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Comment on 'The challenge in restoring magma-rich rifted margins: The example of the Mozambique-Antarctica conjugate margins' by Tomasi S. et al

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In their recent article (https://doi.org/10.1016/j.gr.2021.03.009), Tomasi,et al. (2021) propose a new tight fit for the Gondwana, with a plume-related scenario for the break-up of this supercontinent. They claim that their study « *not only adds new constraints on the regional breakup of Gondwana but also presents a new multidisciplinary methodology for restoring magma rich rifted margins formed in the presence of mantle plume ».* Their methodology includes: seismic reflection interpretation, gravity inversion to determine regional Moho depth, analysis of subsidence, determination of crustal basement thickness and a kinematic scenario-approach, which is relatively outdated (Aslanian and Moulin, 2012). All potential methods, incuding gravity modeling, are non-unique solution ; Tomasi et al. (2021) therefore propose to compare their 3D-gravity-inversion results with wide-angle findings. Tomasi et al. (2021) consequently applied « the *refraction seismic Moho depths from the IFREMER MOZ campaign (Watremez et al., 2020) ».* The proposed break-up model is based on a number of errors, oversights, misunderstandings and even concealment of contrary results. We propose an overview of these points, without considering the model itself as it is based on flawed hypotheses.

The Pamela-MOZ3-5 campaign (Moulin et al., 2020), including PAMELA-MOZ3 (Moulin and Aslanian, 2016) and PAMELA-MOZ5 (Moulin and Evain, 2016) cruises, is a part of the Pamela (PAssive Margins Exploration Laboratories) project, conducted by TOTAL and IFREMER and in collaboration with Université de Bretagne Occidentale, Université Rennes 1, Sorbonne Université, CNRS and IFPEN. A total of 10 scientific cruises were conducted within the scope of the project. In 2016, the Pamela-MOZ3-5 campaign acquired new geophysical and geological data (bathymetry, piston cores, water column, sub-bottom profiles, gravity, magnetism, dredges, wide angle and reflection seismic) that represent a total of 193 Ocean Bottom Sismometers (OBS) recordings over seven profiles on the southern Mozambique margins (Moulin et al, 2020; Lepretre et al., 2021; Evain et al., 2021, Watremez et al., 2019). Four of these profiles were extended on land by deploying 125 additional land seismic stations. At present and as far as we know, this area is one of the most globally covered by deep wide-angle seismic data, with several crossing profiles to prevent over-interpretation on a single profile and what the authors call the '*non-unique interpretation of velocities',* which concerns mainly the interpretation of velocities in crustal nature not in geometry terms. Our collaboration with Schlumberger and TOTAL provided access to a collosal number of industrial profiles over the entire study area which in turn involved significant processing. This involved a large number of people which prevented over-interpretation by a single person working on several profiles. It is also worth noting that all wide-angle models are tested by comparing observed gravity anomalies, free-air gravity anomaly derived from satellite altimetry and gravity anomaly measured on board along the profiles with inverted gravity anomalies computed on the basis of the model (Lepretre et al., 2021, Evain et al, 2021). The Pamela-MOZ3-5 results have been presented to TOTAL and Pamela partners at several occasions and the data of the PAMELA-MOZ3 (Moulin and Aslanian, 2016) and PAMELA-MOZ5 (Moulin and Evain, 2016) cruises are archived and referenced at SISMER and accessible on request at https://doi.org/10.17600/16009500 and https://doi.org/10.17600/16001600.

