REVIEWER 1

In this manuscript, Tomašových et al. assess the preservation, pyritization and age and depth distribution of valves of the hypoxia-tolerant bivalve Varicorbula gibba in Adriatic Sea sediments. The authors compare these V. gibba taphonomic data to sedimentary and radiometric proxies for mixed layer depth and sedimentation rate, as well as sedimentary biogeochemical data. They conclude that sedimentation rate likely played a strong role in enhancing long-term pyritization of V. gibba valves (i.e., by limiting extents of oxidation in the uppermost sediment pile, and by shuttling valves below the mixed layer on relatively rapid time scales). The authors also observe that V. gibba valves with pyrite linings appear to be more prevalent in the portions of cores corresponding to the late 20th century, correlative with increases in seasonal hypoxic events and episodes of eutrophication. They therefore conclude that these hypoxic episodes, by deleteriously impacting the local infaunal community (particularly bioirrigators), directly resulted in valve-associated reducing microniches and decreased potential for reoxidation of valve pyrite linings, allowing burial of pyritized valves to outpace bioirrigator-mediated reoxidation in sites characterized by high sedimentation rates. With this work, the authors lend new insights into the role played by bioirrigation (and feedbacks between sedimentation and bioirrigation) and eutrophification in pyritization, with important implications for how pyritized fossils in the stratigraphic record can be used to reconstruct not only the taphonomy of body fossil assemblages but also changes in the extent and timescales of bioturbation. This manuscript represents an impressive body of work with potentially important implications for not only reconstructing environmental-ecological-taphonomy feedbacks on historic time scales but also in the deep-time stratigraphic record. I am therefore supportive of publication, and below I highlight a few relatively minor aspects that I have confidence the authors should be able to readily address in a revised version of the manuscript:

Response: We thank the reviewer for taking the time to read the manuscript and for offering her comments and constructive criticisms.

I would have liked to have seen more extensive discussion, up front (e.g., in the Introduction, the Methods or a new section of its own) of the ecology of Varicorbula gibba—for instance, whether it is infaunal, semi-infaunal or epifaunal; feeding ecology; seasonal variation in abundance; and ecological relationships to other local taxa. We are not told until near the end of the manuscript (l. 580-581) that V. gibba is among the assemblage of shallowly burrowing detritivores and deposit-feeders that have been previously documented at Adriatic prodelta sites such as Po and Isonzo. However, the ecology of V. gibba seems very relevant to the manuscript's consideration of impacts of hypoxia and eutrophification on local benthic communities. For instance, is it an opportunistic taxon? Does its relative abundance in benthic communities actually increase under conditions of hypoxia—or in spite of being hypoxia-tolerant, are impacts of hypoxia on V. gibba, on the whole, deleterious (as they are inferred to be for the bioirrigating community)? This in turn could impact some of the authors' assumptions regarding rates of V. gibba input to the sediment pile.

Response: We have followed this advice. We have added more information about the burrowing depth, feeding habits, lifespan and abundance of *Varicorbula gibba* into the Methods as follows (this information is then also used in the Discussion):

"*We target specimens of the bivalve V. gibba because this species tends to be common in all cores. V. gibba is a small-sized (<15 mm), shallow-infaunal bivalve that has short siphons and thus lives in the upper 3 cm of sediment (Faresi et al., 2012), very close to the sediment-water* *interface. It feeds on suspended phytoplankton but also exploits benthic diatoms, bacteria and organic detritus at the sediment-water interface (Yonge 1946). This species has higher tolerance to reduced oxygen levels relative to molluscs and other invertebrate groups (Holmes and Miller, 2006; Riedel et al., 2012) and can survive for several days and even weeks in anoxic conditions (Christensen 1970). In the northern Adriatic Sea, it increases in abundance in the wake of short-term, seasonal anoxic or hypoxic events to more than 1,000 individuals/m^2 (Hrs-Brenko 2006, Nerlović et al. 2011), and grows to 7-8 mm during the first year, achieving the maximum size of ~15 mm in two years (Hrs-Brenko 2003). It is classified as an opportunistic species in the assessments of benthic ecosystem health in the Mediterranean Sea (Simboura and Zenetos, 2002; Moraitis et al. 2018). Soft-bottom molluscan assemblages at water depths below the seaspnal thermocline in the northern Adriatic became dominated by this species during the late 20th century Sea (Tomašových et al., 2018).*

