Middle Miocene extensional faulting events and Alpujárride Units in the Central Betics

Eventos de fallamiento extensional del Mioceno medio y Unidades Alpujárrides de las Béticas centrales

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ABSTRACT

In the Central Betics, the Alpujarride Complex is made up of units which result from the dismembering of pre-Miocene fold nappes during a Late Burdigalian (?)-Langhian extensional event. Superimposed low-angle normal faults and extensional detachments belonging to a second event were sealed by Tortonian marine deposits.

RESUMEN

Las unidades del Complejo Alpujárride en las Béticas centrales resultan del desmembramiento extensional de pliegues recumbentes pre-miocenos. El evento extensional neógeno más antiguo de los referidos puesto de manifiesto se desarrolló durante el Burdigaliense Superior (?)-Langhiense. El siguiente ocurrió durante el Serravalliense ya que una segunda generación de fallas normales de ángulo bajo y despegues han sido fosilizados por sedimentos tortonienses.

Key words: *Alpujarride units, Betics, tectonic events, low-angle normal fault, Middle Miocene.*

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Introduction

The Alboran Domain (Balanyá and García-Dueñas, 1988) is formed mainly by the Alpujarride Complex. Nowadays, most of the boundaries between units previously considered as pre-Miocene thrusts are reinterpreted as low-angle normal faults (LANF) and extensional detachments developed during Lower and Middle Miocene (e.g. García-Dueñas *et al.*, 1992). These faults have been folded —large-scale E-W directed anticlines and other folds— and faulted during the Upper Miocene.

In the central Betics, a review of the Alpujarride Complex, constituted by various tectonic units, has been proposed by Aldaya *et al.*, (1982). These authors and later on Cuevas *et al.*, (1986) and Tubía *et al.*, (1992), regarded them as nappes limited by brittle northward thrusts. In this paper, we will show that the limits of the Alpujarride units are extensional faults. MAGNA geological maps and the accompanying cross-sections will be used to support our conclusions because the transport sense and geometry of the brittle shear zones have been generally well established but mistakenly related to thrusts.

Main low-angle normal faults and extensional events

The extensional detachments and LANF south of Sierra Nevada and Granada Basin are represented in Figure 1. Breccias, gouges and striae or grooves developed along the fault surface. The kinematics, transport sense and extensional character of the brittle shear zones which are bounding the units, or which are within them, have been determined according to the following criteria: 1) omission of unit or group of them whose initial structural position is known or inferred; 2) substractive character of some boundaries between sequences of the same unit; 3) geometric position of the key surfaces with respect to the LANF, and 4) extensional minor structures associated with LANF, such as S-C shaped structures with striae on the c surfaces ("almond" structures), trails of crushed pebbles, drag folds in phyllites, rough foliation in the fault rocks and associated microfaults. Cross-sections of Figure 2 are in agreement with the extensional character of the limits. They have been only slightly modified from the geological MAGNA maps (Aldaya *et al.*, 1983a and b; Avidad and García-Dueñas, 1981) as most of their geometry has been confirmed by recent field studies.

Contraviesa area (Fig. 1A):

Cross-section I (Fig. 2) clearly illustrates the omission along a LANF which separates the Lújar unit from the Escalate or Murtas unit. Towards the NNW this fault, SSE-dipping because of the Upper Miocene folding, goes down through the axial plane of a post-metamorphic recumbent fold (Campos and Simancas, 1989) that is pre-Miocene in age. Cross-sections II and III (Fig. 2) are situated respectively in the southern and northern limbs of the Contraviesa anticline, whose core is occupied by the Lújar unit. They show how the listric normal faults (see geometric relationship between dipping of the key surface and fault) separating the Alpujarride units coalesce with the sole detachment of this extensional system (Turón detachment of García-Dueñas *et al.*, 1992), leading to a high extension zone (Gibbs, 1984) where the Adra unit lies directly on the Lújar unit. In the Contraviesa, almost all the boundaries between units belong to this extensional system, with a NNWward transport direction. This system is known as the

