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Short communication

Discussion: Triassic-Miocene paleogeography and basin evolution of the Subbetic Zone between Ronda and Málaga, Spain. Reply by the Author

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The stratigraphic data in Van der Meer (1995) concentrates on the area around Ronda since there is a relatively complete section and because sedimentation patterns reflect the change from the NE–SW oriented Betic trend to the more N–S oriented Gibraltar trend. Subsequent paleogeographic reconstructions and subsidence analysis, however, are based not only on field investigations but also on published stratigraphic data and on verified information from the Spanish geological maps. Martín-Algarra et al. (this issue) state that I 'ignore the great number of papers published about the geology of the area'. They present a list of seven examples of which five are Ph.D. theses published in Spanish, French and German. Such information is not easily accessible because it circulates only between small groups of researchers. It would be worthwhile if the results of these Ph.D. research projects were published in international journals to gain a widespread diffusion. In their opening statement, Martín-Algarra et al. present a number of interesting theories as if they were irrefutable facts. They state that in the investigated area, sediments of the Campo de Gibraltar complex are backthrusted onto Burdigalian transgressive sediments that unconformably overlie units of the Internal Zones. Many unanswered questions arise from this statement, such as: when did this backthrusting take place?, over what distance were these units transported?, where were these sediments deposited originally? etc. According to the Spanish geological maps, the sediments of the Campo de Gibraltar complex only exist in the form of Burdigalian olistostromes in the area of Teba (ITGE 1990b) and not as widespread as is suggested by Martín-Algarra et al. It should be noted that A. Martín- Algarra and C. Sanz de Galdeano were involved in the preparation of several of these maps. Furthermore, Martín-Algarra et al. claim that the 'area between Ronda and Málaga does not correspond primarily to the Subbetic Zone but principally to the Internal Zone' and that 'the Subbetic units are present only in the area immediately to the south and east of Ronda'. It is this subdivision that forms the difference in interpretation of the stratigraphy between Martín-Algarra et al. and myself. I will try to explain this by describing the stratigraphy of the area south and east of Ronda.

According to the geological map of the Ronda area (ITGE 1990a), prepared amongst others by A. Martín-Algarra and C. Sanz de Galdeano, the area can be divided into a Betic Zone, a Circumbetic Zone, a Subbetic Zone, and a number of postorogenic units. The Betic (Internal) Zone consists of Malaguide and Alpujarride units. The Circumbetic Zone can be subdivided into a pre-Dorsal complex and a Dorsal complex. The pre-Dorsal complex consists of a Triassic–Cretaceous series of limestones and marls unconformably overlain by Paleocene limestones containing *Microcodium* which are in turn overlain by a thick series of Eocene to Early Miocene marls and limestones with a shallow marine origin. According to ITGE (1990a), the Tertiary units of the pre-Dorsal complex (their numbers 41–44) are allochthonous and belong to the Internal Zone. In fact, around El Burgo these units are mapped as klippes on the limestones with Couches Rouges facies of the Subbetic Zone, and south of Ronda they are mapped as backthrusts onto the Muschelkalk of this zone. I have investigated these sites and found no evidence to support the tectonic nature of these contacts. In reality, as can be seen clearly in the area just east of the Cortijo de Gomez some 2km SE of Ronda, these sediments unconformably overlie the Subbetic limestone sequence without any signs of tectonic displacement. No fault breccia, slickensides or other shear indicators were observed in the field which should be abundant if we were dealing with units that supposedly originated far to the southeast of their present position. On the basis of this knowledge, I re-interpreted these units as autochthonous and thus belonging to the External rather than to the Internal Zone. From this it may be clear that none of my figures depicting the Tertiary deposits and related text sections match with the 'geological reality of the area' as inferred by Martín-Algarra et al. and that I 'assign outcrops to the Subbetic Zone that (according to the authors) actually belong to other tectonic units'. Under 'Paleogeographic reconstructions' I will demonstrate that a careful examination of the lithologies in question confirms this idea.

Martín-Algarra et al. state that the stratigraphic mapping and facies analysis and the subsequent paleoenvironment reconstructions were not done by myself and that I do not mention all of my sources. I find this accusation offensive and wonder what is meant by this. I acknowledged the work of former ITC students in the area and refer to 24 papers from international journals to support my conclusions. Furthermore, I have worked four field summers in the Ronda–Málaga area and have examined many thin sections in the laboratory to come to the study presented.

