

NOTE ON THE CYCLIC SEDIMENTATION IN THE CENTRAL CARBONIFEROUS BASIN OF ASTURIAS

M. J. M. BLESS (*)

WITH A DESCRIPTION OF RHYTHMIC UNITS ALONG THE ROAD OF LA NUEVA
BY R. H. WAGNER (**) & C. F. WINKLER PRINS (***)

RESUMEN

Una de las mayores dificultades con que se tropieza en la Cuenca Carbonífera Central de Asturias es la identificación de los estratos y capas de carbón. Esta es necesaria para poder hacer una evaluación de la potencia útil, que puede servir de base para una cubicación de las existencias de carbón en la cuenca. El gran número de horizontes marinos en el tramo productivo de la Formación de Sama hace improbable que se encuentren allí elementos faunísticos que sirvan de guía para un sólo nivel. Por otra parte, el carácter rítmico de los sedimentos estudiados en la parte nordeste de la cuenca podría ser utilizado para correlaciones detalladas entre minas vecinas, y para correlaciones sobre distancias más largas, si se conocen las características de estos ritmos. Un análisis de los ritmos encontrados en una zona comprendida entre Mieres, Sama de Langreo y Lieres indica la presencia de grupos de ritmos con estratos claramente marinos en su base, y con fauna abundante, siempre seguidos de un grupo de ritmos con estratos puramente continentales. Esto hace pensar que ritmos de mayor escala (los megaritmos de BLESS 1968) han sido superpuestos a los ritmos mencionados arriba. En la zona entre Sama y Lieres se aprecian diez de estos megaritmos. Han sido encontrados también en la región de Mieres, pero parece que estos megaritmos (al igual que los ritmos mencionados arriba) pueden cambiar de carácter en distancias de unos kilómetros; cambios que dependen de las condiciones paleogeográficas en el momento de la sedimentación. Desde luego, esto reduce su utilidad para la correlación estratigráfica. Ahora bien, parece que se puede calcular la dirección y la envergadura de estos cambios de carácter dentro de cada megaritmo por medio de estudios paleoecológicos. Tales estudios se encuentran todavía en su primera fase.

La descripción detallada de unos ritmos en la parte superior de la Formación de Lena en las cercanías del pueblo de La Nueva se da como ejemplo del carácter rítmico de estos estratos.

ABSTRACT

A large number of rhythmic units has been recognized in the area between Mieres, Sama de Langreo and Lieres (Central Carboniferous Basin of Asturias). They can be subdivided into rhythmic units with marine beds at their base, and rhythmic units consisting exclusively of non-

(*) Rijks Geologische Dienst, Geologisch Bureau v.h. Mijng gebied, Akerstr. 86-88, Heerlen, The Netherlands.

(**) Geology Department, University of Sheffield, St. George's Square, Sheffield 1, England.

(***) Rijksmuseum van Geologie en Mineralogie, Hooglandsche Kerkgracht 17, Leiden, The Netherlands.

marine strata. A group of rhythms with marine influence is always followed by a group of rhythms without marine influence, thus suggesting the presence of large scale rhythms (mega-rhythms) superimposed on the basic rhythmic units. The mega-rhythms are probably useful for the correlation of stratigraphic sections, although a problem is encountered in that lateral facies changes may alter the character of the mega-rhythms to a considerable degree. The suggestion is made that a palaeoecological study may solve this problem. A detailed description of some rhythmic units in the upper part of the Lena Formation in the vicinity of La Nueva is given at the end of this paper.

INTRODUCTION

The Central Carboniferous Basin of Asturias can be divided into several mining areas: the zone of Riosa - El Viso in the western part of the basin, the zone of the Río Aller in the south, and the economically most important district of Mieres - Sama de Langreo - Lieres in the northeast. The economic importance of these mining districts has attracted a large number of geologists since the beginning of the past century, but the complicated structure of the basin has made a detailed subdivision of the approximately three thousand metres of sediment almost impossible up to the present time. An exception must be made for the work of ADARO (e.g. 1926), who made the first useful stratigraphic subdivision of the Upper Carboniferous in the Asturian basin. In the past two decades, new information on the stratigraphy and tectonics of parts of the basin has become available. For instance, JONGMANS (1952) illustrated stratigraphically useful plant fossils, and JONGMANS & WAGNER (1957), WAGNER (1962),

