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### Tsunamis and earthquakes in Spain during the Early Middle Ages

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This work discusses some of the most important reported tsunamis and earthquakes that occurred in Spain during the Early Middle Ages. We can confirm 23 earthquakes with 4 associated tsunamis for the whole medieval period. The oldest event (for this time period) is dated to 350 AD, and the most recent occurred on January 26, 1494. These phenomena in Spain, are occasionally well documented. For study and analysis, we depend mainly on historical information, which is partly inherited from the oral tradition. **Keywords**: Iberian Peninsula, Early Middle Ages, tsunamis, earthquakes

Questo articolo discute alcuni dei più importanti tsunami e terremoti che hanno colpito la Spagna nell'alto medioevo. Per l'intero periodo medievale sono documentati 23 terremoti con 4 associati tsunami, dei quali l'evento più antico è databile al 350 d.C., mentre il più recente al 26 gennaio 1494. Questi fenomeni in Spagna sono stati occasionalmente ben documentati, e per la loro analisi dobbiamo basarci per lo più sulle fonti scritte, parzialmente derivate dalla tradizione orale.

Parole chiave: Penisola Iberica, alto medioevo, tsunami, terremoti

#### 1. Introduction

The history of research on earthquakes and tsunamis in the Iberian Peninsula extends back only a little over 200 years. Indeed, the first seismic catalogs and studies were made in the 18<sup>th</sup> century (Nipho 1755; Moreira de Mendoza 1759; Feyjoo 1756, and Roche 1756). All these works were influenced in part by the greatest catastrophe that ever occurred in the Iberian Peninsula: the 1755 Lisbon earthquake. Later, the Galbis' seismic catalog (1932), is one of the most important documentary references, although, some information given is of dubious

research

origin. An example is the lack of credibility with regard to some sources used by the author, such as citing an earthquake in 1030 BC, where he says: "An earthquake or other natural event, separated Africa from Europe". This is an event that we know happened millions of years ago after the Messinian Crisis (Selli 1973; Hofrichter 2004). Sometimes Galbis used the medieval chronicles of Spain (*Cronica General de España*) as sources, and in these cases myth and legend mingle with reality, because very often these writings served to justify the monarchy and its relationship with the Bible and the divine.

As such, these early catalogs, still far from providing an understanding the Theory of Plate Tectonics, justified these phenomena with religious explanations, philosophical or scientific discussions and even poetry (Muñoz, Udias 1982; Roca *et al.* 2004).

Spain is less known for its seismic catastrophes compared to other Mediterranean countries. However, the earthquake in Lorca on May 11, 2011 with 324 serious injuries and the deaths of 8 people, reminded us that while these episodes are rare in the Iberian Peninsula, that does not mean they will not occur and could represent a serious hazard in some regions.

During the medieval period, the Spanish territory was affected by the occurrence of several earthquakes occurring principally along the southern coast (fig. 1). But, we can establish four seismic risk regions: first Andalucía, less frequently Levante (Murcia, Alicante, Valencia, etc.), Galicia and finally the Pyrenees. According to the database of the Spanish Geographical Institute, over the last 1000 years, Spain has been shaken by one earthquake every 35 years (IGN 2014) and it is estimated that there has been an average of 1 earthquake above magnitude 7 every 150 years.

The seismicity in this area is characterized by the predominance of moderate magnitude earthquakes. Large earthquakes happen after long periods of time and the seismicity is spread over large areas. These earthquakes are connected to the location of the Iberian Peninsula in relation to the plates and these phenomena are caused by the convergence between Eurasia and Africa's plates (Morales *et al.* 2013).

With the historical documents analyzed so far, it has been calculated that in the period between the  $15^{\rm th}$  and  $19^{\rm th}$  centuries alone, earthquakes and tsunamis (a total of 23 earthquakes and 3 tsunamis) caused more than 5,650 deaths in Spain. More specific to the Early Middle Ages, about 15 seismic events with 3 tsunamis have been estimated.

