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1 Breaking the Waves: Earthquake and Tsunami Research in the Iberian Peninsula from a Historiographical Perspective

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Abstract

This chapter performs a historiographical overview for the purpose of describing the evolution of recent earthquake and tsunami research in the Iberian Peninsula, characterised by the convergence of information deriving from different scientific disciplines, such as historical seismology, geology and archaeology. From the early 1990s down to the present day, several stages of research are identified, while placing the spotlight on the boom years in geological research on paleotsunamis in Portugal and Spain, in the wake of the catastrophic tsunamis in the Indian Ocean in 2004 and in Japan in 2011, as well as addressing future perspectives for interdisciplinary collaboration. The final section describes the aim of this book, plus the organisation and content of its chapters, as well as reflects on the future challenges facing research in this field.

Keywords

Historical earthquakes · Historical tsunamis · Historical seismology · Paleotsunamis · Historiography · Iberian Peninsula

In the past decades, research on historical earthquakes and tsunamis in the Iberian Peninsula has gone from strength to strength in different scientific fields enquiring into these phenomena, above all geology, paleoseismology, stratigraphy, geochemistry, geomorphology, archaeology, geoarchaeology and historical seismology. This has made it possible to gain a much deeper understanding of the footprints of both well-known seismic and tsunamigenic events, such as the famous AD 1755 Lisbon earthquake and tsunami, and other events occurring in previous ages.

In the specific case of the historical tsunamis that struck the coasts of the Iberian Peninsula, the subject on which this book focuses, research is relatively recent, for it began in the 1990s, before coming into its own following the catastrophes in the Indian Ocean in 2004 and Japan in 2011. Be that as it may, the increase in knowledge of these phenomena and the growing body of literature in this regard have been constrained by a number of methodological problems arising in the intersection between different scientific disciplines at the forefront of this progress, such as geology and history, whose evolution will be approached in this introductory chapter from a diachronic perspective.

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In the first three sections of this chapter, a historiographical review is performed on the evolution of research on historical earthquakes and tsunamis in the Iberian Peninsula over time, stressing the interrelation between historiographical, historical seismological, geological and archaeological data. With this review, the aim is to identify some of the keys that define the present state of the question and to underline the need for closer interdisciplinary collaboration in order to make further progress. In the fourth section, the genesis of this book is described, and, lastly, in the fifth section, the structure and content of its chapters are presented.

1.1 The Written Sources

Earthquake and tsunami research in the Iberian Peninsula has been marked by the impact of the AD 1755 Lisbon cataclysm (Mendes-Victor et al. 2009). This event marked the advent of modern historical seismology, with compilations of accounts of ancient earthquakes and tsunamis as influential as Moreira de Mendonça's *Historia universal dos terremotos* (1758), published only three years after the catastrophe.

As shown in Chap. 3 of this book, before the Muslim conquest of the Iberian Peninsula in the eighth century AD, the written sources dealing with seismic events in the peninsula are very thin on the ground. In fact, they are limited to references to the cataclysm that caused Atlantis to sink into the sea, as described in the Platonic account—a literary myth written in the fourth century BC (see López-Ruiz, this volume)—, a succinct account of earthquakes in the Pyrenees at an unspecified date, appearing in the anonymous *De mirabilibus auscultationibus* (third century BC), a fleeting reference to an event occurring in Cordova between 79 and 72 BC, found in a fragment of Sallust's *Histories* (first century BC), the vague information contained in the *Chronicle* of Hydatius (fifth century AD) concerning the occurrence of earthquakes in *Gallaecia* in AD 451 and 454, and the description of an earthquake in Bordeaux—which would have been felt in the Pyrenees and Spain, in ca. AD 580—in Gregory of Tours' *History of the Franks* (sixth century AD).

From the beginning of Muslim rule in the Iberian Peninsula, the historians of Al Andalus and the Maghreb began to record contemporary seismic events, as was the case with the earthquakes occurring in Cordova in AD 971, 973 and 974, mentioned by the historian Isa ibn Ahmad al Razi (tenth century), and with those also affecting this city in AD 881, 944 and 955, which are known to us through the oeuvre of the Moroccan author Ibn Adhari (thirteenth–fourteenth century) and to which his compatriot Ibn Abi Zar (fourteenth century) also referred.

The AD 881 earthquake is a good example of the complications arising when using historical sources, a problem to which we shall return in this chapter. In diverse Arab and Christian sources, there are testimonies of a major earthquake on 26 May AD 881, which was felt in southern Spain and North Africa. The main sources are Ibn Adhari, who describes its effects on Cordova, and Ibn Abi Zar, who mentions the damage that it wrought in the Maghreb and Andalusia. The Spanish historian Juan de Mariana (1601) also mentions an earthquake in Spain in that year, but none of the aforementioned authors describe associated sea phenomena. Several centuries later, in his *Historia de la dominación de los árabes en España*, the historian Conde (1820) describes a receding ocean and the disappearance of islands and reefs associated with that earthquake, claiming that it also destroyed many localities in southern and western Spain. However, Conde does not specify the sources from which he drew this information on that possible tsunami (Udías 2015), about which we know practically nothing.

