

ON THE CLASSIFICATION OF TECTONIC UNITS IN THE NEVADO-FILABRIDE COMPLEX OF THE NORTHERN SIERRA DE LOS FILABRES, BETIC CORDILLERAS, SE SPAIN¹

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ABSTRACT

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A layer of calcareous cataclasites, formerly considered to be interstratified in Permo-Mesozoic rocks in the lowest Nevado-Filabride tectonic unit – the Nevado-Lubrín unit – locally contains fragments of pre-Permian black schist. It is argued that the cataclasite represents a fault-rock formed in association with an important overthrust. This leads to a revision of the lithostratigraphy of the Nevado-Lubrín unit, with the cataclasite forming the uppermost rock-body.

The cataclasite is tectonically overlain by the Secano unit (composed of pre-Permian black schist and quartzite) and – where this unit is absent – by the Umbria de las Canteras unit (consisting of a sequence of marble and calcschist). This latter thrust-mass was hitherto misinterpreted as the stratigraphic upper part of the Nevado-Lubrín unit, which led to a seemingly enigmatic position of the Secano-unit within the Nevado-Filabride rock-pile. The present interpretation solves this 'Secano-problem', as thrusting of the Umbria de las Canteras unit over the Secano unit is recognized.

INTRODUCTION

The Sierra de los Filabres, the easterly extension of the Sierra Nevada in the province of Almería, forms part of the Internal or Betic Zone of the Betic Cordilleras, the alpine fold belt of southern Spain. The structure of the Betic Zone is dominated by large overthrust units, that mainly consist of Palaeozoic (and older?) and Mesozoic metasediments (BROUWER, 1926). In the central and eastern parts of the Betic Zone, these units are usually grouped into four tectonic complexes (EGELER & SIMON, 1969-a, b; EGELER & FONTBOTE, 1976) which are – from below to above – the Nevado-Filabride complex, the Ballabona-Cucharón complex, the Alpujarride complex, and the Malaguide complex. As discussed by EGELER ET AL. (1971), this grouping is done largely on the basis of level of the various units in the rock pile and on the basis of degree of alpine metamorphism. The mineral assemblages in

the Nevado-Filabride complex indicate a first stage of alpine metamorphism in the glaucophane-schist facies, overprinted by a second stage of high greenschist to amphibolite-facies metamorphism, in turn followed by low greenschist-facies conditions (DE ROEVER & NIJHUIS, 1964; NIJHUIS, 1964-b). The Permo-Triassic rocks of the Ballabona-Cucharón and Alpujarride complexes are mostly of low metamorphic grade and the rocks of the Malaguide complex show at most a very weak metamorphism.

A serious problem in establishing the lithostratigraphy of the tectonic units of the Nevado-Filabride complex stems from the lack of reliable data on age of the rocks. Apart from two radiometric age determinations discussed below, the current stratigraphic interpretations are based entirely on lithologic comparisons with the less metamorphosed and locally fossiliferous rock sequences in the higher tectonic complexes. NIJHUIS (1964-a) thus suggested a lithostratigraphy for the Nevado-Filabride complex based on a correlation with an 'idealized Alpujarride columnar section'. In structurally complicated areas, however, the disadvantage of this method of correlation is the ambiguity implied by the method: tectonic interpretation is based on interpretation of the lithostratigraphy and vice versa.

Application of NIJHUIS' (1964-a, b) Nevado-Filabride stra-

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topography in the central and northern parts of the Sierra de los Filabres by VOET (1967) and HELMERS & VOET (1967) faced these authors with a structural problem. It appeared that the second Nevado-Filabride tectonic unit, the Secano unit, overlies a layer of calcareous breccia with gypsum and metabasites. Beyond the exposure of the Secano unit, however, the same breccia appeared to be overlain by a body of calcareous schist and marble. This latter superposition was consistent with Nijhuis' lithostratigraphy of the deepest Nevado-Filabride tectonic unit – the Nevado-Lubrin unit – in which the breccia was thought to be interstratified. As a consequence, the geometry of the Secano overthrust structure became a problem. This paper aims to review the classification of Nevado-Filabride tectonic units and their lithostratigraphy, and to explain the geometry of the Secano structure.

GEOLOGICAL SETTING

The geology of the area discussed is shown in figures 1 and 2. The Nevado-Filabride rock sequence in the area is summarized in figure 3. For reviews of the geology of the Sierra de los Filabres: HELMERS & VOET (1967); EGELER & SIMON (1969-a); KAMPSCHUUR (1975) and IGME (1975).

