Response to Reviewers
In the following, we provide answers to the reviewer's comments. All comments are given in black; our answers are given in green.

Reviewer 1

We thank the reviewer for the general appreciation of the manuscript and the constructive comments. The reviewer raises two important points. First, he pointed us to some missing literature on the topic. In the new version of the manuscript, we included the suggested references and updated our reference list.
Secondly, the reviewer rightly states there is continuous deformation in the Aegean, and consequently objects to the term "polyphase deformation". We fully agree there is no quiet tectonic phase, but the tectonic evolution of Naxos has to be placed in continuously active Aegean tectonic framework. However, the large scale processes integrate deformation over geologic timescales, during which changes in rates, stress orientations or the like are expected. It is clear from field data that distinct orientations of structures are present, and we lack evidence for intermediate stages. This is however expected, and seen in many orogens worldwide. We thus consider the problem foremost semantic. In the new version of the manuscript we clarified this issue in the discussion. For detailed responses to individual comments see below.

** Highlight, page 1: reflecting the transition from high-strain - high-temperature ductile deformation to medium to low strain brittle boudins on the retrograde path during cooling and exhumation*
This shows a continuum of deformation, not different deformation phases
We agree that the deformation is possibly continuous on the large scale, however the structures observable in the field are consecutive and discrete in orientation over many outcrops. They do not show any systematic rotation or spread within a set which would indicate a continuous change in the extension direction. So even if the large-scale deformation was continuous, the resulting structures do not reflect this.
An explanatory note was added to the discussion.

** Highlight, page 1: All boudin generations indicate E-W horizontal shortening*
How do you know it is shortening?
This is an important comment. Indeed, based on the observation on the boudinaged amphibolites alone it is not possible to rule out non-coaxial information and vorticity. However, all sets of pinch-and-swells and boudins require a layer normal shortening and net layer parallel extension. Our interpretation is therefore limited to the rough identification of the principal strain axes of these structures. We added a discussion on the limits of this interpretation to chapter 4.

** Highlight, page 1: variable directions of bedding parallel extension*
Boudinage is chocolate tablet, which can be observed in the figures showing floor and walls of quarries
It is true that the multiple sets of boudinage may be termed chocolate tablet boudinage, however this may be an oversimplification and misleading: chocolate tablet boudinage implies two consecutive deformations with sub normal directions of extension and is

therefore a special (but common) case of multiphase boudinage. In the present case we distinguish 3 sets of boudins (not counting the pinch-and-swell sets) which intersect in most locations at a much lower angle. A section was added to the manuscript to clarify this.

** Highlight, page 1: Two phases of E-W shortening can be inferred, indicating E-W shortening*
Two phases of E-W shortening can be inferred, indicating E-W shortening
The duplicate was removed.

** Highlight, page 1: layer parallel extension*
Cite Marques et al. (2012)
Citation included

** Highlight, page 1: our understanding of these structures has greatly improved*
How does your ms. improve our understanding of boudinage and pinch-and-swell?
The "improvement of understanding" refers in this context to the historical review. Our main findings of this case study are foremost of regional relevance but we corroborate the importance of 3D analysis and multiphase evolution in the context of boudin structures.

** Highlight, page 1: more than one deformation event*
more than one deformation event
"deformation events" refers in this context to deformations on the scale of the observed structures and do not imply a non-continuous origin on the larger scale.

** Highlight, page 1: for*
of
corrected

** Highlight, page 1: Chocolate Tablet Boudins*
Chocolate Tablet Boudins
See comment above?

** Highlight, page 1: reconstruction of the deformation history of rocks*
Cite Marques et al. (2010)
Marques, F.O., Burg, J.-P., Lechmann, S. M., Schmalholz, S. M., 2010. Fluid-assisted particulate flow of turbidites at very low temperature: A key to tight folding in a submarine Variscan foreland basin of SW Europe. Tectonics 29, TC2005, doi:10.1029/2008TC002439.
The reference was added.

** Highlight, page 1: studies of boudinage*
This is not the case in Marques et al. (2010)
The reference was added to the previous sentence

** Highlight, page 1: polyphase*
Why polyphase? Why not continuous deformation with rotation and rheological evolution of the rocks? See Marques et al. (2010)

Polyphase see above. We thank the reviewer for his comment on evolving rheology. We included it in a new paragraph of the discussion section in the new version of the manuscript.