Triassic. I regret that my Fig. 2 is not of sufficient detail for Martín-Algarra et al. to be able to properly locate the sections used. Careful examination shows that section 2 was taken at the northern foothills of the Sierra Hidalga and section 3 runs through the northern flank of the folded Jurassic limestones forming the Sierra Blanquilla mountain range. At these two sites, a complete undisturbed Triassic (combined with site 1) and Jurassic sequence can be investigated. Dürr, already back in 1967, described these same sections. Martín-Algarra et al. appear to contradict themselves when they claim that points 4, 5, 7, 8, 10, 12, 14, 15, 18, 19, 23, 24, 26, 27, 28 and 29 are within the Campo de Gibraltar Complex while in their opening statement they claim that only a small portion of the area belongs to this complex. In fact, the sites belong largely to Early Miocene sequences that were interpreted previously as allochthonous but are now confirmed to be autochthonous units belonging to the External Zone.

The Triassic sequence shown in my Fig. 4 and described on pages 45 and 46 is the same sequence that can be found in Dürr (1967: 9–11), following partly the Rio Grande and then into an anticlinal structure east of it. Dürr describes the basis of the Triassic as a 'klastisch-salinaren Schichtfolge' and refers to the red-coloured sandstones when he says 'sie umfasst grünlichbraungraue, Hellglimmer und kohliges Häcksel führende, teils auch eisenschüssige Sandsteine'. The dating of these clastic sequences (as stated in my paper) is inferred from the relationship with the overlying well-dated limestones. The 'dolomites containing *Myophoria..*' that I describe are not of Carnian–Norian age, but of Anisian–Ladinian age and they are found some 3km SE of Ronda where the Arroya de Linarejos and the Arroyo Negro meet. Again Dürr (1967) dates these as Anisian (possibly Ladinian; see also ITGE 1990a: 29) and thus infers the age of the underlying clastic sequence. The thickness of the calcareous Triassic was measured in several sections along the foothills of the Sierra Hidalga. My approximate figure of 300m is consistent with ITGE (1990a) who state that the Muschelkalk is around 250m thick. The 1100m given by Martín-Algarra et al. for the Carnian–Norian only is preposterous. This corresponds to a subsidence rate which is outrageously high for a stable passive margin with carbonate sedimentation. *Trocholina* species were interpreted to indicate a backreef environment in the Carnian–Norian. This is consistent with the local occurrence of ferruginous oolites in limestones related to the shallowing into the Rhaetian (dated among others by Blumenthal 1933).

Jurassic. My location 2 in Fig. 2 refers to the starting point of a section running on the Sierra Blanquilla whereas location 3 is located in between the Sierra de los Merinos and the Cerro de las Palomas. Within a radius of 3km from point 2, Dürr (1967) made his observations regarding the corals, disputed by Martín-Algarra et al., and his observations on the Tithonian limestones containing ammonites which I will address below. To be precise, the latter observations were at 3km NE of the Viento and 1km S of the Cortijo del Boqueron (3.5km E of point 2). I apologize for the fact that the annotations of the stratigraphic columns might be mis-interpreted by Martín-Algarra et al. who must have mixed the patterns of oolitic limestones and sandstones.

In their reference to corals that were used for dating by Dürr (1967), Martín-Algarra et al. draw a wrong conclusion when they dispute the dating as Malm and claim that Dürr found these at a site near Jarastepar. The Jarastepar mountain, located 9km SW of Ronda, itself is formed by Jurassic limestones dated by ITGE (1990c) as Liassic–Middle Malm (their unit 44) and confined to the Subbetic Zone. The only two datings given by Dürr (1967) from the area of the Jarastepar come from *Aphanotyxis* species yielding a Dogger–Malm age, and a dating of Kimmeridgian based on *Sowerbyceras loryi* and *Perisphinctes* species in a unit equivalent to my unit J4. I refer to observations in the area of the Sierra Blanquilla just 3km NE of the Viento where the age cited in the paper was established on the basis of several observations. In their argumentation, Martín-Algarra et al. put my and their own geological world upside down when they claim that 'nodular limestones rich in ammonites of Middle Oxfordian' (dated on the basis of ...?) are found 'just above the coral-bearing formation that should correspond to the top of the Dogger'.