The classification of several structural units in the Nevado-Filabride complex is primarily based on the assumption that rock sequences of mainly graphite-bearing garnet micaschist and micaceous quartzite, exposed at a number of distinct levels in the rock-pile, are all of pre-Permian age. These rocks are considered to represent Palaeozoic (and/or older?) basement, affected by pre-alpine orogenic events, in contrast with the overlying cover sequences of metasediments of supposedly (Permo-)Triassic (and possibly also younger) age (EGELER & SIMON, 1969-a; VISSERS, 1977-b). For the purpose of this discussion a number of important contacts have been labelled in the illustrations. The basement rocks outcrop below contact (a), above the contacts (1), (3) and (4), and locally also below contact (2). The cover rocks are exposed immediately above contact (a), and below the contacts (1), (2), (3) and (4).

For the purpose of this paper the four basement sequences have been labelled Nevada I, II, III, and IV, respectively. Although they are all characterized by a preponderance of dark-coloured graphite-bearing garnet-chlorite micaschist and micaceous quartzite, there are important differences between the four basement sequences, as shown in Table I. The most striking of these is the presence of tourmaline-bearing gneiss intercalated in the Nevada III and IV sequences. In the southeastern Sierra de los Filabres similar tourmaline-gneiss passes laterally into granite-gneiss and metagranite with diminishing intensity of deformation. These rocks yielded a Rb-Sr isochron age of 269 ± 6 Ma (Early Permian) for the intrusion of the granite (PRIEM ET AL., 1966). If the gneiss bodies are of the same origin as in the present map-

area (see HELMERS & VOET, 1967), a pre-Permian age can be assigned to the basement sequences containing them (i.e. Nevada III and IV sequences), and a Permian or younger age to the respective cover rocks.

Gneiss and metagranite have not been found in the two lower basement sequences (Nevada I and Nevada II). These rocks can therefore only be dated by lithologic correlation.

The basement rocks are overlain by light-coloured (garnet-) (albite-)chlorite micaschist, micaceous quartzite, calcareous rocks ranging from calcschist to marble, amphibolite, and metabasite, exposed at various levels in the Nevado-Filabride rock pile (see Fig. 3). The thickest cover-sequence is the lowermost one overlying the Nevada I sequence. This cover-sequence contains an approximately 1000 m thick series of locally garnet-bearing albite-chlorite micaschist and quartz-chlorite schist, named Tahal schist. The contact of the Nevada I sequence with the Tahal schist is thought to be of stratigraphic nature for two reasons:

- (1) the presence of a continuous zone of yellowish chloritoid-garnet micaschist at the top of the Nevada I sequence (interpreted by LINTHOUT (1965) as a metamorphosed weathering zone of late Palaeozoic age);
- (2) the widespread occurrence of conglomerate near the base of the Tahal schist.

The Tahal schist is overlain by a heterogeneous layer of marble, calcareous breccias (locally with gypsum), commonly blastophitic metabasite, and albite-epidote amphibolite. Small outcrops of serpentinite locally occur in association with these rocks. This heterogeneous assemblage was first described by NIJHUIS (1964-a) as Huertecica brecciated marble zone. In this paper we refer to it as the Brecciated Zone.

In contrast to all other Nevado-Filabride rock units the Brecciated Zone varies remarkably in thickness. The unit is locally absent under both the contacts (1) and (2) as shown in Fig. 2, sections III and VI. The Brecciated Zone contains fragments of the Tahal schist and the Nevada II sequence, some of them of mappable size (see Figs. 1 and 2, cross section VII). The zone thus appears to be a strongly brecciated rock unit, in fault contact with the underlying schist. The occurrence of minor marble intercalations at the top of the Tahal schist, however, suggests that the two bodies may have originally been in stratigraphic contact. Moreover, metabasites cut the Tahal schist, as well as the overlying calcareous rocks of the Brecciated Zone, suggesting a close relationship between the two units. A Rb-Sr whole-rock age of 146 ± 3 Ma (Late Jurassic) has been reported from unaltered olivine diabase occurring in the core of a metabasite body in the southeastern Sierra de los Filabres (HEBEDA ET AL., 1977). This indicates a Jurassic or older age for metasediments in the Brecciated Zone and from the upper part of the Tahal schist, in which these intrusive rocks are found.

