Reviewer 2

Synopsis

Paradis et al. presented a comprehensive study containing geochemical parameters (OC, TN, δ13C, δ15N, and Δ14C), biomarker signatures (proteins, carbohydrates, phytopigments, GDGTs, and n-alkyl lipids), and compound-specific δ13C analyses of surface sediments to assess the sources of OC deposited on the shelf and in the three major canyons in the Mediterranean Sea. A particularly interesting aspect of this study is the use of a wide of source-assignment methods to investigate the role of submarine canyons in transporting terrigenous OC across continental margins. However, due to the limited number of samples (total n=7), any observed differences should be interpreted with caution. While I have no major concerns, I offer several suggestions that could help improve the manuscript.

We would like to thank the reviewer for his/her time in reading the manuscript and providing these constructive suggestions to help improve the quality of the manuscript.

My specific comments are outlined below.

Line 16: add ", and" before "Δ14C".

Done

Lines 19-21: please specify which method was used to assess the contribution.

This has been added to the abstract, which now reads:

> "According to a dual isotopic end-member mixing model with $\delta^{13}C$ and $\Delta^{14}C$, the contribution of terrigenous OC was highest on the shelf (80 %) and decreased offshore, with contributions that ranged between 50 to 70 % across the studied submarine canyons."

Line 23: It would be better to add "relatively" before "lowest".

We agree with the reviewer, and this has been added.

Line 30: Are you referring to the Arenella and Oreto Canyons, which are not connected to rivers? If so, could you explain the potential sources of terrigenous OC into these two canyons?

We are actually referring to all three submarine canyons, which neither of them are connected to rivers. We have clarified this with the following sentence:

> "This study provides further evidence that even non-river connected submarine canyons, such as Arenella, Oreto, and Eleuterio canyons in the Gulf of Palermo, are important sites of terrigenous OC sequestration and transfer to deep-sea environments, and that bottom trawling activities within submarine canyon environments can contribute to its resuspension and dispersal towards deeper regions."

Lines 48-49: What about differences in marine primary production, which also influence the relative proportion of terrigenous OC.

The reviewer is right in pointing that we focused the introduction on the dispersal of terrigenous OC but did not address the dispersal of marine primary production, which also influence in the accumulation of OC and the relative proportion of terrigenous OC. We have included this in the revised manuscript as follows:

> "Higher marine OC tend to accumulate in submarine canyons incising continental margins with high marine primary productivity (Pusceddu et al., 2010), whereas the proportion of terrigenous OC in submarine canyons can be very variable depending on the proximity of riverine sources, their suspended sediment yield, and the magnitude of littoral transport (Alt-Epping et al., 2007; Pasqual et al., 2013; Kao et al., 2014; Romero-Romero et al., 2016; Prouty et al., 2017; Gibbs et al., 2020)."

Lines 72-73: distinguish between specific sub-pools of terrigenous OC (e.g., vegetation, soils, and fossil OC).

This has been modified.

Lines 157-159: What is the carbonate content? Could it affect the mean grain size of the terrigenous sediments?

Carbonate content in surficial sediment samples range between 17 to 33 %, and it is correlated to the mean grain size of sediments as explained by Palanques et al. (2022).

Line 216: the CPI index formulae is wrong, please correct it.

We appreciate the reviewer's sight in identifying the typo in the formula, which has now been corrected. Since there was only a typo in the written formula, this does not affect the CPI values provided in the manuscript.

Line 224: rewrite the δ13CCH3 to δ13CMeOH and consider adding a sentence explaining how the δ13C value of HMW compounds (n>24) was calculated.

This has been modified and a short explanation of how the weighted-average $\delta^{13}C$ of HMW FA was calculated has also been included:

> "Since $\delta^{13}C$ of the FAME fractions could only be measured on specific carbon chains (C_{16}-C_{28}), weighted-average $\delta^{13}C$ values of HMW FA were calculated as follows:

$$\delta^{13}C_{HMW\ FA} = \frac{\sum(\delta^{13}C_{24-28} * C_{24-28})}{\sum(C_{24}-C_{28})}\text{"}$$

Table 1: please also include the reference for the marine end-member values.

The reference of both the terrigenous and marine end-member values are included in the table. The marine end-member values refer to phytoplankton analyses in suspended sediments from the Gulf of Lions (Harmelin-Vivien et al., 2008).

Lines 275-293: What about the relative proportions of these OC classes based on OC content rather than sediment mass? They could provide insight into the reactivity of OC. Or is it already normalized to OC content?