As of the end of the fourteenth century, the quantity of contemporary information on seismic events in the Iberian Peninsula increased, as evidenced by the greater number of accounts of earthquakes, which would be subsequently included in the most important seismic compilations and catalogues (e.g., Galbis 1932; 1940). In relation to earthquakes associated with possible tsunamis, noteworthy are those of Almeria in AD 1522 (López Marinas 1985; Reicherter and Becker-

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Heidmann 2009), Lisbon in AD 1531 (Baptista et al. 2014), Malaga in AD 1680 (Goded 2006), the Algarve in AD 1722 (Baptista et al. 2007) and Cadiz in AD 1731 (see Gracia et al., this volume). Nevertheless, whether those earthquakes actually triggered tsunamis in some cases, such as that of Malaga in AD 1680, is a moot point (Goded 2006).

Indeed, no contemporary—or more or less contemporary—accounts of the vast majority of earthquakes and tsunamis occurring before AD 881, which have subsequently found their way into the most important Portuguese and Spanish seismic catalogues (Galbis 1932, 1940; Oliveira 1986), have come down to us. The sources in which the first news of these events appears include the works of the Spanish chronicler Florián de Ocampo and his Portuguese counterpart Bernardo de Brito, written between the sixteenth and seventeenth centuries, namely a long time after they had occurred. In Ocampo's *Crónica General de España* (1543, 1553), there is information about earthquakes and sea floods in Cadiz in 241, 216 and 210 BC; while in Brito's *Monarchia Lusytana* (1597, 1609), there is news about earthquakes and sea floods affecting the coasts of Portugal and Galicia in ca. 63 BC and the Portuguese seaboard in 47 BC, plus a description of the impact of the famous "universal earthquake" in AD 365 on the coasts of Portugal. The historicity of these accounts is highly questionable because, as already noted, both produced their works many centuries after the narrated events and, furthermore, resorted to spurious sources. Nonetheless, Ocampo's and Brito's reports were subsequently recuperated by historians like Esteban de Garibay (1571), Juan de Mariana (1601) and Manuel de Faria y Sousa (1678), to whom should be added others including Miguel Lafuente (1843), who described the impact of the AD 365 tsunami on the coasts of Malaga and Granada (see Álvarez-Martí-Aguilar, this volume).

1.2 The Seismic Catalogues

This information was gradually included in successive seismic compilations and catalogues, both with a global scope and covering Portugal and Spain, starting with the abovementioned work by Moreira de Mendonça (1758). The complex process of transmitting this information, thus, got underway, from the eighteenth century down to the present day, during which the dates of some events have been altered slightly, owing to typos or misunderstandings when transcribing them. This has resulted in the duplication of events in successive compilations, a tradition that has been followed by the most recent seismic catalogues (Udías 2015, 2020; Udías et al. 2020; Álvarez-Martí-Aguilar 2017a, b, 2020).

In the case of Spain, the current catalogue of earthquakes occurring before AD 1370, published by the Spanish National Geographic Institute (hereinafter IGN) (https://www.ign.es/web/ign/portal/sis-catalogo-terremotos; accessed 31/12/2020), fundamentally draws from the compilations appearing in the first half of the twentieth century, such as M. M.ª Sánchez Navarro-Neumann's (1921) and, above all, J. Galbis' *Catálogo sísmico* (1932, 1940). This last work has been a mandatory reference for several generations of geologists, archaeologists and historians interested in the Iberian Peninsula's seismological past. It is a meritorious compilation of an enormous quantity of data retrieved from previous historical works and seismic catalogues. However, no critical review was performed on the information contained in the catalogue in order to gauge its historicity, for which reason it includes, especially for the most ancient period, duplicated events and other non-existent ones.

The evolution of seismic catalogues in Spain continued with works such as Munuera's (1963), which is based on the information contained in Galbis' *Catálogo*, although including magnitudes and geographical coordinates, even for events on which information is scarce or dubious (Muñiz Gómez 2001). The most recent compilations were performed by Mezcua and Martínez-Solares (1983), whose *Catálogo sísmico de la península Ibérica (880 a.C.–1900)* (Martínez-Solares and Mezcua 2002) served as the main source for the IGN's earthquake catalogue. Notwithstanding the fact that these recent catalogues contain more filtered and updated