The authors explore various models for the distribution of V. gibba valves at depth (and from that exercise conclude that a model of uniform loss from the mixed layer for pyritized and non-pyritized valves is most parsimonious), but this appears to be premised upon an assumption of invariant input rates. If V. gibba abundance (or relative abundance) varies with bottom-water redox state and degree of nutrient loading this may not be a valid assumption, however. In addition to providing further detail on V. gibba ecology earlier in the manuscript, the authors should discuss these assumptions and the extent to which they can be constrained or justified.
Response: Yes, estimates of loss rates on the basis of age distributions depend on the assumption that the temporal input of shells to death assemblages is relatively constant. However, although whole-core age distributions and stratigraphic changes in abundance of V. gibba indicate that input rates were not constant over the duration of core deposition, with abundance changes occurring at multi-decadal scales, this assumption is important over the time scale of residence time of shells in the mixed layer. The residence time is rather short at Panzano and Po (less than few decades, shorter than time scale of recentmost shift that occurred in the mid-20th century), and we thus assume that this assumption is not violated. To clarify this in the Discussion, we have added: *"Although multimodal whole-core age distributions and stratigraphic changes in abundance indicate that input rates of V. gibba were not constant over the duration of core deposition at all sites (especially increasing in abundance after~1950 AD, Tomašových et al., 2018), the burial-rate parameter based on the exponential model (assuming the temporally-constant input of V. gibba) can be realistic when based on the topcore increments characterized by yearly to decadal time averaging at Po and Panzano (i.e., these increments were deposited after the mid-20th century increase in dominance by V. gibba)."*

Similarly, in the manuscript's discussion of rates of "loss" of valves from the mixed layer (e.g., l. 201-204 and elsewhere), I suggest replacing use of the term "loss" (which is interpretive and connotates a null model that other processes—for instance, additive processes that may variable impact pyritized vs. non-pyritized valves, or those of different age 'cohorts'—do not lead to differences in abundance or distribution) and instead phrasing this in terms of relative abundance or distribution—at least prior to the Discussion section of the manuscript.
Response: We have updated our description and terminology about "loss" rates. The term/parameter (lambda in the simple exponential model, reflecting the steepness of an age distribution) is just used initially in the Methods where the models are introduced. This parameter descriptively encompasses all mechanisms that lead to loss of valves from the

mixed layer (by disintegration, transport, burial), regardless of whether they will be lined by pyrite. However, as independent estimates of sedimentation rates (210Pb-based and based on downcore changes in median ages) are equivalent to the value of "loss" parameter at Po and Panzano, we removed "loss rate" and just refer to this parameter as "burial rate" in the main text. To clarify this in Methods, we have added: *"We estimate burial rates of valves below the mixed layer by fitting age distributions of valves with and without pyrite linings from Po and Panzano to two models that assume that the input of dead shells to death assemblage is constant over the duration of time averaging. The parameters estimated by these models are related to burial rate and depend on the steepness of age distributions in the mixed layer. However, they are also determined by disintegration rate within the mixed layer (Tomašových et al., 2014). First, a simple model with temporally-constant loss rate of valves (λ) from the mixed layer (with loss occurring by disintegration and/or burial) predicts that age distributions can be well-fitted by the exponential distribution (disintegration-burial model). Second, a more complex (sequestration) model where loss rate declines from λ_1 to λ_2 with postmortem age at some sequestration rate τ predicts that the resulting age distributions are heavy-tailed, typically owing to exhumation of older valves to sediment surface, with λ_1 corresponding to disintegration rate of young valves, λ_2 corresponding to reduced disintegration rate of older valves, and τ to sequestration rate that can correspond to burial rate (Tomašových et al., 2014). The Akaike Information Criterion corrected for small sample size shows similar support for these two models at Po and Panzano both in valves with and without pyrite linings, with either a lower AICs for the simple model or a slightly higher support for the sequestration model that does not exceed 2-3 units, and small differences between λ_1 and λ_2 in the sequestration model. λ parameter estimated by the simple model at Po and at Panzano is similar both to ^{210}Pb-based estimates of sedimentation rate and to ^{14}C shell-based estimates (1-2 cm/y at Po and 0.2 cm at Panzano). Therefore, we infer that this λ parameter at Po and Panzano corresponds to burial rates and can be used to contrast burial rates of valves with and without pyrite linings.*

