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The Cretaceous of the Southwestern Iberian Ranges (Spain)

By

LORENZO VILAS, ANGELA ALONSO, CONSUELO ARIAS, ALVARO GARCIA, JOSE RAMON MAS, RICARDO RINCON & NIEVES MELENDEZ*)

With 8 text figures

ABSTRACT

The distribution of facies and tectosedimentary episodes of the Cretaceous of the Southwestern Iberian Ranges have been studied in the present paper. Two main paleogeographic areas are being established: the Southwestern Iberian Trough and the Gulf of Albacete, both of which are valid during the Lower Cretaceous but it is not possible to distinguish these areas during the Upper Cretaceous because the basin is wider and homogeneous. The amplitude and characteristics of the complex stratigraphic gap between the Jurassic and Cretaceous records have been analysed, establishing five episods of tectonic mobility.

Eighteen paleogeographical maps have been established representing the whole of the Cretaceous evolution. This paleogeographic evolution took place during eight main sedimentary cycles, grouping into five tectosedimentary episodes separated by important changes in the configuration of the basin. These five episodes represent the evolution of an aulacogen: a) The graben stage during the Lower Cretaceous, b) The flexure stage during the Middle and Upper Cretaceous and c) The folding phase starting at the end of the Cretaceous.

KURZFASSUNG

Die Faziesverteilung und die durch Tektonik beeinflußte Sedimentationsgeschichte während der Kreide in den südwestlichen Iberischen Ketten wird vorgestellt. Zwei paläogeographische Hauptgebiete können unterschieden werden: Der südwestliche Iberische Trog und der Golf von Albacete; beide lassen sich in der Unterkreide gut unterscheiden, jedoch in der Oberkreide wird das Gesamtbecken breiter und homogener. Der Umfang und die Besonderheiten des Komplexes ,,Stratigraphic Lacune" zwischen dem Jura und der Kreide wurden analysiert; es konnten 5 Phasen tektonischer Mobilität ausgeschieden werden.

Auf 18 paläogeographischen Karten ist die gesamte Kreideentwicklung dargestellt. Diese paläogeographische Entwicklung zeigt 8 Haupt-Sedimentationszyklen, die in 5 tecto-sedimentäre Epochen zusammengefaßt werden, jeweils durch eine Veränderung in der Becken-Konfiguration unterscheidbar.

Diese 5 Epochen repräsentieren die Entwicklung eines Aulacogens:

a) Graben-Bildung während der Unterkreide,
b) Verbiegungen (Flexuren) während der Mittleren und Oberen Kreide, und
c) die mit dem Ende der Kreide beginnenden Faltungsphasen.

INTRODUCTION

We study here the Cretaceous facies distribution and tectonosedimentary evolution in the southwestern area of the Iberian Range (Spain). Many authors have previously worked in this area. Some of them have mainly studied the Cretaceous in its regional contest: FOURCADE (1970), GARCIA (1977), ARIAS (1978), MAS (1981). Others have carried out more general studies giving special attention to Cretaceous rocks: VIALLARD (1973), – MELENDEZ (1973), CHAMPETIER (1972). Some other stratigraphical studies have been also useful here: MELENDEZ et

*) L. VILAS, A. ALONSO, C. ARIAS, A. GARCIA, J. R. MAS, R. RINCON, N. MELENDEZ, Departamento de Estratigrafía, Universidad Complutense y U. E. I. Correlaciones Estratigráficas y Paleogeografía, C. S. I. C., Madrid – 3, España.

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alt. (1974), MAS et al. (1977), GARCIA et al. (1978), ARIAS et al. (1979), MAS et al. (1982). The are some non published studies about Cretaceous stratigraphy in this area: GIMENEZ (1981), PEREZ DEL CAMPO (1982), ZABALA (1982), REY (1982). ALVARO et al. (1981) propose a general geotectonic model for this area.