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information, in Spanish tsunami research, the reference work has always been Galbis' *Catálogo*. There is a simple reason for this. Unlike the most recent ones, it includes descriptions of coastal phenomena and sea floods associated with earthquakes. This is the reason why it served as a fundamental reference for Campos (1991, 1992) in two works addressing the risk of tsunamis in Spain, which have been very influential in recent geological research. These works describe a series of earthquakes and tsunamis occurring before AD 1755: those of Cadiz in 218–216 and 210–209 BC; that of Portugal and Galicia in 60 BC; that of Malaga and Adra (Almeria) in AD 365; that of Cape St. Vincent in AD 382; that of Cadiz in AD 881; that of Lisbon and southern Portugal in AD 1531; that of Malaga in AD 1680 and that of the Algarve in AD 1722. For the period before AD 1755, the IGN's *Catálogo de Tsunamis en las Costas Españolas* records tsunamis in Cadiz in 218 and 210 BC (both with reliability = 0, very improbable), in south-western Portugal in 60 BC (reliability = 1, improbable), in southern Spain in AD 881 (reliability = 0, very improbable) and in Garachico (the Canary Isles) in AD 1706 (reliability = 3, probable).

Something similar has occurred in the tradition of Portuguese seismic catalogues. The influential work by Moreira de Mendonça (1758) includes brief descriptions of the events that it records and, as a result, has also been a permanent touchstone for tsunami research among Portuguese scholars. Nonetheless, the current reference works include the review of the seismic catalogue by Oliveira (1986) for the Portuguese National Laboratory for Civil Engineering (LNEC), the catalogue by Martins and Mendes-Victor (2001) and the review of the Portuguese tsunami catalogue by Baptista and Miranda (2009). Oliveira's review contains succinct descriptions of seismic events, including references to sea floods associated with earthquakes, for which reason it has been the major reference work for recent research in Portugal when linking geological and historical records of tsunamis. This work includes references to sea floods linked to earthquakes in 63 ("tsunami (?)") and 47 BC ("sismos variados i grandes marés"; *various earthquakes and great tides*) and AD 382 ("Desaparecimento de ilhas"; *Disappearance of islands*) (Oliveira 1986, p. 133). In reality, these accounts have been drawn from Bernardo de Brito (1597, 1609).

The compilations of Galbis (1932, 1940), Oliveira (1986) and Campos (1991, 1992), whose aim was not to determine the historicity of the recorded events, especially for the most ancient period, have made a powerful contribution to consolidating the perception that the earthquakes and tsunamis recorded in them are unquestionably historical events. Those teams that, as of the beginning of the 1990s, started to document the geological footprints of ancient extreme wave events (hereinafter EWEs) on the coasts of the Iberian Peninsula, based their research on that conviction.

1.3 The Historical Records and Geological Research

This section offers an overview of the process of reception of this historical information by those performing geological research on tsunamis in the Iberian Peninsula and the methodological problems to which it has given rise. The intention here is not to offer a comprehensive summary of the research and studies conducted during the past few decades, a task that exceeds the scope of this chapter, but to provide a number of keys to understand some of the most relevant questions posed by tsunami research in Portugal and Spain, in whose development it is possible to distinguish several stages.

In the 1990s, geomorphic and sedimentary evidence of the AD 1755 tsunami was first detected in Portugal, in places like Boca do Rio, Martinhal and Ria Formosa (Andrade 1992; Andrade et al. 1994, 1997, 1998; Dawson et al. 1995, 1996; Hindson et al. 1996; Hindson and Andrade 1999; Kortekaas et al. 1998a, b; see Costa et al. this volume). In the case of Spain, in the 1990s, geomorphological studies were performed in the estuaries of the rivers Tinto-Odiel, in Huelva (Lario 1996), in the marshlands of the

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river Guadalquivir, in the area of Doñana National Park (Lario et al. 1995, 2001; Lario 1996), at the mouth of the river Guadalete, in the Bay of Cadiz (Lario 1996; Dabrio et al. 1998; Luque et al. 2001, 2002) and in the south-easternmost coastal lowlands of the Gulf of Cadiz (Luque 2002; Whelan and Kelletat 2003, 2005; Alonso et al. 2004; Luque et al. 2004). These studies revealed an increasingly higher number of geomorphological footprints of EWEs, such as washover fans and *cheniers*, as well as a greater quantity of sedimentary records obtained from geological trenches and survey drilling.

The geological and sedimentary footprints of the tsunami of 1 November AD 1755 were the most evident and studied in this stage of research, particularly on the western seaboard of Portugal and the Algarve, although they were also documented on the coasts of Huelva and Cadiz (Dabrio et al. 1998; Luque et al. 2004). However, in research conducted on the coasts of the provinces of Huelva and Cadiz, the footprints of more ancient high-energy events also began to be documented.

Rodríguez Vidal (1987) and Zazo et al. (1994) had already detected an erosion event interrupting the progradation phase of the Punta Umbría and the Doñana spit bars, which they dated to ca. 2500 BP. But it was studies like those performed by Lario (1996), Lario et al. (2001), Rodríguez-Ramírez (1998) and Luque et al. (2001) in which sedimentary evidence of previous EWEs, datable to the prehistoric age or Antiquity, was discovered in the Doñana marshlands and at the mouth of the river Guadalquivir and to which a possible tsunamigenic origin was tentatively attributed.