I would also have liked to have seen additional information on sedimentation rates and mixed layer depths, specifically how these were constrained—given the importance of each of these to the authors' conclusions. For instance, it would be good to include the ^{210}Pb data, which do not appear to currently be part of any of the figures or tables."

Response: The excess activity in ^{210}Pb data and shell ages calibrated by radiocarbon for all cores analyzed in this study were published in our former studies (with source data) that are referenced in Methods. To explain the data sources better, first, in Methods, we have added: *"Core geochronology and the estimates of sedimentation rates and the depth of the mixed layer are based (i) on the profiles in the excess activity of ^{210}Pb and (ii) on the stratigraphic distribution of median bivalve shell ages based on amino acid racemization (AAR) calibrated by ^{14}C published formerly in studies devoted to individual sites (at Panzano in Tomašových et al., 2017, at Po in Tomašových et al., 2018, at Piran in Mautner et al., 2018 and Tomašových et al., 2019b, and at Brijuni in Schnedl et al., 2018 and Gallmetzer et al., 2019)."*

Second, to directly show the 210Pb profiles, age homogenization, and downcore changes in median shell ages, we have added a new figure 3 that summarizes these data in the upper parts of cores and thus provides information about the depth of the mixed layer and about net sedimentation rates based on both methods mentioned above. We have added this information about the definition of the depth of the mixed layer to Methods: *"The estimates* *of sedimentation rates based on the slope of the ^{210}Pb profiles below the mixed layer are similar to those based on downcore changes in median shell ages at both Po sites and at Panzano (Fig. 3). However, the ^{210}Pb segments located below the fully-mixed surface mixed layer at Piran and Brijuni are still steepened by biomixing (and thus overestimate sedimentation rates), as is typical of conditions when rate of biomixing exceeds rate of sedimentation rate (Johannessen and Macdonald 2012). The thickness of the surface well-mixed layer, based on homogeneity of median per-increment shell ages (amino acid racemization calibrated by ^{14}C, Fig. 3A) is 20 cm at Po and at Brijuni, 5 cm at Panzano, and 8 cm at Piran (where a coarse skeletal shell bed occurs at 8-35 cm below the seafloor). The thickness of the surface well-mixed layer, based on the vertical extent of uniform or irregular segments of profiles in ^{210}Pb excess is ~16 cm at Po, and 6 cm at Panzano, Piran, and Brijuni (Fig. 3B). With the exception of Brijuni, the estimates of the mixed-layer depths based the ^{210}Pb profiles and the ^{14}C-based shell age profiles are thus similar. At Brijuni, the 6 cm-thick mixed layer based the ^{210}Pb profiles relative to the 20 cm-thick ^{14}C-based mixed layer probably reflects the shorter (multi-decadal) half-life of ^{210}Pb relative to the longer time needed to mix the upper 20 cm of sediment."*

