Answers to reviewer RC2 Eline Le Breton

We thank reviewer Eline Le Breton for the review and her fruitful comments that in our opinion improve the manuscript.

We place the comments of RC2 in black and our answers and changes to the manuscript in green letters.

Referee comment on "Basin inversion: Reactivated rift structures in the Ligurian Sea revealed by OBS" by Martin Thorwart et al., Solid Earth Discuss.,

https://doi.org/10.5194/se-2021-9-RC2, 2021

This manuscript is a short paper presenting seismic activity in the Ligurian Sea, detected by the recently deployed AlpArray seismic network (offshore component LOBSTER), and therefore fits very well with this special edition of Solid Earth. The data and results are very interesting as it shows clusters of compressive earthquakes in the center of the Ligurian Basin, suggesting inversion of this part of the basin, and at intriguing high depths (10-16 km; lower crust - upper mantle). However, the authors need to better present/discuss the uncertainties of the method applied and their results, and improve the discussion of their results in terms of rift-related structures and strength of the lithosphere (see main comments below). Therefore, I suggest major revision.

Main comments:

- Section 3 - Data, methods & results: Section 3 lacks information on the uncertainties of the method applied and the results, especially regarding the depth of earthquakes and the orientation of the fault planes, which are essential to assess/support the interpretation in terms of rift-related structures and rheology that follows in section 4. Table 1 provides uncertainty range on the depth of each event but it is not explained how this was estimated?

We added the horizontal uncertainties in Table 1 and inserted a second table with strike directions and uncertainties. Programs that were used to estimate the uncertainties are named in the text. We added the sentence in section 3.2: "*Strike directions and their uncertainties are presented in figure 4c. The uncertainties result from a systematic grid search for polarity and amplitude ratios using FOCMEC. Afterwards, the 20 best possible solutions for each event were averaged and the standard deviation was calculated (Tab. 2).*". We added the section Appendices to provide more information on the data quality and results.

- Section 4.2 – Orientation pre-existing rift-related faults: the title of section 4.2 should be changed. This studies provides insight on the present-day seismic activity of the basin but not on the rifting history. The authors discuss here the orientation of the faults obtained from the focal mechanisms of the earthquakes and that they interpret to be inverted, pre-existing rift-related faults. I agree, a change of strike from c. SW-NE to more SSW-NNE may reflect (not 'mimic') the rotation of normal faults formed during rifting during the CCW rotation of Corsica-Sardinia towards the SE relative to Europe. But this paragraph needs rephrasing and more information should be given, e.g. the exact strike (and dip?) of the fault planes obtained from the focal mechanisms. The authors should also quote papers concerning the evolution of continental rifting that shows younging of rifting-related structures towards the center of the basin (e.g. Brune et al. 2014, Nature communications) to support their interpretation. Also, the rotation of Corsica-Sardinia, was not only between 21-16 Ma but started with continental rifting at about 35-30 Ma, as indicated by the age of syn-rift sediments (e.g. Séranne 1999,

J. Geol. Soc. London; Jolivet et al. 2015, Tectonics; note the total amount of rotation between 35-0 Ma is estimated to a minimum of c. 53°, Le Breton et al. 2017). The phase between 21-16 Ma is often interpreted as the phase of oceanic spreading in the Liguro-Provencal Basin (e.g. Speranza et al. 2002; Le Breton et al. 2017), as suggested by the age of post-rift sediments along the margin of Gulf of Lion (e.g. Séranne 1999; Jolivet et al. 2015) and Sardinia (e.g. Sowerbutts and Underhill, 1998, J. Geol. Soc. London).

We changed the title to "*Orientation of pre-existing rift-related faults*". We changed "mimic" to "*reflect*" in the abstract and conclusion. We added the reference to Brune et al. (2014) and added the sentence in the discussion to support our interpretation: "*Thermo-mechanical modelling suggests that rifting-related structures get younger oceanwards (Brune et al., 2014).*". We rephrased the section on the rotation angles and timing.