Lario (1996) described two ancient erosive events in the southwest coasts of Spain dated to 4500–4200 BP and 2600–2350 BP, respectively. Rodríguez-Ramírez (1998) described three ancient erosive episodes in the Doñana and Algaida spit bars, at the end of the third millennium BC, ca. 2600 BP, and in the Roman imperial age, between the first and third centuries BC (Rodríguez-Ramírez 1998; Rodríguez-Ramírez et al., this volume). For their part, Lario et al. (2001) and Luque et al. (2001, 2002) described a series of washover fans in the Valdelagrana spit bar, in the Bay of Cadiz, some of which are attributed to a tsunami occurring during the late Roman Empire and others to the AD 1755 Lisbon tsunami. Later on, Luque et al. (2004) found geological evidence of the AD 1755 Lisbon tsunami in washover fans in Conil (Cadiz).

The growing suspicion that the high-energy marine events documented on the coasts of Huelva and Cadiz might have been tsunamis logically led research teams to contrast the radiocarbon dates obtained from geological surveys with the earthquakes and tsunamis recorded in the most important seismic catalogues. Thus, from the beginning of the 2000s up until the mid-2010s, there was a second stage of research on earthquakes and tsunamis in the southwest of the Iberian Peninsula characterised by a paradoxical drift.

On the one hand, in both Portugal and Spain, a greater number of more sophisticated studies were performed on paleotsunamis, driven by the growing interest aroused by the major catastrophes in the Indian Ocean in 2004, in Chile in 2010 and in Japan in 2011. The concern for determining the number, intensity and return periods of this type of phenomenon with such devastating consequences was reflected in scientific initiatives like TRANSFER (Tsunami risk and strategies for the European region, 2006–2009) and NEAREST (Integrated observation from NEAR shore sourcES of Tsunami: Towards an early warning system, 2006–2010), both funded by the European Commission, whose actions included updating European earthquake and tsunami catalogues. This was coupled with an upsurge in fieldwork in search of the footprints of ancient tsunamis. In both Portugal and Spain, there was an increase in the number of geomorphological and stratigraphic studies, accompanied by sets of mineralogical and paleofaunal analyses and radiocarbon dating, including studies of the off-shore earthquake record on the south-western seaboard of the Iberian Peninsula (Gràcia et al. 2010). Additionally, some of the key questions in recent research were posed, such as how to distinguish

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the footprints of tsunamis from those of violent storms (Kortekaas and Dawson 2007; Lario et al. 2010a) and how to determine the influence of the marine reservoir effect of coastal waters off the southern Atlantic coast of the Iberian Peninsula on radiocarbon dating (Lario et al. 2010b; Martins and Soares 2013; Monge 2015).

The 2000s and the beginning of the 2010s saw the publication of evidence of ancient EWEs, documented in areas like Cabo da Roca-Cascais, west of Lisbon (Scheffers and Kelletat 2005), the Alentejo (Ramos-Pereira et al. 2009), the Algarve (Schneider et al. 2010; Costa et al. 2010, 2012a, b), the Azores archipelago (Andrade, Borges and Freitas 2006), the Huelva estuary (Morales et al. 2008), the Bay of Cadiz (Gutiérrez-Mas et al. 2009a, b; Gutiérrez-Mas et al. 2011), the Atlantic coast of the Strait of Gibraltar (Alonso et al. 2004; 2007; Luque et al. 2004; Arteaga and Prados 2008; Koster and Reicherter 2014) and, in particular, the Doñana marshlands (Ruiz et al. 2004, 2005, 2008; Cáceres et al. 2006; Rodríguez-Vidal et al. 2008). While at the end of that decade and at the beginning of the 2010s, overviews of the results of the intense research activity during the previous decade, especially on the coasts of the Gulf of Cadiz (Luque 2008; Reicherter et al. 2010; Morales et al. 2011; Lario et al. 2010a, 2011; Ruiz et al. 2013), and reviews of Portuguese seismic catalogues (Baptista and Miranda 2009) saw the light of day. Lario et al. (2010a, 2011) concluded that at least seven very severe EWEs hit the southwest coast of the Iberian Peninsula in the last 7000 years, dated to ca. 7000 cal BP, ca. 5700–5300 cal BP, ca. 4500–4100 cal BP, ca. 3900–3700 cal BP, ca. 2700–2200 cal BP, ca. 2000 cal BP, ca. 1500 cal BP and AD 1755 (Lisbon earthquake).

On the other hand, despite this significant progress in the quantity and quality of geological research on EWEs in the Iberian Peninsula, during this stage, there was a tendency to employ insufficiently contrasted historical data of doubtful veracity. As of the beginning of the 2000s, the radiocarbon dates associated with these EWEs were compared with the dates recorded in the most important seismic catalogues, for the purpose of checking whether or not they coincided with the—allegedly—historical tsunamis recorded in them. Accordingly, recourse was had to the information appearing in Galbis' catalogue (1932, 1940), the summary of Spanish tsunamigenic events in a monograph published by Campos (1992) and, in the case of Portugal, Moreira de Mendonça's work (1758) and Oliveira's catalogue (1986), because, as already noted, they were the only ones that included descriptions of seismic events and sea phenomena compatible with tsunamis.

