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Calcareous Plankton in the Tortonian/Messinian Transition Series of the Northwestern Edge of the Guadalquivir Basin

By JOSÉ-ABEL FLORES & FRANCISCO-JAVIER SIERRO*)

With 15 Figures

Spain
Guadalquivir Basin
Tortonian–Messinian
Calcareous nannoplankton
Planktonic foraminifera

Contents

Zusammenfassung

Diese Arbeit vergleicht die kalkigen Nannoplanktonvergesellschaftungen mit den wichtigsten „Events“ in der planktonischen Foraminiferenfauna des NW-Randes des Guadalquivir-Beckens. Folgende Profile wurden untersucht: Guillena, Cantillana – Arroyo Trujille, Beas – Trigueros, Gibraleón, Arroyo Galapagar und Carmona. Die beiden letztgenannten Profile wurden von PERCONIG (1966, 1974) als Stratotypen des Andalusiens definiert.

Die quantitative Verteilung der kalkigen Nannoplanktonarten wurde ermittelt und die Resultate in zwei Abbildungen für jedes Profil dargestellt. Anstatt der üblichen stratigraphischen Begebenheiten wie dem ersten Auftreten von *E. quinqueramus* und *A. primus* werden hier das erste regelmäßige Auftreten von *E. berggrenii* und das erste Auftreten der Gattung *Amaurolithus* für die Korrelation verwendet. Dem totalen Verschwinden von *E. quinqueramus*, das in DSDP Sites, jedoch nicht in den aufgeschlossenen Profilen beobachtet wurde, geht ein deutlicher Häufigkeitsabfall voraus. Weiters wurden folgende Inversionen der Häufigkeitsverhältnisse beobachtet und für die Korrelation verwendet: *R. haqii/R. minutula* vs. „kleine Placolithen“, *G. jafarii* vs. *G. rotula* und *C. pelagicus* vs. *D. antarcticus*. Diese Inversionen werden als Ergebnis einer Abkühlung der Wassermassen interpretiert. Das erste und das letzte Auftreten von *E. berggrenii, E. quinqueramus, Amaurolithus* und *T. rugosus* scheinen hingegen von bathymetrischen Parametern kontrolliert zu werden.

Die Torton/Messiniano-Grenze, wie sie anhand von planktonischen Foraminiferen definiert wurde, liegt nur wenig über dem ersten Auftreten von *Amaurolithus*.

Abstract

The present work compares the assemblages of calcareous nannoplankton to the principal events recorded in the fauna of planktonic foraminifera in six sections situated on the northwestern edge of the Guadalquivir Basin, SW-Spain. The sections chosen were: Guillena, Cantillana – Arroyo Trujillo, Beas – Trigueros, Gibraleón, Arroyo Galapagar and Carmona. In the latter two sections PERCONIG (1966, 1974) defined the Andalusian stratotype.

For the study of the calcareous nannoplankton a series of quantifications were conducted on the same reference pattern, thus elaborating two types of plots for each section and hence obtaining information regarding the relative variation of each of the species composing a series and also with respect to the absolute variations of the groups which were considered to be significant , as in the case of asteroliths, several "groups" and species of "Reticulofenestrids" (these are discussed in a chapter on taxonomy) and others.

The biostratigraphical model developed for the calcareous nannoplankton establishes as events which should be taken into account the first regular record of *Eudiscoaster berggrenii* and the first record of the genus *Amaurolithus*. The conventional biostratigraphic scales are not employed because the boundaries used, even though they are similar to some of these scales, cannot be fitted perfectly to those examined in this study.

Together with these events, others hitherto not used are determined; this is the case of the abrupt inversion of the dominance of the *Reticulofenestra haqii/R. minutula* "group" over that of the "small placoliths", an event which in turn was accompanied by the inversion of the dominance of *Geminilithella jafarii* over *G. rotula* and of *Coccolithus pelagicus* over *Dictyococcites antarcticus* which can also be used as references.

Furthermore it is shown that in the interval prior to the inversion in the dominance of the *R. haqii/R. minutula* "group" over the small placoliths relatively warmer conditions than in the upper level existed in the water masses. The disappearance and first record of *E. berggrenii, E. quinqueramus*, together with that of *Amaurolithus* und *Triquetrorhabdulus rugosus* seem to be mainly controlled by bathymetric parameters.

With the joint use of calcareous nannoplankton and planktonic foraminifera the Tortonian/Messinian boundary falls slightly above the first record of *Amaurolithus*.

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*) Author's address: JOSÉ-ABEL FLORES, FRANCISCO-JAVIER SIERRO, Departamento de Paleontologia, Facultad de Ciencias, Universidad de Salamanca, 37008 Salamanca, Spain.

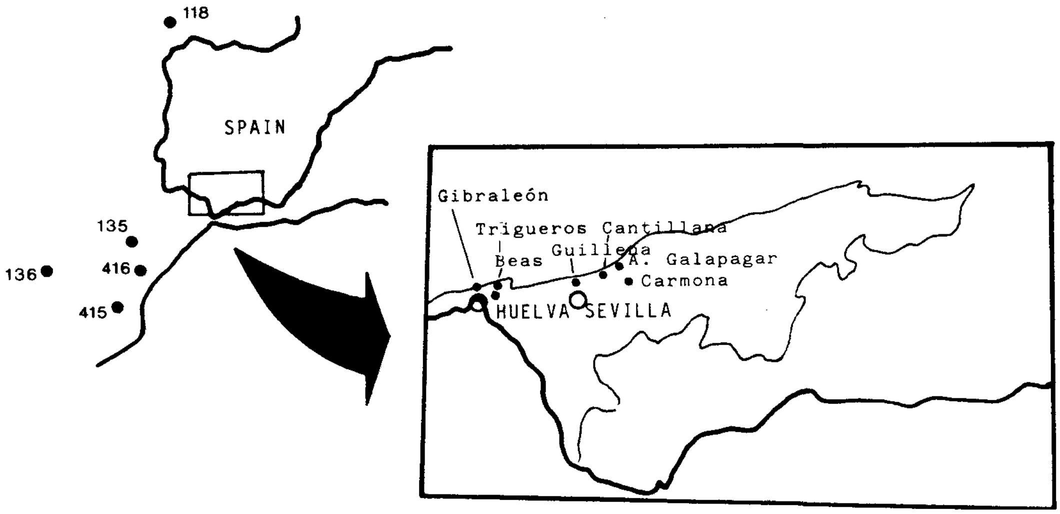


Fig. 1: Geographical location of the DSDP Sites and of the sections studied.

1. Introduction

The study area is situated on the NW edge of the Guadalquivir basin in the provinces of Huelva and Sevilla, Spain (Fig. 1). Here the sedimentation during the Neogene comprised an upper Tortonian – lower Pliocene interval but in this paper we shall mainly refer to the sections in which the Tortonian/Messinian boundary can be determined. The following sections were chosen: Gibraleón, Cantillana, Beas – Trigueros, Arroyo Galapagar, Guillena and Carmona. The latter has been included in view of the interest in presenting the complete section defined as the stratotype of the Andalusian.

For the defined area the following papers issued after the definition of the Andalusian stratotype by PERCONIG (1966, revised in 1971) are referred to: MARTINI (1971), BERGGREN & HAQ (1973), BOSSIO et al. (1977), BENSON (1976), BERGGREN & VAN COUVERING (1975), CRESCENTI et al. (1973), SIERRO (1985) and SIERRO et al. (1985).

2. Techniques and Methods

Following FLORES (1985) two kinds of analyses were carried out with the light microscope using a magnification of 1,250. Observations were performed on slides prepared with a constant volume of suspension and a constant observation area.

The first step was to perform a routine scanning operation for the determination of the components of the assemblage; at the same time approximations to the relative abundance were performed (Fig. 2); to do so, between 15,000 and 20,000 specimens (= nannoliths) were handled. The aim of this was to obtain information regarding those taxons whose recorded frequency was situated between 0.01 % and 0.005 %. Groups of taxons or morphotypes with a representation greater than 0.1–0.5 % are considered to be dominant and were quantified. The number of individuals (= nannoliths) counted in each sample ranged between 200 and 600, the number varying as a function of the minimum frequency of the elements considered. In the same way, counts of the presumably "autochthonous asteroliths" were performed, starting out from a number between 200 and 2,500 individuals.

The scanning electron microscope was only used to obtain precise informations on the morphology of the specimens and to determine their conservation status.

3. Etching and Overgrowth

Analyses were made of the preservation status of the nannoliths, taking into account both the forms which were considered to be easy to dissolve and those which were believed to be resistant. An appreciative scale was employed based essentially on the works of BUKRY (1973), ROTH & THIERSTEIN (1972), ROTH (1973) and BUKRY et al. (1973) as well as on observations by the author (FLORES, 1985).

With the joint use of the data obtained from the counts and conservation status, together with sedimentary characteristics taken from the column, our aim was to obtain a scheme in which each of the samples would be comparable in absolute terms, thus allowing us to mark the pertinent differences and similarities for later interpretations.

4. Resedimentation

In each of the samples studied a count was made of the "evidently resedimented" individuals whose chronostratigraphic distribution did not coincide with the age of the sediments in which they were found. To do so, as a function of the regularity of appearance of such individuals, between 200 and 2,500 nannoliths were counted depending on their frequency of between 5–6 % and 0.04 %.

