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Interference of compressional and wrenching tectonics in the Alicante region, SE-Spain

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Abstract

The Alicante region forms part of the External Zone of the Betic Cordilleras. The regional fold trend is ENE, but in the central part of the area studied, an anomalous N-S trend dominates. In previous publications the N-S folds have been interpreted as structures formed by diapiric movements of Triassic evaporites. However, analysis of tectonic stylolites and structural style of the folds show that both trends were formed by crustal shortening. Interference patterns suggest overprinting of the two fold trends.

A model is proposed in which the N-S trending folds are interpreted as the result of right-lateral movement along a basement fault. The wrench fault involved would be an offshoot of the important Crevillente fault.

The occurrence of both wrenching and compressional tectonics in the Alicante region is discussed in respect with existing plate tectonic models.

Introduction

The Betic Cordilleras of southern Spain form the westernmost part of the Alpine Mediterranean chain. They are roughly subdivided in an Internal Zone in the south and an External Zone in the north. The Internal Zone forms part of the Alboran plate (Andrieux et al., 1971) and mainly consists of metamorphic Triassic and Paleozoic rocks. The External Zone consists of non-metamorphic Mesozoic and Tertiary sediments deposited on the Iberian continental margin (Garcia Hernandez et al., 1980). A subdivision of the External Zone distinguishes a Prebetic Zone in the north, characterized by shallow water facies sediments, and a Subbetic Zone in the south, where pelagic facies prevail. The Prebetic and Subbetic Zones are separated by the so-called Intermediate Units, Which represent continental slope deposits. In the classical interpretation of the structure of the External Zone, the contacts between the Zones correspond to important thrusts, which place the Subbetic tectonically on the top of the Prebetic. Recently (De Smet, 1984) the External Zone has been interpreted as a strike-slip orogen.

The main focus of our study is the structural evolution of the Alicante-region, which is situated in the easternmost part of the External Zone (see Fig. 1), on the boundary of the Prebetic and Intermediate Units. Former studies are mainly concerned with the stratigraphy of the area. In recent structural studies of the region Rodriguez Estrella (1977) and Moseley et al. (1981) distinguished two fold trends, a regional ENE-WSW trend and a local, anomalous N-S trend, which they attributed to diapiric movement of Triassic evaporites. However, new field data (this paper) show that both fold trends have been formed by compressive stresses.