We initially showed the contents of proteins, carbohydrates, lipids and phytopigments in terms of sediment ($mgC \cdot g^{-1}$) since this is how these parameters are often reported (Dell'Anno et al., 2002; Pusceddu et al., 2005; Moccia et al., 2019; Paradis et al., 2019). However, in light with the other biomarkers presented in this study, we normalized the contents if these compound classes on the OC content. Despite the variable OC content across the sites, this normalization did not modify the spatial patterns.

With regard to the reactivity of OC, we actually measured protein turnover rates, and the data was shown in the supplementary appendix (Paradis, 2025), but not discussed in the first manuscript to simplify the message. Since this is a topic that Reviewer 4 also pointed out, we have included it in the revised manuscript and in a figure of the supplementary information.

Below is the description of the turnover rates in the Results section, along with the modified Fig. S2:

> "Protein turnover rates in selected sediment samples showed a general increase with depth and distance from shore (Fig. S2c). Lowest turnover rates were measured in Eleuterio canyon head (EC-200, 0.85 ± 0.20 yr^{-1}) which increased with depth (EC-500, 4.69 ± 0.99 yr^{-1}). In Oreto Canyon, turnover rates also increased downcanyon where highest turnover rates were observed in the canyon mouth (OC-500, 2.52 ± 0.54 yr^{-1}; OC-800, 17.5 ± 1.8 yr^{-1}). Finally, Arenella mid-canyon had the highest turnover rates in comparison to the other sediment samples located at a similar depth-range (AC-500, 12.1 ± 2.7 yr^{-1})."

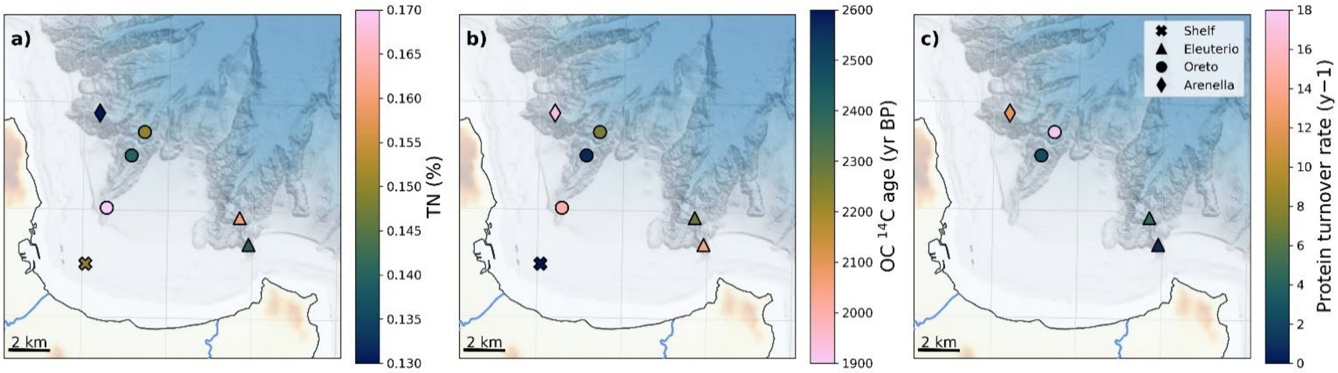

Figure S2. Spatial distribution of bulk parameters: a) TN, b) radiocarbon age, and c) protein turnover rate. Colour bars are adjusted to highlight the minimum, mean, and maximum values for each variable.

The importance of this variation in protein turnover rate, as a proxy for OM reactivity, has also been included in section 4.1 of the discussion:

> "Interestingly, the spatial distribution of OC sources is somewhat related to its reactivity, estimated as protein turnover rates (e.g., Soru et al. 2022 and Soru et al. 2024). Highest protein turnover rates were observed in Arenella mid-canyon, which had one of the highest marine OC fractions, whereas lowest protein turnover rates were observed in Eleuterio canyon head, which had one of the highest terrigenous OC fractions (Fig. S2c). However, we pinpoint here that other factors may also be contributing to the reactivity of OC (see section 4.3)."

As well as in section 4.3:

> "Furthermore, continuous sediment resuspension and erosion at this site due to repetitive bottom trawling promotes a reduction of OC contents in surficial sediment (Tiano et al., 2024), either associated to erosion or degradation of OC. Given the high sedimentation rates in this site (Paradis et al., 2021), the reduction of OC associated to bottom trawling in this site may be dominated by enhanced degradation of OC, potentially due to sediment mixing (e.g., (Middelburg, 2018)) and oxygenation (e.g., increasing oxygen exposure time of OC (Hartnett et al., 1998))depleting the most reactive OM components such as phytopigments from the seafloor (Fig. 3d). This process shifts the OC source toward less marine and more terrigenous OC, which tend to be less reactive, as seen by the low protein turnover rate in this site (Figs. 3d, S2c). This process leads to older

(i.e., more ^{14}C-depleted) and less reactive OC on surface sediments, which could impair ecosystem functioning (Danovaro et al. 2008) in this area, ultimately affecting benthic biodiversity and biomass (Pusceddu et al., 2014; Good et al., 2022)."