5. Taxonomic Notes

Our studies focus on the "Reticulofenestrids". Essentially, with these taxons the differentiation protocol

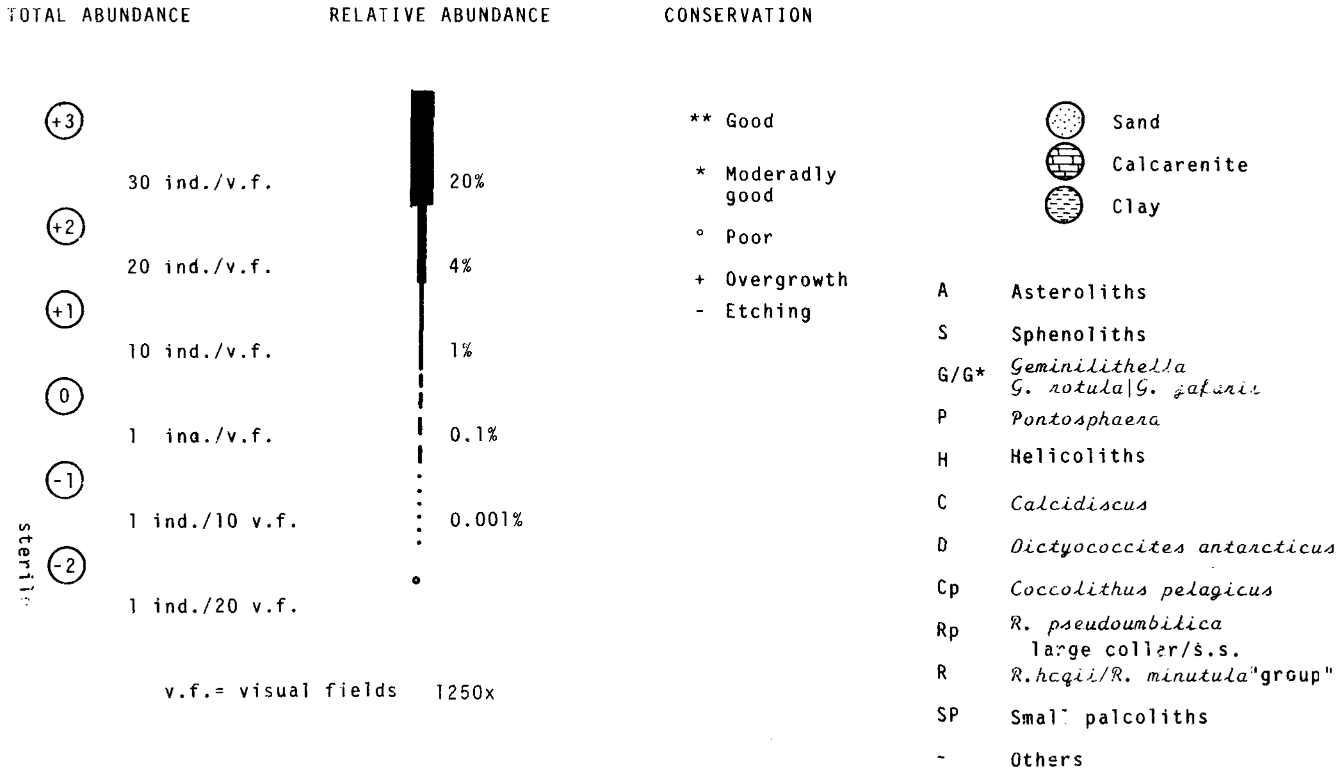


Fig. 2: Legend for figures 3 to 15. Between 15,000 and 20,000 specimens of each sample were analyzed.

proposed by BACKMAN (1980) using biometric and morphological data (s.l.) was employed. Accordingly, it is possible to distinguish between *Dictyococcites* and *Reticulofenestra* as a function of whether they possess a closed or open central area. In turn, as a function of size and/or relative surface occupied by the collar of the central area (or having it open), the following were differentiated: *D. antarcticus* more than 3.5–4 μm) and *R. pseudoumbilica* (more than 5 μm, including the morphotype „*R. gelida*"), *R. minutula* and *R. haqii* (more than 3.5–5 μm, with the central area more or less open) and *D. productus* and *R. minuta* (less than 3.0–3.5 μm).

Though often differentiation is possible, working with the light microscope sometimes makes it difficult to distinguish between two taxons; therefore all specimens smaller than 3–3.5μ were labelled "small placoliths". *R. haqii/R. minutula* form another "group" with the name of both taxons. This differentiation is essentially due to the differences observed regarding the existing distributions, compared with those recorded in other taxons or morphotypes. The fact that all the intermediate cases are recognized, from completely open forms to those possessing a closed central area, and in all sizes, leads us to question their true biological identity as species. For the moment we are unable to propose another solution. However, it is possible to infer that to a large extent such differences have something to do with environmental variations.

6. General Lithological Sequence

The stratigraphical succession defined in the area is generally uniform, though the overall scheme may vary locally.

Neogene calcarenitic deposits, accompanied by abundant organic fragments usually lie directly over Paleozoic layers. The second unit comprises medium- to fine-grained sand with occasional layers of silt and/or clay, together with lenticular accumulations of molluscs. Abruptly or progressively there is a change to clays which include greater portions of sandy material towards the top. A transgressive cycle is visible from the bottom to the first few metres of clays and is followed by a regressive cycle. The absolute abundance of nannoplankton together with the variations in the planktonic/benthic foraminifera ratio (SIERRO, 1984) are consistent with this interpretation.

The Beas – Trigueros section is more litoral than the other sections due to its situation closer to the edge of the basin.

7. Events Defined with Calcareous Nannoplankton

The following events are considered for the Guadalquivir basin and nearby DSDP sites:

- The start of a regular record of *Eudiscoaster berggrenii*.
- The first record of *Amaurolithus*.

Others, similar to those employed on other occasions in classic biozones by BUKRY (1973, 1975), OKADA & BUKRY (1980), ROTH (1973), MAZZEI et al. (1979), MAZZEI (1977) will be added to these.

8. Analysis of the Sections

The first event defined with the calcareous nannoplankton seems to be visible in the basal sand unit of

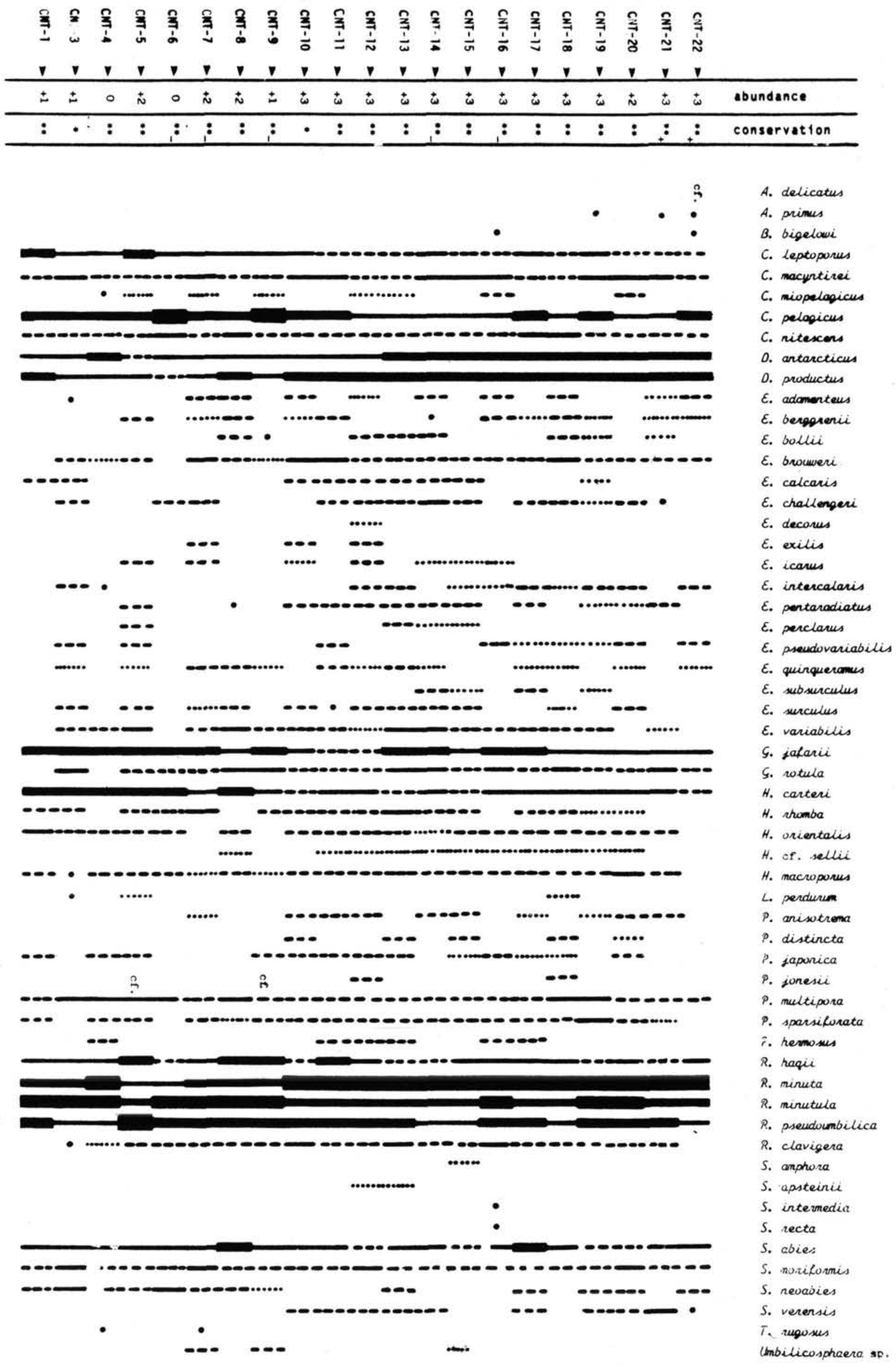


Fig. 3: Abundance, conservation and relative abundance of species in the Cantillana – Arroyo Trujillo section.

