Revista Geográfica de América Central
ISSN: 1011-484X
revgeo@una.cr
Universidad Nacional
Costa Rica

Revista Geográfica de América Central. Nº 57
ISSN 1011-484X, julio-diciembre 2016
pp. 223–233

MORPHOTECTONIC INTERPRETATION OF THE 23-02-2015 ALBACETE EARTHQUAKE, SPAIN

INTERPRETACIÓN MORFOTECTÓNICA DEL TERREMOTO DEL 23-02-2015 EN ALBACETE, ESPAÑA

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ABSTRACT
On 02-23-2015, an earthquake took place in the Iberian Peninsula megablock. This event is of the intraplate-type (Mw= 4,7 / h= 17 km) where there is a deformed morphotectonic zone. The epicenter and the normal and strike-slip solution focal mechanism were determined in the Albacete block -which has an uplifting tendency inside of the Albacete and Cuenca mesoblocks.

Keywords: Albacete, earthquake, morphotectonic, seismicity, Spain

RESUMEN
En el megabloque Península Ibérica ocurrió un terremoto (23.02.2015). El evento es del tipo de interior de placa (Mw= 4,7 / h= 17 km), donde existe una zona de deformación morfotectónica. El epicentro y el mecanismo focal del tipo normal y deslizamiento lateral, fueron determinados en el bloque Albacete. Este último con tendencia al levantamiento dentro de los mesobloques Albacete y Cuenca.

Palabras clave: Albacete, España, morfotectónica, sismicidad, terremoto

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Fecha de recepción: 27 de enero de 2016
Fecha de aceptación: 10 de mayo de 2016

Introduction

By the data of the National Geographic Institute of Spain [IGN], on February 23, 2015 (16:16:31 GMT time) recorded an earthquake of 5,2 (mbLg) and 4,7 (Mw). Another known data are: h= 17 km, coordinates 39,048 N and 02,673 W (*Sotuélamos, Albacete*), I= 5 (EMS98) with 198 reports (Figure 1A). The determined focal mechanism is of normal type with strike-slip movements and the main and secondary planes of 78 º and 303 º, respectively. This event is the first in the zone.

The major seismic intensity is associated to 3 localities (*Ossa de Montiel* (11 km), *El Bonillo* (14 km) and *Munera* (14 km)), that surround to the epicenter for the SW, SE and E, respectively. The perceptibility of the earthquake reached for: 1) the N and NE *Zaragoza* (290 km) and *Valladolid* (380 km); 2) the SE *Sanlúcar de Barrameda - Cádiz* (400 km) and *Sevilla* (390 km). In the relief there was not determined any rupture.

Table 1 indicates 85 aftershocks in the *Castilla La Mancha Community*. They are located to the S and in the surrounding of the main earthquake. The territory is adjacent with the Administrative Communities of: *Andalucía* (to SW y S), *Murcia* (to SE), and *Valencia* (to E) (Figure 2). They have been sceneries of strong earthquakes, which do not happen in *Albacete* (Figure 1A).

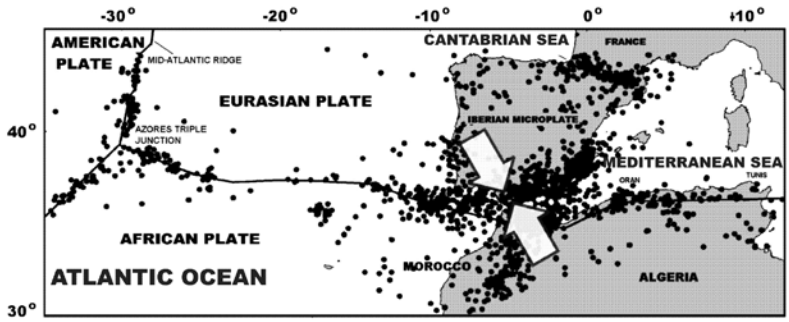
The authors presented, for the Iberian Peninsula [IP], an approach to the study of the neotectonic movements that is based on the principles of morphostructural analysis (Cotilla and Córdoba, 2004). These principles were mainly elaborated by Russian researchers as Rantsman (1979). Morphotectonic analysis has as its theoretical basis the set geostructure, morphostructure and morphosculture. It is based on the genetic principle of the development of relief, where relief is considered to be the result of the reciprocal action of internal and external processes.

