

## ***Interactive comment on “Alpine tectonic wedging and crustal delamination in the Cantabrian Mountains (NW Spain)” by Jorge Gallastegui et al.***

**Jorge Gallastegui et al.**

jorge@geol.uniovi.es

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We would like to express our gratitude to the anonymous reviewer (#1). for his thorough review. The constructive comments helped to improve the manuscript. In this file, we will reply the detailed comments included in the revision. All changes will be added to the last version of the manuscript. We attach a commented pdf version of the final text after the revision from both reviewers as a supplement file. Lines and pages in our reply refer to those in the supplement file.

### REPLY TO COMMENTS REFEREE 1

I.10 p.1 dip of the thrust is 30 to 36; what is the geometry of the thrust? Is it a ramp or does it form a ramp flat structure? It would be interesting to have a more detailed description of the fault system.

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We agree with your comment and have added in I.14 p1 that thrusts have a “ramp geometry and sole in the boundary with the middle crust.”

I.10 p.2 reactivation of older Variscan structures: what is the criteria to demonstrate that the structures are Variscan?

This statement is taken directly from the two references in the text (Alonso et al., 1996, Pulgar et al., 1999) and is a regional scale conclusion derived from geological maps and outcrops. These authors base their conclusion on observations made in nearby areas with Mesozoic and Cenozoic outcrops such as: 1) The boundary between the Variscan Cantabrian Zone and the Mesozoic Basque-Cantabrian basin where the alpine reactivations of older Variscan structures are affecting the Mesozoic units. This reactivation is evident in the map in figure 1 to the east of ESCIN-2 profile. 2) The deformation of the Meso-Cenozoic Oviedo Basin, to the west of ESCIN-2 profile, which is located in figure 1 but not mentioned in our text and also the deformation along the coastal section. In areas where there are no Mesozoic levels involved in the alpine deformation it is difficult or even impossible to evaluate whether there is any alpine deformation superposed to the Variscan structures or its amount.

I.20 p.6 lower and upper crust: how can they be recognized, based on what criteria?

They can be recognized in terms of differences in reflectivity. We explain the upper-middle crust boundary in section 3.1 (I.8-13 p.5). The upper crust is poorly reflective and extends to 5.5 s, where there is an increase of reflectivity interpreted as the top of the middle crust. The middle-lower crust boundary is not evident in the reflection profile and that is why we don't refer to it in the description. It was included in our model at the depth interpreted in the refraction profile. It is explained in I.24 p.6 that this boundary “was directly taken from the refraction profile described in next section and it was included in the model in order to check the compatibility between refraction and reflection data.” We have added the word “reflective” in I.12 p.5 to emphasize that the whole middle and lower crust are reflective. We have interpreted the lowermost re-

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flective band at 10-12 s as the reflection Moho in the base of the middle-lower reflective crust.

I.25 p.6 boundary between upper and middle crust: how defined? What is the nature of this interface?

We have interpreted this boundary at 5.5 s in the stack section (I.8 p.5) which is equivalent to 14 km in the modelled section (I.13 p.9). This boundary is interpreted at that depth where there is an important increase in reflectivity and it is coincident in depth with the boundary between the upper and middle crust in the refraction profile (Fig. 9a). It is also the boundary where the upper crust thrusts sole (I.13 p.9) and the local depth of the seismic zone (we have added a reference from Llana-Fúnez and López-Fernández, 2015). We don't know the reason for the reflectivity increase or the nature of this boundary. Articles that deal with the refraction experiment do not argue the nature of the boundary either.

I.25 p.8 What is "Campillo uplift"?

The Campillo uplift is the uplift of the Meso-Cenozoic succession in the hanging wall of the crustal thrust that we name C (Figs 4 and 6a). We have included a longer sentence in I.31 p.8 to explain it and added a reference and named it as "c.u." in figure 6a and its figure-caption I.15 p.16.

I.30 p.8 Band D (how interpreted)

Band D is interpreted from a series of N-dipping short reflections, parallel to band C, which is more conspicuous. In this sense we have added this characteristic in I.11 p.5 "...and the latter (D) is less conspicuous and fades...". We have to say that this band of reflections is more evident in larger plots of ESCIN-2, but unfortunately it is slightly less visible in the reduced figures built for publication. Anyway, we think that it can be seen in figure 6.a.

I.30 p.9 The comparison/differences with the Pyrenees (and other chains?) need to be

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better developed and can not be based only on statements.

We refer to the similarities of the Pyrenees and Cantabrian Mountains in the introduction (section 1) and in the discussion (section 5). In the final part of the introduction we give references to articles that deal with the similarity and continuity of the crustal thickening between the Pyrenees and Cantabrian Mountains (added one more) and in the discussion we describe briefly the structure of the Pyrenees after the description of the structure in the Cantabrian Mountains. So we think that we base the comparison and differences on results from other experiments described in the references included. Any reader can refer to those articles for more detailed descriptions. We have deleted the reference to the Alps because it is out of the scope of this article to compare it with another mountain belts.

I.20 p.10 Crustal roots of the Pyrenees are connected to those of the Cantabrian Mountains (this is neither shown nor is there a reference that supports this statement).

We think that this statement is well supported by a number of references in the text: 1) In section 1 we give three references of studies that have demonstrated this continuity, based on different experiments (I.29-p.2: "Pedreira et al. (2003, 2007) and Díaz et al. (2012) proved that this structure extends eastwards..."). 2) In I.33-p.2 there are two more references, in the original text, and we have rewritten the sentence to make it clearer "Crustal depth models (Fig. 2) compiled from deep sounding experiments by Gallastegui (2000) and by Díaz and Gallart (2009) also show: i) the crustal thickening, with Moho depths up to 50 km in the NW of the Iberian Peninsula and ii) the continuity of this E-W crustal structure from the Pyrenees to the Cantabrian Mountains".

I.25 p.10 Westward migration of the Alpine deformation: what is the evidence? Provide either observations or references

Thank you for the comment, we did not include references to support this statement. We have added references from three studies in section 5 (I.3-6 p.10) that have discussed the westwards migration of the onset of deformation from the Pyrenees to

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the studied area and even further west, in the westernmost areas of the Cantabrian Mountains: 1) Teixell, 1998, 2) Gallastegui, 2000, 3) Martín-González et al 2014.

Please also note the supplement to this comment:  
<http://www.solid-earth-discuss.net/se-2016-23/se-2016-23-AC1-supplement.pdf>

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