In the following pages, I will discuss the most characteristic events described by the historical sources.



Fig. 1. Areas of greatest seismic risk and location of major earthquakes in the Early Middle Ages in Spain.

### 2. Early medieval earthquakes: some examples

Information on earthquakes and tsunamis in Spanish territory in the Middle Ages is obtained in 2 ways:

a) Historical documentation and information provided by the chroniclers of that period; unfortunately, as often happens, some of these types of documents exhibit exaggerations, gaps or confuse reality with legend.

b) Geoarchaeological evidence: for example, architectural infrastructure damage, or even, sedimentary records of tsunamis; but these are uncommon after a thousand years of diverse alteration.

We must also distinguish between information previous to the 11<sup>th</sup> century, which is quite poor, and information related to later centuries, which is enriched by the incorporation of Muslim chroniclers. This is visible

in the details included in the later sources, such as the number of dead and wounded, which are virtually nonexistent in those sources from the Early Middle Ages.

In recent years, there has been an increased scholarly interest in Spain concerning these catastrophic events, and we hope to get more interesting facts about them in the near future (Álvarez-Gomez, Martín González 2014).

# 2.1. Earthquakes of the 4<sup>th</sup> century in the Iberian Peninsula: confusion and doubts

Usually, the accessible information consists of very short and confusing stories. There is no agreement on the number of earthquakes that occurred. For example, in the oldest catalog (Sánchez Navarro-Neumann 1917), 4 earthquakes are described. Galbis (1932) subsequently increases it to 12, and Martínez and Mezcua (2002) refer to 15 (fig. 2).

The end of the Roman Empire in the Iberian Peninsula was accompanied by major natural disasters. According to Galbis, there are three po-

Year (AD)	Epicenter/Date	Seismic event
346	Portugal	Earthquake
365	Málaga, Adra, July 21st	Earthquake and tsunami
382	Portugal and Andalusia	Earthquake and tsunami
565	Andalusia	Earthquake and tsunami
580	South France and central Pyrenees	Earthquake
722	Asturias	Earthquake
881	Gulf of Cádiz, Andalusia, May 26 <sup>th</sup>	Earthquake
944	Córdoba, July 2 <sup>nd</sup>	Earthquake
949	W Iberian Peninsula	Earthquake and tsunami
955	Córdoba, August 29 <sup>th</sup>	Earthquake
955	Córdoba, September 2 <sup>nd</sup>	Earthquake
957	Gulf of Cádiz	Earthquake and tsunami
971	Córdoba, December 19 <sup>th</sup>	Earthquake
973	Córdoba, May 20 <sup>th</sup>	Earthquake
974	Andalusia, November 9 <sup>th</sup>	Earthquake

Fig. 2. Inventory of earthquakes and tsunamis in the  $4^{\rm th}$  century, according to different authors and catalogs.

tential dates: AD 309, 365 and 382. But here again there are serious doubts. In fact, the first date, AD 309, is based on some confusion about and a misinterpretation of the original source (Sánchez Navarro-Neumann 1917), which really speaks of a cataclysm in AD 109.

The cities of *Baelo Claudia* and *Carteia* (Cádiz, southern Spain), which had been very successful in the past, were shaken by a combination of an earthquake and a tsunami, which greatly affected their urban structures and contributed to their decline and fall. In *Baelo Claudia* the archaeological stratigraphy of the city shows evidence of two major episodes of abrupt city destruction bracketed in AD 40-60 and AD 350-395. These were separated by an intervening horizon of demolition for city rebuilding, which is characteristic of many earthquake-damaged archaeological sites in the Mediterranean (Silva *et al.* 2005). The *Carteia* case is different; the tsunami of AD 40-60 is very clear (found in sedimentary records), but we are still investigating the earthquake of the 4<sup>th</sup> century, although we have several suspicions because we do not have any documentary evidence.