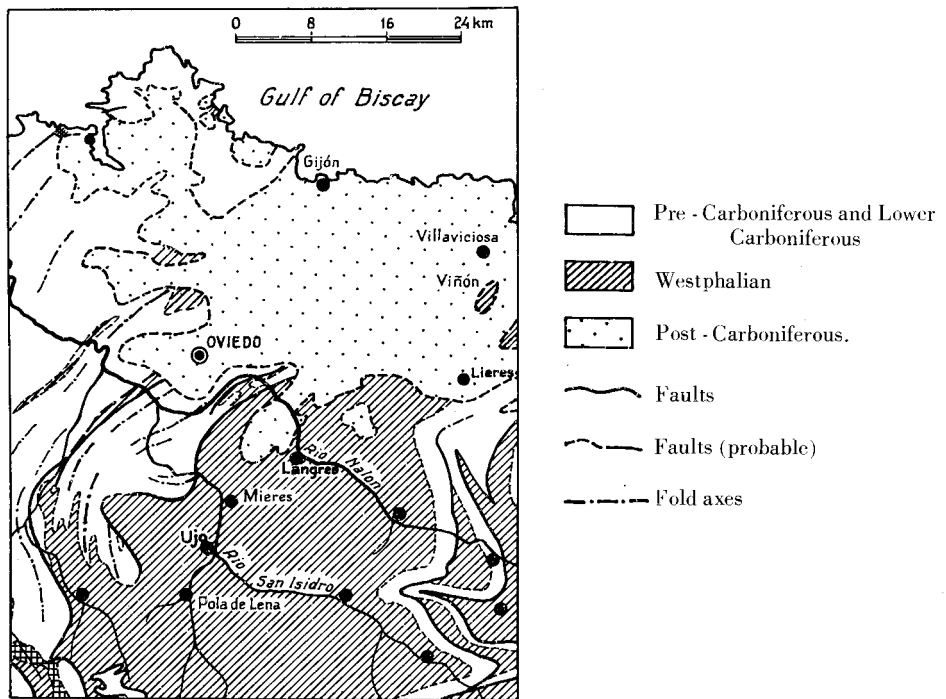


Fig. 1.—General map of the northern part of the Central Carboniferous Basin of Asturias.

PELLO (1968) and MARTÍNEZ DÍAZ (1969) provided numerous data on the stratigraphy of the Riosa coalfield. MARTÍNEZ ALVAREZ (1962) has given information about the sedimentary and tectonic history of the eastern border of the basin. In the last few years the Empresa Nacional «Adaro» has started a detailed investigation on the tectonic structure and stratigraphy of the whole basin.

In order to study the possibility of a detailed correlation of the coal seams throughout the basin the present author visited several coal mines in a zone roughly located between Ujo and Lieres (Fig. 1), and measured a number of stratigraphic sections in detail. Some of these have been published previously (BLESS 1968), and two sections are presented in this contribution.

DESCRIPTION AND DISCUSSION OF RHYTHMIC UNITS

An analysis of the sections studied indicates that they consist of a large number of rhythmic units. Each rhythmic unit contains a series of beds deposited during a single sedimentary cycle. The number of beds and their character may vary in each region since they are dependent on local conditions. They also vary within the stratigraphic column of one region if the conditions in that region changed during the time involved. In the sections studied all these variants are shown to be present. A comparison with the classic cyclothems of North America and with cyclothems from northwestern Europe might be made, but both the causes of their development and the character of their strata may be different. An ideal rhythmic unit in the Central Carboniferous Basin of Asturias is composed of the different members (Fig. 2), which are described overleaf.

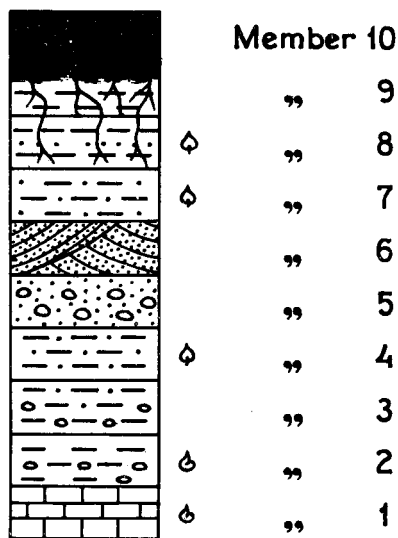


Fig. 2.—Idealized section of the standard rhythmic unit in the north-eastern part of the Asturian coalfield.

Member 1. Greyish or black limestone, very fossiliferous, especially at the base. Fusulinids, algae, brachiopods, crinoids and molluscs are abundant. Solitary corals and bryozoans have been frequently found.

Member 2. Greyish-black mudstone, often with ferruginous/dolomitic concretions, which are concentrated in thin laminae. This mudstone may be very fossiliferous, especially near the base. The fauna represents in most cases a marine environment, rarely a brackish-water environment. The pyrite content of the shale is often high. The palaeoecology of these shales has been dealt with by BLESS (1970) and BLESS & WINKLER PRINS (*in*: VAN AMEROM, BLESS & WINKLER PRINS 1970).

Member 3. Laminated or thinly bedded arenaceous shales and siltstones, with the thickness of laminae varying between 1 and 50 mm. Often laminae of shale (siltstone) alternate with laminae of very fine sandstone. Reddish concretions, concentrated in thin laminae, have frequently been observed.

