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THE JURASSIC-CRETACEOUS BOUNDARY NEAR MIRAVETES (CARAVACA, SE SPAIN); ARGUMENTS FOR ITS POSITION AT THE BASE OF THE OCCITANICA ZONE

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RESUMEN: Se demuestra en esta nota que la principal variación en la fauna de ammonites se localiza en la base de la Zona de Occitanica, que a su vez coincide con la base de la Zona de Calpionella elliptica. Estos criterios recomiendan localizar en este nivel el límite entre Jurásico y Cretácico.

ABSTRACT. It was demostrated that the deepest caesura in the mediterranean succession of ammonite faunas was situated at the base of the Occitanica zone and that this caesura coincides with the most easily definable break in the calpionellid faunas at the base of the C. elliptica zone providing a worldwide correlation. This caesura was therefore recommended as the Jurassic-Cretaceous boundary.

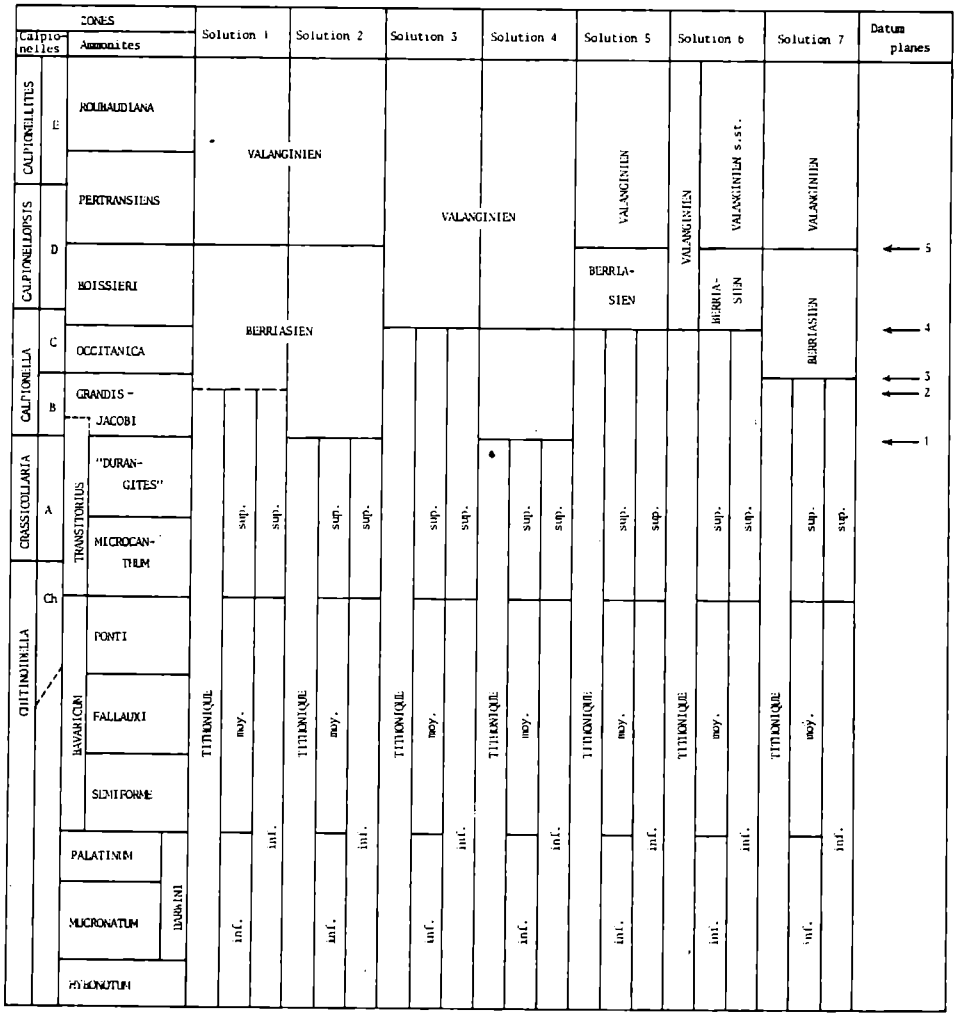
One of the investigation projects of the National Museum of Geology and Mineralogy of the Netherlands is the study of the ammonite biostratigraphy of the Lower Cretaceous along the Río Argos, W of Caravaca (SE Spain). This investigation was partly financed by the Netherlands Organisation for the Advancement of Pure Research.

The upper Tithonian-Berriasian-lower Valanginian sequence, with which our investigations started, is 312, 5 m thick, without lacunas and well exposed near Miravetes, a farm alongside the Rio Argos. It has a uniform facies, viz. a monotous rhythmic alternation of gray marlstone and marly coccolite limestone beds and yielded about 2000 ammonites. This sequence is therefore particularly well suited to examine the vertical stratigraphic ammonite distribution, not obscured by facies changes. All zones and subzones defined by LE HÉGARAT (1971) are well and recognizably represented in Miravetes; his zonal scheme is therefore well applicable in SE Spain. Papers on the detailed ammonite biostratigraphy and palaeontology are in preparation.

The stratigraphically lowest bed incorporated in our study apparently coincides with the lower limit of the Calpionella alpina zone of ALLEMANN et al. (1971), because it was alternately put in the Crassicolaria intermedia zone (by GEEL, 1966; by GELL in VAN VEEN, 1966, 1969; by REMANE in SEYFRIED, 1979) and in the C. alpina zone (by ALLEMANN in ALLEMANN et al., 1975; by GEEL, who studies the tintinnid biostratigraphy in the present investigation). So all five Jurassic-Cretaceous boundaries proposed during the colloque on this subject, held in Lyon and Neuchâtel in 1973, are involved in the present study. (table 1).

During this colloque no agreement on the stratigraphic position of the Jurassic-Cretaceous boundary could be reached. Therefore special attention was paid to the ammonite faunal changes at each of the proposed boundaries. In this respect the tables with the ammonite species ranges, known since the thorough studies of LE HÉGARAT (1971) on the Berriasian in SE France and supplemented with the ranges in Tunisia (MEMMI & SALAJ, 1975) and Miravetes (this investigation), are in particular elucidative, for it appears from them that none of the boundaries between the Jurassic and Cretaceous proposed during the colloque are important enough to be a boundary bet-

TABLE 1



ween systems except one, namely at the base of the Occitanica zone of LE HÉGARAT (1971). Ironically this boundary scored only one vote in the inquiery set up after the colloque.