Higher in the Nevado-Filabride rock pile a series of predominantly (albite-)chlorite micaschist and micaceous quartzite overlies the Nevada III sequence. According to VOET

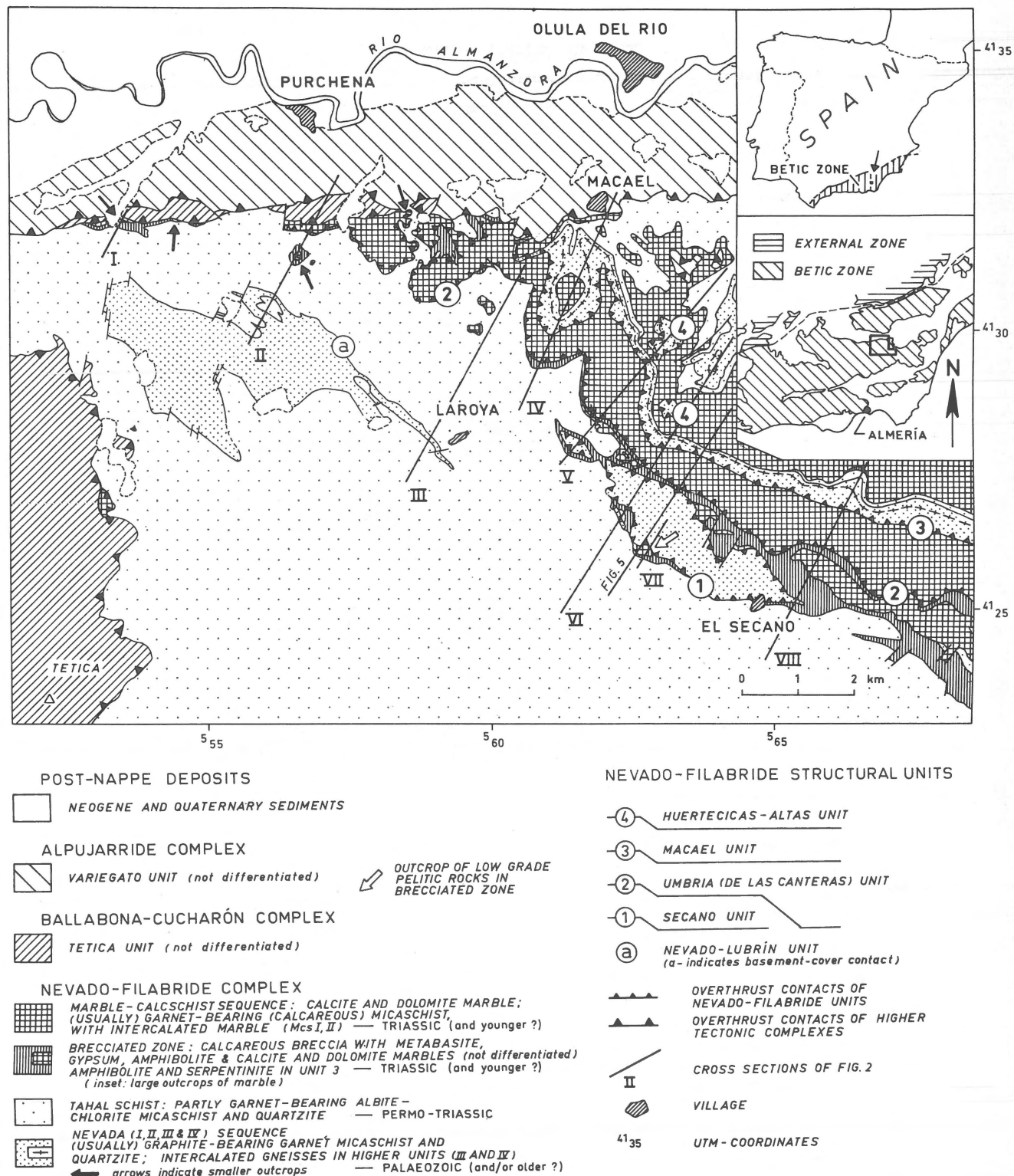
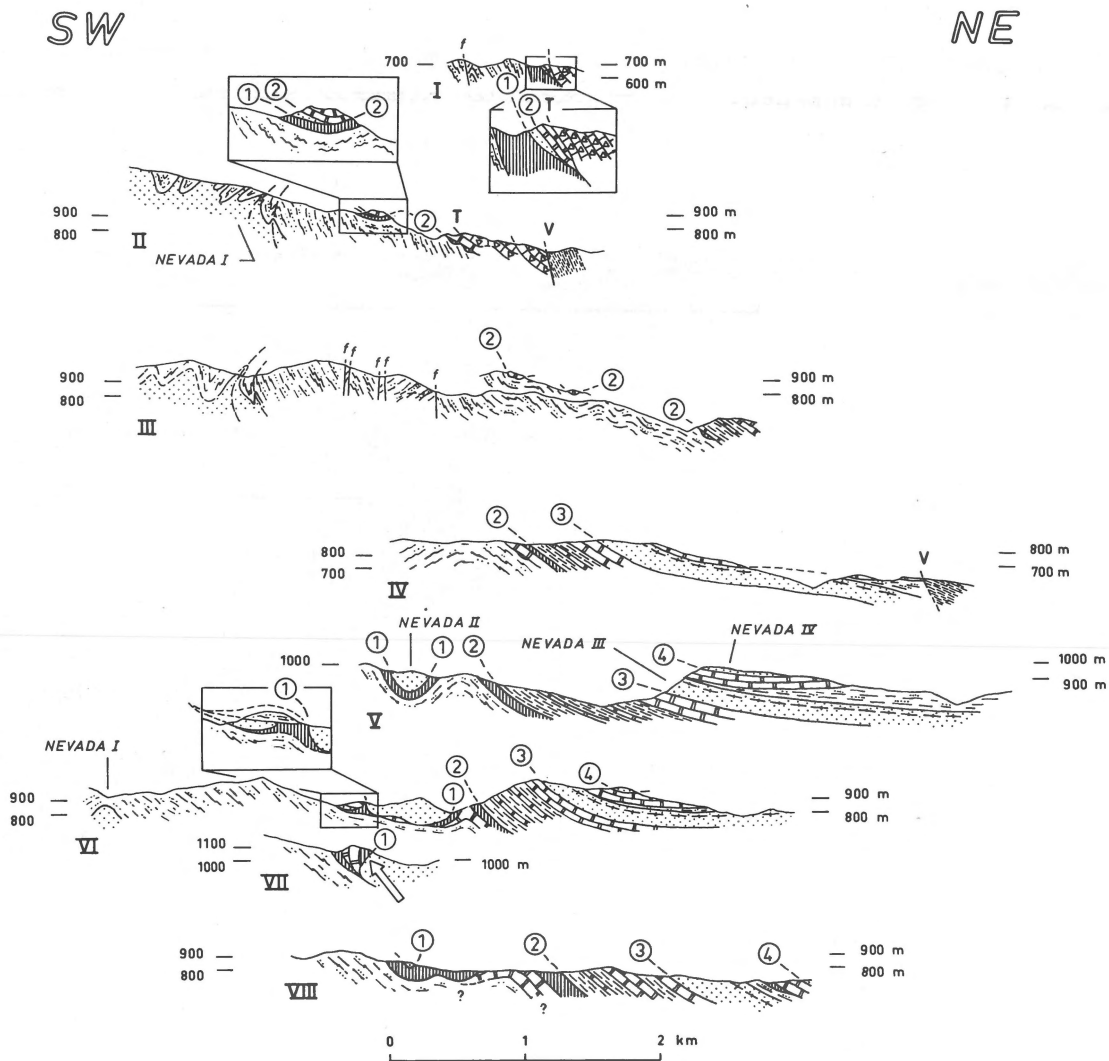