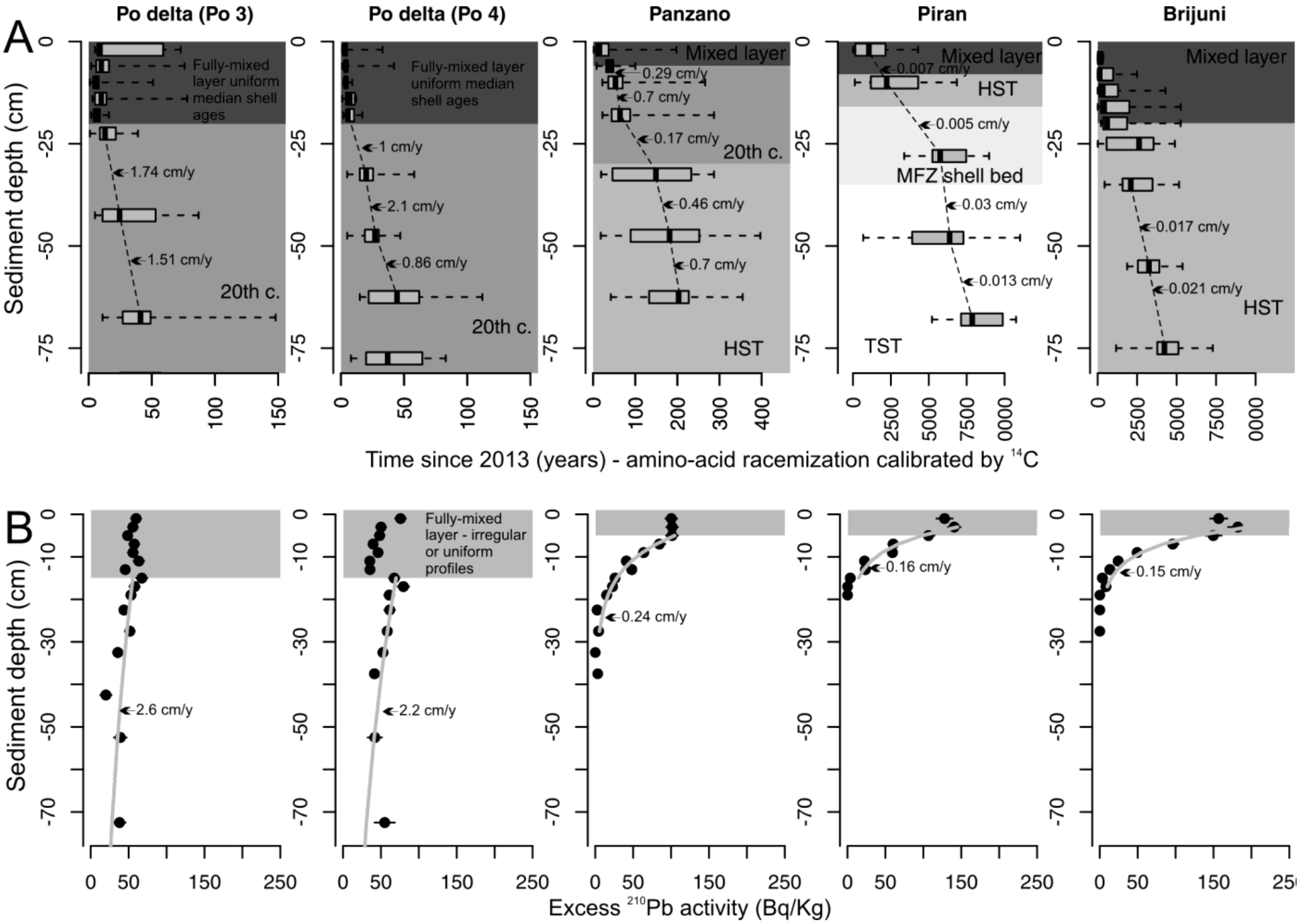

Figure 3 *– Downcore changes in shell ages (A) and the excess in ^{210}Pb profiles (B) and that form the basis for inferences about the depth of the mixed layer (absence of downcore changes in median shell age in the uppermost parts of cores and irregular or uniform segments of the ^{210}Pb*

excess) and sedimentation rate (thickness deposited over a duration defined by differences in median ages, and the slope of the ^{210}Pb segments below the mixed layer in gray color). We note that some variability in these estimates is also affected by biomixing when the thickness of sediments over which the deposition is measured is too low relative to the thickness of the mixed layer, leading to overestimation of sedimentation rate.

