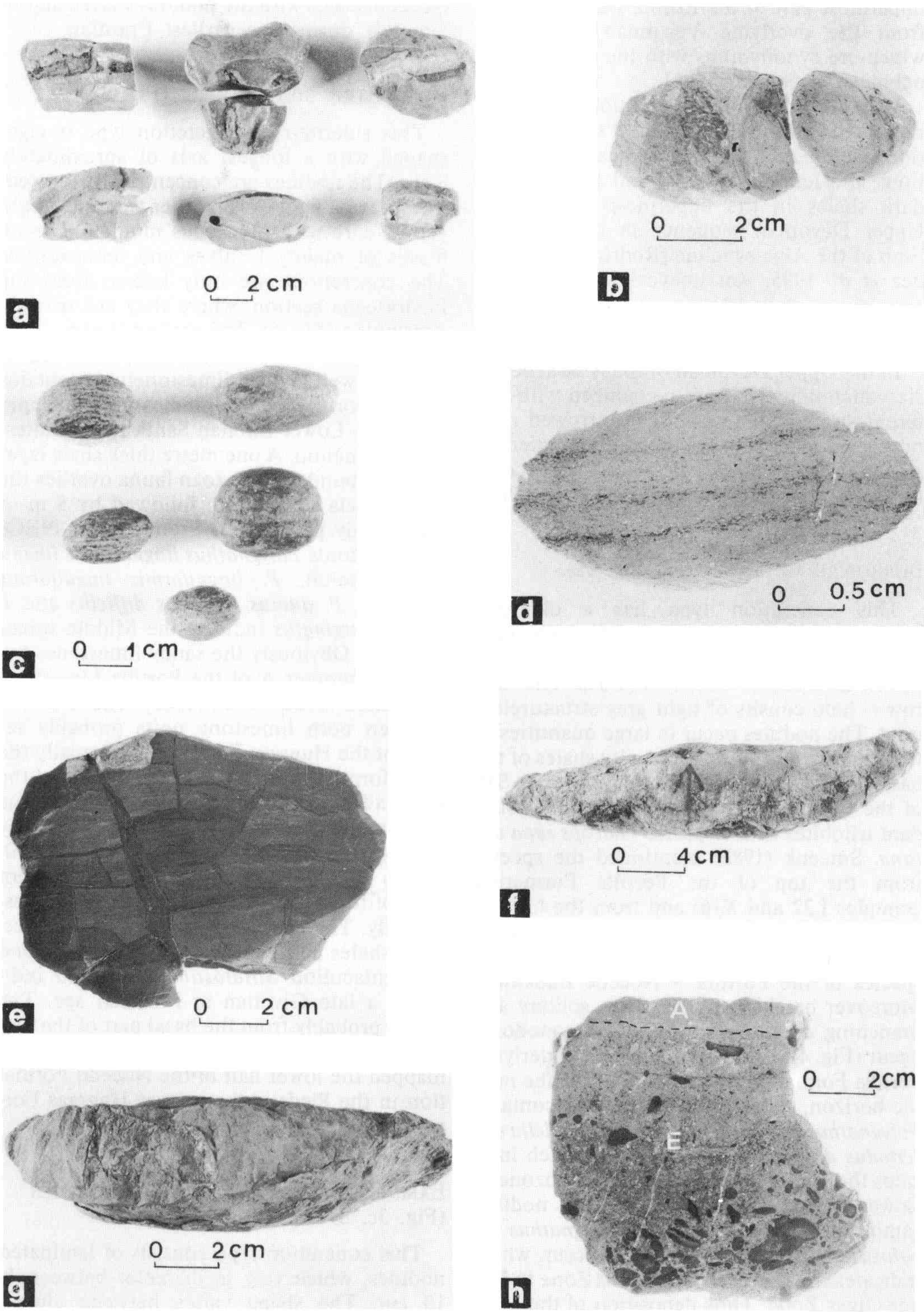
This concretion type has a diameter between 2-10 cm, and is formed around branching burrows. These are filled with yellow – brown iron oxides and hydroxides. The burrow – halo consits of light grey structureless mud. The nodules occur in large quantities in the fossiliferous bioturbated silty shales of the basal 2 m of the Nocedo Formation 500 m SW of the Barrios de Gordón village, with abundant trilobites of the species *Phacops rana* aff. *rana*. Smeenk (1983) mentioned the species from the top of the Portilla Formation (samples L22 and X16) and from the base of the Nocedo Formation (sample X17). Obviously *Phacops rana* aff. *rana* is a common species of the Portilla – Nocedo transition. Moreover brachiopods, bivalves, solitary and branching corals, gastropods and conodonts occur (Fig. 4). From the top of the underlying Portilla Formation, about 3.5 m below the nodule horizon, conodont sample BGC1 contains *Polygnathus decorosus, P. dubius, Belodella* sp., *Icriodus difficilis* and *I. Eslaensis,* which indicates the Upper *hermanni cristatus* Subzone to Lower *asymmetricus* Zone. In the nodule-sample BGC2 the conodonts *Polygnathus decorosus* and *Icriodus symmetricus* occur, which indicates the Lower *asymmetricus* Zone to Upper Gigas Zone. Thus deposition of the basal Nocedo shales with the nodules started approximately during the earliest Frasnian.

