-20913

Sheet ORIHUELA

27 - 36

used in text		mapa
very thickly bedded	> 100 cm	= capas masiva y bancos
thickly bedded	100-30 cm	= capas gruesos
mediumly bedded	30-10 cm	= capas medianas
finely bedded	< 10 cm	= capas finos
laminated	10-3, 3-1, < 1 cm	= gruesos, medianas y finos laminas

I N T R O D U C T I O N

The Sierra de Orihuela and the Sierra de Callosa de Segura are isolated mountain ranges trending approximately SW-NE. The geology of the central and eastern part of the Sierra de Orihuela is in course of investigation by Prof.Dr.C.G.Egeler, Dr.H.E.Rondeel and Dr. O.J.Simon of the staff of the Department of Structural Geology of the Geological Institute of the University of Amsterdam. This work forms part of a detailed study of the tectonics of the structural complexes of the eastern Betic Zone. The western part of the mountain range is being studied by Mr. A.A.van Winkoop, and the adjoining region, between Monteagudo, Santomera and the Embalse de Santomera, by Mr. A.de Boer. The geology of the Sierra de Callosa de Segura was studied in the summer of 1972, by Dr. W.Kampschuur as part of the MAGNA-project. The present manuscript is based on the work of the above-mentioned persons. The compilation and adaption was made by O.J. Simon.

Geological setting. - The Sierras de Orihuela and Callosa de Segura form part of the Internal Zone of the Betic Cordilleras, which is generally indicated as Betic Zone. In a recent publication by Egeler & Simon (1969a; see also 1969b) the broad outlines of the Betic Zone are given. Within its central and eastern part four major groups of tectonic units are distinguished, viz. (from below to above): (1) the Nevado-Filabride complex, (2) the Ballabona--Cucharón complex, (3) the Alpujarride complex, and (4) the Malaguide complex.

The investigations of the afore-mentioned members of the Amsterdam team have resulted in the distinction of several tectonic units within the sheet Orihuela. In the Sierra de Orihuela, and the adjoining region to the west, the following units have been recognized: (1) the Tunnel unit, (2) the Bermejo unit and (3) the Orihuela unit. The Orihuela unit tectonically overlies the Tunnel and the Bermejo units. The relationship between the two last-mentioned units is still uncertain. In the Sierra de Callosa de Segura two tectonic units are distinguished, viz. (from below to above): (1) the Redovan unit and (2) the Callosa unit. The relationship between the units of the Sierra de Orihuela and those of the Sierra de Callosa de Segura is unknown. All the afore-mentioned units - on account of their lithological development - are referred to the Ballabona-Cucharón complex.

According to Nicklès(1904,p.245 and p.246)the Sierra de Callosa de Segura consists of Paleozoic rocks.

Some isolated rock sequences occur, which could not be simply incorporated in one of the afore-mentioned units. On the geological map they are provisionally indicated as "undifferentiated rock sequences". On litho-stratigraphical grounds they are considered to belong to the Ballabona-Cucharón complex. A possibly exception is the outcrop to the NW of Benferri, which may represent the Malaguide complex.

Previous work. - When in 1970 the Amsterdam team started the systematic mapping of the Sierras de Orihuela and de Callosa de Segura, no detailed investigations within these regions had yet been carried out. Older publications reveal, however, considerable difference of opinion concerning the stratigraphy and tectonic position. Some examples may be mentioned.

On the geological map of Spain (scale 1:400.000; hoja 45, tercera edición) the rocks of the Sierras de Orihuela and de Callosa de Segura are indicated as "Triásico superior", and the sediments to the west and south-west of the Sierra de Orihuela as "Triásico inferior". Near Santomera an outcrop of "ofitas" is mentioned.

Brun (1909) gives the following succession for the rock sequences in the region between Monteagudo and Albatera:

(d)	"calcaires magnésiens"	approx. 100 m.	Keuper sup.
(c)	"série argilo-gréseuse"		Keuper
(b)	"calcaires fortement magnésiens"	at least 600 m.	Keuper inf.
(a)	"grès, schistes et calcaires gréseux"	150-200 m.	Raible ou un peu inférieur

Furthermore, Brun (op.cit.) mentions the presence of a "coulée importante de gabbros" within the afore-mentioned succession.

On the geological map of the province of Alicante (Novo y Chicarro, 1915) and of the Iberian Peninsula (edición 1919) the rocks of the mountain ranges in question are indicated as Triassic, with some isolated outcrops of "ofitas".

According to Staub (1934) a continuous section - ranging from the "Buntsandstein" up to and including the Liassic - can be studied in the Sierra de Orihuela. As to the litho-stratigraphical development he wrote (op.cit., p.291): "Es ist die schönste ostalpine Trias Spaniens, die jeder ostalpine Geologe ohne die geringsten Schwierigkeiten in das alpine Schema einordnen kann", and furthermore (op. cit., p.292): "Diese murcianische Triasfolge, vom Buntsandstein bis hinauf zum Rhät, ist am schönsten entwickelt in dem wilden Bergzug der Sierren von Orihuela, zwischen Murcia und Callosa de Segura.

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On the geological map of Spain and Portugal(1952)the rocks of the Sierra de Oruhuela and Sierra de Callosa de Segura are considered to be Triassic("Muschelkalk y Keuper"),with an occurrence of "rocas volcánicas".

On the geological map of the "Península ibérica,Baleares y Canarias" the rocks of the Sierra de Oribuela and Sierra de Callosa de Segura are indicated as belonging to the Triassic("Muschelkalk y Keuper").In the region between Monteagudo and the Sierra de Oribuela - besides Triassic rocks - the presence of "rocas metamorficas" is mentioned.

Die systematische Auflösung dieses prachtvollen Triasprofils wäre wohl eine der schönsten stratigraphischen Aufgaben im südlichen Spanien".

In a 1945 publication by Fallot, on the Subbetic Zone between Alicante and the rio Guadiana Menor, the rocks of the Sierras de Orihuela and Callosa de Segura are indirectly discussed. The presence is mentioned of "dolomías occuras de pátina leonada, calizas azul oscuro con pistas, de tipo claramente mediotriásico, asi como calizas más o menos cristalinas".

(edición 1951) On the geological map of Spain (sheet 913) the rocks of the Sierras de Orihuela and de Callosa de Segura, as well as most rocks outcropping to the west of the Sierra de Orihuela, are referred to the "Triásico" and specifically to the "Virgloriense". The minimum thickness of this sequence - which according to the authors of the explication of sheet 913 consists almost exclusively of "calizas magnesianas muy oscuras" - is indicated as 500 metres. "Pizarras" and "cuarcitas" of Permian age, with a minimum thickness of 300 metres, are described from the southern border of the Sierra de Orihuela, and from the southwesternmost part of the sheet. To the north of Orihuela, and to the west and north-east of Santomera "rocas hipogénicas (ofitas)" are mentioned. The contact between the carbonate sequence and pelite-psammite sequence is considered to be of tectonic nature.

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On the geological map of the province of Murcia (~~Brigueros & Navarro~~, scale 1:200.000, edición 1966) the rocks of the western Sierra de Orihuela and adjoining region to the west, are indicated as "Triásico-facies alpina-dolomias". The region towards the north of the road Espinardo-Santomera (comprising inter alia the Loma del Barranco Largo and the Loma los Cantalares) figures on the afore-mentioned map essentially as "Triásico-facies alpino-Triásico inf., Permiano-pizarras, areniscas, filitas". The Mina region is referred to the "Paleozoico inferior(epi/mesometamorfico)-silicatos, silice". Isolated outcrops of "rocas intrusivas (diabasas, ofitas) post-hercinicas, triasicas" are indicated along the southern border of the Sierra de Orihuela and in the region to the west of Santomera.

Simon (1967) claimes that the rocks of the Sierras de Orihuela and de Callosa de Segura have an essentially Upper Triassic age.

Opinions also differ with respect to the tectonic position of the rock sequences of the afore-mentioned mountain ranges. In the following table the different views are listed:

	Sierra de Orihuela + Sierra de Callosa de Segura
Staub (1926)	"Betische Kalkzone"
idem (1934)	"Murcia Decke"
Fallot (1930)	Penibetic
idem (1945)	"Elementos béticos"
idem (1948)	"Bétique de Málaga"
Blumenthal (1933)	"Betikum von Málaga"
idem (1950)	"Penibetische Randzone"
Durand Delga & Fontboté (1960)	Alpujarride complex
Simon (1963, 1964)	at least partly belonging to the "Almagro unit"*)
idem (1967)	"Almagro-Cucharón unit"*)
Egeler & Simon (1969a,b)	Ballabona-Cucharón complex

*) These elements are now incorporated in the Ballabona-Cucharón complex (see a.o. Egeler & Simon, 1969a).

Stratigraphy

Sierra de Orihuela and adjoining regions to the west and south-west

BERMEJO UNIT (see Fig. 1)

General statement

The Bermejo unit is exposed over extensive areas in the western Sierra de Orihuela and in the adjoining regions to the west and south-west. In the Sierra de Orihuela the Bermejo unit tectonically underlies the Orihuela unit. In the region between Monteagudo and the Sierra de Orihuela the following bipartite subdivision can be made in the Bermejo unit: the Mina formation (below) and the Cantalares formation (above).

