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NEW DATA ON THE (PERMO-)TRIASSIC OF THE BETIC ZONE (SOUTHERN SPAIN)

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SUMMARY

A synopsis is given of the lithostratigraphic development of the (Permo-) Triassic sequences of the major tectonic complexes of the Betic Zone. Results of microfaunal investigations are provided. Three ostracode zones have been distinguished. The lower and middle zones are attributed to the Ladininan (Longobardian and-? Late Fassanian) and the upper zone to the Early Carnian (Cordevolian). Microfauna proved very useful for solving paleontologic, stratigraphic, paleoecologic, paleogeographic and tectonic problems.

RESUMEN

Se hace una sinopsis del desarrollo litoestratigráfico de las sucesiones (Permo-)Triásicas de los mayores conjuntos tectónicos de la Zona Bética. Se presentan los resultados de las investigaciones microfaunísticas. Se distinguen tres zonas de ostrácodos. Las zonas inferior y media se atribuyen al Ladiniense (Longobardiense y (?) final del Fassaniense) y la zona superior al principio del Carniense (Cordevoliense). La microfauna resultó útil para resolver problemas paleontológicos, estratigráficos, paleogeográficos y tectónicos.

INTRODUCTION

The Betic Zone embraces the internal part of the Betic Cordilleras, the alpine fold-belt of southern Spain. On the basis of lithostratigraphic development of the (Permo-)Triassic sequences and of structural position, four major tectonic complexes have been distinguished (EGELER & SIMON,

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1969 a, b). They are, in ascending order: 1) Nevado-Filabride Complex; 2) Ballbona-Cucharón Complex; 3) Alpujárride Complex, and 4) Malaguide Complex (Fig. 1). All complexes include «cover» sequences of (Permo-) Triassic (meta)-sediments. The Nevado-Filabride, Alpujárride and Malaguide

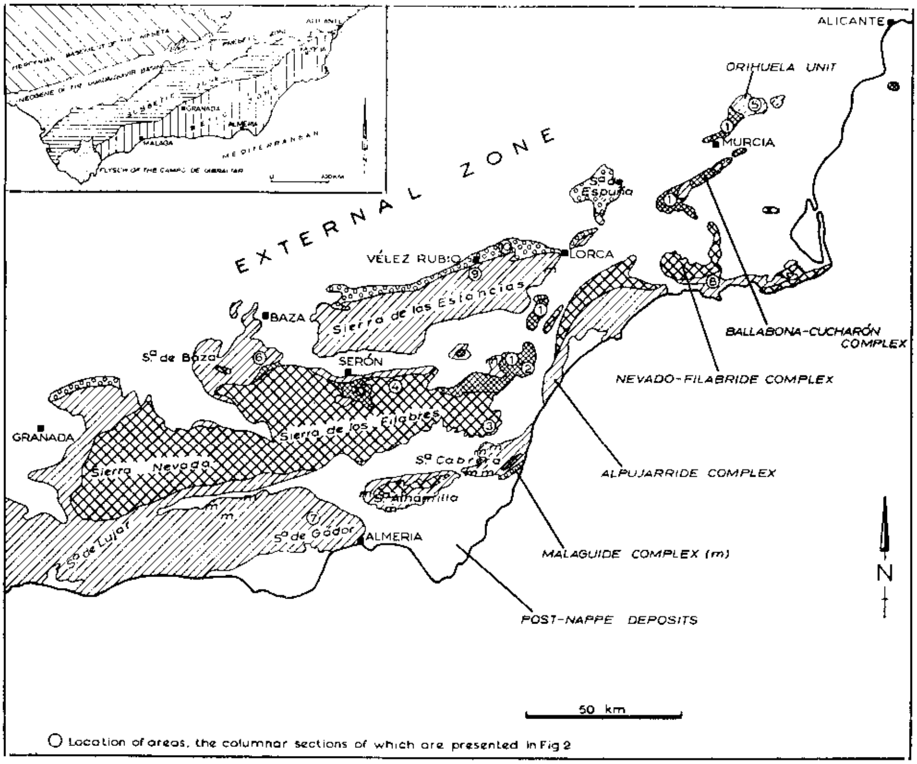

Fig. 1. *Tectonic sketch-map of the Betic Zone*

complexes, in addition, contain pre-(Permo-)Triassic «basement» sequences. Only in the Malaguide Complex have post-Triassic sediments been found. Consequently only (Permo-)Triassic sequences can be used for correlation of the various tectonic units and complexes, and hence for a reconstruction of the Betic paleogeography. At only a few localities have well-preserved macrofaunas been reported, which warrant paleontologic and stratigraphic conclusions (SIMÓN, 1963). Until recently, therefore, dating of the (Permo-) Triassic sequences of the Betic Zone has been based almost exclusively on lithologic comparison with dated Triassic sequences from other parts of Europe and Northern Africa. In view of the fact that in the last ten years Triassic sequences from many parts of the world have been dated with the aid of microfauna, a systematic programme has been set up for dating of the (Permo-)Triassic sequences of the Betic Zone by microfauna (KOZUR et al., 1974). In this paper a short review will be given of the (Permo-) Triassic lithostratigraphy of the various complexes, followed by a synopsis of the results of microfaunal investigations.

