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Comment on se-2021-9

Christophe LARROQUE (Referee)

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-RC1, 2021

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.

- 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.

- 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.

- 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).

- 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.

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.

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).

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, ….).

Line 54 : « Lamotte » is Frizon de Lamotte.

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).

Line 159 : can you explain « faulty recording » ?

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.

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.

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.

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.

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).

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….

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

Technical corrections

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

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