Mina formation ($P\text{-}T^{b}_{A2}$)

Lithology. - The Mina formation consists essentially of laminated to mediumly bedded quartzites and slates. Brownish and yellowish carbonate beds are scantily represented. A detailed stratigraphy could not be established, in view of the absence of characteristic horizons, which might be helpful for unravelling the sometimes complicated tectonics. The lower part - outcropping in the Esparragal region - consists of greyish, brownish-grey, blackish-purple and greenish slates and quartzites. Current-bedding is locally observed in the slaty rocks. The higher part of the Mina formation consists of generally reddish, pinkish and flesh-coloured quartzites and wine-red to purple slaty rocks. Brownish, whitish and greenish coloured slates and quartzites are subordinate. Detrital mica is a conspicuous component of the quartzites. Veins of quartz may be present, both parallel and oblique to the stratification. The uppermost part of the formation is built up by generally wine-red blackish-purple, pinkish and violet coloured slates and quartzites. Conglomeratic intercalations are sometimes present in this part of the formation. The possibility cannot be excluded that rocks of the Mina formation are locally present in the Bermejo unit from the Sierra de Orihuela (see also p. 4).

Fossils. - With the exception of "structures" which may represent burrow-structures no fossils have been found in the Mina formation.

Contact relations. - In the La Cuevas region rocks of the Mina formation rest upon carbonate rocks, which have been tentatively incorporated within a "undifferentiated rock sequence" (outcrop C, p. 36).

The age of these carbonates is supposed to be younger than that of the Mina formation; consequently the contact is considered to be of tectonic nature. Elsewhere the base of the Mina formation is not exposed. The contact with the overlying Cantalares formation is of stratigraphic nature.

Thickness. - In view of the fact that no detailed stratigraphy of the Mina formation has been established, it is not possible to give a reliable estimate of the thickness. A figure in the order of 300-400 metres would, however, appear reasonable.

Igneous rocks. - Small bodies of metabasite have been found locally in the uppermost part of the Mina formation, at the junction with the overlying Cantalares formation.

Age. - The age of the rocks of the Mina formation will be discussed together with that of the rocks of the Cantalares formation (see p. 8).

Cantalares formation (T^{b}_{A2-A3})

Lithology. - This formation consists essentially of carbonate rocks. In the Loma los Cantalares region a differentiation can be made in 5 sequences. Sequence 1, forming the base of the formation, consists of finely to very thickly bedded, greyish, yellowish-grey and brownish-grey carbonate rocks; the basal part locally consists of dolomites with a discontinuous black colour. Rocks of sequence 1 can be studied inter alia in the region to the S and to the N of the Rambla de Cañada Ancha. Sequence 2 comprises laminated to thickly bedded, yellowish to brownish-ochre carbonates, greenish slates, and reddish to pinkish "marly" rocks. Purple to blackish--purple slates locally occur in the uppermost part of sequence 2. In the basal part gypsum, up to several metres, has been found in several places; it sometimes alternates with finely to mediumly bedded carbonates, or is associated with rauhwackes. Rocks of sequence 2 have been found inter alia to the N of Cobatillas and approx. 900 m to the SW of Casa del Cuello. In sequence 3 in several places a subdivision can be made in a lower part (sequence 3a) and a higher part (sequence 3b). Sequence 3a generally consists of greyish to black-grey, sometimes brecciated carbonates, giving rise to relatively steep slopes. Sequence 3b is built up by thickly to very thickly bedded, usually greyish to brownish-grey coloured

protruding carbonate rocks alternating with poorly exposed zones, which consist of laminated to mediumly bedded greyish and yellowish-grey carbonates, reddish, pinkish, reddish-green and greenish-white "marly" rocks, and of pale-green slates. Yellow to ochre-yellow carbonate beds, up to 2 m, occur especially in the lower part of sequence 3b. Good exposures of the sequence 3b are inter alia found in the region to the N and NW of Cobatillas, and in the mountain range to the N of the Rambla de Cañada Ancha. Sequence 4 comprises finely to mediumly bedded, yellowish, greyish, brownish and pinkish-grey carbonate rocks, greenish, purple and blackish slates, reddish, pinkish and whitish to beige quartzitic rocks, rauhwackes, (sometimes with a typical box-work structure), and gypsum. Outcrops of this sequence can be seen inter alia to the west of km 5 of the road 3223 to Fortuna and between km 1 and km 2 of the same road to the east of pt. 196. The sequence 5 consists of mediumly to very thickly bedded, brownish to brownish-grey, sometimes mineralized carbonates. Locally these rocks contain brownish coloured chert. Outcrops of this sequence have been found inter alia in the region to the east of the Embalse de Santomera, in the Puerto de Zacacho region and in the region around pt. 196 (to the west of road 3223 to Fortuna, between km 1 and km 2).

Fossils. - In the region to the N of Cobatillas, approximatively 25 metres above the base of sequence 3, Placunopsis flabellum SCHMIDT (det.Dr.F.Hirsch, Jerusalem) has been found. The microfauna of the Placunopsis-bearing carbonate rocks comprises conodonts (a.o. Pseudofurnishius murcianus VAN DEN BOOGAARD), foraminifers, crustaceans and fish remains (Van den Boogaard & Simon, in press). In the same section, eight metres above the level with Placunopsis, rather well-preserved lamellibranchs, most probably representing Aviculopecten sp., have been found, in reddish to reddish-green "marly" rocks. Burrow-structures are present in sequence 2, sequence 3 and sequence 5; they are especially abundant in the sequence 3b.

Contact relations. - The contact with the underlying Mina formation is conformable. The upper contact of the Cantalares formation is tectonic. The contact between sequence 3 and 4 is also of tectonic nature, and characterized by the presence of tectonic breccias (rauhwackes). For geometrical reasons, however, it is assumed that sequences 3 and 4 belong to an essentially continuous stratigraphic succession, the tectonic contact being due to a difference in competency.

Thickness. - The exact thickness of the Cantalares formation is unknown. It is estimated to be in the order of 150-200 metres.

Igneous rocks. - Bodies of metabasite are especially abundant at the junction of sequence 1 and sequence 2, o.a. in the region between Cobatillas and Santomera. In this region the metabasites occur essentially below the gypsiferous basal part of sequence 2. The thickness varies and locally amounts to several tens of metres. Smaller bodies are locally found within sequence 4 of the Cantalares formation.

Age of the rocks of the Bermejo unit

Fossils indicative of age have only been found in the basal part of sequence 3b of the Cantalares formation. They comprise Placunopsis flabellum SCHMIDT and Pseudofurnishius murcianus VAN DEN BOOGAARD. On the basis of the afore-mentioned fossils, it is assumed that the rocks of this part of the Bermejo unit are Upper Ladinian to Carnian. Nothing can be said with certainty on the exact age of the other rocks of the Bermejo unit. On the basis of litho-stratigraphical comparison with the rock sequences of the Romero unit of the Ballabona-Cucharón complex in the Sierra de Carrascoy (Kampschuur, 1972; explanation to sheet 26-38, Totana) it is tentatively assumed that the rocks of the uppermost part of the Mina formation are Ladinian. The underlying rocks of this formation would consequently be Ladinian or older. The afore-mentioned assumption implies a much younger age for at least the higher part of the Mina formation, than assumed until now. According to "classical" views, the rock sequence of the Mina formation - and analogous reddish coloured pelite-psammite sequences elsewhere in the Betic Zone - are Permo-Triassic (=Permo-Werfenian). According to our line of thought the succession comprising sequence 1, sequence 2 and sequence 3a is Ladinian in age. The higher part of sequence 3b, sequence 4 and sequence 5 are considered to be Upper Triassic.

Metabasites

As mentioned already the basic igneous rocks, intercalated in the rock sequences of the Tunnel unit, the Orihuela unit and Redovan unit will be discussed together with those intercalated in the rock sequence of the Bermejo unit. Metabasites have been found in:

Redovan unit:	- phyllite-quartzite formation
Orihuela unit:	- Lucia formation
	- upper part of the Gertrudis formation
	- lowermost part of the Aguila formation
	- uppermost part of the Jaime formation
Tunnel unit:	- uppermost part of the "lower carbonate" sequence
	- lower part of the "upper carbonate" sequence
Bermejo unit:	- uppermost part of the Mina formation
	- lowermost part of sequence 2 of the Cantalares formation
	- sequence 4 of the Cantalares formation

Under the name "metabasite" all the rocks of igneous origin are included. It should be emphasized, however, that there is considerable variation, both as to original habit and as to degree of metamorphic alteration. In one or two cases this metamorphism is almost negligible. Textural and mineralogical relics of magmatic origin indicate that they are original diabases. The intrusive origin of the bodies is evidenced by the presence of finely granular "chilled borders" and by the metamorphism suffered by the adjacent sediments. The relation with the countryrock is concordant and the bodies are obviously sills, intruded in zones of weakness.

Petrography. - Relict minerals of magmatic origin include: clino-pyroxene, brownish hornblende, biotite, calcic plagioclase, and ore. An ophitic to subophitic texture is generally well-preserved.

The minerals produced by the regional metamorphism include: greenish, greenish-blue and pale blue coloured amphibole, colourless mica, and minerals of the epidote group. In the metabasite sample from the ~~quartzite-phyllite~~ phyllite-quartzite formation of the Redován unit, glaucophane ~~or~~ of crossite is suspected to be present in minor amount. This metabasite has suffered considerably more from the low grade regional metamorphism than the metabasites of the Sierra de Orihuela and adjoining regions to the west and south-west. The mineral assemblage formed by metamorphism indicates the greenschist facies. However, the presumed presence of a mineral of the glaucophane group in the metabasite of the Redován unit suggests a local transition to the glaucophane schist facies.

Contact phenomena. - The invaded sediments locally show the effects of metasomatic metamorphism. The carbonate rocks may be alterated within a narrow zone into pale-greenish coloured rocks, containing brownish spots which consist of colourless mica, ore, albite and quartz. These rocks are adinoles, resulting from introduction of soda from the basic magma. At one place in the Jaime formation (Tunnel region) a carbonate rock (27-36/AD-SI/1) was found which contains forsterite and minerals of the spinel-group. Although no metabasite body was found, these minerals are considered as products of a thermal metamorphism, due to the intrusion of a basic body. A carbonate rock, collected in the Casa Forestal area, from the uppermost part of the "lower carbonate" sequence of the Tunnel unit, was found to contain a.o. forsterite. In this case the carbonate rock was found in the close vicinity of a metabasite body.

