Response to the reviews including a list of all relevant changes made in the manuscript

For the Referee #1

The authors would like to thank the Anonymous Referee #1 for his valuable comments and suggestions, they will be seriously taking into consideration and corresponding corrections will be made in the next version of the manuscript. However, we present some clarification and answers (R) to his questions (Q) in the following text :

Settings :

Q1 :The setting lacks of basic information such as: the lithology of the bedrock surrounding the lagoon and forming the Medjerda river catchment; the Medjerda water and solid discharges (average and during floods); the amplitude of local tides and the existence of long-shore littoral currents; present wave heights and sea surge during severe storms.

R1: We have formulated this paragraph in the new version as following :

This work focuses on the Ghar el Melh lagoon situated in the Northeast of Tunisia. This lagoon is called also "the Porto Farina". It has an elliptic shape and approximately a surface of 28.5 km^2. Its average depth is about ~0.8 m (Romdhane, 1985; SCET-ERI, 2000; Moussa et al., 2005). This lagoon is directly limited in the north side by a mountain range called "Jbel Nadhour" (325 m). This mountain is composed of a marine Pliocene material (Figure 1) represented by sandstone sediments (Hamouda, 2014). The lagoon is bordered in the west and south side by recent quaternary marshy grounds formed by clay and silt sediments. While in the eastern side, it is separated from the sea by a sandy barrier, with a local opening (El Boughaz) allowing a permanent hydraulic communication (Oueslati et al., 2006). This sandy barrier has formed by a littoral drift oriented from the North-East to the South-West (KHRYSTAL Engineering, 2003).

According to Paskoff (1994), the lagoon was considered as a vestigial and remaining part of the Utique Sea that was formed during the last postglacial transgression since 6000 years ago. Progressively, this small gulf has been disconnected from the Utique Sea, due to Medjerda fluvial deposits (Paskoff and Trousset, 1992). This caused a progressive reshaping of the lagoon to its present morphology, which could be attributed to an association of the shape of the coastline and alluvium deposition from the Medjerda River (Moussa et al., 2005). Over time, the delta of Medjerda was distinguished by a high flood peak and a high interannual discharge variability. This river's average sediment yield is about 10 g/l and it is characterized by an annual average flow of 30 m3/s and reached 3500 m3/s in the exceptional flood of March 1973 where solid discharge is calculated around 100 g/l (Claude et al., 1977). A Large amounts of alluvium was carried by the Oued, estimated over 22 millions tonnes per year in the Gulf of Tunis before the construction of dams (Oueslati et al., 2006). The materials are deposited when the Oued reaches the low flood zones, contributing then to an extension of his delta towords the sea and a numerous changes of channels (Delile et al., 2012).

In the Gulf of Tunis, the mean amplitude of semi-diurnal micro-tidal activities measures between 12 and 30 cm (El Arrim, 1996; Saïdi et al., 2012) The amplitude of the tidal range in this region was estimated around 35 cm (Oueslati, 1993). The coastal environment of the Gulf of Tunis was exposed to natural erosion processes provoked by waves, tides, and periodic storm-surges (Hzami et al., 2021). This erosion is the effect of the long shore coastal drift from the south-east to north-west direction.

Methods :

Q2 : There is no indication of the method adopted for coring GEM3 and GEM4 ("piston core" is very general, e.g.: were they manually-operated? Which was the diameter of the core?) and for the collection of surface samples. Concerning these latter, no information is provided on how shallow they were (few centimetres? Few decimeters?), their geomorphological position in the landscape (river bed? Floodplain? Beach? Dunes? Etc.) and if they were collected from present-day soil horizons (meaning they may be slightly weathered sediment). No indication is provided on the grain-size classification applied.

R2 : We have formulated this paragraph in the new version as following :

Two piston cores were **manually** collected in 2012 in the Northeast of Ghar el Melh lagoon. These cores are 126 cm (GEM4) and 98 cm (GEM3) in length and **10 cm in diameter** (Figure 1). They were manually sampled according a transect East West into the lagoon (~200m from the sandy barrier for GEM3 and ~400m for GEM4). In the laboratory, the two cores GEM4 and GEM3 were divided, photographed, and described in detail. Before granulometric and geochemical analysis, the cores were split into 1 cm vertical sections. Moreover, 29 surface sediment samples of around 20 to 30g were collected from present-day soil horizons from the Medejerda watershed to the littoral area (beaches and dunes) to assess the origin and all sources of the lagoon sediment arriving in the study area: (i) 6 samples comes from the Medjerda River (Gr01 to Gr06), (ii) 12 samples from different small affluents located in the northern and western part of the lagoon (from Gr07 to Gr18) and (iii) 11 samples from the sandy barrier (Gr19 to Gr29) (Figure 1).