SITUATION

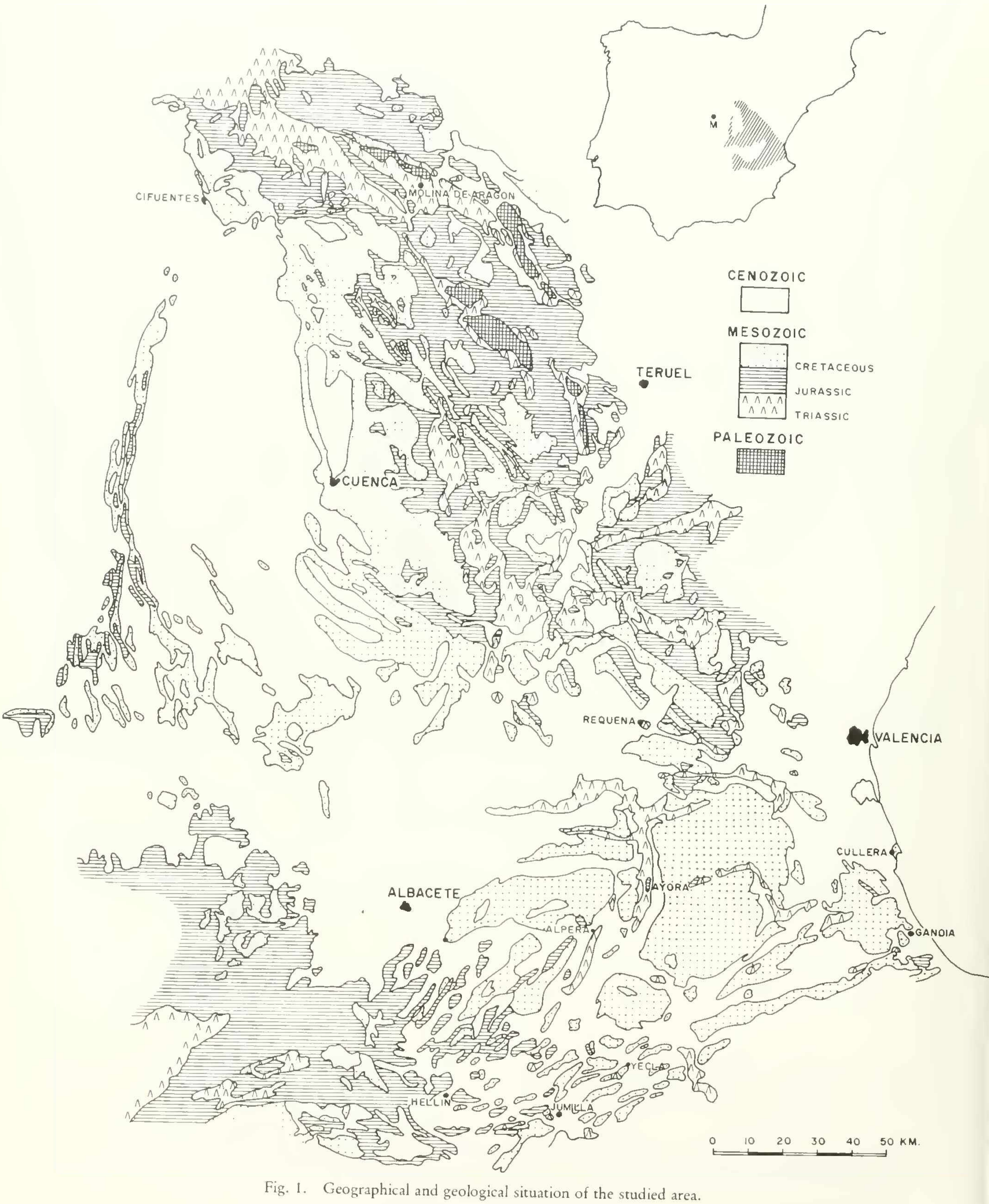

Fig. 1. Geographical and geological situation of the studied area.

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The Cretaceous sediments of the Iberian Peninsula can, in outline, be divided into two groups:

One whose marine influence comes from the West or the North, as is the case of the Portuguese Cretaceous and that of Castille North of Spain, and another whose influence comes from the East or South, as is the case of the Béticas, Ibérica s. s. and Catalánides.

Keeping in mind the paleogeographic distribution during this period this first group could be called Proto-Atlantic Cretaceous and the second, Tethys Cretaceous. The areas described skirt the Meseta which, at times, acts as a source area. Within the Cretaceous having a clear influence from Tethys, is that belonging to the area we have named Ibérica s. s. within which it is possible to distinguish two areas that are well separated, especially in the Lower Cretaceous: one in the northeast that includes the Aragonese sector of this Range and the Maestrazgo, and the other in the southwest with its Castillian sector and the southern Levantine region (Fig. 1).

Within the area studied in this paper, a series of zones can be established according to their present disposition as well as some paleogeographic features, even though this division is only valid for the Lower Cretaceous (Fig. 2), since during the Upper Cretaceous the extent of the transgressions makes a characteristic paleogeographic division difficult.

The area of our study for the Lower Cretaceous is limited in the west as well as in the east by two basin edges that have behaved differently: the Meseta that behaves as an active edge as regards the contribution of sediments, and the High of Javalambre-Valencian Massif that only acted as an obvious source area during the first episodes of Cretaceous sedimentation. In the south, the boundary of the Betic basin is formed at present by a tectonic accident that is the reflection of a flexion that existed during the Cretaceous and that was the cause of a depressed area that we call the Jumilla-Yecla zone (outer Prebetic). In this basin with its boundaries, two areas can be distinguished: the southwestern Iberian Trough, with SE-NW transgressions and the Albacete Gulf with E-W transgressions. Finally, there is the fracture zone that borders on the Albacete Gulf in the north, and affects the southwestern Iberian trough as well as the Valencian Massif. This fracture zone is clearly related with the Sierra Martés High (ARIAS et al. 1979).

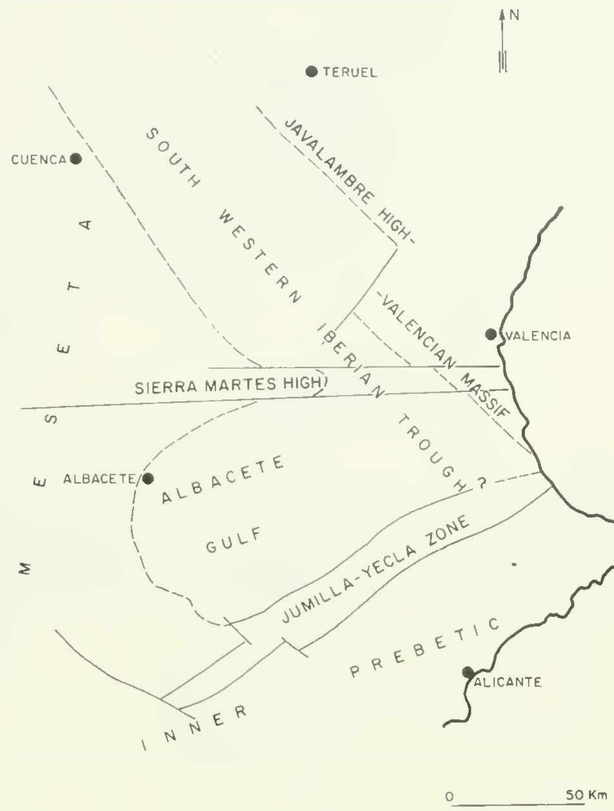

Fig. 2. Main paleogeographical features for the Lower Cretaceous.

STRATIGRAPHIC DISCONTINUITY OF THE CRETACEOUS BASE

Of the three areas in which the region has been divided for the Lower Cretaceous, a stratigraphic lacuna exists in the Albacete Gulf and the Southwest Iberian Trough between the Jurassic and Cretaceous sediments extending, at least, part of the Portlandian, the Berriasian and part of the Valanginian. However, in the Jumilla-Yecla zone, this lacuna is either quite reduced, or does not exist at all. For this reason, the problem will be dealt with only as regards the first two areas mentionned above. The basement of the Cretaceous sediments throughout the region is formed by Jurassic sediments, although there are some very local exceptions where they lie directly on Triassic sediments. The farther west one goes in the Albacete Gulf or northwest in the Iberian Trough, the older the Jurassic sediments forming the basement become. At the same time, it can be seen how the Jurassic sediments have been affected by periods of erosion and tectonic mobility prior to Cretaceous sedimentation. Moreover, the age of the first Cretaceous deposits varies all along the zone. If we consider only the Cretaceous sediments, starting from the first expansive stage in the basin, that is, from the Upper Barremian, the age of the base of these sediments becomes younger the farther northwest or west one goes, depending on the zone.