F 27-36/AD-SI/14.

Age of the metabasites

The intrusive nature of the metabasites implies a younger age than that of the invaded rocks, which are locally influenced contact-metamorphically. This indicates a Triassic or younger age for the basic intrusives. A more exact age cannot be given, on account of the lack of post-Triassic sediments in the tectonic units.

TUNNEL UNIT (see Fig. 2)

General statement

Outcrops of the Tunnel unit have been recognized in two areas, viz. (a) in the Tunnel area between the Cabezo Cruz de la Muela and the Village of Orihuela, and (b) along the southern border of the Sierra de Orihuela to the north and north-east of the hamlet of Rincón de Bonanza. This area will be referred to as the Casa Forestal area*), On the geological map, the rocks of the Tunnel unit have been taken together within the San Anton formation ($T^{E}_{A22-A31}$). This formation mainly consists of carbonate rocks, with intercalations of slates and quartzites; basic sills are represented by metabasites.

(a) Casa Forestal area

Lithology. - In this area the San Anton formation comprises the following sequences:

top: "upper carbonate" sequence
"purple slate" sequence
"lower carbonate" sequence

The "lower carbonate" sequence embraces thinly bedded greyish and greenish-grey carbonate rocks, with intercalations of light-green slaty rocks. Gypsum is locally found near the top of the sequence, sometimes associated with grauhwackes. In the south-eastern part of the Casa Forestal area a sequence occurs which mainly consists of greyish, yellowish and brownish carbonate rocks, with "marly" intercalations. This sequence is provisionally incorporated in the "lower carbonate" sequence.

The overlying "purple slate" sequence is built up by purple to reddish-purple slates, interfingering with greenish slates. Discontinuous intercalations of brownish-red quartzitic rocks are locally present.

*) The Casa Forestal, which does not figure on the topographic sheet 1:50.000, is situated within the ~~Lambert~~ U.T.M. quadrant 42.19-42.20/6.78-6.79.

Above the "purple slate" sequence follows the "upper carbonate" sequence. It mainly consists of finely laminated to thickly bedded, multi-coloured carbonate rocks; carbonate rocks with a "marly aspect" and slaty and quartzitic rocks are intercalated. In the lower part of the sequence greyish and brownish colours predominate, whereas in the upper part pink, orange and yellowish colours are conspicuous. The highest part of the "upper carbonate" sequence consists of purple and greenish slates, alternating with purple-reddish and greenish coloured quartzitic rocks.

Fossils. - Approximatively 30-35 metres above the base of the "upper carbonate" sequence well-preserved lamellibranchs have been found, i.e. Costatoria kiliani (SCHMIDT) and Gervilleia cf. joleaudi SCHMIDT. Microfauna comprises foraminifers, fish remains, crustaceans (i.a. ostracods) echinoderms and conodonts (i.a. Pseudofurnishius murcianus VAN DEN BOOGAARD (see further Van den Boogaard & Simon, ~~1972~~ in press and Kozur et al., in prep.) Undeterminable lamellibranchs are found in the lower part of the "lower carbonate" sequence.

Contact relations. - The base of the San Anton formation is not exposed. The contact between the sequences is of stratigraphic nature. The upper contact of the formation is tectonic.

Thickness. - The minimum thickness of the San Anton formation is in the order of 120 metres ("lower carbonate" sequence at least a tens of metres; "purple slate" sequence - max. exposed thickness 20 m (tectonization); "upper carbonate" sequence: approx. 90 metres.

Igneous rocks. - Bodies of metabasite have been mainly found in the uppermost part of the "lower carbonate" sequence. A small body is found in the lower part of the "upper carbonate" sequence. These metabasites will be discussed together with the metabasites of the ~~Orihuela~~ Bermejo unit (see p. 8-10).

Age

The combined data on the macro- and microfauna (Van den Boogaard & Simon, ~~1972~~ in press; Kozur et al., in prep.) indicate an Upper Ladinian to Lower Carnian age for at least the major part of the "upper carbonate" sequence. The age of the "purple slate" sequence and of the "lower carbonate" sequence can only be estimated via a correlation with dated rock sequences of the Romero unit of the Ballabona-Cucharón complex in the Sierra de Carrascoy (Kampschuur, 1972); Van

den Boogaard & Simon, ~~1972~~ in press; explanation to sheet Totana-26-38). On litho-stratigraphical grounds the following correlation seems warranted:

Tunnel unit, Sa. de Orihuela	Romero unit, Sa. de Carrascoy	
"upper carbonate" sequence	"variegated carbonate member" / "tres bancos member"	Ladinian-Carnian
"purple slate" sequence	"green slate" member	Ladinian
"lower carbonate" sequence	"Palas member" (upper part)	Ladinian

(b) Tunnel area

In view of the strong tectonization it proved impossible in the Tunnel area to establish a complete stratigraphy of the Tunnel unit. Rocks of the "upper carbonate" and of the "purple slate" sequence have been recognized with certainty. Approximatively 35 metres above the base of the "upper carbonate" sequence the horizon with Costatoria kiliani (SCHMIDT) has been found. The total thickness of the "upper carbonate" sequence is in the order of 75 metres. In the cores of antiform-structures a sequence of at least several tens of metres occurs, consisting of generally finely to mediumly bedded, multi-coloured carbonate rocks (sometimes with "marly aspect") with intercalations of greenish slaty rocks. Undeterminable lamellibranchs are present in several horizons. In this stage of investigation, it seems most probable that rocks of the "lower carbonate" sequence are dealt with here. A conspicuous feature in the Tunnel area is the abundance of bodies of metabasite at the junction of the "upper carbonate" and "lower carbonate" sequences.

Orihuela unit (see Fig. 3)

General statement

The Orihuela unit, which tectonically overlies the Tunnel unit and the Bermejo unit, comprises the following formations:

top: Cabezo Ros [illegible] formations (T^{o}_{A3})
Benferri and Maria formations (T^{o}_{A22-A3})
Otón and Virginia formations ($T^{ot}_{A22-A31}$)
Muela and Lucia formations ($T^{o}_{A22-A31}$)
Aguila and Gertrudis formations (T^{o}_{A2})
Jaime formation ($P\text{-}T^{o}_{A2}$)

The Jaime formation essentially consists of quartzites and slates. All the other formations essentially consist of carbonate rocks. The rock sequences of the Aguila, Gertrudis and Lucia formations locally contain basic bodies, represented by metabasites.

Jaime,

Jaime formation ($P\text{-}T^{o}_{A2}$)

Lithology. - In the Jaime formation two sequences can be distinguished:

top: quartzite-slate sequence
carbonate sequence

The carbonate sequence consists of mediumly to thickly bedded, usually greyish coloured carbonate rocks. Gypsum has been found locally in the lowermost part of the sequence. Rocks of the carbonate sequence are only exposed in a restricted area, approximatively one kilometre south-west of the Orihuela summit (634 m.).

The overlying quartzite-slate sequence consists of an alternation of generally finely bedded pink, reddish, purple, violet, whitish and greenish quartzites and wine-red, purple, violet, greyish, bluish-grey and almost black slates. Bluish-grey slates are mainly present in the uppermost part of the sequence. The dominating colour of this sequence is reddish to purple. Detrital mica is sometimes a conspicuous component in handspecimens. ~~Malachite~~ Cu-minerals occurs locally in the quartzites. Finely to mediumly bedded, orange to brownish carbonate rocks, sometimes developed as grauhwackes, are intercalated locally.

(See also p.40)

Fossils. - Burrow-structures have been found in the lower part of the carbonate sequence.

Contact relations. - The contact between the quartzite-slate sequence and the carbonate sequence is transitional. The base of the Jaime formation is formed by a major thrust-plane. Its boundary with the overlying Aguila formation is of normal stratigraphic nature. The contact has been drawn where carbonate rocks begin; it is usually strongly tectonized.

Thickness. - The thickness of the Jaime formation varies very strongly; the maximum exposed thickness amounts to about 170 metres. In view of the intense tectonization this is obviously not the true thickness.

Igneous bodies. — Small bodies of metabasite have been found locally (a.o. in the Tunnel region) in the upper part of the Jaime formation (see further p. 8-10).

Aguila formation (T^{o}_{A2})

Lithology. - This formation constitutes the "backbone" of the Sierra de Orihuela. The impressive steep walls, which are visible from the road Santomera-Orihuela (carretera nacional N 340), consist of carbonate rocks of this formation (forming a.o. the two highest points of the mountain range, viz. the Orihuela and the Cabezo del Aguila). The Aguila formation mainly consists of well--layered, usually greyish to brownish-grey coloured, finely to very thickly bedded, carbonate rocks, sometimes with a crystalline aspect. Yellow to yellow-oranhe carbonates occur at several levels throughout the formation, forming conspicuous beds (up to 150 cm thick) within a rather monotonous succession. Both the lower and the upper part of the Aguila formation have a characteristic lithological development, and therefore will be described in some detail.

In the lower part of the Aguila formation the following succession can locally be recognized (a.o. in the region to the S and NW of the summit Orihuela):

top: (d) greyish and brownish-grey carbonate rocks, forming the base of the part of the Aguila formation, which gives rise to the steep walls already mentioned.
The lowermost part of the sequence (d) consists of a yellowish carbonate bed, (thickness in the order of several decimetres), comprising very conspicuous horseshoe-shaped burrow-structures which measure up to 15 cm. across.

(c) brownish-grey and yellowish-grey carbonate rocks. There is generally an alternation of thickly to very thickly bedded carbonate beds and finely to mediumly bedded carbonates, sometimes with a "marly aspect". In the upper half of sequence (c) a yellowish carbonate bed is present, containing greyish burrow-structures. Its thickness amounts to approx. one metre.