Table 1. Earthquake data (2015)

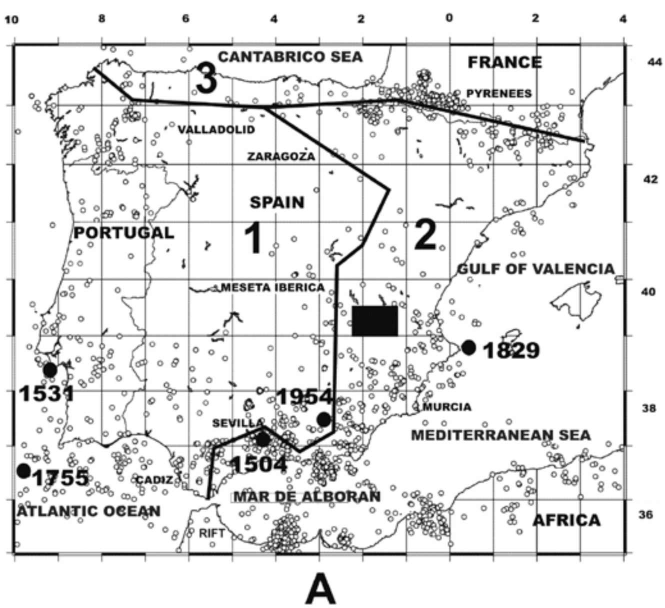
	Locality			
h(km)	**Ossa de Montiel**	**El Bonillo**	**Munera**	**Σ**
10-15	20	9	28	57
15-20	16	3	7	26
>20	2	-	-	2
Σ	38	12	35	85

Our aim is exposes briefly and the usefulness of this methodology for the recognition of the possible places of earthquake occurrence in the IP. Other authors have applied similar methods with very good results as: Zhidkov *et al.* (1975), Assinovskaya and Solovyev (1994), Gorshkov *et al.* (2000) and Cotilla and Córdoba (2013).

Figure 1. Seismicity



B



A

1A. Seismicity in Iberian megablock and surroundings.
Appear: A) black square= Albacete area; B) main fluvial basin (1) [*Atlántico*, 2) *Mediterráneo*, 3) *Cantábrico*]; C) irregular black line= main watershed; D) white circle= epicenter (M> 3 and h<

30 km); E) black circle= epicenter of strongest earthquakes (1504 Mw~6,8; 1531 Mw~8,0; 1755 Mw~8,5; 1829 and 1954 Mw~6,6); E) neighboring countries (France, Portugal); F) some localities.

1B. Sketch map of the Western region (Europe-Africa).
Appear: A) Main litospheric plates; B) black circle= epicenter; C) black line= main faults; D) white large arrows= plate convergence tendency.