Throughout this stage, which got underway at the beginning of the 2000s, different pieces of evidence documented in the geological record of the peninsula were linked to the purported tsunamis in Cadiz in 218–209 BC, in Galicia and Portugal in 63 BC and in Cape St Vincent in AD 382, whose historicity was taken for granted (Luque et al. 2001, 2002; Ruiz et al. 2005, 2008; Cáceres et al. 2006; Morales et al. 2008; Rodríguez-Vidal et al. 2009; Gutiérrez-Más et al. 2009a; Baptista and Miranda 2009; Gràcia et al. 2010; Silva and Rodríguez-Pascua 2014, among others). Thus, the dates of those supposedly historical tsunamis had a powerful influence on the chronological contextualisation of events whose radiocarbon dates placed them in more or less close temporal horizons. The most explicit example was the linking of a body of evidence of EWEs documented in the Huelva estuary and the Doñana marshlands, with radiocarbon dates in the last three quarters of the first millennium BC, to the earthquakes and tsunamis that, according to Galbis (1932), occurred in Cadiz at the end of the third century BC, information that was ultimately drawn from Ocampo (Rodríguez-Vidal et al. 2011, 2015; Silva et al. 2015; Gómez et al. 2015).

An early critical assessment of the available information on allegedly historical tsunamis led researchers to place less faith in the entries appearing in seismic catalogues. This is the case of the research conducted on the ruins of the Roman city of *Baelo Claudia*, in the cove of Bolonia (Tarifa, Cadiz). The archaeological excavations carried out there since 1967 soon documented destruction layers attributable to

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seismic events (Le Roux 1973). Following the first comprehensive geological survey of the ruins and their surroundings (Menanteau et al. 1983), it was suggested that this evidence might be associated with the earthquakes and tsunamis, with epicentres in the Alboran Sea in AD 365 and in Cape St Vincent in AD 382, recorded in seismic catalogues such as that of Stahl (1971). However, the analyses performed by specialists on those historical sources containing references to the earthquake and tsunami occurring in the Eastern Mediterranean in AD 365 soon evinced that their impact on the far west was historically untenable (Jacques and Bousquet 1984; Lepelley 1984). In his seminal work on *Baelo Claudia*, Sillières (1997) rejects those events dated to the fourth century AD and, instead, claims that the city was struck by two major earthquakes in the mid-first century BC and in the second half of the third century AD. Sillières' thesis and the dates proposed by him have usually been taken very much into account by the research teams that have carried out pioneering archaeoseismological research work at the site of *Baelo Claudia* over the past few decades (Silva et al. 2005, 2009, 2015, 2016; Grützner 2011; Grützner et al. 2012). The recent discovery of EWE deposits at the site, dated to ca. AD 400 (Röth et al. 2015; see Reicherter et al., this volume) and possibly related to the tsunamigenic event that has been documented around the same time at sites on the coast of Huelva (see Bermejo Meléndez et al., this volume), does not allow us, by any means, to renew our trust in information like that provided by Brito on the impact of the AD 365 earthquake and tsunami in Portugal.

1.4 New Perspectives: The Need for Interdisciplinary Collaboration

Over the past few years, there has been growing evidence of possible tsunamigenic events affecting the coasts of the Iberian Peninsula in Antiquity, which are not mentioned in the ancient sources or in seismic catalogues. In the archaeological literature, there is a reference to evidence of a possible tsunami at the Phoenician site of Cerro del Villar, in the Bay of Malaga, between the eighth and seventh centuries BC (Aubet et al. 1999; see Álvarez-Martí-Aguilar et al., this volume), as well as at the site on Méndez Núñez Street, in the city of Huelva, in the first quarter of the sixth century BC (Osuna, Bedia and Domínguez 2000). A high-energy marine deposit, dated to ca. 2200–1800 cal. BP, has been documented in the vicinity of *Baelo Claudia* (Alonso et al. 2003, 2004), and indications of an EWE, dated to ca. AD 400–450, have been documented at the archaeological site (Röth et al. 2015), which are reviewed in this book (Reicherter et al., this volume). Similarly, evidence of a tsunami in the mid-first century AD has been discovered at the Roman archaeological site of Villa Victoria, in the Bay of Algeciras (Arteaga and Prados 2008; Arteaga, Blánquez and Roldán 2015). There are also further indications of an EWE, perhaps a tsunami, which would have affected the peninsula's southwestern seaboard between the second and third centuries AD, in both the geological and archaeological records. The footprints of events in that time horizon have been identified in the Guadalquivir estuary (Rodríguez-Vidal et al. 2008; Rodríguez-Ramírez et al. 2016), in the Bay of Cadiz (Luque et al. 2001; Gutiérrez-Mas 2011), at the site of Cerro da Vila in the Algarve (Teichner 2008, 2017) and even in the city of Seville, where a flood deposit has been documented in the port area of the ancient Roman city of *Hispalis* (Barral and Borja 2015), which is the object of study of one of the chapters of this book (Gutiérrez-Rodríguez et al., this volume). There has also been a steady accumulation of evidence of earthquakes at Roman sites in the south of the peninsula, including *Corduba*, *Munigua*, *Baelo Claudia* and *Carthago Nova* (for a recent summary, see Ruiz-Bueno 2017) in the third century AD, which are not mentioned either in the most important seismic catalogues.