The possibility that *Carteia* was partly destroyed by an earthquake in the 4<sup>th</sup> century, was defended by one of the first excavators of *Carteia*, Julio Martínez Santa-Olalla, when he referred to how: "...for the first time direct evidence has been found for the great catastrophe caused by the earthquake of the 4<sup>th</sup> century, some of the victims of which have reached us in the same position in which they died, squashed by the great columns of the municipal baths" (Roldán *et al.* 2003, pp. 49-50).

For *Baelo Claudia*, the chronological range provided by the researchers is very long (forty-five years) and therefore it is difficult to say whether it corresponds to the seismic event of the year AD 365, the year 382 or even if it belongs to another date altogether.

In addition to its beauty and magnificence, *Baelo Claudia* is of particular interest because it suffered a terrible disaster and thus serves as a great example of how an earthquake could destroy, if only in part, a city. We can see the following proofs: oriented fallen objects; dropped key stones; fallen walls and columns; impact marks, ripples and cracks in the pavement, tilted aqueducts and other infrastructures; and finally, the abandonment of the worst affected areas (fig. 3a-b).

Some authors associate the disaster with the earthquake and tsunami related by Ammianus in Book XXVI, Chapter X (15-19) and dated AD 365 (Yonge 2009):

"15. While the usurper, whose various acts and death we have been relating, was still alive, on the 21<sup>st</sup> of July, in the first consulship of Valentinian and his brother, fearful dangers suddenly overspread the



Fig. 3a. Some earthquake damage in *Baelo Claudia*. a) Ripples in the soil caused by an earthquake. b) Impact on the ground resulting from the fall of a column caused by the earthquake. c) Aqueduct altered by the seismic wave.







Fig. 3b. Some earthquake damage in *Baelo Claudia*: ondulated and broken pavement.

whole world, such as are related in no ancient fables or histories. 16. For a little before sunrise there was a terrible earthquake, preceded by incessant and furious lightning. The sea was driven backwards, so as to recede from the land, and the very depths were uncovered, so that many marine animals were left sticking in the mud. And the depths of its valleys and the recesses of the hills, which from the very first origin of all things had been lying beneath the boundless waters, now beheld the beams of the sun. 17. Many ships were stranded on the dry shore, while people straggling about the shoal water picked up fishes and things of that kind in their hands. In another quarter the waves, as if raging against the violence with which they had been driven back, rose, and swelling over the boiling shallows, beat upon the islands and the extended coasts of the mainland, levelling cities and houses wherever they encountered them. All the elements were in furious discord, and the whole face of the world seemed turned upside down, revealing the most extraordinary sights. 18. For the vast waves subsided when it was least expected, and thus drowned many thousand men. Even ships were swallowed up in the furiCarlos Arteaga-Cardineau





Fig. 4. New walls of *Baelo Claudia* after the earthquake.

ous currents of the returning tide, and were seen to sink when the fury of the sea was exhausted; and the bodies of those who perished by shipwreck floated about on their backs or faces. 19. Other vessels of great size were driven on shore by the violence of the wind, and cast upon the housetops, as happened at Alexandria; and some were even driven two miles inland, of which we ourselves saw one in Laconia, near the town of Mothone, which was lying and rotting where it had been driven".

Some researchers of the last century thought that this earthquake and tsunami affected the whole Mediterranean (Pérez Barradas 1933; Puertas Tricas 2009). Galbis even believed that the epicenter was off the coast of southern Spain between the cities of Málaga, *Exi* (unknown city, could be the phoenician city called Almuñecar today?) and *Adra* (Almería).



Fig. 5. Medieval fortress in Salobreña, Granada Coast (13<sup>th</sup> century), rebuilt after its destruction in the earthquake of Andalusia in 1494.

