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NORTHEASTERN PART OF THE
SIERRA DE ESPUNA
Sheet ALCANTARILLA

26 - 37

## INTRODUCTION

The Sierra de Espuña, a section of which occupies the SW part of this hoja, is in its geological sense the mountainous area of Paleozoic and Mesozoic rocks comprised between the Rio de Pliego in the northwest and the villages of El Berro, Alhama de Murcia, Totana and Aledo. Its geology was studied in the summer of 1972 by W. Kampschuur and C.W. Langenberg as part of the MAGNA-project. Previously the area was studied by a small group of students of the University of Amsterdam in the summer of 1970. The present work is by M.E. Rondeel. It is mainly based on these studies.

Geological setting. - The Sierra de Espuña occurs in the Betic Zone s.s., the internal zone of the Betic Cordilleras, where the rocks, affected by the alpine orogeny, are mainly of Triassic and older age, and where alpine metamorphism has been active. In the Betic Zone several nappe complexes can be distinguished (Egeler & Simon, 1969), viz. from above to below: the Malaguide complex; Alpujarride complex; Ballabona-Cucharón complex; Nevado-Filabride complex. The rocks of the Sierra de Espuña are usually considered to pertain to the Malaguide and Alpujarride complexes.

The Sierra de Espuña is composed of a number of overthrust tectonic units. The recognition of this fact for the first time appears in the 1929 publication of Fallot. The essentials of the subdivision have hardly been challenged since. The lower units largely contain Permo-Triassic and Triassic material. They occupy the southern part of the Sierra, mainly the area south of the Rio Espuña. They are extensively represented in this hoja, as on the adjoining hojas Lorca (25-38) and Totana (26-38). The higher units consist of Jurassic, Cretaceous and Tertiary material in addition to Permo-Triassic and Triassic deposits. The Jurassic rocks form the high summits of the Sierra de Espuña, north of Rio Espuña. They cover large areas of this hoja.

The map of Fig. 1 shows the geological subdivision of the Sierra de Espuña in relation to the various hojas de la Mapa geologico nacional and to the main topographic features. The tectonic units figuring on this map are, from tectonic high to low:

| | |
|---|---|
| Morron de Totana units | (t) |
| Atalaya unit | (at) |
| Morron Largo unit | (l) |
| Santa-Yechar unit | (s) |
| Los Guillermos unit | (g) |
| Los Molinos unit | (m) |



Following the aforementioned scheme of the Betic Zone, the Los Molinos and Los Guillermos units are referred to the Alpujarride complex and the Atalaya and Morron de Totana units to the Malaguide complex. The Morron Largo and the Santa-Yechar units are of intermediate character: lithologic development and degree of metamorphic recrystallization are of a transitional character between typically Alpujarride elements and typically Malaguide elements. In the present study these 'intermediate units' are provisionally grouped with the tectonically higher units, thus within the Malaguide complex. In fact, the stratigraphic development of each of the tectonic units in the Sierra de Espuña is 'intermediate' between the overlying and the underlying unit, resulting in a gradual change from Los Molinos unit to Morron de Totana unit.

Previous work. - Fallot synthesized the large scale structure of the Sierra de Espuña in his 1945 publication, herein expressing his doubts on the presence (or absence) of large scale recumbent folds and herewith on the origin of the overthrust units. The lowermost unit is compared with the Alpujarrides, higher ones are compared with the Betic of Malaga.
During the period 1960-1965 several publications appeared on the Sierra de Espuña. In the case of those of Trigueros and of Navarro, the results are - apart from a more detailed presentation of the geological map - comparable with those of Fallot.
Since that time appeared the thesis of Paquet (1969) that includes a description of the entire mountain chain. He distinguished the following overthrust units, hereafter indicated in relation to those recognized on our map (Fig. 1).

| PAQUET (1969) | 20933 | this report |
|---|---|---|
| Morron de Totana unit | | Morron de Totana units |
| | | Atalaya unit |
| Morron Largo unit | | Morron Largo unit |
| Santa unit<br>Yechar unit | | Santa-Yechar unit |
| Los Molinos unit | | Los Guillermos unit<br>Los Molinos unit |

The Alpujarride character of the rocks incorporated in the Los Molinos unit and the Malaguide character of those of the Atalaya and Morron de Totana units have never been challenged. The units inbetween are usually said to be of Malaguide or of "intermediate" character.