- Section 4.3 – Rheology of the lithosphere: This section is important as the depth and location of the earthquakes in the upper mantle, in the middle of the basin is indeed quite intriguing. First, the author should better present the uncertainty on the nature of the crust and depth of crystalline basement (CB on Figure 5) in this part of the basin. Then, they discuss the seismicity in terms of strength of the lithosphere. However, Handy & Brun (2004, EPSL) discussed that seismicity is an ambiguous indicator of strength and proposed that earthquakes are more reasonably interpreted as a manifestation of transient mechanical instability within shear zones and may be used to locate active weak zones within the continental lithosphere. This should be mentioned and discussed here, as shear zones commonly form through lower crust-upper mantle during continental rifting (see for example Naliboff et al. 2017, Nature communications). Finally, when discussing the strength of the lithosphere, temperature is indeed an important parameter but the discussion here is not clear. Why does stretching of the lithosphere would cause "lower" temperature at the crust-mantle boundary (l. 229)? Stretching involves thinning of the lithosphere thus increasing of the geotherm, which is reflected by higher heat flow, as mentioned later in the text (l.248-253). This is contradictory and should be clarified.

We added to the discussion the uncertainties of the model for the crystalline crustal thickness: "*The crustal structure in the vicinity of clusters C1 and C2 is well imaged by the LOBSTER seismic refraction profile p02 (Dannowski et al., 2020)**. Uncertainties remained for the depth of the crystalline basement and the thickness of the crystalline crust, while the depth of the crust-mantle boundary is well imaged. The study** provides no indication of a high amount of mantle serpentinisation at its southern end.*".

We added Handy and Brun (2004) to the discussion which indeed helps to make our argumentation clearer. The seismicity is not reflecting strong lithosphere but rather weak zones in a possibly strong lithosphere. The high mantle S-wave velocity (Vs=4.7) and the low Vp/Vs ratio (1.72) argue for a strong lithosphere. We also rephrased the conclusions and abstract according to the new discussion: "*~~The observed cluster events~~A high mantle S-wave velocities and a low Vp/Vs ratio support the hypothesis of strengthening of crust and uppermost mantle during rifting-related extension and thinning of continental crust.*".

We rephrased according to the reference to write clearer why crust can strengthen during extension: "*Stretching of the lithosphere will cause **cooling of rocks within the crust and result in a decrease of pressure** ~~lower temperatures~~ at the crust-mantle boundary, which in turn, will strengthen the entire crust **(Pérez-Gussinyé and Reston, 2001)**.*"

Specific comments:

Abstract (lines 20-22) and Conclusions (lines 259-263) need to be improved/rephrased (see main comments above). For example, I would not say 'away from the abandoned rift' but away from the center of the rift basin; 'mimic' -> 'may reflect'

Changed to "*rift-related*", "*rift basin*" and "*may reflect*"

Line 35: the entire basin might be under compressive stress but the inversion is mostly observed along the margins of the Tyrrhenian Basin

Rephrased: "*… of the ~~entire~~ basin **that is mainly observed along the margins** (Zitellini et al., 2020)*.".

Line 45: 8 months – precise 2017-2018

Added

Line 52: rollback of the Apennines, Calabrian and Gibraltar subduction zones

Added

Lines 53-54: south-eastward migrating (or retreating) Apennines-Calabrian arc (Frizon de Lamotte et al.)

Changed as proposed

Line 56: Alboran Basin: c. 25 – 8 Ma (see for example Comas et al. 1999, Proceedings of the Oceanic Drilling Program, Scientific Result, Vol. 161)

Changed and Reference added

Lines 62-63: I would call it Liguro-Provencal Basin (SW part), not Balearic Sea. Gailler et al. 2009; Afilhado et al. 2015; Moulin et al. 2015 are geophysical studies between Gulf of Lion – Sardinia, which is the southwest part of the Liguro-Provencal Basin. And they mentioned "atypical" oceanic crust, it should be mentioned.

Changed and added 'atypical'

Line 70: Gattacceca et al. (2007, EPSL) should be also mentioned here.

Added

Lines 73-75: please add time constraints here, since when the opening of the Tyrrhenian Sea ceased?