Some archaeologists believe that there is evidence of the 365 AD earthquake and tsunami in the proximity of the Roman city of *Cilniana* (or *Silniana*) in Málaga. The only proof is a statement by the archaeologist Pérez Barradas (1933) in relation to the reconstruction of the early christian church of Santa María de la Vega in San Pedro de Alcántara (Málaga). Pérez Barradas (1933), after working on the excavation of the church says: "What has been discovered in Silniana corresponds to the empire,

and is due to rebuilding the city after its destruction in the year 365 AD, when a tsunami swept away all the coastal towns. After this time, we have found evidence suggesting that the city, including the basilica, was rebuilt after suffering extensive damage in another tsunami in 526 AD".

In 2014 we conducted a geophysical survey in the vicinity of the church, together with colleagues from the Department of Geography at the University of Granada (Dr. Gómez Zotano Team). For the moment this survey has not yielded any tsunami deposits.

In short, archaeological surveys in *Baelo Claudia* and perhaps *Carteia*, point to an earthquake in the 4<sup>th</sup> century. It also seems that archaeologists working last century were somehow influenced by the writings of Galbis, since they casually give the same exact year, mentioned by the author, without providing further proofs.

Furthermore the earthquake that hit *Baelo Claudia* forced a different form of construction: a lattice of smaller blocks separated by major alignments in the main walls. This architecture also has been seen in medieval towns and fortresses of Spain, Algeria and Italy after a seismic event because it helps to decrease the effects on subsequent earthquakes.

Geological witnesses and documents of different investigators place this earthquake and tsunami in Crete, confirming an affected area that would reach Alexandria, the Peloponnese region, Libya and Sicily (Stiros 2010). The magnitude of the uplift would indicate one of the largest earthquakes ever recorded on Earth with a magnitude over 8 (Ambraseys *et al.* 1994; Stiros 2001), and we must recognize that we can not rule out that the tsunami affected in some way the area through to the Western Mediterranean.

Finally, the AD 365 earthquake, directly or indirectly reported by more than 30 ancient authors of the 4<sup>th</sup>-14<sup>th</sup> century (Bousquet 1984; Stiros 2010). Even if this first earthquake did not destroy *Carteia* and *Baelo Claudia*, we can not rule out the seismic event of the year AD 382. Not recognized in the Seismic Catalog of the "Spanish Geographical Institute", this event is mentioned very briefly by Galbis, Sanchez Navarro-Neumann and Moreira de Mendoza: "with the disappearance of the islands in the Cape of St. Vincent and the Epicenter in Cadiz". However, we do not know much more than this.

### 2.2. Centuries 6<sup>th</sup> to 8<sup>th</sup>: a period of relative calm?

There is no relevant information related to seismicity in Spain for the 5<sup>th</sup> century. In the 6<sup>th</sup> century, there are references to two potential earthquakes, but the current Spanish Seismic catalogs has recognized none. The first is believed to have occurred on the Málaga coast in AD 526 (Pérez Barradas 1933; Martínez, Mezcua 2002) and the other, dated to AD 580 or 585, hit the south of France and the Spanish Pyrenees: "...there were strong earthquakes in France that also reached Spain, where large boulders fell in the Pyrenees, wreaking havoc on men and cattle" (Sánchez Navarro-Neumann 1917).

The latter was also described by French writers (Plinius, Poinsinet 1771, p. 251; Leguay 2005, p. 50). Despite the brevity of the reference, it is interpreted to mean that there was a great disaster and an unknown number of people died.

There is a date in the 8<sup>th</sup> century that arouses interest in the history of Spain: AD 722. The *Chronicle Albeldense* and the *Chronicle of Alfonso III* describe an earthquake that lies between myth and legend (collected by Galbis too but poorly dated). These historical sources, record the victory of Christians over Muslims in the famous "Battle of Covadonga". In the texts, as it is widely known, the beginning of the Reconquest of Spain is associated with the first King of Asturias, Don Pelayo, and with an earthquake resulting from divine intervention. This assistance was made by a spectacular "rain of stones", hence the subsequent interpretation by some that it had a seismic origin. No other source seems to mention an earthquake of such magnitude that aided 300 men against 187.000, numbers which are also doubted by historians (Zabalo 2004). Furthermore, the scenario of confrontation is itself a favorable geomorphological field for landslides resulting from non-seismic factors: abrupt escarpments with gravitational processes, and gelifluction and solifluction processes, etc.