## Stratigraphy



### SANTA-YECHAR UNIT

This unit occupies the southeastern part of the Sierra de Espuña over a length of 12 kms. It comprises two formations (fig. 2):

top: Yechar formation - $T_A^S$

Fontanar formation - $P\text{-}T_A^S$

#### Fontanar formation ($P\text{-}T_A^S$)

Lithology. - The sequence is built up of purple red, reddish brown and green argillites, of red and green slates and of sandstones and quartzites which are mostly red of reddish brown coloured, but which also appear in grey, greenish and white. The quartzites are very thin- to thick-bedded. Conglomerates are present in two varieties, i.e. a red variety rich in white quartz, black chert, brownish quartzite and red jasper pebbles ("Verrucano-type" conglomerate) and a greyish variety rich in carbonate fragments (carbonate pebble conglomerate). The red conglomerates are intercalated in the basal part of the formation. The carbonate pebble conglomerates occur higher in the sequence. The uppermost part of the formation contains some intercalations of thin-bedded carbonate layers of yellow to greyish colour. The slates exhibit a slaty cleavage, occasionally parallelled by quartz veinlets.

Fossils. - None

Contact relations. - The basal contact of the Fontanar formation always is of tectonic nature. The contact with the overlying Yechar formation is stratigraphic with carbonate layers intercalated in the top part of the Fontanar formation.

Thickness. - The maximum exposed thickness is estimated at about 80 m.

Age. - On the basis of lithologic correlation with the Carrasquilla formation of the Atalaya unit and with the Garita formation of the Morron de Totana units, the Fontanar formation is attributed to the Permo-Triassic.

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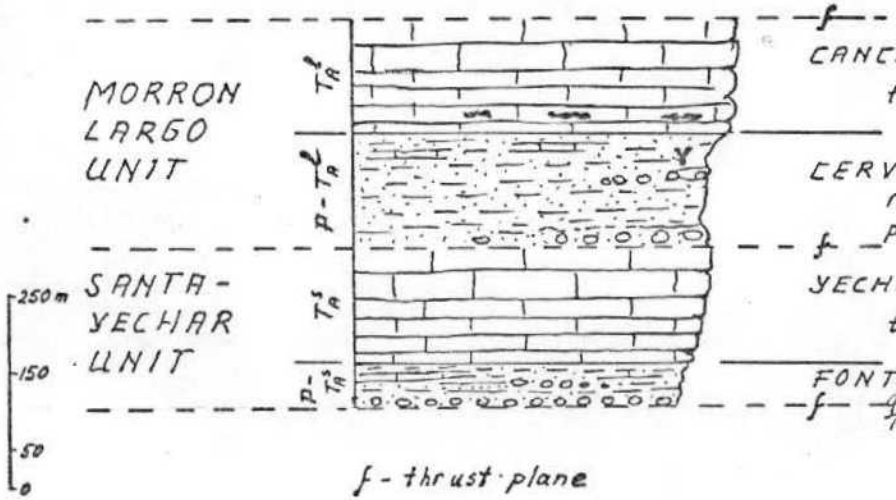
Fig. 2 - COMPOSITE COLUMNAR SECTION OF THE "INTERMEDIATE" UNITS




CANCARI FORMATION: carbonate rocks (dark grey to black; medium- to thick-bedded); silex in lower part. TRIASSIC

CERVANTES FORMATION: argillites (red, reddish brown, green); quartzites (red, reddish brown, grey, green and white); intercalated grey conglomerates; in upper part carbonate intercalations and gypsum; in basal part red conglomerates PERMO-TRIASSIC

YECHAR FORMATION: carbonate rocks (dark grey to black; medium- to thick-bedded) TRIASSIC

FONTANAR FORMATION: argillites and slates (red, reddish brown, green); quartzites (red, reddish brown, grey, green, white); intercalated grey conglomerates; in upper part intercalated carbonate rocks; in basal part red conglomerates. PERMO-TRIASSIC