Fig. 1
Tectonic sketch-map of the area discussed.



ALPUJARRIDE COMPLEX

LOW-GRADE PHYLLITE (VARIEGATO UNIT)

BALLABONA-CUCHARÓN COMPLEX

LOW-GRADE CARBONATE ROCKS (PARTLY BRECCIATED) (TETICA UNIT)

NEVADO-FILABRIDE COMPLEX

MARBLE - CALCSCHIST SEQUENCE: MARBLE, (USUALLY) GARNET-BEARING (CALCAREOUS) MICASCHIST, WITH INTERCALATED MARBLE (Mcs I, II)

BRECCIATED ZONE: CALCAREOUS BRECCIA WITH METABASITE, GYPSUM, AMPHIBOLITE, AND MARBLE (not differentiated) INSET: LARGE OUTCROPS OF MARBLE (AMPHIBOLITE, AND SERPENTINITE IN UNIT 3)

TAHAL SCHIST: PARTLY GARNET-BEARING ALBITE-CHLORITE MICASCHIST AND QUARTZITE

NEVADA (I, II, III & IV) SEQUENCE (USUALLY) GRAPHITE-BEARING GARNET MICASCHIST AND QUARTZITE; INTERCALATED GNEISSES IN HIGHER UNITS (III & IV)

STRUCTURAL UNITS

V VARIEGATO UNIT

T TETICA UNIT

4 HUERTECICAS - ALTAS UNIT

3 MACAEL UNIT

2 UMBRIA (DE LAS CANTERAS) UNIT

1 SECANO UNIT

NEVADO-LUBRÍN UNIT

(in cross section VII) OUTCROP OF LOW-GRADE PELITIC ROCKS IN BRECCIATED ZONE

FOR LOCATION OF CROSS SECTIONS SEE FIG. 1

Fig. 2

Diagrammatic cross-sections in the area discussed. Note the occurrence, in sections I and II, of graphite-bearing garnet micaschist and quartzites underneath rocks of the Marble-calcschist sequence.