** Highlight, page 1: Schmalholz et al., 2008; Schmalholz and Maeder, 2012;*
This is not boudinage, this is pinch and swell. You should make clear the difference between these two types
We realize that originally these two features were treated separately. However, in his seminal paper Ramberg 1955 showed these structures are related, and only differ rheologically. Consequently, pinch-and-swell structures have for instance been included in the boudin classification scheme of Goscombe et al. 2004. To comply with the established terminology we updated the manuscript as proposed and added an explanatory note as an introduction to the results.

** Highlight, page 1: new toolbox*
Where is this new toolbox?
Read and cite Mandal et al. (2007)
“New toolbox” was changed to “useful toolbox”.

* Highlight, page 1: five different boudinage phases
Why phases?
Phases was changed to sets to avoid implication of non-continuous deformation on the larger scale

* Highlight, page 1: each phase provides insights into the rheology
Where is this insight soundly supported by Physics?
This is a great remark! It has been mentioned in the literature many times that boudins provide insights on rheology, but nobody has as of now managed to provide a full inversion. A quantitative and sound inversion of the rheology is not an easy task and would require numerical models. This is beyond the scope of this particular study but is of course an important and obvious subject for a follow up study. A paragraph was added to the discussion to clarify this.

** Highlight, page 2: this study may help to constrain the nature of East-West shortening of the domain*
How can you do it if you don't analyze and estimate the vorticity of the deformation?
Is it pure shear, simple shear, or both?
We agree that this is a very important question that needs to be resolved in future studies. We added a paragraph to the discussion to highlight this.

** Highlight, page 3: Zircon and apatite fission track data from all tectonic units exposed on Naxos as well as 5 U-Pb ages show a consistent cooling and exhumation scenario: cooling started at ~25 Ma, and continued until ~ 8 Ma (Seward et al. 2009, Brichau et al., 2006, John and Howard, 1995).*
This is not consistent with polyphase deformation, it is a continuum
This may be correct, however the structures in outcrop are consecutive and discrete in orientation over many outcrops. They do not show any systematic rotation or spread within

a set which would indicate a continuous change in the extension direction. So even if the large-scale deformation was continuous, the resulting structures do not reflect this.
An explanatory note was added to the discussion.

* Highlight, page 3: was
were
corrected

** Highlight, page 3: Orientation data was collected in situ*
How did you measure correct orientations on "saw cut surfaces"?
Measurements were taken only where sufficient topography allowed for unambiguous identification of the orientation of structures. For planar, saw cut surfaces this is only possible at corner intersections. Often the marble is conveniently broken off along the amphibolite layers which allows confident and precise measurements. *We added this clarification to the method section.*

** Highlight, page 3: We use cross cutting and interaction relationships to establish a relative temporal order of the structural elements*
Where are the pictures to clearly show this?
A figure with age relationship observations will be included in the revised manuscript.

** Highlight, page 4: The bulk marble appears to have an isotropic texture;*
You don't know that because you did not measure and statistically analyze the measurements
This is correct, due to the large grainsize of the calcite a statistical analysis of the texture is impractical and was not performed. A note on that was added to the text.

** Highlight, page 4: for*
of
corrected

* Highlight, page 4: Spacing
The spacing
corrected

* Highlight, page 4: which
that
corrected

** Highlight, page 4: all thin sections the amphibolite has an isotropic texture*
You don't know that
“isotropic texture” changed to “apparently isotropic texture”

** Highlight, page 4: a*
delete
corrected

** Highlight, page 4: for*
of
corrected

** Highlight, page 4: some*
delete
corrected

** Highlight, page 5: If the distance is high enough, very thin amphibolite layers do not boudinage but act as passive deformation marker horizons in 5 the marble (Fig. 7e).*
This should be carefully discussed
We agree. This phenomenon was very surprising to us and we encountered it regularly in these rocks. Amphibolite layers thinner than about 10mm do not boudinage. Since preparing this manuscript we have analyzed this phenomenon in more detail and were able to reproduce it with discrete element modeling. We will include some of the preliminary findings in the discussion.

** Highlight, page 5: across*
along
corrected

** Highlight, page 5: isotropic texture*
You don't know that
it is correct that we have not conducted a proper textural analysis. We have reformulated the section to make this clear.