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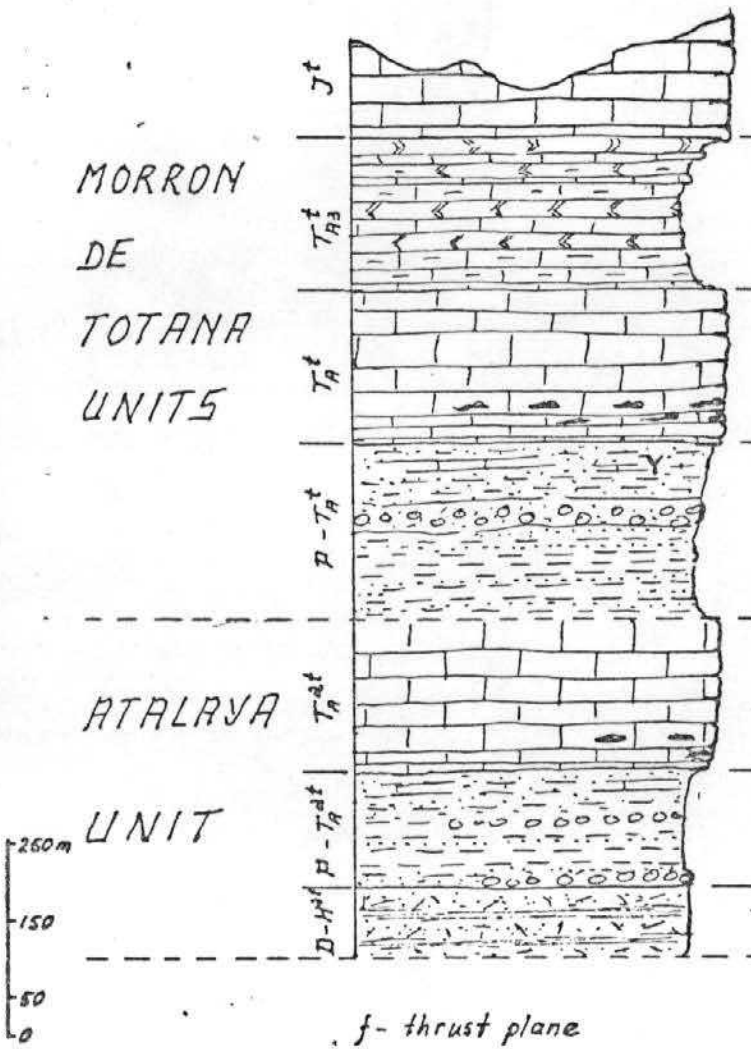
Fig. 3 - COMPOSITE COLUMNAR SECTION OF THE MALAGUIDE UNITS s.s.




ESPUÑA FORMATION: carbonate rocks — JURASSIC

SANATORIO FORMATION: carbonate rocks, marly carbonate rocks (yellow-green; thin-to medium-bedded); alternating gypsum beds (white to dark grey). — UPPER TRIASSIC

LEIVA FORMATION: carbonate rocks (grey to light grey; very thin- to medium bedded), often breccious; silex in lower part. — TRIASSIC

GARITA FORMATION: argillites (red, reddish brow, green); quartzites (reddish brown, red, grey; thin-to thick-bedded); intercalated grey limestone pebble conglomerate; in upper part carbonate layers (yellow to grey) with associated rauh wackes and gypsum. — PERMO-TRIASSIC

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LOBOS FORMATION: carbonate rocks (grey to dark grey; very thin- to medium-bedded), breccious; silex in lower part. — TRIASSIC

CARRASQUILLA FORMATION: argillites (red, reddish broun, green); quartzites (red, brown, whitish-yellow; very thin-to thick bedded); intercalated grey carbonate pebble conglomerate; in upper part carbonate layers (yellow to grey); in lower part red conglomerate. — PERMO-TRIASSIC

ALGARROBO FORMATION: grey wackes (olive-green; thin- to very thin-bedded); carbonak rock intercalations (olive-green to grey; (very thin bedded). — DEVONO-CARBONIFEROUS

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f- thrust plane

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Yechar formation ($T_A^s$)

Lithology. - The formation consists essentially of dark-grey to almost black carbonate rocks with a massive habit. It is medium- to thick-bedded, except for its basal part in which thin-bedded limestones occur. The rocks are often strongly breccious. Light brown chert concretions are sporadically found in the lower part of the formation.

Fossils. - Only some indeterminable organic remains have been found.

Contact relations. - The upper contact of the Yechar formation is of tectonic nature. It represents a thrust-plane at the base of the Atalaya unit, transecting the layering of the Yechar carbonate rocks.

Thickness. - The formation attains a thickness which is about 150 m maximally. The character of the thrustplane at the base of the overlying unit is the reason for the presence of much smaller thicknesses.