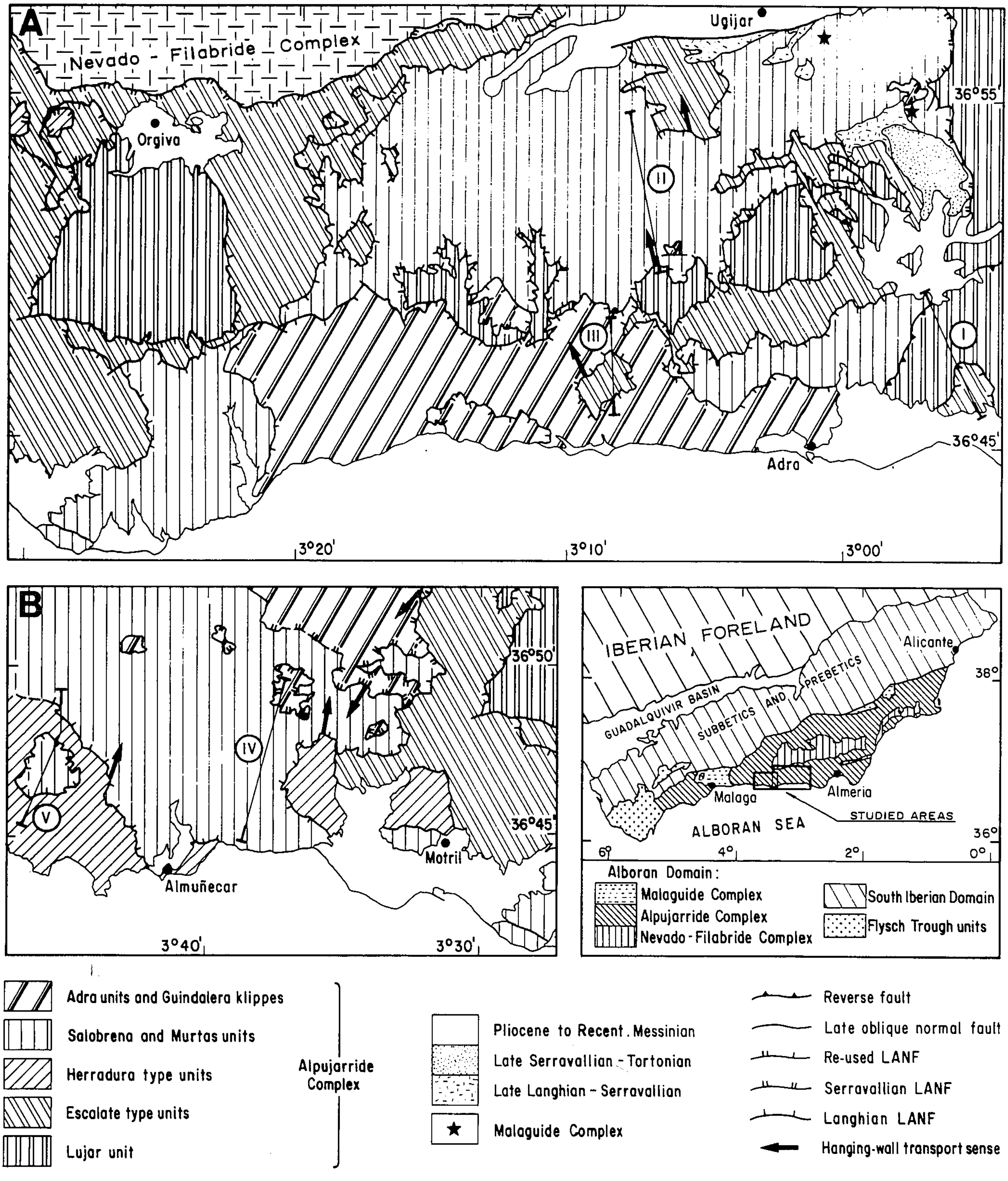

Fig. 1.— Extensional detachments and main low-angle normal faults in the Central Betics. A: Contraviesa area (according to García-Dueñas et al., 1992). B: Sierra Almijara area. I, II, III, IV cross-sections of the Fig. 2.

Fig. 1.— Despegues extensionales y principales fallas normales de bajo ángulo en las Béticas Centrales. A: Area de la Contraviesa (según García-Dueñas et al., 1992). B: Area de la Sierra Almijara. Cortes geológicos I, II, III, IV, V de la Fig.2.

