IGCP Project 495
"Quaternary Land-Ocean Interactions:
Driving Mechanisms and Coastal Responses"

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ABSTRACT BOOK

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Project 495

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A review of the high energy events in the Gulf of Cadiz: tsunami vs. storm surges

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During the last decade many papers have appeared devoted to the occurrence of high energy marine episodes associated with sedimentological, palaentological o geomorphological features.

Currently the most complete record of Holocene high energy marine events comes from the Gulf of Cadiz (SW Iberia) (Fig. 1). These studies focused on the recognition and description of different deposits from high energy events which have been interpreted as having occurred from tsunamis.

A revision of these data reveal that only few of these events left clear evidence that can be considered of tsunamigenic origin.

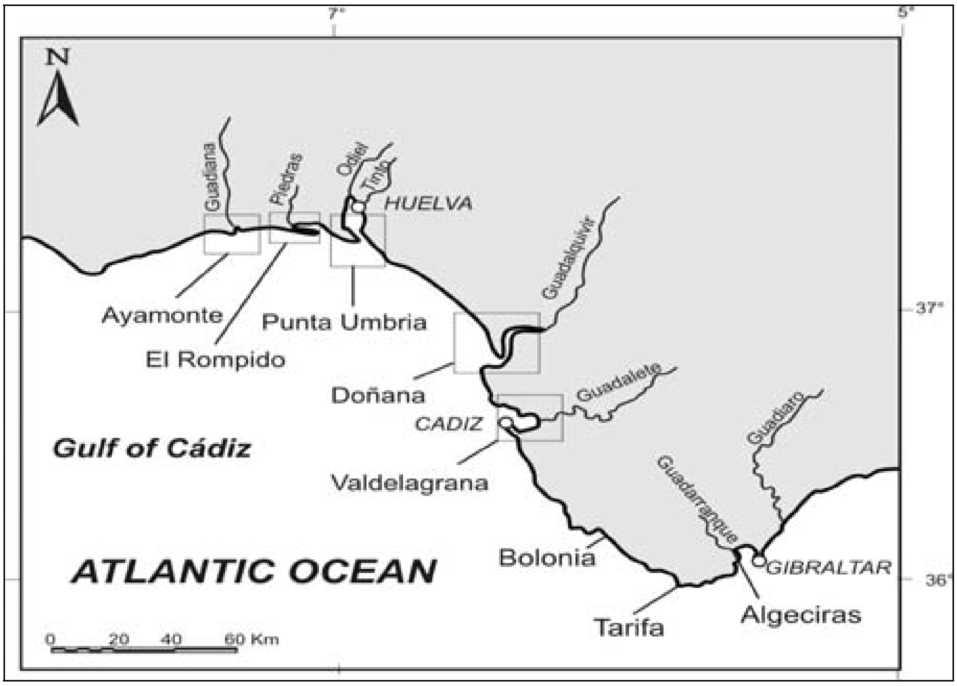

Figure 1. Location of sites cited in text with geological record of high energy event in the Gulf of Cadiz (SW Spain).