CONCENTRIC SILT NODULES (Fig. 3b)

This siderite-rich concretion type is cigar shaped with a longest axis of aproximately 8 cm. The nodules are concentrically layered: They have a light brown outer part and a light yellow core with numerous moulds of small fossils of mainly bivalves and tentaculitids. The concretions are only known from the Piedrasecha section, where they are sparsely distributed (Fig. 5). The section is complicated by faults. Sample PIEC7 from the top of the grey, well bedded limestone unit contains *Icriodus corniger corniger* indicating the Upper Emsian – Lower Eifelian Santa Lucia Limestone Formation. A one metre thick shale layer with an abundant bryozoan fauna overlies the Santa Lucia Formation, followed by 5 m of grey, sandy packstones. From sample PIEC6 the conodonts *Polygnathus linguiformis linguiformis* (delta), *P. linguiformis linguiformis* (gamma), *P. dubius, Icriodus difficilis* and *I. obliquimarginatus* indicate the Middle *varcus* Subzone. Obviously the sandy limestones belong to member A of the Portilla Limestone Formation sensu Raven (1983). The shales in between both limestone units probably represent the Huergas Formation. Normally the latter formation is 200 to 300 m thick, and the Portilla Formation 100 to 200 m thick, but due to complicated thrusting as described by Rodríguez Fernández *et al.* (1985), the thickness of these formations in the southern limb of the Alba syncline were reduced substantially. The concentric nodules in the overlying shales contain the bivalve *Buchiola* and the tentaculitid *Striatostiliolina striata* indicating a late Givetian to Frasnian age. The shales probably from the basal part of the Nocedo Formation. Alvarez Marrón (1985) mapped the lower half of the Nocedo Formation in the Piedrasecha area as Huergas Formation. This has to be revised now.

LAMINATED ARGILLACEOUS SILT NODULES (Fig. 3c, d)

This concretion type consists of laminated nodules, which vary in diameter between 1-10 cm. The shape varies between almost