On the other hand, studies casting doubt on the historical underpinnings of Spanish and Portuguese seismic catalogues and, specifically,

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the historicity of the information on earthquakes and tsunamis appearing in the works of Ocampo (Compatangelo-Soussignan 2013; Rodríguez Ramírez et al. 2016; Álvarez-Martí-Aguilar 2017a) and Brito (Ces Fernández 2015; Andrade et al. 2016; Álvarez-Martí-Aguilar 2017b) have begun to appear. In this vein, Udías (2015, 2020) has suggested reviewing the information on historical earthquakes in Spanish and Portuguese seismic catalogues, a task that has recently been undertaken by Álvarez-Martí-Aguilar (2020), who disputes the historicity of most of the information contained in them for the period before AD 881.

Thus, since the mid-2010s, it appears that a new research stage has commenced. This is based on the widespread belief that there is a need for fostering collaboration between the different disciplines—specifically, geology, archaeology and history—involved in research on historical earthquakes and tsunamis in the Iberian Peninsula, as highlighted in several contributions appearing in the 2015 monographic number of *The Spanish Journal of Quaternary and Geomorphology*, devoted to "Marine Events and Coastal Settlements in SW Iberia" (Rodríguez-Vidal, Campos and Cáceres 2015; see especially Campos et al. 2015; Bernal et al. 2015; Alonso et al. 2015; Gómez et al. 2015).

Imbued with that same spirit of interdisciplinary dialogue and with an eye to critically review the state of the research, the international congress *Historical Tsunamis in the Iberian Peninsula* was held in Malaga in February 2019, in collaboration with the Museum of Malaga and Malaga University. The congress was attended by a large number of specialists and research teams who have been at the forefront of the advances in the knowledge of this subject over the past few decades. The congress' keynotes and debates were the seed of this book. Both initiatives are framed in the activities of two research projects coordinated by the University of Malaga, *The Tsunami in the Cultural Representations of the Ancient World: Gadir-Gades and the Gulf of Cádiz as a case study* (HAR2015-66011-P) and *Earthquakes and Tsunamis in the Iberian Peninsula: Social Responses in the longue durée* (PGC2018-093752-B-I00), funded by the Spanish Ministry of Science, Innovation and Universities (MCIU), the Spanish State Research Agency (AEI) and the European Regional Development Fund (ERDF).

That scientific encounter placed special emphasis on the historical period in whose study there is a convergence between the historiographical tradition represented by the most important Portuguese and Spanish seismic catalogues, on the one hand, and by recent geological and archaeological research, on the other, namely between ca. 1000 BC and AD 1000. It was precisely in this period during which earthquakes and tsunamis purportedly occurred in Cadiz in 218–216 and 210–209 BC, in Portugal and Galicia in ca. 60 BC and in Cape St Vincent in AD 382—the available information on which has ultimately influenced recent geological research—and in which the most relevant progress in research on seismic and tsunamigenic events that are not recorded in seismic catalogues has been made.

1.5 Purpose and Organisation of the Book

This book has a dual purpose. On the one hand, the intention is to review the state of recent research on earthquakes and, in particular, tsunamis in the Iberian Peninsula, with special attention being paid to those events occurring between the first millennium BC and the first millennium AD. In its different chapters, this topic is approached from various perspectives: history and archaeology essays, geological overviews and case studies of specific sites and events.

Another of the book's aims is to deepen the necessary dialogue between the different scientific disciplines involved in research on this topic. Throughout this introduction, the emphasis has been placed on some of the methodological problems that have arisen in geological and geoarchaeological research on earthquakes and tsunamis in the Iberian Peninsula, resulting from

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the excessive trust that has been placed in historical information whose reliability is now being contended increasingly more. Accordingly, it offers excellent examples of a more updated and prudent use of the historiography on natural catastrophes in the Iberian Peninsula in Antiquity by those conducting geological and geoarchaeological research.