Member 4. Laminated shales and sandy shales, the latter sometimes psammitic and with abundant comminuted plant fragments. A non-marine fauna occasionally occurs in this member, especially in black shales.

Member 5. Coarsely grained sandstones with well-rounded pebbles, which may form true conglomerates. Sometimes in place of pebbles, large fragments of carbonized tree trunks may be present. Conglomerates of limestone pebbles are called «calizas gonfolíticas» (a local mining term). Lateral and vertical changes are frequent in this member. They are often very abrupt.

Member 6. Finely to coarsely grained sandstone with cross-bedding.

Member 7. Laminated fine sandstones, often psammitic and with a high clay content. Comminuted plant fragments may be abundant.

Member 8. Homogeneous mudstones with rootlets and *Stigmaria* «*in situ*».

Member 9. Seat-earth with high carbon content, sometimes even workable. This member has been recognized below the coal in more than 50 % of the coal beds with a thickness of more than 15 cm, and in more than 30 % of the coal beds with a thickness of at least 1 cm.

Member 10. Coal.

In contrast to BLESS (1968) the coal is here considered to be the top of the rhythmic unit, since the contact coal - overlying bed is usually abrupt and easily discernable. The limits between the members within a single rhythm are usually not well defined, and gradual transitions are the rule. Members 1 and 2 are assumed to represent marine to brackish-water environments. Members 3 and 4 have been deposited in a more doubtful environment, but may represent mainly brackish, deltaic and lacustrine facies. Members 5 to 10 represent fluvial or deltaic environments. Each rhythmic unit is thus characterized by a gradual decrease of the marine influence in upward direction, the sharp limit between two rhythmic units representing a transgressive period without sedimentation. As suggested by BLESS (1970) the abrupt contact between two rhythmic units may be related to rapid transgressions caused by sudden movements of the basin floor. Also WAGNER and WINKLER PRINS (see

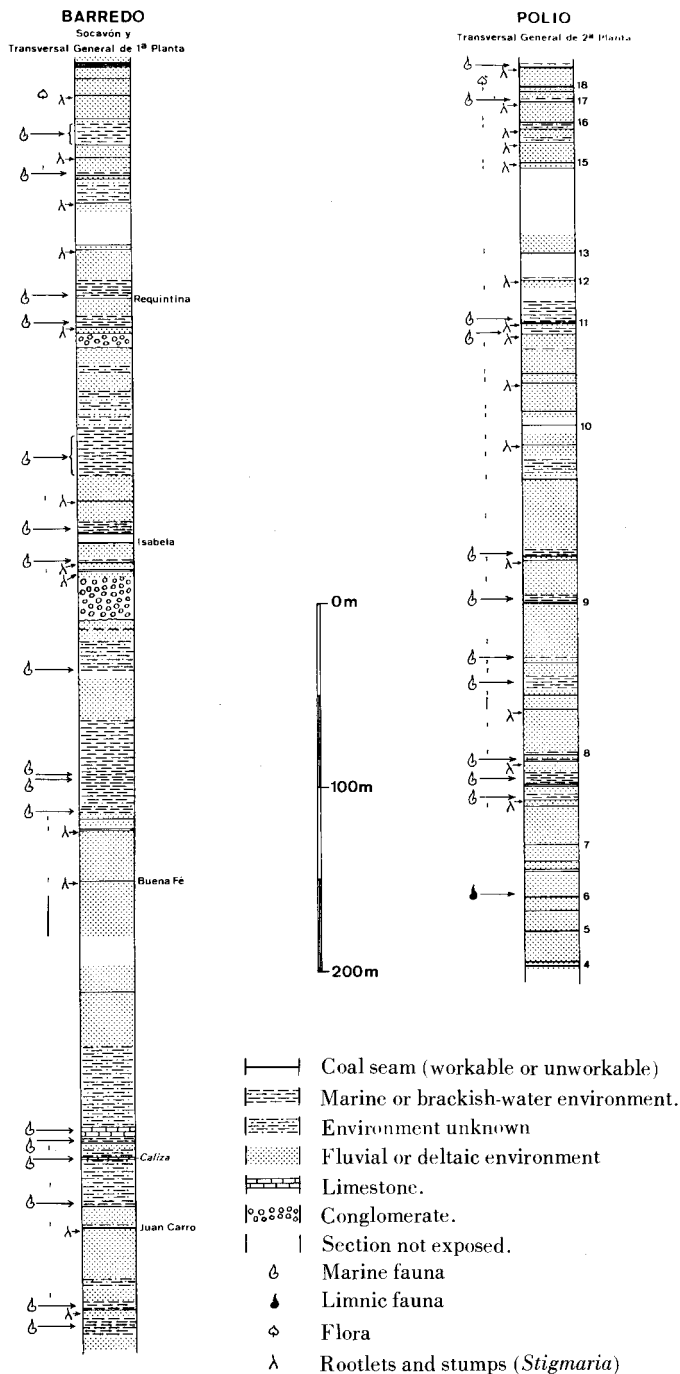


Fig. 3.—Stratigraphic sections of Barredo and Polio Collieries (both near Mieres); with a palaeo-ecological interpretation of strata (sections measured with the kind permission of HULLERAS DEL NORTE S. A.).

their description of rhythmic units along the La Nueva road) come to this conclusion. This diastrophically controlled type of rhythm is to be distinguished from some of the classic cyclothem and rhythms known in North America and Europe, which may be linked to eustatic movements.