Discussion and conclusions

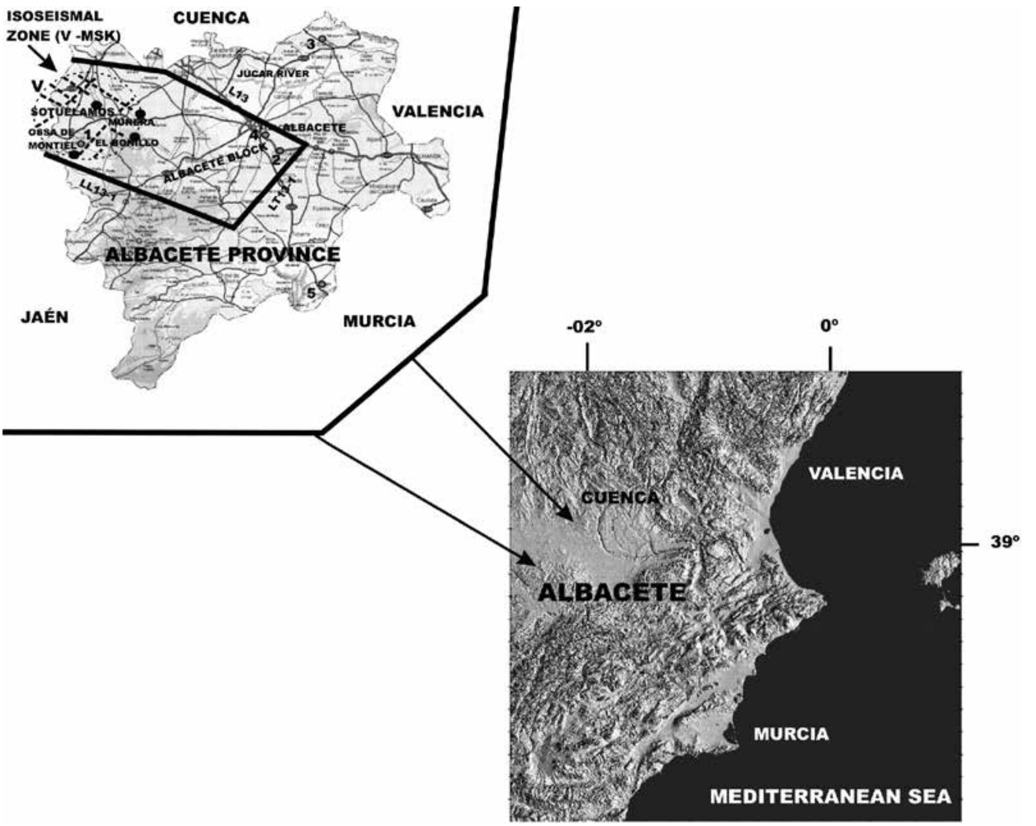
Recently deformed structures were located in the IP (mainly at its southern and eastern limits) (Herráiz *et al*., 1998). The relative motion between the European and African plates has been convergent throughout the Neogene (Figure 1B) (Dewey *et al*., 1989). In the Iberian microplate (or Iberian megablock), during the N-S to NNW-SSE convergence and slip between these plates, stresses from the Pyrenean and Betic borders were transmitted into the Iberian *Meseta* (a part of the Iberian Massif outcropping in Central Iberia) (Figure 1B). This stress field produced a set of new intraplate chains and basins. Their structural characteristics are influenced by previous crustal structures and discontinuities, and by the thickness of the sedimentary cover.

We proposed, for first time, that an extensive (~800 km) and deformed line of tectonic weakness exists in the middle-eastern part of the Iberian megablock (Figure 3, Table 2). This line is fundamentally the A5 lineament (in white color) which possesses the greatest deformation index (Ks= 0,72) of all the identified elements of equal category. It includes 7 second-order knots (8, 15, 14, 20, 29, 30 and 31) and one third-order knot (28). There is a great tectonic contrast on either side of this linear structure, with 157 blocks identified to the west and 98 blocks to the east. However, there is a very strong neotectonic contrast around the A5 lineament but the seismic activity (SA) is not significant. The macroblock defined by this lineament was called *Intercalado* (Nº 4) (Figure 3). It has two mesoblocks (*Albacete* (4.1) and *Cuenca* (4.2)) with different tendencies to uplift. These mesoblocks are separated by a zone of alignments (L13) of NW-SE strike, which has a significant inflexion in the surrounding of *Albacete* to ~75 º strike.

Studies of major details and complexity have demonstrated the efficiency of the morphotectonic methodology for the determination of places of earthquake occurrence in 6 regions of the IP: 1) *Galicia* (Cotilla and Córdoba, 2003); 2) *Córdoba-Granada* (Cotilla *et al.,* 2003); 3) *Asturias* (Cotilla *et al.,* 2004); 4) *Sistema Central* (Cotilla and Córdoba, 2007); 5)

Murcia (Cotilla and Córdoba, 2009); 7) *Almería-Jaén* (Cotilla and Córdoba, in press) (Figure 4). These studies recognized the activity of the *Intercalado* macroblock and its tendency to the movements of vertical type, inside a frame of regional compressions (Figure 3).