Let us examine first the Berriasian-Valanginian boundary, one of the proposed Jurassic-Cretaceous boundaries (WIEDMANN, 1975; DRUSHCHITS, 1975; BADALUTA, 1975; PATRULIUS et al., 1976). In Miravetes this limit is not marked by a hiatus as in SE France and is well characterized by the first appearance and the rapid increment in number of *Tirnovella pertransiens* (SAYN) and *Thurmanniceras otopetum* THIEULOY directly above the last occurrence of *Berriasella callisto* (D'ORB.) and *Subthurmannia boissieri* (PICT.). This observation differs from that of ALLEMANN et al. (1975) near Miravetes, for they erroneously assumed an overlap of 43'5 m between their sections, where there is in reality only 5'5 m overlap.

Though the change in the ammonite fauna near this limit is very important (all «Berriasian» perisphinctacean (sub) genera, except *Kilianella*, were successively replaced by «Valanginian» ones, table 2), it appears to be a gradual one and comes about mainly in the course of the Callisto subchron. Our investigations revealed that the «typically Berriasian» species of *Berriasella* (2), *Subthurmannia* (6), *Substeueroceras?* (5), *Spiticeras*, *Kilianiceras*, *Groebericeras*, *Malbosiceras*, and *Pomeliceras* n. subgen. (9) become extinct somewhat below or above the top of this subzone, whereas the «typically Valanginian» species of *Tirnovella* (8), *Thurmanniceras* (11), *Neocomites*, *Neohoploceras*, *Olcostephanus*, *Rogersites*, and *Sarasinella* first appear somewhat below or above the base of this subzone. So the successive extinctions were at the same time well compensated by successive appearances of new species; the stratigraphic interval containing the peak in the concurrence of ranges is rather extended and comprises the entire subzone. «*Berriasella constricta*» ARNOULD-SAGET, non UHLIG, 1910, the earliest representative of *Kilianella*, a generic group hitherto considered characteristic for the Valanginian, has been reported from the lower part of the Occitanica zone of Tunisia (MEMMI & SALAJ, 1975; BUSNARDO et al., 1976). In Miravetes the stratigraphically lowest *Kilianella* was found in the Privasensis subzone; it becomes frequent and diverse in the Boissieri and Roubaudiana zones.

The faunal change at the boundary between the Occitanica and Boissieri zones sensu LE HÉGARAT, which is also one of the proposed Jurassic-Cretaceous boundaries in support of which CASEY (during the colloque, 1973) adduced many arguments, is the least important one and is enacted merely at the species level. The (sub) genera *Berriasella*, *Kilianella*, *Neocosmoceras*, *Mazenoticeras*, *Euthymiceras*, *Malbosiceras*, *Dalmasiceras*, *Subalpinites*, *Subthurmannia*, *Strambergella* (7), *Spiticeras*, *Negreliceras*, *Kilianiceras*, *Jabronella* (10), *Pomeliceras* n. subg., and *Substeueroceras?* cross the boundary without gaining or losing in importance.

The ostensible faunal jump at this bounday appearing from LE HÉGARAT'S range charts is probably caused by particular, local ecological circumstances that resulted in a great proliferation of *Dalmasiceras dalmasi* (KIL.) and its sexual dimorph *D. punctatum* DJAN. at the cost of other species. In Miravetes this jump is far less marked, because it appeared from our studies that several of Le HÉGARAT'S ranges of ammonite species should be extended upward and downward into the Dalmasi subzone. Informatively could be added that *Calpionellopsis simplex* first appears somewhat below the base of the Boissieri zone, only five metres below the bed in which ALLEMANN et al. (1975) found it, and that the level from which GRÜN & ALLEMANN (1975) reported their first *Retacapsa crenulata* and *Speetonia colligata* (coccolithophorids) in Miravetes practically coincides with the top of the Paramimou-

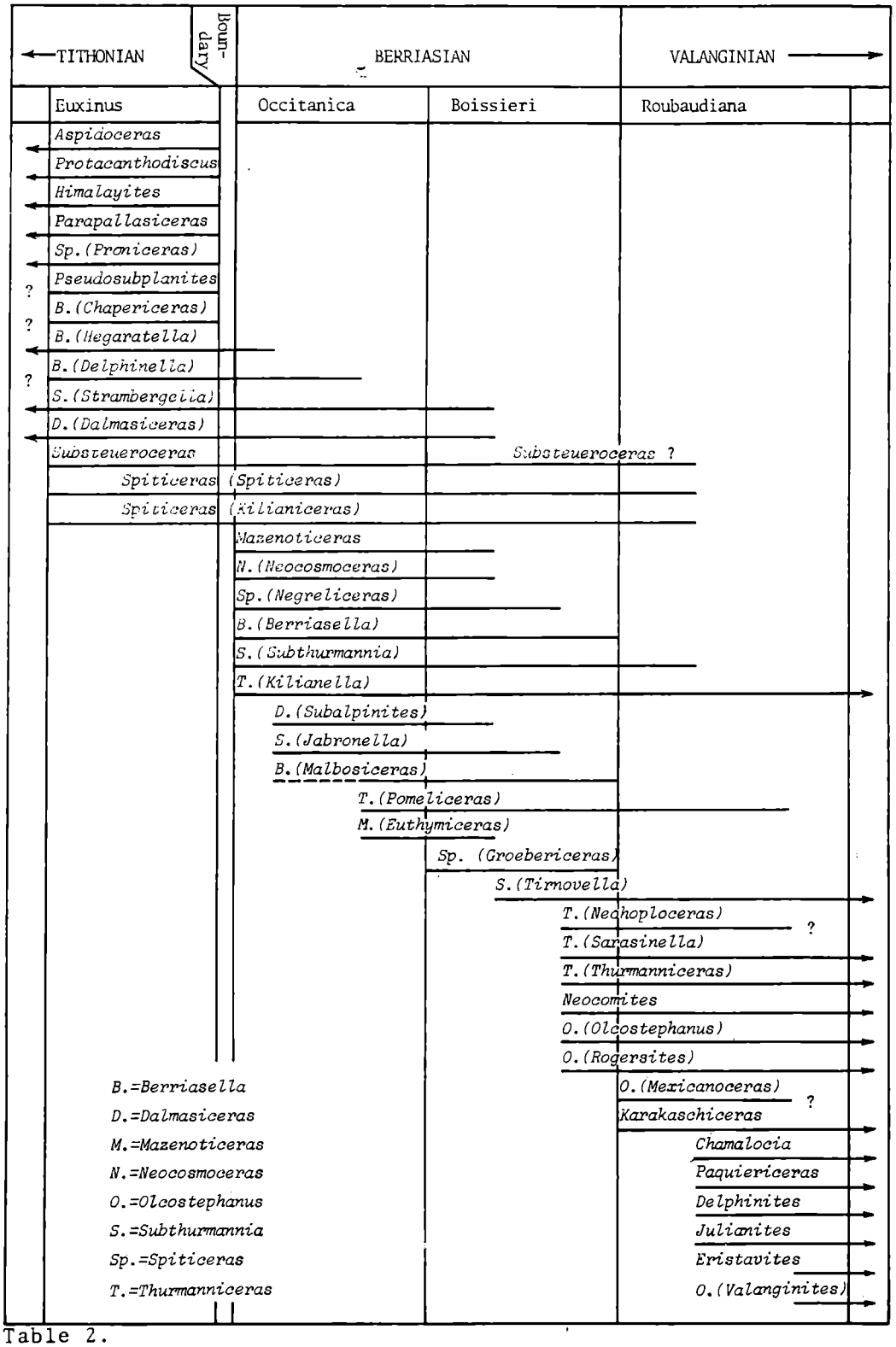


Table 2.
Ranges of mediterranean perisphinctacean genus groups.

num subzone instead of its base, with which THIERSTEIN (1975) correlates this level.