Added "***slowed down or** ceased*" to express that it is very recent if it ceased.

Lines 75-76: today

Added

Lines 180-181: The uncertainty on the depth of the crystalline basement (CB on Figure 5), especially for this part of the profile where the distinction between sediments and thinned continental crust cannot be done (Dannowski et al. 2020), should be mentioned and discussed (here and/or in section 4).

Added here: "***There remains uncertainty on the depth of the crystalline basement from the refraction seismic study (Fig. 5e) (Dannowski et al., 2020), however, the** ~~The~~ C1 and C2 events …*"

Line 191: How does the counter-clockwise rotation of Adria would generate regional compression in the Ligurian Basin? Larroque et al. (2016) discuss the southward propagation of the deformation from the Alps-Ligurian basin junction to the southern margin of the basin, for me this goes in (1) Africa-Europe convergence.

We only summarise the different observations of motion and this includes the rotation of Adria as a possible source for the compression of the two clusters.

Lines 193-194: Le Breton et al. (2017) and van Hinsbergen et al. (2020) are not really relevant here. Our plate reconstructions do not indicate where the Europe-Adria convergence is accommodated today, but provide information on the long-term plate motion and kinematics. They would be more relevant in geological setting, when presenting the geodynamic evolution of the area over the last 35 Ma.

We agree and removed both works in this context.

Line 195-196: what about the inversion of the northern margin of the Ligurian Basin? (as mentioned in section 2, see also Billi et al. 2011, Bulletin de la Société Géologique de France 182).

We added: "*An analysis of two decades of dense GPS data presents a ~0.4 mm/y motion of Corsica representing a NNW-SSE shortening that is compatible with the tectonic and seismicity observations at the Ligurian margin (Masson et al., 2019).*"

Sentences lines 182-183, 200-201 and 203-204: This is not very clear, do the authors suggest that these earthquakes occur along one fault plane (as projected in their profile AB, l. 200-201) or along different fault planes (as mentioned l. 182-183; 203-204)? And why (based on what arguments/observations)? The rupture lengths/areas must be small, as indicated by the low magnitude of these earthquakes, and may explain why the postrift sediments are not affected. But how does it tell more information on the location of theses earthquakes along one or more fault plane(s)?

We added an explanation to section 4.1 based on the waveform families observed in the data (section 3): "*C1 consists of two waveform families indicating repeated activation of the same fault plane for events of the same family. Events of one family have very similar waveforms (Fig. 4a) because they originate from the same fault plane. Events of family 1 occur at greater depth than events of family 2. We observe two possible fault planes (Fig. 4c, Tab. 2). For the second fault plane the event locations and the direction of the fault plane coincide indicating that the same fault was activated at different depths. For the first fault plane the events occurred on two neighbouring faults. The same is true for the relationship between C1 and C2, where we observed a third waveform family. Based on the data we cannot conclude if the clusters C1 and C2 belong to one fault plane or to two separate nearby fault planes, therefore we use the term 'rupture area' in the further discussion.*".

Line 200-201: 'push' direction -> slip direction (?)

Changed SE to NW

Line 204: 'can be taken up by these remaining' -> could reactivate pre-existing ; 'rifting structures' -> rift-related structures (check throughout the text); 'enabling' -> suggesting ongoing

Changed (throughout the manuscript)

l. 216: 'turned' -> inverted

Changed

l. 224: water in the formation of ?

Rearranged

Answers to reviewer RC1 Christophe Larroque

We thank reviewer Christophe Larroque for the very helpful review and comments that in our opinion improve the manuscript.

We place the comments of RC1 in black and our answers and changes to the manuscript in green letters.

Comments on the paper « Basin inversion: Reactivated rift structures in the Ligurian Sea revealed by OBS » by M. Thorwart et al., submitted to Solid Earth.

General comments

The paper by Thowart et al. presents the seismotectonic interpretation of the data acquired in the Ligurian basin during 8 months in 2017-2018 by the 24 OBS of the Alparray experiment. This is the first data set of such importance acquired in this basin, with atypical oceanic crust or very thinned continental crust, located between the front of the southern subalpine chains and the Corso-Sardinia continental block. This area is known since a long time as an active intraplate setting with a very low deformation rate.