Q3 : Calibration of ^{14}C ages Inaccuracy inherent to radiocarbon dating is not expressed in Table 1 and 2. Probability of the calibrated ages as 1 or 2 sigma is not reported. Altogether, these errors are not discussed when integrating the ^{210}Pb and ^{137}Cs chronologies and estimating sedimentation rates. This raises concerns on the effective existence of the hypothesized time-correlations between the datasets and the Bond events.

R3 : We have taken your comments into consideration as following :

Table 1

N°	Labo code	Mollusk used	Depth (cm)	$\delta^{13}C$ (‰)	^{14}C ages (BP)	^{14}C ages (Cal AD) (One Sigma ranges) [Start: end]
1	Sac A 42679	*Cerastoderma glaucum*	42	-0.8	565±30	[cal AD 1692: cal AD 1765]
2	Sac A 42685	*Cerastoderma glaucum*	54	1.5	930±30	[cal AD 1399: cal AD 1451]
3	Sac A 42683	*Cerastoderma glaucum*	60	0.2	1195±30	[cal AD 1186: cal AD 1260]
4	Sac A 42681	*Cerastoderma glaucum*	70	0.2	1535±30	[cal AD 811: cal AD 902]
5	Sac A 42680	*Cerastoderma glaucum*	76	1.4	1830±30	[cal AD 550: cal AD 630]
6	Sac A 42686	*Cerastoderma glaucum*	80	0.6	2015±30	[cal AD 332: cal AD 424]
7	Sac A 42684	*Cerastoderma glaucum*	88	-1.1	2350±30	[cal BC 67: cal AD 33]
8	Sac A 42682	*Cerastoderma glaucum*	93	-1.4	2490±30	[cal BC 267: cal BC 144]

Table 2

N°	Labo code	Mollusk used	Depth (cm)	$\delta^{13}C$ (‰)	^{14}C ages (BP)	^{14}C ages (Cal AD) (One Sigma ranges) [Start: end]
1	Sac A 42676	*Cerastoderma glaucum*	40	-3.7	490±30	[cal AD 1807: cal AD 1906]
2	Sac A 42675	*Cerastoderma glaucum*	45	1.8	615±30	[cal AD 1652: cal AD 1712]
3	Sac A 42673	*Cerastoderma glaucum*	55	0.3	1181±30	[cal AD 786: cal AD 1344]
4	Sac A 42672	*Cerastoderma glaucum*	72	-2.9	2545±30	[cal BC 332: cal BC 225]
5	Sac A 42674	*Cerastoderma glaucum*	85	-4.3	2660±30	[cal BC 431: cal BC 353]
6	Sac A 42678	*Cerastoderma glaucum*	101	-6.6	2625±30	[cal BC 399: cal BC 339][a]
7	Sac A 42677	*Cerastoderma glaucum*	110	-4.8	2725±30	[cal BC 512: cal BC 400]

[a]Age inversion

Table 3

Labo code	^{210}Pb age (AD)	^{14}C year (BP)	Tree-ring ^{14}C age (BP) IntCall 13	Reservoir age R(t) (year)	Model age Marine 04	Δ R (year)
Sac A 44506	1845	450±30	114±8	336	488±23	-38±20

R : In order to determine a mean value to be used with marine calibration curves, more studies are needed and our ΔR should be taken with prudence. The eight and seven shells collected respectively from GEM3 and GEM4 cores were calibrated using the oxcal 4 program with a ΔR value of − 38 ± 20 years. The results are described in Tables 1 and 2 with an error range of 1σ. For the GEM4 core, we note that sample n°6 must be a remobilized material from older sediments since sample n°7 taken from a lower sedimentary level has a younger age.

R : In order to determine the ΔR, these errors of ^{14}C were discussed when integrating the ^{210}Pb and ^{137}Cs chronologies and the comparison was done. From ligne 180 to the ligne 183.