The sum of the erosion of the Jurassic basement and the diachrony of the definite beginning of Cretaceous sedimentation, gives an increase in the stratigraphic lacuna in the direction indicated in Fig. 3. Keeping in mind the present disposition of the outcrops, some sediments from the Lower Barremian age appear in this lacuna, but lacking in continuity; although in the eastern zones, they are situated, by age, almost in continuity with the rest of the Cretaceous sediments, in the western zones, there is an ever-increasing separation between them. This is due to the fact that from the Oxfordian to the Upper Albian, a series of tectonic mobility stages were usually accompanied by periods of erosion. Considering the information available at present, together with the contribution made in this report, an attempt can be made to establish the main episodes:

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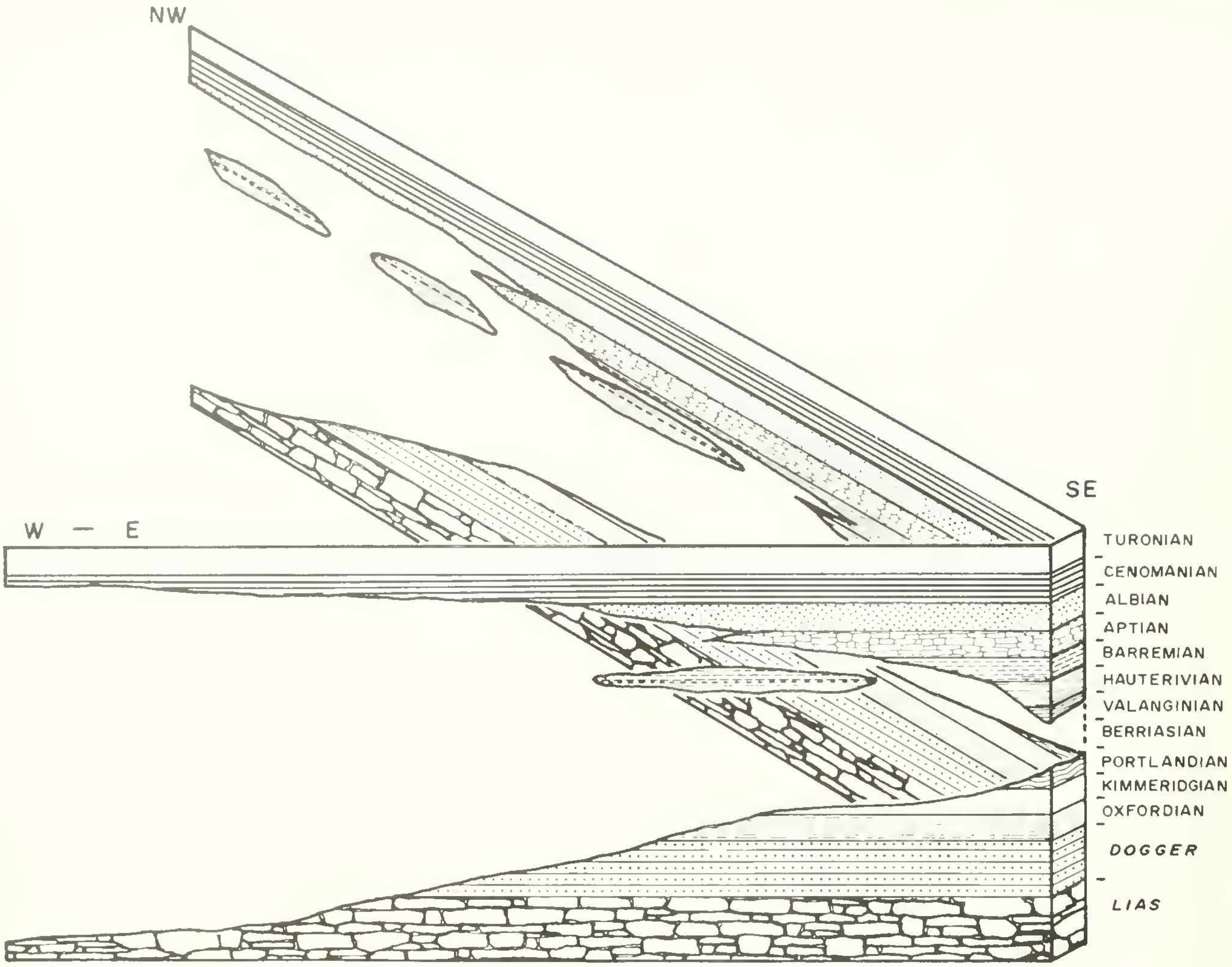

Fig. 3. Stratigraphical lacune between the Jurassic and Cretaceous sediments.

a) Beginning in the Oxfordian, it corresponds to a slow elevation of the entire zone, accompanied by an eastward tilt.
b) Post-Portlandian – Pre Upper-Valanginian, with fracturing in blocks due to the reactivation of Hercinic fractures.
c) Intra-Hauterivian – similar to the above.
d) Intra-Barremian: with fracturing in blocks and a first, general enlargement of the sedimentation area of the basin.
e) Base of the Upper Albian: with a general eastward tilt and an elevation of the Meseta.

FACIES DISTRIBUTION

An analysis of the division, geometry, facies and chronostratigraphic position of the differentiated Cretaceous formations has made it possible for us to establish the distribution of the main sedimentary environments for each differentiated chronostratigraphic interval. The choice of intervals was made according to the possibility of datings or the need to demonstrate important paleogeographic changes during certain time lapses within the Cretaceous.

From the Berriasian only marine sediments with marine characteristics similar to those of the Portlandian are known in the Jumilla-Yecla zone. In the remaining areas, either there was no sedimentation, or it was later eroded. (Fig. 4.1).