The authors state that sedimentation rates, although variable between the different sites and cores, appear to have been largely invariant throughout the deposition of individual cores (e.g., l. 266). It would be good to see that data upon which that assessment is based, as well as further discussion by the authors of whether this is surprising or expected for the prodeltaic sediments of their study sites over the hundred- to thousand-year time scales recorded by these cores.
Response: Although over longer time scales, prograding and lobe-switching delta at Po led to high variability in sedimentation as documented over the past several centuries (and is probably typical of other major prodeltas), shorter temporal duration preserved in our cores (~100 years at Po) were still characterized by relatively constant sedimentation rate. We have replaced "invariant" by "moderately-oscillating", with the key point that the variability in net sedimentation rates within cores at Po and Panzano was not trending and was smaller than variability between the cores. This within-core variability still led to decadal-scale residence times at Po and Panzano (as opposed to longer, millenial-scale residence times at Piran and Brijuni).

As mentioned above, the within-core variability was documented in our former studies based on downcore changes in median shell ages of 5 cm increments – we refer to these references in our statement now inserted into the Methods (see above), and the new figure shows this variability in the upper part of cores.
In Methods, to better explain this variability, we have added: *"Upcore changes in median shell age show that sedimentation rates moderately oscillated through time and do not show any increase in the uppermost levels that correspond to the late 20th century. The within-site variability in sedimentation rates is smaller than the marked variability among sites. Sedimentation rates fluctuated between ~1 and 2.4 cm/y during the 20th century at Po sites (Tomašových et al., 2018) and between ~0.2-1 cm/y over the past 500 years at Panzano (Gallmetzer et al., 2017; Tomašových et al., 2017). Sedimentation rates at Piran and Brijuni were persistently one or two orders of magnitude lower both during the transgressive and highstand phase (~0.01-0.02 cm/y) than at Po and Panzano (Tomašových et al., 2019b, 2021), and we thus refer to Po and Panzano as sites with high sedimentation rate and to Piran and Brijuni as sites with low sedimentation rate. The estimates of sedimentation rates based on the slope of the ^{210}Pb profiles below the mixed layer are similar to those based on downcore changes in median shell ages at both Po sites and at Panzano (Fig. 3)."*

We have also added to the caption of Figure 3 that some variability in these estimates is also affected by biomixing when the thickness of sediments over which the deposition is measured is too low relative to the thickness of the mixed layer, leading to overestimation of sedimentation rate.

There is also some ambiguity in the authors' discussion of the role of organic matter in fostering precipitation of pyrite linings on V. gibba valves. Pyritization is, as the authors acknowledge, typically limited by the supply of organic matter (as well a requiring a redox interface between iron and sulfate reduction at the localized supply of organic matter). However, something the authors do not directly discuss (though they perhaps allude to this in l. 529-532) but which is, in contrast, discussed by some of the studies they cite (e.g., Raiswell et al., 1993, Marine Geology; Farrell et al., 2009, Geology; as well as Raiswell et al., 2008, AJS) is that the presence of abundant disseminated organic matter in the sedimentary matrix tends to be detrimental to extensive pyritization of macroorganism carcasses. So although the hypoxic conditions fostered by eutrophification may, in the case of their Adriatic sediment samples, have played an important role in the development of a shallow redoxcline and thus pyrite precipitation on V. gibba, high rates of organic matter delivery to the seafloor are unlikely to foster extensive and exceptional fossilization of macroorganism carcasses via, for instance, pyrite templating or replacement in geologic analogues. In other words, early diagenetic precipitation of pyrite framboids on V. gibba valves under these conditions does not necessarily equate to exceptional pyritization—particularly given the abundance of sedimentary organic matter noted by the authors. The authors should therefore temper their discussion of how their findings bear upon understanding of pathways of exceptional fossilization via pyritization, and incorporate discussion of these caveats.