The experiment allows to detect 39 microearthquakes. This work focus on two clusters in the center of the basin, the first one with 13 events and the second with 3 events but only 4 focal mechanisms could be determined among the 13 events of the cluster 1. These 4 focal mechanisms, consistent with each other, are interpreted by the authors as evidence of the Ligurian basin inversion.

There is little new data but in this marine and low seismicity context any new data is welcome to be discussed and should be considered positively. The active inversion of the Ligurian basin has already been evidenced based on other structural and seismic datasets (Larroque et al., 2011; Sage et al., 2011; Larroque et al., 2016) and from this perspective this work confirms what is proposed. However, it seems to me that there are several important problems of substance and form in this article which require a serious reworking of the presentation of the data and their interpretation in the context of the work already carried out in this area. I recommend major revision.

I make few remarks and suggestions in the following.

- On the substance, the major problem concerns the exploitation of the seismic signal from very low magnitude earthquakes (1.5 to 2.5) recorded at stations located more than 150 km away (Fig1) to build the focal mechanisms. This essential part of the work must be strengthened to be credible. Firstly, as these are new mechanisms it is necessary to provide for each of them a clear diagram with the polarities and nodal planes (currently, only the diagram of the strongest earthquake is shown : c, fig4). Secondly, taking into account the large distances with some of the stations and the smallness of the magnitudes, the seismograms must be shown in order to attest the quality of the polarities read on this signal.

We updated figure 3c and provide a diagram for each event for which the focal mechanisms could be calculated. We included an Appendices as a new section in the manuscript and show there additional information on the 4 events with focal mechanism solution. This includes the seismograms, first motion plots and amplitude ratios of Sv/P.

- The context of the deformation in the Ligurian basin must be presented in its entirety. Particularly, the high rate of seismicity on the northern margin in relation to the center of the basin and its southern margin must be emphasized as it is an essential point in the discussion of the inversion process. From this point of view, mention of the work of Béthoux et al (2008) is essential. Also from a structural point of view, it should be mentioned that active north dipping reverse faults have been identified on the northern margin (Larroque et al., 2011; Sage et al., 2011). These faults allow the accommodation of most of the basin inversion since 5 Ma, as evidenced by the cumulative deformation which shows a margin uplift of more than 1000 m with respect to the basin. These 2 points are important because they show that the basin inversion started at least 5 Ma ago in the northern part while the absence of cumulated deformation and low seismicity in the central and southern part (this paper and Larroque et al., 2016) attest to a weaker and/or much more recent deformation.

We included the works about the basin inversion of Larroque et al. (2011) and Sage et al. (2011) in the introduction section and explained better previous knowledge on the past and recent deformation of the Ligurian basin in section 2. And we modified section 4.1 according to the suggestions: "*The main portion of the basin inversion in the Ligurian Basin is accommodated at the northern margin where a high rate of seismicity is observed compared to the basin centre and the Corsican margin (Béthoux et al., 2008). Active northward dipping reverse faults have been mapped that are evidence for a 5 Ma cumulative deformation with a margin uplift of more than 1 km (Larroque et al., 2011, Sage et al., 2011). The centre of the Ligurian Basin and the Corsican margin are characterised by low seismicity and diffuse distribution of rupture areas of small size spread over a wide area, which indicates the absence of cumulated deformation and points to a weaker or more recent deformation (Larroque et al., 2016).*".

- The input of new data is really low for such a paper in a major scientific journal. May be the authors could try to get more informations from the continuous seismic recordings of the OBS by using template matching method ? Even if the signals are not usable to determine focal mechanics, it would be interesting to know if a larger number of low magnitude events can be detected.