During the Valanginian-Hauterivian (the fossils found do not permit greater precision), the marine influence quickly advanced in a narrow, elongated basin predetermined by basement tectonic together with the reactivation of Tardihercinian strike-slip faults, basically in a NW-SE direction. Lagoon and tidal plain environments appear which, in turn, are bordered on the NW by coastal alluvial plains with a certain tidal influence, (Fig. 4.2). In the Jumilla-Yecla region, the sedimentation is marine of a recifal nature.

In the Lower Barremian (Fig. 4.3), probably covering as well the Upper Hauterivian, the sedimentation continues in a narrow trough, reaching more northernly positions and developing as well in other points within the Albacete Gulf. During this stage, in the entire basin within the Iberian trough, there was a predominant appearance of paralic environments with a more littoral nature in the extreme southeast and more

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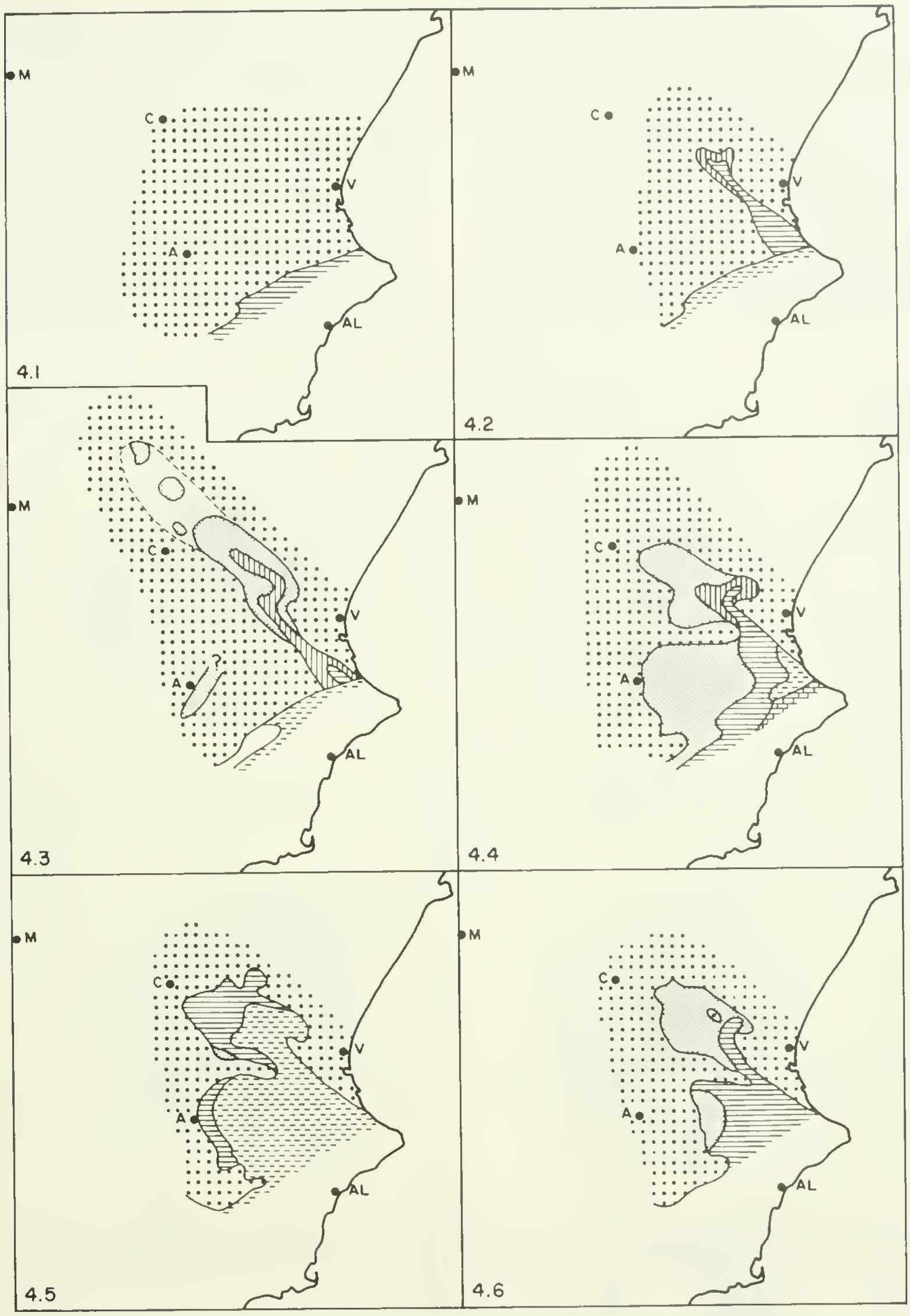

Fig. 4. Paleogeographical maps: 4.1 Berriasian. 4.2 Valanginian-Hauterivian. 4.3 Lower Barremian. 4.4 Upper Barremian. 4.5 Bedoulian. 4.6 Lower Gargasian.

continental towards the NW. A narrow connecting band existed between the two in which marsh environments prevailed of mixed terrigenous-carbonate nature. In general, within this group of paralic environments, the carbonate facies prevailed towards the SW in the Albacete Gulf, while the siliciclastics were concentrated round the High of Javalambre-Valencian Massif. In the northeastern area of the Jumilla-Yecla zone, the sedimentation is of a carbonate nature with a very strong marine influence.

From this moment, the paleogeography of the region undergoes an important change due to an important interval of tectonic instability. This new stage begins with the appearance of coastal alluvial plains, during the Upper Barremian, together with extensive silty inundated plains, with lacustrine subenvironments. In the southeasternmost part, calm environments prevail with an internal, carbonate platform of the Urgonian type, with a wide development of Rudists, essentially Requienids. Between these marine environments and the continental ones, there is a wide band of coastal environments of a mixed terrigenous-carbonate nature, surrounded on the north by marshes, (Fig. 4.4).