Response: We have adjusted the Discussion according to the comment, i.e., extensive organic enrichment will lead to the excess in H_2S, not confining it to the location of decay. We have thus removed the statements that may indicate that sediment organic enrichment is enhancing the formation of pyrite framboids within shells. First, although organic enrichment is associated with seasonal hypoxic events, but it is rather the oxygen depletion that negatively affects bioirrigator activities. Second, sediment mixing (i.e., the second component of bioturbation, in addition to irrigation) by weakly-irrigating organisms still occurs in soft-bottom habitats, providing one mechanism for enrichment of porewaters in dissolved iron in the suboxic zone. This is also confirmed empirically (we mention the importance of iron reduction as observed in pore-water studies in the Setting) - even under sediment organic enrichment observed in the northern Adriatic Sea, uppermost sediment zones still show some iron reduction that provides dissolved iron for rapid formation of linings. We have added to Discusion this information at the beginning of section 5.2: **"***Although organic enrichment with abundant disseminated organic matter can lead to porewater sulfidization and to exhaustion of highly reactive iron in porewaters, organic-rich sites at Po prodelta still show high concentrations of dissolved irons in the uppermost few cm (Barbanti et al., 1995). Sediment mixing by (weakly-irrigating) infauna can counteract the potential buildup of H_2S in porewaters because burrowers transfer particles with iron oxides from the sediment-water interface to reducing conditions in subsurface zones (Faganeli and Ogrinc, 2009). In contrast to bioirrigation, and mixing alone also contributes to higher oxygen consumption, thus further reducing the exposure of sedimentary particles to O_2; van de Velde and Meysman, 2016)."*

At the end of section 5.2., we have revised our discussion of anoxic scenario, as follows: *"If the nutrient-fueled eutrophication or other sources of sediment organic enrichment lead to permanent anoxia of bottom waters and high sulfate reduction, the concentrations of pyrite framboids within shells will be prohibited because sulfide production by bacterial sulfate reduction in organic-rich sediments can exceed in-situ availability of reactive iron oxides, H_2S diffuses and precipitates elsewhere (Raiswell and Berner, 1985; Schenau et al., 2002; Raiswell et al., 2008; Farrell et al., 2009). Iron limitation can be driven by iron bounded to framboids linked to disseminated organic matter under high sediment organic enrichment but also to release of* *ferrous iron from sediments to water column (if water column is not sulfidic, Pakhomova et al., 2007). In addition, as mentioned above, mixing of sediments by burrowers that underlies the iron-based redox shuttle is aborted under anoxic conditions, and iron-limitation in pore waters is thus further enhanced by the lack of bioturbation. The absence of pyrite linings in anoxic sediments documented in the deep-time stratigraphic record (e.g., Brett et al., 1997) indicates that in marine environments with persistent bottom-water anoxia, the window for the early and rapid formation of pyrite linings (e.g., within shells of nektonic groups as cephalopods that fell on the anoxic seafloor) will be closed when organic matter degradation in surface sediments leads to the excess of hydrogen sulfide."*

Similarly, obrution in the typical sense need not involve deep burial, but rather rapid burial (and the associated 'smothering' of benthic communities).
Response: Yes, we add "rapid (burial)" as a characteristic that is necessary for obrution. However, we stress that deep (rather than just shallow) burial by obrution is necessary to ensure that pyrite linings escape the re-oxidation that would follow in the wake of the obrution event (by re-colonizing burrowers) and thus for the long-term preservation and transition of pyrite into the subsurface stratigraphic record. When mentioning the obrution pathway in the Discussion, we have added: "*These early-sequestration conditions can be attained (i) when freshly-dead shells are episodically buried under a deposition of new sediment (obrution, Brett et al., 1997) sourced by river floods or storms, and can decay in reducing conditions beyond the reach of burrowers; the thickness of the obrution deposits needs to be sufficiently high so that pyrite is not reoxidized by burrowing infauna later (Allison, 1988; Brett et al., 2012a, b; Schiffbauer et al., 2014)"*

Particularly if the redoxcline (due to hypoxic conditions) is located in the uppermost centimeters of the sediment pile, an "obrution scenario" and a "hypoxia-mediated reduced bioirrigation scenario" are entirely compatible, and should not be discussed as diametrically opposed alternative models (e.g., as in l. 475-484, l. 622-627).
Response: Yes, these two scenarios are mutually not exclusive and can be complementary. However, in the non-obrution scenario, when infaunal shells die in situ and start decaying, then the obrution is not needed for the initial precipitation of linings formed by pyrite framboids. To ensure that such linings are not re-oxidized, the irrigation needs to remain limited (even when sediments are still affected by mixing of weakly-irrigating organisms), and there can be environmental conditions that generate such conditions (frequent disturbance and/or hysteresis after initial disturbance). This scenario can be especially useful for depositional environments where storms or floods are not necessarily apparent or expected.