These doubts are very difficult to solve for the moment.

## 2.3. The 9<sup>th</sup> and 10<sup>th</sup> centuries: Spain trembles at the end of the millennium

With the arrival of the Muslims, the reliability of information improves, due to their chroniclers and historians, whose writings have come down to us. Most of the seismic data of the Middle Ages in the Iberian Peninsula are due to them. However, historical information for the 10<sup>th</sup> century is still well below that which exists for later centuries.

There is only one clear example of an earthquake in the  $9^{th}$  century, which happened in the year AD 881. The translation of Muslim chroniclers collected by different historians says (Conde 1820, p. 311):

"In the year 267, Thursday 22 Moon Xawal, the earth shook with such dreadful noise and shudder, which fell many palaces and magnificent buildings and others were very broken, the mountains were opened, and the land fell and collapsed towns and heights, the sea retreated and islands and reefs disappeared at sea ... many villages in the southern and western coast of Spain were ruined ... no one ever saw such a panic, which involved the same beasts".

According to José Antonio Conde (1820), the earthquake also struck southern Spain. His text can be interpreted to say that the catastrophe was such that the Christian king and the Muslim king made a truce in Córdoba.

The 10<sup>th</sup> century stands out from others due to an increase in seismic activity. It should be noted that there is evidence for about seven potential earthquakes and one tsunami (see fig. 2). We do not have much information about them, but the historical sources seem to indicate that Andalusia, especially around the city of Córdoba, suffered from significant seismic activity during the second half of the 10<sup>th</sup> century. These earthquakes were characterized by their low intensity and magnitude, as indicated by the fact that the descriptions are less catastrophic and are limited to confirming the occurrences of the earthquakes. For example, according to Galbis (1932, p. 8), the Muslim chronicler Al Bayano'l Mogrib note: ... July 15<sup>th</sup> of the year 944, "a violent earthquake was felt in Córdoba on the night of Sunday to Monday, nobody had ever felt this kind of trembles or had heard of them. Tremors occurred after prayer of evening (sundown) and lasted an hour".

A singular earthquake occurred five years later in 949 AD. It is significant not only because it has been attributed to an underwater eruption, but also because of its location in the territory of Castilla León. This region is perhaps one of the least seismic zones of the Iberian Peninsula. Galbis says (1932): "... Shortly before the death of the monarch Ramiro and Bishop Dulcidio in 949, say the annals of Compostelano monk, a geological event of major importance for our region occurred. Several Arab chronicles confirm the existence of the cataclysm but not the causes that produced it. This region of the Earth suffered a very violent shock, attributed by some to the eruption of an underwater volcano, spewing furiously boiling lava and igniting the coastal waters and the mouths of rivers... the tremor sank the mountains. Villages, neighborhoods, magnificent palaces, collapsed. People fled in terror from the village to the fields, and frightened birds and beasts abandoned their nests and burrows".

In addition, this earthquake marked changes in the configuration of rivers, such as the river Valderabuey (Zamora), and destroyed various infrastructures like a Roman bridge on the river Duero. According to the text, the earthquake was accompanied by a tsunami that affected the western coast of the Iberian Peninsula. Surprisingly, it is not recorded by any modern earthquake catalog.

Meanwhile, Conde (1820, p. 446) speaks of a possible tsunami in the year AD 957, about which there is only a brief description: "The sea ebbed 80 fathoms discovering islands and reefs never seen". We do not know more than that; it is not recorded in other catalogs.