The ideal rhythmic unit in Asturias, consisting of all the ten members described above, has not been recognized in any one particular unit. Member 1, for instance, has only been found in the rhythmic units of the Lena Formation and in those of the lowermost part (the Calizas Superiores Coal Member) of the Sama Formation. Member 2 has been commonly found in the Lena and Sama formations, but appears to be restricted to special groups of rhythmic units, which are always followed by groups of rhythmic units without member 2 and apparently without any influence of a marine transgression (Fig. 3). Because of this peculiar distribution of rhythmic units BLESS (1968) distinguished between three types of rhythms. Type A with members 1 and 2 was considered to show the maximum marine influence, type B with member 2 still showed a clear marine transgression, and type C consisted exclusively of non-marine strata. Although this distinction is not made in the present paper, the peculiar distribution of rhythms with and without marine influence suggests that large scale rhythms (the «mega-rhythms» of BLESS 1968) were superimposed upon the rhythmic units as described above. A mega-rhythm was defined as a group of rhythmic units with distinct marine influence followed by a group of rhythmic units consisting exclusively of non-marine beds. The contact between two mega-rhythms is always well discernable, but the contact between the lower and upper part of a single mega-rhythm is usually not too well defined. These mega-rhythms (ten of which have been recognized in the Sama Formation of the area between Sama de Langreo and Lieres - Fig. 4) are regarded as having regional value for correlation purposes (BLESS 1968). However, their usefulness seems to be restricted to the correlation of stratigraphic sections in adjoining coal mines, since lateral facies changes may alter the character of a mega-rhythm completely within some kilometres distance (see Fig. 5). An investigation is in progress to determine whether these lateral facies changes of the mega-rhythms follow a recognizable direction. If this proves to be the case one might be able to predict the kind of facies that is likely to occur in some sections, when following a mega-rhythm from one area into another within the Asturian basin. The sections shown in Figure 5 suggest an increase of marine facies in a north-eastern direction. The same pattern has been recognized by PELLO (1968) for the Riosa-Olloniego area. BLESS (1970) and BLESS & WINKLER PRINS (*in*: VAN AMEROM, BLESS & WINKLER PRINS 1970) described faunal assemblages representing different degrees of marine influence. These appear to be distributed over the basin in such a way that the assemblages characteristic for the maximum marine influence are mainly found in the north-eastern part of the basin, and those characteristic for a less marine facies in the south-western part. BLESS & WINKLER PRINS found a biostrome facies (described by BLESS 1970) to be the most common marine environment in the stratigraphic sections of the coal mines between Sama de Langreo and Lieres. A prediction on the basis of the foregoing information would point to a faunal assemblage with a less marine charac-