In the Discussion, first, we have thus simplified the two pathways and we have added that they can be complementary: (1) obrution (that would need to be sufficiently deep to avoid subsequent re-oxidation) and (2) without obrution, initiated just under a shallow burial of shells in their living position, but associated with subsequently low bioirrigation, and we have expanded on our inference that rapid burial is not a likely scenario triggering the formation and preservation of pyrite linings at Po and Panzano as follows (repeating partly the former citation): "*These early-sequestration conditions can be attained (i) when freshly-dead shells are episodically buried under a deposition of new sediment (obrution, Brett et al., 1997) sourced by river floods or storms, and can decay in reducing conditions beyond the reach* *of burrowers; the thickness of the obrution deposits needs to be sufficiently high so that pyrite is not reoxidized by burrowing infauna later (Allison, 1988; Brett et al., 2012a, b; Schiffbauer et al., 2014) and/or (ii) when biomass of decaying infaunal organisms is tightly enclosed within shells or in intra-skeletal pores (as in V. gibba), generating reducing microenvironments even without the obrution (Jorgensen, 1977; Thomsen Vorren, 1984), and the oxygen penetration by bioirrigation is shallow or intermittent (as can be typical of poorly-permeable fine-grained sediments). Although these two pathways can be complementary, they may also act independently.*

The first scenario with obrution is frequently invoked in the deep-time stratigraphic record because it explains the short exposure of organic remains to O_2 *and their rapid sequestration below the mixed layer (Brett et al., 2012a). Distinct layers deposited by major decadal floods preserved in cores at Po prodelta (Tesi et al., 2012; Tomašových et al., 2018) may have triggered episodic burial of benthic communities, but similar flood-event layers were not detected at Panzano. However, first, the major discharge events that lead to the deposition of flood deposits occur at decadal scales at Po prodelta (seven events during the 20th century, Zanchettin et al., 2008), whereas age distributions of pyrite-lined valves indicate that pyrite linings form almost every year. The frequency of flood events did not increase during the 20th century, in contrast to the increasing frequency of pyrite-lined valves."*

Second, when assessing their roles at our stations, we ultimately suggest that pyrite linings were not triggered by rapid (shallow or deep) obrution and that it is the lack of irrigation that is a crucial condition for final preservation of pyrite linings in soft-bottom deposits of the northern Adriatic Sea on the basis of age and depth distribution of pyrite-lined valves. Even if rapid burial would occur, the shallow burial alone would not protect linings from re-oxidization in well-irrigated sediments. In Discussion: "*Second, pyrite-lined valves younger than 10 years old occur in the uppermost 5-10 cm of the mixed layer close to the sediment-water interface. Their high abundance in the uppermost zones indicates that they do not represent transient valves that were just recently exhumed from deeper zones. Although mixing after the deposition of thin flood layers can rework some subset of valves upward, exhumation of initially-buried valves to oxic conditions would lead to removal of pyrite linings. Third, equally-old valves with and without pyrite linings occur at similar depths and age distributions of pyrite-lined valves and valves without pyrite at Po and Panzano are similar (Fig. 9A-F), indicating that valves with and without pyrite were buried below the mixed layer at the similar rate. A single episodic burial pulse that mixes living or recently-dead shells (with decaying biomass and potential for framboid formation) with older shells (without biomass) will generate one age distribution of valves with pyrite linings dominated by younger cohorts and another age distribution of valves without pyrite linings dominated by older cohorts whereas Under mixing, age distributions will be smoothed by stochastic movement of valves, but age distributions of valves wit pyrite linings should be steeper and their median ages should be still lower, in contrast to our observations both at Po and Panzano."*

On a more minor note, previous studies of pyritization have suggested that relatively more recalcitrant organics may preferentially undergo pyritization (or more rapid pyritization) (e.g., Briggs et al., 1991, Geology; Raiswell et al., 1993, Marine Geology); the authors should therefore take care to not oversimplify fossil pyritization as targeting solely the most labile tissues.
We have followed this and have removed "labile" and just refer to "organic tissues".

l. 196: Although D/L amino acid ratios are of course broadly used, given that this paper may attract a broad audience (including those who do not commonly employ organic geochemical methods), I suggest providing further detail here.