Finally, three consecutive earthquakes struck Córdoba and Andalusia (years 971, 973 and 974), but the accessible data do not allow us to establish the severity of them (Martínez, Mezcua 2002).

### 3. Conclusions

The analysis of written sources and historic catalogs allows us to conclude that:

1) In the Early Middle Ages, the Iberian Peninsula was affected by more than a dozen earthquakes and three tsunamis.

2) The accessible historical sources only describe what happened and never provide quantitative information on damage, death or injury. This means that we can not really measure the magnitude and severity of the events.

3) Many questions remain about whether any of the earthquakes of the late 4<sup>th</sup> century (in the south of the Iberian Peninsula) were an extension of the great cataclysm that had its epicenter in Crete in AD 365. The geoarchaeological evidence has not yet clarified an exact chronology.

4) Apparently the second half of the 10<sup>th</sup> century was a time of major seismic activity in Spain, especially in Andalusia.

5) This situation forces us to denounce the absence of policy measures in Spain in order to avoid in the future catastrophes that may recur. A tsunami with similar characteristics to the one that occurred in 1755 AD, or even at the end of the 4<sup>th</sup> century, in southern Spain's highly urbanized coast, could have consequences difficult even to calculate.

Geoarchaeological studies confirm that during the Early Middle Ages various cataclysms affected the Iberian Peninsula. In some cases, they appear to have had important magnitudes and to have caused extensive damage and loss, although the passage of time and the lack of documents prevent faithful reconstructions of what happened. It remains to fill this gap through a joint effort by all possible disciplines: historians, archaeologists, geologists and geographers among others. Again, knowledge of the past should serve to prevent future catastrophes.

#### References

- J. ALONSO-HENAR, A. JIMÉNEZ-DÍAZ 2014, Análisis de la fracturación y Geología del Sistema Central, in ÁLVAREZ-GOMEZ, MARTÍN GONZÁLEZ 2014, pp. 2-5.
- J.A. ÁLVAREZ-GOMEZ, F. MARTÍN GONZÁLEZ (eds), 2014, Una aproximación multidisciplinar al estudio de las fallas activas, los terremotos y el riesgo sísmico. Segunda reunión Ibérica sobre fallas activas y paleosismología, Lorca.
- J.A. ÁLVAREZ-GOMEZ, M. OLABARRIETA, M. GON-ZALEZ, L. OTERO, E. CARRENO, J.M. MAR-TINEZ-SOLARES 2010, The impact of tsunamis on the island of Majorca induced by north Argelian seismic sources, "Turkish Journal of Earth Sciences", 19(3), pp. 367-383.
- N. AMBRASEYS, C. MELVILLE, R. ADAMS 1994, The Seismicity of Egypt, Arabia and the Red Sea, Cambridge.
- C. ARTEAGA, J.A. GONZÁLEZ 2004, Presencia de materiales marinos y dunares sobre un alfar romano en la bahía de Algeciras (Cádiz, España), in G. BENITO, J. DÍEZ (eds), Contribuciones recientes sobre Geomorfología, Actas de la VIII Reunión Nacional de Geomorfología (Toledo, 22-25 septiembre 2004), vol. I, Madrid, pp. 393-407.
- J.A. CONDE 1820, Historia de la dominación de los árabes en España. Sacadas de los manuscritos y memorias arábigas, tomo I, Madrid.
- C.H. DE BRUIJNE, P.A.M. ANDRIESSEN 2002, Far field effects of Alpine plate tectonism in the lberian microplate recorded by faultrelated denudation in the Spanish Central System, "Tectonophysics", 349(1), pp. 161-184.
- J. DERCOURT, L.P. ZONENSHAIN, L.E. RICOU, V.G. KAZIM, X. LE PINCHON, A.L. KNIPPER, C. GRANDJAQUET, I.M. SBORTSHIKOW, J. GEYSSANT, C. LEPVRIER, D.H. PECHERSKY, J. BOULLIN, J.C. SIBUET, L.A. SAVOSTIN, O. SOROKHTIN, M. WESTPHAL, M.L. BAZHENOV, J.P. LAUER, B. BIJU-DUVAL 1986, Geological evolution of the Tethys belt from the Atlantic to the Pamirs since the Lias, "Tectonophysics", pp. 123, 241-315.