(b) "black as soot" dolomitic carbonate rocks, alternating with greyish-green and greyish coloured dolomitic carbonates. The blackish colour is irregularly distributed.

(a) heterogeneous sequence of laminated to mediumly bedded, generally yellowish, brownish and brownish-grey carbonate rocks, greyish and pinkish brecciated carbonate rocks, yellowish and greenish-white "marly" rocks, greenish slates and yellowish-brown coloured rauhwackes. Lamellibranchs

occur in the middle part of sequence (a) (see further below). Gypsum, usually associated with rauhwackes, has been found locally at the junction of sequence (a) and the quartzite-slate sequence of the Jaime formation (~~see also p. ——~~). The gypsum is incorporated in the Aguila formation.

The thickness of the aforementioned succession is rather difficult to establish, in view of the usually very strong tectonization of the lower part of the Aguila formation. The most probable total thickness of sequences (a), (b) and (c) is in the order of (50-100) metres.

In the upper part of the Aguila formation the following succession can generally be distinguished:

top: (g) Alternating finely to mediumly bedded, usually beige-grey coloured carbonates and thickly to very thickly bedded carbonates (13 m). This sequence (g) concordantly underlies the Gertrudis formation.

(f) orange-yellow carbonate bed (approx. 25 cm)

(e) alternation of finely and mediumly bedded greyish carbonates (approx. 4 metres).

(d) yellowish carbonate bed with greyish, protruding burrow-structures (45 cm).

(c) generally thickly to very thickly bedded greyish carbonate rocks (11m).

(b) yellow carbonate bed (approx. 150 cm).

(a) greyish carbonate rocks, generally mediumly to very thickly bedded, constituting the uppermost part of the portion of the Aguila formation, which forms the steep walls.

As can be concluded from the foregoing, the total thickness of sequences (b) - (g) is approximatively 30 metres.

Fossils. - Burrow-structures have been found throughout the Aguila formation, especially in its lower and upper parts. Strongly tectonized lamellibranchs have been found in the middle of sequence (a) of the lower part of the formation. Most probably they represent Costatoria betica (HIRSCH).

Contact relations. - The Aguila formation is stratigraphically intercalated between the Jaime and Gertrudis formations.

~~Lyrioniophoria~~ Lyrioniophoria betica

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Thickness.- The maximum thickness of the Aguila formation is in the order of 250 metres.

Igneous bodies. - Bodies of metabasite are found in the lowermost part of the ~~found at the junction of the Aguila and Jaime formations.~~ Aguila formation, at the junction with the Jaime formation.

Gertrudis formation (T^{o}_{A2})

Lithology. - This formation consists of an alternation of protruding, mediumly to thickly bedded carbonates (varying in thickness from 45 to 370 cm), and of generally poorly exposed, laminated to finely bedded carbonates, sometimes with a marly aspect. Intercalations of slaty rocks are of common occurrence in the higher part of the formation. The lower part of the formation has a very characteristic lithological development and will therefore be described in detail. It comprises seven conspicuous carbonate beds (A to G), separated by generally poorly exposed, laminated to finely bedded, dolomitic rocks with a "sugary" aspect. The following seven beds can be distinguished:

top: Bed G orange carbonates (115 cm)

bed F
- (4) dark grey carbonates with orange streaks (250 cm)
- (3) white to greyish limestones with orange ~~veins~~ veins. (30 cm
- (2) brownish-grey limestones (25 cm)
- (1) orange-yellow dolomitic carbonates (65 cm)

bed E
- (3) orange-brown dolomitic carbonates (30 cm)
- (2) brownish-grey dolomitic carbonates with "sugary" aspect (30 cm)
- (1) orange-brown dolomitic carbonates (60 cm)

bed D
- (3) bluish-grey limestones with orange to yellow streaks (30 cm)
- (2) yellowish dolomitic carbonates (45 cm)
- (1) dark-grey carbonates (60 cm); the carbonates from the upper part contain "nodules" of orange dolomitic carbonate (up to 7 cm)

bed C
- (2) orange to yellow carbonates (45 cm) with dark-grey burrow structures in the lower part
- (1) dark-grey burrow-structures "embedded" in an orange carbonate matrix (30 cm)

bed B — Carbonates (40 cm). The upper half of bed B consists of brown to orange coloured carbonates with greyish burrow-structures, up to 10 cm; the lower half comprises rust-brown coloured carbonates.

bed A — Buff to reddish-brown coloured carbonates with rust-brown veins and orange spots.

The sequence A to G, together with the intercalated "sugary" dolomitic carbonates, has a total thickness of approx. 22 metres.

In the higher part of the Gertrudis formation two carbonate beds occur, each with a thickness of approx. 2 metres, consisting of laminated to finely bedded brownish-grey to cream coloured limestones. In contrast to the lower part of the formation, the upper part is characterized by the presence of several intercalations of greenish coloured slaty rocks. It further contains laminated yellowish coloured "calcaires feuilletés" and marly carbonates. Near the top of the Gertrudis formation brownish-yellow carbonates, crowded with burrow-structures and sometimes with fossils, and reddish and orange--yellow rauhwackes have been found. Gypsum locally occurs at the junction of the Gertrudis and Muela formations.

Fossils. - Burrow-structures occur throughout the formation, especially in its lower and uppermost part. Undeterminable lamellibranchs are present in the uppermost part. The microfauna of carbonate rocks from the uppermost part of the Gertrudis formation comprises conodonts (a.o. Pseudofurnishius murcianus VAN DEN BOOGAARD), foraminifers, fish remains and ostracods) (Van den Boogaard & Simon, in press; Kozur et al., in prep.).

Contact relations. - The Gertrudis formation is stratigraphically intercalated between the Jaime formation (below) and the Muela formation (above).

Thickness. - The thickness of the Gertrudis formation is in the order of 60 metres.

Igneous rocks. - Small bodies of metabasite occur very locally in the upper part of the formation. They will be discussed together with the metabasites of the Bermejo unit (see p. 8-10).

Muela formation ($T^{o}_{A22-A31}$)

Lithology. - In the Muela formation a bipartite subdivision can be made into a lower carbonate sequence and an upper carbonate sequence. The lower carbonate sequence consists of generally thickly to very thickly bedded, usually greyish to greyish-brown coloured carbonate rocks. The lowermost part consists of an orange coloured, brecciated, carbonate bed with a thickness up to 3 metres. Yellowish beds, up to 2 metres, occur at some levels. Brecciated carbonates are especially abundant in the higher part of the sequence. The rocks of the lower carbonate sequence often give rise to steepwalls (o.a. in the region

to the NNW of point 486). The upper carbonate sequence comprises 6 conspicuous, protruding, greyish coloured carbonate beds (I-VI), with a thickness varying from 70 to 450 cm, separated by generally poorly exposed zones, consisting of laminated to finely bedded greyish and yellowish limestones, "marly" carbonates and "calcaires feuilletés". The base of the upper carbonate sequence - approx. 2 metres below the lowermost bed (I) - consists of a conspicuous ochre to yellow carbonate bed (ca. 65 cm), usually with a rauhwacke aspect. Between beds I and II a striking light-yellow dolostone with a thickness of 70 cm occurs. In the basal part of bed III an ochre coloured carbonate level is present with a thickness of 20 cm. Bluish-grey and greenish slaty rocks are of rare occurrence in the zone between beds V and VI.

Fossils. - Burrow-structures occur throughout the formation. In the upper carbonate sequence they are especially present in the upper part. Undeterminable lamellibranchs have been found in greenish-grey to greenish-brown carbonates between beds V and VI. Microfauna from these carbonates comprises foraminifers, fish remains, ostracods and gastropods (Kozur et al., in prep.).

Contact relations. - The Muela formation is stratigraphically intercalated between the Gertrudis formation (below) and the Lucia formation (above).

Thickness. - The total thickness of the Muela formation amounts to 115 metres (lower carbonate sequence up to 85 metres; upper carbonate sequence up to 30 metres).

Lucia formation ($T^{o}_{A22-A31}$)

Lithology. - This formation consists of an alternation of protruding, mediumly to thickly bedded, greyish and ochre to yellow coloured carbonate beds (thickness 30 to approx. 215 cm), and very badly exposed zones, consisting of laminated to finely bedded yellowish "calcaires feuilletés" rauhwackes, "marly" carbonates, ochre dolostones, and greyish to greenish-grey limestones; pale-green (and purple) slaty rocks are present in the uppermost part of the formation. In the region to the NNW of Rincon de Bonanza gypsum has been found in the Lucia formation. Due to strong tectonization it proved impossible to establish the stratigraphic position of the gypsum. In the lower half of the formation three conspicuous carbonate beds occur, separated by poorly exposed laminated carbonate rocks, viz:

top:

bed C
- (5) ochre-yellow dolostones (40 cm)
- (4) yellow carbonates (50 cm)
- (3) grey to yellowish-grey limestones (20 cm)
- (2) grey limestones (75 cm)
- (1) ochre-yellow dolostones (30 cm)

bed B
- (2) greyish limestones (20 cm)
- (1) ochre-yellow dolostones, somestimes with a rauhwacke aspect (50 cm)

bed A: orange to ochre carbonates, sometimes with a rauhwacke aspect (70 cm)

Fossils. - Burrow-structures are of rare occurrence. They have been found in carbonate rocks from the poorly exposed zone between beds B and C.

Contact relations. - The Lucia formation is stratigraphically intercalated between the Muela formation (below) and the Otón formation (above).

Thickness. - It amounts to 20 metres.