LITHOSTRATIGRAPHY OF THE (PERMO-)TRIASSIC SEQUENCES OF THE TECTONIC COMPLEXES

Ballabona-Cucharón Complex

In former publications three major tectonic units have been distinguished, viz., from below to above, Ballabona, Romero-Carrascoy and Orihuela units (IGME, 1974; SIMON et al., 1976). For reasons to be discussed later on, the Orihuela unit in this publication will not be incorporated in the Ballabona-Cucharón Complex (see pág. to be filled ont and págs. according to page numbering.

The (Permo-)Triassic column of the Romero-Carrascoy unit of the Sierra de Carrascoy (and of equivalents elsewhere) has been subdivided into four lithologic formations (Fig. 2). Other characteristics are: *a)* intercalations of gypsum and rauhwackes, locally in large quantities, *b)* intercalations of pelites and psammites in the carbonate sequences, *c)* presence of beds with *Costatoria kiliani* (SCHMIDT) and *Gervillia* cf. *joleaudi* SCHMIDT, approx. 150 metres above the base of the lower carbonate sequence, *d)* common occurrence of Fe-mineralisation, and *e)* presence of large diabase masses (SIMON, 1963, 1966 b; EGELER & SIMON, 1969 a, b; KAMPSCHUUR, 1972 a; KOZUR et al., 1974).

A correlation of the rock sequences of the Ballabona unit with the higher part of the Romero-Carrascoy unit seems warranted on the basis of the lithostratigraphic development (SIMON, 1963; EGELER & SIMON, 1969 a; Fig. 2).

Nevado-Filabride Complex

The Nevado-Filabride sequences have been strongly tectonised and metamorphosed during the Alpine orogeny. Therefore, one encounters serious difficulties when attempting to establish reliable columnar sections. The lithologic criteria mentioned for the Ballabona-Cucharón Complex apply also to the cover series of the Nevado-Filabride units, although gypsum and rauhwackes occur in far lesser quantities. The cover of the lowest Nevado-Filabride unit shows a lithologic subdivision comparable with the (Permo-)Triassic sequence of the Romero-Carrascoy unit of the Ballabona-Cucharón Complex (HELMERS & VOET, 1967; EGELER & SIMON, 1969 a, b; EGELER et al., 1971; Fig. 2). The cover series of the higher Nevado-Filabride units are usually substantially thinner than that of the lowermost unit, due to stratigraphic effects (Mr. H. HELMERS, pers. com.). They consist essentially of rocks correlatable with those forming the higher part of the cover of the lowermost unit.

Alpujarride Complex

A large number of tectonic units that overlie Nevado-Filabride and Ballabona-Cucharón units and underlie Malaguide units are incorporated in the Alpujarride Complex. Systematic grouping and correlation of the various Alpujarride units throughout the Betic Zone has not yet been done (1). In the central and eastern Betic Zone a bipartite subdivision can generally be made into a lower and a higher group of units, to be named here Lower and

(1) In 1974 a project has been started (by teams from München, Salamanca, Bilbao, Granada and Amsterdam), in order to make a detailed stratigraphic, tectonic and petrologic study of the Alpujarride Complex.