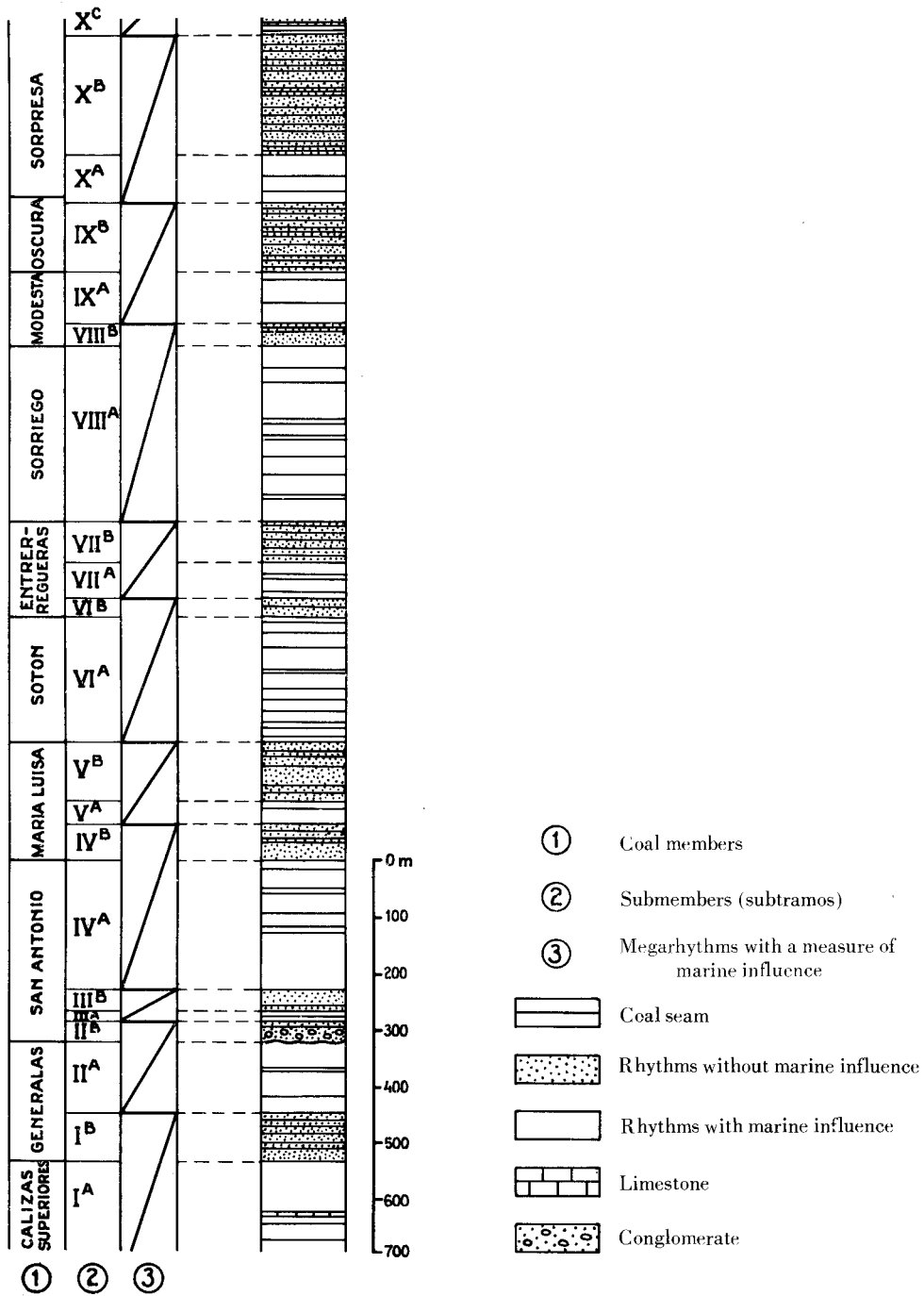
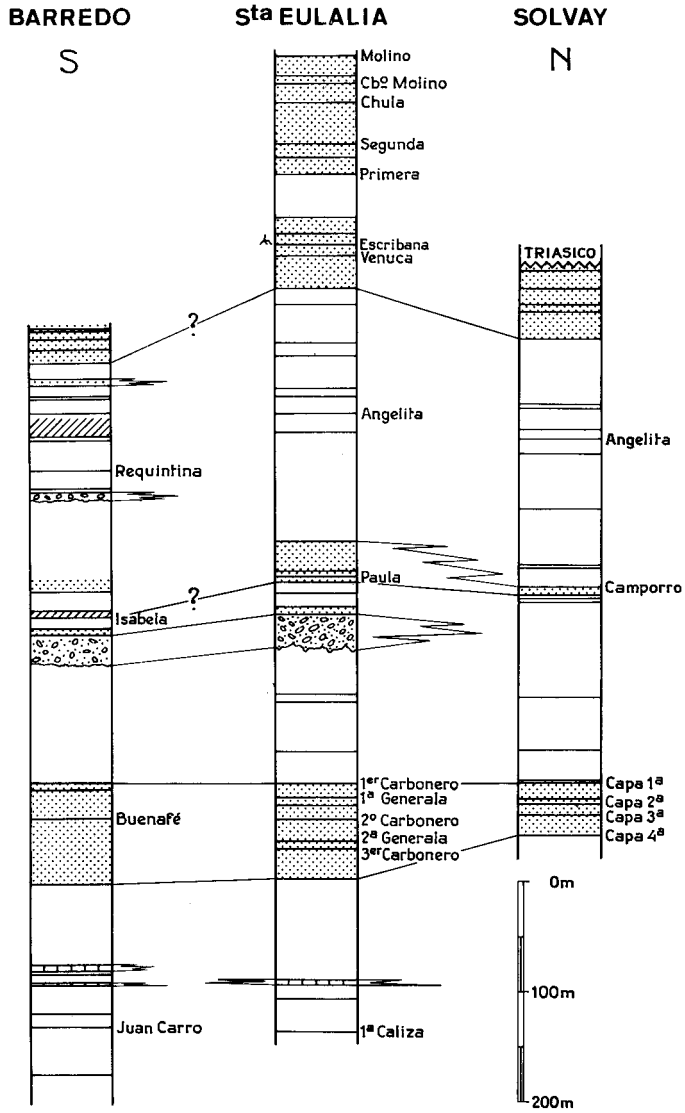


Fig. 4.—Composite section through the Sama Formation in the north-eastern part of the Central Asturian coalfield (after BLESS 1968).