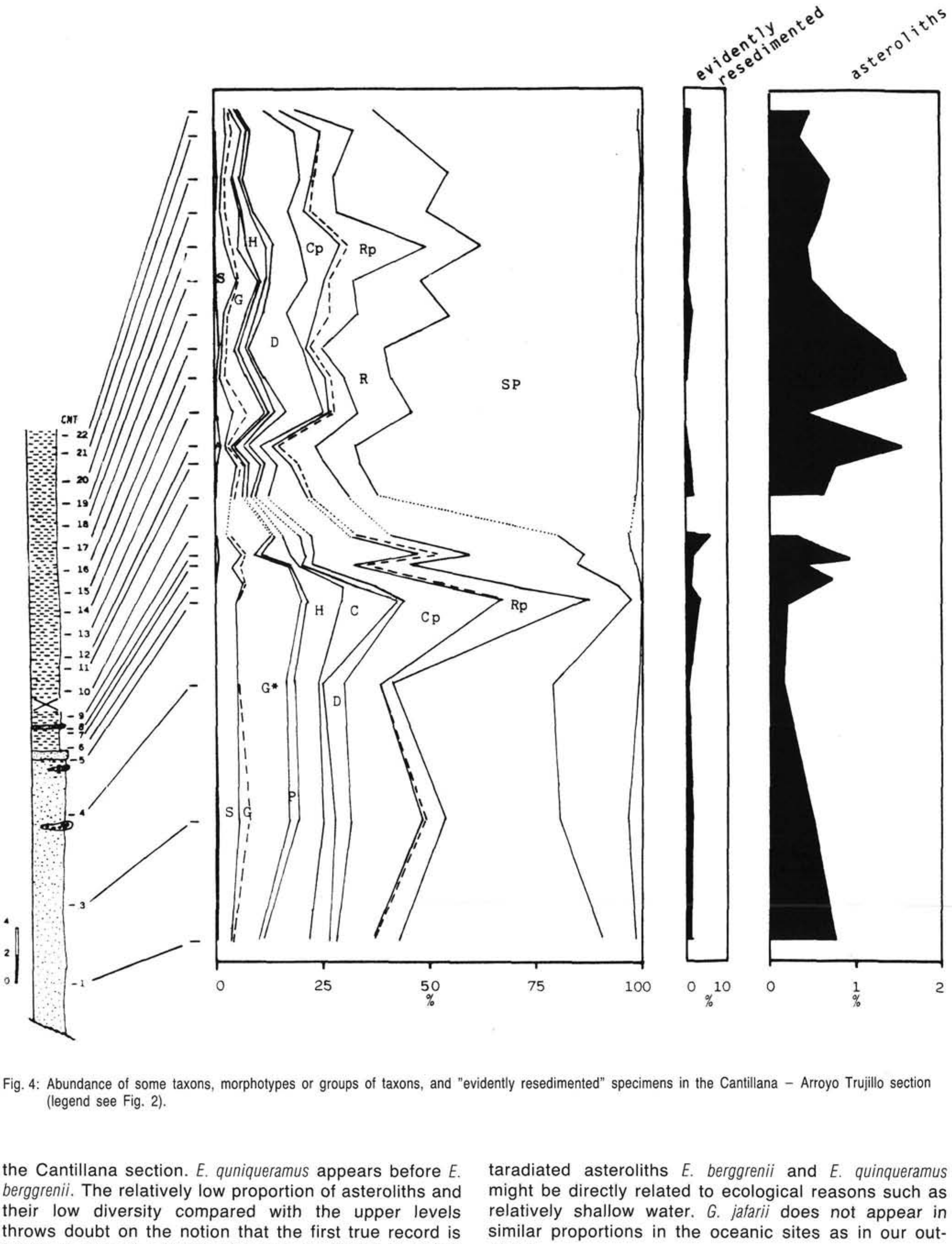


Fig. 4: Abundance of some taxons, morphotypes or groups of taxons, and "evidently resedimented" specimens in the Cantillana – Arroyo Trujillo section (legend see Fig. 2).

the Cantillana section. *E. quniqueramus* appears before *E. berggrenii*. The relatively low proportion of asteroliths and their low diversity compared with the upper levels throws doubt on the notion that the first true record is found at that site. Studies by FLORES (1985) in DSDP Site 135 (Core 3, Sections 1 and 2) and Site 415 (Core 2) show a clearly different assemblage of asteroliths and irregular occurrences of the two species below where one would expect to find them. We do not exclude the possibility that the absence of the pentaradiated asteroliths *E. berggrenii* and *E. quinqueramus* might be directly related to ecological reasons such as relatively shallow water. *G. jafarii* does not appear in similar proportions in the oceanic sites as in our outcrops.

Once the continuous presence of *E. berggrenii* and *E. quinqeramus* has been established and prior to the appearance of *Amaurolithus* an interval is found in which the plankton shows the following characteristics: The dominance of the *R. haqii/R. minutula* group over the "small

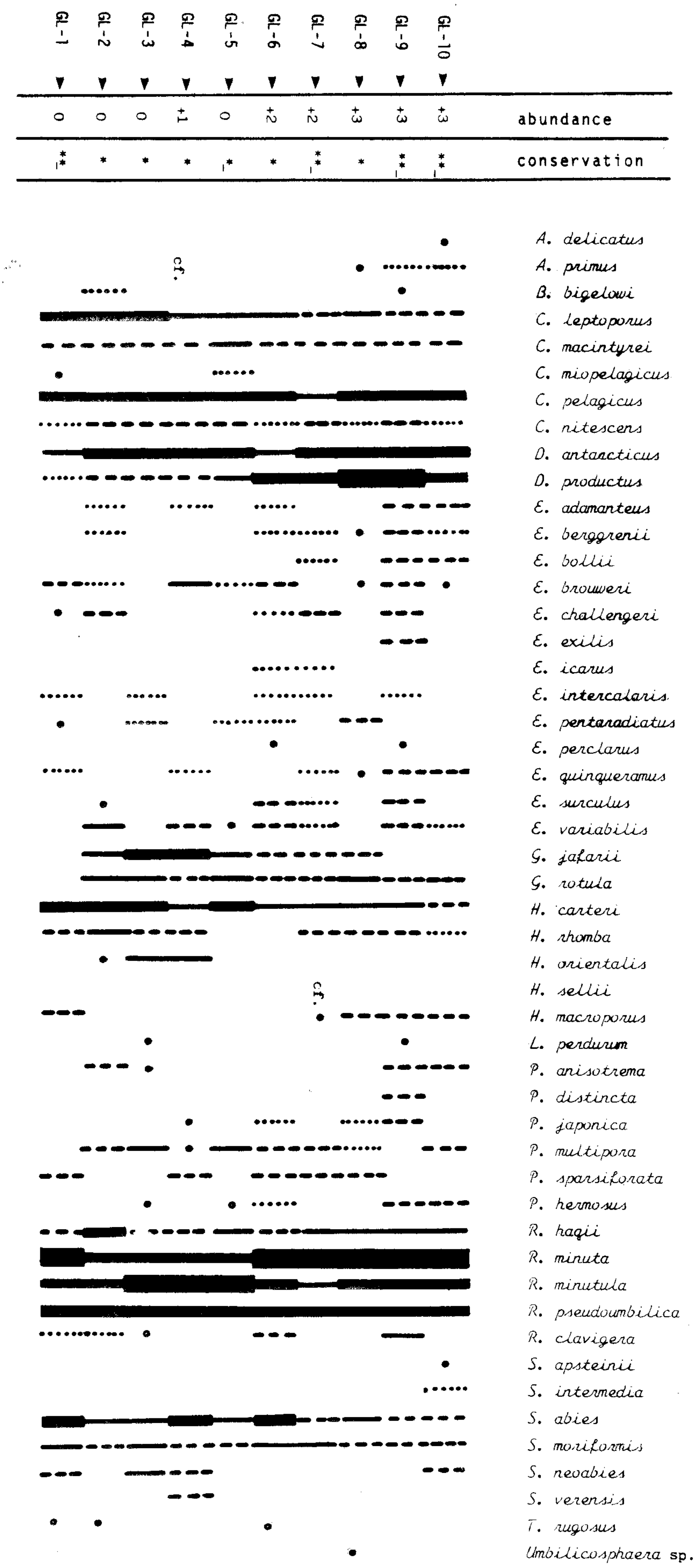


Fig. 5: Abundance, conservation and relative abundance of species in the Guillena section.