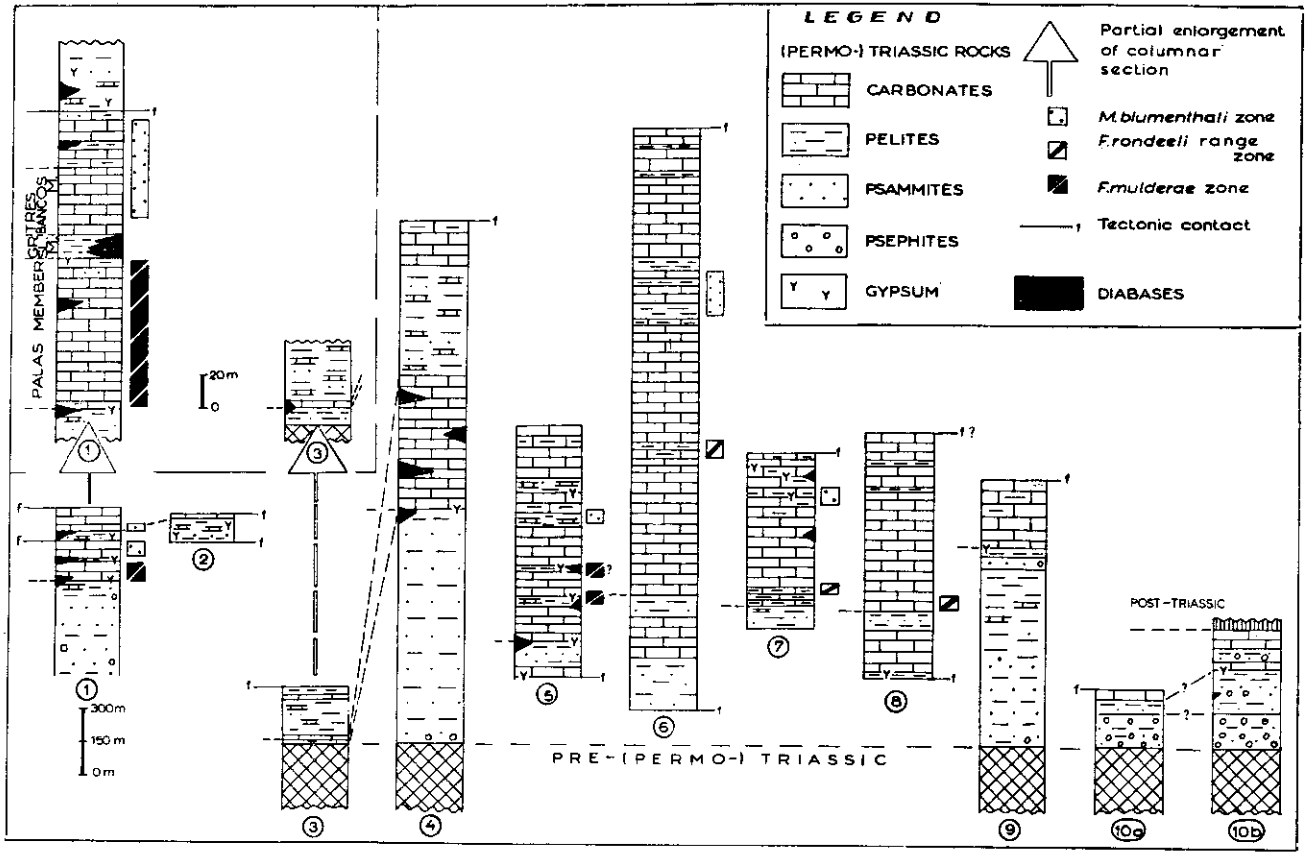

Fig. 2. *Columnar sections of tectonic units from areas indicated in figure 1;* 1: *composite columnar section of the Romero Carrascoy unit (Ballabona-Cucharón Complex) (after* SIMÓN, *1693;* KAMPSCHUUR, *1972 a;* IGME, *1974;* KOZUR *et al., 1974);* 2: *Ballabona unit (Ballabona-Cucharón Complex) (after* VOERMANS, *1973);* 3: *Bédar unit (higher Nevado-Filabride unit) (after* HELMERS & VOET, *1967;* EGELER *et al., 1971);* 4: *Nevado-Lubrín unit (Lowermost Nevado-Filabride unit) (after* RONDEEL & SIMÓN, *1974;* EGELER *et al., 1971);* 5: *Orihuela unit (? Lower Alpujarride Subcomplex) (after* IGME, *1974;* KOZUR *et al., 1974);* 6: *Barbara unit (Lower Alpujarride Subcomplex)* (*after* IGME, *in press, a)* 7: *Gádor unit* (*Lower Alpujarride Subcomplex*) (*after* IGME, *in press, b*); 8: *Peña Blancas unit* (*Lower Alpujarride Subcomplex*) (*after information supplied by Mr. G. J.* DE BRUNIN); 9: *Alpujarride unit* (*Higher Alpujarride Subcomplex*) (*after* DE VRIES & ZWAAN, *1967*); 10 a: *composite columnar section of the Peña Rubia - Casolidad unit* (*lower Malaguide unit*) (*after* ROEP, *1972*); 10 b: *composite columnar section of the Colorado and Castillos units* (*higher Malaguide units*) (*after* ROEP, *1972*)

Higher Alpujarride Subcomplexes resp. (SIMON et al., 1976). Transitional elements occur, indicating that the rocks of the two subcomplexes have been deposited in one major paleogreographic realm.

Lower Alpujarride Subcomplex. So far pre-(Permo-)Triassic sequences have not been found. The (Permo-)Triassic series show a bipartite lithologic subdivision. The lower sequence consists essentially of pelites and psammites. In some regions it comprises carbonates, with a thickness up to several tens of metres (Fig. 2). The upper sequence consists mainly of carbonates with intercalations of pelites and psammites. In addition it contains sedimentary breccias, slumps, nodular carbonate rocks, and peculiar banded rocks («Franciscaine» dolomites and «Pierres indiennes») (JACQUIN, 1969, 1970; SCHWERD, 1974). Pb-F mineralisations of stratiform type commonly occur in the middle and higher parts of the upper sequence. They are thought to be of (endogenic-) syngenetic-sedimentary origin (JACQUIN, 1969, 1970; SCHWERD, 1974). Gypsum and diabases occur locally. The units of the Lower Alpujarride Subcomplex attain their greatest thickness (up to 2,500 metres) to the north and south of the Sierra Nevada and in the Sierra de Baza. In the more eastern part of the Betic Zone thicknesses are generally in the order of some hundreds of metres.

Orihuela unit. This unit until now has only been distinguished in the northeasternmost part of the Betic Zone. In previous publications it has been incorporated in the Ballabona-Cucharón Complex (IGME, 1974; SIMON et al., 1976). Its lithostratigraphy, however, is more similar to that of the Lower Alpujarride units (Fig. 2), and also the fauna content favours incorporation in this subcomplex (see pág. in agremel wilh later p.). Gypsum and diabases accur locally. In the higher part of the Orihuela unit, sedimentary breccias and rocks resemblig «Franciscaine» dolomites have been found in places.