Age.- The rocks are dated in analogy with the carbonate rocks of the other tectonic units in the area (see Atalaya unit). They are supposed to be Triassic.

## MORRON LARGO UNIT

The Morron Largo unit is only present on this hoja in the most extreme SW corner. Two separate formations are distinguished (fig.2)

top: Cancari formation - $T_A^l$

Cervantes formation - P-$T_A^l$

Only the Cancari formation occurs on this hoja.

Cancari formation ($T_A^l$)

Lithology. - The sequence strongly serembles that of the Yechar formation. It likewise consists of essentially dark-grey to almost black carbonate rocks, which are often breccious. The sequence is medium- to thick-bedded, except for the lower part of the formation in which well-bedded levels occur. The lower part of the sequence occasionally contains brown chert concretions and levels, which seem to be indicative of the stratification.

Fossils. - None

Contact relations. - The upper contact is tectonic. The formation is truncated by the thrust-plane at the base of the Atalaya unit. The lower contact is stratigraphic. It is not exposed on this hoja.

Thickness. - The maximum exposed formation thickness is 150 m.

Age. - The rocks are dated as Triassic, in analogy with the carbonate rocks of the Atalaya unit with which they are correlatable on lithologic grounds.

## ATALAYA UNIT

The unit is represented on this hoja over large areas. The Atalaya unit consists of three formations (fig. 3), which are:

top: Lobos formation - $T_A^{at}$

Carrasquilla formation - $P\text{-}T_A^{at}$

Algarrobo formation - $D\text{-}H^{at}$

Rocks of the Algarrobo formation have not been found on this hoja.

### Carrasquilla formation ($P\text{-}T_A^{at}$)

Lithology. - The sequence consists of argillites in a light red, reddish brown and light green colour and of well laminated to thick-bedded quartzites which are of a red, brown or whitish-yellow appearance. Intercalated are grey carbonate pebble conglomerates with pebbles of carbonate rock and of quartzite. The basal part of the formation directly on top of the greywackes of the Algarrobo formation, contains red conglomerate levels (Verrucano-type) in which the rockfragments mainly are quartzite, chert and carbonate rock. The higher parts of the formation contain yellow to grey intercalations of carbonate rock.

Fossils. - None

Contact relations. - The lower contact is of tectonic nature since the rocks of the Algarrobo formation are missing and the Carrasquilla formation thus is in direct contact with rocks of underlying units. The contact is with rocks of the Yechar and of the Cancari formation. The upper contact is of stratigraphic nature, though be it often disturbed.

Thickness. - The maximum exposed thickness is in the order of 150 m. Where thicknesses are larger, it is the result of imbrication.

Age. - On the basis of lithologic correlation, the age of the formation can be said to be comparable to that of the Garita formation of the Morron de Totana units that is situated under rocks of Liassic age belonging to the Espuña formation. Since the Carrasquilla formation furthermore lies on top of the Algarrobo greywackes of inferred Devono-Carboniferous age, it can be dated as Permo--Triassic.

In the strongly tectonized zone along the Rio de Vélez - and its continuation towards Lorca - occur Malaguide rocks in an identical stratigraphic position. These rocks have been incorporated in the so-called Saladilla formation which in its most complete development is thought to consist of five members (Roep, 1972). They are, from top to bottom:

E top dolomite member (max. 40 m)
D yellow conglomeratic member (max. 115 m)
C intercalated dolomite member (max. 65 m)
B variegated sandstone member (max. 350 m)
A red conglomeratic member (max. ± 325 m)

The formation thickness is reported to be 780 m as a maximum. As the result of intense alpine tectonization, incompleteness of the section is rather rule than exception. Fossils have not been recorded. Comprised between Paleozoic rocks of the 'greywacke formation' and early Liassic sediments, most authors favour a Permo-Triassic age of the members a through D, or their equivalents; member E is usually said to be Triassic in age. The Carrasquilla formation is correlatable with the members A through D; the Lobos formation with member E.

Lobos formation ($T_A^{at}$)

Lithology. - The sequence consists of grey to dark grey, very thin- to medium-bedded carbonate rocks, containing chert in its lower part.

Fossils. - A thin-section from the higher part of the formation revealed some organic remains of undeterminable origin.

Contact relations. - The lower contact is of stratigraphic nature, the upper is tectonic against rocks of the Morron de Totana units.