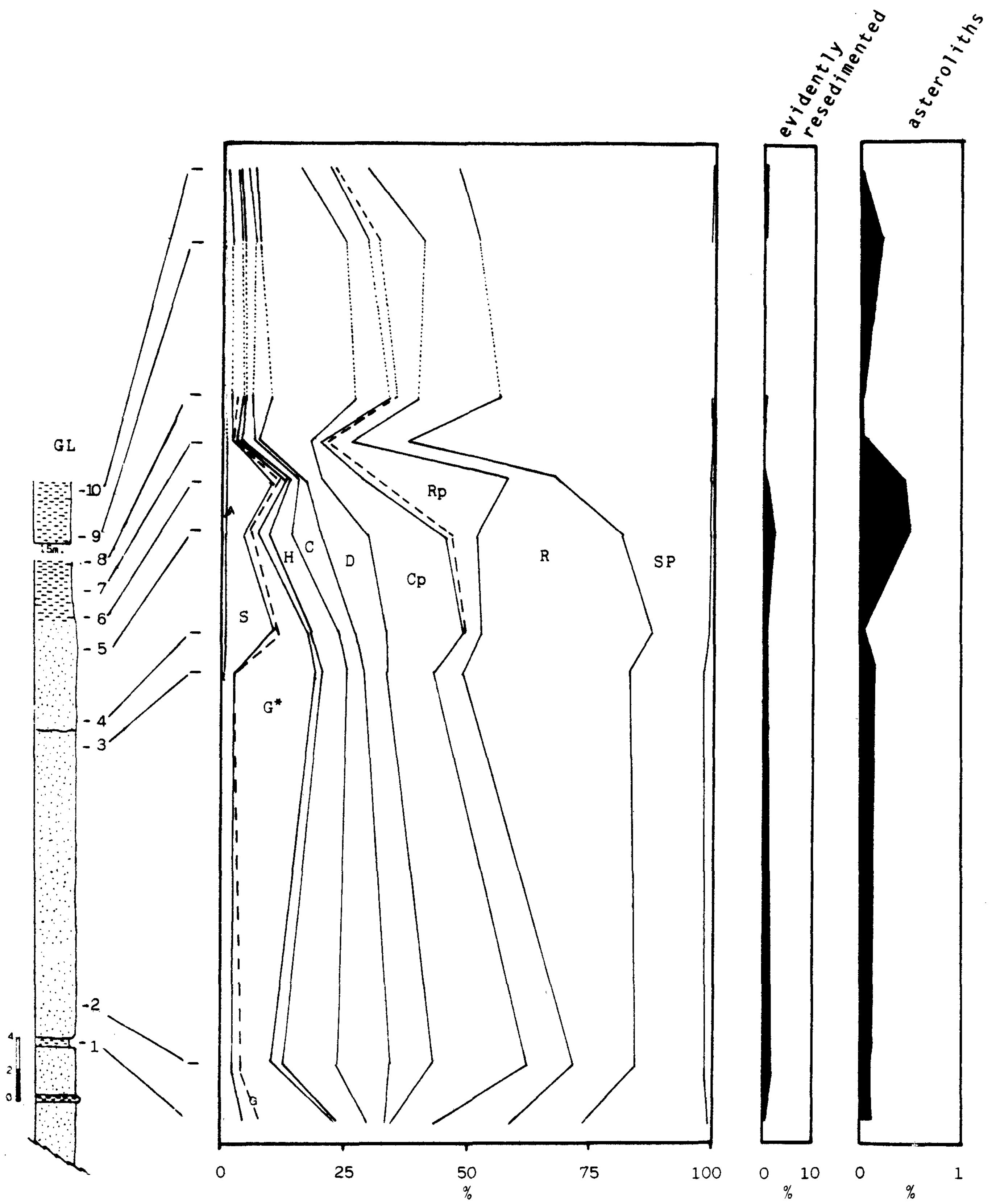


Fig. 6: Abundance of some taxons, morphotypes or groups of taxons, and "evidently resedimented" specimens in the Guillena section (legend see Fig. 2).

placoliths" is outstanding until a point very close to the upper limit. The relative abundances of *G. jafarii* and *G. rotula*, *C. pelagicus* and *D. antarcticus* are inverted from the point referred to. The helicoliths start to decrease in absolute terms (Figs. 3–14).

This event prior to the first record of *Amaurolithus* took place at approximately the same time as the events defined by SIERRO (1985) as 1 and 2 which correspond to

1) the abrupt disappearance of group 1 of *"Globorotalia menardii"* (sinistral)
   and

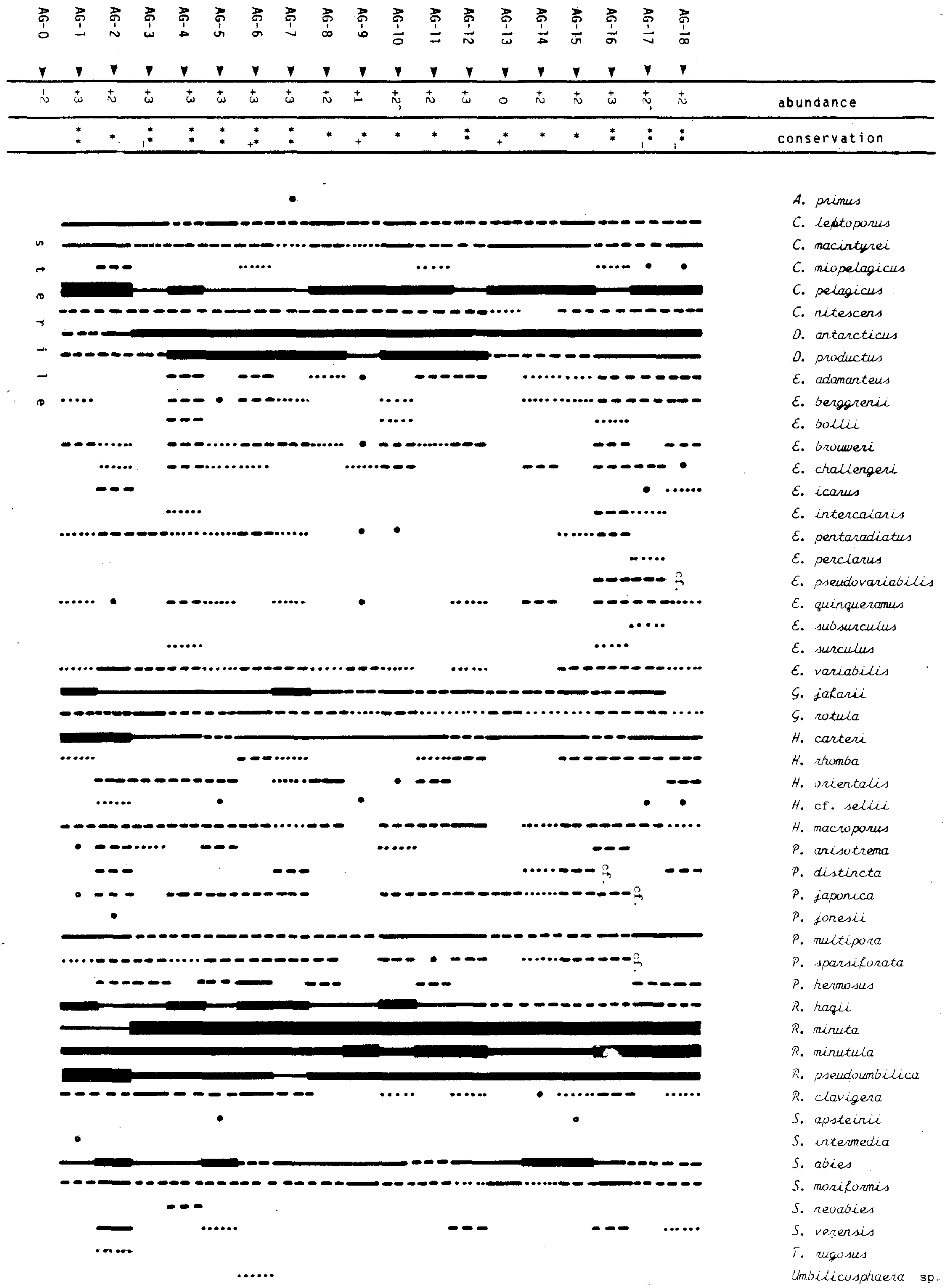


Fig. 7: Abundance, conservation and relative abundance of species in the Arroyo Galapagar section.