** Highlight, page 5: Wavelength λ of the boudinage correlates with amphibolite thickness and can reach several meters for amphibolites with a thickness of a few decimeters*
Cite previous work analyzing this relationship (e.g. Marques et al. 2010, 2012, and references therein)
We will add a paragraph to the discussion elaborating on the thickness/width relationships of the boudins and their implications, including the given references.

** Highlight, page 5: Estimated from the length of the pinches (M') and the thickness difference between pinches and swells (W/W'), the amount of extensional strain is at least 100%, probably several hundred percent*
Why can extensional strain be estimated this way? How do you know the original thickness of the amphibolite layer? It could have been much thicker
You should read and cite Mandal et al. (2007)
Since the original thickness is unknown, as you pointed out, we are only able to estimate the minimal value of layer parallel extension by comparing the combined mean length of pinches and swells to the length of the pinches. The sentence was modified to make this clear.

** Highlight, page 5: (sλ) overprint lλ*
This should be shown clearly and unambiguously with an image, not stated with words
We added another figure with more clear age relationships.

** Highlight, page 5: in both sλ boudin necks have the same orientation, showing that sλ is clearly younger*
This argument must be clarified
An explanatory note was added to the paragraph. Together with the new figure, this argument should become clear now.

** Highlight, page 5: is dipping*
dips
corrected

** Highlight, page 5: (20°- 45°)*
This is not shallow
The adjective was removed.

** Highlight, page 5: estimated minimum of 50%*
Why is this extensional strain much smaller than in the long wavelength P-a-S?
This is a good question. The decrease of strain from is a trend in all consecutive generations of boudins. Our interpretation (as it is included in the discussion) is that the high strains of lλ are a result of the synmigmatic convergent flow during M2b metamorphosis. The later generations of boudins formed at lower temperatures on the retrograde path after solidification of the surrounding migmatite where strain is generally lower and not a result of convergent flow anymore but rather N-S extension.

** Highlight, page 5: suggest a*
suggests
delete "a"
corrected

** Highlight, page 5: ductile deformation of both amphibolite and marble.*
But the viscosity cannot be the same
This is true, we do not claim it is. We added a respective note.

* Highlight, page 5: which is interpreted as a granular flow deformation of the amphibolite postdating static recrystallization
This is a data section, and no argument is given to support this interpretation
We moved the interpretative parts to the discussion.

** Highlight, page 5: 40 deformation. This granular flow could have occurred in the final stages of s λ, or, during the domino boudin phase (see below) when amphibolite layers already thinned in the l λ, and s λ, were more susceptible to*
Idem
We moved the interpretative parts to the discussion.

** Highlight, page 6: on*
at
corrected

* Highlight, page 6: both S and Z chirality
What can you infer from this?
Our interpretation on the changing chiralities is given in the discussion.

* Highlight, page 6: an, statically
an, statically
corrected

* Highlight, page 6: Brittle boudins
These are true boudins
The manuscript was changed accordingly to use the established terminology for pinch-and-swell and boudins.

** Highlight, page 6: but by far not in all.*
Delete
deleted

* Highlight, page 6: θranging
separate teta from ranging
corrected

* Highlight, page 6: -
replace with to
corrected

* Highlight, page 6: dramatically
Avoid these adjectives and quantify grain size reduction
We agree, a quantification was added.

* Highlight, page 6: to each other.
with one another
corrected

* Highlight, page 7: The length to width ratio (L/W)
Marques et al. (2012) analyzed this relationship in boudins
A paragraph on the L/W ratios of the boudins will be added to the discussion

** Highlight, page 7: Looking down on the quarry floor, over distances up to 30 m, within one amphibolite layer the sense of block rotation and shear displacement is commonly consistent. Along one amphibolite layer, antithetic shear fractures and block rotations in the opposite sense are rare. Adjacent amphibolite layers usually show the same sense of block rotation and shear displacement. However, both senses of block rotation and shear displacement are common and these bundles of layers with the same sense of block rotation and shear displacement are usually separated by layers without domino boudins*

Where are the figures to illustrate all this?
The occurrence of both senses of block rotation as well as the consistency of rotation sense within a layer and neighboring layer are shown in figure 7. Unfortunately, no location was found where the change in rotation sense across several amphibolite layers could be sufficiently documented on a photo.

* Highlight, page 7: Domino boudin necks
What do you mean by attitude of boudin necks?
As far as we can see the term “attitude of boudin neck” was not used in the manuscript.