Higher Alpujarride Subcomplex. In contrast to the Lower Alpujarride Subcomplex, the units of the Higher Alpujarride Subcomplex commonly have a pre-(Permo-)Triassic «basement». The «cover» series consist of a pelite-psammite sequence (below) and a carbonate sequence (above). Carbonate intercalations (up to several tens of metres thick) are found locally in the lower sequence. The carbonate sequence in general is thinner than that of the Lower Alpujarride Subcomplex, and rocks of the «Franciscaine» type, sedimentary breccias, slumps, Pb-F mineralisations, psammites, pelites and gypsum are scarce or absent. Diabases are very rare. In the region to the south of the Sierra Nevada the thickness of the «cover» series decreases from below to above in the pile of Higher Alpujarride units (ALDAYA, 1969).

Malaguide Complex

Due to strong tectonism, absence of determinable macrofauna, and scarcity of microfaunal data, detailed columnar sections of the (Permo-)Triassic «cover» series are very rare. The work of ROEP (1972) indicates that the (Permo-)Triassic of the higher Malaguide units in the region between Vélez Rubio and Lorca consists, from below to above, of a lower psammite-pelite sequence with psephitic intercalations, a lower dolomite sequence, an upper psammite-pelite sequence with psephites and an upper dolomite sequence. Gypsum has been found in the uppermost part of the lower psammite-pelite sequence (Fig. 2). Diabases occur rarely. In several places the lower dolomite sequence is absent, resulting in a single psammite-pelite sequence, overlain by carbonate rocks. The lower Malaguide units in the Sierra de Espuña and in the region between Lorca and Vélez Rubio, which are considered to be «transitional» between the higher Malaguide units and the Higher Alpujarride Subcomplex, show a bipartite subdivision of the (Permo-)Triassic «cover», viz. a psammite-pelite sequence with psephites (below and a carbonate sequence (above). The correlation of the (Permo-)triassic columnar sections of the lower Malaguide units with those of the higher Malaguide units still poses serious problems (ROEP, 1972).

MICROFAUNAL RESULTS AND THEIR IMPLICATIONS

General

The first microfossils, viz. conodonts from epimetamorphic, strongly tectonised Triassic rock sequences of the Betic Zone have been reported by VAN DEN BOOGAARD (1966; see also SIMON, 1966 a). Afterwards KOZUR & SIMON (1972) described holothurian sclerites, VAN DEN BOOGAARD & SIMON (1973) conodonts and KOZUR et al. (1974) ostracodes. These studies have demonstrated the value of microfauna for solving paleontologic, stratigraphic, paleoecologic, environmental, paleogeographic and tectonic problems.

Paleontologic and stratigraphic remarks

Using the phylogenetic succession *Falloticythere mulderae* - *Falloticythere rondeeli* - *Mostlerella blumenthali*, KOZUR et al. (1974) established three ostracode zones. Recent investigations have shown that the boundary between the *Falloticythere rondeeli* and *Mostlerella blumenthali* zones must be slightly changed. *Mostlerella blumenthali minuta* is a separate species and represents a transitional form between *Falloticythere* and *Mostlerella*. The sparse *M. blumenthali blumenthali* from the former lower *blumenthali* zone do not belong to this species, but to a transitional form between *F. rondeeli* and *M. blumenthali*. The presence of highly developed *F. rondeeli* has been described from the lower *blumenthali* zone by KOZUR et al. (1974, pág. 23). Therefore, the *rondeeli* zone should be used in future as a species range zone including the former lower *blumenthali* zone (Fig. 3). The original definition of the *rondeeli* zone, viz. range of *Falloticythere rondeeli* without *Mostlerella blumenthali*, should be changed to: range of *F. rondeeli* (for a more detailed discussion, see KOZUR et al., in press, b and c).

The *mulderae* zone (with *F. mulderae*) is represented in the Ballabona-Cucharón Complex and in the (Lower Alpujarride?) Orihuela unit. The frequent occurrence of *Lutkevichenella egeleri* is also typical for the *mulderae* zone. In the lower part of the Palas member of the Romero-Carrascoy unit (Ballabona-Cucharón Complex) a rich assemblage of *L. egeleri* is present together with *Bythoceratina (Praebythoceratina) rietveldae* n. sp. (2). The same association has been found in the lowermost part of the carbonate sequence of the (Higher?) Alpujarride unit from the Sierra Cabrera (KOZUR

(2) For ad escription of species indicated with n. sp., see KOZUR et al., in press, a and b.

