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Comment on “A multidisciplinary overview of the lower Miño River terrace system (NW Iberian Peninsula)” by E. Méndez-Quintas et al

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ABSTRACT

The paper by E. Méndez-Quintas et al. (2020) aims to give an interdisciplinary overview of the lower Miño River terrace record in NW Iberia by combining geological and archaeological data. The authors also pretend to re-interpret the geological-geomorphological evolution of this river by presenting new data and by comparing them to data published in our five related papers. However, a wrong interpretation of the data they present as well as incorrect and selective citations of ours lead to the production of a publication containing numerous errors. The most flagrant ones are the mapping of fluvial terraces on one side of the river only and an incorrect interpretation of the sedimentological information used to correlate terrace remnants along-river. This results in incorrect longitudinal profile reconstructions and an improper proposal of the evolution of the Miño terraces that is even contradicted by the data they present. On the upside, the ages of the Porto Maior terrace site published by these authors confirm our previously published longitudinal profile reconstructions and evolutionary model of the Miño valley.

Forum communication

Méndez-Quintas et al. (2020) mapped nine terrace levels whose altitudes reach up to 91–108 m above the Miño floodplain (+FP). We mapped ten levels with similar elevation (Viveen et al., 2013a; see Fig. 1 this paper). It is unclear why Méndez-Quintas et al. (2020) decided to re-map the lower Miño terraces, since they do not provide arguments why our previous mapping would be problematic. The authors state that we “ …. *define a large number of terrace levels that, depending on the publication and the section analysed, comprise between 6 and 16 levels* (Viveen et al., 2012b, 2012a; 2013b; 2013a; 2014*)*”. However, all of these cited publications build up to our published, unifying model for the terrace correlations in Viveen et al. (2013a), resulting in a terrace map with ten levels for the lower, 55-km-long reach (Supplemental Material in Viveen, 2013a). In addition, while our map included the terraces from both the north (Spanish) and south (Portuguese) river banks, Méndez-Quintas et al. (2020) inexplicably only mapped the Spanish part. It is obvious that the Miño has unpaired terrace staircases across the valley, as shown in Viveen et al. (2013a, 2014a). Consequently, the mapping of only one side of the valley gives an incomplete overview of the terraces, which makes it impossible to correlate the different terrace remnants into levels. In Viveen et al. (2012a, 2012b), following the accepted model at that time (cf. Lautensach, 1945; Teixeira, 1952; Nonn, 1967; Butzer, 1967), the model of terrace threads parallel to the current Miño floodplain (FP) was applied, resulting in up to 16 levels. In Viveen et al. (2012b), this model of terraces parallel to the current floodplain was questioned, and the legitimacy of this questioning was confirmed in Viveen et al. (2013b). There, we demonstrated in detail that the terrace threads are not parallel to the current river FP, but make an angle with respect to it. Ample evidence showed that the terraces were formed during the low stands of eccentricity-forced glacioeustatic cycles, when sea level lowering caused the formation of a deeply incised Miño River valley (Viveen et al., 2013b). Evidence stemmed from elevations of the highest terraces diminishing downstream, weathering tendencies of quartzite clasts in the terraces showing a trend oblique to the current valley gradient, and longitudinal profile modelling of the Miño River, all backed up by ^{10}Be cosmic ray exposure (CRE) ages of the different terraces (Viveen et al.,