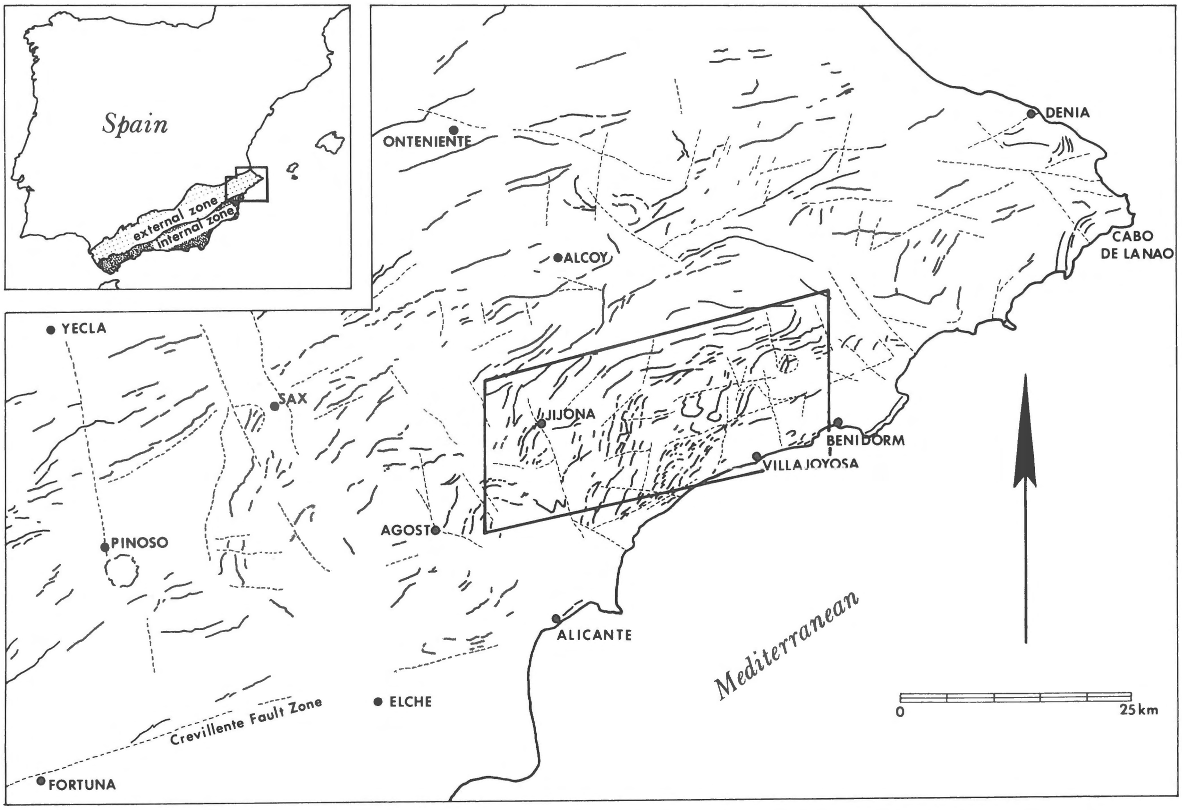

Fig. 1. Satellite image interpretation of the eastern Betic Cordilleras (ESA-Earthnet). Solid lines: topographic features. Dashed lines: lineaments. Framed area: area studied. Inset shows the location of the Betic Cordilleras.

Outline of stratigraphy

The pre-Alpine basement, which is not exposed in this part of the Betic Cordilleras, is covered by an almost 3 km thick sequence of Mesozoic and Tertiary rocks, which mainly consist of marine carbonates, deposited on the outer shelf and upper slope of the former continental margin.

The oldest rocks exposed are brightly coloured gypsiferous mudstones of Upper Triassic (Keuper) age. The mudstones are strongly deformed, and intercalations of dolomite, siltstone, sandstone and diabase sill occur as tectonically isolated blocks.

The Upper Jurassic is exposed in the area as a 400 m thick series of massive oolitic limestone with sandy lenses.

On top of this limestone a marly gravel sequence, up to 50 m thick, occurs, which contains several hardgrounds that represent stratigraphical gaps between the Upper Jurassic and Middle Aptian. These rocks are overlain by a rhythmic series of marly limestones of Aptian-Albian age, with considerable variations in facies and thickness of the sequence. It shows a gradual change from the NW, where limestones form the dominant lithology, to the SE, where marls become more important. Abrupt facies changes occur at the Cabezon de Oro (see map), where the sequence contains massive reef limestones and attains its minimum thickness (250 m). To the W and E of the Cabezon de Oro the thickness rapidly increases, up to about 700 m near Finestrat.

The Cenomanian-Turonian is characterized by a formation of massive limestone, up to 150 m thick, with intraformational conglomerates at the base.

The Upper Cretaceous-Lower Paleogene is rep-

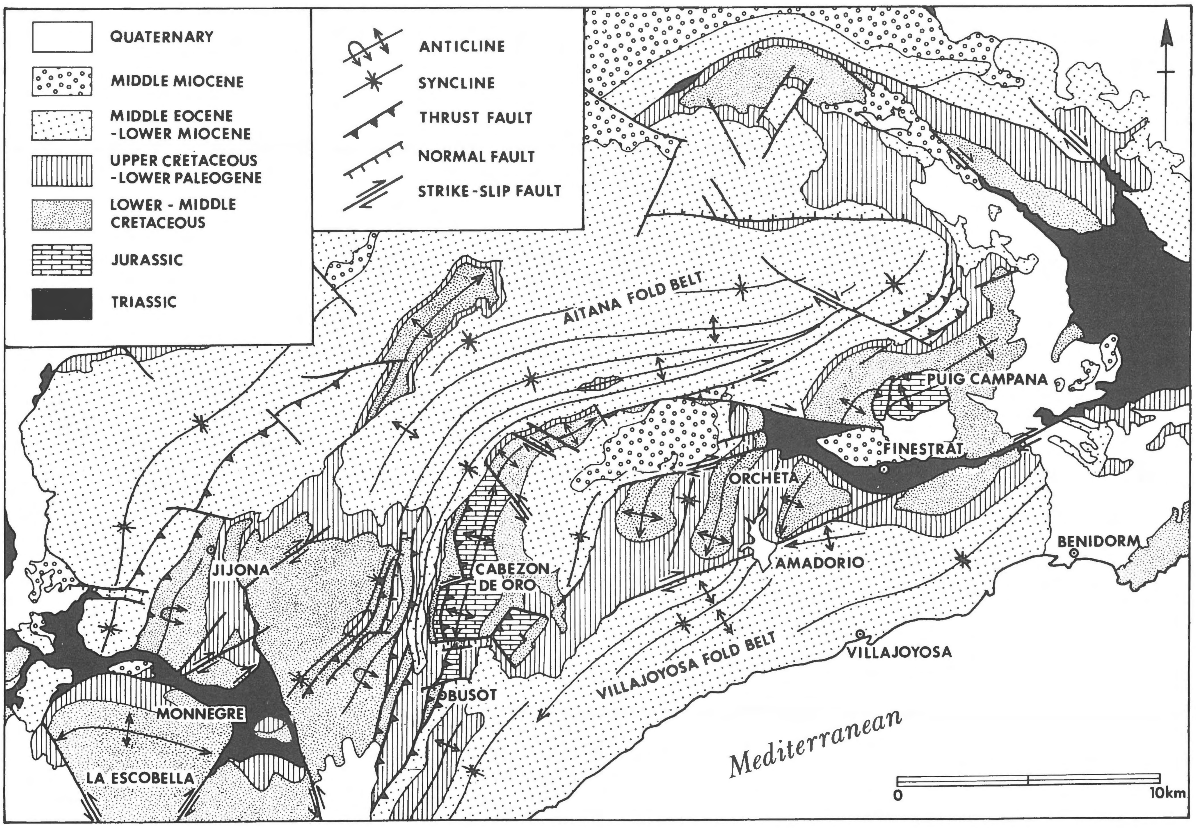

Fig. 2. Simplified geological map of the Jijona fold belt (central part) and adjacent structural domains.

resented by a roughly 250 m thick sequence of white, thinly bedded limestones and marls of Couches Rouges facies.