Thickness. - The maximum exposed thickness amounts to ca. 200 m. Due to tectonics, the exposed thickness decreases from W to E on this hoja.

Age. - The formation is correlatable with the Leiva formation and with member E of the Saladilla formation. It is therefore considered to be of Triassic age.

## MORRON DE TOTANA UNITS

The Morron de Totana units cover large areas in the SW part of the hoja. The units consist of three pre- Jurassic formations (fig. 3), which are:

top: Sanatorio formation - $T^t_{A3}$

Leiva formation - $T^t_A$

Garita formation - $P\text{-}T^t_A$

The lower Morron de Totana units exclusively contain rocks of the Leiva and of the Garita formation; younger deposits are absent. In the higher units participate rocks of the Sanatorio formation and of the Jurassic Espuña formation.

### Garita formation ($P\text{-}T^t_A$)

Lithology. - The sequence is almost identical to that of the Carrasquilla formation. In addition to reddish and brownish, sometimes greenish argillites, it contains red, brownish and yellowish quartzites. Limestone pebble conglomerates are quite frequently found. The top of the formation is characterized by yellow, greenish and grey carbonate beds with yellowish and orange-coloured rauhwackes, amidst reddish and greenish argillites. Gypsum is associated with these rocks.

Fossils. - None

Contact relations. - The lower contact with the carbonate rocks of the Atalaya unit is of tectonic nature. The contact with the overlying carbonate rocks of the Leiva formation is stratigraphic. It often is strongly tectonically disturbed, especially in the area WNW of Alhama de Murcia.

Thickness. - The maximum exposed thickness is in the order of 220 m. Strong tectonic reduction is observed in the area WNW of Alhama de Murcia. More to the W, the exposed thickness is much larger as the result of imbrications, restricted to the Garita formation.

Age. - On the basis of lithologic correlation with the Carrasquilla formation and of its position below Liassic rocks of the Espuña formation, the Garita formation is dated as Permo-Triassic.

Leiva formation ($T_A^t$)

Lithology. - The formation consists of light grey to grey carbonate rocks which are thin- to mediu-bedded. The rocks usually are lighter coloured than those of the comparable Lobos formation of the Atalaya unit. The rocks are locally breccious. Light brown chert intercalations are of frequent occurrence in the lower part of the formation. They mostly are parallel to the layering of the rock. The basal part of the formation is formed of thin-bedded grey carbonate rocks, occasionally with argillite interlayerings.

Fossils. - In thin section, the rock frequently reveals undeterminable fossil remains.

Contact relations. - The lower contact is with the Garita formation. It originally is stratigraphic. The upper contact with the Sanatorio formation is stratigraphic as well. In the area WNW of Alhama de Murcia the upper contact ~~against~~ is a thrust contact against rocks of the Garita formation of the next higher unit.

Thickness. - The maximum formation thickness is estimated at 200 m. Thicknesses are usually smaller, especially in the area WNW of Alhama de Murcia, where a thrust plane forms the upper contact of the formation.

Age. - The formation is dated as Triassic on basis of comparison with other rock units in the area, and on basis of its stratigraphic position below the Espuña formation in which Liassic fauna is found.

Sanatorio formation ($T_{A3}^t$

Lithology. - The sequence consists of light green to yellow and pale grey coloured carbonate rocks which are thin- to medium-bedded and which are often marly. They alternate with white to dark grey layers of gypsum. Rauhwackes are widespread. Other rock types are only locally represented.

The occurrence of gypsum, sometimes in extremely thick layers, is the reason for the chaotical appearance of the formation.

Fossils. - None

Contact relations. - The contact with the Leiva formation and with the Espuña formation is of stratigraphic nature, though often tectonically influemced. In the area W and NW of El Berro, the lower contact of the formation is tectonic against rocks of the Espuña formation due to tectonic doubling.

Thickness. - The maximum exposed thickness is about 200 m. The stratigraphic thickness can hardly be estimated due to the chaotic appearance of the formation which results from the mobility of the gypsum and the incompetent behaviour of the entire formation.

Age. - Lack of fossils hamper the dating of the formation. It is, however, situated under Liassic rocks. Triassic age is therefore most likely, especially when considering the stratigraphic position with respect to the older formations. Since gypsum is held to have been deposited during the Triassic in two episodes only, i.e. during the Upper Triassic in Germanic development and during the lower Triassic in Alpine development, it is reasonable to assume an upper Triassic age for the rocks of the Sanatorio formation.

