

Interactive comment on “From subduction to collision in the Parautochthon and autochthon of the NW Variscan Iberian Massif” by Francisco J. Rubio Pascual et al.

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Reply to the comments by Referee #2, Alicia López Carmona (14 April 2020).

We sincerely acknowledge the review work and constructive comments made by López Carmona. We will try to reply here the general comments. Really most of the suggested corrections in the RC #2 annotated PDF supplement are correct and reasonable, specially those referred to clearly distinguishing new contributions from previous works by other authors, and including formal and English corrections that we truly appreciate and will be introduced in the corrected version of the manuscript.

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About your introductory resume:

In your lines 3-4 you write "...concluding [the authors] that the uppermost parautochthonous nappe, composed of Upper Paleozoic syn-orogenic rocks with high-pressure relicts..." but we do not conclude, even mentioned, that in any place: In our lines 2-23 we write that the uppermost nappe is made of Lower Paleozoic rocks, and only the other upper and the lower parautochthonous nappes are formed by both, Lower Paleozoic pre-orogenic and Upper Paleozoic syn-orogenic rocks. It is the same in L86-90. Besides, in L112-114 we write about the syn-orogenic deposits covering the CIZ autochthon.

On the specific comments by sections:

Section 1

L43 about correlation between the GTMZ and the OMZ:

You have to note that we say "other correlatable Variscan suture outcrops", avoiding using "same suture". The cited GTMZ and OMZ outcrops are, at least, correlatable in matter of HP conditions and age of HP metamorphism. However, in view of your comment and other possible misunderstandings by other readers, we will better eliminate the whole reference to other suture outcrops. Thank you.

L47-48 about misinterpretation of references from the Armorican Massif:

We never wrote that Pitra et al. (2010) (or Ballèvre et al.) ascribed Barrovian metamorphism to the parautochthonous Mauves Unit. Effectively, you are right, it was considered as a parautochthonous unit beneath the Lower Allochthon in Ballèvre et al. (2009) and Pitra et al. (2010) and it was later attributed to the Lower Allochthon in Ballèvre et al. (2014). Pitra et al. (2010) obtain wide metamorphic conditions < 10 kbar and < 540 °C for the matrix foliation of the albite-bearing schists, but they textually suggest an earlier higher pressure event related to the inclusions in the albite porphyroblasts, and that is our reason to cite the work. Effectively, there is a change of nomenclature

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in Ballèvre et al. (2014), and both parautochthonous and Basal Units are then grouped as Lower Allochthon, but the question is not that, because the albite-bearing schists of Mauves, former parautochthon, are anyway correlated by you (as co-author) with the HP Basal Units of Galicia. So that, as in the case of our work, there are units sometime considered as parautochthon that experienced HP-LT metamorphism, and it was not always considered that way in some places such as the GTMZ, even my self as co-author, for example, in a reference cited in the manuscript. We will introduce the references by Ballèvre et al. (2009; 2014), thank you.

Section 2

About sorting of descriptions following the same scheme in all sections and subsections:

Yes, you are right, thank you. We will try to homogenize the content of the subsections, at least for the Parautochthonous Domain and the autochthon. The allochthons are a very more complex issue, and only the Basal Units were of interest in our work.

About including a table summarizing deformation phases, foliations, metamorphic events and ages:

It is a very good idea, thank you. We will include it.

About missing references:

You are right, references will be included. Thank you very much.

Section 3

About clarifying original contributions or taken from reference structural data in the text, figures 2, 3 and 5 (or in a new one), cross sections, structural data and outcrop images:

You are right. We must clarify what is what and to include the references when necessary. We are going to include new figures with more detailed structural map at least for the Fumaces Thrust and the Arnoia Detachment areas. Including cross sections

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in these new figures would be a good idea and we will try to do it. We consider that adding a new table in section 2 and at least two new figures in section 3 are necessary enough. Including also some outcrop images probably does not deserve the length increase, but as you also ask for more images further in Section 5, we will try to include some of them, thank you.