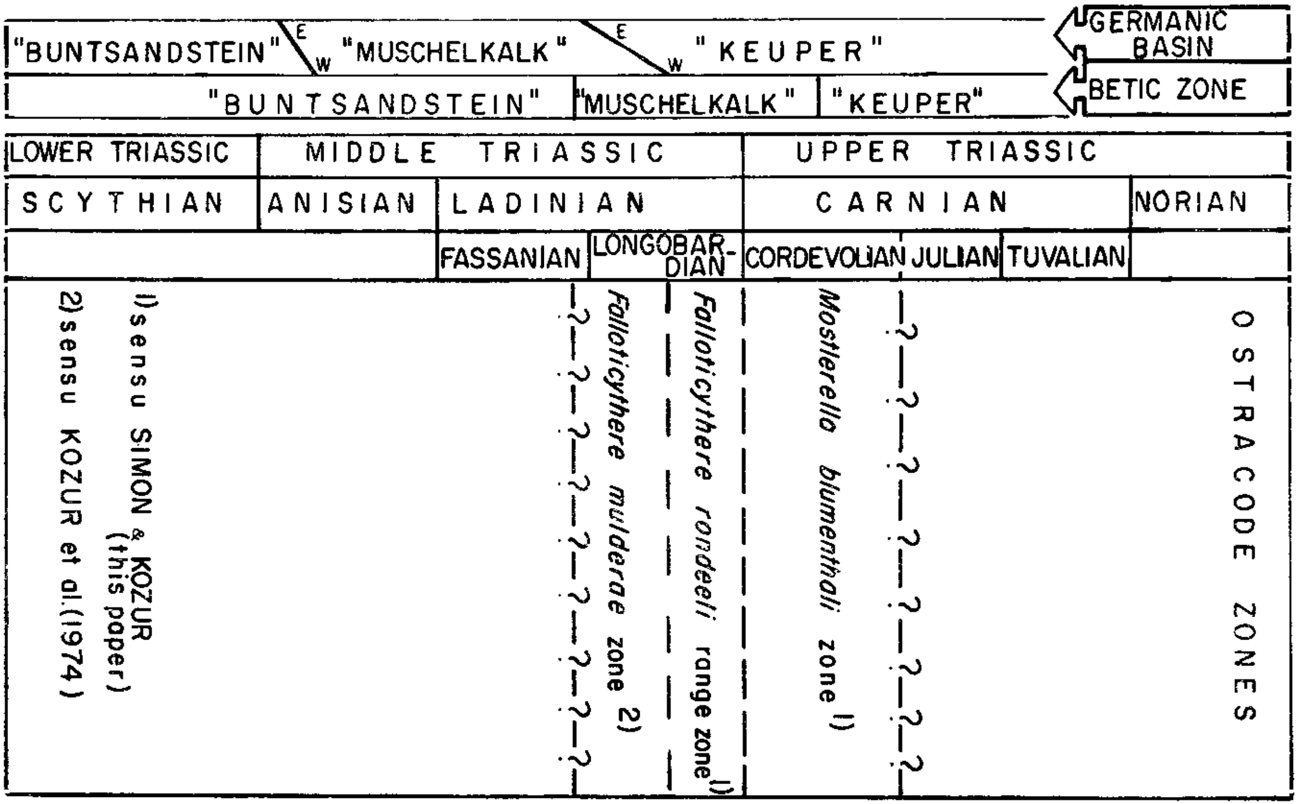

Fig. 3. *Correlation of the ostracode zones of the Betic Zone with the Triassic standard subdivisions*

et al., in press, c). Consequently, the *mulderae* zone is represented in the Ballabona-Cucharón and Alpujarride Complexes.

The *rondeeli* range zone is represented in the Lower and the Higher Alpujarride Subcomplexes (Fig. 2). In the Ballabona-Cucharón Complex transitional forms between *F. mulderae* and *F. rondeeli* are frequent in the uppermost part of the Palas member. The overlying green slate member and the lowermost part of the «Tres bancos» member, which are most probably the time equivalent of the *rondeeli* range zone, have not yielded ostracodes.

The *blumenthali* zone is present in the Ballabona-Cucharón and Alpujarride Complexes (Fig. 2).

A bipartite subdivision of the (Permo-)Triassic of the Betic Zone is possible on the basis of conodonts. *Pseudofurnishius huddlei* occurs in the *mulderae* zone of the Palas member (Ballabona-Cucharón Complex), whereas in the *blumenthali* zone the genus *Pseudofurnishius* is only represented by *P. murcianus*. Unfortunately, in the Betic Zone conodonts are mostly too sparsely represented for stratigraphic subdivision, but they are very useful for correlation purposes (see below).

Holothurian sclerites have been found only in a few horizons, sometimes in large amount. In the upper *rondeeli* range zone (Lower Alpujarride Subcomplex, Sierra de Baza) only *Calclamma germanica* —a species without special stratigraphic value— has been found (DELGADO et al., in press). The *blumenthali* zone of the Higher Alpujarride Subcomplex is characterised by the frequent occurrence of *Zawidzkella kampschuuri* n.gen.n.sp., associated with *Acanthotheelia oertlii* and some new *Acanthotheelia* species. A third holothurian association of similar age, but with a different species assemblage (many *Acanthotheelia mostleri* and other *Acanthotheelia* especies as well as *Kuehnites schallreuteri)* is present in the *blumenthali* zone of the Ballabona-Cucharón Complex (KOZUR & SIMON, 1972). The fourth and youngest association has yielded numerous small *Theelia* species *(Theelia barkeyi, Theelia guembeli, Theelia tubercula, Theelia zankli)*. This fauna was found in the upper *blumenthali* zone in the Ballabona-Cucharón Complex, in the Lower Alpujarride Subcomplex (Barbara and Gádor units) and in the Malaguide unit of the Sierra Alhamilla (see further KOZUR et al., in press, a).