Igneous rocks. - Small bodies of metabasite have been found locally amidst rocks of the Lucia formation (a.o. in the region to the NNW of Rincon de Bonanza and 1250 m to the NE of point 486). In the latter region the metabasite body occurs in the higher part of the formation. The metabasites of the Lucia formation will be discussed together with those of the Bermejo unit (see p. 8-10).

Otón formation ($T^{ot}_{A22-A31}$)

Lithology. - The Otón formation consists essentially of a rather monotonous succession of mediumly to very thickly bedded, usually greyish coloured carbonate rocks, giving rise to scarps of several tens of metres. Laminated to finely bedded greyish limestones and yellowish-grey "calcaires feuilletés" form subordinate components of the formation. Fe-Mineralizations are of common occurrence throughout the sequence, giving the rocks a reddish-brown to yellowish-brown colour.

Fossils. - With the exception of some burrow-structures no fossils have been found.

Contact relations. - The Otón formation is stratigraphically intercalated between the Lucia formation (below) and the Virginia formation (above).

Thickness. - The maximum exposed thickness is in the order of 150-200 metres.

Virginia formation (T^{ot}_{A22-31})

Lithology. - The Virginia formation consists of an alternation of protruding carbonate beds and poorly exposed zones. The carbonate beds, with a thickness up to approx. 300 cm, are generally greyish or brownish-yellow coloured. They sometimes have a crystalline aspect. The lowermost bed consists of laminated to finely bedded, brownish-yellow, "sugary" dolostones. Approximately 4 metres below the top of the formation a conspicuous carbonate bed occurs, in which the following subdivision can be made (from below to above): (1) buff to ochre dolostones (25 cm), (2) ochre dolostones (20 cm), and (3) greyish limestones (25 cm). The poorly exposed zones between the carbonate beds consist of laminated to finely bedded, yellowish to greyish carbonates, pale-green and bluish-grey slaty rocks, and greenish quartzites; yellowish "marly" carbonate rocks and orange to yellowish "calcaires feilletés" are mainly found in the upper half of the formation.

Fossils. - Burrow structures are mainly present in the lower part of the formation. In the uppermost part of the formation an undeterminable lamellibranch has been found ~~xxx xxxxx~~ (approx. 1350 metres to the NNE of point 486). The microfauna of carbonates from the same bed comprises conodonts (a.o. Pseudofurnishius murcianus VAN DEN BOOGAARD), foraminifers, fish remains and gastropods (Van den Boogaard & Simon, in press).

Contact relations. - The Virginia formation is stratigraphically intercalated between the Otón formation (below) and the Benferri formation (above).

Thickness. - The maximum thickness of the Virginia formatoin amounts to ca. 60 metres.

Benferri formation (T^{o}_{A22-A3})

Lithology. - The Benferri formation consists mainly of carbonates. The ~~lower~~ basal part (ca. 24 m) comprises essentially thickly to very thickly bedded greyish carbonates, giving rise to scarps. The base of the formation is built up by an ochre coloured carbonate bed with a thickness of 110 cm. The top of the basal sequence is formed by a

conspicuous yellow carbonate bed (175 cm). The next ten metres of the Benferri formation are very poorly exposed; they consist of greenish slates, alternating with laminated to finely bedded carbonates. The remaining part of the formation comprises mediumly to very thickly bedded, greyish, yellowish-brown and pink to reddish, sometimes brecciated carbonates, alternating with poorly exposed, laminated to finely bedded, greyish and yellowish coloured carbonates, sometimes with "marly" aspect, and slaty rocks. The possibility cannot be excluded that at least part of the afore--mentioned brecciated carbonates represent sedimentary breccias. "Black as soot" coloured dolomitic carbonates occur locally in this part of the Benferri formation. The black colour is discontinuous.

Fossils. - With the exception of some burrow-structures no fossils have been found.

Contact relations. - The Benferri formation is stratigraphically intercalated between the Virginia formation (below) and the Maria formation (above).

Thickness. - The maximum thickness of the Benferri formation is in the order of 80-100 metres.

Maria formation (T^{o}_{A22-A3})

Lithology. - The Maria formation comprises laminated to mediumly bedded yellow, ochre and yellowish-grey to brownish-grey coloured carbonates, forming protruding beds up to approx. 1 metre. Yellow colours predominate. Alternating with these carbonates are poorly exposed zones formed by greenish and sometimes pinkish to reddish slaty rocks. These slates form an important and characteristic component of the Maria formation. The basal part of the formation (approx. 10 metres) is built up by gypsum, associated with polymict rauhwackes, and sometimes violet and greenish slaty rocks. Approximatively 33 and 41 metres below the top of the formation finely laminated greyish oolitic limestones are found with a thickness of 50 cm and 20 cm resp. Typical cavernous yellow to ochre rauhwackes ("Zellendolomit"), with a thickness up to 80 cm, occur at various levels in the higher part of the formation. Near the top of the Maria formation a quartzitic intercalation has been found amidst greenish to reddish slaty rocks.

Fossils. - Undeterminable fossils are present in mediumly laminated greyish to brownish-grey limestones, just above the gypsiferous basal part. Burrow-structures have been locally found in the upper part of the formation.

Contact relations. - The Maria formation is stratigraphically intercalated between the Benferri formation (below) and the Cabezo Ros formation (above).

Thickness. - The maximum thickness of the Maria formation is in the order of 65 metres. Generally, however, the thickness amounts to no more than ten metres, due to strong tectonization.

Cabezo Ros formation (T^{o}_{A3})

Lithology. - The Cabezo Ros formation mainly consists of carbonate rocks. The lower part (ca 70 m) is built up by poorly layered, sometimes brecciated greyish carbonate rocks, giving rise to rather steep slopes. Approximatively 14 metres above the base mediumly bedded carbonates with black "nodules" of chert occur. Just above this horizon a yellowish coloured, "marly" carbonate intercalation (thickness 1 metre) is present, giving rise to a morphological interruption in the steep carbonate sequence. The middle part of the Cabezo Ros formation (approx. 100 metres) is represented by an alternation of finely to mediumly bedded very dark grey, orange, yellowish and sometimes reddish carbonate beds and of laminated to finely bedded usually greyish coloured carbonates. "Marly" rocks and pale-green to pinkish slaty rocks are of local occurrence. The darkgrey carbonate beds sometimes contain abundant orange-yellow streaks (thickness some mm), giving the rocks a "pyjama aspect". Rauhwackes are scantily represented. Above this part of the formation follows a poorly exposed zone (15 m), consisting of black to black-purple and greenish coloured slaty rocks, slaty quartzites, and ochre carbonates. The remaining part of the Cabezo Ros formation (60 m), is built up by well-layered, finely to mediumly bedded, brownish-grey to brownish carbonates. They generally have a crystalline aspect. Ochre and yellow coloured carbonates are less frequent than in the middle part of the formation. Rocks forming the upper part of the formation have only been found directly to the north of of the road from Orihuela to Los Riquelmes de Matanza (Coord. U.T.M. 6.78-6.79 / 42.21-42.22).

~~6'78-6'79 / 42 42~~
~~21 22~~

Contact relations. - The Cabezo Ros formation stratigraphically overlies the Maria formation; it is unconformably covered by Quaternary deposits.

Fossils. - Burrow-structures are of a common occurrence in the middle part of the formation.

Thickness. - The minimum thickness of the Cabezo Ros formation amounts to 245 metres.

Age of the rocks of the Orihuela unit

The age of the rock sequence of the Orihuela unit poses serious problems. No macrofauna has been found, giving reliable indications as to the exact age of the rocks in question. As already mentioned on p. 16, in the basal part of the Aguila formation lamellibranchs have been encountered, amongst which, most probably, Lyriomyophoria Costatoria betica (HIRSCH). This fossil was recently described for the first time by Hirsch (1966), from Triassic rock sequences from various parts of the Betic Zone. Its range is, however, unknown. The lamellibranchs, found in the uppermost parts of the Gertrudis, Muela and Virginia formations could not be identified. Ostracod- and conodont--faunas from the uppermost part of the Gertrudis formation lead to the assumption that these rocks have an essentially ~~Langobardic~~ Langobardic (= Upper Ladinian) age. The ostracod-fauna from the higher part of the Muela formation indicates a Langobardic (= Upper Ladinian) to Cordevolic (= Lower Carnian) age (Kozur et al., in prep.). On the basis of litho-stratigraphic correlation with the rock sequemce of the Romero unit of the Ballabona-Cucharón complex in the Sierra de Carrascoy (Kampschuur, 1972, explanation to sheet 26-38, Totana), it is assumed that the rocks of the uppermost part of the Jaime formation and of the lowermost part of the Aguila formation have a Ladinian age. According to this line of thought the older rocks of the Jaime formation would be Ladinian or older, leaving open the possibility that the rocks of the lowermost part of the formation are Permo-Triassic (=Permo-Werfenian). In the uppermost part of the Virginia formation Pseudofurnishius murcianus VAN DEN BOOGAARD has been encountered. Until now this conodont has only been found in the Betic Cordilleras in rock sequences believed to be Upper Ladinian- to (Lower)Carnian. The rocks of the Benferri, Maria and Cabezo Ros formations are considered to be essentially Upper Triassic, leaving open the possibility that the rocks of the Benferri formation represent, at least partly, the Ladinian.

Sierra de Callosa de Segura

REDOVAN UNIT ($P\text{-}T^{re}_{A}$) (see fp. 4)

General statement

The Redován unit comprises the following formations:

top Carbonate formation
Phyllite-quartzite formation

Phyllite-quartzite formation

Lithology. - This formation consists of laminated to mediumly bedded, light to dark-grey and steel-grey coloured phyllites, light--grey and greenish slates and whitish, reddish and pinkish quartzites.

Fossils. - None

Contact relations. - The base of the Phyllite-quartzite formation is not exposed. The contact with the overlying Carbonate formation is of stratigraphic nature.