# Tectonics



As mentioned already in the foregoing, the Sierra de Espuña comprises a large number of tectonic units of overthrust character, i.e. (from below to above): the Los Molinis unit and the Los Guilermos unit, representing the Alpujarride complex, the Santa-Yechar unit and the Morron Largo unit, which are 'intermediate units' but which have been conveniently grouped within the Malaguide complex s.l., and the Atalaya unit and the Morron de Totana units which clearly belong to the Malaguide complex.

The rock sequences constituting these tectonic units have been effected by at least three clearly distinguishable phases of alpine deformation. Pre-alpine deformation cannot be proven to have affected the eldest rocks in the area.

The eldest structure discernable on meso- and microscopic scale within rocks of pelitic origin is a slaty cleavage. It is commonly well-marked and in the phyllitic rocks of the Los Molinos unit, it takes the form of a conspicuous schistosity. In a number of folds, usually of isoclinal character, the cleavage can be observed to be of the axial plane type. Folds are, however, few. In the carbonate rocks, folding attributable to this first deformation phase ($D_1$) has been observed in one case only.

Generally speaking, $D_1$ appears to have been accompanied by low-grade synkinematic metamorphism.

The first phase cleavage and associated metamorphism are discontinuous at the contacts of the tectonic units. It is concluded that thrusting along these contacts took place subsequent to $D_1$ since metamorphism of the rocks of the individual units could have only occurred under physical conditions which require a certain tectonic depth. This depth is thought to be attained in what is indicated as the "initial pile of nappes". Cleavage formation and metamorphism thus occurred during or after the empilement of a number of tectonic units. Thrusting resulting in this initial pile is here tentatively linked with cleavage formation.

It may be recalled that Egeler & Simon (1969) stressed the occurrence in the Betic Zone of at least two different phases of overthrust movements, the first of which took place in an early stage of the orogenic evolution and which resulted in the development of a pile of nappes with which generation of the kinematic metamorphism

was connected. The second phase disturbed the 'initial pile' of nappes. It brought about the discontinuity of the metamorphism at major thrust planes since translations of considerable magnitude were effected.

The reconstruction of the 'initial pile' of units in the Sierra de Espuña is not possible from the data available. It is not even possible to state whether contacts between units actually represent rethrusted first phase contact or whether they were formed during the second thrust movement. To illustrate this point, the contact is considered between the Morron Largo unit and underlying units which most certainly is of secondary character, as is the contact between Atalaya unit and underlying units. The evidence is found in the fact that these contacts cut-off the underlying units. Whether they are rethrusted first phase thrust contacts cannot be proved. They are, however, considered as such. It is suggested that thrust contacts within the units are of the second phase.

The low-angle thrust planes at the contacts of the units represent a second phase of deformation ($D_2$), responsible for strong tectonic reduction, occasionally causing wedging out of entire formations.

A third phase of deformation ($D_3$) is reflected in the folding of the thrust-planes produced during $D_2$, a phenomenon well-illustrated in the cross-sections. These folds are of an open type, and on a macroscopic scale. On mesoscopic scale, the deformation phase is thought to be reflected by weak refolding of the cleavage and of the axial planes of first phase folds. These are open folds.

Upthrusts in southern direction are locally found. They displace the second phase thrust-planes.

Several normal faults formed subsequent to the thrust movements. They appear in two sets which normally are oriented NNE-SSW and NW-SE. The faults dip very steeply.

## Metamorphism



The rock sequences of all of the tectonic units of the Sierra de Espuña show the effects of alpine metamorphism. As mentioned already, it is a synkinematic metamorphism, related to the first phase of alpine deformation. The grade is low; it never surpasses the lowermost subfacies of the greenschist facies.

Decrease in the degree of metamorphic recrystallization with decreasing tectonic depth is reflected in the descriptive terms used for the rocks of pelitic origin, i.e. 'phyllites' in the Los Molinos unit, 'slates' in the Los Guilermos unit, 'argillites and slates' in the Santa-Yechar unit and 'argillites' in the Morron Largo unit, Atalaya unit and Morron de Totana unit.

Recrystallization mostly is incomplete, as shown by the preservation of grains of sedimentary origin, even in rocks of the most highly metamorphic unit, i.e. the Los Molinos unit.