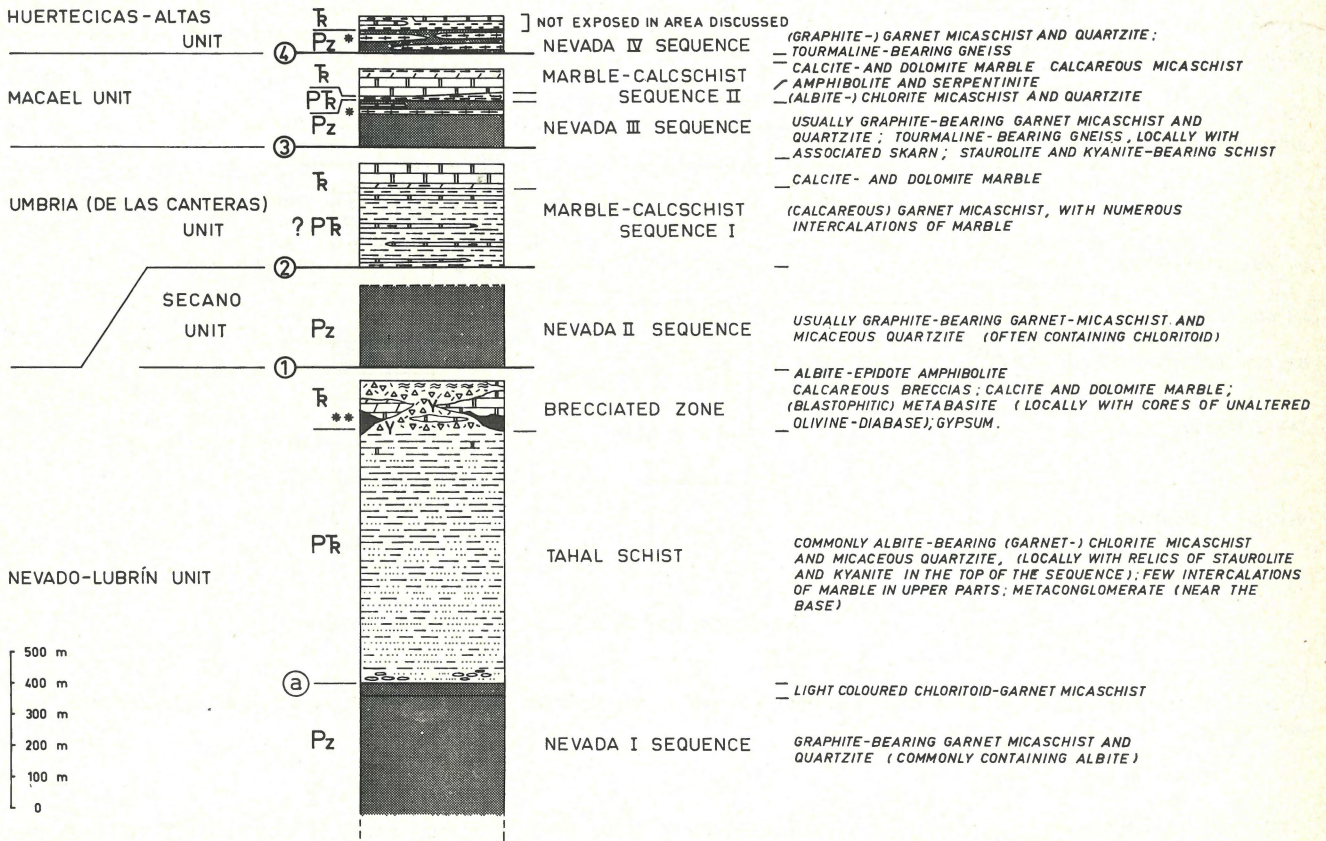


Fig. 3
Columnar section of the Nevado-Filabride rock pile in the area discussed. P = Palaeozoic (and/or older?); PTr = Permo-Triassic; Tr = Triassic (and younger?).

(1967) these rocks strongly resemble the Tahal schist. The nature of the contact with the Nevada III sequence is not certain; most authors assume a stratigraphic contact in view of the similarity with the Nevada I - Tahal schist succession.

