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Interactive comment on "A reconstruction of Iberia accounting for W-Tethys/N-Atlantic kinematics since the late Permian-Triassic" *by* Paul Angrand et al.

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Responses to the major points

We thank Alexander L. Peace for his is a very constructive review that led us to improve the manuscript, in particular the presentation of the methodology. Find below our responses to the major points raised by the reviewer and further minor points.

1. Description of the reconstruction method

We add a dedicated 'Methodology' section before the section 'Kinematics of Iberia between Atlantic and Tethys'. In this new section we present the published kinematic

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models used in our reconstruction and the modifications we made. We added a new figure to present the models from the literature and a new table to present the rotation poles of the main plates of our GPlates model.

2. Kinematics of minor plates

a. Definition of an independent plate

A very interesting point raised in this comment is about the definition of what is an individual plate. We define Ebro as a continental block rather than an independent plate. We think that this definition is better appropriate than 'plate', as its motion cannot be simply related to the forces typically driving lithospheric plates such as mantle convection, slab pull, ridge push etc. No localized plate boundaries can be defined such as spreading centers or subduction zones. Rather, the Ebro block represents a rigid continental body surrounded by deformed areas moving independently between 'plates'. Further study is required to fully understand the origin, nature and evolution of the Ebro block and we cannot answer to these questions in the present manuscript.

In the light of recent publications (e.g., Nirrengarten et al., 2018; Peace et al., 2019a), which show the importance of intra-plate deformation in plate kinematic models, the definition of what is a tectonic plate needs to be thought not only in term of continental region bounded by oceanic crust. In our manuscript, we have adopted the terminology "block" to Ebro whereas Europe, Africa and Western Iberia, all bordered by spreading centers, are plates.

b. Strike-slip deformation

Concerning the crustal thickening related to the strike-slip deformation, we also experienced difficulties to accurately represent the strike-slip deformed areas using the GPlates topological network over such large distances (∼200 km). This results in inappropriate mesh and local high strain (both compressive or extensive). The precise study of these deformed areas is out of the scope of this paper. However, this is something we are working on. We would be very interested to discuss this further in order to establish a proper methodology that would apply to strike-slip settings.

c. Breaking Iberia into small blocks

Recent works that separate the Ebro continental block from Iberia (Tugend et al., 2015; Nirrengarten et al., 2018) are presented in the Introduction. We add a sentence in the discussion to better say that the conclusion about breaking Iberia into smaller blocks supports previous works. According to Referee #1 comments, we also better discuss the nature of the Iberia-Ebro tectonic boundary. 'Our results support recent studies (e.g., Tugend et al., 2015; Nirrengarten et al., 2018) that postulate that breaking Iberia into smaller blocks results in more realistic models.'

d. N Atlantic blocks

The N Atlantic blocks (Flemish Cap, Orphan Knoll, Porcupine) are included in our GPlates model. These blocks follow the kinematics of Peace et al. (2019) although they are not distinctly represented (they are delimited by the background diffuse area and the fault features), nor studied with the same intention, in our study. In the revised manuscript we make an effort to better represent these blocks in the figures but we do not want to overload the figure too much.

Responses to the minor points

L 3: we replaced 'rift systems' by 'oceanic systems'

L 4: we shortened this sentence: "The Late Permian-Triassic Iberian rift basins have accommodated extension, but. . .Âă"

Introduction: "Global plate tectonic reconstructions are mostly based on the knowledge and reliability of magnetic anomalies that record age, rate and direction of sea- floor spreading (Stampfli and Borel, 2002; Müller et al., 2008; Seton et al., 2012). Where these constraints are lacking or their recognition ambiguous, kinematic reconstructions rely on the description and interpretation of the structural, sedimentary, igneous and metamorphic rocks of rifted margins and orogens (e.g., Handy et al., 2010; McQuarrie and Van Hinsergen, 2013). However, the required quantification and distribution of finite strain into deformed continents remain often uncertain due to the poor preservation of pre-kinematic markers."

L 17: cf Introduction.

L 20: cf Introduction.

L27-29: done

L 29-30: "Because of the lack of geological constraints about the timing and localization, this displacement has been supposedly exported along the North Pyrenean Fault."

L 46: Reworked based on Referee #1's comments.

Section 2: we reworked this section based on both referees' comments.

L 60: This is not a quote.