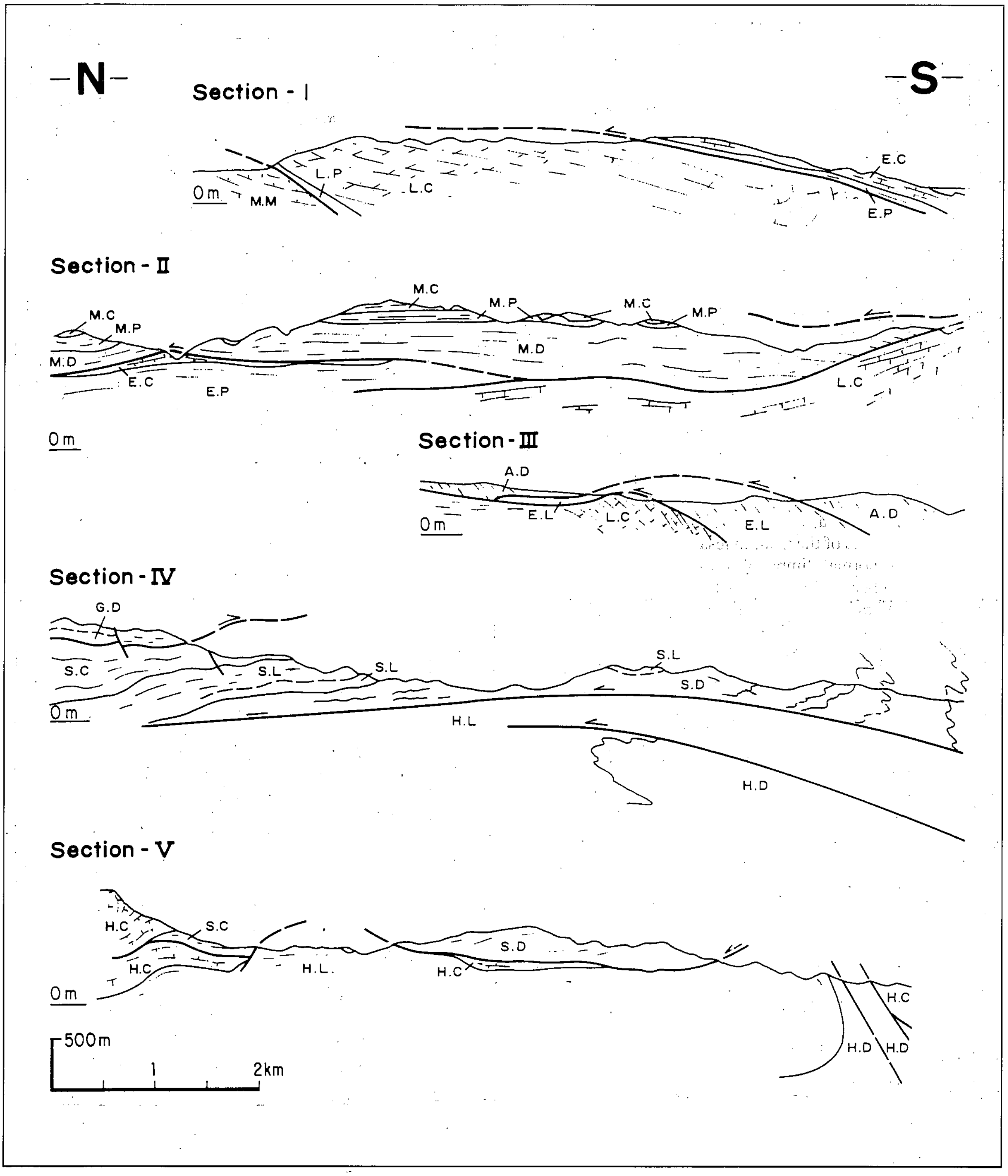

Fig. 2.— Seried cross sections of the studied region (location in Fig. 1), according to Aldaya et al. (1983a and b) and Avidad and García-Dueñas (1980), slightly modified. The first letter of the lithostratigraphic formation represents the unit name which appears in Fig. 1; the second corresponds to the lithology. L: Lújar. E: Escalate. H: Herradura. S: Salobreña. M: Murtas. A: Adra. G: Guindalera. C: Carbonated rocks. P: Phyllites. L: Light coloured schists and quartzschists. D: Dark coloured schists.

Fig. 2.— Cortes seriados de la región estudiada (localización en Fig. 1), según Aldaya et al. (1983a and b) y Avidad y García-Dueñas (1980), ligeramente modificado. La primera letra de las formaciones litoestratigráficas representa el nombre de la unidad, tal como aparece en la Fig. 1; la segunda corresponde a la litología. L: Lújar. E: Escalate. H: Herradura. S: Salobreña. M: Murtas. A: Adra. G: Guindalera. C: Rocas carbonatadas. P: Filitas. L: Esquistos claros y cuarzoesquistos. D: Esquistos oscuros.

Contraviesa normal fault system, and it has been described in Crespo-Blanc *et al.*, (1993). It is sealed by Serravallian sediments (García-Dueñas *et al.*, 1992) and developed during Late Burdigalian (?) - Langhian. The whole system is situated in the hanging wall of the Filabres detachment (García-Dueñas *et al.*, 1992).