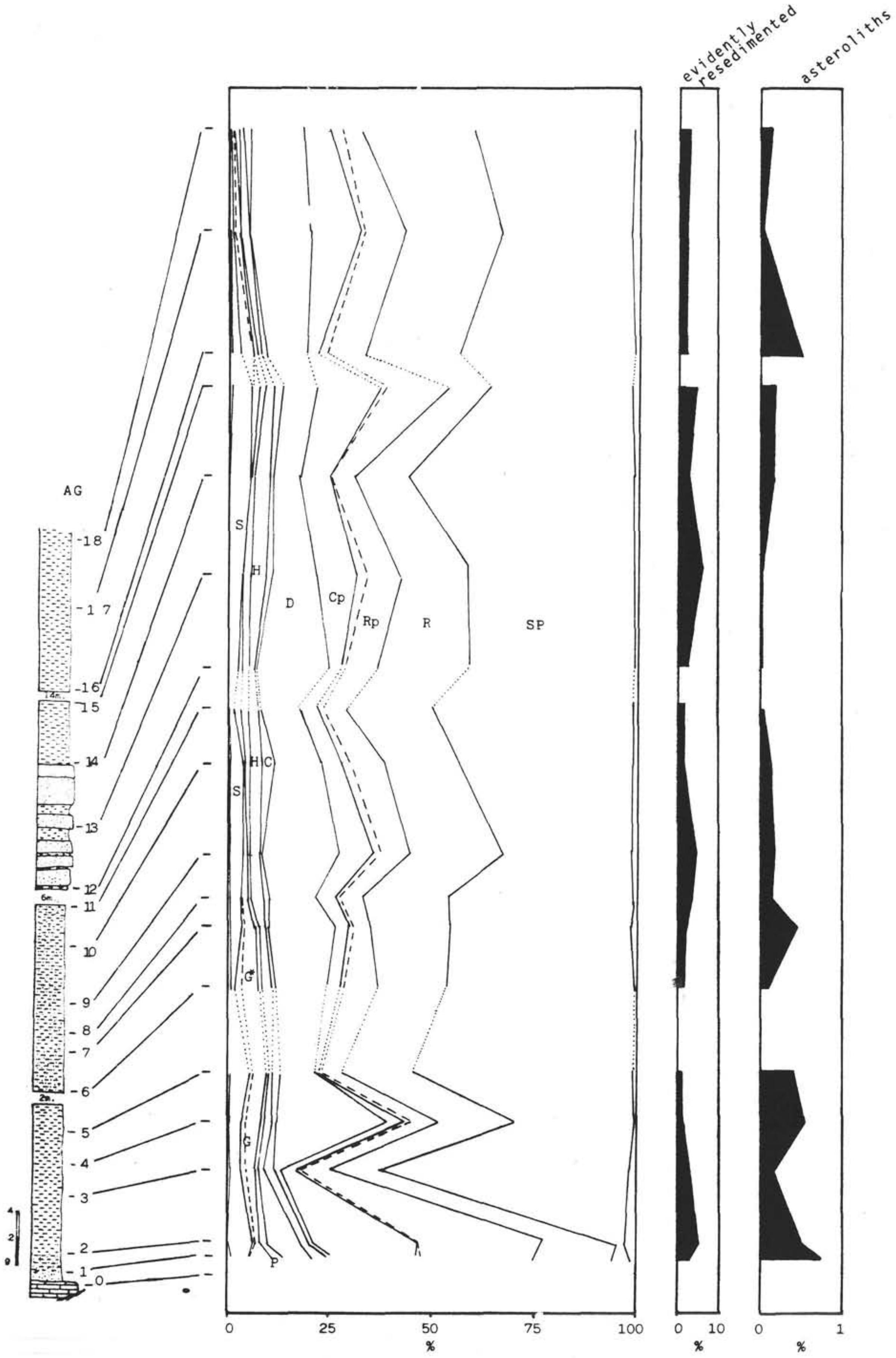


Fig. 8: Abundance of some taxons, morphotypes or groups of taxons, and "evidently resedimented" specimens in the Arroyo Galapagar section (legend see Fig. 2).

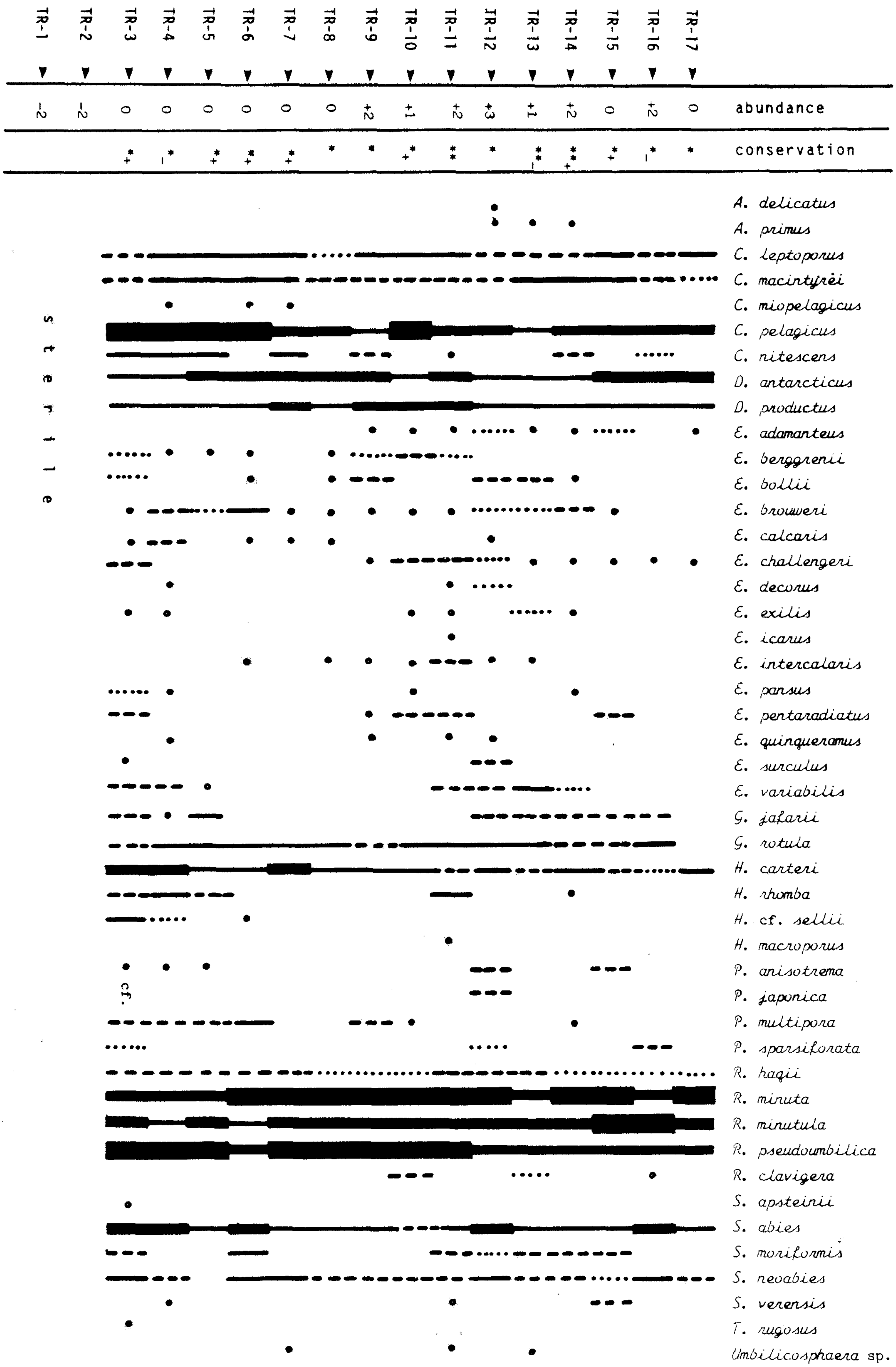


Fig. 9: Abundance, conservation and relative abundance of species in the Beas-Trigueros section.

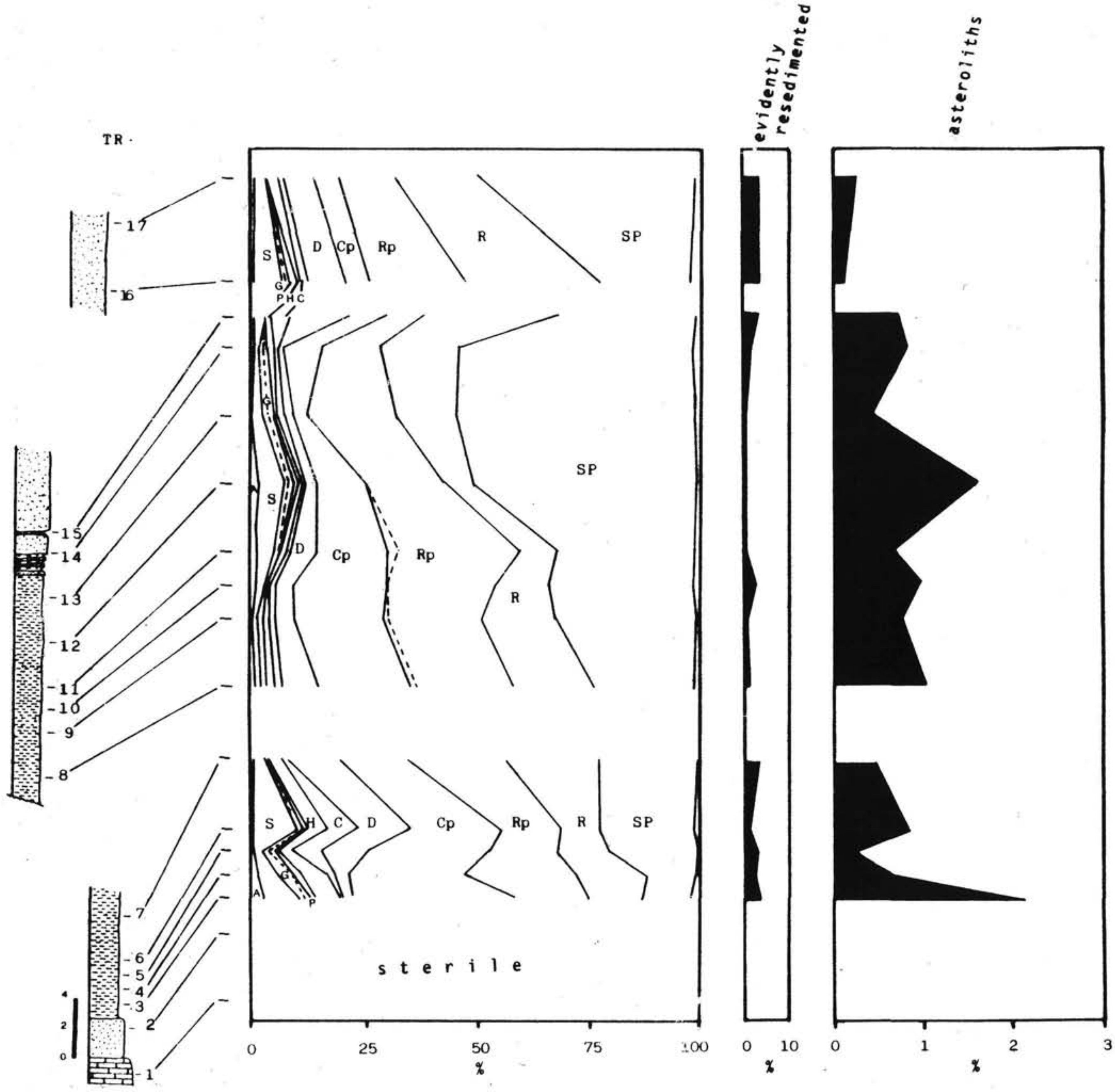


Fig. 10: Abundance of some taxons, morphotypes or groups of taxons, and "evidently resedimented" specimens in the Beas-Trigueros section (legend see Fig. 2).