Age	Sedim. or geomorphological features	Reference	Interpretation	Data support
Doñana spit barrier / Guadalquivir Marshland				
5500-3500 calBP				
5309 calBP	Fines deposit with shell fragments, breaching of the spot barrier, cherniers development	(Ruiz et al. 2005, Cáceres et al., 2006)	Tsunami	Correlation with others authors
4500-4200 calBP	Spit barrier breaching	(Lario et al.,1995; Lario, 1996)	*Storm surge*	
4200-4100 CalBP	Deposits with marine fauna in the estuary	(Ruiz et al. 2005)	Tsunami & storms	Correlation with others authors
4200-4100 calBP	Cherniers development and fines deposits	(Cáceres et al., 2006)	Tsunami	Correlation with others authors
3900-3700 calBP	Cherniers development and spit barrier breaching + erosion at the bottom of the lagoon and in old cherniers	(Ruiz et al. 2005, Caceres et al., 2006)	Tsunami	Correlation with others authors
2500-2000 calBP				
2600-2500 calBP	Sand layer with marine fauna between estuarine deposits, erosional limit, high magnetic susceptibility. Spit barrier erosion.	(Lario, 1996; Lario et al., 2001, 2002)	Tsunami	Historical seismic catalogue
2700-2400 calBP	Spit barrier erosion and breaching	(Lario et al., 1995, Lario, 1996)	Storm surges	Climatic instability
2400-2200 calBP	Silt and sand with marine and estuarine fauna. Spit barrier breaching	(Ruiz et al., 2004)	High energy event (storm? tsunami?)	
2400-2250 calBP	Spit barrier erosion and breaching	(Cáceres et al., 2006)	Tsunami	Correlation with others authors or seismic catalogue
ca.2000 calBP	Cherniers development	(Ruiz et al., 2004)	High energy event	
2020-1990 calBP	Erosion at the bottom of the lagoon, marine fauna and cherniers development	(Cáceres et al., 2006)	Tsunami	Correlation with others authors or seismic catalogue
1559-1510 calBP	Bioclastic sandy silts on erosive surface	(Ruiz et al., 2006)	Tsunami	Historical seismic catalogue
Punta Umbría spit barrier/ Tinto-Odiel marshland				
5700 calBP	Sands with micro- and macro- marine shells	(Ruiz et al., 2007)	Storm	
2700-2400 calBP	Spit barrier breaching and reorganisation of the back-barrier drainage system	(Lario, 1996)	Storm surge	
Valdelagrana spit barrier/ Guadalete marshland				
ca.7000 calBP	Input of coarse sediment (sands), marine shells fragments and increase in magnetic susceptibility	(Lario, 1996)	Storm	
ca.5600 calBP	Input of coarse sediment (sands), marine shells fragments and increase in magnetic susceptibility	(Lario, 1996)	Storm	
2700-2400 calBP	Spit barrier breaching and reorganisation of the back-barrier drainage system	(Lario et al., 1995; Lario, 1996; Dabrio et al., 1999)	High energy event	
2300-2200 calBP	Washover fans, repeated fining upward sequence (2 to 3 times), marine shell fragments, armed mounted clasts, erosional lower limit	(Luque et al., 2002)	Tsunami	Concluding characteristics of the deposits
1755	Washover fans, repeated fining upward sequence (3 to 4 times), marine shell fragments, armed mounted clasts, erosional lower limit	(Dabrio et al, 1998; Luque et al., 2001)	Tsunami	Concluding characteristics of the deposits. Dated by historical documents and historical maps
SW coast of Cadiz				
2150-1825 calBP	Bolonia. Coarse sand with bioclast	(Alonso et al., 2004)	Tsunami	Correlation with the Baelo Claudia earthquake
ca.50 AD	Carteia, Algeciras. Coarse sandy layer, fining upward sequence, mounted clast, bioclast, calcareous rodolites, erosional lower limit	(Arteaga Cardineau and González Martín, 2004)	High energy event, probable a tsunami	Dated by roman archaeological remains. Near concluding characteristics of the deposits
1755?	Cabo de Trafalgar. Large orientated rock blocks	(Whelan y Kelletat, 2003, 2005; Alonso et al., 2004)	Tsunami associate with the 1755 Lisbon earthquake	
1755?	Los Lances beach, Tarifa. Washover fans	(Alonso et al., 2004)	Tsunami associate with the 1755 Lisbon earthquake	No sedimentological data
1755	Conil. Washover fans	(Luque et al., 2004)	Tsunami associate with the 1755 Lisbon earthquake	Dated by historical documents and historical maps

Table 1. Geological record of Holocene high energy episodes in the Gulf of Cadiz coast with possible origin of the event

Even though there is evidence of some occurrences of tsunamis in the area during the Holocene, the geological record does not definitely distinguish storm from tsunami events.

There are some geological features common to both types of events such as breaching of the spit barriers with formation of washover fans, fining upward sequences, erosional limit or presence of marine shell remains. The record of such features indicates only that thses deposits have high energy marine origin. There are some other characteristics of the sedimentary record that more definitely attribute the event to a tsunami episode, such as the presence of some fining-upward sequences presence of mud clast, presence of mud laminae, high variation in grain size (from clays to boulders) or presence of clay layer on the top (as a cap). Also, there is other geomorphological evidences will be associated with a tsunami event: reorganisation of the barrier-estuary systems with extensive flooding, breaching of the spit barrier, presence of multiple washover fans and complete reorganisation of the drainage system (Andrade, 1992; Goff et al., 2004;Tuttle et al., 2004; Kortekass & Dawson, 2007, Morton et al., 2007).

Data available from Gulf of Cadiz, summarized in Table 1, show that even though there is evidence of some occurrences of tsunamis in the area during the Holocene, the sedimentological and geomorphological record does not definitely distinguish storm from tsunami events. Some of them only will be associated with a high energy event of marine origin that will be also produce by an storm surge episode. In order to calculate recurrence interval both from severe storm surges and from tsunami events more detailed studies should be completed.

For now the occurrence or high energy marine event in this area during the Holocene is summarized as:

ca.7000 calBP: High energy event, storm?

ca.5600-5300 calBP: High energy event, storm?

ca.4200-4000 calBP: High energy event

ca.2700-2400 calBP: High energy events: probably tsunami during climatic instability period with severe storms. The event present features all along the coast. Concluding record of tsunami in Valdelagrana (Luque et al., 2003) probably present in other areas of the Gulf of Cadiz.

ca.2000 calBP: High energy event. Probably tsunami (maybe the same that the last one, problems in dating)

ca.1500 calBP: High energy event 1755 AD: Lisbon earthquake tsunami. Even though historical data describe the occurrence of the tsunami in some sites, there is not always a geological record. Lack in concluding dates from this record in some areas.

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