Thickness. - The exposed thickness amounts to 20 metres.

Igneous rocks. - To the north of the village of Redován a small body of metabasite has been found amidst rocks of the phyllite-quartzite formation. It will be discussed together with the metabasites of the Bermejo unit (see p. 8-10).

Carbonate formation

Lithology. - This formation is built up by finely to thickly bedded, greyish, greyish-brown, orange and yellowish carbonate rocks. In the basal part of the formation intercalations of light-grey to greenish slates are present, as well as yellowish-brown coloured rauhwackes.

Fossils. - None

Contact relations. - The contact with the underlying Phyllite--quartzite formation is of stratigraphic nature. The Carbonate formation is tectonically overlain by rocks of the Callosa unit (see also Chapter on Tectonics).

Thickness. - The exposed thickness is approximatively 40 metres.

Age

The age of the rocks of the Redován unit will be discussed together with that of the rocks of the Callosa unit.

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Mr. Luis F.Granados
Enadimsa
Serrano 116
Madrid -6

Dear Colleague and friend,

Referring to the letter d.d. 10.I.1973 by Carlos Martinez Diaz, I can inform you that I have send to-day - under separate cover - the following data of the Magna project:

Sierra de Espuña: Columnas estratigraficas (en la Memoria)
Memoria
Cortes estructurales
Fichas bibliograficas

Hoja de Orihuela(Sierras de Orihuela y Callosa de Segura)

Columnas estratigráficas ✓
Fichas bibliográficas ✓

Towards the end of the week, I hope to send you the remaining data i.e. the "mapa situación muestras de la Sierra de Carrascoy" and the "Cortes estructurales" of the sheet Orihuela.
Concerning the "columnas estratigráficas de la Sierra de Carrascoy and the Sierra de la Tercia", I can inform you that these columns are incorporated in the text-books("memorias") of the Sierras in question, which we send you already. In the case of the Sierra de la Tercia the scale of the columns is 1:10.000. The columnar sections of the Sierra de Carrascoy have another scale. As already communicated to Prof. Perconig, this has been done to give the compilator of the sheets in question more "freedom" to make simplifications etc.
Furthermore, I give you some corrections concerning the Memoria of the sheet Orihuela:

1) opposite p.3 : add after "...Baleares y Canarias" : (1966)
2) At several places in the text I wrote: Placunopsis flabellum SCHMIDT. This must be : flabella! 3) At several places I wrote

~~Redovan~~ Redovan. This must be : Redovén!

4) In the Chapter Literature:

Boogaardt,M.van den,& Simon,O.J., omit: Further notes on the occurrence of.

Fallot,P.,Les Cordillères ..... Read: Estud ios geol.,2, in stead of 4.

Kampschuur,W.,Geology of the Sierra de Carrascoy ..... Read: G.U.A. Papers,series 1,no.4,... in stead of : Thesis Amsterdam,...

Kozur, H. & Simon, O.J. Contribution ..... omit: (in press) and add: Número Extraordinario, XXX Aniversario E.N. Adaro, pp 143-158 (1972).

With my best greetings,

(OTTO J. SIMON)

pag. 16, 24, 26

CALLOSA UNIT (T^{c}_{A2-A3}) (see fig. 5)

General statement

The Callosa unit comprises the following formations:

top Cox formation
Green slate formation
Callosa formation
San Pedro formation

San Pedro formation

Lithology. - This formation consists of finely to mediumly bedded, brownish-grey to greyish coloured carbonates, laminated to finely bedded, orange-yellow carbonates, and brownish-yellow carbonates with a "marly" aspect. The lower part of the formation contains intercalations of greenish coloured slates.

Fossils. - Burrow-structures occur in the upper half of the formation.

Contact relations. - The San Pedro formation stratigraphically underlies the Callosa formation. The base is unknown.

Thickness. - The minimum thickness of the formation is ca. 75 metres

Callosa formation

Lithology. - This formation forms the "backbone" of the Sierra de Callosa de Segura. It consists essentially of carbonate rocks. The upper part (thickness at least 45 m) is built up by mediumly to thickly bedded, brownish to greyish coloured carbonates. The middle part - with a minimum thickness of 45 metres - comprises mediumly to thickly bedded, grey to dark-grey carbonates, with intercalated finely to mediumly bedded, yellowish to greyish carbonates and yellowish calcareous slaty rocks. The lower 25 metres of the middle part of the Callosa formation consists of mainly black coloured carbonates. The black colour is discontinuous and due to post--sedimentary processess. The lower part of the formation (with a thickness of at least 25 m) comprises mediumly to thickly bedded, greyish carbonate rocks.

Fossils. - Two levels with lamellibranchs have been found in the middle part of the Callosa formation, approx. 5 and 17 metres above the top of the black coloured carbonates. The lamellibranchs probably represent Costatoria cf. betica (HIRSCH). Burrow-structures occur in

Lyriomyophoria

the middle part of the formation, above the black carbonates.

Contact relations. - The Callosa formation is stratigraphically intercalated between the Green slate formation (above) and the San Pedro formation (below).

Thickness. - The minimum thickness is ca. 115 metres.

Green slate formation

Lithology. - This formation consists of an alternation of thinly to mediumly bedded, brownish-grey, greyish-brown, orange to yellow, sometimes brecciated carbonates and zones built up by greenish slates and laminated to finely bedded yellow to orange-yellow carbonate rocks with a "marly" aspect.

Fossils. - Undeterminable lamellibranchs have been found in the higher part of the formation.

Contact relations. - The Green slate formation is stratigraphically intercalated between the Cox formation (above) and the Callosa formation (below).

Thickness. - The thickness of the Green slate formation is 90 metres.

Cox formation

Lithology. - The Cox formation consists essentially of carbonate rocks. The higher part is built up by finely to mediumly bedded, yellowish, greyish-brown and greyish carbonates. Laminated to finely bedded "marly" carbonates, rauhwackes and greenish slates occur intercalated in this part of the formation. The remaining part is essentially built up by mediumly to thickly bedded, greyish to brownish-grey coloured carbonates, the lowermost part comprising thickly bedded, brownish to orange-yellow carbonates.

Fossils. - None

Contact relations. - The rocks of the Cox formation are covered by Quaternary deposits.

Thickness. - The minimum exposed thickness is ca. 20 metres.

Age of the rocks of the Redovan unit and the Callosa unit

An exact dating of the sedimentary rocks of the Redovan and Callosa units is rendered impossible by the lack of diagnostic fossils. On the basis of a litho-stratigraphical comparison with the Bermejo

unit and the Orihuela unit, the rocks of the Redovan unit are tentatively referred to the Triassic, leaving open the possibility that Permian rocks are also represented. The rocks of the Callosa unit are considered to be of Middle to Upper Triassic age.

Undifferentiated rock sequences ($P\text{-}T_A$)

Under this heading a number of isolated rock sequences is taken together, which could not be definitively incorporated in one of the aforementioned tectonic units. The following outcrops occur:

a) Cabezo del Calvario (to the West of Espinardo)
b) El Puntal (to the NE of Espinardo)
c) La Cuevas
d) Cabezo de los Buitragos
e) Los Rocamoras de Matanza
f) Cabezo Gordo (173 m)
g) Cabezo Pequeño (129 m).
h) An outcrop 1750 m to the NE of Cabezo Gordo
i) An outcrop 2500 m to the N of Siete Casas
j) An outcrop around pt.62 m (1600 m to the NE of Cabezo Cruz de la Muela)
k) An outcrop 250 m to the NE of the "Cementerio de Orihuela"
l) An outcrop around pt. 50 m in El Campo, between the Sierra de Orihuela and the Sierra de Callosa de Segura
m) An outcrop 1000 m to the SW of Granja de Rocamora
n) An outcrop around pt. 85 m, 1250 m to the NNE of Granja de Rocamora

In the rock sequences of these outcrops no determinable fauna has been found. On litho-stratigraphical grounds the rocks are considered to have a Triassic age, leaving open the possibility that Permian rocks are also present (for instance in the rock sequences of outcrops a and i).

In the following table a brief description is given of the various outcrops:

outcrop a

Lithology. - Mainly reddish and purple slates and quartzites; pale-green and greyish slates and quartzites and yellowish "marly" rocks occur subordinately. In the uppermost part of the sequence conglomerates and whitish quartzites have been found.

Remarks. - In the lower part of the sequence ripple-marks are present.

Possible tectonic relationship. - Bermejo unit (Mina formation).

Outcrop b

Lithology. - Well-layered, greyish coloured carbonates (ca.90 m). Approximatively ten metres above the "base" a sequence occurs (thickness ca. 5 m) of yellowish and brownish-yellow "marly" carbonate rocks, locally containing gastropods and undeterminable lamellibranchs.

Possible tectonic relationship. - Bermejo unit (Cantalares formation).

outcrop c

Lithology. - Greyish coloured, well-layered carbonate rocks.

Possible tectonic relationship. - Uncertain; the rocks of outcrop c tectonically underlie rocks of the Mina formation of the Bermejo unit.

outcrop d and outcrop e

Lithology. - Greyish coloured carbonate rocks, sometimes with orange streaks. Greenish, pinkish and yellowish "marly" carbonates occur subordinately.

Remarks. - Locally burrow-structures.

Possible tectonic relationship. - Orihuela unit (Cabezo Ros Formation).

outcrop f

Lithology. - Dark-grey carbonates. The beds sometimes contain abundant orange-yellow streaks (thickness some mm), subparallel to the bedding-planes, giving the rocks a "pyjama aspect".

Remarks. - Locally abundant burrow-structures.

Possible tectonic relationship. - Orihuela unit (Cabezo Ros formation).

outcrop g

Lithology. - top (4) greyish carbonates
(3) yellowish carbonates forming a single bed
(2) greenish slates with ochre carbonates
(1) greyish carbonates with orange patches

Remarks. - Burrow-structures occur in the sequence mentioned under (1).