During the colloque on the Jurassic-Cretaceous boundary it has repeatedly been argued that the Jacobi and Grandis zones of LE HÉGARAT (1971) had better be thrown together into one zone because of the difficulty to differentiate them faunistically. Also for Miravetes this is but too true. This zonal combination was provisionally called the «Berriasella grandis zone sensu lato» by YEGOYAN (1975), the «Ponticus-Euxinus zone» by DRUNSHCHITS (1975), and the «Jacobi-Grandis zone» in the discussion during the colloque. WIEDMANN in ALLEMANN et al. (1975) introduced the name Euxina zone for the stratigraphic interval near Miravetes that, after our exhaustive search for ammonites, proved to be exactly equivalent to the «Jacobi/Grandis zone». This name was adopted because it has been defined by a stratotype. The Jacobi and Grandis «zones» were retained as subzones of the Euxina zone. ALLEMANN et al. (1975) thought that their Euxina zone was time-equivalent to he Grandis and the Subalpina subzones; this error is partly due to the assumption of an overlap of 31'5 m between their sections where there is no, or possiblv only 2.5 m overlap.

By priority, and this should be apprehended as a *status institutus* (YEGOYAN, 1975), the Berriasian should be considered the lowest chronostratigraphic unit of the Cretaceous System, because it has been shown to be almost equivalent to the socalled «Inferior Oolitic Limestone» and «Marbre Bâtard» rockunits (DONZE, 1965; LE HÉGARAT, 1971; PERSOZ & REMANE, 1976), which have been included in the original definition of the Valanginian (DESOR, 1854), the lowest stage of the Cretaceous Neocomian Series. The stratigraphic interval that COQUAND later (in 1875) happened to call Berriasian was subsequently incorporated in the Tithonian Stage by OPPEL (1865), who defined this Upper Jurassic Stage as the stratigraphic interval between the Kimmeridgian sensu OPPEL and the Neocomian without designating a stratotype. This incorporation must however be attributed to false correlation, very excusable, for the lowest ammonites known to be of Neocomian age in Oppel's time were from the Roubaudiana zone. If the «Marbre Bâtard» had yielded ammonites, it seems likely that Oppel would have excluded them from those he thought characteristic for the Tithonian.

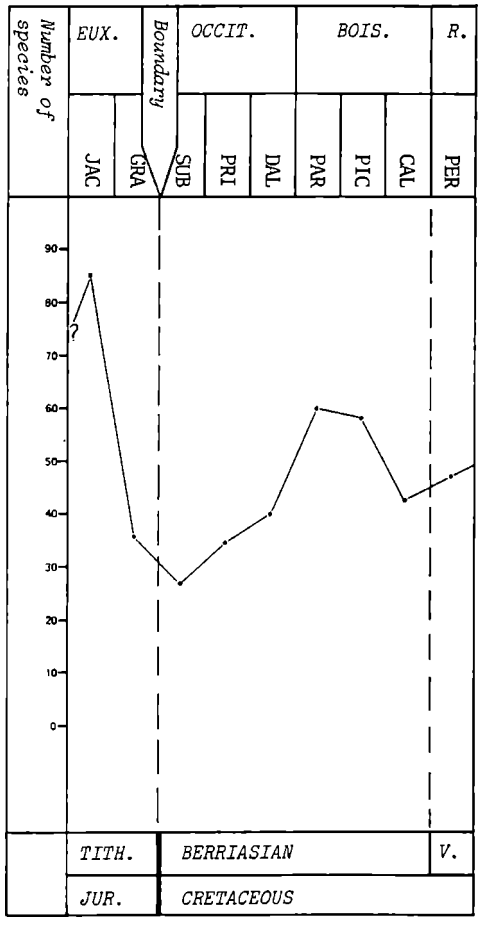
The type section of the Berriasian near Berrias (Ardèche, France) was conceived by KILIAN (1896, 1907, 1910), MAZENOT (1939), and the Colloque on the Lower Cretaceous (1965) to begin with the lowest stratum that yielded identifiable ammonites above the upper Tithonian limestones which did not produce identifiable ammonites. Unfortunately this horizon appears to be a level halfway the Calpionella alpina zone and therefore very difficult to recognize by tintinnid biostratigraphy. It also appears to be a level halfway the Euxina zone, which is just as difficult to recognize by ammonite biostratigraphy. This boundary is therefore most unsuited to be the Jurassic-Cretaceous boundary. According to the correlations of PERSOZ & REMANE (1976: they correlated the first appearance of kaolinite in various sections), if correct, this horizon could approximately be correlated with the base of the Valanginian stratotype as indicated by DESOR (1854). Therefore this boundary should be respected until an in every respect acceptable alternative boundary could be found, well correlatable on a worldwide scale and as close as possible to the traditional one; for, if too large a deviation from the traditional views is made, geological maps and literature cannot be read anymore.

The only thing that matters now is where the Tithonian-Berriasian boundary could best be drawn, taking into account that it is also the boundary between the Jurassic and Cretaceous Systems. Rejecting the idea of the «golden spike» as an unalterable boundary between systems and stages, I prefer the idea that sys-

tem and stage boundaries should be defined by words to coincide with biostratigraphic boundaries and changed in accordance with any subsequent change in the definition or stratigraphic scope of the adjacent biostratigraphic zones. Since all systems and stages of the Mesozoic are founded on ammonite associations, the Jurassic-Cretaceous boundary should preferably be defined by ammonites as well. Accordingly the most qualified boundaries are obviously the lower and the upper limit of the Euxina zone; they are far better correlatable than the classical boundary anyway. For worldwide correlation, however, tintinnids appear to be the best guides. Fortunately BARTHEL et al. (1966) and ENAY & GEYSSANT (1975) showed that the base of the Calpionella alpina zone approximately coincides with the base of the Jacobi subzone, whereas our investigations indicated that the base of the Calpionella elliptica zone practically coincides with the top of the Grandis subzone. So the C. alpina zone comprises virtually the same stratigraphic interval as the Euxina zone, and both boundaries are apt to be correlatable on a worldwide scale. Though both boundaries are in a certain sense qualified to be the Jurassic-Cretaceous bounday, the lower has been far the most favoured one during the colloque. I cannot understand this.