LEGEND







-  Coal seam (workable or unworkable)
 -  Rhythms without marine influence
 -  Rhythms with marine influence
 -  Limestone
 -  Conglomerate
 -  Sección not exposed
- ▲ Small coal seams or rootlets

Fig. 5.—Stratigraphic sections of Barredo Colliery (near Mieres), Santa Eulalia Colliery (north of Sama de Langreo), and Solvay Colliery (near Lieres). The distance between Barredo and Santa Eulalia and that between Santa Eulalia and Solvay are about 12 km. Note the increase of marine influence in a northern direction (sections of Santa Eulalia and Solvay after BLESS 1968).

ter, for instance of the lamellibranch or *Lingula* facies, to become predominant in the mega-rhythms of the region around Mieres (at some 10 - 15 km south of the Langreo District). A preliminary study of the fauna of the sections measured in the Mieres District seems to confirm this hypothesis. A good knowledge of palaeoecological assemblages thus seems to be important, if a long distance correlation of mega-rhythms and coal seams is to be achieved in the Asturian basin.

The coal seams (both workable and non-workable) are located rather irregularly throughout the stratigraphic sections, although there is a slight tendency for the coals to be concentrated in the upper parts of the mega-rhythms, i.e. in the exclusively continental part of these mega-rhythms. The same tendency has been recognized considering only the workable and worked coal seams (at least in the sections examined). But there seems to be no difference in thickness or regularity of the coal seams between the upper and lower part of the mega-rhythms (i.e. between the parts with rhythmic units without marine influence and with marine influence, respectively).

DESCRIPTION OF RHYTHMIC UNITS IN UPPER MOSCOVIAN (WESTPHALIAN C) ROCKS EXPOSED ALONG THE ROAD OF LA NUEVA (ASTURIAS)

(R. H. WAGNER & C. F. WINKLER PRINS)

Rhythmic units representative of the kind described by M. J. M. BLESS have been measured by the present authors in collaboration with Mr. J. PELLO of the University of Oviedo. M. J. M. BLESS selected the outcrop, which was examined conjointly.

The section (Fig. 7) shows a seat-earth with dirty coal overlain by a fusulinid-bearing limestone, passing into marl, calcareous mudstone, mudstones and shales with sandstone partings and, eventually, sandstones with channel bases. A repetition of limestone and mudstone occurs before a current bedded sandstone developed with seat-earth and coal. Limestone/coal and limestone/sandstone contacts are abrupt, whereas the other changes between lithologies are gradual. Therefore, the base of the rhythmic units lies at the transgressive base of the limestones. The remainder of the unit shows a regressive sequence with a gradual increase in terrigenous clastics, together with an overall increase in grain size, and this is coupled with indications of decreasing depth of marine basin leading to non-marine sedimentation at the top. The evidence for sudden transgression at the base of the units and the more gradual regression indicate repeated basin fill sequences, interrupted by sudden incursions of the sea. This type of rhythmic unit can be most easily explained by repeated, sudden downwarp of the basin floor, and not by eustatic movements which should produce equally abrupt changes from marine to non-marine as from non-marine to marine.

The environments represented in the regressive rhythmic units of the Upper Carboniferous in Northwest Spain have been discussed recently by H. G. READING (1970) for sequences in northern Palencia. His explanatory diagram (see Fig. 6) pro-

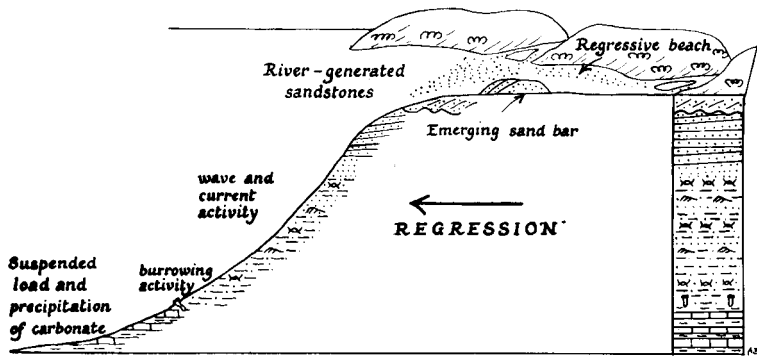


Fig. 6.—Explanation of the environments of the regressive rhythmic units as encountered in the Upper Carboniferous of Northwest Spain (after H. G. READING (1970) - by permission of the author).

vides a visual aid to the understanding of the vertical facies changes in a section as described here.