Possible tectonic relationship. - Orihuela unit (Cabezo Ros formation?).

outcrop h

Lithology. - NW part of outcrop: greyish carbonate rocks with some intercalated yellowish carbonate beds. SE part of outcrop: blackish dolomites and reddish, brownish and beige limestones.

Possible tectonic relationship. - Orihuela unit (Cabezo Ros formation?).

outcrop i

Lithology. - Wine-red and whitish sandstones.

Possible tectonic relationship. - Malaguide complex.

outcrop j

Lithology. - top

sequence 4 (ca. 12 m):
strongly tectonized zone comprising yellowish--brown coloured rauhwackes, ochre dolomites, greyish limestones, pale-green slaty rocks and pale-green to whitish quartzites.

sequence 3 (ca. 50 m):
finely bedded to very thickly bedded greyish, brownish, yellowish and grey carbonates. In the upper half of the sequence intercalations of greenish slates, yellowish "calcaires feuilletés", ochre-yellow carbonates and yellowish "marly" rocks occur. In the lower half locally whitish "marly" intercalations are present. In the basal part three conspicuous yellowish carbonate beds are distinguished (thickness ca. 40 cm).

sequence 2 (ca. 10 m):
strongly tectonized zone built up by greenish, violet and whitish quartzites and slaty rocks; ochre and yellowish carbonate rocks occur subordinately.

sequence 1 (ca. 55 m):
This sequence comprises 5 protruding greyish to greyish-brown coloured carbonate beds

(varying in thickness from 1 to 6 metres). They alternate with poorly exposed zones consisting of yellowish-brown, greenish grey and brownish-grey laminated to thickly bedded greyish carbonates. Subordinate are greenish slates, and ochre to orange coloured carbonates (sometimes with a rauhwacke aspect).

Remarks. - Burrow-structures occur in sequences 1 and 3.

Possible tectonic relationship. - Sequences 1-3: Tunnel unit or Bermejo unit; sequence 4: Tunnel unit, Bermejo unit or Orihuela unit. The rocks of sequence 4 tectonically underlie rocks of the Aguila formation of the Orihuela unit.

outcrop k

Lithology. - The higher part of the sequence - situated above a quarry - consists of an alternation of brownish-yellow dolomitic carbonates and greyish limestones. The rocks are sometimes brecciated. The basal portion of this part of the sequence comprises yellowish "marly" limestones, whitish dolomitic carbonates with a "sugary" aspect, and dark-grey limestones (greyish to pinkish in the fresh handspecimen). In several places the latter rocks are browmish coloured due to mineralization . The lower part of the sequence - forming the quarry above-mentioned - is built up by finely to thickly bedded, creamy to yellowish aphanitic carbonates. The total thickness of the sequence amounts to several tens of metres.

Remarks. - Burrow-structures are locally present.

Possible tectonic relationship. - The sequence of outcrop k underlies rocks of the Jaime formation of the Orihuela unit. For litho-stratigraphical reasons the contact is supposed to represent a major thrust-plane. The base of the sequence is not exposed. The possibility cannot be excluded that the sequence of outcrop k belongs to the Bermejo unit or the Tunnel unit.

outcrop l

Lithology. - Greyish to greyish-brown carbonates.

Possible tectonic relationship. - Unknown.

outcrop m

Lithology. - Well-layered, dark-grey to brownish-grey carbonates.

Possible tectonic relationship. - Redován unit or Callosa unit.

outcrop n

Lithology. - top sequence 2

Well-layered, dark-grey to pinkish coloured carbonate rocks with a crystalline aspect.

sequence 1

Like sequence 2, with intercalations of orange and brownish-green, finely bedded carbonate rocks with "marly" aspect, and of greenish coloured slaty rocks.

Possible tectonic relationship. - Redován unit or Callosa unit.

T e c to n i c s

General statement

As mentioned in the foregoing, sheet 27-36 comprises several tectonic units i.e. in the Sierra de Orihuela, the ~~Tunnel~~ Bermejo and ~~the~~ Tunnel units (below) and the Orihuela unit (above), and in the Sierra de Callosa de Segura the Redován unit (below) and the Callosa unit (above). In addition, a number of isolated outcrops is present, which could not be referred with certainty to one of the above-mentioned units. Their possible position within the tectonic framework has been discussed on p. 29-33.

All the major tectonic units represented on the sheet Orihuela are incorporated within the Ballabona-Cucharón complex, on account of the litho-stratigraphical development of their rock sequences. The combination of the following characteristics is considered as "diagnostic" for the rock sequences of the Ballabona-Cucharón complex elsewhere in the Betic Zone:

a) intercalations of clastic deposits within the carbonate sequences
b) the generally well-layered aspect of the carbonate sequences
c) occurrence of gypsum, sometimes in great quantity
d) presence of metabasite bodies, sometimes in considerable abundance
e) presence of macrofauna
f) low degree of regional alpine metamorphism
g) apparent absence of pre-Alpine "basement" rocks, suggesting that the tectonic units are "strip-sheets".

From a regional point of view the Ballabona-Cucharón complex is situated between the Nevado-Filabride complex (below) and the Alpujarride complex (above) (Egeler & Simon, 1969a,b). Only in the case of the rock sequence of outcrop i (see p.3/), it is possible that an element of the Malaguide complex is dealt with. This would be understandable in view of the position of this outcrop within the general arrangement of the tectonic complexes in the eastern Betic Zone (see "esquema regional" and also Egeler & Simon, 1969b, Table II).

Relationship of the various tectonic units

a) Relationship Tunnel unit - Orihuela unit.- The assumption that the Tunnel unit and the Orihuela unit represent two major tectonic

units is based on the preliminary results of macro- and microfauna investigations (Kozur et al., in prep.). These seem to indicate that the rocks of the uppermost part of the Gertrudis formation of the Orihuela unit - and consequently those of the underlying formations of this unit - are older than the rocks of the "upper carbonate" sequence of the Tunnel unit.

b) Relationship Bermejo unit - Orihuela unit.- On the basis of the preliminary results of macro- and microfauna investigations, the rocks of the upper part of the Gertrudis formation of the Orihuela unit - and consequently those of the underlying formations of this unit - are thought to be older than those of sequence 3 of the Bermejo unit (Kozur et al., in prep.). This may imply that the Bermejo unit and the Orihuela unit represent two major tectonic units.

c) Relationship Bermejo unit - Tunnel unit.- In this stage of investigations it is impossible to decide whether one major tectonic unit or two separate tectonic units are dealt with here. Comparison of the available columnar sections suggests the presence of two units. However, a more exact dating of the various rock sequences with the aid of micro- and macrofauna will be necessary to confirm or to refute this assumption.

d) Relationship Redován unit - Callosa unit.- The fact that part of the pelitic rocks of the Redován unit are phyllitic and thus are more intensely recrystallized than the comparable rocks of the Callosa unit, which are merely slates, led to the distinction of these units (see further p.36-37).

e) Relationship tectonic units Sierra de Orihuela - tectonic units ← of the Sierra de Callosa de Segura.- The Sierra de Orihuela and Sierra de Callosa de Segura are separated by an alluvial plain, rendering it impossible to establish a direct relationship between both groups of tectonic units. On the basis of the available columnar sections the possibility is not excluded that the rock sequence of the Callosa unit is correlatable with part of the rock sequence of the Orihuela unit.

Structures

The detailed study of the structures of the rock sequences of the various tectonic units is as yet not completed. Therefore we restrict ourselves here to some general remarks.

A. Sierra de Orihuela

Megascopic and mesoscopic structures. - The most conspicuous structures are tight to isoclinal folds facing roughly to the south. These folds occur in the rock sequences of all three tectonic units, both on a megascopic and on a mesoscopic scale. They are well exposed, e.g. in the Casa Forestal area (Tunnel unit), in the region to the west of Rincón de Bonanza (Orihuela unit), in the region to the north of Riguero Bajo (Orihuela unit), in the region to the north of La Aparecida (Bermejo unit and Orihuela unit) and, furthermore, in the western slope of the Bermejo, west of Santomera (Bermejo unit). Special attention is drawn to the fact that the tight to isoclinal folding also affects the thrust plane between the Bermejo unit and the Orihuela unit, as seen in the region to the north of La Aparecida (see section 4). It is still uncertain whether the afore-mentioned fold structures result from only one or from more than one deformation phase. After the folding a southward-directed overthrusting and imbrication took place, generally disturbing the preëxisting structures in a considerable degree. A later deformation phase led to production of folds, grading from open to close. Finally the rock sequences of the Sierra de Orihuela were affected by three main sets of steep faults, with a WNW-ESE, NNW-SSE and NE-SW direction.

Microscopic structures. - In rocks of the Orihuela unit a slaty cleavage (S_1), and two crenulation cleavages (S_2 and S_3) have been found. The S_2 crenulation is intense, whereas the S_3 crenulation is weak. The relationship between the megascopic and mesoscopic structures on the one hand and the microscopic structures on the other is uncertain.

B. Sierra de Callosa de Segura

According to Kampschuur (1972 b), a first deformation phase (D_1) produced tight to isoclinal folds on a mesoscopic and megascopic scale, both in the Redován unit and in the Callosa unit. The folds face to the south to south-west. The folding led to production of a slaty cleavage (S_1) in the pelitic rocks of both units and was accompanied by low-grade synkinematic metamorphism. The metamorphism resulted in formation of phyllites and slates in the Redován unit and of slates in the Callosa unit. A second deformation phase (D_2) is held responsible for the disturbance of the D_1 structures and for the discontinuous character of the Alpine

kinematic metamorphism at the contacts between the two units. A third phase (D_3) resulted in open to close folds on mesoscopic and megascopic scale with an axial-plane crenulation cleavage (S_3). The axial-planes dip to the SW at an angle of at least 55°. Under the microscope it can be seen that the S_3 is locally conjugate. D_3 caused the folding of the overthrust-planes formed by D_2. Finally the rocks of the Sierra de Callosa de Segura were affected by normal faults arranged in two main sets, with a N-S and a E-W direction. These faults are believed to be related to updoming of the Sierra de Callosa de Segura.