We used the template matching method using a cluster event as template and observed 2 events near station A423A and displayed their occurrence in figure 3a with black bars (2 events in September). In this work we focus on the two cluster, thus we did not look for more low magnitude events near other stations. But this is indeed a good suggestion to go back to the entire dataset. We added the method in section 3.1 by changing the sentence: "*Two low magnitude events were only observed at station A423A* ***using the template matching method (e.g. Shearer, 1994)*** *and were not further analysed (Fig. 3a, black bars).*"

- You need to take better account of existing work when it relates to your interpretations. For instance, the proposal by Dannowski et al (2020) on the nature of the crust in the Ligurian Basin is very interesting but at the moment it is not a consensual result. So highlight other interprétations such as Contrucci et al. (2001), Rollet et al. (2002), Gailler et al. (2009).

We included the works of Contrucci et al. (2001) and Rollet et al. (2002) in the discussion section 4.1: "*Additionally, no spreading axis was mapped in* ***previous*** *seismic studies* ***that interpreted the nature of the basin centre as atypical oceanic crust (Contrucci et al., 2001; Rollet et al., 2002). Analysis of*** *the LOBSTER seismic refraction profile p02 (Dannowski et al., 2020) proposes that rifting failed before seafloor spreading was initiated.*". We did not include the work of Gailler et al. (2009) in this discussion since it is far away from the cluster.

- The use of the results of the Pérez-Guissinyé and Reston model does not seem to me very adapted to the case of the Ligurian rifting. This model has been proposed by its authors to describe a possible evolution of Atlantic-type rifted margins in the case of cratonic and old orogen models. It is therefore difficult to consider that this model is generalizable to all types of non-volcanic rifting. The Ligurian basin is a back-arc basin, the crust was strongly affected by the alpine orogeny. The initial rheological conditions are therefore strongly different from what is considered in the Pérez-Guissinyé and Reston model. This comparison should therefore be discussed and justified.

We stay with the comparison as a possible explanation for the observed events in the uppermost mantle. The differences between both margins in initial conditions and evolution do not exclude similar changes in rheology due to rifting. We emphasize that there are differences between both types of rifted margins by extending the discussion: "*The initial conditions and the evolution of the Atlantic-type rifting of old orogens differs from the Ligurian Sea as back-arc basin where rifting took place during the alpine orogeny. Both margins show similarities and differences: common features are highly attenuated continental crust in the ocean-continent transition to a wide and thick basin starting rifting in subaerial conditions; the major difference is that in the Gulf of Lion the continent-ocean transition is probably made of exhumed lower continental crust, while the in the Atlantic the upper crust rests directly on top of mantle (Jolivet et al., 2015).*".

Specific comments

- Revise the title because most of the inversion is active on the northern margin that is not discussed. For the moment, only a recent and low compression is carried out in the center of the basin.

We change the title to point out that the study is about the basin cenre: Basin inversion: "*Reactivated rift structures in the **central** Ligurian Sea revealed by OBS*".

line 27 : usually, moderate activity is less than magnitude 6 and strong activity start with Mw 6.5 thus the 1887 Ligurian eq (Mw > 6.5 Larroque et al., 2012, Manchuel et al., 2017) attests that the sismicity on the Ligurian margin is mainly moderate but with possible strong earthquakes (this is of concern for hazard assement).

We included the possibility for strong earthqueakes and added the reference: "*… indicating a moderate seismic activity **with occasionally strong earthquakes** (Béthoux, 1992; Courboulex et al., 2007; Béthoux et al., 2008; Larroque et al., 2012, 2016; **Manchuel et al., 2017**).*".

Line 51 : the geodynamic setting WAS controlled by the Africa/Euraisa convergence, now it is not so clear (see Nocquet and Calais, 2004, Serpelloni et al., 2007, ….).

Changed and references added

Line 54 : « Lamotte » is Frizon de Lamotte.

Changed

Line 70 : specify the rotation pole near Genoa and give the range of the counter-clockwise rotation from 23° (Speranza) to 45° (Gattacceca et al., 2007).

References added and changed to: "*The Corsica-Sardinia block underwent a counter-clockwise (CCW) rotation (Alvarez et al., 1973; Rehault et al., 1984; Speranza et al., 2002; Maffione et al., 2008) of ~23° (Speranza et al., 2002) to 45° (Gattacceca et al., 2007) or 53° (Le Breton et al., 2017) with an Euler rotational pole near Genoa, onshore or in the Gulf of Genoa (Fig. 2).*".