For a better fundamented choice between the two boundaries of the Euxina zone, first a synopsis of its characteristic perisphinctacean ammonite association should be given: the majority of the ammonites belongs to species of *Pseudosubplanites*, *Hegaratella* (1), *Delphinella*, *Dalmasiceras* (12), and *Proniceras* (13); the minority belongs to species of *Aspidoceras*, *Himalayites*, *Protacanthodiscus* (4), *Chapericeras* n. subgen (3), *Strambergella* (7), *Parapallasiceras*, *Substeueroceras* (5), *Spiticeras*, and *Kilianiceras*. (table 2 and 3).

The examination of the literature on mediterranean upper Tithonian ammonite faunas revealed disappointingly that bed by bed collecting has very rarely been done. Notwithstanding that, it appears that representatives of at least eight of these 14 (sub) genera have been reported from beds that are stratigraphically below the Jacobi subzone, for instance *Hegaratella*, *Dalmasiceras*, *Proniceras*, *Aspidoceras*, *Himalayites*, *Protacanthodiscus*, *Parapallasiceras*, *Strambergella*, and possibly also *Pseudosubplanites*, *Delphinella*, *Chapericeras* n. subgen., and *Spiticeras*. So the Euxina assemblage has very close affinities with the Tithonian faunas and more than half of it consists



Number of perisphinctacean species in the successive subzones near the mediterranean Jurassic-Cretaceous boundary.

TABLE 3

of ammonites belonging to subgenera of unquestionable Tithonian origin. Nevertheless according to ENAY & GEYSSANT (1975) a clear, though gradual, faunal change comes about near the lower limit of the Jacobi subzone. This change mainly consists of a marked increase and decrease in the number of ammonites that belong to certain (probably) already existing (sub) genera: *Pseudosubplanites*, *Hegaratella*, *Delphinella*, *Dalmasiceras*, and *Proniceras* become abundant, whereas the representatives of Himalayitinae strongly decrease in number.

This faunal change cannot be observed near Miravetes, because the lowest bed (Z1) incorporated in our study marks a hiatus comprising the upper part of the Crassicolaria intermedia zone. WIEDMANN in ALLEMANN et al. (1975) and GEYER in SEYFRIED (1979) reported however *Hegaratella jacobi* (MAZ.), *Chapericeras tarini* (KIL.) (3), *Parapallasiceras* cf. *preacox* (SCHN.), *Dalmasiceras* sp., and *Protacanthodiscus* sp. from about one metre below bed Z1, well within the Cr. intermedia zone. This ammonite association probably belongs to the Microcanthum zone or «Durangites» zone sensu ENAY & GEYSSANT (1975).

Less gradual, however, is the faunal break that marks the boundary between the Euxina and Occitanica zones (table 3 and fig. 1). The Euxina zone can pre-eminently be typified as a zone in which extinction of ammonite species is general and remarkably not compensated by newcomers as is the case at the Berriasian-Valanginian boundary. This extraordinary event merits full attention. The generality of the extinction not compensated by appearances of new taxa is particularly conspicuous from the range charts of LE HÉGARAT (1971) to which our investigations can add only minor details. *Delphinella tresannensis* LE HEG., for instance, continues into the Grandis subzone and *Himalayites cortazari* (KIL.) was found in the Jacobi subzone; also *Strambergella «shipkovensis»* (LE HEGARAT, non NIKOLOV & MANDOV) possibly already occurs in the Jacobi subzone; the specimens from the Jacobi subzone assigned to *Delphinella «boisseti»* by LE HÉGARAT (1971) were regarded as coarsely ornamented varieties of *D. obtusenodosa* (RET.).

The total number (about 85) of perisphinctacean species that have been distinguished in the mediterranean Jacobi subzone is cut down by half in the Grandis subzone, whilst only thirteen perisphinctacean lineages excaped the extinction wave and cross the boundary. This drastic reduction in the number of species is also conspicuous from the range charts of MEMMI & SALAJ (1975). All species of *Pseudosubplanites*, *Parapallasiceras*, *Aspidoceras*, *Protacanthodiscus*, *Himalayites* (14), *Chapericeras* n. subg., and *Proniceras* died out, whereas of the 13 species of *Hegaratella* only four survived the crisis to become extinct soon afterwards. Also *Substeueroceras*, *Delphinella*, and *Dalmasiceras* heavily lost their importance. As the ranges of *H. cortazari* and *D. boisseti* do not cross the boun dary, only ten species have actually been recorded to survive the crisis (table 3), but next to these also one lineage of *Kilianiceras* must have crossed the boundary. Moreover *Substeueroceras? davidi* (LE HEG.) was considered the lineal descendant of *S? allobrogense* (MAZ.) and *Strambergella clareti* (LE HEG.) the lineal descendant of *Str. carpathica* (ZITT.). *Str. carpathica* recorded by MEMMI & SALAJ (1975) from the Subalpina ammonite association may therefore be a transitional form. The ancestor of *Str. subalpina* (MAZ.), which appears near the upper limit of the Grandis subzone, should be sought for in the neighbourhood of *Str. «shipkovensis»* (LE HEG., non NIK. & MAND.); *Hegaratella oxycostata* (JAC.) was considered the ancestor of both *Berriasella* and *Kilianella*. Only the denizens of the open seas as phylloceratids, lytoceratids, haploceratids and apparently also *Strambergella* and *Substeueroceras?* do not seem to be appreciably affected by

the extinction wave, which was probably effected by the Purbeck regression.

Particularly significant is the extreme rarity of ammonites directly above the beds containing the Grandis ammonite assemblage. At first the absence of ammonites in this, 4 m thick, interval near Miravetes was thought to be a local peculiarity, but a critical examination of the many sections published by LE HÉGARAT in his thesis (1971) reveals that, whenever the beds containing the ammonites of the Grandis assemblage are not separated by a horizon of non-deposition, erosion, or resedimentation from the beds in which the 15 newcomers (apart from *Strambergella subalpina)* of the Subalpina assemblage have been found, the latter beds are invariably separated from those containing the Grandis assemblage by a few beds from which rarely only *Str. subalpina* or some of the few species that survived the extinction wave have been reported. These boundary beds are however generally devoid of ammonites and one may ask whether they should be incorporated in the Euxina or in the Occitanica zone. The stratigraphic interval containing the peak in the concurrence of ranges is very thin and comprises mainly the upper part of the already thin Subalpina subzone (about 13 m near Miravetes, whereas the other subzones are 31 to 41 m thick).

