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# REPLY TO THE COMMENT BY A. RODRÍGUEZ RAMÍREZ ON "THE GEOLOGICAL RECORD OF THE OLDEST HISTORICAL TSUNAMIS IN SOUTHWESTERN SPAIN" BY FRANCISCO RUIZ, MANUEL ABAD, JOAQUÍN RODRÍGUEZ VIDAL, LUIS MIGUEL CÁCERES, MARÍA LUZ GONZÁLEZ-REGALADO, MARÍA ISABEL CARRETERO, MANUEL POZO & FRANCISCO GÓMEZ TOSCANO, PUBLISHED IN RIVISTA ITALIANA DI PALEONTOLOGIA E STRATIGRAFIA, 114(1): 147-156 (2008)

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These reply comments were focused on the different affirmations made by Rodríguez Ramírez (2009, this volume) about our previous paper.

## The last nine years

Between 2000 and 2005, a multidisciplinary research team studied different short cores collected in the southern part of the Doñana National Park. This group was constituted by specialists in geomorphology (Dr. J. Rodríguez Vidal, Dr. L. M. Cáceres, Dr. A. Rodríguez Ramírez), paleontology and stratigraphy/sedimentology (Dr. F. Ruiz, Dr. M. Abad, Dr. M. L González-Regalado) and petrography and mineralogy (Dr. M. I. Carretero, Dr. M. Pozo). The main results are published in Carretero et al. (2002) and Ruiz et al. (2004; 2005), together with numerous short papers and proceedings.

Ruiz et al. (2004) realized a study of Las Nuevas system, based on a multidisciplinary analysis of the sediments present in drill cores. They indicated than some bioclastic beds (not only cheniers) may be due to high-energy events (storm, tsunami). More recently, Ruiz et al. (2005) (including Dr. Rodríguez-Ramírez as co-author) used similar techniques to study older cores collected in other systems (e.g., Carrizosa). Results from these new data and a comparison with the geological record of tsunamis in the southwestern Spanish coast and other areas around the world lead them to infer that Las Nuevas was originated by, al least, two tsunamis (p. 225: 218-210 BC and 60 BC).

In this paper and others published previously (e.g. Luque et al. 2001), the bioclastic layers detected by Lario (1996) in long cores collected in the northern part of the Doñana National Park were related with the 218-210 BC tsunamis. His incorporation as reference in Ruiz et al. (2008) not only is reasonable but unavoidable. Moreover, some comparations with other papers related to tsunamis and storms (e.g. Goff et al. 2001) or cheniers (e.g. Augustinus 1989) are necessary.

Since 2005, this research team (except Dr. Rodríguez-Ramírez) has studied new short (e.g. core S in Ruiz et al., 2008) and long cores (e.g. cores PLN and CM in Pozo et al., 2008) collected in the same area. A new researcher (Dr. Gómez Toscano) has been included during this phase in this team.

Methodology applied to these new cores includes: a) sampling campaign: definition of the main lithological units, analysis of different sections in the same sedimentary beds, sedimentary structures, spatial distribution of the bioclastic elements (e.g. "rafted" in Zone F), morphosedimentary studies, etc.; b) mineralogical and geochemical analysis; c) datings; d) paleontological record (macro- and microfauna); and e) other additional data (petrography, magnetic properties, etc.). During this period, we have analyzed the Holocene storm/tsunami record in other adjacent estuaries of southwestern Spain, not only in the Doñana National Park (e.g. Ruiz et al. 2007; Rodríguez Vidal et al. 2008), funded by two DGYCIT Spanish Projects (CTM2006-06722 and CGL2006-01412) and three Research Groups of the Andalousia Board (RNM-135, RNM-238 and RNM-293).

These new data allow us to propose recently a new, more complete facies scenario in this area (Pozo et al. 2008) than the almost completely geomorphic analysis effectuated by Rodríguez-Ramírez and Yáñez-Camacho (2008). In this paper, these authors used mainly the short cores collected by our research team but they do not bear in mind the information obtained in our previous multidisciplinary studies.

Consequently, the tsunamigenic origin proposed by us for Las Nuevas system is not marked by the 2004 December tsunami or by temporal fashions, as seems to indicate Rodríguez-Ramírez (2008), but by multidisciplinary studies developed throughout a decade. The following paper (Ruiz et al., 2005) was received on January, 2005, only a few days after this tsunami. So, it was already made at this time and its conclusions do not depend on the later repercussion of this high-energy event. The last paragraph of Rodriguez-Ramirez (2008) is clearly non-scientific and unsupported by any evidence.