0 2 cm
a
0 2cm
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c
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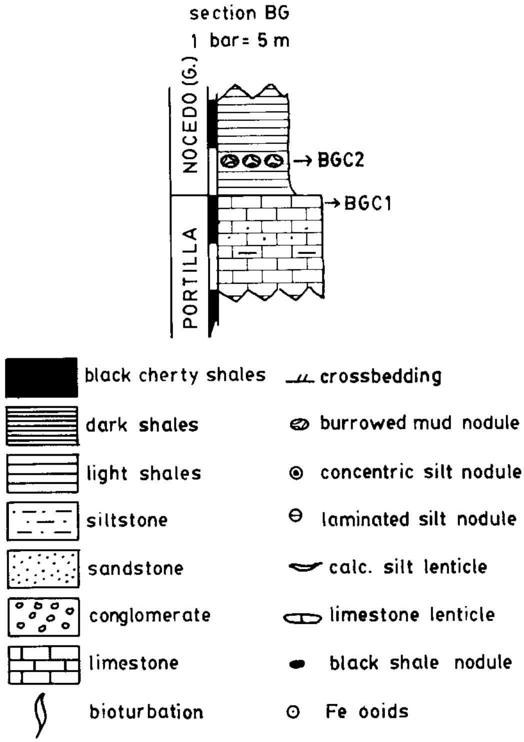

Fig. 4.–Portilla-Nocedo transition in the Barrios de Gordón section, with the position of the burrowed mud nodules.

spherical forms to flat ellipsoid forms. Characteristical is the fine laminated structure in the nodules, which can be traced into the surrounding sediment. The laminations are formed by an alternation of argillaceous rich and argillaceous poor sediment. The nodule crusts consist of ferruginous sediment. No fossils were found in this concretion type, which is synonymous with the «nodules argilo - siliceux» of Comte (1959), who found them in the lower shale unit of the type section of the Fueyo Formation in the Bernesga valley, and with the «geoden Horizonten» from the Piedrasecha section mentioned by Frankenfeld (1981). Rodríguez Fernández *et al.* (1985) consider them characteritical for the lower shale unit of the Fueyo Formation, but in the Piedrasecha section the nodules occur also in large quantities in the entire Millar Member of the Nocedo Formation (Fig. 6). Similar nodules have been found in the shales from the top of the Millar Member of the Santiago de las Villas section and in the entire shale unit of the Millar member of the Olleros de Alba

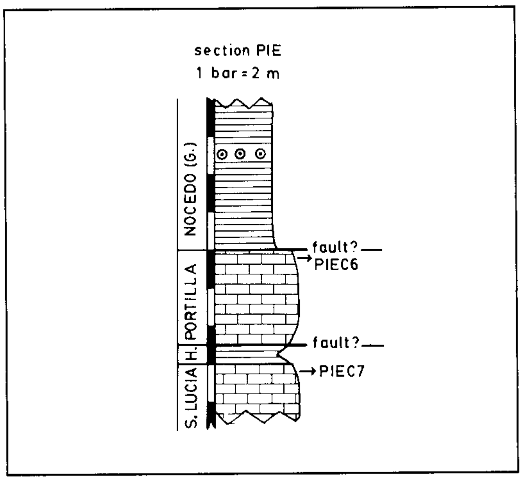

Fig. 5.–Basal part of the Piedrasecha section (PIE), with the position of the concentric silt nodules; H = Huergas Formation. See Fig. 4 for legend.

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Fig. 3.–a) Mud concretions which are formed around branching burrows in silty shales. These concretions are only found in the shales in the base of the Gordón Member of the Barrios de Gordón section, where they occur in large quantities. b) Concentric concretion from the basal shales of the Gordón Member of the Piedrasecha section. In the concretion core numerous moulds of small fossils occur. c) Laminated silt concretions, which occur in large quantaties in the shales of the Millar Member of the Nocedo Formation and in the Fueyo Formation. d) Thin section of a laminated concretion. The dark laminae consist of argillaceous silt, whereas in the light laminae the argillaceous matter is almost absent. The crust consists of ferruginous sediment. e) Calcareous silt nodule from the basal part of the Fueyo Formation of the Piedrasecha section, with internal shrinkage cracks filled with calcite cement. f) Calcareous silt lenticle from the same location as Fig. 3e. g) Limestone (mudstone) lenticle from the limestone – shale unit of the uppermost part of the Fueyo Formation of the Sorribos de Alba section. h) Sample of the uppermost part of the Ermita Formation (E) of the La Robla section. The lower half of the sample consists of a mixture of calcareous sandstones and black shale nodules. The upper half of the sample consists of fossil fragments with only, a few irregular distributed nodules. The boundary between the fossil debris and the mudsupported limestones of te Alba Formation (A) is sharply delineated.

section. Obviously these nodules are not restricted to a formation, but are facies controlled (laminated shale facies).