In the monograph accompanying the geological map of Ronda (ITGE 1990a), which is published more recently than the Ph.D. theses of Cruz-Sanjulián (1974), Sequeiros (1974) and Martín-Algarra (1987), and thus contains the most recent views (bear in mind that this Ph.D. material forms the basis for the geological map of Ronda and accompanying monograph), the stratigraphy of the Jurassic of the Subbetic Zone in the Sierra Blanquilla is described by a number of scientists from the University of Granada, among others C. Sanz de Galdeano. The 'coral-bearing limestone formation' in this publication is described as unit 50 and the following is stated (ITGE 1990a: 31): 'Respecto a la edad del tramo, aunque no hemos encontrado por nuestra parte restos de macrofauna, podemos citar los datos de Durr quien, a partir de sus determinaciones de corales de hydrozoarios, concluye que el límite Oxfordiense–Kimmerdgiense se encuentra en la parte superior del mismo'. The overlying 'nodular limestones rich in ammonites of the Middle Oxfordian' are denoted as 'calizas noduloso-brechoides' (ITGE 1990a: 31; their unit 51) in which 'se observan secciones frecuentes de ammonites de varios centímetros de diámetros y otros macrofósiles, tales como lamelibranquios, belemnites, etc.', dated as Kimmeridgian–Tithonian (ITGE 1990a: 32). This dating conflicts with the Middle Oxfordian age given in Martín-Algarra (1987).

Dürr (1967) describes oolitic limestones from the Subbetic Zone in the Sierra de los Merinos and Sierra Blanquilla as he says 'ein sehr auffallendes Schichtglied bildet, in den profilen der Sierra de los Merinos (i.e. some 10km NE of Ronda in the Subbetic Zone!) und der Blanquilla ein wechselend (30–80m) mächtiges paket grober Oolithe...In diesen Oolithen finden sich manchmal Crinoidenstielglieder, kleine Muscheln, Einzel- und Stockkorallen und Hydrozoën'. Next, Dürr describes the presence of *Cladocoropsis mirabilis* and *Acrosmilia* aff. *fromenteli* (recognized by E. Flügel) which yields an age between Oxfordian and Kimmeridgian. The 'nodular limestones of Middle Oxfordian age' of Martín-Algarra et al. are actually partly massive mudstones becoming more nodular towards the top of the Jurassic and containing amongst others ammonites and belemnites that document a deepening of the depositional environment that continues into the Cretaceous. Dürr (1967: 16) refers to these 'nodular limestones' as 'Knollenkalke die ausser fast unkenntlichen Korallen, Bryozoën und Echinodermresten fast immer Belemniten und dazu Ammoniten erhalten'. These were dated at several locations (e.g. Sierra de la Hidalga near Taho de Golera and near Puerto de Lifa, Sierra Blanquilla near Viento and Cortijo de los Ballesteros) as Kimmeridgian to Tithonian (Dürr 1967: 16). From the assemblages given in Dürr's (1967) respectable publication I see no reason to dispute this dating. Moreover, a widespread deepening of the depositional environment at the end of the Jurassic is well known for the western Mediterranean area. The coral-bearing limestones of the Oxfordian–Kimmeridgian record a shallow environment as opposed to the ammonite-containing limestones that are typical for what Dürr (1967) refers to as the 'Tithonfacies des Tethys'. Finally, this strong subsidence and contemporaneous deepening of the depositional environment in the Tithonian coincides with mafic volcanism in the External Zone (Puga et al. 1989a), with the widespread occurrence of olivine-bearing gabbros in the Mulhacen Complex (De Jong & Bakker 1991), and with pillow lavas in the Nevado-Filabride Complex (Puga et al. 1989b).

Overall, the Jurassic stratigraphy presented in my Fig. 5 may not be representative for the entire area between Ronda and Málaga; however, it 1) is based on observations in the Subbetic of the Sierra Blanquilla, Sierra de los Merinos and Sierra de la Hidalga (and I thus did not 'mix the various Subbetic domains' but rather described what can be observed at the two ends of the spectrum), 2) is consistent with data published by Dürr (1967) and ITGE (1990a), and 3) is consistent with regional tectonic and magmatic events. It is not possible to judge the validity of the dating given by Martín-Algarra et al. since no species are mentioned; however their deepening in the Middle Oxfordian is inconsistent with recently published paleogeographic data for the area.