Neocrystallized minerals include quartz, colourless mica, chlorite and ore material. In the carbonate rocks one often finds idioblastic albite crystals which are considered to be diagenetically formed; they are not the product of metamorphism.

The pre-alpine rocks of the Algarrobo formation of the Atalaya unit witness a degree of metamorphism equivalent to that deduced to have affected the alpine rocks of this unit. A hercynian metamorphism in this area can therefore not be concluded to.

## Geological history



Only the stratigraphic column of the Atalaya unit has the possibility to furnish information about the pre-alpine geological history of the region now represented by the Sierra de Espuña. The other tectonic units are lacking in pre-Permo-Triassic deposits. The Devono-Carboniferous greywackes of the Algarrobo formation, however, appear to be overlain by the Permo-Triassic sequence without any appreciable angularity. Differences in degree of metamorphism or in tectonic style between rocks on opposite sides of this contact could not be concluded to either.

The "Verrucano-type" conglomerates situated in the basal part of the Permo-Triassic sequences witness a sudden change in influx in the basin of sedimentation and a sudden change in mode of deposition. The underlying rocks are deposited by turbidity currents and the "Verrucano-type" conglomerates are supposed to be laid down in alluvial fans. This might be the only evidence for hercynian diastrophism and uplift.

Conditions of deposition during the Permo-Triassic are thought to be fluviatile and shallow marine (and probably lake) as discussed by Roep (1972). The overlying carbonate rocks are marine.

It is of importance to note that the stratigraphic columns of the Permo-Triassic to Triassic rock sequences of all of the units of the Sierra de Espuña reflect an abrupt change of depositional conditions during the Triassic from pelitico-quartzitic to carbonate, which is characteristic for a major part of the units of the Betic Zone.

It has been preferred to indicate all of the Triassic sediments as having been deposited in a single facies, i.e. the Alpine facies. This has been done since the MAGNA-mapping necessitates a choice to be made between Triassic sediments deposited in Alpine or in Germanic facies, whereas the criteria for distinguishing between the two are quite arbitrary. It must be noted that especially the litho-stratigraphic development of the higher of the Morron de Totana units justifies the use of the term "Germanic facies" (see however Egeler et al., 1972). Nothing is still known about the fauna present in the carbonate rocks of the Sierra de Espuña. Is it germanic or alpine, or does it belong to a separate betic faunal province, and are these provinces equivalent with what can be named Germanic, Alpine and Betic facies? So many

questions being unanswered, it illustrates the per force choice for an Alpine facies.

With the exclusion of the higher of the Morron de Totana units, no post-Triassic deposits are supposed to be present in the tectonic units. Several hypothesis can be ventured for this absence, which are i.) "tectonic transgression" during the Jurassic, ii.) a prolonged period of non-deposition during the younger Mesozoic and parts of the Tertiary, and iii.) complete erosion of a relatively thin sequence of post-Triassic deposits.

The close analogies in the stratigraphic development of the structural units of the Sierra de Espuña, especially the analogies between adjoining units, suggest a close paleogeographic relationship. Taking into account the present superposition, a paleogeographic arrangement:
Malaguide realm (Morron de Totana units + Atalaya unit) - Morron Largo unit - Santa-Yechar unit - Alpujarride realm (Los Guilermos + Los Molinos units) seems logical. In view of the lack of knowledge concerning the direction of transport of the units, the question whether the Malaguide realm was situated north of the Alpujarride realm remains unanswered.

The units are thought to have been emplaced during at least two separate tectonic phases characterized by important horizontal translations. During the first, the units individualized. This phase is considered to be syn- or premetamorphic (and syn- or pre-cleavage), as reflected in the general decrease in metamorphic grade towards higher units. Thrusting during the second phase caused strong tectonic reduction and discontinuity in degree of metamorphic recrystallization at the contacts of units. Subsequently, large scale folding influenced the units.

Dating of the thrust-phases and of the other deformations is very inaccurate since in the southern Sierra de Espuña the youngest rocks affected are of Jurassic age and the oldest non-affected sediments are of younger Neogene age. Data from the northern Sierra de Espuña lead to a more precise dating.

In a late stage of the orogenic history, the Sierra de Espuña has been actively engaged in faulting, mostly normal faulting. Some of the faults affect the younger Neogene deposits. Since younger Neogene deposits cover some high parts in the Sierra de Espuña, it is tempting to explain its occurrence by faulting.