In the field of history, for its part, it is essential to pay greater attention to the role played by natural catastrophes in the evolution of historical processes affecting past societies, above all in periods before the Middle Ages, following the example of the work performed by Estévez (2005) on prehistoric cataclysms. In a world shaken by the COVID-19 pandemic, the capacity that phenomena of this type have for bringing about deep crises in many spheres of society and their role as catalysts or triggers of processes of structural change have been yet again evinced. As to the havoc wrought by major earthquakes and tsunamis, like that of AD 1755, their long return periods mean that societies—especially modern ones—tend to perceive them as extraordinary and distant phenomena, if at all, with the evident risk that this entails. So, it is essential that the results of geological and geoarchaeological research on ancient earthquakes and tsunamis in the Iberian Peninsula be taken into consideration in the field of history and that their implications for all facets of the social life of past communities be assessed.

With a view to meeting these objectives, this book includes a series of chapters written by some of the researchers and research teams who, in recent years, have been among the first to engage in the most interesting and relevant lines of enquiry into earthquakes and tsunamis in the Iberian Peninsula. Following this introduction, Chaps. 2 and 3, both of a historical and historiographical nature, comprising Part I of this book, focus on the study of accounts of cataclysms in the Iberian Peninsula in Antiquity appearing in the—ancient, mediaeval and modern—written sources.

Chapter 2 presents an updated analysis of Plato's account of Atlantis, whose catastrophic destruction has given rise to a distorted vision of the tsunami phenomenon in the field of pseudo-archaeology. In her essay, López-Ruiz highlights, on the one hand, the relationship of the story, invented by the Athenian philosopher, with images of marine or fluvial catastrophes in the mythical-religious traditions of the ancient Mediterranean and, on the other, the existence of a narrative language of cataclysms and ends of ages shared by the Middle East and Ancient Greece.

Chapter 3 delves into the origins of the accounts of earthquakes and tsunamis occurring in the Iberian Peninsula in ancient times, as well as analysing the historiographical context in which they emerged, for the purpose of assessing their historicity. It revolves around the Spanish historian Florián de Ocampo (sixteenth century) and the Portuguese chronicler Bernardo de Brito (sixteenth and seventeenth centuries), who are the sources for most of the information on ancient cataclysms in Spain and Portugal contained in modern seismic catalogues and whose historicity is very controversial.

Part II includes Chaps. 4–7 which offer overviews of the geological record of tsunamis in the Iberian Peninsula.

Chapter 4 offers a general description of the triggering mechanisms of tsunamis in the Gulf of Cadiz and the Alboran Sea, both areas characterised by noteworthy geological activity owing to the plate convergence between Eurasia and Africa. It briefly discusses the tsunamigenic faults and submarine landslides in both areas, stressing that both are likely to generate more destructive tsunamis in the Gulf of Cadiz than in the Alboran Sea. Moreover, the chapter also sets out the future challenges for research in order to gain a deeper understanding of seismogenic faults and landslides.

Chapter 5 presents a comprehensive summary of the state of the knowledge of storm and tsunami deposits on the Atlantic seaboard of the Iberian Peninsula, encapsulating three decades of research on the coasts of Portugal and Spain. This being the spirit of the book as a whole, the chapter discusses some of the sedimentological interpretations and dating of deposits associated with tsunamis appearing in the recent literature

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and, therefore, is a timely reassessment of reviews conducted in this regard at the beginning of the 2010s (Lario et al. 2010a, 2011; Ruiz et al. 2013).

Chapter 6 reviews the EWEs documented in the Guadalquivir estuary in the Late Holocene. This is a unique area due to the accumulation of geological evidence of events of this type and due to the fact that it was the geographical centre of one of the most relevant protohistoric phenomena in the Iberian Peninsula, namely the development of Tartessian culture, which coincided with the earliest Phoenician presence in Iberia. The chapter places special emphasis on the paleogeographic, cultural and historical implications of the EWEs documented in the area from a *longue durée* perspective.

Chapter 7 addresses the record of historical EWEs in the Bay of Cadiz, an area—as in the previous case—of special interest owing to the convergence between its geological record of tsunamis, its strong tradition of urban culture since the beginning of the first millennium BC and accounts of ancient cataclysms associated with the city of Cadiz. The chapter offers a detailed description of the characteristics of the Bay of Cadiz and a systematic review of the seven high-energy marine events documented in the area during the last 7,000 years, including the footprint of the AD 1755 Lisbon tsunami.

Lastly, Part III, comprising Chaps. 8–15, focuses on case studies of specific places where earthquakes and tsunamis have occurred, including important firsts, which are presented in chronological order in relation to the described event or the most significant among those addressed.

Chapter 8 provides an updated review of the evidence of an EWE documented at the archaeological site of Cerro del Villar, originally located on an island in the Guadalhorce estuary in Malaga, where the ruins of a Phoenician colony, which was struck by a high-energy marine event in about the last quarter of the seventh century BC, are to be found. Specifically, the chapter summarises the research carried out at the site, assessing the possibility that this EWE was of a tsunamigenic nature.