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### Ruiz et al. (2008) vs Ruiz et al. (2004)

The main conclusions of Ruiz et al. (2008) are based on new different bidimensional sections of Las Nuevas system effectuated in the field and the multidisciplinary analysis of core S. This core was collected during the new sampling campaigns developed in the last two years, without any collaboration of Dr. Rodríguez-Ramírez. Effectively, as pointed Rodríguez-Ramírez (2009, this volume), methodology is the same that Ruiz et al. (2004), but this is a condition *sine qua non* to compare the new data with those derived from our previous papers.

In a very superficial analysis, it resembles core D included in Ruiz et al. (2004). Nevertheless, the multidisciplinary research carried out indicates some clear differences:

a) Core S is located in the central part of Las Nuevas. This location was decided because the northern part of Las Nuevas (e.g. core D) was undated (Ruiz et al. 2004; p. 50) and the lithological, textural, mineralogical and palaeontological data of this system indicated different features in the southern (e.g. core B; Ruiz et al. 2004) and northernmost areas (e.g. core D). This duality is clear, for example, in the mineralogical data apported of this system (Ruiz et al. 2004; p.52-53), but it was not taken into account by Rodríguez-Ramírez &Yáñez (2008).

b) This core is shorter (147 cm) than core D (162 cm). The multidisciplinary approach permits to delimitate six zones in core S, whereas only three intervals have been separated in core D. This later core is also differentiated by the presence of a lower silty level (91-79 cm depth), not observed in core S. In addition, sandy contents of core S are generally higher than those observed in core D.

c) The macropaleontological record is clearly more abundant in core D than in core S. Eleven bivalves species were found in core D, whereas only six were determined in core S. Similar results were observed in gastropods.

d) On the contrary, the ostracod record is more diverse in core S (30 species) that in core D (only 12 species). Other groups (e.g., characeans) were found exclusively in core S. All these data refute the similarity pointed out by Rodríguez-Ramírez (2008, this volume).

e) Finally, datings obtained in cores S (Ruiz et al. 2008) and B (Ruiz et al. 2004) and the comparison of lithological, mineralogical and palaeontological data obtained with those extracted from long and short cores extracted in the southern part of Las Nuevas indicate a different origin between the southern part and the central-northern areas of this system.

### Cheniers and tsunamis

Rodríguez-Ramírez (2009, this volume) stated that '*...in none of the published studies are chenier ridges given as direct evidence for tsunamigenic processes*'. In Batemans Bay on the New South Wales coast of Australia, Bryant et al. (1992) indicated the presence of six cheniers and related them to tsunami events with chronological evidences. These cheniers included a mixing of both bioclastic and muddy layers (as core B -Ruiz et al. 2004- or core CR -Ruiz et al. 2005).

In addition, Bryant (2001) stated that '*under extreme conditions, tsunami waves may cross a lagoon, overwash the landward shoreline, and deposit marine sediment as chenier ridges*'. A similar situation was inferred in the palaeogeographical evolution of Las Nuevas, with the presence of an old lagoon in this area (Ruiz et al. 2004; fig. 7). This possibility is also considered by Nott (2006), which indicated that '*it is likely that most, if not all, cheniers are deposited by storm waves (or in some cases possibly tsunamis)*'. Consequently, a possible tsunamigenic origin must not be rejected *a priori* in any study on cheniers or chenier-like, bioclastic ridges.

### The geological record of tsunamis in southwestern Iberia: absences or 'misabsences'?

The southerwestern Spanish littoral is a low-probability tsunamigenic area, but sixteen tsunamis have been documented historically between 218 BC and 1900 AD (Campos 1991). The geological record is still poorly known and additional investigations are necessary to confirm, reject or outline these data. Some washover fans observed in the Guadalete estuary, located towards the southeast of the Doñana National Park, have been attributed to tsunamis that eroded sandy littoral spits at 218-210 BC or 1755 AD (Luque et al. 2001; Luque 2002). In addition, some bioclastic layers with a tsunamigenic origin have been described in the Tinto-Odiel estuary, situated towards the northwest of this park (Morales et al. 2008).

The Doñana National Park is a part of the Guadalquivir estuary, the biggest one of this region and located between the Guadalete and the Tinto-Odiel estuaries. Nevertheless, any tsunamigenic deposit has been cited in the different geomorphological studies carried out in the Doñana National Park and the adjacent areas by Rodríguez-Ramírez (1996; 1998). Moreover, the geomorphic analysis of the cheniers (with a very surface palaeontological and lithological control) made by Rodríguez-Ramírez & Yáñez-Camacho (2008) is incapable to differentiate storm or tsunami deposits in this area.

Therefore, it is reasonable: a) to suspect that tsunamigenic deposits are included in the geological record of this area; and b) to suppose than a multidisciplinary study is more adequate to detect them than a partial analysis. This tsunamigenic origin must be demostrated layer to layer (or chenier to chenier), without any previous conception that annuls this possibility.

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