Cretaceous. Most of the Cretaceous in the Ronda area and throughout most of the southern Subbetic is pelagic. Typically these are red-coloured marly limestones and marls with abundant planktonic foraminifer species which have been used by many authors to provide dating. However, Martín-Algarra et al. reject the fact that limestones were deposited in a shallow-marine environment at the onset of the Cretaceous as I demonstrated by the occurrence of *Praealveolina*. Thus, Martín-Algarra et al. neglect many observations supporting my conclusions. In the area of the Víbora Baja in an unfortunately somewhat tectonized section at the northeastern continuation of the Mesa Juan Pérez anticlinal structure, a hardground separates deep-marine Jurassic limestones containing ammonites from red-coloured limestones containing bryozoans and gastropods. In the Sierra Blanquilla, located 6km W of Cañete la Real (not to be confused with the Sierra Blanquilla just east of Ronda), red-coloured detrital limestones of Middle Cretaceous age contain oolitic horizons (these are just two examples).

Antequera is geologically located in the Triassic that is named after the town (Trias de Antequera). To the north-northeast of Antequera, Cretaceous Subbetic units are cropping out that form a continuation of the Cretaceous exposed in the Cerro de las Palomas and the north flank of the Sierra de Archidona (north of Archidona to the east of Antequera). Just north of Antequera, these Cretaceous sediments are overlain by recent deposits of the Guadalhorce river. However, a few kilometres to the east we find a relatively undisturbed and continuous sequence (all this can also be seen on sheet 1023 of the 1:50,000 geological maps of Spain produced by ITGE). The sequence is similar to the Cretaceous described by Delgado & Sanz de Galdeano (1981) for the Sierra de Gibalto, and it is described in detail in Peyre (1974). It comprises a lower part of 15m of marls and marly limestones of Neocomian age overlain by a series of 60m thickness of bituminous marls with radiolaria of Cenomanian–Turonian age. The Couches Rouges facies overlying the Cenomanian–Turonian marls is represented by 200m of red-coloured marls and thin-bedded limestones. Interestingly (see also below) the Cretaceous is overlain conformably by Paleocene calcarenites containing *Microcodium*.

Tertiary. Tertiary Subbetic units do exist in the Ardales, El Burgo and Teba areas. The legend of the geological map of the Ronda–El Burgo area (ITGE 1990a), for example, learns us that the Cretaceous limestones of the Couches Rouges facies are overlain by detrital limestones containing in- situ *Microcodium*. In places, however, the Paleocene is also pelagic and the limestones of the Couches Rouges facies are overlain by white marls and limestones which are dated by ITGE (1990a, their unit 54) and described as follows: 'la fauna encontrada en las margas (*Globigerinas* y *Globorotalias*) y en las calizas (*Nummulites*) nos da para estos materiales una edad varía del Eoceno inferior al Oligoceno medio (Rupeliense)'. These are in turn overlain by a turbiditic sequence (unit 55: ITGE 1990a) dated as Oligocene to Early Miocene (ITGE 1990a: 33). This section confirms my data given in Fig. 7, although some new findings have been added. I can give similar examples for the other locations disputed by Martín-Algarra et al. Furthermore, it seems very unlikely that if all the observed benthic foraminifers would be re-sedimented into Burdigalian turbidites of the Campo de Gibraltar Complex any consistent dating could be made (as is the case in my data) on the different units. Finally, I would like again to point out that the Paleocene–Lower Miocene can now be considered autochthonous. Supporting evidence for this comes from the occurrences of similar Paleocene detrital limestones with in-situ *Microcodium* that are assigned to different structural complexes on the Spanish geological maps. These detrital limestones are found in small isolated outcrops, for example, 3.5km S of Alozaina (Rio Riachuelo section; Circumbetic Zone, pre-Dorsal Complex), 2km E and 2km SE of El Burgo ('Formaciones Tectosedimentarias'), around Olvera (Median Subbetic), north of Loma de las Carabiteras (Median Subbetic), at the northwest flank of the Sierra del Endrinal (west of Grazalema; Ultra-internal Subbetic), northeast of Grazalema (Neonumidico; here, undisturbed blocks, up to 3km in diameter, of limestones with *Microcodium* occur in a 'tectonic melange'), in the Sierra de Camarolos (SE of Villanueva de Rosario; Subbetic Zone), and north of Arroyo de Serrano (12km NW of Archidona; Median Subbetic). This indicates that the differentiation between the paleogeographic zones of the Internal, Median and External Subbetic post-dates the Early Miocene. Furthermore, the fact that similar coastal-zone deposits (i.e. the *Microcodium*-bearing limestones) with an overlying deeper shelf turbiditic sequence are found in the Subbetic Zone as well as in the units previously assigned to the Circumbetic Zone, makes me believe that we are actually dealing with the same sediments.