The Middle Eocene-Oligocene shows large variations in thickness and facies, which will not be discussed in detail. Near the Cabezón de Oro the Middle Eocene rests unconformably on Cretaceous rocks. The dominant lithology is an alternation of allochtonous calcarenites and pelagic marls. Syndepositional slumping, olistostromes and debris flows are common in the sequence.

Near the western limit of the area the Oligocene is unconformably overlain by marls and an at least 200 m thick series of massive bioclastic limestone of Aquitanian-Burdigalian age. Near the Triassic outcrop of Rio Monnegre (see Fig. 2) reworked Triassic rock fragments occur in Burdigalian limestones (J. v.d. Zwan, 1987, pers. comm.)

Near Finestrat a 350 m thick sequence of conglomerates and well bedded marly limestones rests with an angular unconformity upon Triassic rocks. The sequence post-dates the main phase of orogeny, but has been folded by late orogenic movements. Its age is estimated Messinian by Moseley et al. (1981) and Burdigalian-Serravallian by IGME (1981). However, a more precise age of Serravallian-Early Tortonian (11 ± 1 Ma) follows from the narrow range-overlap of specific Neogloboquadrina and Globorotaloides faunas (det. by Manuputty).

Unconformities of middle Cretaceous and Middle Eocene age, as well as highly variable thicknesses and facies of the various formations indicate continuous tectonic activity during deposition. Sedimentation shows that during the Cretaceous and Lower Tertiary evolution the Alicante region constituted a zone of weakness, possibly associated with basement fault activity. It is assumed that stratigraphical unconformities of post-Middle Eocene age are associated with crustal shortening, since tectonic movements in the External Zone were mainly compressional from the Eocene onward (Paquet, 1974; Dercourt et al., 1986).

Structure

The Mesozoic and Tertiary sedimentary cover has been folded and fractured during the Alpine Orogeny. The Triassic evaporites form the main decollement level; the basement was not involved in folding (Garcia Hernandez et al., 1980). It is generally assumed that the immediate cause for deformation in the Prebetic is the overthrusting of the Subbetic.

The regional tectonic trend in the Alicante region is ENE. This trend is characterictic of the Betic Cordillera and will be referred to as the 'Betic trend'. In the area studied, two major fold trends are found. In the central part of the area, which runs approximately E-W (Jijona fold belt, Fig. 2), the folds show a N-S trend, while to the north and south of this domain (Aitana and Villajoyosa fold belts) the regional Betic trend dominates. Several structures show an interference pattern of N-S and ENE-WSW trending folds.

Due to the large variation in mechanical behaviour, the rocks have been folded in a strongly disharmonic way. Competent Jurassic and Cenomanian-Turonian limestones form large-scale box folds, while in the more ductile Senonian marly limestones small-scale chevron folds occur. In the following section the most important structures of the studied area will be discussed in more detail.

Aitana and Villajoyosa fold belts

The Betic trend is represented in the Aitana and Villajoyosa fold belts (see map, Fig. 2). The structure of these fold belts is relatively simple, with NW-vergent folds and minor thrusts. The fold axes gently plunge to the west, and the hinges are often faulted and brecciated. Only Tertiary rocks are exposed in these foldbelts.

The northern boundary of the Villajoyosa fold belt is formed by the Amadorio fault (Fig. 2). This fault has been interpreted by Garcia Hernandez (1980) and IGME (1981) as the overthrust-contact between the slope deposits of the Intermediate Units and the outer shelf deposits of the Internal Prebetic. However, overthrusting towards the north is unlikely, as the fault plane is vertical and Tertiary rocks on the south side are in tectonic contact with Cretaceous rocks on the north side. Horizontal slicks and minor dextral strike-slip faults parallel to the main fault indicate dextral wrenching instead.

Jijona fold belt

The Jijona fold belt with its large Triassic and Jurassic occurrences forms the main subject of this paper. The mainly Mesozoic rocks are more intensely deformed than in surrounding areas and local structural trends are decidedly oblique to the regional Betic trend.

Most impressive in these anomalous structures are the N-S trending en-echelon folds. The en-echelon arrangement can be clearly seen around Orcheta (Fig. 2), where the folds are discontinuous and confined to a small wedge-shaped area.