The Occitanica zone, on the contrary, can pre-eminently be typified as a zone in which new appearance of species and genera highly predominates over extinction. This is also conspicuous from LE HÉGARAT'S range charts, though slightly obscured by the peculiar ecologic event in the Dalmasi subchron in SE France. Our investigations revealed that several of LE HÉGARAT'S ranges should be extended upward and downward into the Dalmasi subzone, through which the number of extinctions and newcomers decreases and increases respectively. In the Occitanica zone at least 54 new species and 11 new (sub)genera appear, viz. *Negreliceras* (13), *Mazenoticeras* (3), *Berriasella, Neocosmoceras, Euthymiceras, Subthurmannia, Malbosiceras* (3), *Subalpinites* (12), *Jabronella, Kilianella,* and *Pomeliceras* n. subg.

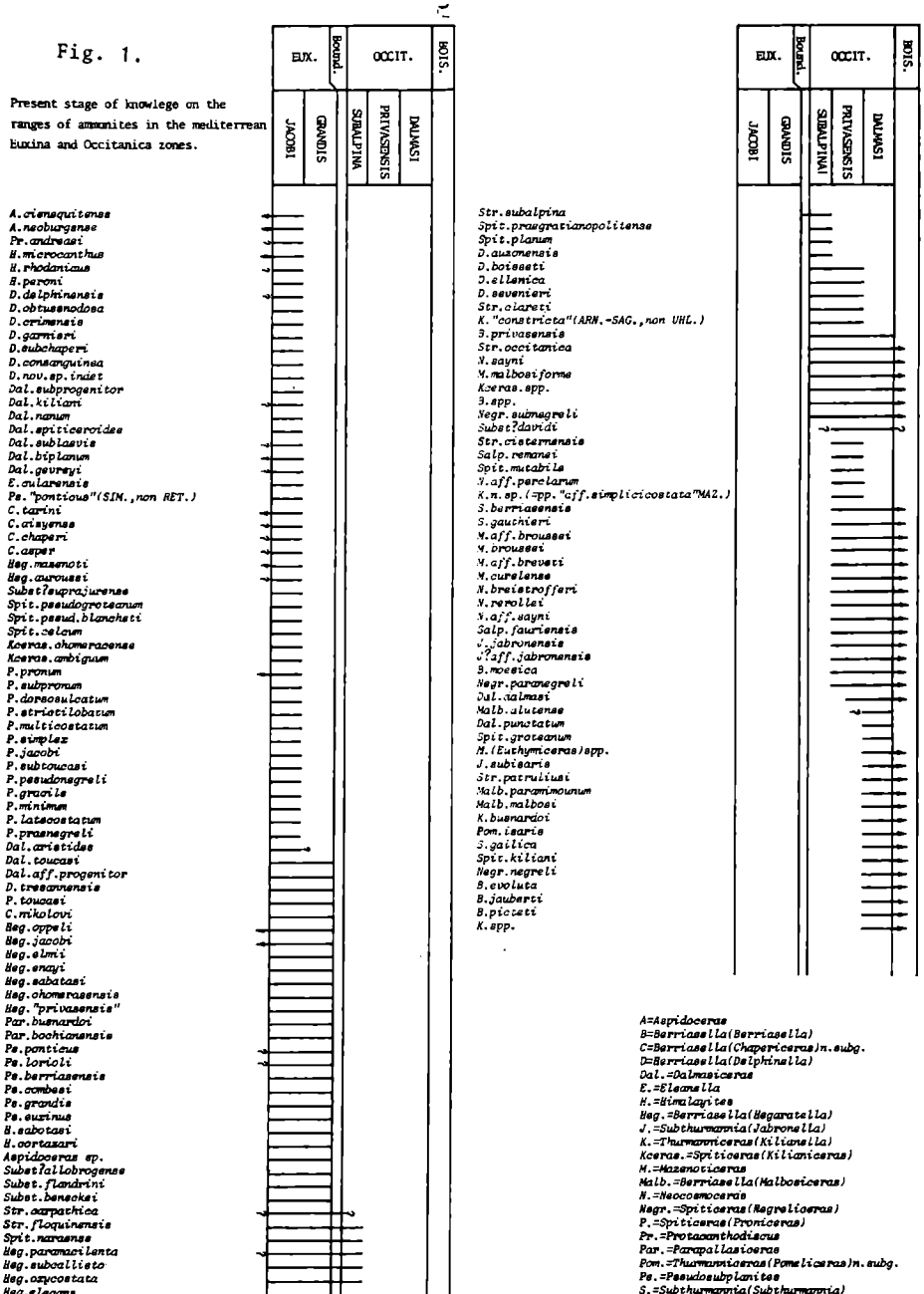
As to the generic groups inherited from the Euxina zone, *Hegaratella* rapidly made room for multifarious new generations of *Berriasella* (with its tuberculated sidebranch *Malbosiceras)* and *Kilianella* (with its tuberculated pendant *Pomeliceras); Strambergella* gradually diversified and blended into *Subthurmannia* and its tuberculated counterpart *Jabronella; Kilianiceras* and *Spiticeras* (from which *Negreliceras* and *Groebericeras* came of) became prolific and even *Delphinella* and *Dalmasiceras* (15) (which gave rise to tuberculated *Subalpinites)* managed to produce more or less successful second radiations; only *Substeueroceras?* continued apparently undisturbed with only one lineage.

An accidental but very fortunate circumstance is, that this important ceasura in the mediterranean ammonite faunas practically coincides with the base of the Calpionella elliptica zone, which ALLEMANN in ALLEMANN et al. (1975) characterizes as «one of the most important and most easily definable breaks in the calpionellid faunas». In Miravetes the last ammonites of the Euxina assemblage were found in the same bed in which ALLEMANN et al. (1975) found their first *C. elliptica* (bed 71.143 = our bed Z203); GEEL found the first *C. elliptica* one metre lower (in bed Z200). In the Cañada Lengua section (SE of Caravaca) ALLEMANN et al. (1975) found their first *C. elliptica* one metre below the bed with the last Euxina zone ammonites. In Tunisia BUSNARDO et al. (1976) also recorded the first appearance of *C. elliptica* between the ammonite associations of the Grandis subzone and the lowest association of the Occitanica zone. So this coincidence can be considered well established and provides an easy worlwide correlation of this event.

The appearance of *C. elliptica*, not far above that of *Remaniella cadischiana*, marks the on-

Fig. 1.

Present stage of knowlege on the ranges of ammonites in the mediterrean Euxina and Occitanica zones.