CALCAREOUS SILT LENTICLES (Fig. 3e, f)

This concretion type consists of up to 30 cm large fractured calcareous silt lenticles. The fractures are very conspicuous at the basal part of the lenticles. The top side however is either flat without any trace of fracturing, or shows a less developed fracture pattern. The fractures are filled with calcite cement. A few concretions have a fracture pattern very similar to the so called septaria nodules with internal shrinkage cracks. These concretions are only known from the Piedrasecha section, where they occur in the shale unit of the Fueyo Formation, about 45 m above the base of the formation (Fig. 6). They contain the conodonts *Icriodus alternatus alternatus, I. alternatus helmsi, Polygnathus brevilaminus,* and a fragment of *Palmatolepis* sp. of which the margin of the outer platform reaches the blade more anteriorly than the margin of the inner platform (sample PIEC4). This fauna ranges from about Middle *Palmatolepis triangularis* Zone up to the base of the Upper *crepida* Zone. Thus deposition of the basal Fueyo shales with the calcareous nodules started approximately during the earliest Famennian.

LIMESTONE LENTICLES (Fig. 3g)

This concretion type consists of argillaceous limestone lenticles (mudstones) varying in length between 10 cm and several metres, with an average thickness of 8 cm. No internal structures are observed in the lenticles, which occur in laminated dark shales in the uppermost part of the Fueyo Formation of the southernmost part of the Alba syncline. In the road section immediately north of the Olleros de Alba village only the upper part of the shale – limestone unit is exposed, but 500 m east of the village in an erosion gully the complete unit is exposed (Fig. 1: section 0). Well exposed sections also occur in erosion gullies 500 m northwest of Sorribos de Alba (Fig. 1: section SA), and 800 m northeast of Santiago de las Villas (fig. 1: section SV). The thickest limestone – shale unit occurs in section 0 (49.5 m). Eastward of Sorribos de Alba and