The microfaunas are of great importance for the correlation of the (Permo-)Triassic sequences of the Betic Zone with comparable beds outside of Spain. They can be well correlated with the Triassic of Israel. Close faunistic relations exist also with the Triassic of Nevada (U. S. A.) and to a lesser extent with the Germanic Basin and the Dinaric and Asiatic fanual provinces. Only few relations exist with the Austroalpine faunal province. In the Betic Zone, *P. huddlei* has been found only in the Palas member of the Ballabona-Cucharón Complex, whereas the *blumenthali* zone only contains *P. murcianus*. The lowest occurrence of the genus *Pseudofurnishius* in Israel is in beds with *Protrachyceras curionii ramonensis* and *Gevanites awadi*. These beds have been referred by PARNES (1975) to the higher part of the Lower Ladinian, but according to KOZUR (1972 a, b; 1973 a, b; 1974 c; 1975) they may also represent the Upper Ladinian *(hungaricus* subzone of the *haslachensis* zone). In this subzone in Hungary ammonites have been found closely related to *Protrachyceras «curionii» ramonensis*. *Judahella tsorfatia* from the *mulderae* zone and the *rondeeli* range zone has been found in the Longobardian and possibly also in the Fassanian of the Westmediterranean faunal province (sensu KOZUR & MOSTLER, 1972 b; KOZUR, 1973 c) which is correlatable with the Sephardic faunal province (sensu HIRSCH, 1972). In the Asiatic and Germanic faunal provinces *Judahella tsorfatia* is older (Olenikian to Middle Anisian). *Leviella sohni* from the *mulderae* zone and the *rondeeli* range zone occurs also in the Ladinian Grantsville Formation of Nevada. *Leviella bentori* is present in the lowermost Carnian of Israel. The specimens of *L. bentori* from the upper *rondeeli* range zone are very primitive and closely resemble the Ladinian *Leviella sohni*. They are therefore somewhat older than the typical *L. bentori* from the lowermost Carnian of Israel and from the *blumenthali* zone of southern Spain. *Falloticythere rondeeli* is probably present in the latest Longobardian of Israel (base of the limestone-gypsum member of the Saharonim Formation). *Acratina muelleri* from the *rondeeli* range zone is found in the Ladinian of Slovakia and of Hungary. *Acratina mostlery* n.sp. occurs in the upper *rondeeli* range zone as well as in the Longobardian *Metapolygnathus mungoensis* assemblage zone (sensu KOZUR & MZSTLER, 1972 b; KOZUR, 1972 a, 1974 d) of the Alps. *M. mungoensis* from the upper *rondeeli* range zone (Lower Alpujarride Subcomplex, Sierra de Gádor) corresponds to *M. mungoensis* of the Upper Longobardian of Hungary. Therefore, on the basis of the ostracodes and conodonts the *rondeeli* range zone is not younger than the Longobardian. The *blumenthali* zone (sensu KOZUR et al., 1974, págs. 23-25) has been assigned to the Cordevolian. Two possibilities have been proposed by KOZUR et al. (1974, pág. 25) for the Ladinian-Carnian boundary in the Betic Zone: 1) the first occurrence of *Leviella bentori* and *Mostlerella blumenthali* (including the *M. blumenthali minuta;* see remarks to the taxonomy, pág. 6), or 2) the first appearance of *Reubenella fraterna* (the base of the *blumenthali* zone as defined in this paper). Recent data are in favour of the second solution (see remarks to the former *blumenthali* zone, pág. 6). KOZUR et al. (1974) have proposed a Carnian age for the *blumenthali* zone (as defined in this paper), because of the occurrence of *Reubenella fraterna*, the occurrence of the typical Cordevolian holothurian association with *Theeia tubercula* and of the conodont association of the *Pseudofurnishius murcianus* assemblage zone (sensu KOZUR, 1972 a). The Lower Carnian age of the *blumenthali* zone is also supported by the recent discovery of typical *Kerocythere* species *(K. tuvalica, K.* cf. *reticulata, K. bicarinata* n.sp.) in the Orihuela unit and in the Lower Alpujarride Gádor unit (KOZUR et al., in press, b).

To sum up, the *mulderae* zone and the *rondeeli* range zone are attributed to the Longobardian, leaving open the possibility that the *mulderae* zone partly represents the Late Fassanian. The *blumenthali* zone belongs to the Cordevolian.