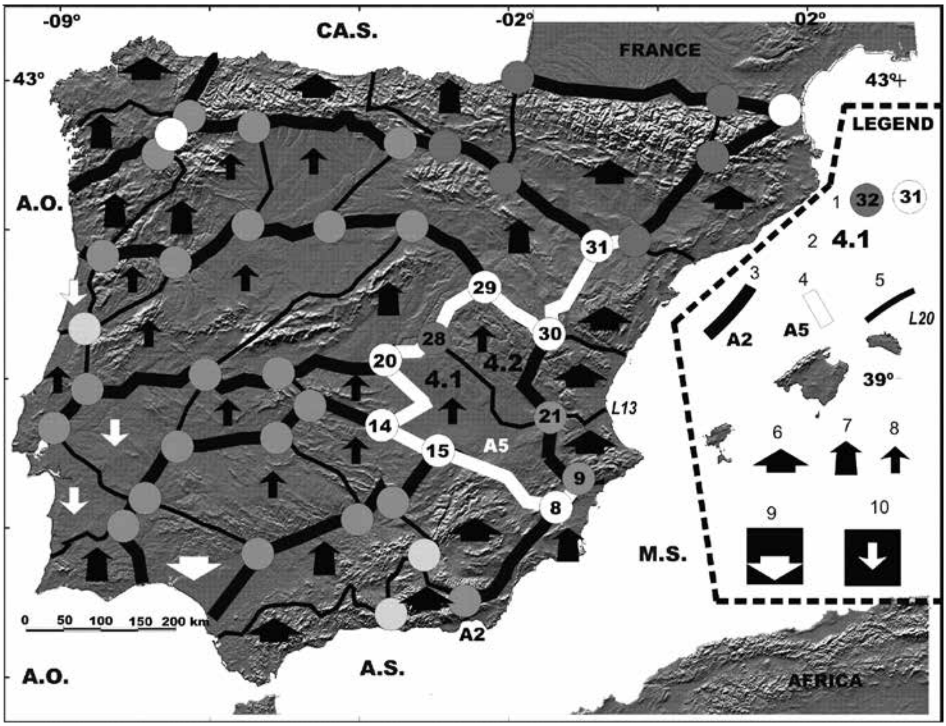
Figure 2. Location of epicenters in *Albacete* Mesoblock



Appear: Albacete province (inside center - eastern Iberian Peninsula); A) black circle= epicenter (*Sotuélamos*) and localities with intensities of V (EMS98) (*Ossa de Montiel, El Bonillo, Munera*); B) gray circles= epicenters (1= 10.08.1930 (I= 5 *Ossa de Montiel*); 2= 20.03.1933 (I= 5 *Chinchilla*); 3= 09.08.1943 (I= 5 *Casas Ibañez*); 4= 18.06.1958 (I= 6 *Hoya Gonzalo*); 5= 14.08.1991 (I= 6 *Caudete*)); C) discontinue black lines= isoseismal zone (in the same scale); D) irregular black line= lineaments (L13, Lt13.1, LL13.1).

Albacete locates in the center-eastern of the IP megablock, concretely in the eastern fluvial basin of the first order (*Mediterráneo*) where exists a marked asymmetry defined by a clear N-S strike of the Main Divide Watershed of the first order (Figure 1A). Also in this segment the *Intercaldo* macroblock tilts to SE, but its mesoblocks (*Albacete* and *Cuenca*) do with certain altimetry differences. This can be deduced also from the spatial location of 85 aftershocks. From the neotectonic point of view the *Albacete* mesoblock is more active than that of *Cuenca*.

Figure 3. Simplified morphotectonic map of Iberian megablock



Appear: [See the legend in the figure] 1= main knots (circles with number inside); 2= mesoblocks (4.1, 4.2); 3, 4, 5= main lineaments (black and white lines); 6, 7, 8= uplifting (very active, active and weak); 9, 10= downthrows (very active and weak) [See Table 2]; A.O= Atlantic Ocean, A.S.= Alborán Sea, CA.S.= Cantabrian Sea, M.S.= Mediterranean Sea [in blue color].

The Seismic Intensity Maps show values of I= V (MSK scale) for the Albacete and surroundings (Martín, 1984). We consider that this region is low-ranking of SA, while the maps of Epicenters Density and SA have the major values in the *Albacete* mesoblock (Cotilla and Córdoba, 2004).