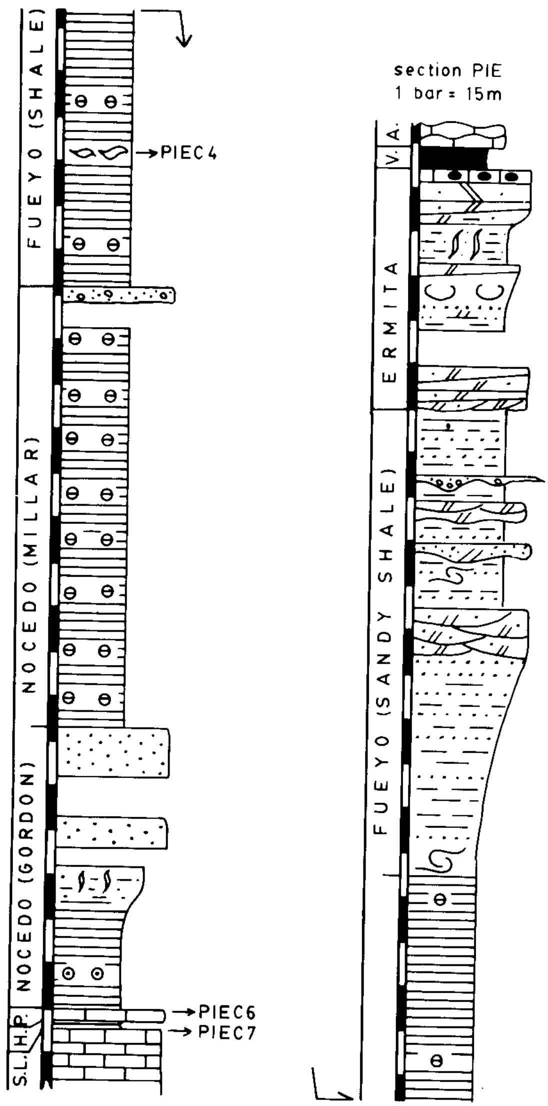

Fig. 6.–The Piedrasecha section (PIE) with the distribution of the concentric silt nodules, the laminated silt nodules, the calcareous silt lenticles and the black shale nodules; S. L. = Santa Lucía Formation, H. = Huergas Formation, P. = Portilla Formation, V. = Vegamián Formation, A. = Alba Formation. See Fig. 4 for legend.

westward of Santiago de las Villas the unit wedges out (Fig. 7). Everywhere the dark limestone – shale unit is underlain by the shale unit of the Fueyo Formation, often with a few meters of bioturbated sediment in between, and is overlain by the black cherty

