Reviewer 4

Paradis and co-workers present organic geochemical data for 7 cores collected by multicorer from 1 shelf site and 3 submarine canyons in the area of the Gulf of Palermo, Sicily. The three investigated canyons differ with respect to morpho-sedimentary characteristics and their catchments. The major aim of the study is to assess the sources of OC deposited on the shelf and in three canyons.

The authors have produced an impressive dataset including geochemical parameters (OC, TN, δ13C, δ15N, Δ14C), biomarker signatures (proteins, carbohydrates, phytopigments, glycerol dialkyl glycerol tetraethers, and n-alkyl lipids), compound-specific δ13C analyses of surficial sediments as well as application of mixing models. However, the spatial coverage based on the relatively few sampling sites is rather low – in particular in the Arenella Canyon area, where there is only one sampling site.

Although the spatial coverage of the study area with sampling sites is rather poor, I think the authors could better exploit their comprehensive data sets available for the studied sites. Furthermore, in some parts of the manuscript the discussion and some related statements are still very vague and general.

We appreciate the reviewer's time reviewing the manuscript and for his/her comments and discussion that help improve the quality of this study. Yes, we agree that the number of sampling sites is rather limited, as pointed out by the other reviewers. To overcome this, we dive into a rich and extensive dataset of different proxies, and complement our dataset with published data in this study area.

The manuscript/study has a strong focus on the downslope transport of terrigenous organic carbon (OC) within the canyons. In this context I would then suggest to elaborate a bit more – maybe in the Introduction - on why it is important to assess how much terrigenous carbon is transported downslope within canyons. What about the OC from marine sources? From my point of view, it would be similarly important to assess how canyons also act as transport routes of marine OC downslope – in particular in light of the observation that the fraction of marine OC increased downslope. It has been shown that sediment transport in canyons is a rapid process and sedimentation rates at the sites of sediment deposition are high. As has been shown (e.g. Müller et al., 2025; Biogeosciences) sedimentation rate exerts one of the key controls on OC preservation. So, I would assume that in such depositional environments also marine OC would be relatively well preserved.

Yes, the reviewer is right in pointing on the importance of the accumulation of marine OC in submarine canyons. This was also raised by Reviewer 2, and we have added a few sentences on this in the introduction.

> "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). These contributions can also vary temporally, with enhanced sediment transport and burial of both marine and terrigenous OC triggered by natural energetic events such as storms, or by anthropogenic sediment resuspension and its posterior downcanyon transport caused by mobile demersal fisheries (Pedrosa-Pàmies et al., 2013; Liu et al., 2016; Paradis et al., 2022)."

We have also expanded on the importance of the high sedimentation rates in submarine canyons in the preservation of OC within them:

> "Shelf-incising submarine canyons can also intercept materials entrained in along-margin sediment transport, funneling large volumes of terrigenous particles towards the canyon's interior (Puig et al., 2014). These high sediment fluxes and mass accumulation rates within submarine canyons lead to efficient OC sequestration within submarine canyons (Masson et al., 2010; Maier et al., 2019; Baker et al., 2024), making these sites hotspots for OC burial."

Both of these aspects are then highlighted in section "4.1 Contribution of terrigenous and marine organic carbon in the Gulf of Palermo" of the discussion as follows:

> "Although no data of mass accumulation rate is available from the continental slope, the rapidly decreasing accumulation rates on the shelf with distance from shore (0.84 to 0.15 $g \cdot cm^{-2} \cdot yr^{-1}$) to values that are considerably lower than in submarine canyons (0.35-0.82 $g \cdot cm^{-2} \cdot yr^{-1}$) indicates that sedimentation rates on the adjacent slope will be considerably lower than in the canyon axis, as observed in other incised continental margins (Buscail et al., 1997; Sanchez-Cabeza et al., 1999; Masson et al., 2010; Paradis et al., 2018). Moreover, surficial sediment from a sediment core collected in the open slope between Oreto and Eleuterio canyons at 712 m depth had higher $\delta^{13}C$ values (-22.7 ‰; Di Leonardo et al. (2009)), similar to marine end-member values, than those in the afore-mentioned canyons (-24 to -25 ‰), which tend toward more terrigenous end-member values. This further supports the notion that submarine canyons transfer terrigenous OC deeper and farther offshore than would occur in their absence.
>
> The observed high accumulation of both marine and terrigenous OC in these submarine canyons confirms their role as important sites of OC sequestration, as shown in other canyon systems (Masson et al., 2010; Maier et al., 2019; Baudin et al., 2020). However, the contrasting accumulation of terrigenous and marine OC in each canyon suggests that even in closely spaced submarine canyons, the main source of the OC can greatly differ."

I also found the parts of the discussion and conclusions that deal with the potential impact of bottom-trawling fisheries (e.g. Zhang et al., 2024) much too vague and general. Do your data allow you to assess how bottom trawling has altered the total OC composition and reactivity? How susceptible/vulnerable is the OM of the different origins/sources to resuspension and oxidation? In other words: How is both the ratio of marine to terrigenous OC as well as the reactivity of OC altered during downslope transport and during (potential) repetitive resuspension induced both by natural processes and anthropogenic activities – namely bottom-trawling – considering that marine organic carbon is more available to remineralization / vulnerable to oxidation when resuspended/re-exposed to oxygen-rich waters.

Also the use of the term „ecosystem functioning" is much too vague and general. Please, specify what you mean or refer to in detail because I have no idea what precisely you refer to.

We agree that this section was very limited and needed to be expanded a bit more.