<u>Discussion and conclusions :</u>

Q : A prominent conceptual inadequacy is the apparent nonconsideration by the authors of the so-called Walther's Law (Walther, 1894). This basic law of stratigraphy states that any vertical progression of facies is the result of a succession of depositional environments that are laterally juxtIaposed to each other (Lopez, 2015, in Encyclopedia of Scientific Dating Methods). This implies that changes in the lithofacies characteristics and grain-size distribution in the two cored locations may be autocyclic, due to, e.g., the migration of the barrier islands, shifting of tidal inlets and channels, progradation of lagoonal deltas. Vertical changes in sediment characteristics can thus occur without the intervention of "extreme" climatic events. This depotentiates the conclusions of the authors, that appear not fully supported by the data. It further shows that alternative interpretations should be considered.

R : Generally and from a geological point of view, I totally agree with you about the importance of Walther's law especially in stratigraphy. But in our case, we have a vertical facies formed by fine sediments interbedded by just two sandy layers. The presence of sand layers and a discontinuity contact is interpreted as a result of intense overwash events. Through the study of the GEM3 and the GEM4 cores, our objective was to identify marine submersion deposits in a general way, through their geochemical and sedimentological characteristics, without making a distinction between storm and tsunami deposits. The entrance of marine sandy materiels into the lagoon cannot be explained by a migration of the barrier islands. Indeed, we could imaginate that on this time scale (2000 years), the displacement of the sandy barrier is progressive with the increase of sea level. In this case, our sedimentary archives should have presented a gradual increase in the percentage of marine sand towards more recent periods. This is not observed. The observation of two discrete sandy deposits can only be explained by two exceptional events. . The same deduction can also be used regarding the progradation of the Medjerda delta. This process is also progressive and we should have seen a progressive trend in the evolution of our facies. This is also not observed. We interpret our marine sand deposits with a sharp contact at their base by exceptional events and not by progressive processes.

The discussion was been formulated in the new version as following :

5.1 Site sensitivity to overwash deposits

The sensitivity of the site to the overwash deposits can result from several factors such as barrier elevation, sediment supply, inlet, and a change in sea level (Donnelly et al., 2004; Scileppi and Donnelly, 2007; Dezileau et al., 2016). Generally, an increase in sea level produces a moving of the barrier landward. Thus, the highest number of sand layers in a sediment core can be the consequence of a simple sea-level change. In the Mediterranean Sea and especially during the last 5000 years, the sea level has stayed more or less stable (< 2 m, Pirazzoli, 1991; Lambeck and Bard, 2000). Studies concerning Holocene sea-level fluctuations along the Tunisian coast remain have suggested a stabilization in relative sea level during the last 6000 years (Jedoui et al., 1998), which is very small and probably not enough to completely change the deposition environment of the Ghar el Melh lagoon. Furthermore, sedimentation in the two cores commenced 2500 years ago, on this short period, the influence of the seal-level change has not drastically affected sedimentation in the center of lagoon. Cores GEM3 and GEM4 present generally a sedimentary sequence dominated by fine-grained sediments (clay and silt), suggesting that the lagoon of Ghar el Melh has succeeded in keeping a low-energy environment during the last 2500 years. The proxies applied in this work (granulometry and geochemistry), as well as the sedimentary indicators (discontinuity contact), showed that all sandy coarse peaks present within the GEM3 and the GEM4 cores were deposited through marine high-energy events and not by a gradual change in sea-level. The presence of a nearby inlet may increase the sensitivity of a particular area to storm-induced deposition. It allows for storm energy to more easily penetrate into the back-barrier area, letting a lesser storm with lower wave surge transport coarse sediment into the back barrier. If a large inlet had existed over a long period and had provided a ready conduit for sand from the Gulf of Tunis to the Ghar el Melh lagoon, this would have been reflected in the cores (deposition of thick sand layer over a long period of time). However, no evidence of such active tidal connection lasting a long time is found in sedimentological and geochemical data for the past 2500 years. -Granulometric and Geochemical observations on the GEM3 and the GEM4 cores show a sedimentary sequence dominated by silty-clay deposits and interrupted over time by some allochthonous coarse materials. To determinate the source of these sandy layers, we compared their geochemical attributes with those from surface samples. This allowed us to establish whether these deposits had a continental (river floods) or marine origin (storms and tsunamis). The two sand deposits present in the GEM3 and GEM4 cores have a geochemical correlation with marine coastal surface samples; both show enrichment with Si and depletion with Fe and Ti, which reveals a marine source for these high-energy deposits. The results demonstrate that Ghar el Melh lagoon has been confronted with different episodes of marine submersion during the last 2500 years.