2) the abrupt appearance of the second group of *"G. menardii"* (dextral) (after an interval in which the keeled Globorotalids are practically absent), respectively.

This horizon (synchronic and hence usable in the area for biostratigraphic references) is seen at the sections of Cantillana – Arroyo Trujillo, Guillena, Beas – Trigueros and Arroyo Galapagar. With respect to the last section, where the base of the Andalusian is defined, it should be noted that *E. berggrenii* and *E. quinqueramus* have been found a few meters below the place where MARTINI (1974) and BERGGREN & HAQ (1973) recorded their first appearance. BACKMAN (1978), in a comparative study carried out on the sediments of the Vera Basin and certain DSDP sites, reported a strong increase in *Dictyococcites minutus*, a taxon which could correspond to our "small placoliths".

Above the first *Amaurolithus* the assemblage is different from a quantitative point of view. Between the appearance of *A. primus* and *A. delicatus* where their first record appears at different levels, the replacement of the second group of *"G. menardii"* by that of *Globorotalia miotumida* was observed. This limit coincides with that of the biozones of *Turborotalia humerosa* and *G. miotumida* and of the Tortonian/Messinian boundary according to the definition of D'ONOFRIO et al. (1975). These events, and the limit they define, can be observed in the Gibraleón, Beas – Trigueros, Guillena, Cantillana and Arroyo Galapagar sections.

In the Beas – Trigueros section the inversion horizon of the dominance of the *R. haqii/R. minutula* group over that of the "small pacoliths" and the first record of *Amaurolithus*, compared with events defined with foraminifera are anomalous due to litorality. A princi-

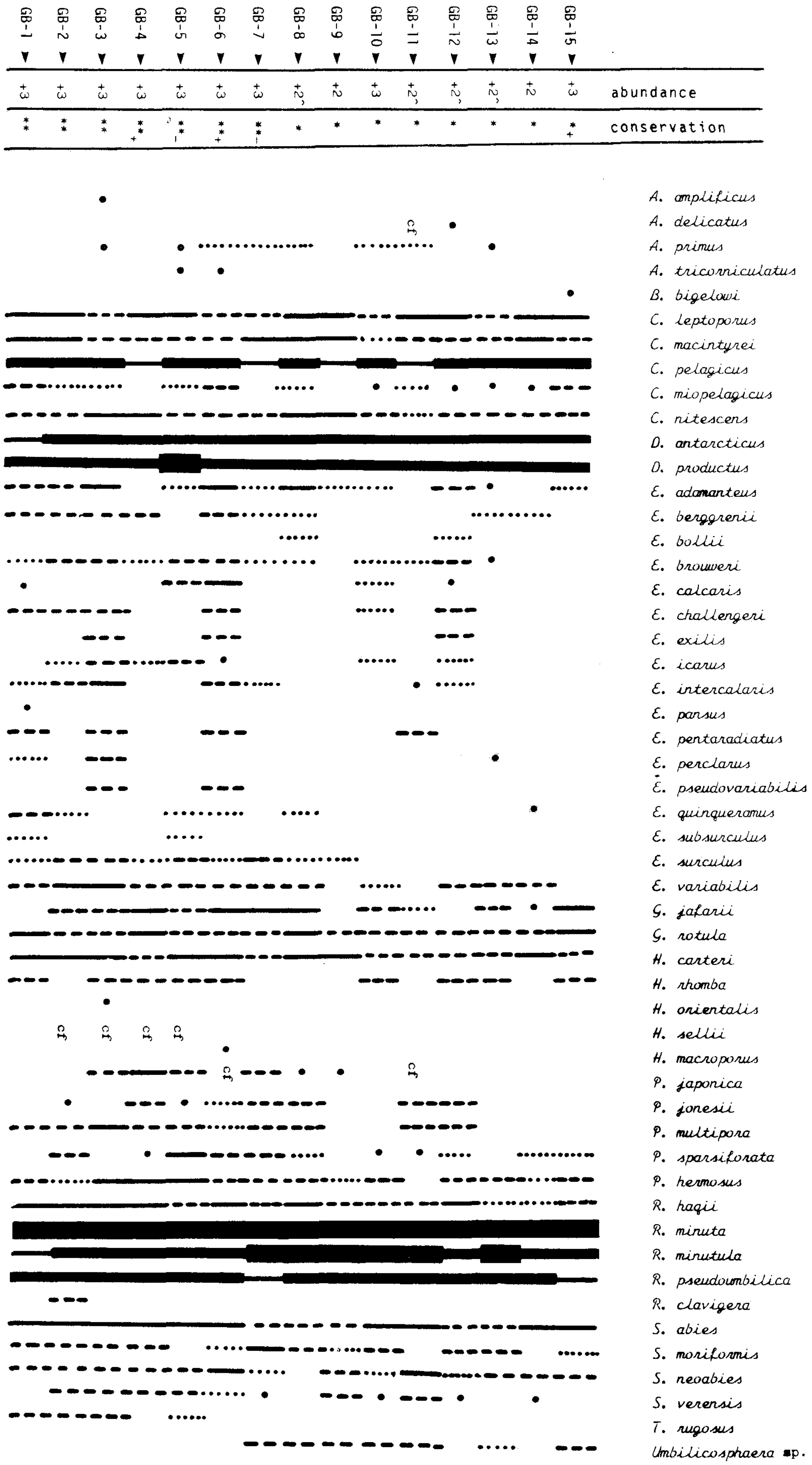
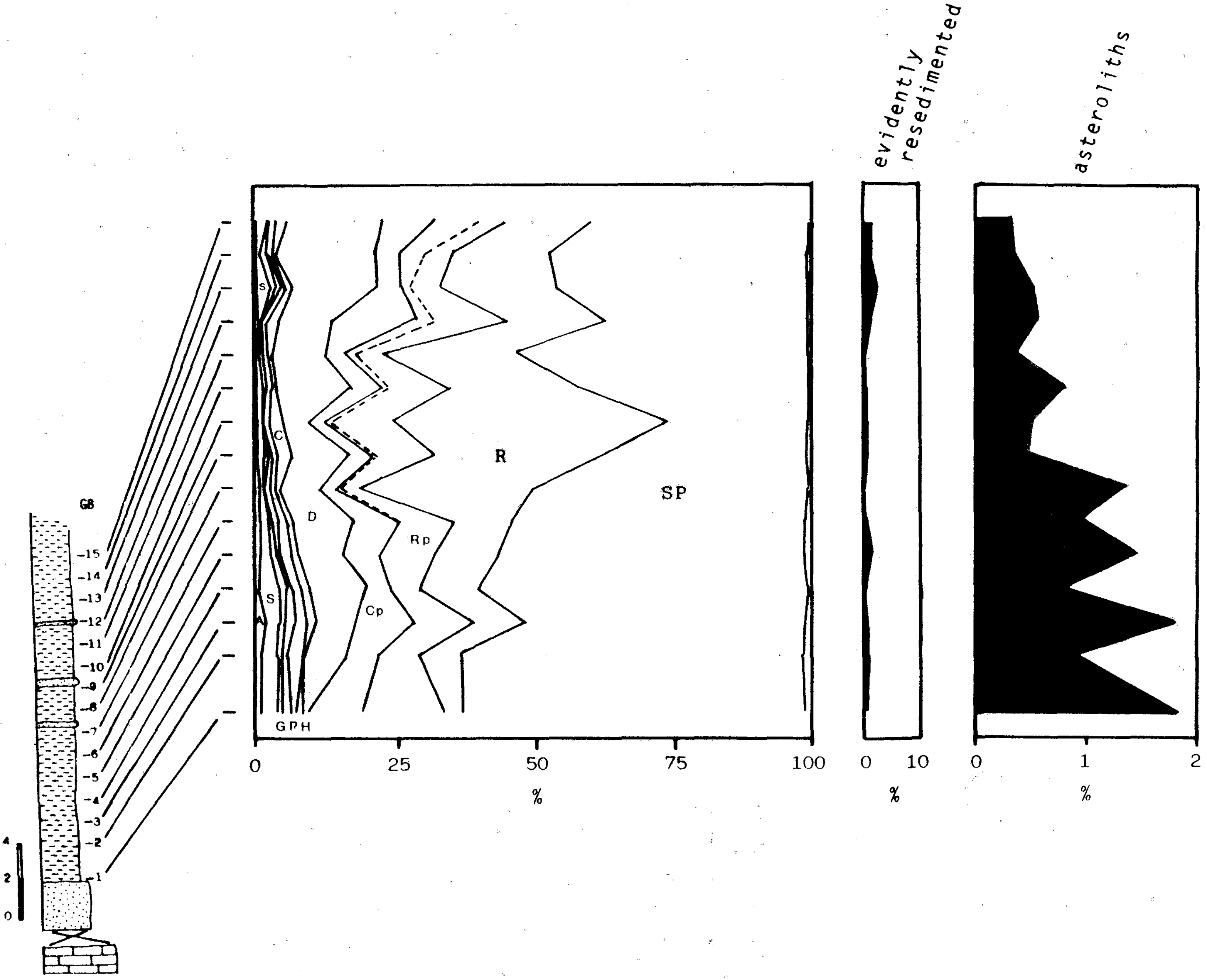


Fig. 11: Abundance, conservation and relative abundance of species in the Gibraleón section.