A=Aspidoceras
B=Berriasella(Berriasella)
C=Berriasella(Chapericeras)n.subg.
D=Berriasella(Delphinella)
Dal.=Dalmasiceras
E.=Elasmella
H.=Himalayites
Heg.=Berriasella(Hegaratella)
J.=Subthurmannia(Jabronella)
K.=Thurmanniceras(Kilianella)
Kceras.=Spiticeras(Kilianiceras)
M.=Mazenoticeras
Malb.=Berriasella(Malbosiceras)
N.=Neocosmoceras
Negr.=Spiticeras(Negreliceras)
P.=Spiticeras(Proniceras)
Pr.=Protacanthodiscus
Par.=Parapallasiceras
Pom.=Thurmanniceras(Pomeliceras)n.subg.
Ps.=Pseudosubplanites
S.=Subthurmannia(Subthurmannia)
Salp.=Dalmasiceras(Subalpinites)
Spit.=Spiticeras(Spiticeras)
Str.=Subthurmannia(Strambergella)
Subst.=Substeueroceras

set of an important change in the tintinnid faunas, which consists mainly in a marked, though gradual and fluctuating increase and decrease in the percentages of *Tintinnopsella carpathica* and *Calpionella alpina* respectively, when the percentage of *T. carpathica* constantly remains above 40% of the total number of tintinnids, one has entered zone C of REMANE (1968). This condition was reached in bed Z240 in the upper part of the Subalpina subzone near Miravetes.

In short, the boundary between the Euxina zone and the Occitanica zone is just the boundary that stratigraphers are so eager to select as a boundary between systems. In an intervention during the general discussion preliminary to the handing in of the motions concerning the stratigraphic position fo the Jurassic-Cretaceous boundary during the colloque, BARTHEL (p. 386) characterized this kind of boundary as «the philosophical principle of delimitation which considers events that caused faunal breaks». According to BARTHEL this was the only kind of boundary treated in the discussion and which apparently could not be found. Well, here it is.

Apart from the fact that this deepest minimum in the mediterranean faunal succession of perisphinctacean ammonites, at the boundary between the Euxina and Occitanica zones, coincides with the most important change in the tintinnid faunas, at the boundary between the C. alpina and C. elliptica zones, and therefore certainly is most liable to be the Jurassic-Cretaceous boundary, this boundary is also quite acceptable as the one between the Tithonian and Berriasian, because it does not obviate COQUAND'S (1869, 1870, 1875) original, pure faunistical concept of the Berriasian. On the contrary, it consolidates this concept, for COQUAND regarded the ammonite fauna described by PICTET (1868) as diagnostic for the stratigraphic interval that he later (1875, p. 686) called «Berriasian», this fauna comprises only ammonites of the Occitanica and Boissieri zones sensu LE HÉGARAT (1971).

This boundary also appears to be the least controversial limit between the Jurassic and Cretaceous systems, because all ammonites described by ZITTEL (1868) from the «Stramberger Schichten» would remain characteristic for the Tithonian, even the socalled «younger elements» of this fauna, such as *Hegaratella oppeli* (KIL.), *Pseudosubplanites lorioli* (ZITT.), *Strambergella carpathica* (ZITT and *Chapericeras chaperi* (PICT.). This would not be the case if the lower boundary of the Euxina zone woulb be the Jurassic-Cretaceous boundary.

Moreover, this boundary has the advantage that the Purbeck beds of the Jura Mountains are left in the Jurassic. For, from the marine intercalations in the upper part of these beds the ostracod *Protocythere revili* DONZE and the ammonites *Pseudosubplanites lorioli* (ZITT.) and *Richterella richteri* (ZITT.) (? = probably *P. lorioli*, with which the middle Tithonian *R. richteri* is often confounded) have been reported (ARKELL, 1956, p. 85, 88; DONZE, 1973, p. 129). The known ranges of these species do not cross the upper limit of the Euxina zone and possibly indicate the Jacobi subzone. If the lower limit of the Euxina zone would be the Jurassic-Cretaceous boundary, at least the greater part of the Purbeck beds would be transferred into the Cretaceous. DONZE (1965), LE HÉGARAT (1971), and DONZE & LE HÉGARAT (1972) have shown that in the Jura Mountain region purbeckian fresh- and brackwater conditions must have persisted into the latest Subalpina subchron, in consequence of which the base of the full marine «Marbre Bâtard» could approximately be correlated with the base of the Privasensis subzone. If the correlations of PERSOZ & REMANE (1976) are correct, this would mean that the «Inferior Oolitic Limestone» unit comprises at least the Grandis and Subalpina subzones. This correlation is not in conflict with those of DONZE and LE HÉGARAT, because this unit also contains lacustrine and

brackwater deposits alternating with more or less marine deposits.

The Berriasian has rightly been considered a stage by itself instead of a substage of the Valanginian, for it has a characteristic ammonite fauna of its own, separated from the Tithonian and Valanginian faunas by profound changes, and has almost the same thickness (193 m) as the other stages in the Lower Cretaceous sequence along the Rio Argos, so that, in view of the great monotony and uniformity of the facies of this sequence for which a nearly uniform rate of deposition may be assumed, also a comparable duration can be assumed for these stages.

CONCLUSION:

The sharpest caesura in the mediterranean faunal succession of the Tithonian-Berriasian ammonites is situated between the Euxina zone (= new name for the «Jacobi/Grandis» zone) - which is typified by the general extinction of ammonite species not compensated by newcomers - and the Occitanica zone - which is typified by the great predominance of new appearances. As this minimum exactly coincides with the most important change in the tintinnid faunas at the base of the Calpionella elliptica zone, easy worldwide correlation of this event is provided.

This boundary is therefore most acceptable as the boundary between the Jurassic and Cretaceous systems, not in the least because it does not require any redrawing of geological maps and does not obviate the original definition of the Berriasian, which remains the lowest stage of the Cretaceous System.

We highly recommend this boundary as the Jurassic-Cretaceous boundary; solution seven of the colloque was considered the only acceptable one.

PALAEONTOLOGICAL NOTES:

These notes are necessary for a better understanding of the conception of the generic groups and their stratigraphic implications mentioned in this paper. The description of the upper Tithonian, Berriasian, and lower Valanginian ammonite faunas from Miravetes will be dealt with in a forthcoming paper.

(1) The scope of *Hegaratella* NIKOLOV & SAPUNOV, 1977 (subgenus of *Berriasella* UHLIG, 1905), type species: *Berriasella paramacilenta* MAZENOT, was emended to comprise all species of the genus *Berriasella* sensu LE HÉGARAT, 1971 (including «*Picteticeras*» LE HEGARAT, 1971) that occur in the Euxina zone and lower.

(2) *Picteticeras* LE HÉGARAT, 1971, type species: *Hoplites Picteti* JACOB in KILIAN, was considered a subjective synonym of *Berriasella* sensu LE HÉGARAT (1971).

(3) In *Chapericeras* nov. subgen. (subgenus of *Berriasella* UHLIG, 1905), type species: *Ammonites Chaperi* PICTET, were grouped the species of the Euxina zone (and lower?) that LE HÉGARAT (1971) has included in *Malbosiceras* GRIGORIEVA, 1938. «*Hoplites*» *Tarini* KILIAN probably belongs to this subgenus instead of to *Mazenoticeras* LE HÉGARAT, 1971.