The conglomerates forming the Tajo de Ronda and belonging to the Tajo Formation of Serrano-Lozano (1980) were interpreted by this author as continental and Late Tortonian (not Early Tortonian). They are only found in the direct vicinity of the town of Ronda and grade toward the northwest into calcarenites of the Setenil Formation. In my text section disputed by Martín-Algarra et al., a description is given of the El Gastor, La Mina and Las Mesas formations from the northern flank of the basin.

Paleogeographic reconstructions. I have, like most authors presenting paleogeographic reconstructions of the Miocene of the Betic Cordilleras, not attempted to incorporate in my Figure 9 the relative position of the Internal with respect to the External Betic Zone for several reasons. For the younger stages this differentiation no longer exists.

At present no unique plate model exists for the Betic Cordilleras. However, several tectonic models have been proposed by Torres-Roldán (1979) and Weijermars (1985, nappe shedding related to gravitationally driven thermal uplift caused by updoming of the Alboran Diapir), LeBlanc & Olivier (1984, thrusting caused by wrenching related to westward movement of the Alboran microplate relative to the Iberian plate margin), Platt & Vissers (1989, radial extension and crustal shortening caused by collapse of orogenic wedges), and Doblas & Oyarzun (1989, extensional collapse). The model by Doblas & Oyarzun is generally rejected because it fails to account for many known Tertiary deformation events. Sanz de Galdeano & Vera (1992) write: 'The model proposed by Doblas & Oyarzun of a Neogene extensional collapse occurring in the Betic–Rif Alpine orogenic belt has serious defects in our opinion.'

In my opinion, firstly, none of these geodynamic models gives with any detail the positions in time of the different paleogeographic realms that can be correlated with the Ronda–Málaga area, and secondly, none of these models has been completely accepted. Or as Martín-Algarra et al. say: 'All of these models accomodate, in different ways, the displacement of the Internal Zone in relation to the External Zone'. The correct way is not yet certain and thus difficult to incorporate.

Martín-Algarra et al. treat the Tortonian as if during this entire period the paleogeography remains unchanged; however, the opposite is the case. Throughout the Tortonian, the Betic realm was under constant and varying deformation. The boundary between Serravallian and Tortonian is marked by compression leading to an abrupt fall in sea-level followed immediately by a sudden transgression. In the Middle Tortonian, tectonic events cause the closure of the north Betic strait as the Prebetic Zone is displaced northward. Towards the end of the Tortonian, the sea retreats (the beginning of the Messinian event) and all except for the southernmost basins dry up. A connection between the Atlantic and Mediterranean may have existed during the Tortonian to the south of the area pictured in my Fig. 11 and the Ronda and Málaga basins may have been connected in the Late Tortonian. My paleogeographic reconstruction reflects the situation at the onset of the Tortonian when the Ronda and Málaga basins developed individually as isolated, possibly tectonically controlled depressions.

Subsidence analysis and basin evolution. From the above discussion it may be clear that the stratigraphy I presented is less erroneous than Martín-Algarra et al. seem to believe. This is also apparent from my subsidence analysis on which Martín-Algarra et al. do not wish to comment although my results are remarkably consistent with the western Mediterranean basin evolution (too consistent for 'completely erroneous data'). The results obtained from backstripping analysis fit well within the framework of western Mediterranean basin evolution. The Mesozoic rifting events can be directly related to tectonic events in the opening of the Atlantic Ocean, and Cenozoic tectonic events deduced from my subsidence curves coincide with magmatic activity. This cannot just be coincidence, thus my synthetic data set must be less fictitious than Martín-Algarra et al. claim.