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2012b, 2013b). This is in line with the current situation showing that the lower 25 km of the Miño estuary only contains fine-grained sediments, whereas the terraces contain coarse-calibre gravels that were deposited during periods of increased stream power, when base level was significantly lower. This in turn was confirmed by geophysical surveys of the estuary showing an incised river valley 30 m below the current water table (Viveen et al., 2013b). Furthermore, deeply incised valleys with glacial, fluvial sediment situated tens of meters below current sea level are common along the western Iberian coast, for instance in the Ria of Ferrol (Cartelle and Garcia-Gil, 2018), in the Ria of Vigo (Martínez-Carreno and Garcia-Gil (2017) and in the Tagus River valley (Vis et al., 2008). Our results indicated a Miño terrace level inclination of 1 m km^{-1} (Fig. 1). This implies, for instance, that a terrace remnant at an elevation of 90 m asl. 50 km upstream from the river mouth was formed at the same time as a terrace remnant at an elevation of 40 m asl. 0 km from the river mouth (Viveen et al., 2013b). Méndez-Quintas et al. (2020) made the mistake of correlating the terrace remnants parallel to the current FP (Fig. 1), notwithstanding that they cited Viveen et al. (2013a, 2013b) and should therefore be aware of the issue. This is from their Figs. 10 and 14. By applying horizontal correlations and not taking into account a paleo-fluvial gradient, they correlated terrace remnants with varying elevations above FP. This results in large, vertical uncertainties of up to 17 m for individual terrace surfaces (Fig. 1). For instance, they report T3 elevations between 21 and 29 m, T4 elevations between 30 and 39 m, T7 elevations between 65 and 77 m, etc. Applying our correlation scheme, such uncertainties do not occur (Fig. 1). As a consequence of these vertical uncertainties, their terrace profiles (Fig. 10) make strange jumps: for example, T9 terrace remnants 45 km downstream are located at higher elevations than upstream terrace remnants. This tendency is similar for the T7 and for the T4 and T3 terrace remnants 30 km downstream. It is highly unlikely that the surface elevation measurements lead to such large jumps as Méndez-Quintas et al. (2020) used the Digital Elevation Models (DEMs) of the Spanish National Geographic Institute (IGN) for terrace mapping. We also used a freely available DEM from the IGN with a 5-m gridcell resolution and a small, vertical error of 0.1 m (Viveen et al., 2013a), which did not induce such a large spread in data point as those shown in the figure of Méndez-Quintas et al. (2020). The error probably originates from incorrect correlations of the terrace remnant surfaces. For their correlations, Méndez-Quintas et al. (2020) used the argument of the presence of fine-grained sediments with a clay illuviation horizon that, according to them, is widespread in the T4 terrace level remnants, leading to a longitudinal terrace profile parallel to the current FP. However, we have investigated over 400 terrace outcrops along the lower Miño River (see Viveen et al., 2013a), and we have encountered fine-grained deposits in, or on top of, the gravels, only in a few occasions. They are not nearly as ubiquitous as Méndez-Quintas et al. (2020) claim. Moreover, the fine-grained sediments of the Porto Maior sequence of these authors (their units PM3 and PM4 in Fig. 13) are overbank deposits that are well preserved because of an abandoned meander bend of the river in the granite bedrock. Nevertheless, the authors correlated these overbank fines to a sandy channel fill in the bedload gravels (their Fig. 12a) and, even worse, to a metres-thick, stacked sequence of sands and clays that accumulated in a subsiding tectonic basin (Fig. 12d), which we described in Viveen et al. (2012a). Only these tectonic basins and possibly Holocene sites, where artificial damming occurred (e.g. Viveen et al., 2014b), have sediment stacks surpassing 10 m thickness. So, it is wrong to correlate these fine-grained deposits because they do not share a common genetic factor. Méndez-Quintas et al. (2020) even go as far as to call the overbank deposits of their studied site a geological Formation, claiming that "*This pattern, and the extensive presence of these deposits throughout the T4 terrace sequence of the basin, has enabled us to define an informal sedimentary formation: the "Porto Maior Formation*" (Méndez-Quintas et al., 2020).

The fact that these authors correlated their terraces parallel to the current FP, whereas we correlated the terraces obliquely to the FP makes it impossible to directly compare their terraces with ours because of the resulting mismatch in terrace order (Fig. 1). They do however make this mistake as shown by their statement "*… while ^{10}Be cosmogenic dating has also been applied to T2 (+13–17 m), T4 (+30–39 m), T5 (+45–51 m) and T6 (+53–61 m)* (Viveen et al., 2012a). *It is worth noting, however, that our review of the geomorphological position of these dating samples suggest that they more closely correspond to terraces T2, T4 and T5 in our classification scheme …*". The authors here clearly conclude that T2 in their, and T2 in our terrace level schemes are the same. But according to our correlation model, our dated T2 remnant corresponds to their T4 terrace remnant at that location (Viveen et al., 2013a, 2013b; see Fig. 1). So, based on their correlation scheme, there is a general mismatch of two terrace levels