(4) *Protacanthodiscus* SPATH, 1923, type species: *Hoplites Andreaei* KILIAN, was restricted in the sense of LE HÉGARAT (1971).

(5) To *Substeueroceras* SPATH, 1923, type species: *Odontoceras Koeneni* STEUER, were assigned *Hoplites Beneckei* JACOB and *Pseudargentiniceras flandrini* LE HEGARAT. The probably related group of *Neocomites suprajurensis* MAZENOT, *N. allobrogensis* MAZENOT, *Tirnovella davidi* LE HÉGARAT and «*Neocomites neocomiensis* variété plate à côtes fines et fasciculées» in SAYN, 1907, is provisionally referred to as *Substeueroceras?*

(6) *Fauriella* NIKOLOV, 1966, type species: *Berriasella gallica* MAZENOT, was considered a subjective synonym of *Subthurmannia* SPATH, 1939, type species: *S. fermori* SPATH.

(7) In *Strambergella* NIKOLOV, 1966 (subgenus of *Subthurmannia* SPATH, 1939), type species: *Ammonites carpathicus* ZITTEL, were included those species of *Subthurmannia* in which fasciculation of ribs appears rela-

tively late in the ontogeny, such as *Fauriella «shipkovgnsis»* LE HÉGARAT (non NIKOLOV & MANDOV), *F. floquinensis* LE HÉGARAT, *F. clareti* LE HÉGARAT, *Neocomites cabrensis* FALLOT, *N. subalpinus* MAZENOT and its descendant *Ammonites occitanicus* PICTET, *Jabronella cisternensis* LE HÉGARAT, and *J. patruliusi* LE HÉGARAT.

(8) The scope of *Tirnovella* NIKOLOV, 1966 (subgenus of *Subthurmannia* SPATH, 1939), type species: *Berriasella alpillensis* MAZENOT, as conceived in this paper, differs radically from that of LE HÉGARAT (1971) and comprises the species of the *«Thurmanniceras» pertransiens* group, but also *«Th.» gratianopolitense* SAYN, *«Th.» allobrogicum* (KILIAN), *«Th. thurmanni* var. à large ombilic» in SAYN, 1907 (pi. 5, fig. 5), and *Tirnovella donzei* LE HÉGARAT.

(9) *Pomeliceras* nov. subgen. (subgenus of *Thurmanniceras* COSSMANN, 1901), type species: *Hoplites Paquieri* SIMIONESCU, comprises at least *P. isare* (POMEL), *P. zianidia* (POMEL), *P. balcania* (NIKOLOV), and *P. michaele* (UHLIG).

(10) In *Jabronella* NIKOLOV, 1966 (subgenus of *Subthurmannia* SPATH, 1939), type species: *Berriasella jabronensis* MAZENOT, were left only *J. subisaris* (MAZENOT) and *J. discrepans* (RETOWSKI) (= *Protacanthodiscus troiani* NIKOLOV & MANDOV).

(11) The subgenus *Thurmanniceras (Thurmanniceras)* COSSMANN, 1901, was restricted to its type species *Ammonites Thurmanni* PICTET & CAMPICHE and the species *Th. otopetum* THIEULOY, *Th. kingi* UHLIG, *Th. salientinum* SAYN, *Th. loryi* SAYN (pro var.), and *Th.* n. sp. aff. *thurmanni*.

12. *«Hoplites» aristides* KILIAN of the Jacobi subzone was considered a *Dalmasiceras* DJANELIDZE, 1921 instead of a *Subalpinites* MAZENOT, 1939.

13. *«Negreliceras» praenegreli* DJANELIDZE of the Jacobi subzone was considerer a *Proniceras* BUCKHARDT, 1919.

(14) The systematic position of *Ammonites Nieri* PICTET remains unknown, but should be discarded from *Himalayites* UHLIG, 1904.

(15) *«Dalmasiceras» panini* LE HÉGARAT of the Picteti subzone was considered a *Berriasella* UHLIG, 1905.

REFERENCES

ALLEMANN, F.; CATALANO, R.; FARES, F. and REMANE, J. (1971). Standard calpionellid zonation (Upper Tithonian-Valanginian) of the mediterranean province. *Proc. II. Planktonic Conference*, Roma (1971), págs. 1.337-1.340.

ALLEMANN, F.: GRUN, W. and WIEDMANN, J. (1975). The Berriasian of Caravaca (Prov. of Murcia) in the subbetic zones of Spain and its importance for defining the stage and the Jurassic-Cretaceous boundary. In: Colloque sur la limite Jurassique-Cretácé (1973) *Mem. Bur. Rech. Geol. Min.*, vol. 86, págs. 14-22.

ARKELL, W. J. (1956). Jurassic geology of the world. Oliver and Boyd Ltd., Edinburg., London. I-XV, 1-806, pl. 1-46.

BADALUTA, A. (1975). Biostratigraphie des formations du Tithonique-Valanginien et la limite Jurassique-Crétacé dans le Banat occidental (Roumanie). In: Colloque sur la limite Jurassique-Crétacé (1973). *Mém. Bur. Rech. Geol. Min.*, vol. 86, págs. 23-28.

BARTHEL, K. W.; CEDIEL, F.: GEYER, O. F. and REMANE, J. (1966). Der subbetische Jura con Cehegín (Provinz Murcia, Spanien). *Mitt. Bayer. Staatssamml. Paläont. Hist. Geol.*, vol. 6, págs. 167-211.

BUSNARDO, R.; DONZE, P.; LE HEGARAT G.; MEMMI, L. and M'RABET, A. (1976). Précisions biostratigraphiques nouvelles sur le Berriasien des Djebel Nara et Sidi Kralif (Tunisie centrale). *Geobios*, vol. 9, 3, págs. 231-250.

COLLOQUE SUR LA LIMITE JURASSIQUE-CRETACE (1975). VII. Discussions sur la position de la limite Jurassique-Crétacé. VIII. Discussión générale préliminaire au dépôt des motions. *Mém. Bur. Rech. Geol. Min.*, vol. 86, págs. 379-393.

COLLOQUE SUR LE CRETACE INFERIEUR (1965). Conclusions générales du colloque, *Mem. Bur. Rech. Geol. Min.*, vol. 34, págs. 827-834.

COQUAND, H. (1869). Note sur les assises qui, dans le Bouches-du-Rhône sont placées entre l'oxfordien supérieur et l'étage valanginien (base du terrain crétacé). *Bull. Soc. Geol. France*. (2), vol. 26, págs. 100-131.

COQUAND, H. (1870). Nouvelles considérations sur les calcaires jurassiques à Diceras du Midi de la France, en réponse à la note de M. Hébert du 9 novembre 1868. *Bull. Soc. Geol. France* (2), vol. 27, págs. 73-106.