Line 159 : can you explain « faulty recording » ?

We changed "*faulty recording*" to "*a low velocity contrast between subsurface and water and might hint to a low shear modulus of the subsurface. Together with the high instrument weight, these effects could not be taken into account to determine amplitude ratios of P- and S-waves for the OBS*".

We did not take into account that even shear waves with a small amplitude would result in a large amplitude recorded at the OBS because the S-wave arrives at a free surface at the seafloor (doubling the amplitude), while the P-wave takes the seafloor as an interface with probably a low velocity contrast (little change in amplitude). Additionally the shear modulus of the subsurface might be small and the mass of the OBS is large, resulting in a high S-wave amplitude. These effects should be taken into account for amplitude ratios.

Line 34 and 190-196 : I disagree with this presentation of the spatial geodetic data. Nocquet and Calais (2004) showed that the convergence of Africa relative to stable Europe is 40% less than the prediction of the Nuvel-1 model (De Metz et al., 1994). Serpelloni et al. (2007) and Nocquet (2012) argue that 90% of the convergence is accomodated along the Maghrebides chain and Algeria margin but ~10% of the motion could be accommodated northward with a possible NW motion of the Corsica–Sardinia bloc of 0.5 mm/yr maximum. Masson et al. (2019) confirmed a NW motion of Corsica in the range of 0.4 mm/yr.

We added the new GPS work and adjusted the text as suggested in section 4.1: "~~*The Ligurian Basin and the Corsica-Sardinia block are seen as rigidly attached to stable Europe (Nocquet, 2012).*~~*An analysis of two decades of dense GPS data presents a ~0.4 mm/y motion of Corsica representing a NNW-SSE shortening that is compatible with the tectonic and seismicity observations at the Ligurian margin (Masson et al., 2019). It was proposed that this shortening is a result from the CCW rotation of the Adriatic microplate rather than from motion of an independent rigid Corsica-Sardinia block (Nocquet and Calais, 2004).*".

Line 194 : In my opinion reference to these long-term plate models (van Hinsbergen, Le Breton) are not relevant to discuss current movements because they have no resolution for the present-day.

Removed

Line 201 : the dip of the ~vertical plane (d, Fig5) is NW not SE ? In any case, in order to discuss the dip, one must have information on the uncertainties of epicenter location and depth because the difference are very tenuous.

We added the horizontal uncertainties to the table. Changed to NW.

Line 215-219 : you should mention the more recent and more precise work carried out on the rotation of the Corsica-Sardinia block by Gattacceca et al (2007). The rotation reconstructed from the paleomagnetic analyses of lavas is 45° counter-clockwise which leads to a much greater extension in the basin than from the 23° proposed by Speranza et al. (2002). At least both values should be mentioned.

Changed to the total amount of rotation that varies depending on the different studies. We use now 23° to 53° and cite works of Speranza et al. (2002), Gattacceca et al. (2007) and Le Breton et al. (2017).

Line 248-253 : the discussion about heat flow and the role of the sedimentary cover should take into account the results of Béthoux et al. (2008).

Reference to Béthoux et al. (2008) added.

Figure 2 : this figure is to be improved by showing the Ligurian thrust to the north, the normal faults of the Tyrrhenian Sea and the thrust to the north of Algeria….

We added the NTBZ taken from Hinsbergen et al. (2014). We added the reference to the list. We removed "*Balearic Sea*". We do not add the suggested zones of inversion. We cited a number of studies that show and describe the zones of inversion in the western Mediterranean. The zones of inversion are wide and of different ages and we want to keep the map as simple and understandable as possible showing the main geological features and location of the basins we describe and discuss. Showing all the faults would need a zoom into the two basins.

Caption figure 5 : (d) « crystalline basement » = top of crystalline crust ; number on (e) = Vp ?

Changed to "*top of crystalline basement*"; the numbers are P-wave velocities as given above in the colour bar.

Technical corrections

Check the references, e.g. Maggi et al. ???