Geological History

Nothing can be said of the pre-alpine geological history of the regions now represented by the Sierra de Orihuela and adjacent regions to the west and south-west, and by the Sierra de Callosa de Segura, as all tectonic units are "strip-sheets", devoid of pre--Permo-Triassic "basement" sequences.

As to the Alpine depositional history one may state that the stratigraphic columns of the Bermejo unit and of the Orihuela unit reflect a rather abrupt change of depositional conditions, from clastic to carbonate sedimentation, probably in the Ladinian. It is unknown under which conditions the psammitic to pelitic sediments were deposited. The basal part of the Jaime formation of the Orihuela unit - which for the major part comprises psammitics and pelitic deposits consists of marine sediments, i.e. carbonate and gypsum. The higher parts of the rocksequences of the Bermejo unit and the Orihuela unit, as well as the sequences of the Tunnel and Callosa units consist mainly of carbonates, which are thought to have been deposited under shallow marine conditions. The carbonate sedimentation was repeatedly interrupted by deposition of psammitic and pelitic sediments, reflecting influx of terrigeneous detritus in Middle to Upper Triassic time. On the geological maps made in relation with the MAGNA-project the (Permo-)Triassic sediments could only be indicated as having either an Alpine (T_a) or a Germanic (T_g) facies. For the (Permo-)Triassic sediments represented on sheet 27-36 a perforce ~~rather than an arbitrary~~ choice has been made in favour of the Alpine facies. It must be noted, however, that the litho-stratigraphical development and macro- and microfauna content of the rocks sequences of the various tectonic units do not justify this choice. In our opinion it is more correct to range the sediments of the tectonic units of sheet 27-36, as well as those of comparable units elsewhere in the Betic Zone, within a separate paleogeographical province with its (proper) facies. For this province the name "Betic province" is proposed, and for the accompanying facies the name "Betic facies".

The tectonic units of sheet 27-36 contain no post-Triassic deposits. Several hypotheses can be ventured for this absence, inter alia (1) "tectonic transgression" in Jurassic time, (2) a prolonged period of non-deposition during the younger Mesozoic and parts of the Tertiary, and (3) complete erosion of a relatively

thin sequence of post-Triassic deposits. A point worth mentioning is the importance of establishing the age of the basic igneous rocks, now represented by metabasites. The fact that they are affected by the Alpine kinematic metamorphism suggests intrusion prior to the nappe movements. Kampschuur (1972a) assumes that the intrusion of the basic bodies in the Triassic rock sequences of the Ballabona-Cucharón complex from the Sierra de Carrascoy took place in unconsolidated, wet sediments. This obviously implies that the basic rocks are of Triassic age.

As to the Alpine structural evolution, Kampschuur's investigations in the Sierra de Callosa de Segura (Kampschuur, 1972b ~~internal report~~) - and in the Sierra de Carrascoy (Kampschuur, 1972a) - may serve as a basis for a tentative scheme. The first phase of deformation (D_1) has caused folding (F_1) with south to southwest vergence, accompanied by slaty cleavage (S_1) and by low-grade regional metamorphism. This folding can probably be linked with major thrust-movements, directed to the S of SW. These are thought to be responsible for the formation of an "initial pile" of nappes, in the sense of Egeler & Simon (1969a,b). The fact that this "initial pile" was disturbed, in a later stage (D_2) by translation of considerable magnitude, is evidenced by the discontinuity of the kinematic metamorphism at the thrust plane between the Redován and Callosa units of the Sierra de Callosa de Segura. In the Sierra de Orihuela no such abrupt change at the contact between the major units is found.

The third phase of deformation (D_3) in the Sierra de Callosa de Segura is reflected in the folding of the overthrust plane formed during D_2. It furthermore produced a crenulation cleavage (S_3).

The dating of the deformation phases in the Sierra de Orihuela and Sierra de Callosa de Segura is necessarily very inaccurate, as the youngest rocks affected by these phases are of Triassic age and as the oldest "post-nappe" deposits are of Quaternary age.

Economic Geology

In the Sierras de Orihuela and Callosa de Segura the exploitation of ore came to an end many years ago.

Approximatively 3 kilometres to the NE of Santomera Cu-minerals (malachite, azurite, chalcopyrite, chalcocite and native Cu) and native gold have been exploited. The effects of former mining activities hamper the study of the geology of the region in question. It can be concluded (see also Brun, 1909) that the Cu and Au mineralization took place in psammitic rocks of the Mina formation of the Orihuela unit, just above the thrust-plane with the underlying Bermejo unit. Brun states that the deposits are of sedimentary origin and that the orebearing solutions originate from the bodies of basic igneous rocks, which are abundant in the region.

Iron ore has been mined on a small scale in the past in several localities, viz:

A. Tunnel region: (1) to the North of the highway Murcia-Alicante, in carbonate rocks of the Tunnel unit
(2) to the North of the highway Murcia-Alicante in carbonate rocks of the basal part of the Aguila formation of the Orihuela unit.

B. Eastern Sierra de Orihuela: Approx. 1 km to the NE of pt.486, in carbonate rocks of the Otón formation

C. Central Sierra de Orihuela: Approx. 1 km to the SW of pt.634, in carbonate rocks of the Aguila formation

D. Cabezo Ros region: Near Benferri, in carbonate rocks of the Benferri formation.

The mineral is haematite, occurring disseminated in strongly limonitized carbonate rocks.

In the explanation to the sheet Orihuela (1951 edition) mention is made of an abandoned Cinnaber exploitation in the region to the SW of the tunnel near Orihuela. No detailed data on the exact locality and the mode of deposition are given by the authors of the afore-mentioned publication. We have found no indications for the presence of mercury deposits in this regions. It would be recommendable to make a detailed prospection - inter alia with the aid of geochemical methods - to determine in which rock sequences the mineralization took place.

Gypsum has been quarried in the following regions:

(1) Between Santomera and Cobatillas	Basal part of sequence 2 of the Bermejo unit
(2) Region between pt.196 and Loma del Barranco Largo	Sequence 4 of the Bermejo unit
(3) Approx. 1 km NNE of Raiguero de Abajo	Lowermost part of the Aguila formation of the Orihuela unit

Carbonates are (or have been) exploited for road-building and construction purposes in the following regions:

(1)	El Puntal (to the NE of Espinardo)	undifferentiated rock sequence (=outcrop b of p. 30)
(2)	La Cuevas	undifferentiated rock sequence (=outcrop c of p. 30)
(3)	Between pt.196 and Casa del Cuello	Cantalares formation of the Bermejo unit
(4)	To the W of the Embalse de Santomera (U.T.M. quadrant 6.68-6.69/ 42.18-42.19)	Cantalares formation of the Bermejo unit
(5)	Approx. 1 km to the SW of Santomera	Cantalares formation of the Bermejo unit
(6)	Approx. 800 m to the NE of Raiguero de Abajo	Aguila formation of the Orihuela unit
(7)	Approx. 250 metres to the NE of the cementerio de Orihuela	undifferentiated rock sequence (=outcrop k of p. 32)
(8)	Just to the NW of the crossing of the roads Orihuela-Benferri and Murcia-Alicante	Aguila formation of the Orihuela unit
(9)	NW Sierra de Callosa de Segura	Callosa formation of the Callosa unit
(10)	Approx. 750 metres to the NE of the cementerio of Callosa de Segura	Callosa formation of the Callosa unit
(11)	Approx. 1250 metres to the NNE of Granja de Rocamora	undifferentiated rock sequence (=outcrop n of p. 33)

The metabasite body to the south of the tunnel near Orihuela is exploited for road-building purposes.

Metamorphism

The rock sequences of all the tectonic units represented on the sheet Orihuela show the effects of alpine regional metamorphism. The grade of this metamorphism is very low, never surpassing the lowermost subfacies of the greenschist facies. It has resulted in neoformation of colourless mica, chlorite, quartz and some albite. According to Kampschuur (1972 b) the formation of these minerals in the rocks of the Sierra de Callosa de Segura is syn-kinematic and related to a first phase of deformation (D 1). The probable presence of a mineral of the glaucophane-group from the Redován unit suggests local transition to the conditions of the glaucophane schist facies (see further p. 9). In many cases the recrystallization is found to be incomplete, as shown in the metasediments by the preservation of grains of clastic origin, and in the metabasites by the preservation of igneous minerals and structures. In the rocks of the various tectonic units from the Sierra de Orihuela and adjoining regions to the west and south-west no marked differences were found in the degree of recrystallization were found - either in the field or under the microscope. In the Sierra de Callosa de Segura the pelitic rocks of the Redován unit are partly more recrystallized than the comparable rocks of the Callosa unit, the former being phyllitic and the latter merely slates.

A study of the illite-chlorite crystallinity of the pelitic rocks of the various tectonic units, as carried out by Kampschuur (1972 A) for those of the tectonic units of the Sierra de Carrascoy, might provide interesting results for a subdivision on the basis of the degree of recrystallization.

Apart from the afore-mentioned alpine regional metamorphism, some carbonatic rocks in the direct vicinity of metabasite bodies show the effects of a thermal-metamorphism, with neoformation of i.a. forsterite and spinel.

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G E O L O G I C A L M A P S

Mapa geológico de España - hoja 45 - tercera edición(1:~~1000.000~~ 400.000)

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