In the south the transition between the Jijona N-S trending folds and the Betic ENE-WSW folds of the Villajoyosa fold belt is often abruptly faulted. The transition between the Jijona- and Aitana fold belts in the north is gradual: the N-S folds curve round to the east to become parallel to the Betic trend.

Some of the larger N-S trending folds, like the Cabezón de Oro and the folds south of Jijona, are associated with important thrust faults. Displacements are in the order of 10 to 200 m in westerly directions. In several cases normal and reverse faults with the same strike have been found near each other (W of Busot, N of Orcheta). Another important feature of the Jijona fold belt is the presence of E-W trending dextral strike-slip faults (e.g. northwest of Finestrat) and, to a lesser extent, NNW trending sinistral strike-slip faults.

In some cases these two sets of strike-slip faults are directly related to the folds, as can be seen at La Escobella and Cabezón de Oro (Fig. 2), where the two fault sets limit the folds to either side. The faults are symmetrically oriented with respect to the fold axis and demonstrate a Coulomb-orientation-relationship at approximately 60° to the fold axis. The orientation and sense of displacement of the faults suggest that they constitute conjugate sets.

The Jijona fold belt extends outside the studied area to the Cabo de la Nao in the east (Fig. 1), where comparable N-S folds are present in the Sierra de la Granadella (IGME, 1975), and towards the Sierra de los Tajos in the west (IGME, 1978). All N-S folds mentioned are confined to an elongate zone, approximately 7 km wide and of at least 80 km length. The long axis of the zone has an orientation of N 70° E, i.e. slightly oblique to the regional Betic trend.

The large Triassic and Jurassic occurrences show anomalous structures, which will be discussed in the following section.

Monnegre and Finestrat diapirs

The extensive Triassic occurrences around the Rio Monnegre and Finestrat roughly follow an ESE-WNW trending outcrop pattern. They are bounded on all sides by subvertical faults which truncate all other structures. Surrounding younger rocks, particularly Senonian marls, are strongly folded and brecciated in the contact zone with the Triassic.

Triassic gypsiferous mudstones, which form the major part of the outcrops, display a very complex and often chaotic structure. Although individual structures in the more competent dolomites and sandstones can be distinguished, a systematic relationship between the structures has not been found. The high gypsum content and the intrusion-like contact with surrounding rocks suggests that the Triassic has risen diapirically (Moseley et al., 1981). The diapirs must have intruded along extension faults with a WNW-ESE orientation. The presence of other extension faults in the area with the same orientation supports this interpretation. In the case of the Finestrat diapir, which is bounded towards the north and south by dextral wrench faults, the Triassic seems to have intruded a small 'pull apart' basin (see below and Fig. 5).

Cabezón de Oro

In the Jijona fold belt there are two large isolated Jurassic occurrences which form part of the N-S trending folds, the Cabezón de Oro and the Puig Campana. These massifs form the highest parts of the relief.

The structure of the Cabezón de Oro basically is a large-scale asymmetric anticline. The main features of the structure are illustrated in the block diagrams of Fig. 3. The fold axis trends N-S and plunges to both sides. The western limb is vertical and forms an impressive 300 m high wall of massive Jurassic limestone. The eastern limb forms a large 45° dipslope at the base of which the Jurassic-Cretaceous sequence is well exposed. In the centre the anticline shows a small secondary syncline, in which strongly folded Cretaceous rocks are exposed. Small scale folds in Senonian marls show N-S and ENE-WSW fold axes. The eastern limb of the Cabezón de Oro anticline is thrust over and onto the western limb, which is cut by several minor horizontal thrust planes associated with the main thrust.

In the north the fold axis forms a wide arc curving into the Betic direction. In this zone the structure is cut by a system of NNW-SSE trending sinistral strike-slip faults. In the south the Cabezón de Oro terminates against a large E-W trending normal fault.

A major steep fault in the centre of the structure dextrally offsets the western limb by 600 m. The fault hardly affects the eastern limb and it is therefore interpreted as a tear fault connecting two segments of the earlier mentioned thrust.

The Cabezón de Oro has been extensively studied by Polveche (1963), Lillo Bevia (1973), Azema (1977), Azema et al. (1975) and Rodriguez Estrella (1977). The most widely accepted theory on the Cabezón de Oro is that of Polveche (1963), in which the structure is interpreted as an 'extrusion' of competent Jurassic limestone. According to this