Changed

Gattacceca, J., Deino, A., Rizzo, R, Jones, D.S., Henry, B., Beaudoin, B., Valeboin, F., 2007. Miocene rotation of Sardinia : new paleomagnetic and geochronological constraints and geodynamic implications. Earth Planet. Sci. Lett., 258, 359–377.

Included in the reference list

Larroque, C., Mercier de Lépinay, B., Migeon, S., 2011. Morphotectonic and fault–earthquake relationships along the northern Ligurian margin (western Mediterranean) based on high resolution multibeam bathymetry and multichannel seismicreflection profiles. Mar. Geophys. Res. 32 (1–2), 163–179, http://dx.doi.org/10.1007/s11001-010-9108-7.

Included in the reference list

Manchuel, K., Traversa, P., Baumont, D., Cara, M., Nayman, E. and Durouchoux, C., 2017. The French seismic CATalogue (FCAT-17). Bull. Earthquake Eng., 8, 16. 2227–2251, doi: 10.1007/s10518-017-0236-1.

Included in the reference list

Masson, C., Mazzotti, S., Vernant, P., 2019. Precision of continuous GPS velocities 20 from statistical analysis of synthetic time series. Solid Earth, 10, 329–342, https://doi.org/10.5194/se-10-329-2019.

We included instead: Masson, C., Mazzotti, S., Vernant, P., and Doerflinger, E.: Extracting small deformation beyond individual station precision from dense Global Navigation Satellite System (GNSS) networks in France and western Europe, Solid Earth, 10, 1905–1920, https://doi.org/10.5194/se-10-1905-2019, 2019.

Sage, F., Beslier, M.O., Thinon, I., Larroque, C., Dessa, J.X., Migeon, S., Angelier, J., Guennoc, P., Schreiber, D., Michaud, F., Stéphan, J.F., Sonnette, L., 2011. Structure and evolution of a passive margin in a compressive environment : example of the southwestern Alps-Ligurian basin junction during the Cenozoic. Mar. Pet. Geol., 28, 1263–1282, doi:10.1016/j.marpetgeo.2011.03.012.

Included in the reference list

Serpelloni, E., Vannucci, G., Pondrelli, S., Argnani, A., Casula, G., Anzidei, M., Baldi, P., Gasperini, P., 2007. Kinematics of the Western Africa-Eurasia plate boundary from focal mechanisms and GPS data. Geophys. J. Int., 169(3), 1180-1200, http://dx.doi.org/10.1111/j.1365246X.2007.03367.x.

Included in the reference list

l. 234: interpreted to reflect inversion along pre-existing normal faults

Changed

Figures

Figure 2: I would remove Balearic Sea and keep only Liguro-Provencal Basin (the authors could add the North Balearic Transform Zone, e.g. van Hinsbergen et al. 2014, Tectonics, as a delimitation between the Liguro-Provencal Basin and the Algerian Basin). I suggest also to add on this map the (inferred) location of oceanic crust (or atypical crust) vs exhumed mantle, and zones of basin inversion described in previous work and mentioned in the text.

We added the NTBZ taken from Hinsbergen et al. (2014). We added the reference to the list. We removed "Balearic Sea". We do not add the suggested zones of inversion and proposed location of oceanic crust. We cited a number of studies that show the outline of the oceanic crust and describe the zones of inversion in the western Mediterranean. The zones of inversion are wide and of different ages and we want to keep the map as simple and understandable as possible showing the main geological features and location of the basins we describe and discuss.

Figure 5: It would be interesting to plot the clusters of earthquakes directly on the seismic velocity model (e). At about 30 km distance, the velocity contour 5.5 km/s deepens, does the location of cluster C1 coincides with this change in velocity?

The deepening of the 5.5-isoline at the profile end is most probably an artefact resulting from lower resolution of the model at the end of the profile. We keep plotting the clusters beside the profile to prevent misunderstanding of the location of the cluster still enabling an easy comparison.

References

Bethoux 1992: Quaternaire (not quate)

Changed

Maggi et al. 2000: Journal (Geology) is missing

Added