The oldest microfauna of the «Muschelkalk» of the Betic Zone, immediately above the «Buntsandstein», belongs to the *mulderae* zone and is assumed to be not older than the Late Fassanian (see Figs. 2 and 3). Therefore, in the Betic Zone, the «Buntsandstein»-«Muschelkalk» boundary does not correspond with the Scythian-Anisian boundary, as generally supposed (see e.g. SIMON, 1963). This most probably is also the case in the External Zone of the Betic Cordilleras, where no «Muschelkalk» carbonates older than the (Upper) Ladinian have been found (see e.g. FOUCAULT, 1971). It thus appears that the «Buntsandstein»-«Muschelkalk» boundary in the Betic Cordilleras lies considerably higher than in the Germanic Basin, where it is situated in the Lower Anisian (KOZUR, 1973 a, b, 1975; Fig. 3).

In the lower part of the psammite-pelite «Buntsandstein» sequence of the

Romero-Carrascoy unit of the Ballabona-Cucharón Complex, to the northeast of Murcia, spores have been found, which indicate the latest Scythian or earliest Anisian (Dr. H. VISSCHER, pers. com.).

The presence of Permian deposits in the «cover» series of the Betic Complexes has not yet been proved by fossils. In view of the data discussed above it seems highly unlikely that Permian rocks are present in the Ballabona-Cucharón Complex. The possibility that they are represented in the lower parts of the «cover» series of the other complexes cannot be excluded. The plant remains [*Lebachia (Walchia) piniformis* (SCHLOTH.) FLORIN] from psammitic rocks of the Malaguide Complex of Morocco, which MILLIARD (1959) considers as Permian, are important in this connection. A reinvestigation of this material seems highly recommendable!

The youngest Triassic fossils known from the Betic Zone come from the highest part of the carbonate sequence of the Lower Alpujarride Barbara unit of the Sierra de Baza. They are algae *(Griphoporella curvata)* which according to LEMOINE (in: FALLOT et al., 1954) indicate the Norian (see also DELGADO et al., in press).

The age of the basal parts of the carbonate sequences of the Alpujarride Complex in the Sierras Cabrera and Alhamilla poses a problem. The microfauna from the basal part of the carbonate sequence of the (Higher?) Alpujarride unit from the Sierra Cabrera belongs to the *mulderae* zone, whereas that from the basal part of the carbonate sequence from the Higher Alpujarride unit from the Sierra Alhamilla belongs locally to the *rondeeli* range zone and locally to the *blumenthali* zone (see KOZUR et al., in press, c). The most logical explanation is that different parts of the carbonate sequence overlie the pelite-psammite sequence, due to tectonism. However, detailed investigations will be necessary to solve this problem.

Another problem concerns the age of some algae from the Lower Alpujarride Barbara unit of the Sierra de Baza. Approximately 650 metres above the base of the carbonate sequence, microfauna has been found, which belong to the *rondeeli* range zone (DELGADO et al., in press). From approximately the same part of the carbonate sequence, FALLOT et al. (1954) have described three horizons with algae, viz., from below to above, *Diplopora* sp., *Teutloporella triasina* and *Oligoporella pilosa.* According to LEMOINE (in: FALLOT et al., op. cit.), in the Southern and Dinarian Alps, *Oligoporella pilosa* and *Teutloporella triasina* respectively indicate the Middle Anisian and the latest Anisian to earliest Ladinian. This would imply that the succession is upside down; however FALLOT et al. consider this highly improbable on the basis of field investigations. This view has recently been confirmed by DELGADO (pers. com). As already noted by FALLOT et al. (op. cit., págs. 34-35 and págs. 56-57), it is probable that the afore-mentioned algae represent different ages for the Alpine-Dinarian realm and the Betic realm. In this connection, it may be mentioned that HERAK (1965) has extended the range of *Teutloporella triasina* in Yugoslavia to the Upper Ladinian.

Paleoecologic and environmental remarks

Stenohaline ostracodes (viz. *Acratina)* have only been found in the *rondeeli* range zone; other stenohaline ostracodes, such as the genera *Bairdia, Healdia*

(3) For the use of Triassic ostracodes for water depth determination and the determination of the salinity, see KOZUR, 1971, 1972 c; KOZUR & MOSTLER, 1972 a.

rich in *Acratina* indicate greater water depth. The absence of ostracodes indicating depths of more than 100-150 metres (e.g. *Nemeroceratina*), however, suggests that the *Acratina*-bearing beds were not deposited at depths greater than 100-150 metres. Most of the samples show typical (very) shallow water associations, indicative of water depths of 0-30 metres, including intertidal conditions. Apart from the ostracodes, the very rare occurrence of conodont faunas with the euryhaline *Pseudofurnishius* association (without *Gondolella* and *Gladigondolella*), the almost total absence of ammonoids and the absence of other stenohaline faunas indicate that the Triassic carbonate sequences of the Betic Zone have been deposited in a shallow to very shallow, partially hypersaline sea, which was largely separated from the «open» Tethyan Sea.