The cover rocks of the Nevado-Filabride rock pile also include calcareous (garnet-)micaschist, marble and small amounts of amphibole-micaschist. In the area discussed this Marble-calcschist sequence (voET, 1967) is exposed at two different levels, i.e. below the Nevada III (labelled here Mcs I) and below the Nevada IV sequence (Mcs II) (see Figs. 2 and 3). The Marble-calcschist sequences show an alternation of calcareous (garnet-) micaschist and impure marble in layers from cm to dm scale. The upper part of both sequences is dominated by a white and blue marble layer up to 200 m thick.

Albite-epidote amphibolite occurs at two levels in the Nevado-Filabride rock sequence of the area. It is usually found in the upper part of the Brecciated Zone, and also occurs higher in the rock pile between the micaschist and the upper Marble-calcschist sequence (Mcs II) as shown in figure 3.

PREVIOUS CLASSIFICATIONS OF TECTONIC UNITS AND THE PROBLEM OF THE SECANO UNIT

Within the Nevado-Filabride rock pile, voET (1967) distinguished four tectonic units, which are - in ascending order - the Nevado-Lubrin unit, the Secano unit, the Macael unit, and the Huertecicas-Altas unit. The Nevado-Lubrin unit in his classification comprises the Nevada I sequence, the Tahal schist with the Brecciated Zone, and the overlying (lower) Marble-calcschist sequence (Mcs I). The Secano unit comprises the rocks of the Nevada II sequence. The Macael unit consists of the rocks of the Nevada III sequence, the overlying micaschists and the upper Marble-calcschist sequence (Mcs II). The Huertecicas-Altas unit (within the area discussed) comprises the Nevada IV sequence. This classification of tectonic units is summarized in figure 4 (left column). Except for the Secano unit, each unit comprises a basement of pre-Permian age, and a cover consisting of a supposedly Permo-Triassic sequence of metapelites and a Triassic (and/or younger?) Marble-calcschist sequence.

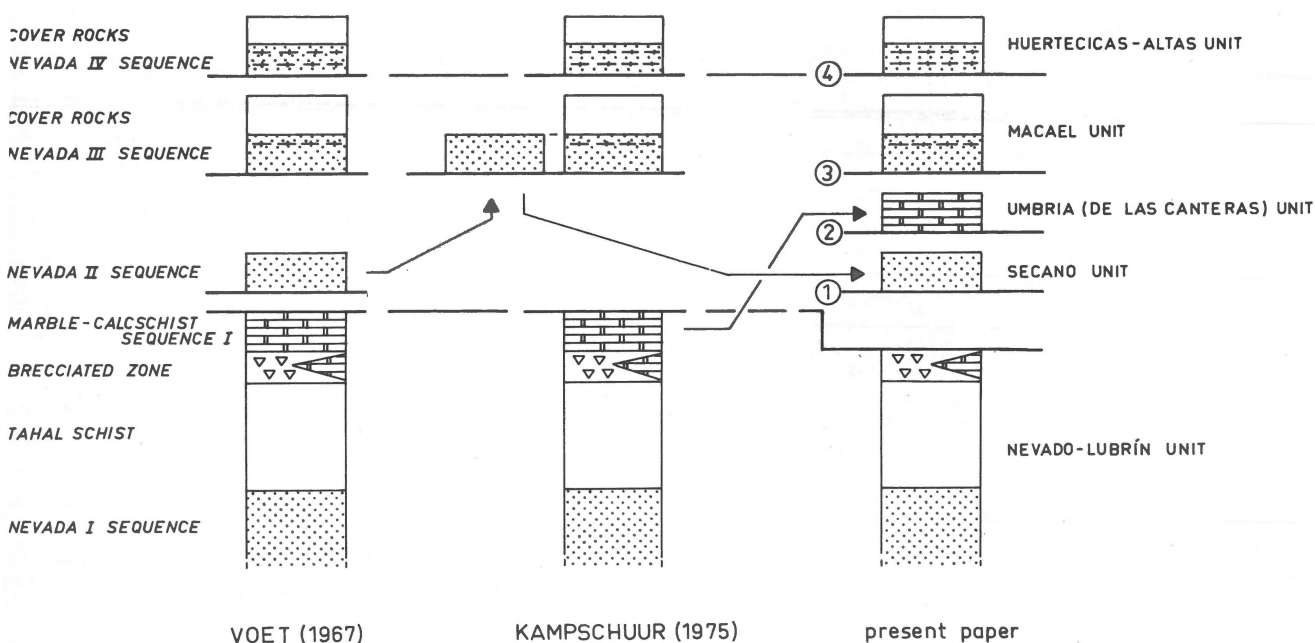


Fig. 4
Three tectonic interpretations of the Nevado-Filabride rock pile in the Northern Sierra de los Filabres. Arrows indicate changes in classification.