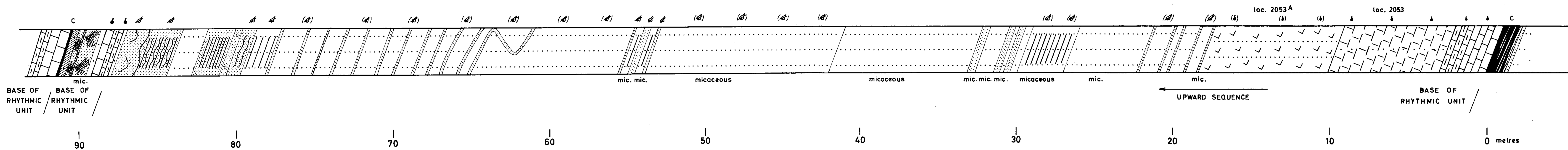
A detailed description of the units measured along the La Nueva road (and which are only a few out of many in this section) is given below (Fig. 7).

The top of a rhythmic unit with a thin seat-earth on sandstone, and a dirty coal, is cut off by a limestone with fusulinids (which are already present at the very base of the limestone), crinoids, solitary rugose corals, algae, gastropods, brachiopods. Algae are apparently abundant. The limestone passes gradually into marly limestone with abundant fossils, e.g. crinoids, brachiopods, bryozoa, lamellibranchs. The brachiopod *Karavankina* was identified here by the second author. Terrigenous clastic material gradually increases upwards, and the marly limestone passes into a calcareous mudstone which is slightly silty. This band is very fossiliferous, with numerous brachiopods, bryozoa, gastropods, crinoids, trilobites, orthocone cephalopods, lamellibranchs and ostracodes. A fragment of a possible goniatite was also observed in this locality (2053). Among the brachiopods the following elements were recognized (C. F. W. P. det.): *Kozłowska* sp., *Karavankina* sp., *Dictyoclostus* cf. *scholvenensis* BÖGER & FIEBIG, Linoproducti, *Rugosochonetes* sp., *Plioichonetes?* sp., *Crurithyris* sp. Further upwards in the succession an increase in siltiness coincides with a decrease in lime content. In silty, slightly calcareous mudstones (loc. 2053A), the following brachiopods were noted (C. F. W. P. det.): *Kozłowska* sp., *Karavankina rakuszi* WINKLER PRINS, *Rugosochonetes* sp., *Crurithyris* sp. Lamellibranchs and crinoids have also been observed in this locality which is slightly less fossiliferous than the preceding one. The brachiopod faunas quoted belong to the *Kozłowska-Karavankina* Zone of WINKLER PRINS (1968, p.67) which is of Westphalian C age.

Above the slightly calcareous, silty mudstones a thin band of micaceous sandstone occurs (0.05 m thick) as a separation from silty mudstone with a few comminuted plant fragments. Another parting of sandstone, 0.06 m thick, separates this lithology from massive, very silty mudstones. These lithologies are repeated as drawn in the

RHYTHMIC UNITS IN UPPER MOSCOVIAN (WESTPHALIAN C) ROCKS IN THE ROAD SECTION NEAR LA NUEVA (LANGREO DISTRICT), ASTURIAS

N. Scale 1:200 S.



- | | | | | | | | | | | | | | | | | | | |
|------------|-------------------------------|--------------------|----------------------|-----------------|-----------------|-----------------|---------------------------|------------|--------------------------|--------------|--------------------------|--------|-------------------------|--------|----------------------------|--------------------|-------------------------------------|----------|
| 90 | | 80 | | 70 | | 60 | | 50 | | 40 | | 30 | | 20 | | 10 | | 0 metres |
| C | coal | [diagonal lines] | seat-earth | [stippled] | sandstone | [cross-hatched] | sandstone, current-bedded | [V-shaped] | sandstone, channel bases | [wavy lines] | sandstone, ripple-marked | [dots] | siltstone | [dots] | silty shales and mudstones | [white box] | slightly silty shales and mudstones | |
| [J-shaped] | mudstone, slightly calcareous | [horizontal lines] | mudstone, calcareous | [brick pattern] | marly limestone | [grid pattern] | limestone | ♣ | marine fauna | (♣) | marine fauna (sparse) | ♣ | comminuted plant debris | (♣) | comminuted plants (sparse) | [horizontal lines] | thinly bedded | |

Fig. 7

section, until a thick unit of slightly micaceous, very silty mudstones is reached. This is followed by thinly bedded, micaceous siltstones with comminuted plant debris, a lithology which is succeeded by alternating very silty mudstones, sandstones and siltstones, all micaceous to some extent. A rather monotonous succession of siltstones follows. They are all micaceous, but comminuted plant debris is only recorded in the top half of this unit. Then, alternating micaceous sandstones and siltstones are recorded, the former with comminuted plant debris. A further, large unit of siltstones with comminuted plant remains is followed by siltstone/sandstone alternations, with a predominance of siltstones. The sandstones occur as thin partings, approximately 0.05 m thick. Comminuted plant remains occur throughout, but are more frequent in the sandstones.