The lithostratigraphic development of the (Permo-)Triassic «cover» series supports this view. Burrow-structures occur at several levels in the carbonate sequences, and are abundant in places; oolitic and nodular carbonates and stratigraphically controlled dolostones (locally associated with gypsum) are present, and there are gypsum intercalations (locally in considerable quantities). According to SCHWERD (1974) the carbonate rocks of the Lower Alpujarride Lujar and Gádor units represent «... sediments in part with a terrigeneous influence from a warm, shallow water environment, mainly lagoonal, sheltered from the open sea (similar to ultra-back reef)» (literal translation from German). ROEP (1972) is of the opinion that the lower member of the lower psammite-pelite sequence of the Malaguide Complex in the Vélez Rubio represents the «lower part of a coarse grained alluvial fan, laid down in front of a mountainous region»; the higher part is inferred to be «a fluviatile sequence merging into a shallow marine or lake deposit». According to ROEP (op. cit.) the rocks of the higher sequences have most probably been deposited under shallow marine conditions, the carbonate rocks at least in part representing algal mats. JACQUIN (1970) assumes that the rocks of the pelite-psammite sequences of the Alpujarride complex in the Sierra de Gádor have been deposited under very shallow water and locally emergent conditions.

Remarks on the Betic paleogeography

Several reconstructions have been proposed for the paleogeography of the Betic realm in Triassic time (see reviews in EGELER & SIMON, 1969 a, b; KAMPSCHUUR & RONDEEL, 1975). Based on the (Permo-)Triassic lithostratigraphy and on tectono-metamorphic and geophysical data, SIMON et al. (1976) suggested that the areas of deposition of the rocks now constituting the tectonic complexes originally had the following relative disposition from NE (E) to SW (W): Ballabona-Cucharón realm - Nevado-Filabride realm - Lower Alpujarride realm - Higher Alpujarride realm - Malaguide realm.

The lithologic development of the (Permo-)Triassic of the Ballabona-Cucharón Complex shows marked affinities to that of the Subbetic Zone (e.g. large quantities of gypsum and diabases); furthermore *Costatoria kiliani* (SCHMIDT) and *Gervillia* (cf.) *joleaudi* SCHMIDT have only been found in the Ballabona-Cucharón Complex and in the Subbetic and Prebetic Zones. This suggests that the rocks of the Ballabona-Cucharón Complex and of the Subbetic Zone were deposited in one major paleogreographic area.

The microfaunal content of the Betic sequences is consistent with this general concept. The ostracodes from the carbonate rocks of the Ballabona-Cucharón Complex indicate a more hypersaline (lagoonal) environment com-and *Hungarella,* do not occur. Many ostracode faunas indicate a more or less hypersaline environment (KOZUR et al., 1974) (3). Most samples contain euryhaline ostracode faunas of very shallow water environment. Only the samples pared with that of the rocks of the Alpujarride and Malaguide Complexes. In the Ballabona-Cucharón Complex Tethyan faunal elements, with the exception of *Reubenella fraterna* (a strongly euryhaline species), have not been found. Other faunal elements, indicating a connection with the «more open» sea and the Dinarian and Austroalpine faunal provinces, have been found only in rocks of the Lower and Higher Alpujarride Subcomplexes and of the Malaguide Complex (e.g. *Kerocythere tuvalica, K. reticulata, Metapolygnathus mungoensis, Clypeina besici*). In this respect the Orihuela unit shows affinities to the LowerAlpujarride Subcomplex (occurrence of *Kerocythere* and some other ostracodes unknown from the Ballabona-Cucharón Complex). Water depths of more than 50 metres, indicated by associations with abundant *Acratina,* are only known from the Lower and Higher Alpujarride Subcomplexes. Furthermore, ammonoids have, with the exception of one problematic finding in the Ballabona-Cucharón Complex, only been found in the Lower Alpujarride Subcomplex, algae only in the Lower and Higher Alpujarride Subcomplexes and in the Malaguide Complex and the lammelibranch *Lyriomyophoria betica* (HIRSCH) —locally in large quantities— in the Lower and Higher Alpujarride Subcomplexes and in the Orihuela unit (4).

Tectonic implications

The detailed stratigraphies established with the aid of microfauna have proved very useful in tectonic interpretation, as the following examples show: 1) It has been proved with the aid of microfauna that the Ballabona-Cucharón Complex of the Sierra del Puerto (to the south of Murcia) has a far more complicated structure than originally assumed (KAMPSCHUUR, 1972 b; KOZUR et al., 1974), 2) SIMON (1963) initially assumed that the Romero unit (and equivalents) and the Carrascoy unit (and equivalents) represented two major «independent» tectonic units in the Ballabona-Cucharón Complex, the rock sequences of which had approximately the same age. He subsequently ventured the hypothesis that the rock sequences of the two units originally belonged to a continuous stratigraphic succession, separated by «décollement» (SIMON, 1966 b). This was verified by KOZUR et al. (1974) with the aid of microfauna.

These and other examples show that microfaunal investigation of the (Permo-)Triassic sequences represents an integral part of the stratigraphic and tectonic study of the Betic Zone.

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(4) In the region to the south of Serón (sierra de los Filabres), *Lyriomyophoria betica* is representad in carbonate rocks attributed to the Ballabona-Cucharón Complex (Doctor. L. LEINE, pers. com., see also KOZUR et al., 1974). On the basis of recent investigations in adjoining areas to the west (Alcontar region and Sierra de Baza), the possibility is envisaged that these carbonates belong to a Lower Alpujarride unit.

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