The Brecciated Zone in this interpretation is considered to be a body interstratified within the Nevado-Lubrín unit, in which cataclastic deformation, leading to the formation of calcareous breccias (rauhwackes), was facilitated by the presence of indigenous gypsum (LEINE, 1968). In the area northwest of the village El Secano (Fig. 1), however, the Brecciated Zone is overlain by the Nevada II sequence. VOET (1967) concluded that the Marble-calcschist sequence (Mcs I) was absent under the Nevada II sequence (Secano unit) for tectonic reasons, and assumed a tectonic position of the Secano unit between the Nevado-Lubrín and Macael units. KAMPSCHUUR (1975) suggested that the Nevada II sequence forms a southern klippe of the Macael basement rocks (Nevada III sequence). The interpretations by Voet and Kampschuur both imply a complete wedge-out of the 300 m thick Marble-calcschist sequence (Mcs I) as shown in figure 5.

This geometrical problem led LINTHOUT (1965) to propose that the Marble-calcschist sequence (Mcs I) forms part of a higher structural unit (see also EGELER ET AL., 1971, p. 471, Fig. 2c). In the following evidence will be presented of important thrust movements along the Brecciated Zone, which favours this alternative interpretation.

THE THRUST CHARACTER OF THE CONTACTS RELEVANT TO THE SECANO STRUCTURE

In examining the 'Secano structure', one contact deserves special attention, viz. the upper contact of the Brecciated

Zone either with the Nevada II sequence (Secano unit) (labelled (1) in Fig. 2), or with the Marble-calcschist sequence (Mcs I) (labelled (2)). Large-scale movements along contact (1) at the base of the Nevada II sequence can be deduced from differences in metamorphic grade of the rocks on either side of this contact. The rocks from the upper part of the Tahal schist just below the Brecciated Zone contain staurolite and kyanite, as well as corroded relics of chloritoid. The rocks of the Nevada II sequence, immediately above the Brecciated Zone never contain staurolite or kyanite, but usually carry unaltered chloritoid. The Nevada II sequence was therefore metamorphosed at a temperature lower than that required for the formation of staurolite by breakdown of chloritoid. This evidence indicates that important thrusting occurred along contact (1) after the blastesis of staurolite and kyanite, which were formed during a second stage of the plurifacial alpine metamorphism (VISSERS & LINTHOUT, in prep.). Further evidence for post-metamorphic thrusting along contact (1) is provided by the presence of tectonic blocks of low-green-schist facies pelitic rock in the Brecciated Zone (LINTHOUT, 1965).

Similar arguments favour thrusting of the Marble-calcschist sequence (Mcs I). Chloritoid-bearing micaschist of the lower parts of the Marble-calcschist sequence lacks staurolite and kyanite, even where it lies in direct contact with staurolite- and kyanite-bearing Tahal schist.

Further evidence of thrusting along contact (2) is provided by recent fieldwork by one of the authors (V), revealing the presence of lenticular bodies up to 20 m thick of graphite-bea-

ring chloritoid-garnet-mica quartzite between the Brecciated Zone and the overlying Marble-calcschist sequence (Mcs I) (see Figs. 1 and 2). In view of their composition and setting these rocks probably represent tectonic fragments of the Nevada II sequence.

The difference in metamorphic grade between the rocks on either side of the Brecciated Zone, and the presence of tectonic blocks of Tahal schist, metabasite, graphite-bearing rocks, and low-grade pelitic rocks within the calcareous breccias of the zone itself, lead us to conclude that it is an important zone of thrusting.

DISCUSSION AND CONCLUSIONS

Previous interpretations of the Secano structure by VOET (1967) and KAMPSCHUUR (1975), shown in Figs. 4 and 5, were based on the premise of a lithostratigraphy of the Nevado-Lubrin unit comprising the Nevada I sequence, the Tahal schist, the Brecciated zone and the overlying Marble-calcschist sequence (Mcs I). This led VOET (1967) to suggest that the Nevada II sequence forms a tectonic unit (the Secano unit) overlying the Nevado-Lubrin unit and underlying the Macael unit.