Table 2. Characteristics of the main knots

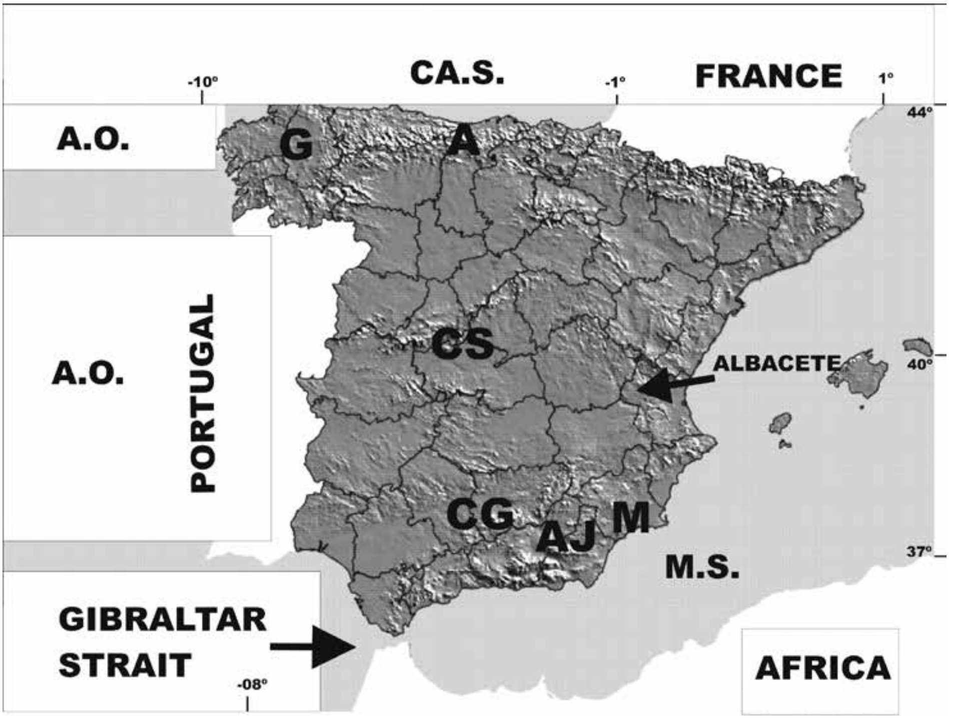
Knot	Name	X	Y	Rank	Lineaments
8	*Murcia*	-01,25	38,05	2	A2/A5
14	*Ciudad Real*	-03,55	38,50	2	A3/A5
15	*Montiel*	-02,50	38,40	2	A1/A5
20	*Mocejón*	-03,50	39,50	2	A4/A5
21	*Cofrentes*	-01,05	39,10	3	A2/L13
28	*Embalse de Buendía*	-02,50	40,30	3	A5/L13
29	*Moreal del Campo*	-01,25	40,45	2	A5/A6
30	*Teruel*	-01,05	40,20	2	A2/A5

Using the IGN data we made Tables 3 and 4 in order to understand the former SA in *Albacete* and *Cuenca* regions. In both the level of this parameter is quite similar. Also, the drawn isoseismals for 2 earthquakes of *Albacete* area: 1) *Hoya Gonzalo* (13.06.1958, I= 6); 2) *Caudete* (14.08.1991, I= 6) show irregular figures but clear strike tendencies to NE and NW, respectively (Mezcua, 1982). The first is related with the L13 alignment and the second one to A2 alignment.

This information permitted to hold that the seismicity in the *Albacete* and surroundings is denominated as intraplate type. In addition, the 85 aftershocks (Table 1) can be considered in: A) 3 ranges of depth; being the maximum value of 22 km; B) 2 ranges of magnitude. We assured that: A) the perceptible aftershocks were 9 (4 in *Ossa de Montiel*, and 5 in *Munera*); B) there is an evident easing of energy (events / days) in lower sense for 84% of the aftershocks for the period 23.02-04.03; C) the main event and the aftershocks are a consequence of the structural reactivation of minor order (Figure 3).

In the *Albacete* block (Figure 2) one can see that: A) the epicenter of the main earthquake is inside; B) the majority of isoseismal with V value (~300 km^2) is also included; C) the predominant strike of the block is 75º. Also, there were represented 5 earthquakes of I> 5 in the *Albacete* province obtained from the catalogue of the IGN. The 65 events of the table 4 are in the *Albacete* mesoblock (4.1) and 3 of them (the strongest) are in the *Albacete* block.

Figure 4. Morphotectonic studied areas



Appear: 1) Morphotectonic Regions in Spain [in gray color] (A= *Asturias*, AJ= *Almería-Jaén*, CG= *Córdoba-Granada*, CS= *Sistema Central*, G= *Galicia*, and M= *Murcia*); 2) A.O.= *Océano Atlántico*; CA.S.= *Cantábrico* Sea, M.S.= *Mediterráneo* Sea [in blue color]; 3) neighboring áreas (Africa, France, Portugal) [in white color].