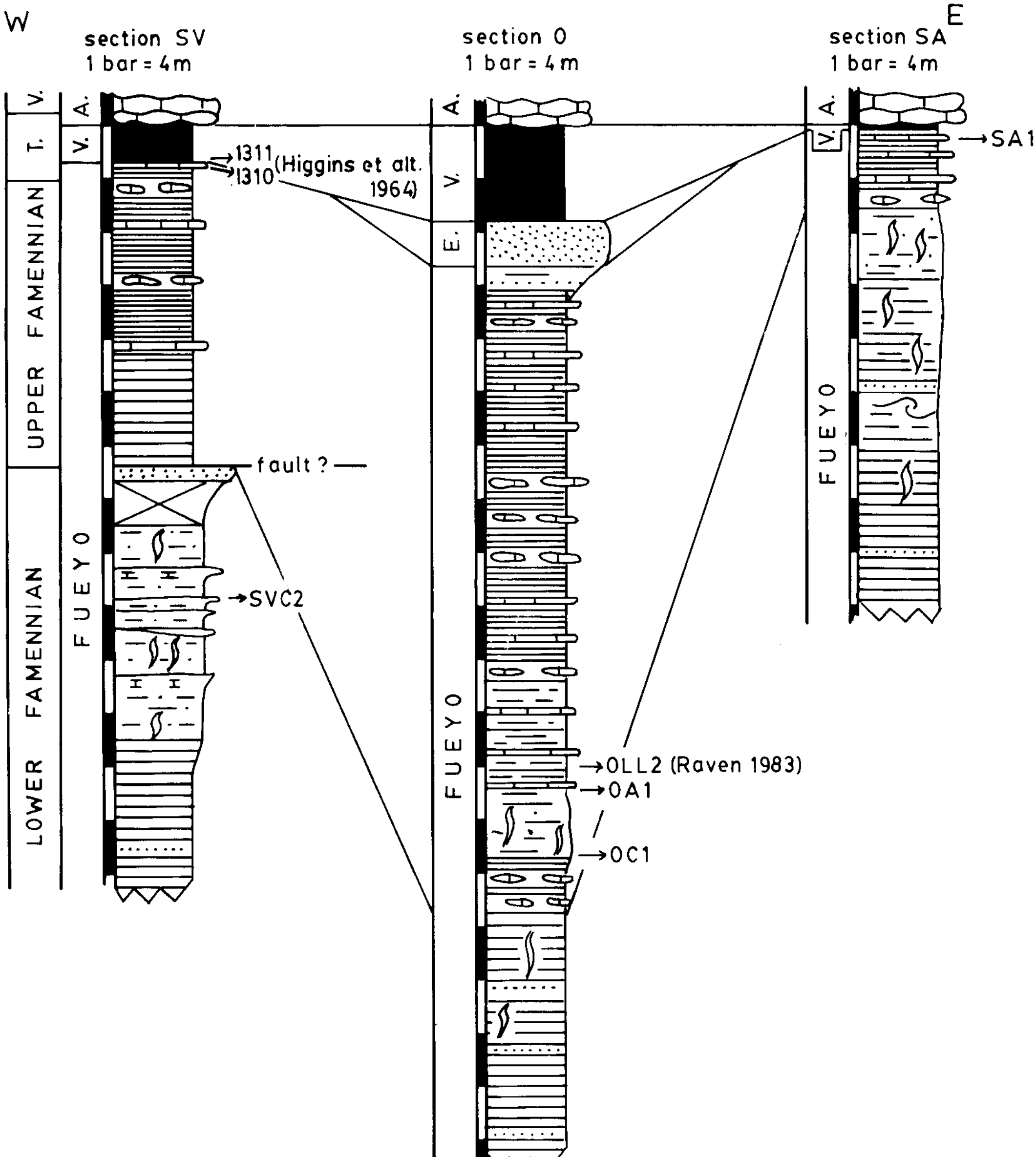

Fig. 7.–East – West Upper Devonian – Lowermost Carboniferous facies correlation in the southern limb of the Alba syncline with the dark shales and the limestone lenticles; SV = Santiago de las Villas, O. = Olleros de Alba, SA = Sorribos de Alba; T = Tournaisian, V = Visean ; E = Ermita Formation, V = Vegamián Formation, A = Alba Formation. See Fig. 4 for legend.

phosphatic shales of the Vegamián Formation; in the southernmost part of the Alba syncline the sandy shale unit of the Fueyo Formation and in most sections also the sandy Ermita Formation are absent. The bioturbated sediment below the limestone – shale unit was deposited during the early Famennian as is proved in the Santiago de las Villas section, where sample SVC2 contains the conodonts *Palmatolepis pectinata, Polyg-*

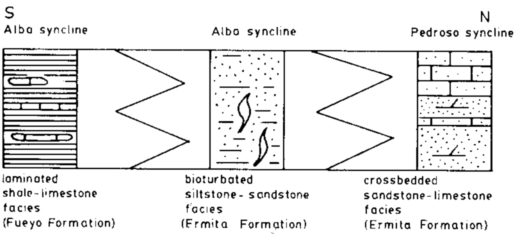

Fig. 8.–North – South facies correlation of the Upper Famennian – Lowermost Tournaisian *(costatus* Zone – *Polygnathus* fauna). See Fig. 4 for legend.

nathus semicostatus and *Pandorinellina insita.* The lower part of the limestone – shale unit at Olleros de Alba was deposited during the late Famennian as is proved by the sample OC1, which contains the conodonts *Pandorinellina plumulus, Polygnathus communis, Palmatolepis gracilis gracilis, P. gracilis sigmoidalis, Spathognathodus* cf. *bohlenanus, S. inornatus, Icriodus* cf. *I. cornutus, Polygnathus* sp., the sample OA1 with the conodonts *Bispathodus costatus, Polygnathus communis* and sample OLL2 with the conodonts *Bispathodus stabilis, Spathognathodus bohlenanus, Sp. strigosus, Polygnathus* sp. Also the upper half of the limestone – shale unit was deposited during the late Famennian as is indicated by the conodonts *Polygnathus communis, Bispthodus stabilis, B. costatus, Palmatolepis gracilis* of sample SA1 at Sorribos de Alba. From the uppermost bed of the limestone – shale unit at Santiago de las Villas Higgins *et al.* (1964) found conodonts of the *Protognathodus* fauna indicating the earliest Carboniferous (sample 1310). Immediately above sample 1310 in the base of the Vegamián Formation, Higgins *et al.* (1964) described a conodont fauna of the *cooperi – communis* Zone (sample 1311). Rodríguez Fernández *et al.* (1985) suppose a Tournaisian age for the entire limestone – shale unit, but from the above mentioned conodont faunas it appears that most of the unit was deposited during the late Famenian, and only the uppermost part during the earliest Tournaisian (Fig. 7). Obviously the dark calcareous shales were deposited contemporaneously with the bioturbated siltstones of the Ermita Formation elsewhere in the Alba syncline, and with the crossbedded Ermita sandstones and limestones in the Pedroso syncline in the north (Fig. 8). Thus the absence of the Ermita is not caused tectonically as is supposed by Rodríguez Fernández *et al.* (1985), but is due to a facies change; although the base of the limestone – shale unit in section SV is probably a fault contact, the similar