* Highlight, page 7: due to the variation discussed above
What variation?
The sources of strike variation are variance in θ as well as the occurrence of dextral and sinistral rotation and varying amounts of rotation. The sentence was rewritten.

* Highlight, page 8: Integrating the observations
You initiate the discussion with a major conclusion. However, you never say how you do it, and do not show images with clear and unambiguous age relationships.
We added a new figure with age relationships and changed the introductory sentence accordingly.

* Highlight, page 8: marble
Calcite can creep at room temperature depending on strain rate and pressure
This is true of course,

* Highlight, page 8: have
Delete
deleted

* Highlight, page 9: have
Delete
deleted

* Highlight, page 9: Alsop and Holdsworth, 2006
Marques et al., (2008) showed that this study is wrong. Besides the experimental work, Marques et al. (2008) also analyzed rocks comprising amphibolite layers in marble, similar to the submitted ms., although with very rare boudinage of the amphibolite layers, which could give the authors an idea of the possible rheological behaviours depending on ambient conditions
We will incorporate the findings of Marques et al. 2008 into this part of the discussion.

** Highlight, page 9: General strain conditions with pure shear and a layer parallel simple shear component may have prevailed in the marbles during some deformation stages*
How do you know this? What have you observed/measured/analyzed to support this inference?

We discuss general strain conditions as a possible explanation for the occurrence of asymmetric folds, possibly coeval with boudins). It is correct that we not yet have any supporting evidence, so this is a hypothesis to be tested in the future.

** Highlight, page 9: rotated domino boudins*
How can you rotate boudins in pure shear? In simple shear it is very easy (e.g. Dabrowski and Grasemann, 200
Based on the rotation of the boudins and asymmetric folds we postulate locally deviating simple shear components. In an earlier version of the manuscript we also included several possible mechanisms that might produce these local variations and contradicting rotation senses but removed them from the manuscript since they were purely speculative.

** Highlight, page 9: The possibility that s-folds are an overturned variation of z-folds*
(compare Llorens et al. (2013)) is considered unlikely since no indication for such high shear strains was found
How do you know that?
The possibility is not ruled out completely, but it is considered unlikely: Overturning these folds would either require a massive amount of layer parallel shortening in the respective amphibolite or alternatively a larger scale recumbent folding of multiple layers including, the previously folded layer. No indication for either alternative was found in the study area. The sentence was expanded to clarify this.

** Highlight, page 9: direction*
directions
corrected

* Highlight, page 9: This high variability in orientation requires low differential stresses, and sigma 3 approximately normal to the amphibolite layers
Why?
Pegmatites intrude following the mechanics of hydrofractures, propagating normal to sigma 3 (a reference was added). Many Pegmatites occur parallel to the Amphibolites but many other orientations are found which indicates a high variability of the principal stresses.

** Highlight, page 9: indicative for E-W shortening*
Why shortening? Nature can make folds without shortening
This is true, in this particular paragraph we relate to folds and other structures that were linked to E-W shortening by the Authors of the cited studies.

* Highlight, page 17: Brittle boudinage structures are best observed on quarry floors.
Why is that so? This could be a critical observation
This is due to the subvertical orientation of fractures. The caption was changed for clarification.

* Anchored Note, page 22
Impossible to see anything useful on this image
The excerpt was changed to bring the relevant elements of the picture into focus.

* Anchored Note, page 23
Why is the marble layering not folded?
The asymmetric folds are rarely visible in more than one parallel layer. We extended the description to make this clear in the results.

* Anchored Note, page 23
Where is the interference?
As stated in the caption it is almost impossible to distinguish whether a pinch belong to the short or long wavelength pinch-and-swell from the profile section only. We agree that interference is therefore an unsuitable term and rewrote the caption accordingly.

Reviewer 2

** Page 1, line 35: "new toolbox"*

Why new (maybe you want to say "a useful tool")? (Please explain)

We agree, "a useful tool" is a more suitable description.

** Page 5, line 3-5: "If the distance is high enough, very thin amphibolite layers do not boudinage but act as passive deformation marker horizons in the marble"*

What means, "the distance is high enough"? Why "layers do not boudinage but act as passive deformation marker horizons in the marble"?

We consistently made the observation that Amphibolite layers thinner than about 10mm do not boudinage. An exception from this rule is when these thin layers layers are very close to thicker layers of amphibolite (~ less than 1cm) in which case they form harmonic boudins or multilayer boudins with the thicker layer.