Response: We have added this statement into Methods, with references: "*Ratios of D- and L-isomers (D/L) of eight amino acids (aspartic, glutamic, serine, alanine, valine, phenylalanine, isoleucine, and leucine), and their concentrations in valves of V. gibba were measured at Northern Arizona University using reverse-phase high-pressure liquid chromatography (RP-HPLC) and the procedures of Kaufman and Manley (1998). D/L ratios measure the extent of razemization and thus represent a geochronological tool (Kosnik et al., 2008; Allen et al., 2013).*"

l. 351-352: Please state here how sites were partitioned into "high-" and "low-" sedimentation rates (e.g., what range of values were used for this categorization).

Response: We have revised our definition and characterization of sedimentation rates in Methods, where we have initially assigned the five stations effectively to these three categories, with the final split defined at the end: "*The two Po cores are characterized by high sedimentation rate (~1-2 cm/y), the Panzano core was deposited under intermediate sedimentation rate (~0.2-0.4 cm/y, occassionally up to 1 cm/y), and the Piran (a 25 cm-thick skeletal shell bed occurs at 8 cm below the seafloor; Tomašových et al., 2019b) and Brijuni sites (a 20 cm-thick sandy mud in the core-top overlies a coarse bryozoan-rich molluscan muddy sand Tomašových et al., 2021) are sediment-starved (~0.01-0.02 cm/y). Upcore changes in median shell age show that sedimentation rates moderately oscillated through time and do not show any increase in the uppermost levels that correspond to the late 20th century. The within-site variability in sedimentation rates is smaller than the marked variability among sites. Sedimentation rates fluctuated between ~1 and 2.4 cm/y during the 20th century at Po sites (Tomašových et al., 2018) and between ~0.2-1 cm/y over the past 500 years at Panzano (Gallmetzer et al., 2017; Tomašových et al., 2017). Sedimentation rates at Piran and Brijuni were persistently one or two orders of magnitude lower both during the transgressive and highstand phase (~0.01-0.02 cm/y) than at Po and Panzano (Tomašových et al., 2019b, 2021), and we thus refer to Po and Panzano as sites with high sedimentation rate and to Piran and Brijuni as sites with low sedimentation rate.*"

As pyrite linings are frequent at Po and Panzano stations and not at sediment-starved stations at Piran and Brijuni, we generally refer in the main text to Po and Panzano as "high-sedimentation" sites (i.e., above ~0.2 cm/y) and opposed them with "slow-sedimentation" sites at Piran and Brijuni. Although Po and Panzano stations still differ in sedimentation rate, we think that this subdivision still helps with the summarizing the pattern of pyrite linings.

Figure 9: the burial rates calculated for A) and D) (without and with pyrite linings, respectively for Po 3) seem substantially different (by a factor of 2). It would be good to see additional interrogation of the grounds on which it was determined that these are essentially indistinguishable.

Response: In Methods, we refer now to two types of estimation of sedimentation rates – based on downcore changes in median shell age and based on 210Pb profiles. The estimates in figure 9 (now figure 10), however, refer to the third method that is fully based on the

shape of age distributions (and is congruent with other methods used to determine sedimentation rates). We have added estimates of 95% confidence intervals into Figure 10 to show that the within-site estimates of burial rate for valves with and without pyrite linings are comparable.

Technical Corrections:
l. 97: "…may not be surprising…" **Fixed**
l. 171-172: This sentence contains two separate notations of the mixed layer depth at Brijuni—perhaps a typo? **Fixed**
l. 388: increments **Fixed**
l. 469: reach **Fixed**

For Figure 11 in particular (and, to a lesser extent, some of the other figures), the plots are so closely packed together that it is a little challenging to read the axis labels and attribute these to the appropriate plots. Could the panel components be spaced slightly further apart?
Response: We have spaced the insets and re-arranged the axis labels in Figure 11 and in other figures.

Figure 15: For the A) label, is this supposed to be > (not <)? **Yes, fixed**