As already mentioned, KAMPSCHUUR (1975) proposed a reinterpretation of the Secano structure and suggested that the Nevada II sequence of the Secano unit forms part of the Macael basement rocks (Nevada III sequence). However, as shown in Table I, there are several marked differences between the two basement sequences (Nevada II and III) across the antiform in figure 5, which cast doubt on Kampschuur's correlation of the two sequences. A layer of tourmaline-bearing gneiss in the Nevada III sequence is continuously exposed along the regional strike for more than 15 km. No such layer occurs in the Nevada II sequence. 500 m to the south. The same holds for layers of skarn and of impure marble. Finally, the basement sequences differ in metamorphic grade. Staurolite and kyanite formed during some early stage in the metamorphic history in the Nevada III sequence, but are absent in the chloritoid-bearing rocks of the Nevada II sequence (Secano unit). These differences preclude correlation of the Nevada II and III sequences by closure over the hinge of an antiform (Fig. 5).

In view of the occurrence of tectonic lenses of rocks of the Nevada II sequence under the lower Marble-calcschist sequence (Mcs I), and of the thrust character of the contacts described here, we favour an alternative interpretation of the Secano structure, and propose a different classification of the various rocks in terms of tectonic units. The lower Marble-calcschist sequence (Mcs I) is interpreted as a thrust-sheet emplaced on the Nevada II sequence of the Secano unit (Fig. 5c, lower cross-section). The Marble-calcschist sequence in this interpretation does not wedge out underneath the Secano unit, but overlies it. After a local hillside, named after its many marble-quarries, we propose the name Umbria de las

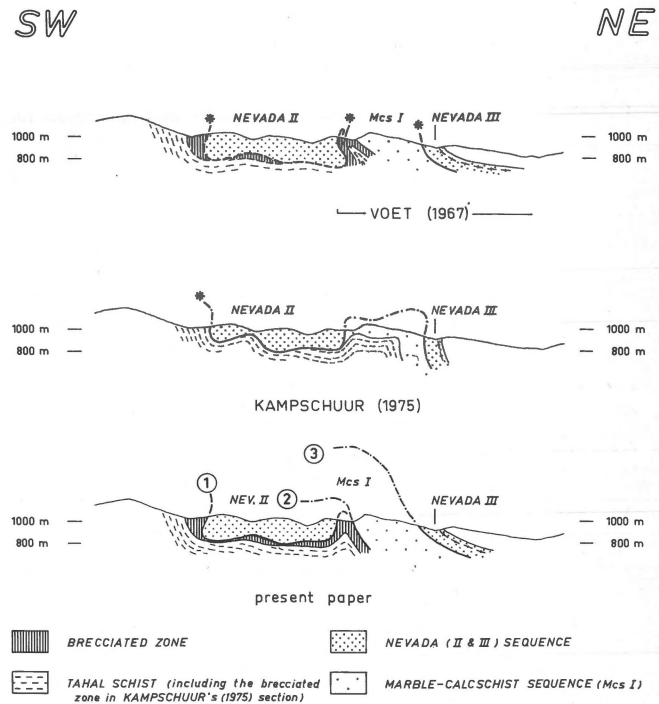


Fig. 5

Three interpretations of the Secano synform on basis of different tectonic subdivisions of the Nevado-Filabride rock pile.

Canteras unit for this thrust-sheet. This leads to the following superposition of tectonic units (Fig. 4):

- Huertecicas-Atlas unit;
- Macael unit;
- Umbria de las Canteras unit;
- Secano unit;
- Nevado-Lubrin unit (with Brecciated Zone in the top of the unit).

The presence of tectonic blocks of low-grade pelitic rock in the Brecciated Zone indicates that large-scale overthrusting took place along this zone in a relatively late stage of the metamorphic history (see also KAMPSCHUUR, 1975; and VISERS, 1977-a). This implies that the superposition of the tectonic units listed above is unrelated to the earlier two stages of alpine metamorphism in the glaucophane-schist facies and almandine-amphibolite facies.

The Secano synform results from a phase of folding that affected the various superposed tectonic units.

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Table I
Metamorphic minerals and rock types in basement sequences of the various tectonic units distinguished in the Nevado-Filabride complex.

| | metamorphic minerals in schist and micaceous quartzites | | | | | | rock types | | | approximate thickness |
|---------------------|---|--------|-------------------|------------|------------|---------|---------------------|------------------------------------|--------------------|-----------------------|
| | graphite | garnet | sodic plagioclase | chloritoid | staurolite | kyanite | tourmaline-gneisses | epidote-biotite-amphibole-gneisses | marbles and skarns | |
| NEVADA IV sequence | + | + | + | + | + | + | + | + | 75 m | |
| NEVADA III sequence | + | + | + | + | + | + | + | - | 150 m | |
| NEVADA II sequence | + | + | - | + | - | - | - | - | 275 m | |
| NEVADA I sequence | + | + | + | + | - | - | - | - | > 5000 m | |

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