Chapter 9 re-examines extreme events documented in the Bay of Lagos (Portugal) by reviewing previous geological and archaeological research and new archaeological evidence. This revision allows for suggesting that the evolution of settlements in the area was affected by the impact of several earthquakes and EWEs from the first millennium BC, in Phoenician times, up until the beginning of the first millennium AD, in the Roman age. This evidence makes it possible to explore the relationship between them and more contemporary historical accounts of extreme events.

Chapter 10 enquires into the role played by EWEs in the decline of the salted fish industry in the western reaches of the Roman Empire between the second and third centuries AD, using as an example the case study of the archaeological site of Boca do Rio (Vila do Bispo, the Algarve). The geoarchaeological research conducted at the site in recent years has revealed that the profound changes detected in the Roman settlement in the second and third century AD were not brought about, in this case, by one extreme event, but by medium-term environmental changes. Additionally, it also offers a description of the sedimentary evidence of a hitherto unknown EWE in the late Middle Ages.

Chapter 11 examines the impact of high-energy marine events on the coastal communities of the province of Huelva in Roman times. The study addresses, on the one hand, the archaeological evidence of EWEs at sites such as El Eucaliptal, *Onoba* and El Terrón in the province of Huelva, while extending the analysis to the coasts of Portugal. On the other, this evidence is contrasted with the geological record of the Guadalquivir and Guadalete estuaries, plus Gibraltar. The chapter identifies two EWEs on the Atlantic seaboard in Roman times, in the third and fourth century AD, which had negative repercussions for the area's fishing industry.

Chapter 12 focuses on the flood deposit associated with a third-century-AD destruction layer at the archaeological site of the Patio de Banderas (Reales Alcázares, Seville), corresponding to the port suburbs of the Roman city of *Hispalis*. It offers a sedimentological analysis

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of this unique deposit and its archaeological context, exploring the possibility that it might have been caused by the combined action of an EWE and fluvial flooding. In addition, a critical review of the literature on the third-century-AD event affecting the SW of the Iberian Peninsula is performed.

Chapter 13 examines the archaeological deposits of marine high-energy events in the ancient Roman city of Baelo Claudia (Bolonia, Cadiz), one of the most important sites for the development of archaeoseismicity studies in Spain. In this contribution, resulting from a multi-disciplinary investigation, three tsunami deposits, dated to ca. 4000 cal. BP (2000 BC), ca. AD 400 and AD 1755, respectively, are described in the Bay of Bolonia. Special attention is paid to the ca. AD 400 event, associated with significant archaeoseismic damage identified in newly excavated buildings, which has been dated to the end of the fourth century AD.

Chapter 14 presents the results of the archaeological excavations carried out in the "Baluarte de la Bandera" in Ceuta—the Roman city of *Septem*—on the African coast of the Strait of Gibraltar, which have brought to light evidence of a powerful earthquake that damaged the city walls in the second half of the seventh century AD. This hitherto unknown seismic event serves as a starting point for a critical revision of the geoarchaeological evidence of earthquakes and tsunamis in the vicinity of the Strait of Gibraltar in Roman times and in the early Middle Ages, with special attention being paid to the city of *Baelo Claudia*.

Lastly, Chap. 15 focuses on the locality of El Palmar de Vejer (Cadiz), which was affected by the AD 1755 Lisbon tsunami, so as to present an example of the use of multi-proxy analyses for identifying tsunami deposits, with the accent being placed on geochemical applications. The results of this study underscore the usefulness of this type of approach when attempting to identify tsunami deposits.

The 15 chapters of this book reflect the trend towards the interdisciplinary integration between the different scientific fields involved in earthquake and tsunami research in the Iberian Peninsula. In turn, they also highlight a growing consensus on the existence of methodological problems arising in the intersection between these different disciplines, which should be ironed out in future research. From these chapters, it can also be deduced that research in this respect will have to meet other important challenges in the coming years, which include gaining a deeper understanding of the number, chronology and nature of the earthquakes and tsunamis affecting the Iberian Peninsula in the past. To undertake this task, it is essential to make progress in the distinction between the sedimentary evidence of tsunamis and violent storms, as well as establishing a more precise chronology for these events, something that will be possible thanks to more radiocarbon dating, a correct assessment of the marine reservoir effect and a better contrast between these dates and those provided by archaeology and the written sources.

All this is crucial for defining return periods of these phenomena with potentially catastrophic consequences for human beings and infrastructures and, therefore, for assessing the risk factors and vulnerability of coastal communities in the Iberian Peninsula. From a historical point of view, all these developments have opened up a fascinating field of research for gaining further insights into the impact that these earthquakes and tsunamis had on the lives of people in the past and come as a necessary reminder that these phenomena will certainly repeat themselves in the more or less distant future.

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primeiro de novembro de 1755, e noticia verdadeira dos seus effeitos em Lisboa, todo Portugal, Algarves, e mais partes da Europa, Africa, e América, aonde se estendeu: E huma dissertaçaõ phisica sobre as causas geraes dos Terremotos, seus effeitos, differenças, e Prognosticos; e as particulares do ultimo. Antonio Vicente da Silva, Lisboa

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