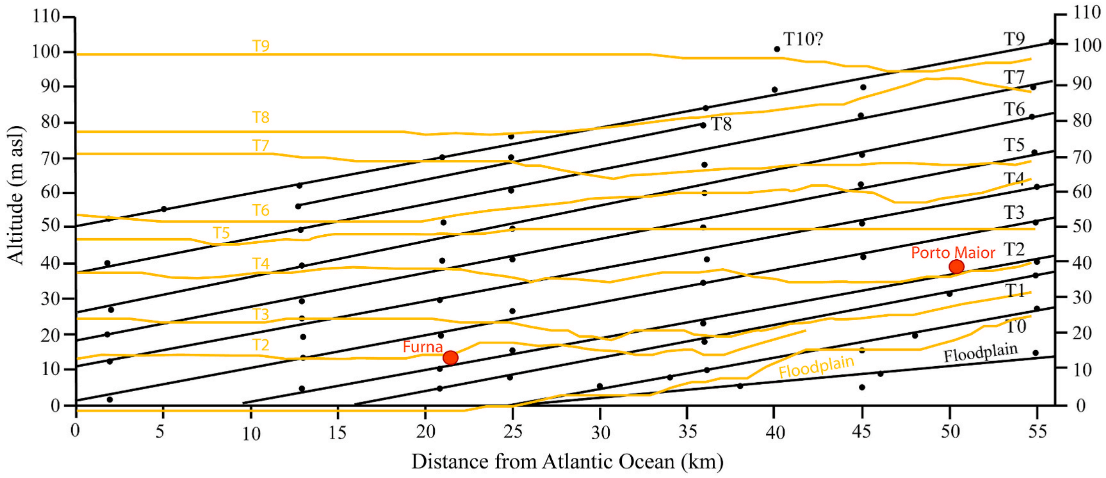

Fig. 1. Comparison of the longitudinal profile reconstruction of Viveen et al. (2013a, 2013b) (black lines) and the profile reconstruction of Méndez-Quintas et al. (2020) (orange-brown lines). Black dots represent some examples of terrace surface measurements used to correlate the terrace levels (Viveen et al., 2013b). The figure clearly shows that the two profile reconstructions do not match as Viveen et al. (2013a, 2013b) reconstructed profiles with a gradient of 1 m km^{-1}, whereas Méndez-Quintas et al. (2020) maintained horizontal profile reconstructions. These differences cause a mismatch of two terrace levels. Locations of the ^{10}Be-dated Furna site (Viveen et al., 2012b) and of the ESR/TT-OSL/piR-IR dated Porto Maior site of Méndez-Quintas et al. (2018) and Demuro et al. (2020) are also shown. As discussed in the text, those sites have, considering the associated uncertainties, identical ages and should be considered as the same terrace level. The longitudinal profile reconstructions of Viveen et al. (2013a, 2013b) correctly predict that the Furna and Porto Maior sites both belong to the same terrace level T2, thus confirming the validity of our profile reconstructions.

between our terraces and theirs (Fig. 1). Consequently, they consistently compare an older, ^{10}Be-dated terrace remnant from our Portuguese record with a younger one from their Spanish record, instead of comparing terrace remnants of the same age. No wonder that these authors finally concluded that "*Closer comparison of the incision ratio model and the aforementioned ^{10}Be dating results for terrace T2-T5 shows that the latter are consistently older for both the low and high terraces (Fig. 15); which may* support *the contention that the existing ^{10}Be ages could be problematic and may represent maximum rather than finite ages*." (Méndez-Quintas et al., 2020). This correlation mismatch is amplified by the fact that they did not map terraces on the Portuguese side of the valley, which makes it impossible to compare our dated terrace remnants with theirs.