In the Bedoulian (Fig. 4.5), an Urgonian type platform ap-

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pears in the basin with calm, carbonate, inner platform environments, with a large development of Rudists, basically Requienids and Monopleurids. Skirting it on the north, there is a coastal band of a mixed terrigenous-carbonate nature in which coastal bars, channels and tidal plains develop.

The Lower Gargasian corresponds to a regressive stage, with a sudden arrival of terrigenous sediments basically from the Meseta to the basin, where coastal alluvial plains appear. In the southern region, mixed terrigenous-carbonate lagoon coastal environments appear, of a more open nature the farther south one goes, (Fig. 4.6).

During the Upper Gargasian-Clansayesian, (Fig. 5.1), the installation of a new Urgonian platform of lesser extension than the previous one occurred which, in the outermost zones, offers a large development of Rudists (Requienids and Monopleurids) and Corals. Skirting this platform, there were mixed terrigenous-carbonate coastal environments with a development of coastal bars and tidal plains. In the northern part, coastal alluvial plains developed. This stage ends with the important arrival of terrigenous sediments to a large part of the basin, corresponding to the Lower-Middle Albian, forming the base of the "Arenas de Utrillas", (Fig. 5.2). The

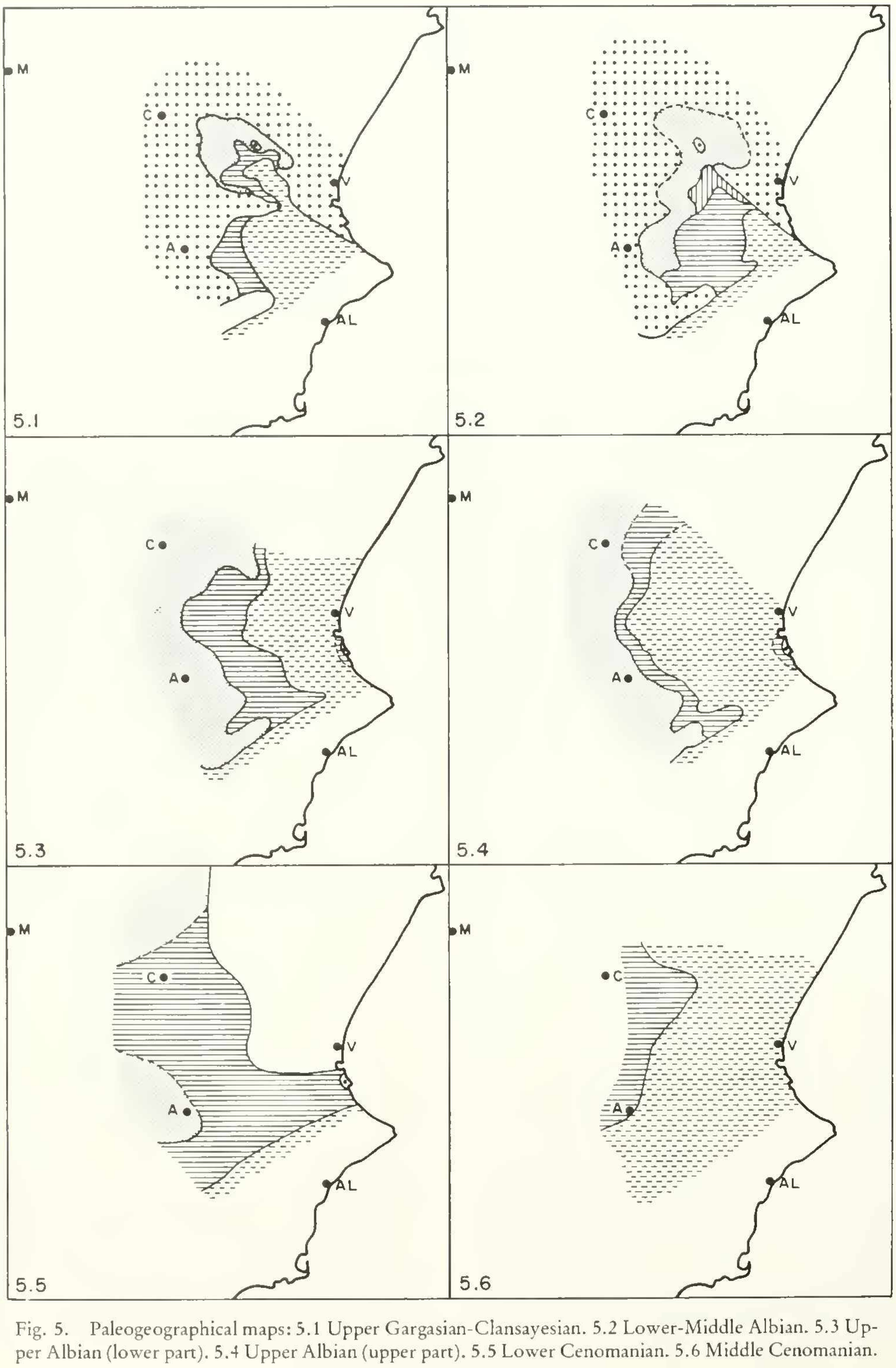

Fig. 5. Paleogeographical maps: 5.1 Upper Gargasian-Clansayesian. 5.2 Lower-Middle Albian. 5.3 Upper Albian (lower part). 5.4 Upper Albian (upper part). 5.5 Lower Cenomanian. 5.6 Middle Cenomanian.

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deposits, corresponding to this time and that display a greater carbonate internal platform marine influence, are limited to the southernmost zone. In the western and northern part of the basin, alluvial and coastal plain environments appear and which, in their most distal areas, were clearly influenced by tides. Between these there is a mixed terrigenous-carbonate coastal band with coastal bars and a lagoon. The expansion of the basin begins at this moment, surpassing the High of Javalambre-Valencian Massif. This process presents two transgressive pulses: one corresponding to the Upper Albian, in which an internal carbonate platform was installed, skirted on the W by mixed terrigenous-carbonate coastal environments, (Fig. 5.3). The zone more to the west parallel to the previous one, facies are found corresponding to proximal to distal alluvial plains that correspond to the "Arenas de Utrillas" Formation. In the second pulse, which took place during the Vraconian, after a short regressive episode, a more complex, more extensive, carbonate, internal platform was installed, (Fig. 5.4).