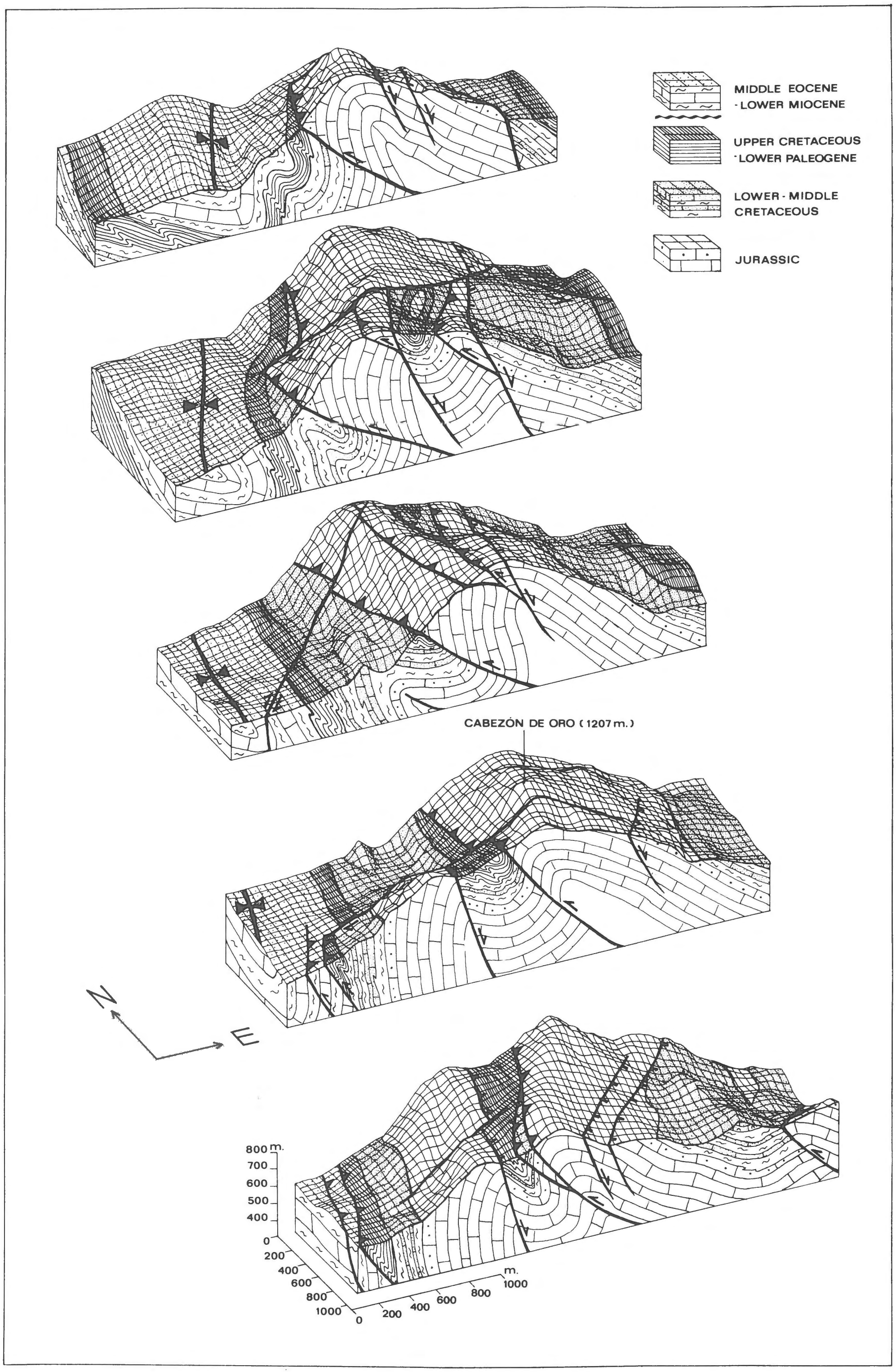

Fig. 3. Sliced block diagram showing detailed structure of the Sierra del Cabezón de Oro.

theory the Jurassic was squeezed out of its surroundings 'comme un noyau de cerise entre deux doigts' ('as a cherry pit between two fingers') (Polveche 1963) as a result of extremely disharmonic folding during the main orogenic phase. Rodriguez Estrella (1977) argued that the extrusion is not associated with the main orogenic phase because of its anomalous direction. He stated that the extrusion is the result of diapiric movement of Triassic evaporites. Since there is no Triassic exposed in or around the complex of the Cabezón de Oro he interpreted the structure as an 'aborted diapir'. This diapirism occurred in a zone of weakness, caused by a basement fault.

It is evident that the structure of the Cabezón de Oro cannot simply be explained within the Betic NNW-SSE compressional regime because of its anomalous direction, but we disagree with the diapir-model of Rodriguez Estrella. Below, it will be argued that the Cabezón de Oro and the other N-S trending folds must have developed as a result of an E-W directed compression which mainly acted prior to the Betic compression. This assumption is supported by interference structures and paleostress directions derived from tectonic stylolites.

Interference structures

Various structures in the Jijona fold belt suggest an interference between the Betic NNW-SSE compression and an E-W directed compression.

In several places refolded small-scale folds have been oberved in Senonian marls. Some of these folds are associated with Triassic occurrences and may be the result of diapiric movement, as suggested by Moseley et al. (1981). In the absence of Triassic rocks (near Busot and Cabezón de Oro), N-S folds are refolded by ENE-WSW folds.