5.2 Extreme events and paleoevironement changes

In this part, we have added a new paragraph (from ligne 274 to the ligne 283) as following:

This sand deposit may have had another origin. Indeed, this deposit was dated at around cal AD 332+/-30. This period coincides with the tsunami event of 365 AD. This extreme event was generated by an earthquake of 8.3 magnitudes and is supposed to have been the powerful ever in the regions of the Eastern Mediterranean. From a numerical modeling, Pararas-Carayannis and Mader, (2010) indicate that the 365 AD tsunami has heavily affected coastal areas throughout the Eastern Mediterranean region; Palestine, South Asia Minor, Cyprus, the Nile Delta, Careen, Apollonia. In the central part of the Mediterranean region the cities of Eastern Sicily, the coastline of Calabria, and the islands of Aiolou have been affected (Pararas-Carayannis, 2011). In Tunisia, the recent archeological discovery of the immersed city of Neapolis in northern Golf of Hammamet in 2017 suggest the occurrence of a tsunami in 365 AD (Aounallah and Fantar, 2006; National Heritage Institute of Tunisia, 2017). We can thus hypothesize that our sand deposited around 365 cal AD could also be associated to this tsunami event.

Q : Poor English language recurrently hinders the comprehension of the concepts presented in the text.

R : The English has been revised by a native.

For the Referee #2

The authors would like to thank the Anonymous Referee #2 for his valuable comments and suggestions, they will be seriously taking into consideration and corresponding corrections will be made in the next version of the manuscript. However, we present some clarification and answers (R) to his questions (Q) in the following text :

Q1 : The first issue is the chronology. Figure 7 clearly illustrates the uncertainty linked with the age model. The core GEM 4 is badly dated (where is the table with the details of the radiocarbon dates?). A chronological gap of ~ 1400 years in the middle of the core hinders any calculation of a secure age-depth model, and may suggest an important chronological issue. The authors must correct this point (more radiocarbon dates in the middle part of the core), otherwise, they must discuss this chronological uncertainty in the manuscript. As it stands, the core GEM 4 is too "subject to caution" to be really used here as evidence. The part "4.2.1. Age model" is clearly insufficient to answer to this issue.

R1: Figure 7B determines a period of inactive deposition process or erosion so-called "a Condensed area" and not a chronological gap in the age model. Supplementary radiocarbon dates between 55 cm and 72 cm (an interval of 17 cm only) will not give more information because we have a condensed area. The GEM4 is well dated with seven radiocarbon dates. We have a 14C date every 10 cm approximatively. It is very rare to observe in the literature sedimentary archives dated every 10 cm. Thus, we will not realize more radiocarbon dates on this core in order to have a better chronological framework. This has never been done in coastal environments.

Q2 : The second problem is the lack of objective analyses to probe what the authors claim. Statistical analyses must be considered here. The PCA (Fig. 2) is a good start but other tests must be used. What is the software used for the PCA? With which parameters? Why the authors did not apply the same PCA on all the data from the cores? Why were only the "surface sediment sources" included in the matrix? The authors must develop this analytical part to probe their conclusions and, mostly, they must use all the data from their cores, not only the surface deposits.

R2 : In coastal environments, the principal component analysis (PCA) was usually performed on the sediment sampled around lagoons in order to characterize the different sources of sediments deposited in the lagoon and to determine the several poles related to potential sediment sources supplies. We choose the Mn, Ti, Zn, Ba, Rb, Fe, Sr, Ca, and Si elements due to their good detection by the mobile XRF. We established the calculation factors F1 61.12% and F2 11.13% of the geochemical dataset using the XLSTAT-2016 statistical software. The apply of the same PCA on al the data from the two cores is a good idea, but in our study, the tracing of sources should be done on recent surface sediments and not on cores deposits (Degeai et al., 2015, Gaceur et., al 2017, Affouri et al.,2017 and Khalfaoui et al,. 2019).

Q3 : The discussion is too weak to really be "a discussion". This part only summarizes the results, with auto-citations, and does not compare or integrate the data in a wider perspective (climate shifts, human impacts, etc: : :). This part must be rewritten and must integrate more references, more comparisons, more "other hypotheses". As it stands, we have the bad impression that the authors take their results as evidences and do not feel the need to compare or integrate their findings with what has been previously published on this subject. More caution is needed here.

R3 : The discussion was been formulated in the new version as following :

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