It is noteworthy that, according to our published terrace map (Viveen et al., 2013a), the T4 terrace remnant which constitutes the Porto Maior site of Méndez-Quintas et al. (2018, 2020) corresponds to our T2 terrace level (Fig. 1), which was dated at two sites (Furna and Furna Top), based on ^{10}Be depth profile, ^{10}Be rejuvenation and luminescence techniques. We stated that "*The rejuvenation approach on the other hand, seems to work better for the Furna terrace as the depth profile approach probably overestimates the amount of inheritance*." (Viveen et al., 2012b). This approach led to CRE ages of 196 ± 5.9 ka for Furna and 187 ± 5.8 ka for Furna Top. ^{10}Be CRE dating determines the moment of terrace abandonment and, as such, our ages will always be slightly younger than those of Méndez-Quintas et al. (2020). See also Demuro et al. (2020) who dated the moment of sediment burial. Our ages should be compared with ages of the samples from the Porto Maior site in the topmost position of the sedimentary sequence, as those sediments were potentially deposited just before terrace abandonment. That would be samples from the PM4 unit, as the uppermost PM5 unit contains reworked material with significantly younger ages (Méndez-Quintas et al., 2018; Demuro et al., 2020). The upper PM4 unit was dated with TT-OSL and ESR (Ti–Li and Al centres), yielding consistent ages of 206 ± 20 ka (Ti–Li), 181 ± 25 ka (Al), 172 ± 21 ka for the single-grain TT-OSL sample (Demuro et al., 2020), and a slightly older piR-IR age of 231 ± 15 ka (Méndez-Quintas et al., 2018). Bayesian modelling of their data led Demuro et al. (2020) to suggest deposition between 223 ka and 179.3 ka. Considering the associated uncertainties, all these ages are identical to our two Furna-Furna Top ^{10}Be CRE ages (196 ± 5.9 ka and 187 ± 5.8 ka) of the T2 remnant located 30 km downstream of the Porto Maior site, and confirm that the Porto Maior and our T2 Furna terrace remnants belong to the same terrace level (Fig. 1). In other words, the ages of their upper PM4 unit, which Méndez-Quintas et al. (2020) claimed as "… *the strongest chronological data for the terrace staircase currently comes from the Porto Maior site*", are an additional argument for the robustness of our oblique terrace correlations. So, on the basis of their own chronological data, Méndez-Quintas et al. (2020) unwillingly illustrated that their correlations parallel to the Miño FP are utterly incorrect.

Ménde-Quintas et al. (2020) also present as a novelty the 0.11 m ka^{-1} incision rates they calculated for their study site. This assertion is false because it neglects to mention that we already calculated in their area incision rates of 0.10 m ka^{-1} (Viveen et al., 2014a) and of 0.07–0.09 m ka^{-1} for the Furna area further downstream (Viveen et al., 2012b). These authors claim that "*Overall, we do not observe significant changes in the position of the different terrace levels … This situation seems consistent with the generally limited influence of tectonic processes during the formation of the terraces or after their final abandonment. This observation does not necessarily preclude the significance of neo-tectonic processes locally, but such processes do not appear to have been widespread …*" (Méndez-Quintas et al., 2020). It is globally accepted that tectonic uplift is necessary to lift floodplains up and preserve them as individual fluvial terraces; otherwise stacked sequences of sediment would form (Bridgland and Westaway, 2008). The entire Atlantic coast is uplifting, possibly because of the Atlantic Push, as shown by uplifted marine and fluvial terraces worldwide (Pedoja et al., 2011). Evidence for western and northern Iberia is also overwhelming (Alvarez-Marron et al., 2008; Cunha et al., 2005, 2008; Ramos et al., 2012). An additional contribution to tectonic deformation of NW Iberia is the northward propagation of compression due to the ongoing Iberia-Africa convergence (De Vicente and Vegas, 2009). Tectonic uplift in combination with glacioeustatic changes have been the main driving factors for terrace formation during the glacial Marine Isotopic Stages as we explored in detail in Viveen et al. (2012b, 2013b).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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