Two large domes W of Orcheta (Amadorio and Carcondo domes) reflect interference between the ENE-WSW and N-S trends, as also suggested by Moseley et al. (1981).

Paleostress directions derived from tectonic stylolites

Locally, well developed tectonic stylolites are found in the competent Cretaceous and Tertiary limestone series. In all cases observed, the stylolithic columns are perpendicular to the stylolithic surfaces, which are at high angles to the bedding planes. The stylolithic surfaces are regularly spaced in the rocks and define a new foliation S_{st}. The stylolites are associated with calcite veins which are perpendicular to S_{st}. The orientation of these structures is closely related to the folds. The strike of S_{st} in most cases parallels the strike of the bedding surfaces.

In domains where the trend of the folds is N-S, the strike of S_{st} is also N-S, while Betic folds are associated with stylolithic surfaces with an ENE-WSW strike. Since the angular relation of S_{st} and S_o is identical on both limbs of a fold, it is inferred that the stylolithic surfaces predate the folding. The orientation relations of folds, stylolites and extension veins are illustrated by Fig. 4. In cases where two folds interfere, two sets of tectonic stylolithic surfaces are found, each set being parallel to one of the folds. Paleostress orientations inferred from these tectonic stylolites will be used here to explain the development of the fold system in the Alicante region.

Conjugate tear faults limit the folds of La Escobella and Cabezón de Oro. Their orientation yields an estimate of the paleostress directions (cf. Arthaud, 1969). In the present case it can be concluded that the direction of the largest principal paleostress σ_1 was perpendicular to the fold-axes, and approximately parallel to the bedding.

The tectonic stylolites and associated extension veins can also be interpreted in terms of paleostress. The stylolithic columns are interpreted as being parallel to the solution direction, which is parallel to σ_1. In the present case the stylolithic columns are perpendicular to the stylolithic surfaces, so S_{st} is perpendicular to σ_1. Extension veins represent opened cracks, the opening direction being parallel to the least principal stress σ_3, in this case a tensile one.

The formation of the stylolites pre-dated the

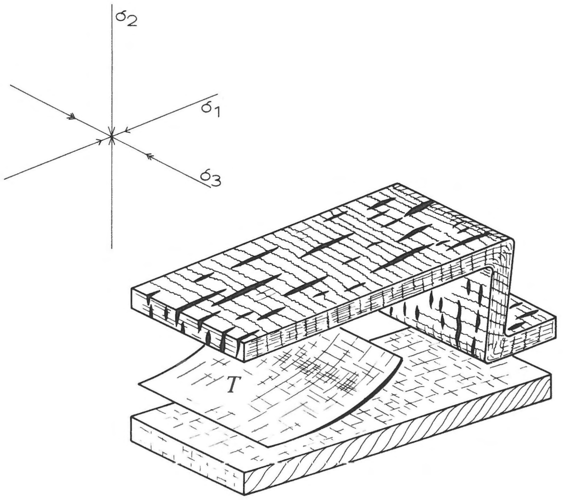

Fig. 4. Relationship of the orientation of folds, stylolites (irregular wavy lines) and extension veins (black). T represents thrust plane associated with the fold. Note that the stylolithic surfaces have been folded.

folding, but since the strike of the tectonic stylolites is everywhere parallel to the fold axis, it seems likely that the structures were formed by the same stress system (cf. Alvaro, 1975).

The time relations of development of the folds and the stylolites can be interpreted as follows. Since the Escobella and Cabezón de Oro folds are limited by thrusts and conjugate tear faults, it seems that the displacement produced by folding is balanced by movement along these faults. Such an interpretation implies that folding and faulting have acted simultaneously. It can be assumed that the associated strain rates are relatively high compared with those associated with stylolite formation (De Boer, 1976). The following stress-strain history can now be envisaged; as a result of a long-term stress regime stylolites are formed over a long period of time. At a certain moment brittle failure of the rocks takes place and conjugate wrench faults and thrusts allow folding. This event has two consequences on the development of the stylolites: they become reorientated due to folding, and further development of the stylolites will be hampered due to the stress drop associated with faulting. The analysis of the orientation of the paleostress indicates that both the N-S and the Betic ENE-WSW folds were formed by compression perpendicular to the fold axes. Furthermore, the interference of folds is related to overprinting of two phases of compressive stresses.

This conclusion allows discussion of an earlier model explaining the N-S fold trend in the Jijona fold belt as being formed due to diapiric movement of the Triassic evaporites (Rodriguez Estrella, 1977, Moseley et al., 1981). Diapirism would be associated with extension in the cover rocks. The overprinting relations shown by the tectonic stylolites in large scale dome structures indicate that they formed by overprinting shortening events, which precludes a diapiric origin of the structure.

A new interpretation is proposed in which the N-S folds of the Jijona fold belt resulted from dextral wrenching in the pre-Alpine basement. The strike-slip movements are thought to have interfered with the compressional movements which caused the Betic ENE-WSW folds.