COQUAND, H. (1875). Note sur les calcaires coralliens à

Terebratula Repelliniana de la Basse-Provence et du Languedoc. *Bull. Soc. Geol. France*, (3), vol. 3, págs. 670-686.

DESOR, E. (1854). Quelques mots sur l'étage inférieur du groupe neocomien (Etage valanginien). *Bull. Soc. Neuchatel. Sci. Nat.*, vol. 3, págs. 172-177.

DONZE, P. (1965). Les ostracodes du Berriasien inférieur dans les massifs subalpines des Bauges et de la Chatreuse. *Mém. Bur. Rech. Geol. Min.*, vol. 34, págs. 547-548.

DONZE, P. (1973). Coupe B. I-1: «Purbeckien» de la cluse de chailles. In: Livret-Guide des excursions, Colloque sur la limite Jurassique-Crétacé. *Documents. Lab. Geol. Fac. Sc. Lyon*, Hors série 1: págs. 126-130.

DONZE, P. (1975). Repartition stratigraphique du genre Protocythere TRIEBEL, 1938, et de quelques formes affines dans le Berriasien - Valanginien inférieur du Sud-Est de la France. Considerations paléogéographiques. In: Colloque sur la limite Jurassique-Crétacé (1973). *Mém. Bur. Rech. Geol. Min.*, vol. 86, págs. 182-187.

DRUSHCHITS, V. V. (1975). The Berriasian of the Crimea and its stratigraphic relations. In: Colloque sur la limite Jurassique-Crétacé (1973). *Mém. Bur. Rech. Geol. Min.*, vol. 86, págs. 337-341.

ENAY, R. and GEYSSANT, J. R. (1975). Faunes tithoniques des chaînes bétiques (Espagne méridionale). In: Colloque sur la limite Jurassique-Crétace (1973). *Mém. Bur. Rech. Geol. Min.*, vol. 86, págs. 39-55.

GEEL, T. (1966). Biostratigraphy of the Upper Jurassic and Cretaceous sediments near Caravaca (SE Spain) with special emphasis on Tintinnida and Nannoconus. *Geol. & Mijnb.*, vol. 45, págs. 391-397.

GRUN, W. and ALLEMANN, F. (1975). The Lower Cretaceous of Caravaca (Spain). Berriasian calcareous nannoplankton of the Miravetes section (Subbetic zone, Prov. of Murcia). *Ecl. Geol. Helv.*, vol. 69, págs. 147-211.

HEGARAT, G. LE (1971). Le Berriasien du sud-est de la France. *Docum. Lab. Geol. Fac. Sc. Lyon*, 43, fasc. 1: 1-308, pls. 1-53; fasc. 2: 309-576, pls. 1-40.

HEGARAT, G. LE, and REMANE, J. (1968). Tithonique supérieur et Berriasien de l'Ardèche et de l'Hérault. Corrélation des ammonites et des calpionelles. *Geobios*, vol. 1, págs. 7-69.

KILIAN, W. (1895). Notice stratigraphique sur les environs de Sisteron et contributions à la connaissance des terrains secondaires du sud-est de la France. *Bull. Soc. Geol. France.*, (3), vol. 23, págs. 659-803.

KILIAN, W. (1907). Allgemeines über Palaeocretacicum; Unterkreide im südöstlichen Frankreich, Einleitung. In: Frech, F. *Lethaea geognostica*, II. Teil. Das Mesozoicum, 3. Bad. Kreide. Erste Abteilung: Unterkreide (Palaeocretacioum). Erste Lieferung: 1-168.

KILIAN, W. (1910). Das bathyale Palaeocretacicum im südöstlichen Frankreich. Valendis-Stufe; Barrême-Stufe; Apt-Stufe. *Ibidem*. Zóeite Lieferung, págs. 169-287.

MAZENOT, G. (1939). Les Palaeohoplitidae tithoniques et berriasiens du sud-est de la France. *Mém. Soc. Geol. France.*, NS, vol. 41, págs. 5-303.

MEMMI, L. and SALAJ, J. (1975). Le Berriasien de Tunisie. Succession de faunes d'ammonites, de foraminifères et de tintinnoïdiens. In: Colloque sur la limite Jurassique-Crétacé (1973). *Mém. Bur. Rech. Géol. Min.*, vol. 86, págs. 58-67.

OPPEL, A. (1865). Die tithonische Etage. Zeitschr. deutsch. *Geol. Gesellech.*, vol. 17, págs. 535-558.

PATRULIUS, D.; NEAGU, T.; AVRAM, E. and POP, G. I. (1976). The Jurassic-Cretaceous boundary beds in Romania. *Anuarul Inst. Geol. Geofiz.*, vol. 50, págs. 71-125.

PERSOZ, F. and REMANE, J. (1976). Minéralogie et géochimie des formations à la limite Jurassique-Crétacé dans le Jura et le bassin vocontien. *Ecl. Geol. Helv.*, vol. 69, págs. 1-38.

PICTET, F. J. (1867). Etudes paléontologiques sur la faune à Terebratula diphyoides de Berrias (Ardèche). *Mém. Soc. Phys. Hist. Nat.* Gènève, 7, Mélanges Paléontologiques, vol. 2, págs. 43-130.

SEYFRIED, H. (1979). Der subbetische Jura von Murcia (Südost-Spanien). *Geol. Jahrb.* B., vol. 29, págs. 3-204.

THIERSTEIN, H. R. (1975). Calcareous nannoplankton biostratigraphy at the Jurassic-Cretaceous boundary. In: Colloque sur la limite Jurassique-Crétacé (1973). *Mém. Bur. Rech. Géol. Min.*, vol. 86, págs. 84-94.

VEEN, G. W. (1966). Note on a Jurassic-Cretaceous section in the Subbetic SW of Caravaca (Prov. Murcia, Spain). *Geol. & Mijnb.*, vol. 45, 11, págs. 391-397.

VEEN, G. W. (1969). Geological investigations in the region of Caravaca, south-eastern Spain. *Thesis*, University of Amsterdam. 7, 143 págs.

WIEDMANN, J. (1975). The Jurassic-Cretaceous boundary as one of the Mesozoic system boundaries. In: Colloque sur la limite Jurassique-Crétacé. *Mém. Bur. Rech. Géol. Min.*, vol. 86, págs. 358-362.

YEGOYAN, V. L. (1975). Tithonian and Berriasian boundary is the boundary between the Jurassic and the Cretaceous Systems. In: Colloque sur la limite Jurassique-Crétacé. *Mém. Bur. Rech. Géol. Min.*, vol. 86, págs. 363-369.

ZITTEL, K. A. (1868). Die Cephalopoden der Stramberger Schichten. *Paleont. Mitth. Mus. königl. hayer. Staates*, Stuttgart, 1: I-VIII, 1-118, 24 pls.