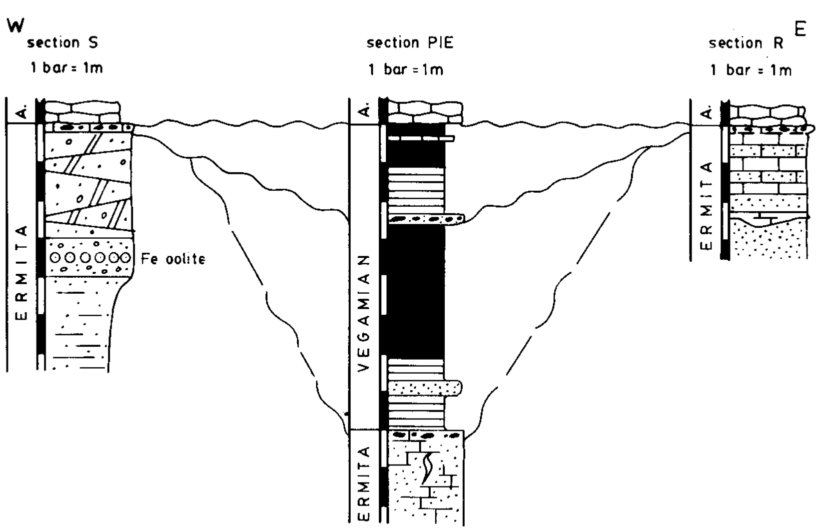

Fig. 9.–Tournaisian East – West facies correlation with the distribution of the black shale nodules; S = Sagüera, PIE = Piedrasecha, R = La Robla; A = Alba Formation. See Fig. 4 for legend.

lithological successions in the sections 0 and SA indicate that if part of the succession tectonically is eroded, it can not be much.

I prefer to include the shales with the limestone lenticles in the Fueyo Formation, instead of in the Vegamián Formation; lithologically the shales are more similar to the shales of Famennian Fueyo Formation, which are locally calcareous, than to the cherty phosphatic black shales with markasite nodules of the overlying Tournaisian Vegamián Formation (for a different interpretation see Rodríguez Fernández *et al.*, 1985).

BLACK SHALE NODULES (Fig. 3h)

The black shale nodules are generally smaller than 10 cm and have irregular rounded forms. They are found in a bioclastic limestone bed in the uppermost centimeters of the Ermita Formation of the Sagüera, Piedrasecha, Huergas and La Robla sections, and in the overlying Vegamián Formation (Fig. 9). The nodules consist of black sandy shales, which are rich in radiolarians and phosphate. The are synonymous with the «Ton-Gerölle» of Frankenfeld (1981), and with the «black shale pebbles» of Raven (1983). The latter correlates them with intraformational erosion phases within the Vegamián Formation and with local erosion before deposition of the overlying Alba Formation. Indeed the nodules are only found where the Vegamián Formation is very thin (La Robla and Piedrasecha sections) or absent (Sangüera and Huergas sections). The nodules probably represent reworked remains of an originally thicker Vegamián sequence.