Fig. 12:
Abundance of some taxons, morphotypes or groups of taxons, and "evidently resedimented" specimens in the Gibraleón section (legend see Fig. 2).



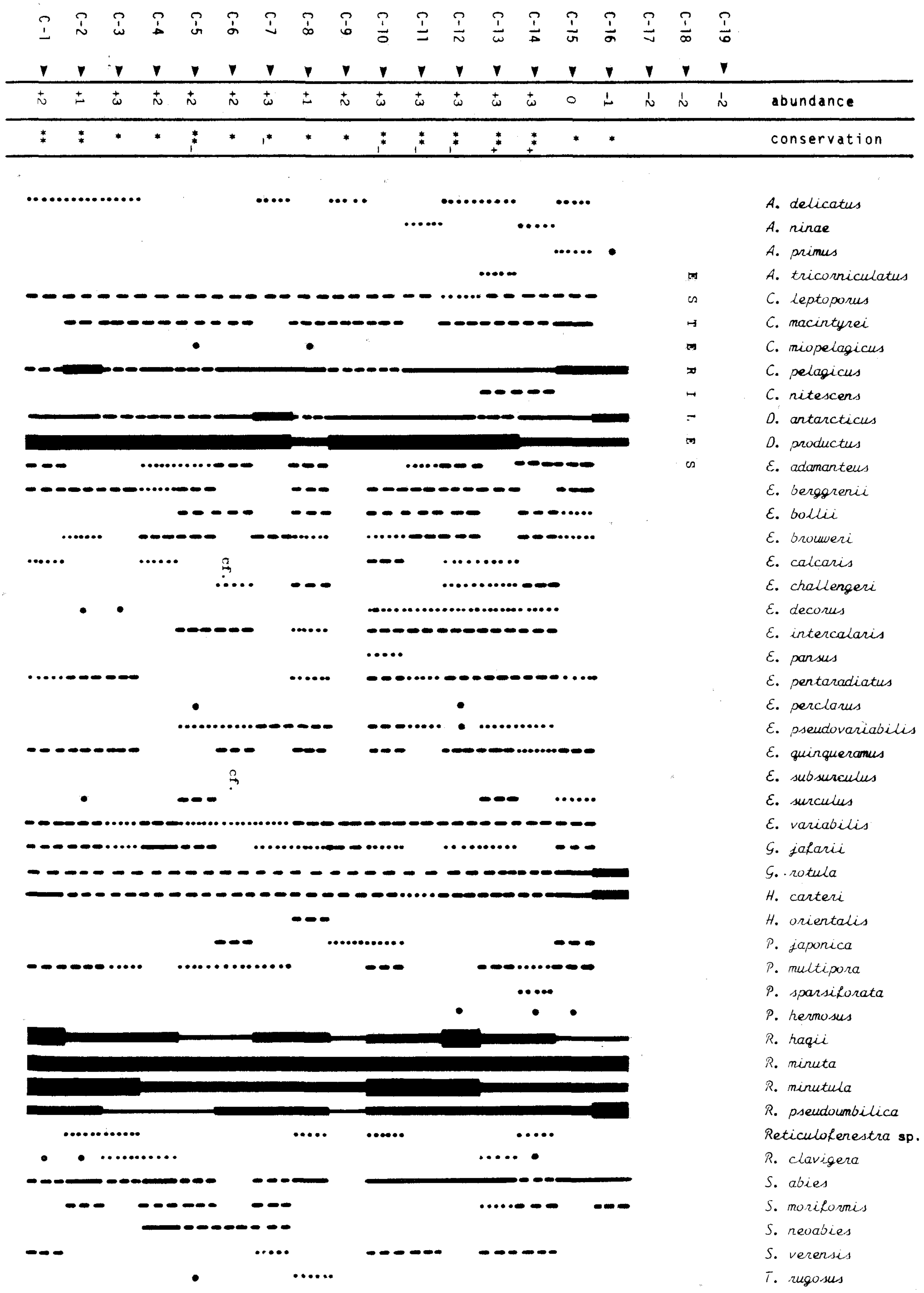


Fig. 13: Abundance, conservation and relative abundance of species in the Carmona section.

Fig. 14: Abundance of some taxons, morphotypes or groups of taxons, and "evidently resedimented" specimens in the Carmona section (legend see Fig. 2).

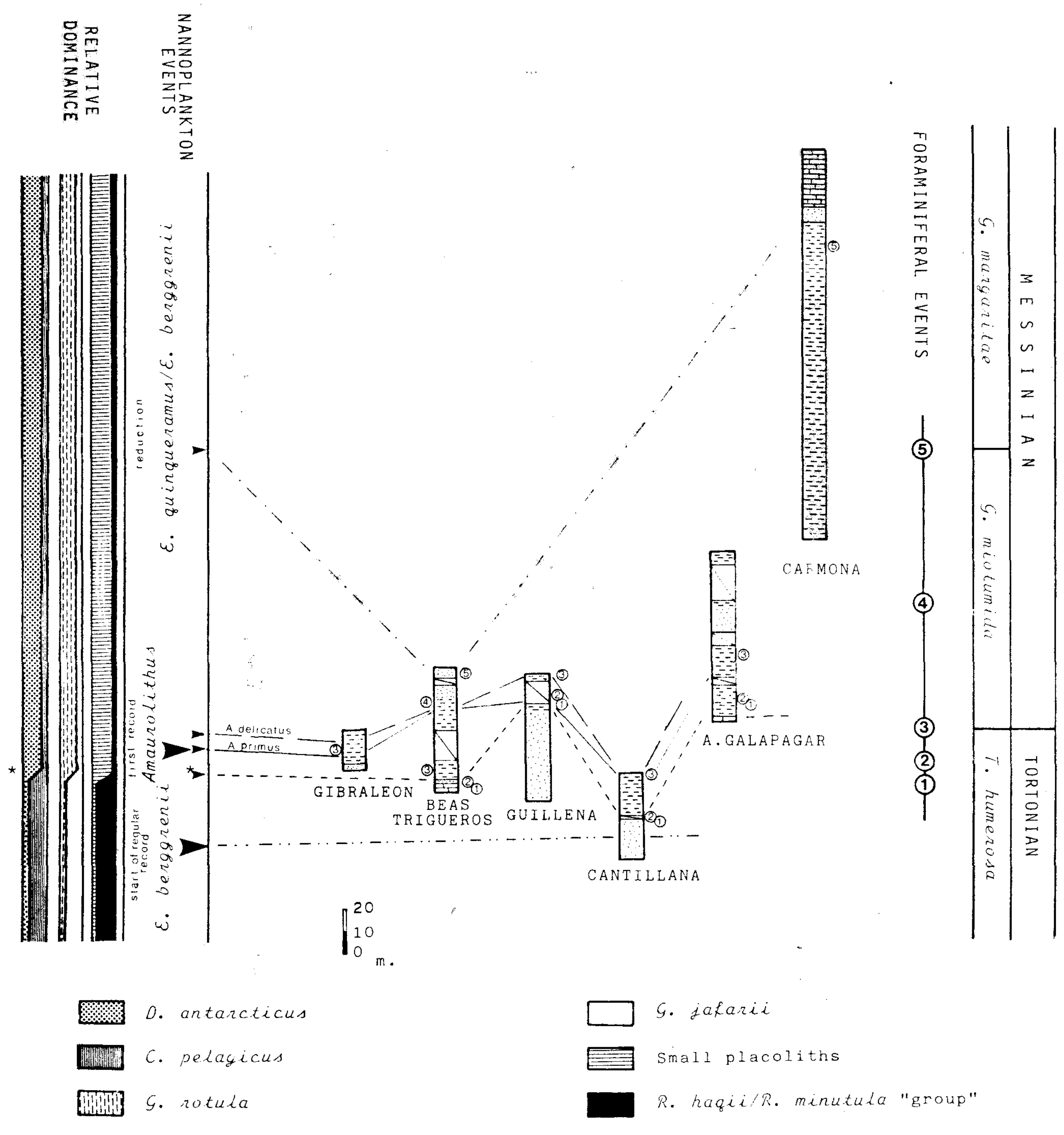


Fig. 15: Correlation of the sections based on the events defined with calcareous nannoplankton and planktonic foraminifera.

pally ecological disappearance occurs in *E. berggrenii* and *E. quinqueramus* towards the top of the sequence.

MARTINI (1971), BUKRY (1973) and MAZZEI et al. (1979) used the disappearance of *E. quinqeramus* as a zonal boundary. In our studies of the Atlantic DSDP sites 136, 118 and 416A we have been able to determine a systematic reduction in *E. berggrenii* and *E. quinqueramus*, before their complete disappearance. This has thrown serious doubt on whether the representatives of these species recorded later are really resedimented (see e.g. MAZZEI et al. 1979, p. 380). For this reason we have again not adopted the conventional biozones, but approximated the point at which the reduction of the two species occurs. Their disappearance towards the top of the Beas – Trigueros section and of the Carmona section is a result of the bathymetric changes and the sedimentation related (in the second case) to the next olistostrome (BENSON, 1976).

Between the first record of *Amaurolithus* and the top of the Carmona and Beas – Trigueros sections event 4 and 5 of planktonic foraminifera are visible; these coincide exactly with the change in coiling direction from sinistral to dextral of the *Turborotalia acostaensis* group and the first record of *Globorotalia margaritae* s.s., respectively.

Regarding the previous data of the Carmona section it should be noted that the establishment at the base of what was called "caliza tosca" (calcarenites of the top of the section) of the upper limit of the zone of *D. quin-*

queramus (or equivalents) by MARTINI (1971), BERGGREN and HAQ (1976) and BOSSIO et al. (1977) is questionable.