** Page 5, Line 17*

add a graph

We can illustrate in a graph how the minimum extensional strain was estimated if this is requested, however, illustrating it on graphically field photograph is challenging since it requires the analysis of very large planar surfaces while at the same time requires detailed oblique and profile view observations to identify the beginning and extent of the pinches. We do not think that a graph would therefore be of much help and, since it does not pose a critical aspect of the study, prefer to not include it in the revised version.

** Page 6, line 7: "Their age relationship with the pinch and swell structures is not fully resolved"*

Asymmetric folds and pinch-and-swell (in the pictures some of these structures seems like shearband boudins) could be cinematically and chronologically related. See, for example, Fig.1 of the following paper: Pamplona J, Rodrigues BC, Fernández C (2014). Folding as a precursor of asymmetric boudinage in shear zones affecting migmatitic terranes. Geogaceta, 55: 15-18

We agree, based on the orientation of some fold axis with the short wavelength pinch-and-swell boudins (which in fact often show signs of shearband boudinage) we suspect a structural relation between them. A paragraph on this possible relation was reintroduced to the discussion, including the given reference.

* Page 6, line 26: "and hairline veins" I do not understand the reasons why you included these structures in this section (3.6). In my opinion these structures are late extensional veins (nothing more). I suggest the following structure: 3.6 Brittle boudins 3.6.1 Domino boudins 3.6.2 Torn boudins 3.7 Hairline veins

The grouping of the structures and especially the terminology used for the chlorite filled hairline veins /boudins was in fact subject of some discussion. The structure can be treated and described either as boudins or veins but both approaches have their shortcomings. Their occurrence is always linked to amphibolite layers and the veins disrupt the amphibolite with a regular spacing what qualifies them as boudins. Threating them only as late extension veins would obfuscate the fact that they (just as the other sets of brittle boudins) need the amphibolite as a brittle heterogeneity to occur. However, the chlorite filled necks often extent into the surrounding marble so it is much more convenient to threat the as veins in the description of their features since the layer that is boudinaged is so poorly defined. Based on these arguments (which we elaborate in more detail in the revised version in section 3.6.3) we would prefer to keep the structure in its current form.

* *Page 7, line 1-2: "The length to width ratio (L/W) of this generation can be as low as 1 but more commonly it is in the order of 3-5 and in extreme cases >8."*
Please, cite other authors for comparing results (you could compare graphically your results with other authors – Make a new figure with a graph).
We added a paragraph in which the range of length to width ratio in comparison to other authors is discussed. Considering the number of existing figures and the fact that a statistically significant collection of ratios was not yet compiled we would refrain from plotting the ratios in a separate graph.

- *Page 8, line 8-11 (introduce a new figure: a sketch that shows the relationships between all the generations of boudinage).*
A schematic 3D sketch of the generations was added illustrating their expression in profile and map view as well as their angular relationship.

- *Page 9, line 8-10: "General strain conditions with pure shear and a layer parallel simple shear component may have prevailed in the marbles during some deformation stages"*
Insert references or explain how do you know this.
We discuss general strain conditions as a possible explanation for the occurrence of asymmetric folds, possibly coeval with boudins). It is correct that we not yet have any supporting evidence, so this is a hypothesis to be tested in the future.

- Page 9, line 10: "domino boudins occur in both polarities" I do not understand this phrase, because domino boudins only occur in non-coaxial shear! Please explain!
"Polarities" relate in this context to the shear sense indicated by the rotation of the blocks (e.g. sinistral or dextral, looking downward). The occurrence of both rotational senses in the field is interpreted to indicate locally deviating non-coaxial shear components.

Figures (The comments/corrections of the figures are, also, in the supplement pdf file)

Figure 1: Add to Figure 1, for example in left corner, a country/regional general map for location of Naxos Island. Add the pattern that you have in the geological map to the Tertiary sediments. The granite symbol is hardly visible in the geological map. Use only the color.
Figure 2: Delete figure 2a (this "Geoeye satellite image", it is unnecessary!) Add a legend to the geological map: Rocks Structures Outcrops locations (1-35)
Figure 4.1: This picture had not enough quality. The structures are not visible. Please change or improve the quality of this picture.
Figure 5b: Show in the picture the interference between the two generations of pinch- and-swell boudins (you could make a sketch to help).
All suggested changes on Figures and captions were implemented.

Technical corrections:
All technical corrections from the annotated manuscript were included accordingly.