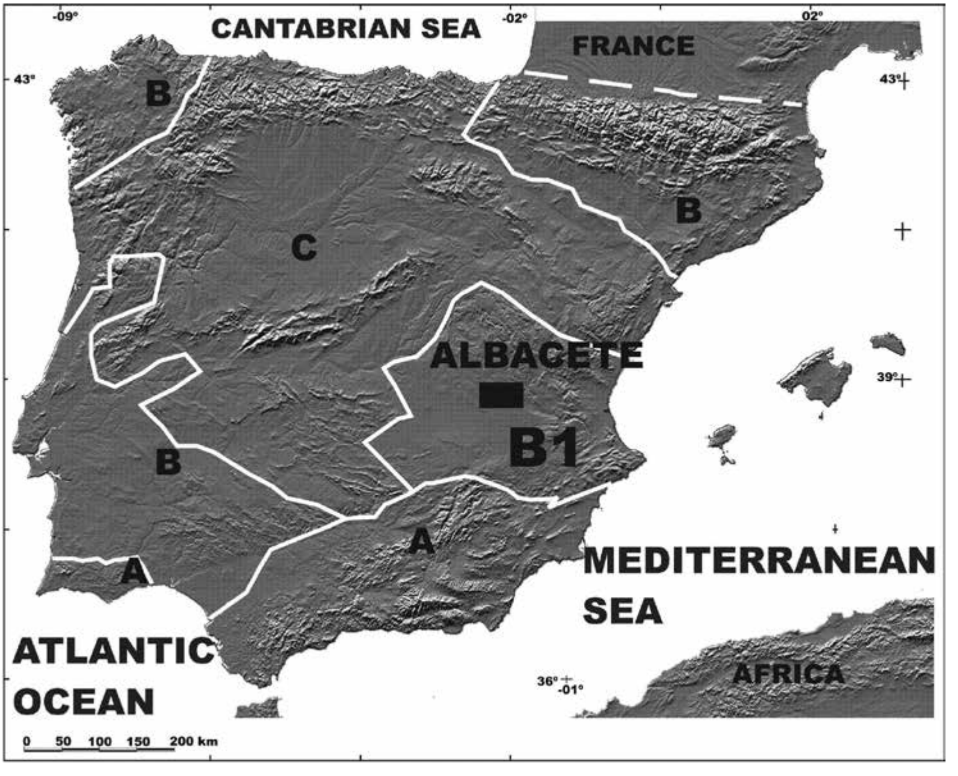
Table 3. Regions of our interest and their first reports

Nº	Region	Date
1	*Jaén*	01.01.1170
2	*Valencia*	01.03.1258
3	*Murcia*	30.01.1579
4	*Albacete*	26.04.1860
5	*Cuenca*	17.09.1860

Table 4. Earthquake data of *Albacete* and Cuenca regions

Nº	Region	Reports	Mmax	Imax	Intensities / reports (Σ)	hmax (km)
1	Albacete	65	4,3	6	6 / 2; 5 / 4; 4 / 5; 3 / 16 (27)	25
2	Cuenca	63	3,7	6	6 / 2; 5 / 3; 4 / 4; 3 / 9 (18)	19
Σ		128				

Figure 5. Seismic zones (See Table 5)



Appear: 1) Seismic zones (A, B [highest level= Zone A]); 2) irregular white line= seismic boundary; 3) Black square (Albacete)= the study area

Table 5. Characteristics of the Seismogenetic Zone

Zone / Localities	Area ($10^3 km^2$)	Mw_{max}	h (km)	b-value	Focal Mechanism
B1 / *Albacete, Castellón de la Plana, Ciudad Real, Cuenca, Teruel, Valencia*	58,9	5,0-5,5	10-20	2,01	Normal / Strike slip

Finally, we concluded that the SA model obtained by Cotilla and Córdoba (2004) have a good adjustment and correspondence with: A) the main earthquake of this series (location, magnitude, intensity and focal mechanism); B) the epicenter locations and depths of aftershocks (Figure 5, Table 5). Therefore, the *Albacete* block and the mesoblock of same name are active structures, and consistently the *Intercalado* macroblock is also active, as forecasted Cotilla and Córdoba (2004).

Acknowledgements
Amador García Sarduy prepared all figures. The budgets mainly came from two projects: TSUJAL (CGL2011-29474-C02-01) and GR35/10-A/910549. Grateful to the anonymous reviewer.

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