The distribution of *T. rugosus* also seems to be affected by the regressive process.

8.1. Chronostratigraphy

In the sections studied, the Tortonian/Messinian boundary, with respect to the data provided by the foraminifera, comparing their variations with the definition in the stratotype, would be equivalent to event 3 (SIERRO, 1984). Thus the boundary is slightly above the first record of *Amaurolithus*.

8.2. Paleoecology

The abrupt variations taking place in the interval and region studied seem to be mainly due to changes in the temperature of the respective mass of water. In this sense, the interval before the definitive dominance of the "small placoliths" is considered by us to pertain to relatively warmer climatic conditions. This agrees with the data provided by the planktonic foraminifera and in particular with respect to the Globorotaliids. In the biozone of *T. humerosa* SIERRO (1984) reported the existence of a great abundance of *G. cultrata* (s.l.), *G. plesiotumida* and *G. merotumida*, all characteristic of tropical and subtropical waters. The gastropod fauna is also characteristic of warmer waters (GONZALEZ DELGADO, personal communication).

Later, following the inversion of the proportions of the taxons or groups of taxons referred to above, the characteristic "Globorotaliids" (characteristic of tropical or subtropical waters) cease being recorded (after event 3). The small diachronism which may be observed between the variations in the nannoplankton and the planktonic foraminifera can be explained by assuming that the reaction time of one and the other is different in the face of the changing conditions.

The asteroliths, which have always been used as indicators of relatively higher temperatures when they appear in greater proportions in the Guadalquivir Basin, are not indicative, since their frequency and variations (with the exception of very localized points, such as in the Gibraleón section) are more controlled by bathymetry. In nearby DSDP sites FLORES (1985) reports that this relationship is in fact satisfied.

The assemblage of nannoplankton examined is considered to pertain to clearly transitional waters with a mixture of representatives of sets from low latitudes, together with others which in high proportions are characteristic of higher latitudes, and also a clear predominance of the "Reticulofenestrids" over other forms.

The differences to the DSDP sites in which the dominant "Reticulofenestrid" is *R. pseudoumbilica*, may be due to pecularities of the hydrodynamics of the area, to the paleogeography of the area, or perhaps to both factors.

Finally, we find the "status" of *C. pelagicus* as an indicator of relatively lower temperature when it occurs in greater numbers is questionable. It is more common in the lower, warmer interval, than above, where *D. antarcticus* increases in the cooler interval.

References

BACKMAN, J.: Late Miocene – Early Pliocene nannofossil biochronology and biogeography in the Vera Basin, SE Spain. – Act. Univ. Stockholmensis. Stockholm Contrib. Geol., **32**/2, 93–114, Stockholm 1978.

BACKMAN, J.: Miocene–Pliocene nannofossils and sedimentation rates in the Hatton-Rockall Basin, NE Atlantic Ocean. – Act. Univ. Stockholmensis. Stockholm Contrib. Geol., **36**/1, 1–91, Stockholm 1980.

BENSON, R. H.: Miocene deep-sea ostracodes of the Iberian portal and Balearic Basin. – Marine Micropaleontology, **1**/3, 249–262, Amsterdam 1976.

BERGGREN, W. A. & VAN COUVERING, J. A.: The terminal Miocene event: Biochronology of the Andalusian and Messinian stages. – Proceed. VI. Congress on Mediterranean Neogene Stratigraphy, 85–89, Bratislava 1975.

BERGGREN, W. A. & HAQ, B. U.: The Andalusian stage (late Miocene). Biostratigraphy, Biochronology and Palaeoecology. – Palaeogeol. Palaeoclimat. Palaeoecol., **20**, 67–129, Amsterdam 1976.

BOSSIO, A., GIANELLI, L., MAZZEI, R., SALVATORINI, G., EL-BIED RAKICH, K. & RUSSO, A.: Biostratigraphy and chronostratigraphy of some stratigraphic sections from western Andalusia (Spain) including the stratotype of the Andalusian stage. – Resúmenes de las comunicaciones, Seminario sobre el Messiniense, Málaga 1977.

BUKRY, D.: Low-latitude coccolith biostratigraphic zonation. – In: EDGAR, N. T., SAUNDERS, J. B. et al.: Initial Reports of the Deep Sea Drilling Project, **14**, 685–703, Washington (US Government Printing Office) 1973.

BUKRY, D.: Coccolith and Siliocoflagellate stratigraphy, Northwestern Pacific Ocean, Deep Sea Drilling Project Leg 32. – In: LARSON, R. L. MOBERLY, R. et al.: Initial Reports of the Deep Sea Drilling Project, **32**, 677–701, Washington (US Government Printing Office) 1975.

BUKRY, D., DINKELMAN, M. G. & KANEPS, A.: Biostratigraphy of the Equatorial East Pacific Rise. – In: VAN ANDEL, T. H., HEATH, G. R. et al.: Initial Reports of the Deep Sea Drilling Project, **16**, 915–935, Washington (US Government Printing Office) 1973.

CRESCENTI, U., GIANELLI, L., MARTINEZ DIAZ, D. & SALVATORINI, G.: Tentative di correlazione tra i piani Andalusiano e Messininano. – Atti Soc. Tosc. Sci. Nat. Mem., ser A, **80**, 17–39, Pisa 1973.

D'ONOFRIO, S., GIANELLI, L., IACCARINO, S., MORLOTTI, E., ROMEO, M., SALVATORINI, G., SAMPO, M. & SPROVIERI, R.: Planktonic foraminifera of the upper Miocene from some Italian sections and the problem of the lower boundary of the Messinian. – Boll. Soc. Paleont. It., **14**, 177–196, Modena 1975.

FLORES, J. A.: Nanoplancton calcáreo en el Neógeno del borde noroccidental de la Cuenca del Guadalquivir (S.O. de España). – Tes. Doct. Univ. Salamanca, 1–714 (inedit.), Abstract: Ed. Univ. Salamanca, Salamanca 1985.

FLORES, J. A. & SIERRO, F. J.: Variations in the calcareous plankton of the Tortonian-Messinian transition of the Guadalquivir Basin (Spain), INA Newsletter, **7**, 62–64, Utrecht 1985.

MARTINI, E.: Standard Tertiary and Quaternary calcareous nannoplankton zonations. In: FARINACCI, A. (Ed. Tecnoscienza) II. Plankt. Conf. Proc. Roma, 739–785, Roma 1971.

MARTINI, E.: Calcareous nannoplankton from the type Andalusian and some other Neogene areas in Spain. – V. Congr. Neog. Med. Lyon 1971, Mem. B.R.G.M., **78**/1, 421–426, Paris 1974.

MAZZEI, R.: Biostratigraphy of the Rio Mazzapiedi Castellania (Type-section of the Tortonian) based on Calcareous nannoplankton. – Atti. Soc. Tosc. Sci. Nat. Mem. A., **84**, 15–24, Pisa 1977.

MAZZEI, R., RAFFI, I., RIO, D., HAMILTON, N. & CITA, M. B.: Calibration of late Neogene calcareous plankton with the paleomagnetic record of Site 397, and correlation with Moroccan and Mediterranean sections. – In: von RAD, U., RYAN, W. B. F. et al.: Initial Reports of the Deep Sea Drilling

Project, **47**/1, 375–389, Washington (US Government Printing Office) 1979.

OKADA, H. & BUKRY, D.: Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation (BUKRY, 1973, 1975). – Marine Micropaleontology. **5**/3. 321–325, Amsterdam 1980.

PERCONIG, E.: Sobre la posición del nuevo término estratigráfico "Andaluciense" para indicar la fase terminal del Mioceno de facies marina. – Notas y Comunicaciones Inst. Geol Min. Esp., **91**, 13–40, Madrid 1966.

PERCONIG, E.: Mise au point du stratotype de l'Andalousien. – V. Congr. Neog. Med. Lyon 1971, Mem B.R.G.M., **78**/2, 663–673, Paris 1974.

ROTH, H. P.: Calcareous nannofossils – Leg 17 Deep Sea Drilling Project. – In: WINTERER, E. L., EWING, J. L. et al.: Initial Reports of the Deep Sea Drilling Project, **17**, 695–795, Washington (US Government Printing Office) 1973.

ROTH, H. P. & THIERSTEIN, H.: Calcareous nannoplankton: leg 14 of the Deep Sea Drilling Project. – In: HAYES, D. E., PIMM, A. C. et al.: Initial Reports of the Deep Sea Drilling Project, **14**, 421–485, Washington (US Government Printing Office) 1972.

SIERRO, F. J.: Foraminíferos planctónicos y bioestratigrafía del Mioceno superior–Plioceno del borde Occidental de la Cuenca del Guadalquivir (S.O. de España). – Tes. Doct. Univ. Salamanca, 1–391 (inedit.), Abstract: Ed. Univ. Salamanca, 1–34, 1984.

SIERRO, F. J.: The replacement of the *"Globorotalia menardii"* group by the *Globorotalia miotumida* group: an aid to recognizing the Tortonian-Messinian boundary in the Mediterranean and adjacent Atlantic. – Marine Micropaleontology, **9**/6, 525–535, Amsterdam 1985.

SIERRO, F. J., FLORES, J. A., CIVIS, J. & GONZALEZ DELGADO, J. A.: New criteria for the establishment of a correlation between the Andalusian and Messinian stages. – Abstracts VIII. Cong. Reg. Comun. Med. Neog. Strat., 514–516, Budapest 1985.

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Autor(en)/Author(s): Flores Jose-Abel, Sierro Francisco-Javier

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