This large unit with rather massive siltstones is succeeded by thinly bedded siltstones with more abundant, finely comminuted plant debris, and this lithology passes upwards into ripplemarked sandstones, thinly bedded, with plant debris (comminuted) on the bedding planes. It looks as if here, at last, the shallow marine sediments give way to littoral deposits. There follow silty sandstones, somewhat nodular, and thinly bedded sandstones which show some ripplemarks and ripple cross-laminations. The latter also contain finely comminuted plant fragments. A sandstone with a channel base and small channels within follows in this succession, and forms the top unit in this rhythmic sequence, since it is overlain by relatively fine marine deposits marking the base of the following rhythm. The channel sandstone may or may not be continental in facies, but certainly shows the activity of rivers.

The marine transgression above the channel sandstone may have reworked some silty mud, while sand was transported further into the sea. This would explain the presence of silty mudstone, at the top of which shell fragments are found. It passes upwards into marly limestone, changing into crinoidal limestone. Indeterminate shell fragments occur throughout the marly limestone, whilst the somewhat purer crinoidal limestone contains brachiopods and bryozoa, among other marine fossils. In quick upward succession, slightly micaceous silty mudstones and micaceous current bedded sandstones are found. They are succeeded by a very silty seat-earth which, after another short interval of current bedded sandstone, becomes firmly established and carries a thin coal (0.15 m thick). This very brief succession of marine and non-marine strata probably reflects a limited downwarp, needing only a small amount of basin fill before a non-marine, deltaic environment is regained and a terminal phase of plant growth is established with a virtual lack of inorganic sedimentation.

The base of the next rhythmic unit is marked by another sudden transgression, with limestone passing into marly limestone.

REFERENCES

- ADARO y MACRO, L. (1926).—Atlas del estudio estratigráfico de la cuenca hullera asturiana. *Monogr. Inst. Geol. Min. España*, láms. I-X.
- AMEROM, H. W. J. VAN, BLESS, M. J. M. & WINKLER PRINS, C. F. (1970).—Some paleontological

- and stratigraphical aspects of the Upper Carboniferous Sama Formation (Asturias, Spain). *Meded. Rijks Geol. Dienst*, (N.S.), 21, pp. 9-56, text-figs. 1-52, Encl. 1, pls 1-10.
- BLESS, M. J. M. (1968).—On two hollinid ostracode genera from the Upper Carboniferous of northwestern Spain. *Leidse Geol. Meded.*, 43, pp. 157-212, pls. 1-10.
- BLESS, M. J. M. (1970).—Environments of some Upper Carboniferous coal basins (Asturias, Spain; Limburg, Netherlands). *C. R. 6e Congrès Carbonifère, Sheffield 1967*, II, pp. 503 - 516, figs. 1-10.
- JONGMANS, W. J. (1952).—Documentación sobre las floras hulleras españolas. Primera contribución: Flora carbonífera de Asturias. *Estudios Geol.*, VIII, 15, pp.7-26. láms. II-XXVIII.
- JONGMANS, W. J., & WAGNER, R. H. (1957).—Apuntes para el estudio geológico de la zona hullera de Riosa (Cuenca Central de Asturias). *Estudios Geol.*, XIII, 33, pp. 7-26, lám. II.
- MARTÍNEZ ALVAREZ, J. A. (1962).—Estudio geológico del reborde oriental de la cuenca carbonífera central de Asturias. *Monogr. Inst. Estudios Asturianos, Oviedo*, pp.1-231, láms.
- MARTÍNEZ DÍAZ, C. (1969).—Carbonífero marino de la zona de Riosa (Asturias, España). *Revista Española Micropaleontología*, I, 1, pp. 59-80, láms. I-IX.
- PELLO MUÑOZ, J. (1968).—Nuevos datos sobre la estratigrafía y tectónica del borde NO. de la cuenca carbonífera central de Asturias. *Bol. Geol. Min.*, 79-2, pp. 115-129, figs I-VIII, mapa y cortes.
- READING, H. G. (1970).—Sedimentation in the Upper Carboniferous of the Southern Flanks of the Central Cantabrian Mountains, Northern Spain. *Proc. Geol. Ass.*, 81, pt. 1, pp. 1-4, figs. 1-7.
- WAGNER, R. H. (1962).—A brief review of the stratigraphy and floral succession in the Carboniferous of NW Spain. *C. R. 4e Congrès Carbonifère, Heerlen 1958*, III, pp. 753-762, pls. 29-33.
- WINKLER PRINS, C. F. (1968).—Carboniferous Productidina and Chonetidina of the Cantabrian Mountains (NW Spain): Systematics, Stratigraphy and Palaeoecology. *Leidse Geol. Meded.*, 43, pp. 41-126, pls. I-IX.