The model

Clay model experiments like that of Wilcox et al. (1973) show that wrenching in a rigid basement causes a characteristic deformation pattern in a rigid-plastic cover. These experiments show good agreement with natural wrench zones. A strain ellipse including the relative orientations of structures that tend to form in right-lateral simple shear is given by Christie-Blick & Biddle (1985). The geometry of the Jijona fold belt shows a striking resemblance with that of a dextral wrench zone, and the predicted orientation of the associated strain (Fig. 5). The wrench zone would have an orientation of N 70° E, corresponding with the long axis of the Jijona fold belt.

The en-echelon N-S folds and thrusts can thus be explained by the compressional components associated with right-lateral movement along the fault zone.

Wrench associated extension is represented by the E-W trending normal faults which cut the N-S folds at right angles to the folds axes. Locally, normal faults occur at what seem to be 'oversteps' of strike-slip faults (Christie-Blick & Biddle, 1985).

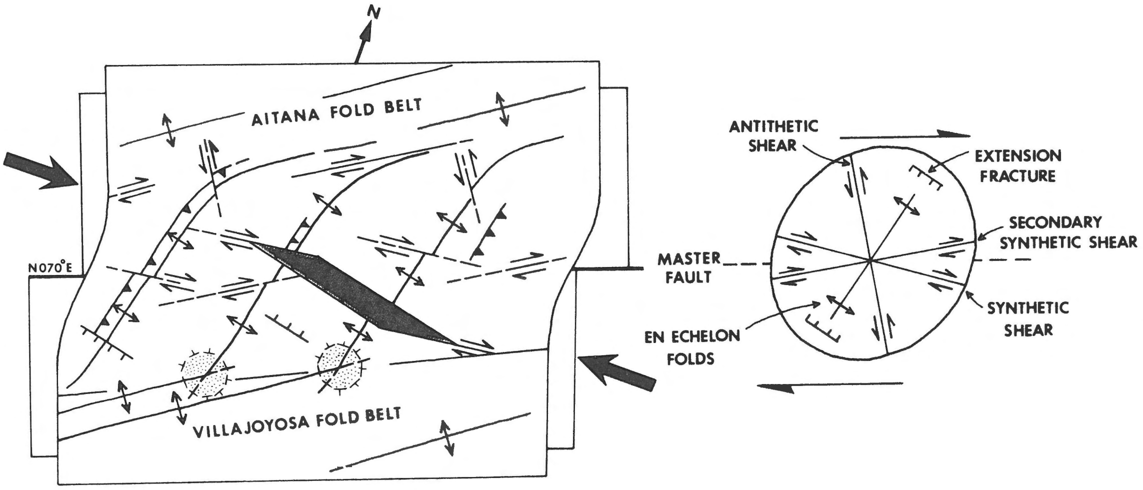

Fig. 5. Interpretation of the Jijona fold belt as a wrench zone. The Aitana- and Villajoyosa fold belts represent the regional Betic trend.Stippled areas are domes formed by interference of Beltic ENE-WSW folds with Jijona N-S folds.

It is in these places (e.g. Finestrat) that the Triassic evaporites have intruded (Fig. 5).

Dextral ESE-WNW and ENE-WSW trending strike-slip faults are interpreted as synthetic and secondary synthetic shears, respectively. A good example of antithetic shears are the sinistral NNW-SSE trending strike-slip faults north of the Cabezón de Oro.

Apart from the geometry, the style and distribution of deformation also support the wrench-model. As mentioned earlier, the Jijona fold belt has suffered a more intense deformation than surrounding areas. A concentration of deformation can indeed be expected in the principal displacement zone of a wrench fault. The presence of both normal- and reserve-separation faults in a given profile (e.g. W of Busot, N of Orcheta, see map, Fig. 2) is considered as one of the characteristics of wrenching-associated deformation (Reading 1980; Christie-Blick & Biddle, 1985). Small, discontinuous areas showing coherent fold structures, like the Orcheta-block, can be explained by a strike-slip setting as individual blocks, tectonically separated in an early stage of wrenching. The alteration of N-S folded areas and fault-bounded Triassic occurrences can have resulted from wrenching-associated compression and extension respectively.

Involvement of the basement in wrenching is inferred from geothermal anomalies near the Cabezón de Oro and seismic activity near Jijona, described by Rodriguez-Estrella (1977). The occurrence of important thickness- and facies-changes in rocks of Lower Cretaceous age and younger suggests instability. It is likely that the supposed wrenching took place along a pre-existing zone of weakness, caused by one or more basement faults. These basement faults would have accompanied subsidence of the basin in earlier times, thus forming the boundaries of the paleogeographic realms.

Former interpretations of the Alicante-region do not include wrenching as a dominant mechanism to explain the structure of the area. Sanz de Galdeano (1983) interpreted a set of dextral wrench faults ('extremos del accidente Cadiz-Alicante') in the area around Jijona with the same WSW-ENE orientation as predicted in Wilcox et al., and Christie-Blick & Biddle's wrench model. This author does not give evidence, but refers to earlier work of Paquet (1974) and Jerez Mir (1979). These hypothetical faults would be offshoots of the important Crevillente fault (see Fig. 1).