L 66: Now reads as follows: 'Crustal thinning, attested by thick late Permian-Triassic detrital rift-basins deposited above an erosive surface, is well documented on seismic lines along the Atlantic margins (Fig. 2): Nova Scotia-Moroccan basins (Welsink et al., 1989; Deptuck & Kendell, 2017; Hafid, 2000); Iberia-Grand Banks (Balkwill & Legall, 1989; Leleu et al., 2016; Spooner et al., 2018); southern North Atlantic (Tankard & Welsink, 1987; Doré, 1991, Doré et al., 1999; Štolfová & Shannon, 2009; Peace et al., 2019a; Sandoval et al., 2020); North Western Approaches (Avedik, 1975; Evans et al., 1990; McKie, 2017; North Sea, McKie, 2017; Jackson et al., 2018; Hassan et al., 2019; Phillips et al., 2019).

Onshore Iberia (Arche & López-Gómez, 1996; Soto et al., 2019) and in the Pyrenean-Provence domains (Lucas, 1985; Espurt et al., 2019; Cámara & Flinch, 2017; Bestani et al., 2016) (Fig. 1b), an angular unconformity is observed between the Paleozoic and the Permian-Triassic strata (Fig. 3).'

L 83; L 87: Now reads as follows: 'An expression of the continued lithospheric thinning and thermal instability associated with high heat flow during the Permian (McKenzie et al., 2015) and the Triassic (Peace et al., 2019b, and references therein). Lithospheric extension prior (or associated with the premises of the subsequent) Early Jurassic continental breakup in the Central Atlantic then favored drainage of mantle melt reservoir (Silver et al., 2006; Peace et al., 2019b), attested by the very rapid emergence of the widespread tholeiitic magmatic CAMP (Central Atlantic Magmatic Province) event at the Triassic-Jurassic boundary (∼200 Ma) in the Central Atlantic (Olsen, 1997; Marzoli et al., 1999; McHone, 2000). The CAMP extends to Iberia as large-scale volcanic intrusions such as the Messejana-Plasencia dyke (Cebriá et al., 2003) in Iberia and the Late Triassic-Early Jurassic ophitic magmatism in the Pyrenees (e.g., Azambre et al., 1987). Extension and salt movements in the North Sea basins during the Late Triassic further point to the propagation of the North Atlantic rift (Goldsmith et al., 2003).'

L 94-95: Now reads as follows: 'Two hypotheses may be invoked to explain the difference with the McKenzie model. (1) Reduction of mantle density during lithospheric thinning, due to mantle phase transitions to lighter mineral phases because of crustal attenuation (Simon and Podladchikov, 2008) and/or due to the trapping of melt in the rising asthenosphere before breakup (Quirk and Rüpke, 2018) in addition to magmatic re-thickening of attenuated crust by underplating. (2) Another possible hypothesis for the Permian-Triassic topographic evolution...'

L 96: done

L 99: done

L 99-100: Now reads as follows: 'Another possible hypothesis for the Permian-Triassic topographic evolution of the Iberian basins relies on the complex post-Variscan evolution of the Iberian lithosphere. Recent studies have shown that during the existence of Pangea supercontinent (∼300 to ∼200 Ma), temperature in the asthenospheric mantle increased due to the thermal insulation by the continental lid (Coltice et al., 2009; Ganne et al., 2016). This thermal insulation would be responsible for the accumulation of magmatic material of the CAMP (see Peace et al. 2019b, and references therein). Such mantle thermal anomaly could have further inhibited lithospheric mantle re-equilibration after late-Variscan mantle delamination over a long-time span. This model requires a strong impermeability of the overlying lithosphere (Silver et al., 2006). Once mantle temperature dropped as a consequence of the Pangea breakup and magmatic emission at the Triassic/Jurassic boundary, lithospheric mantle started to cool and thicken, causing isostatic subsidence of the thinned Iberian crust and resulting in topographic drop.'

L 110-115: This part is mostly a description of our figures. We however added some references.

L 121-122: We calculated the stretching factor (so called beta factor) from from the tectonic subsidence, as defined in Watts (2001).

L 153; L 155; L 165; L 220: done with the Methodology section.

L 239: done

L 256: Now reads as follows: 'To revolve several long-lasting problems of the Mesozoic kinematics of Iberia, we propose to better consider: the late Permian-Triassic basins evolution in Iberian kinematic reconstructions, the role of the Ebro continental block in the partitionning of the deformation, and to replace Iberia in a larger-scale plate reconstruction of the Atlantic and Tethys domains. We show that: (1) left-lateral strike-slip movement did occur in the Pyrenees from the late Permian to the Early Cretaceous but ended as the Bay of Biscay opened, (2) late Permian-Triassic extension in the Atlantic and Iberia (including Ebro) is key to quantify the strike-slip movement in Iberia that is otherwise not well resolved from the geological constraints in Iberian basins and from full-fit reconstructions in the Jurassic. Salt tectonics that decouples syn-rift Iberian basins evolution from their basement likely explains the lack of geological constraints.'

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Figures: We increased font size and better described the figures and subfigures in the captions.

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