About “tedious” regional terminology, standardising the internal divisions of the Parautochthon and establishing their connections with all the existing tectonostratigraphic models:

There are few tectonostratigraphic models apart from those derived from Rodrigues et al. (2003) in Trás-os-Montes, which is already treated in the text. Most of the Parautochthon in Galicia is yet commonly considered a continuous stratigraphic sequence (with little exceptions: Valverde Vaquero et al. (2005) in Cabo Ortegal; Farias and Marcos, 2019 in the Alcañices Synform). We have tried to avoid as much as possible to name or describe formations. Our study areas in the Parautochthon are focused in the SACG, Verín Synform, Bande-Celanova Dome and, with a minor extent, the Cabo Ortegal area. The three first zones have been commonly described in literature following the Santabaia-Nogueira-Paraño Gps stratigraphic classification (there was not any structural subdivision), and it has been treated in our work. The fourth one has an old former different stratigraphic subdivision (Loiba and Queiroga series, Arce Duarte and Fernández Tomás, 1976; Arce Duarte et al., 1977) that we have not cited expressly, but we used more recent works (originally based on that subdivision, references therein) that present chronological data with structural implications which are our real interest and so are exposed in our manuscript. Other local stratigraphic or petro-stratigraphic units have been cited exclusively because of its structural or metamorphic relevance. To introduce a comprehensive table of formations is out of our scope, and it inevitably would lead to an even more “tedious” list of local names.

About L150-152 and misinterpretation of Dias da Silva et al. (2014a, 2014b, 2016):

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Please, contemplate carefully this question. The limit between the Centro-Trasmontan Domain (allochthons) and the Peri-Trasmontan Domain (the Parautochthon) was first established in the Main Trás-os-Montes Thrust of Ribeiro et al. (1990), a well mapped structure in the whole region since Ribeiro (1974). The works by Dias da Silva et al. in the eastern area of Morais concluded that most of the previously considered Lower Allochthon (e.g. Ribeiro et al., 2006) is currently a part of the parautochthonous section. The lawsonite-bearing rocks (HP) described in that area by Schermerhörn and Kotsch (1984) -and cited in their work-, were then interpreted as belonging to a possible, thin, uppermost unit of the top of the Parautochthon (please see Fig. 1 in Dias da Silva et al., 2014b). This conclusion was also extended to the rest of Morais (except for the Valbom dos Figos blueschists and Mascarenhas rocks), and it was also extended to the Bragança Complex, where all the former Lower Allochthon was considered a part of the Parautochthon in Dias da Silva et al. (2014a, please see Fig. 1), or alternatively it was restricted in 2014b (please see Fig. 1) to the uppermost part of the previously commonly considered LA section, with not any tectonic boundary described there. So that, we consider to be right when we write that, according to those works, i) most of the former Lower Allochthon is considered as a part of the Upper Parautochthon, ii) there is not any other recognized basal thrust structure for the Lower Allochthon of the Bragança Complex, and iii) some of the HP-LT rocks of the Morais Complex stay in the Upper Parautochthon. This said, it must be clear that the main results of Dias da Silva et al. in eastern Morais are not in contradiction with ours, as our conclusion is also open to consider an uppermost parautochthonous unit with HP rocks.

Section 4

About the title “constraints” when it is a “synthesis of the background” including original contributions disguised/unnoticed:

Yes, you are right. Thank you very much. We will change the title to “Tectonometamorphic background and new data” or similar, and then we will separate clearly both

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blocks of information in every subsection.