## Literature.-



Dupuy de Lôme & Sánchez Lozano - Mapa geológico de España: Explicación de la hoja 954, Totana. Inst.geol.min. Esp., 70 p. (1958).

Dupuy de Lôme, E. & Trigueros, E. - Mapa geológico de España. Explicación de la hoja 932, Coy. Inst.geol.min.Esp., 96 p.(1958).

Egeler, C.G. & Simon, O.J. - Sur la tectonique de la zone bétique (Cordillères bétiques, Espagne). Verh.Kon.Ned.Akad.Wetensch., 1ste reeks, deel XXV, No.3, 90 p. (1969).

Egeler, C.G., Rondeel, H.E. & Simon, O.J. - Considerations on the grouping of the tectonic units of the Betic Zone, southern Spain. Est.geol. XXVII, p.467-473 (1971).

Fallot, P. - Esquisse géologique du massif de la Sierra Espuña (prov.de Murcie). Bol.r.Soc.esp.Hist.nat., XXIX, p.199-215 (1929).

Fallot, P. - Estudios geologicos en la zona subbetica entre Alicante y el Rio Guadiana Menor. Inst."Lucas Mallada" C.S.I.C., Madrid, 719 p. (1945).

Fallot, P. - Les Cordillères bétiques. Est.geol., 8, p.83-172(1948).

Fernex, F. - Remarques sur la tectonique du Bétique de Malaga oriental de Lorca-Velez Rubio (Espagne méridionale).Arch.Sc.15, p.333-361 (1962).

Fernex, F. - Tectonique et paléogéographie du Bétique et du Péni-bétique orientaux. Transversale de la Paca-Lorca-Aguilas (Cordillères Bétiques, Espagne méridionale). Thèse Paris, 576 p.(1968).

MacGillavry, H.J., Geel, T., Roep, Th.B. & Soediono, H. - Further notes on the geology of the Betic of Málaga, the Subbetic and the zone between these two units, in the region of Vélez Rubio (Southern Spain) - Geol.Rundsch., 53, p.233-256 (1963).

Navarro, A. & Trigueros, E. - Estudio geologico del borde oriental de la Sierra Espuña. Notas y Comuns. Inst.geol.min.Esp. 70, p. 205-210 (1963).

Paquet, J. - Age de mise en place des unités supérieures de la Sierra de Espuña et de la partie méridionale du Subbétique (Province de Murcie, Espagne). Bull.Soc.géol.France (7), VIII, p. 946-955 (1966).

Paquet, J. - Les différentes phases orogéniques des Cordillères bétiques dans l'Ouest de la Province de Murcie, Espagne méridionale. XXIII, Int.geol.Congress, 3, p.43-48 (1968).

Paquet, J. - Étude géologique de l'Ouest de la Province de Murcie (Espagne). Mém.Soc.géol.France, 111, 270 p.(1969).

Roep. Th.B. - Stratigraphy of the "Permo-Triassic" Saladilla formation and its tectonic setting in the Betic of Málaga (Vélez Rubio region, SE Spain). Proc.Kon.Ned.Ak.Wetensch., Series B, 75, p.223-247 (1972).

Soediono, H. - Geological investigations in the Chirivel area, province of Almeria - south-eastern Spain, Thesis Amsterdam, 144 p (1971).

Templado Martínez, D., Meseguer Pardo, J., Fernández Becerril, Y.M. & Abbad y Berger, M. - Mapa geológico de España, Explicación de la hoja 933, Alhama de Murcia. Inst.geol.min.Esp., 71 p.(1958).

Trigueros, E. & Navarro, A. - Estudio geológico de los términos de Aledo y Totana (parte norte)(prov.Murcia). Notas y Comuns. Inst. geol.min.Esp., 61, p.3-20 (1961).

Trigueros, E. & Navarro, A. - Le Trias des Sierras de Espuña et de Chichar (ou de Tercia)(province de Murcie, Espagne). In Livre à la mémoire du Professeur P.Fallot, I, p.163-168, Mém.h.série Soc.géol.France (1960-1962).

Vries, W.C.P.de & Zwaan, K.B. - Alpujarride succession in the central Sierra de las Estancias, Province of Almería, SE Spain. Proc.Kon.Ned.Ak.Wetensch., Serie B, 70, p.443-453 (1967).