Line 299: When discussing the concentration of each GDGT, please remember the data are semi-quantitative. It would be more appropriate to present relative abundances rather the absolute.

Yes, which is why we provided measures of the relative abundance of crenarchaeol concentrations in comparison to all isoGDGTs. Moreover, we compare concentrations among samples, as a relative measure of where we find higher/lower concentrations of each measured compound.

Figure 4: Specify if HMW FA include all compounds with C≥24 or only even-numbered ones?

In addition to specifying that the HMW FA concentrations only include even C chains, we also remind the reader about the ranges of C number chains for both LMW and HMW FA in the figure caption:

"Figure 4. Spatial distribution of concentrations of a) crenarchaeol, b) LMW FA $(C16\text{-}C18)_{even}$, c) HMW FA $(C24\text{-}C32)_{even}$, and d) spatial distribution of $\delta^{13}C$ signature of HMW FA $(C \geq 24)_{even}$. Colour bars are adjusted to highlight the minimum, mean, and maximum values for each variable."

Line 320: The CPI value is quite low, could please double-check the calculation? Even in highly degraded, sandy sediments, CPI values typically ranged between 4 and 5.5 (See Wei et al. (2025), https://doi.org/10.1016/j.chemgeo.2025.122712)

Yes, the CPI value in our dataset is quite low, which has prompted to revising the calculation several times, but the values obtained are correct. We appreciate the reviewer for providing us with an additional study site to compare our CPI values to.

A closer comparison of the high CPI values reported in the North Sea (4-5.5; Wei et al., 2025), the East China Sea (3.4-4.7; Tao et al., 2016), and in the Laptev Sea (3.7-5.9; Bröder et al., 2016), also coexist with relatively high HMW FA contents in the North Sea (173–1150 µg/g OC; Wei et al., 2025), the East China Sea (400-900 µg/g OC; Tao et al., 2016), and in the Laptev Sea (300-7200 µg/g OC; Bröder et al., 2016). This suggests that the higher HMW FA contents in these margins may be related to a better preservation of plant-derived OC, whereas the limited plant-derived OC (18-35 µg/g OC) that is exported to the Gulf of Palermo are inherently highly degraded ($CPI_{(C24\text{-}C32)}$ 1.8-2.4).

Also note that the Helgoland Mud Area of the North Sea is located relatively close to the Elbe and Weser rivers, which have an average discharge of 760 $m^3 \cdot s^{-1}$ and 350 $m^3 \cdot s^{-1}$, respectively, which is 1000-3000 times higher than the discharge of the Oreto and Eleuterio rivers. Note that we are only comparing river discharge and not suspended sediment yield of these rivers, since the latter metric is not available for the Oreto and Eleuterio rivers. This contrasting river discharge could have a substantial influence in the preservation and degree of degradation of land-derived plants in these systems, since the majority of Mediterranean rivers are ephemeral torrential rivers.

All of this has been included in the revised manuscript as follows:

"It is important to note that these $CPI_{(C24\text{-}C32)}$ values (1.8-2.4) are lower than those observed in other continental margins with significant riverine input as well as high HMW FA contents in surficial sediments, such as East China Sea (400-900 $\mu g \cdot g^{-1}$ OC, $CPI_{(C24\text{-}C32)}$ 3.4-4.7; Tao et al., 2016), the Laptev Sea (300-7150 $\mu g \cdot g^{-1}$ OC, $CPI_{(C24\text{-}C32)}$ 3.7-5.9; Bröder et al., 2016), and the Helgoland Mud Area in the North Sea (170-1150 $\mu g \cdot g^{-1}$ OC, $CPI_{(C24\text{-}C32)}$ 4-5.5; Wei et al., 2025), indicating that the limited plant-derived OM deposited in the Gulf

> of Palermo is already considerably degraded, which could be a characteristic of continental margins affected by ephemeral, torrential rivers."

Line 484: Are there any specific rivers?

Given the direction of the regional current, possible rivers that could provide terrigenous OC into the Gulf of Palermo are the small torrential rivers that discharge in the adjacent Gulf of Castellammare, such as the Nocella River and San Bartolomeo River. Also per request of Reviewer 1, we added these possible sources in the text:

> "[…] (e.g., distal rivers such as those that discharge into the adjacent Gulf of Castellammare, aeolian input, or coastal erosion)."