About L226, to specify the reasons for a likely continuation of the HP nappe of the SACG in the uppermost part of the Paraño Group in the Verín Synform:

Well, the next sentences in the manuscript pretend to explain those reasons. L227 “Farias (1990) also mentions there the presence of albite porphyroblasts with an internal schistosity of aligned micro-inclusions of quartz, chlorite and white mica”, that is, the presence in both places of albite porphyroblast-bearing schists. L228-229 “The Fumaces Thrust of Verín has outcropping continuity into the basal thrust of the lower allochthonous Centro-Trasmontan Complex with HP-LT rocks”, and L230-231 just add another element of possible continuity between the uppermost part of the Paraño Group in the Verín Synform and the LA in Portugal. From this, the upper part of the Verín Synform seems to have continuity in Portugal through an unit that have been identified for many authors in Portugal as a Lower Allochthon that includes HP-LT rocks, and both sections present alkaline-peralkaline rocks. Thus, uppermost SACG and uppermost Verín Synform-LA in Portugal seem to share not only some characteristic type of rocks, but also the early HP history. Probably you mean that both are, at last, just one reason, if you consider that the albite-bearing rocks are HP rocks, and in that case you are right, so we will suppress “For several reasons”. Thank you.

Section 5

About relating the petrographic images in figure 4 and the chemical analyses in table 2, and also indicating, in figure 4, to which sample does each image correspond. To show images of the albite porphyroblasts inclusions showing white mica crystals:

Ok, if you consider it necessary, though it introduces again a problem of length. We used one single picture illustrating an albite porphyroblast, and it was chosen on textural and micro-structural more than mineralogical or probe analyses location criteria. To accomplish with your suggestion, we have to add an extra figure better than replacing pictures. We could also include then some outcrop images (that you asked for above)

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to complete the figure.

About providing a report of the mineral chemistry that matches the P-T constraints. Si values in muscovite:

Maximum Si p.f.u. contents, those used in thermobarometry, are effectively shown in Table 2 as you say, with the complete oxides weight and cations. Albite porphyroblasts are small, the relic schistosity is very thin and rich in organic matter (Fig. 4 caption), garnet and even apparently epidote-free, and everything points to a really low temperature of crystallization. White mica inclusions are scarce and very few times they are sized into the beam diameter. Failed analyses yielded aberrant compositions with high Na₂O content and were easy to discard.

About describing the albite content in plagioclase and comparing this content with those in the samples from the Lower Parautochthon:

The chemical compositions of porphyroblastic albite used in the thermobarometry of the uppermost nappe are also shown in Table 2. We will include in the text some synthetic information about the molecular content in all the analyses we performed: Ab% 98.44 - 99.63 in porphyroblast cores with internal schistosity, 89.94 – 95.94% in inclusion-free rims. Plagioclase is practically absent of the other pelitic rocks in the Upper Parautochthon, and it is present again only in the Lower Parautochthon rocks of medium or high metamorphic grade. In the Arnoia River section these are granoblastic to small porphyroblastic crystals oriented in the matrix foliation (SE1). Oxides composition of the chemical analyses used in thermobarometry are included in Table 3. We can also include in the text that the Ab content in all the performed analyses is 87.06 – 93.96%.

About how are our albite porphyroblasts related to those of rocks belonging to the Basal Units:

Please note L222-224 “Albite-bearing schists are characteristic rocks in the al-

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lochthonous Basal Units, where the porphyroblasts present a more advanced textural development and include more complete HP-LT mineral parageneses (Arenas et al., 1995).” We can also add that those from the SACG are of much lower size, typically below 0.5 mm. About their Ab content, we will include that it is slightly higher than the core compositions of porphyroblasts from the Santiago Unit (> 97%) and close to those from the Ceán Schists. Of course, we will include your references, thank you.

About your Minor comments:

Yes, you are right. We apologize and we will do it, thank you very much.

References not included in the manuscript or the referee’s review

Arce Duarte, J. M., and Fernández Tomás, J.: Mapa Geológico de España a escala 1:50.000, Hoja 8 (7-3), Vivero. Instituto Geológico y Minero de España, Madrid, 45 pp, 1976.

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Ribeiro, A., Pereira, E., Ribeiro, M. L., and Castro, P.: Unidades Alóctones da Região de Morais (Trás-os-Montes oriental). In: Dias, R., Araújo, A., Terrinha, P., Kullberg J.C. (eds), Geologia de Portugal no contexto da Ibéria, Univ. Évora, 85–105, 2006.

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