As a result of all this, the basin offers conditions from which a clear homogenization of the same is produced during the Cenomanian with the definite installation of a relati-

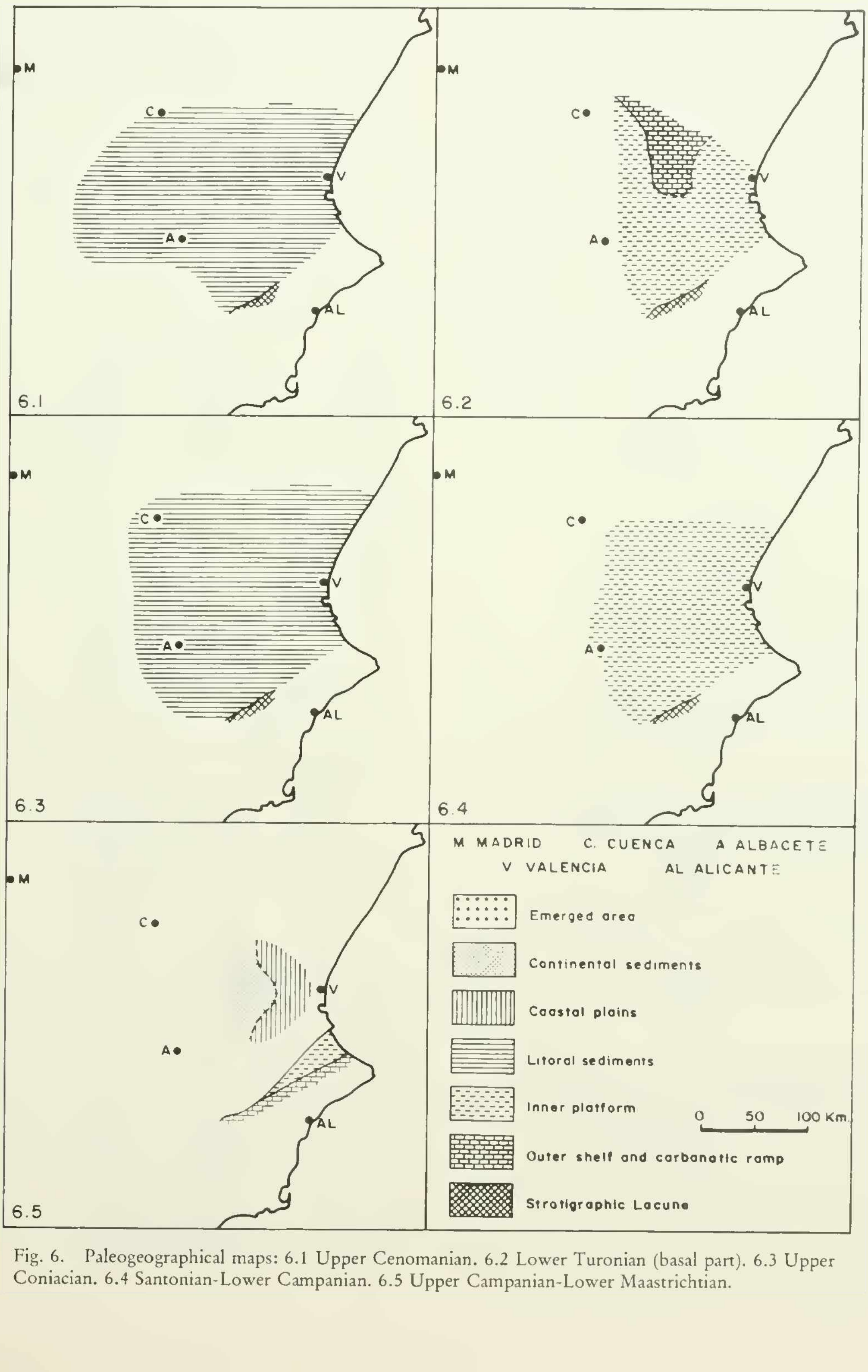

Fig. 6. Paleogeographical maps: 6.1 Upper Cenomanian. 6.2 Lower Turonian (basal part). 6.3 Upper Coniacian. 6.4 Santonian-Lower Campanian. 6.5 Upper Campanian-Lower Maastrichtian.

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vely stable epicontinental platform throughout the entire Iberian region, (Fig. 5.5). The sedimentation in this platform begins in the western part with open, carbonate lagoon environments, showing a strong influence of fine terrigenous sediments. In the western and northern parts, restricted lagoon environments prevail of a mixed fine terrigenous and carbonate nature. Related with these are extensive zones of marshy tidal plains, changing into continental terrigenous facies towards the NW and W.

During the Middle Cenomanian, a carbonate internal platform was installed throughout the entire region, (Fig. 5.6). The Upper Cenomanian is characterized by a basic fact which is the general homogeneization of the basin, with the appearance of wide carbonate tidal plains, (Fig. 6.1).

Another transgressive period begins in the Lower Turonian (Fig. 6.2), which, during the first stage, causes a complete homogeneization, with the installation of an extensive carbonate platform tilted northwards in which the outermost environments are found, including ammonites and planctonic foraminifers. During the second stage, a regressive tendency is initiated and a carbonate ramp is formed with more external zones of micritic sedimentation and Rudist patches, together with other more superficial zones where large calcarenitic bars develop. After this, there is an interruption episode throughout the entire area and which includes, at least, the Upper Turonian and part of the Coniacian. Starting at this point, an extensive, superficial and complex, internal carbonate platform appears, reaching its maximum development during the Upper Santonian, (Figs. 6.3 and 6.4).

The regressive tendency ends during a second stage developed in the Upper Campanian-Maastrichtian, and in which extensive plains appear near the coastline with permanent marshes and lakes containing carbonate and lutitic sedimentation, (Fig. 6.5).