References

Blumenthal, M. 1933 Geologie der Bergen um Ronda – Ecl. Geol. Helv. 26: 44–92

Cruz-Sanjulián, J.J. 1974 Estudios geológicos del sector Cañete la Real-Teba-Osuna - Ph.D. thesis, Univ. Granada; 431 pp

De Jong, K. & H.E. Bakker 1991 The Mulhacen and Alpujarride Complex in the Sierra de los Filabres, SE Spain: Litho- stratigraphy – Geol. Mijnbouw 70: 93–103

Delgado, F. & Sanz de Galdeano, C. 1981 Estudio geológico de la Sierra de Gibalto y sectores próximos (provincias de Granada y Málaga) – Estudios Geol. 37: 69–75

Doblas, M. & Oyarzun, R. 1989 Neogene extensional collapse in the western Mediterranean (Betic–Rif Alpine orogenic belt): Implications for the genesis of the Gibraltar Arc and magmatic activity – Geology 17: 430–433

Dürr, S.H. 1967 Geologie der Serrania de Ronda und ihrer Südwestlichen ausläufer (Andalusien) – Geol. Romana 6: 1–73

ITGE (Instituto Technológico GeoMinero de España) 1990a Mapa Geologico de España, Escala 1:50.000, Hoja 1051 Ronda, Segunda Serie, Madrid

ITGE 1990b Mapa Geologico de España, Escala 1:50.000, Hoja 1037 Teba, Segunda Serie, Madrid

ITGE 1990c Mapa Geologico de España, Escala 1:50.000, Hoja 1064 Cortes de la Frontera, Segunda Serie, Madrid

LeBlanc, D. & Ph. Olivier 1984 The role of strike-slip in the Betic-Rifian orogeny – Tectonophysics 101: 345–355

Martín-Algarra, A. 1987 - Evolución Geológico Alpina del contacto entre las Zonas Internas y las Zonas Externas de la Cordillera Bética (Sector Occidental) – Ph. D. thesis, Univ. Granada; 1368 pp

Peyre, Y. 1974 Géologie d'Antequera et de sa région (Cordillères Bétiques), Espagne - Ph.D. thesis, Univ. Paris I: 538 pp

Martín-Algarra, A., A.C. Lopez-Garrido, M. Martín-Martín & C. Sanz de Galdeano 1996 Discussion:Triassic-Miocene paleogeography and basin evolution of the Subbetic Zone between Ronda and Málaga, Spain – Geol. Mijnbouw, this issue

Platt, J.P. & Vissers, R.L.M. 1989 Extensional collapse of thickened continental lithosphere: a working hypothesis for the Alboran Sea and Gibraltar arc – Geology 17: 540–543

Puga, E., M. Portugal, A. Diaz de Federico, G.M. Bargossi & L. Morten 1989a The evolution of the magmatism in the External Zones of the Betic Cordilleras during the Mesozoic – Geodyn. Acta (Paris) 3: 253–266

Puga, E., A. Diaz de Federico, G.M. Bargossi & L. Morten 1989b The Nevado-Filabride metaophiolite association in the Cobdar region (Betic Cordillera, SE Spain): preservation of pillow structures and development of coronitic eclogites – Geodyn. Acta (Paris) 3: 17–36

Sanz de Galdeano, C. & Vera, J.A. 1992 Stratigraphic record and palaeogeographical context of the Neogene basins in the Betic Cordillera, Spain – Basin Research 4: 21–36

Sequeiros, L. 1974 - Paleobiogeografía del Calloviense y Oxfordiense en el sector central de la Zona Subbética - Ph.D. thesis, Univ. de Granada: 636 pp

Serrano-Lozano, F. 1980 Los materiales del Mioceno Superior de la Cuenca de Ronda (Málaga) – Estudios Geol. 36: 231–236

Torres-Roldán, R.L. 1979 The tectonic subdivision of the Betic Zone (Betic Cordilleras, southern Spain): its significance and one possible geotectonic scenario for the westernmost Alpine belt – Am. J. Sci. 279: 19–51

Van der Meer, F. 1995 Triassic-Miocene paleogeography and basin evolution of the Subbetic Zone between Ronda and Málaga, Spain – Geol. Mijnbouw 74: 43–63

Weijermars, R. 1985 Uplift and subsidence history of the Alboran Basin and a profile of the Alboran diapir – Geol. Mijnbouw 64: 349–356