- M. ESPINAR MORENO 1994, Los estudios de sismicidad histórica en Andalucía: los Terremotos históricos de la provincia de Almería, in A.M. POSADAS CHINCHILLA, F. VIDAL SÁNCHEZ (eds), El Estudio de los terremotos en Almería, Almería, pp.115-182.
- B.G. FEYJOO 1756, *Nuevo systema, sobre la causa physica de los terremotos*, Puerto de Santa María.
- J. GALBIS 1932, Catálogo sísmico de la zona comprendida entre los meridianos 5°E y 20° W de Greenwich y los paralelos 45° y 25° N., tomo I, Madrid.
- J. GALBIS RODRÍGUEZ 1940, Catálogo sísmico de la zona comprendida entre los meridianos 5°E y 20° W y paralelos 45° y 25° N, t. II, Madrid.
- R. HOFRICHTER 2004, Crisis de salinidad del Messiniense: cuando se desecó el Mar Mediterráneo, in El Mar Mediterráneo, Barcelona, pp. 86-94.
- J.A. ÁLVAREZ-GOMEZ, F. MARTÍN GONZÁLEZ (eds), 2014, Una aproximación multidisciplinar al estudio de las fallas activas, los terremotos y el riesgo sísmico. Segunda reunión Ibérica sobre fallas activas y paleosismología, Lorca.
- IGN-INSTITUTO GEOGRÁFICO NACIONAL 2014, Base de datos. Online in: http://www.ign.es/ign /layoutln/sismoTerremotosEspana.do? value=1
- F. JACQUES, B. BOUSQUET 1984, Le cataclysme du 21 Juillet 365: phénomène régional ou catastrophe cosmique?, in Tremblements de terre: histoire et archéologie, IV<sup>emes</sup> Rencontres Internationales d'Archeologie et d'Histoire d'Antibes, Valbonne, pp. 183-198.
- J.P. LEGUAY 2005, Les catastrophes au Moyen  $\hat{A}ge$ , Paris.
- J.M. MARTÍNEZ SOLARES, J. MEZCUA RODRÍGUEZ 2002, *Catálogo Sísmico de la Península Ibérica (880 a.C.-1900)*, Madrid.
- J. MILNE 1899, Catalogue of Destructive Earthquakes A.D. 7-1899, London.
- A. MORALES-ESTEBAN, F. MARTÍNEZ-ÁLVAREZ, J. REYES 2013, Earthquake prediction in seismogenic areas of the Iberian Peninsula based on computational intelligence, "Tectonophysics", 593, pp. 121-134.