SEDIMENTARY CYCLES AND TECTOSEDIMENTARY EPISODES

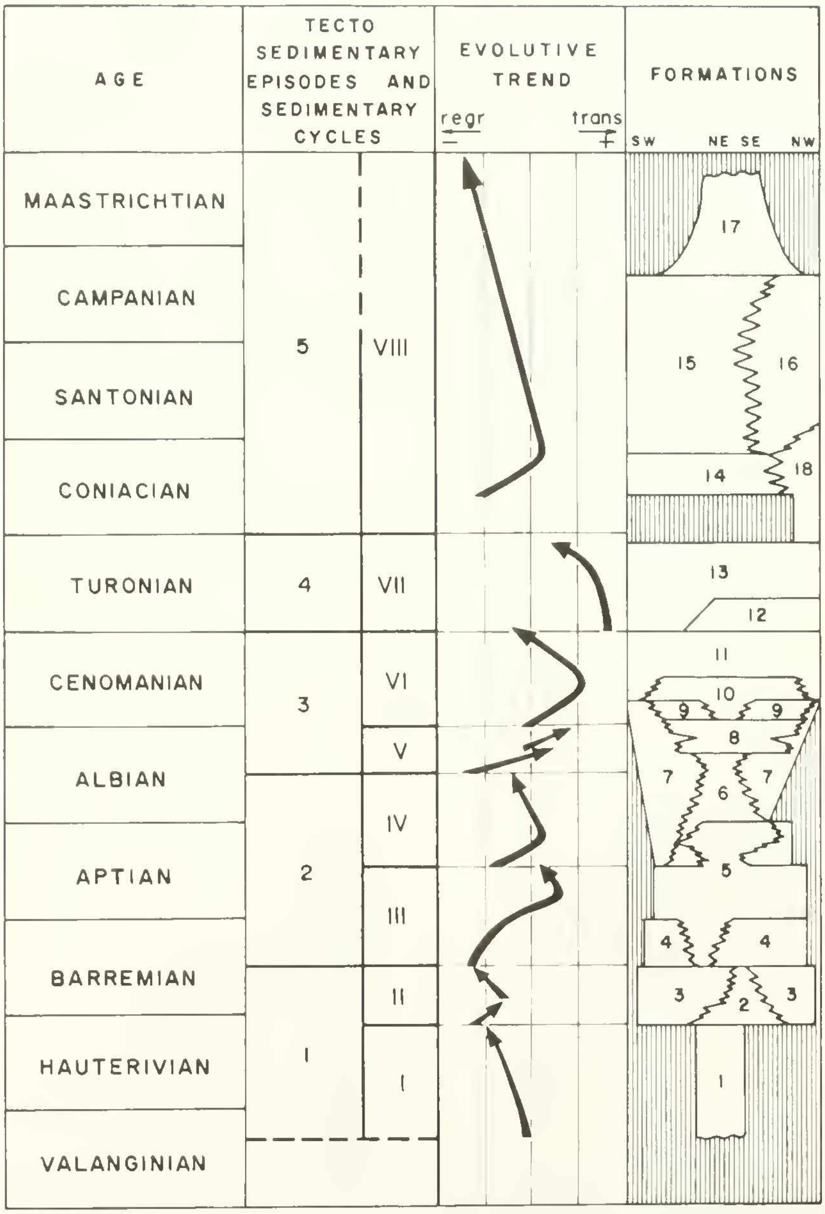

Fig. 7. Sedimentary cycles and tectosedimentary episodes.

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The different types of facies described, their horizontal distribution for each age and the variations in their vertical distribution, have made possible to establish eight sedimentary cycles for the Cretaceous of this sector of the Iberian Range (Mas et al. 1982). These sedimentary cycles are usually separated by stratigraphic discontinuities of different classes, reflected by important changes in their sedimentologic and paleogeographic evolution. These eight sedimentary cycles can be grouped, at the same time, into five large tectosedimentary episodes (see below) whose boundaries are determined by events that effect on the whole entire area in question. The cycles, the tectosedimentary episodes, as well as the temporal and spatial position occupied by the eighteen differentiated lithostratigraphic units, are represented in Fig. 7.

The first cycle (I), developed during part of the Valanginian and/or part of the Hauterivian (no definite paleontological confirmation on the same exists), appears only in limited areas within the southwestern Iberian Trough. It corresponds to the beginning of sedimentation after an absence of deposits and erosion, during which time important episodes of tectonic instability occurred in almost the entire area studied. The sediments were deposited in a narrow, elongated basin, predetermined by a tectonic of basement blocks together with the reactivation of Hercinian strike-slip faults. In general, this cycle offers a regressive nature and terrigenous sediments predominate.

After another interval of tectonic instability, reflected by sedimentary interruption with a period of erosion, an abrupt change was brought about in sedimentation conditions, but the paleotectonic guidelines that condition the shape of the basin were maintained. Under these circumstances, cycle II evolved mainly during the Lower Barremian, although it can also be represented at the top of the Hauterivian. It begins with a short period characterized by a transgressive trend followed by another regressive period. The sediments, corresponding to this cycle, are terrigenous or carbonatic, depending on the area.

Cycle III, which includes the Upper Barremian and the Bedoulian, corresponds to the expansive stage of the basin, with the development of the transgression that produced the installation of a marine platform with Urgonian sedimentation. This transgression is complex, as it developed from a double pulse, the first corresponding to this cycle, (Arias et alt. 1979). The base contains mainly fine terrigenous sedimentation, changing into carbonate as the transgression advances. Only at the very end of this cycle can regressive features be found.

Cycle IV includes the Upper Aptian and the Lower and Middle Albian, and corresponds to the second pulse of the Aptian transgression. A large part of the "Arenas de Utrillas" Formation is found at the top. The base of the cycle is transgressive, starting with terrigenous sediments that correspond to coastal alluvial plains, passing to lagoons and ending, towards the top, in an Urgonian carbonatic platform, less extensive than the previous one. This cycle finishes with a regression caused by the powerful arrival of terrigenous sediments from the Meseta that cover a large part of the basin.