Sierra Almijara area (Fig. 1B):

Most of the brittle shear zones between units indicate movement sense broadly towards the north, the general structure being similar to that described in the Contraviesa area. Nevertheless, some differences in the internal structure of the extensional units of the two areas are observed: 1) the lowermost Alpujarride units do not crop out in the Almijara area, 2) the Herradura type units disappear in the Contraviesa area (Aldaya and García-Dueñas, 1976), 3) the extensional units of the Contraviesa area represent normal limbs of pre-Miocene recumbent folds, 4) and by contrast, most of the units of the Almijara area preserve part of large scale fold hinges and/or reverse limbs. Cross-sections IV and V (Fig. 2) show how the LANF situated at roof and floor of the Salobreña unit, with a northward transport direction, have a ramp geometry respect to the axial plane of a preexisting large scale recumbent fold (idem cross-section I of Fig. 2).

The structural relationships between the brittle shear zones with a northward transport direction and Middle Miocene deposits in the Almijara area (Fig. 1B) confirm the existence of the LANF belonging to the Late Burdigalian (?) -Langhian extensional event described in the Contraviesa area. In the eastern part of the Almijara area, the hanging wall of the so-called Izbor LANF is constituted by the Guindalera klippes. This LANF and associated faults show a southwestward transport sense. This set of faults probably produced the aforementioned disappearance of the Herradura type unit towards the east. They cut the northward system (northern part of Fig. 1B) and are sealed by Upper Miocene sediments, which means they must have been active during the Serravallian.

Conclusions

In the Alboran crustal Domain, the Alpujarride nappes underwent significant thinning during extensional tectonic events that ocurred from early Burdigalian to early Tortonian (García-Dueñas *et al.*, 1992). In the Almijara and Contraviesa areas (Central Betics), two of these events can be observed, the first with a N-S extension and the second with a NE-SW one. Both are Middle Miocene in age. The associated LANF, underlined by cataclastic rocks (brittle regime), delimited new tectonic units originated from the progressive dismembering of the Alpujarride nappe sheets. The LANF cut obliquely the metamorphic foliations and axial planes of pre-Miocene recumbent folds.

In the Contraviesa area, an E-W directed large scale antiform is drawn by the Contraviesa extensional system. As the LANF often coalesce over the antiformal hinge, the crest of these Late Miocene E-W folds corresponds to the zone of major thinning of the units. When their initial position is restored, the main LANF of the Contraviesa system is north dipping and the faults show listric geometries with respect to the key surfaces. Geometries such as hanging- and foot-wall ramps are dominant, whereas flats are less common.

The fault set associated with the Izbor LANF show tectonic transport to the SW. This set has probably re-used LANF originated during older extensional events, and cut the Contraviesa fault system. The Izbor LANF is contemporaneous with the Filabres system defined to the east, but it is located in an upper level, over the Filabres detachment.

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References

Aldaya, F., García-Dueñas, V. and Navarro-Vilá, F. (1982) *in: Homenatge a Lluís Solé i Sabarís, Acta Geol. Hisp.*, 14, 154-166.

Aldaya, F., Baena, J. and Ewert, K. (1983a) *Mapa y memoria explicativa de la Hoja n° 1043 (Berja) del Mapa geológico Nacional a escala 1:50.000, IGME.*

Aldaya, F., Baena, J. and Ewert, K. (1983b) *Mapa y memoria explicativa de la Hoja n° 1057 (Adra) del Mapa geológico Nacional a escala 1:50.000, IGME.*

Aldaya, F. and García-Dueñas, V. (1976) *Bull. Soc. Geol. France, (7), XVIII, 3*, 635-639.

Avidad, J. and García-Dueñas, V. (1981) *Mapa y memoria explicativa de la Hoja n° 1055 (Motril) del Mapa geológico Nacional a escala 1:50.000, IGME.*

Balanyá, J.C. and García-Dueñas, V. (1988) *II Congreso Geológico España (Simposios), Sociedad Geológica de España*, 35-44.

Campos, J. and Simancas, F. (1989) *Geogaceta*, 6, 50-52.

Crespo-Blanc, A., Orozco, M. and García-Dueñas, V. (1993), Tectonics.

Cuevas, J., Aldaya, F., Navarro-Vilá, F. and Tubía, J.M. (1986) *C.R. Acad. Sci. Paris, II, 302*, 1177-1180.

García-Dueñas, V., Balanyá, J.C., and Martinez-Martínez, J.M. (1992) *Geo-Mar. Lett., 12*, 157-164.

Gibbs, A.D. (1984) *Jour. Geol. Soc. (London), 141*, 609-620.

Tubía, J.M., Cuevas, J., Navarro-Vilá F., Alvarez, F. and Aldaya, F. (1992) *Jour. Struct. Geol., 14/2*, 193-203.