With regards to the influence of bottom trawling to reactivity, we indeed see a reduction in the protein turnover rates, a proxy for OC reactivity (data previously given in the appendix but not discussed in the previous manuscript) in the site with highest fishing effort (OC-500).

With the term "ecosystem functioning" we refer to the ability of ecosystems to let trophic webs to work properly (sensu Danovaro et al., 2008 Current Biology). Accordingly, in the amended manuscript we refer to the possible impairment of benthic biodiversity and biomass caused by bottom trawling activities, especially in deep-sea settings (Pusceddu et al. 2014).

We have expanded this section further and modified the text as follows:

> "The dispersal of terrigenous OM is not only affected by the regional currents, but also by trawling-derived sediment resuspension, both of which displace large amounts of sediment from the shelf and slope into these submarine canyons (Paradis et al., 2021; Arjona-Camas et al., 2024). This transfer of sediment into submarine canyons has not only increased sedimentation rates within all three canyons since the industrialization of the bottom trawling fishing fleet in the 1980s (Paradis et al., 2021), but it has contributed to the dilution of heavy metals accumulating in the canyons (Palanques et al., 2022). Hence, this anthropogenically-induced sediment transport could also be affecting the dispersal of terrigenous and marine OC in the Gulf of Palermo submarine canyons, possibly delivering more OC into the canyons (Fig. 8). In addition, the higher sedimentation rates in submarine canyons associated to sediment resuspension by bottom trawling activities on the flanks could be increasing the preservation potential of OC within submarine canyons, and further studies should address this.
>
> Bottom trawling activities could also be affecting OC content and composition due to the continuous sediment resuspension. This would be the case in the Oreto Canyon, where bottom trawlers continuously fish along the canyon axis and highest fishing effort of the region have been recorded in this canyon (Fig. 8). Here, the repetitive resuspension and down-canyon transport of sediment and its terrigenous OC would explain the down-canyon increase of terrigenous OC and plant-derived (HMW FA) OC in this canyon (Figs. 4c, 6). 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, affecting benthic community composition and abundance (Pusceddu et al., 2014; Good et al., 2022)."

Minor/Specific comments

Line 377: Maybe rephrase to „In contrast to …"

We prefer the current phrasing of this sentence.

L. 380: … had decreasing terrigenous OC contribution „with depth"

This has been added.

L. 394: Do you mean „sediment" or „OC" mass accumulation rates here?

We mean OC mass accumulation rates. This has been clarified.

L. 448: What precisely do you mean with „very distinct composition“ here? Can you specify a bit more.

As shown in Fig. S8 (see below), the composition of brGDGTs of the surface sediment of the Gulf of Palermo in terms of tetra-, penta-, and hexa-methylated brGDGTs are substantially different than those of global soil and peat, indicating that brGDGTs are not originated from soils but rather produced by bacteria in marine environments.

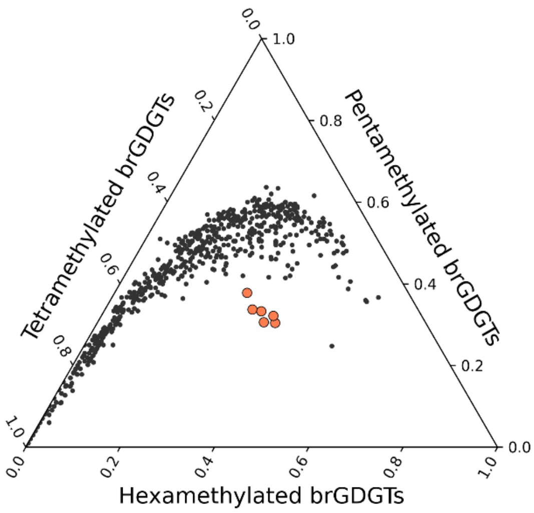

Figure S8. Ternary diagram showing the tetra-, penta-, and hexa-methylated brGDGTs in surface sediments of the Gulf of Palermo (pink circles) plotted together with the global soil and peat dataset (black dots) (Dearing Crampton-Flood et al., 2020). The clear offset of the Gulf of Palermo samples points to brGDGTs produced in-situ rather than being representative of soil-derived GDGTs.

We consider that it is not necessary to provide this much detail in the main text, as Reviewer 3 also points that it is already quite clear that brGDGTs are produced in-situ.

Ls. 510 ff.: Can you expand a bit more here how/by which process and conditions resuspension enhances/promotes the degradation of OM … please also cite the relevant references – e.g. Hartnett et al. (1998) … maybe see Zonneveld et al. (2010, Biogeosciences) for a review.

As shown in our previous reply, this has been expanded.

Ls. 512 ff.: needs to be „direct“; Which type of "ecosystem function" precisely do you refer to here? This sounds very vague and needs to be specified – otherwise delete this part of the sentence. Can you also elaborate a bit here how the total amount of OC varies?

As mentioned earlier, this has been clarified with the following sentence:

> “[…] which could impair ecosystem functioning (Danovaro et al., 2008) in this area, affecting benthic community composition and abundance (Pusceddu et al., 2014; Good et al., 2022).”

Ls. 516/517: Maybe rephrase to: "… and shown to be primarly of phytoplankton origin"

This has been rephrased.

Ls. 529 ff.: What about the total amount of organic carbon? Based on your data does trawling reduce the amount of organic matter transported and deposited in the canyons? How susceptible is the terrigenous OC to trawling-induced resuspension and transport – compared to the OC of marine origin?

As mentioned earlier, this has been expanded and clarified.

L. 531: Again, what precisely do you mean or refer to when you speak of „ecosystem functioning“? Please, explain and specify. Otherwise delete.

As mentioned earlier, this has been clarified.