Cycle V develops during the Upper Albian and includes two transgressive pulses, abruptly interrupted at the top. The upper is more extensive than the lower one, and both develop in a northwestern direction, according to the model given by Garcia et al. (1978). This cycle represents the base of the large transgression of the Upper Cretaceous in the Iberian Range, where the expansion of the basin is considerable, surpassing for the first time the Javalambre High and the Valencian Massif which, till the moment, had closed the basin on the northeastern side.

Cycle VI occurs throughout the entire Cenomanian and includes a transgressive-regressive series with carbonate sediments. During this cycle, a clear homogenization of the basin is produced. The most important point is the installation of extensive carbonatic tidal flats.

Cycle VII represents the Turonian (s. l.); however, its continuity cannot be determined in the Upper Turonian. In general, it has a regressive nature which is abruptly interrupted towards the top. It corresponds to the stage in which the basin underwent a maximum opening towards the open sea, with the installation of Ammonite and planctonic Foraminifera environments. Towards the top Rudist patches predominate.

After this cycle, it has not been possible to make a paleontological distinction of the Upper Turonian nor of a large part of the Coniacian throughout the southwestern Iberian Range. This coincides with a stage in which there are signs of evident sedimentary interruption in the entire area. For this reason, and due to a lack of more conclusive evidence, we believe there is a possible lacune which would include the above mentioned time interval.

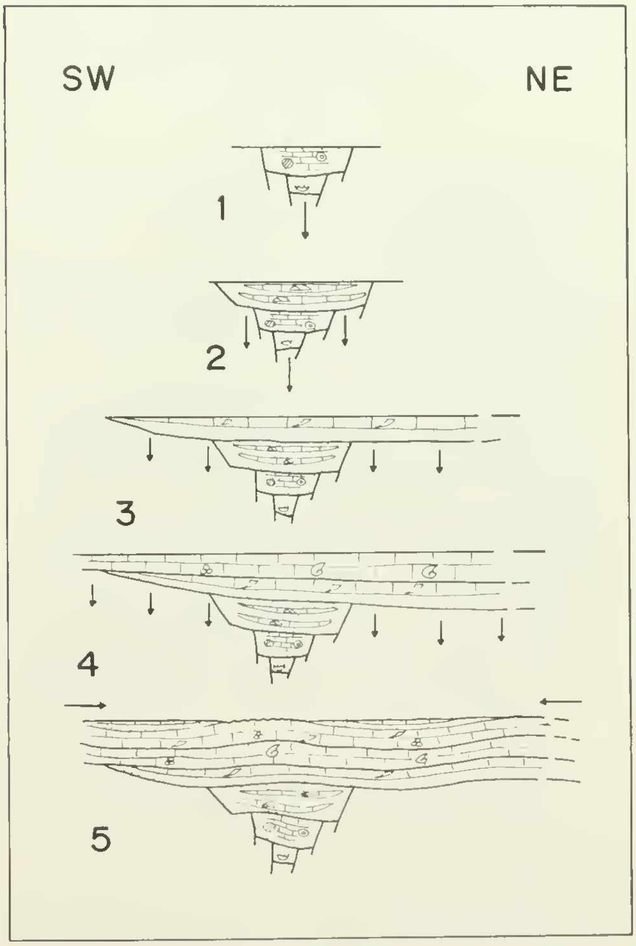

Fig. 8. Tectosedimentary episodes (see text).

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After this interruption, the sedimentation is renewed with sediments of an obvious continental influence which form the base of cycle VIII. This cycle, belonging to the Senonian, develops rapidly into a shallow carbonatic platform, initiating at once a regressive period that occupies the greater part of the cycle. The cycle ends with the intallation of continental environments near the coastline.

These eight sedimentary cycles in which the Cretaceous sediments of this region have been divided, can be grouped into five tectosedimentary episodes, based on tectonic phenomena of varying importance with repercussions in sedimentation.

In Fig. 8 the different tectosedimentary episodes are represented by way of an imaginary section of the SW Iberian Trough in a SW-NE direction.

The first episode includes cycles I and II and is characterized by a strong sedimentation influenced by a tectonic of basement blocks, with the formation of throughs and little bassins related with grabens that offer strong subsidence and a large amount of sedimentation. Within this episode, and between cycles I and II, a greater expansion of the basin can be seen in the latter, taking into consideration the present outcrops. In the second episode, which includes cycles III and IV, instability continues, represented by the movement of blocks that divide the basin in zones of differentiating subsidence. But, in general, this mobility is much less than in the previous episode, which allows for a greater expansion of the sedimentation area that coincides with the "Aptian transgression", causing the development of Urgonian carbonate platforms. By the end of this espisode, the arrival of terrigenous contributions begins in the Albacete Gulf, representing the regressive stage of cycle IV, without any discontinuity with the Urgonian limestones. The third episode, which includes cycles V and VI, begins with the arrival and expansion of terrigenous sediments in the basin, having caused an evident previous erosion in some areas. This fact may be a reflection of an elevation of the Meseta area at this time. During this episode, the subsidence is of a generalized nature and not differentiated in blocks, causing a homogenization of the basin in the upper part with the installation of an extensive epicontinental shelf. In the fourth episode, which includes cycle VII, the epicontinental platform is enlarged and deepened, opening northwestwards by means of a tilt on a NW-SE axis. During this episode, the Proto-Atlantic and the Tethys basins were possible joined together through the high of the westernmost part of the region under study. Finally, and after an important interruption in sedimentation, the fifth tectosedimentary episode appears, which includes cycle VIII. During this episode, the basin becomes shallow and is finally divided into little basins with an increasingly more continental nature. The geometry of this division does not appear to have any relation with that of the Lower Cretaceous.

Following the consideration of aulocogene, established for the Iberian Range by ALVARO et al. (1981), with reference to all the sediments from the Permian to the Cretaceous, the evolution we described for the Cretaceous with its stages of fracturing and graben (Lower Cretaceous), flexure (Upper Cretaceous) and folding (Final Cretaceous), corresponds in itself to the internal development of an aulacogenous through.

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Autor(en)/Author(s): Vilas Lorenzo, Alonso Angela, Arias Consuela, Garcia Alvaro, Mas Jose Ramon, Rincon Richard, Melendez Nieves

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