While they referred to still unpublished results (Watremez et al., 2020, https://doi.org/10.17882/, which access and use are allowed only under specific conditions), Tomasi et al. (2021) should have better refer to the first published article of the Pamela-MOZ3-5 experiment (Moulin et al., 2020 – online in Nov 2019, https://doi.org/10.1111/ter.12448). Moulin et al. (2020) presented an overview of the Pamela-MOZ3-5 results on the Mozambique Coastal Plain (MCP) and North Natal Valley (NNV) revealing the presence of a 35-km-thick continental crust in the MCP and a 30-km-thick crust in the NNV. The crustal velocity structure across the MCP, at its southern extremity, presents a perfect fit with the velocity field of shields throughout the world (Christensen and Mooney, 1995) indicating that the crust in this region is of continental nature. Both crustal structures estimated along the two conjugate cratons at the time of the Gondwana assemblage: the Lebombo monocline (35–38 km) (Kwadiba et al., 2003) and below the Grunehogna craton in Antarctica (Hubscher et al., 1996) are comparable> to the one described by the wide-angle results. Recent articles by Lepretre et al. (2021), and Evain et al. (2021) relate these results with detailed error analysis and uncertainty estimation using VMONTECARLO (Loureiro et al., 2016). At the Limpopo Margin, the wide-angle data show that the Mozambique crust has a thickness reaching ~35 km along Pamela-MZ4 and Pamela-MZ5 profiles (Watremez et al., 2019) in accordance with gravity studies in the area (Gwavava et al., 1992). As quoted previously by Moulin et al. (2020), the presence of 30-km-thick continental crust in the NNV, in continuation of the continental MCP (Domingues et al., 2016), together with the presence of the Beira Continental block in the Zambezi Basin (Mueller et al., 2016) exclude a potential overlap between the Antarctica and Africa plates in that area, as inferred by the most recently published tight restorations, including the proposition of Tomasi et al. (2021) but excepting the model of Thompson et al. (2019). This last model is not a "*break-up fit between India, Africa and Antarctica"* as mentioned by Tomasi et al. (2021), but a holistic model of coherent kinematic evolution from the tightest restoration to Aptian time.

Unfortunately, the three scenarios tested by Tomasi et al. (2021) all produce varying degrees of the overlap of the Antarctica plate and the MCP, and more overlaps or gaps at the boundary limits of the restoration (see the analysis of all previously published models up to 2018 *in* Thompson, 2017 and Thompson et al., 2019). The lack of a global view of the entire system of the involved plates, with properly calculated Eulerian Poles, as presented by Tomasi et al., does not allow to see and analyse the gaps, overlaps and misfits and their consequences on the continental passive margin genesis from each of the different models. Their proposed restoration is therefore inconsistent with the results of the accurate cross-sectional analysis of the seven wide-angle seismic profiles of the Pamela project.

As minor remarks, but useful for further articles, "*the M33n (165 Ma)* [is not] *the first undisputed magnetic anomaly"*. Indeed, the existence of these older magnetic anomalies M33n (and M41n ; Leinweber et al., 2013) is still puzzling as no conjugate M33n and M41n are observed on the aeromagnetic data from the western Enderby Basin, at the conjugate Antarctica Margin (Jokat et al., 2010). A ridge jump might explain this absence, but is not described in the data (Leinweber et al., 2013). Therefore, the first undisputed magnetic anomaly is M25 (Kimmeridgian time), which is recognized on both conjugate margins. Interestingly enough, these M25 chrons are located at the same distance from the coast (250 km) on both conjugate margins, showing a rather good symmetrical process at least until the Kimmeridgian. It is also worth noting that this is consistent with the adjacent Somali Basin, also produced by the Gondwana break-up, where M25 is also the oldest recognised magnetic anomaly (Davis et al., 2016). Likewise, Tomasi et al. (2021) claim that the "*Mozambique and the conjugate Riiser-Larsen Sea margins offshore Antarctica are the result of the Gondwana dispersal that occurred about 180 My ago",* which corresponds to the Karoo magmatic event. Notwithstanding, the only information we have for that area is from the cuttings of wells, which can be reworked material from surrounding areas, showing both Karoo and Bombeni-Movene (140 Ma) basalts (Funhalouro-1, and Sunray-12 wells). The first sediment layers overlying these basalts are the Red Beds and the shallow marine Maputo formation, dated to the Neocomian (145-130Ma - Salman and Abdula, 1995; Said et al., 2015; Baby et al., 2018), more than 35 Ma after the Karoo magmatic event, which represents a large sedimentary gap that requires explanation. Lastly, it is worth noting that, according to new Sr/Nd analysis (Revillon, 2019), the basalts sampled in the wells seem to have neither a composition of MORB nor SDRs.

The Pamela-MOZ3-5 experiment has provided a new huge set of combined multi-channel and wide-angle seismic data that preclude any overlap between Antarctica and Africa and confirm the looser reconstruction and evolution of Thompson et al. (2019). This, well known by Tomasi et al. (2021), must at least be referenced and discussed.

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