- J.J. MOREIRA DE MENDOZA 1758, Historia Universal dos Terremotos que tem havido no mundo, de que ha noticia, desde a sua creaçao ate o seculo presente. Com unanarraçam individual do Terremoto do primeiro de Novembro de 1755, e noticia verdadera dos seus effeitos em Lisboa, todo Portugal, algarves, e mais partes da Europa, Africa, e America, aonde se estendeu: e huma Disertaçao Physica sobre as causas geraes dos Terremotos, seus effeitos, differenças, e Prognosticos e as particulares do ultimo, Lisboa.
- D. MUÑOZ, A. UDÍAS 1982, Historical development of Spain's catalogues of earthquakes, "Bulletin of the Seismological Society of America", 72(3), pp. 1039-1042.
- F.M. NIPHO 1755, Explicación physica y moral de las causas, deñales, diferencias y efectos de los terremotos, con una relación muy exacta de los más formidables y ruinosos que ha padecido la tierra desde el principio del Mundo, hasta el que se ha experimentado en España y Portugal el día primero de Noviembre de este año 1755, Biblioteca Nacional, Madrid, Ref. R/34858.
- J. PÉREZ BARRADAS 1993, Nuevos datos sobre las excavaciones de Silniana (San Pedro de Alcántara, Málaga), "Anuario de Prehistoria Madrileña", pp. 409-415.
- A. PERREY 1847, Sur les tremblements de terre de la Péninsule Ibérique, "Annales des Sciences Physiques et Naturelles, d'Agriculture et d'Industrie", X, pp. 461-513.
- PLINIUS SECUNDUS, ed. L. POINSINET DE SIVRY 1771, Histoire Naturelle: traduite en François, avec le texte latin rétabli d'après les meilleures leçons manuscrites: accompagnée de notes critiques pour l'éclaircissement du texte & d'observations sur les conneissances des Anciens comparées avec les découvertes des Modernes, vol. 1, Paris.
- R. PUERTAS TRICAS 2009, Los siglos oscuros en la historia de Málaga (siglos IV-VII), "Jabega", 63, pp. 9-20.
- A. Roca, A. IZQUIERDO, C. SOUSA-OLIVEIRA, J.M. MARTÍNEZ-SOLARES 2004, An outline of earthquake catalogues, databases and studies of historical seismicity in the Iberian Peninsula, "Annals of Geophysics", 47, pp. 561-570.

- J.L. ROCHE 1756, Relacion y observaciones physicasmathematicas, y morales sobre el general terremoto, y la irrupcion del mar del dia primero de Noviembre de este año de 1755, que comprehendio a la Ciudad, y Gran Puerto de Sta. Maria, y a toda la costa, y tierra firme del Reyno de Andalucía, Puerto de Santa María, Instituto Geológico y Minero, Ref. 454-20.
- L. ROLDÁN GÓMEZ, M. BENDALA GALÁN, J. BLÁN-QUEZ PÉREZ, S. MARTÍNEZ LILLO, D. BERNAL CASASOLA 2003, *Carteia II*, Madrid.
- M. SÁNCHEZ NAVARRO-NEUMANN 1917, Lista de los terremotos más notables sentidos en la Península Ibérica, "Memorias de la Real Academia de Ciencias de Madrid", XII(8), pp. 179-188.
- R. SELLI 1973, An outline of the Italian Messinian, in Messinian events in the Mediterranean, Utrecht Colloquiuum, Amsterdam, pp. 150-171.
- P.G. SILVA, F. BORJA, C. ZAZO, J.L. GOY, T. BAR-DAJÍ, L. DE LUQUE, C.J. DABRIO 2005, Archaeoseismic record at the ancient Roman City of Baelo Claudia (Cádiz, south Spain), "Tectonophysics", 408(1), pp.129-146.
- S.C. STIROS 2001, The AD 365 Crete earthquake and possible seismic clustering during the 4-6<sup>th</sup> centuries AD in the Eastern Mediterranean: a review of historical and archaeological data, "Journal of Structural Geology", 23, pp. 545-562.
- S.C. STIROS 2010, The 8.5+ magnitude, AD 365 earthquake in Crete: coastal uplift, topography changes, archaeological and historical signature, "Quaternary International", 216(1), pp. 54-63.
- A. UDÍAS 1984, El terremoto de 21 de julio del 365, erróneamente atribuido a la costa de Málaga, in Sismicidad histórica de la región de la Península Ibérica, Madrid, pp. 53-55.
- D.C. YONGE 2009, *The Roman History of Ammianus Marcellinus*, Online in: http://www. gutenberg.org/files/28587/28587-h/28 587-h.htm
- J. ZABALO 2004, *El número de musulmanes que atacaron Covadonga*, "Historia. Instituciones. Documentos", 31, pp. 715-727.