The Crevillente Fault Zone has been mentioned by several authors (Azéma, 1977; Paquet, 1972, 1974; Hermes, 1978; Leblanc & Olivier, 1984; Sanz de Galdeano, 1983; De Smet, 1984). It runs subparallel to the trend of the External Zone of the Betic Cordillera, over a distance of several hundreds of kilometres. Most authors agree on a right-lateral movement along the fault. However, uncertainty exists about the eastern continuation of the fault. It is possible that the fault branches off in the Alicante region, as proposed by Sanz de Galdeano (1983). If so, the fault proposed in this paper (Jijona Fault) could be an offshoot of the Crevillente Fault as the strike (N 70° E) and the sense of movement of the faults are consistent.

Displacement along the Crevillente Fault Zone is estimated at 20 to 100 km (Sanz de Galdeano, 1983; Leblanc & Olivier, 1984) to even 400 km (De Smet, 1984). Displacement along the Jijona Fault is considered to be less, as in the case of a large displacement one would expect the basement fault to propagate into the cover as a narrow through-going principal displacement zone (Wilcox et al., 1973; Christie-Blick &Biddle, 1985).

Age of deformation and the relation between wrenching and compression

The main orogenic phase in the External Zone occurred in the Middle Miocene (Garcia Hernandez et al., 1980; Croese, 1982). This timing agrees with biostratigraphic data in the area studied, where the main tectonic movements took place in Langhian-Serravallian times. The age of the Crevillente Fault is a point of controversy. According to Paquet (1974), Azéma (1977) and Leblanc & Olivier (1984) the fault developed in Tortonian times, after the emplacement of the Subbetic nappes, because the fault cuts the Subbetic nappes. According to Jerez Mir (1979) the largest movements along the fault occurred in Late Aquitanian to Burdigalian times, followed by continued movement at a lower rate.

The age of the main orogenic event in the Jijona fold belt does not seem to differ from that in surrounding areas, and consequently compression and wrenching seem to have occurred at approximately the same time. The gradual transition between the N-S folds and the Betic ENE-WSW folds supports this. However, in the Jijona fold belt local disconformities in Eocene-Oligocene (this paper; Rodriguez Estrella, 1977; Baena Perez & Jerez Mir, 1982) and reworked Triassic in Burdigalian deposits suggest earlier movements, possibly caused by wrenching. The interference structures also suggest that wrenching occurred prior to compression. This apparent contradiction may be explained by assuming episodic movement along the Jijona fault.

De Smet (1984) has stated that the Crevillente Fault is the main cause of deformation in the External Zone; he denied the existence of Subbetic nappes and interpreted the External Zone as a strike-slip orogen or a wrenched continental margin. We agree that wrenching was an important factor in the Betic orogeny; yet De Smet's proposed strike-slip/compression ratio of 4:1 cannot be envisaged in the Alicante region. In view of the limited extent of the Jijona fold belt, wrenching seems to be subordinate to the regional compression that formed the Betic folds.

Plate tectonic setting

Several authors have tried to explain both the Betic Cordilleras and the Crevillente Fault within the plate tectonic framework of the Mediterranean (e.g. Andrieux et al., 1971; Jerez Mir, 1979; Olivier & Leblanc, 1984). The occurrence of both compressional and wrenching tectonics in the Alicante region fits into most of the existing plate tectonic models, although the age and importance of different tectonic movements are still a matter of discussion. Most authors agree that the Late Mesozoic position of the Alboran plate (including the Internal Zone and part of the External Zone) was further east in the Mediterranean than its present position. According to Olivier and Leblanc (1984) the Alboran plate moved westward as a result of the N-S convergence between the African and Iberian plate. This movement caused right-lateral wrenching along the Iberian plate margin (Crevillente Fault).

Dextral wrenching along the Iberian plate margin could also have been caused by oblique movement of Africa towards Iberia. A right-lateral transpressional phase has been proposed for the Early Eocene (Dewey et al., 1973) or Late Oligocene-Early Miocene (Dercourt et al., 1986).

Conclusions

Interference structures, structural style of folds and analysis of tectonic stylolites show that the N-S trending folds of the Jijona fold belt were formed by crustal shortening, and not by diapiric movement of Triassic evaporites. The shortening was generated in a deformation zone above an ENE trending basement fault. Dextral wrenching along this fault caused en-echelon folding and fracturing of the Mesozoic and Tertiary cover sediments. Triassic evaporites intruded diapirically along extension faults that formed in the process.

Superposition of the regional ENE Betic fold trend on structures formed by wrenching caused local refolding and the formation of domes. As suggested by local stratigraphical unconformities wrenching started in Late Oligocene or even Eocene times. During the main phase of orogeny, in Langhian-Serravallian times, wrenching and compression seem to have been acting simultaneously.

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