SYNTHESIS AND CONCLUSIONS

In the Upper Devonian of the Alba syncline six concretion types with their stratigraphic occurrence are differentiated. The burrowed mud nodules and the concentric silt nodules only occur in the basal part of the Lower Frasnian Gordón Member, the former in the Barrios de Gordón section, and the latter in the Piedrasecha section. The laminated silt nodules are restricted to the shale facies of the Upper Frasnian Millar Member and the Famenian Fueyo Formation. The calcareous silt lenticles with the septaria nodules are only found in the Lower Famennian basal part of the Fueyo Formation in the Piedrasecha section, and the limestone lenticles are restricted to the Upper Famennian shale — limestone facies in the southern limb of the Alba syncline. Black mud nodules occur in the uppermost part of the Upper Famennian — Lower Tournaisian Ermita Formation and in the Tournaisian Vegamián Formation. Beyond the Alba syncline Upper Devonian concretions are only known from the southwestern limb of the Palomas syncline (van den Bosch, 1969), with calcareous silt nodules in the basal shales of the Fueyo Formation.

The origin of the nodule types is still uncertain. It seems that nodules may originate in various ways under different conditions, during sedimentation or diagenesis. Biological activity seems to play in important role by the origination of the burrowed mud nodules and the concentric silt nodules, which is indicated by the burrows in the former nodule type, and by the accumulation of small fossils in the core of the latter nodule type.

The laminated argillaceous silt nodules only differ from the surrounding argillaceous sediments by a higher iron content in the crusts (mainly limonite). The main source of the iron was probably biotite, which altered during the diagenetic evolution mainly into muscovite and haematite (Gietelink, 1972).

The origin of calcareous silt lenticles and limestone lenticles may be caused by differentiation of calcareous clays during diagenesis. The calcareous content of the clays may have played an important role in the distribution of the lenticle horizons in the shales.

The occurrence of black shale nodules seems to be related to erosional phases, when non — lithified or partly-lithified clays were reworked (Frankenfeld, 1981; Raven, 1983; van Loevezijn, 1986).

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REFERENCES

Alvarez-Marrón, J. (1985).–Estructura de la Unidad de Correcilla en el sector situado al Este del Río Luna (León, Zona Cantábrica). *Trabajos de Geología,* **15,** 189-202.

Bosch, W. J. van den (1969).–Geology of the Luna – Sil region, Cantabrian Mountains (NW Spain). *Leidse Geol. Meded.,* **44,** 137-226.

Comte, P. (1959).–Recherches sur les terrains anciens de la Cordillère Cantabrique. *Mem. Inst. Geol. Min. España,* **60,** 1-440.

Frankenfeld, H. (1981).–Krustenbewegungen und Faziesentwicklung im Kantabrischen Gebirge (Nordspanien) vom Ende der Devonriffe (Givet/Frasne) bis zum Tournai. *Clausthaler Geol. Abh.,* **39,** 1-91.

Gietelink, G. (1972).–*Sedimentation of a linear prograding coastline followed by three high-destructive delta-complexes.* Ph. D. thesis, University of Leiden, 61 pp.

Higgins, A. C., Wagner-Gentis, C. H. T. and Wagner, R. H. (1964).–Basal Carboniferous strata in part of northern León, NW Spain. Stratigraphy, conodont and goniatite faunas. *Bull. Soc. belge Géol. Paléontol. Hydrol.,* **72,** 205-247.

Loevezijn, G. B. S. van (1986).–Stratigraphy and facies of the Nocedo, Fueyo and Ermita formations (Upper Devonian to lowermost Carboniferous) in León, N Spain. *Scripta Geol.,* **81,** 1-116.

Raven, J. G. M. (1983).–Conodont biostratigraphy and depositional history of the Middle Devonian to Lower Carboniferous in the Cantabrian zone (Cantabrian Mountains, Spain). *Leidse Geol. Meded.,* **52,** 265-339.

Rodríguez Fernández, L. R., García Alcalde, J. L. y Menéndez Alvarez, J. R. (1985).–La sucesion del Devónico Superior y Carbonífero Inferior en el Sinclinal de Alba (León, NO de España). *C. R. 10 Congr. Int. Estr. Geol. Carb., Madrid 1983,* **1,** 133-144.

Smeenk, Z. (1983).–Devonian trilobites of the southern Cantabrian Mountains (northern Spain) with a systematic description of the Asteropyginae. *Leidse Geol. Meded.,* **52,** 383-511.