The crustal structure of the Lomgmenshan fault zone and its implications for seismogenesis: New insight from aeromagnetic and gravity data

MS No.: egusphere-2023-1119
MS type: Research article

Reply to Reviewer Comments (Chuntao Liang)

Comment from Author to Reviewer 1

We thank Chuntao Liang for his very thoughtful and knowledgeable comments. Based on the changes due to raised issues we believe that the manuscript has improved significantly. The detailed replies are listed in the supplement file.

Kind regards,
Hai Yang
On behalf of the authors

Specific comments:

- Line 83: "Triassic syntectonic adakitic-type granitoids are widely distributed in the SGB, which are likely sourced from the partial melting of an underlying Proterozoic basement that is part of the Sichuan Basin". The Sichuan basement may extend further west beyond the LFZ, but I don't think it can account for the "syntectonic adakitic-type granitoids"far west from the LFZ.

  Agreed. The syntectonic adakitic-type granitoids with Mid-proterozoic TDM age (1.23-1.44Ga) and some geochemical indicators suggest that the Songpan-Ganzi terrane is underlain with Yangtze-type basement (Zhao et al., 2007). Recently, the SinoProbe-02 deep seismic reflection profile suggests the crust of the Yangtze crystalline crust probably extends beneath the easternmost Tibetan Plateau to the Longriqu fault (west of the Longriba fault). However, the evidence is still insufficient to prove the syntectonic adakitic-type granitoids from the partial melting of the Sichuan basement. Therefore, we change the sentence to "Triassic syn-tectonic adakitic-type granitoids are widely distributed in the SGB, which are likely sourced from the partial melting of an underlying Proterozoic Yangtze-type crystalline basement".

- Figure 1: add descriptions for the black lines (profiles?), pink squares (measurement points?) to the captions.

  Yes. The descriptions add to the captions. The blue line is the seismic profile from He et al. (2017). The pink squares are magnetic susceptibility measurement points.

- Figure 2b, 3a, 3b actually show that the anomaly across F6 (Longquan fault) are different. On Figure 3b, the values are positive (>3) and negative (<-7) to the west and east of the F6. On figure 4, the F6 is also a feature to separate low/high gravity. These observations are contrary to your interpretation on Line 225 that the F6 is a shallow fault.

  Thank you. The magnetic and gravity anomaly data is integrated information from Earth's surface to deep (theoretic curie depth and Moho depth). We can use different data processing methods to enhance information from different kinds of geological bodies. Figure 2b is a reduction to the pole (RTP) image of the aeromagnetic ΔT data that shows magnetic anomaly generated by geological bodies with the elimination of oblique magnetization. Figure 3a is a 20 km upward continuation of RTP aeromagnetic ΔT data that show regional magnetic anomaly generated by large-scale or deep geological bodies. Figure 3b is the first vertical derivative of the RTP aeromagnetic ΔT image that shows local magnetic anomaly generated by shallow or high magnetic geological bodies. These images give different information about the deep structure of the Sichuan Basin. Two NE-trending high magnetic anomaly belts are interpreted as Precambrian magmatic rock belts because the sedimentary cover of the Sichuan Basin is non-magnetic. The Longquan fault does not match with the boundary of magnetic anomaly, therefore we suggest the fault is distributed in sedimentary cover rather than cut through the magnetic basement. The Longquan fault doesn't show an obvious high/low gravity boundary in Figure 4a. However, it is a clear boundary in Figure 4b, because the first vertical derivate of Bouguer gravity anomalies enhances the density information from the shallow crust.

- The obvious magnetic discontinuous distributed from Daofu and Danba to Chengdu is interpreted as a concealed fault. If look at the Figure 3, the trace of this discontinuity may actually continue to the south of Nanchong. There are other discontinuities too, but only this one is interpreted as a concealed fault? This feature doesn't show up on the gravity map (Figure 4). do you have other evidences to support your interpretation?

  The magnetic discontinuity along Daofu and Danba to Chengdu is consistent with the anomaly feature of concealed fault. It can be divided into two segments. The western segment is distributed along Daofu-Qiaoqi and merges into the Xianshuihe fault in the northwest. The magnetic anomaly features are different on both sides of the Daofu-Qiaoqi fault. The magnetic highs on the north side are caused by Triassic and Jurassic granites and syenites. The irregular magnetic anomalies on the south side are closely related to strata consisting of volcanic rocks and Precambrian magmatic rocks. The eastern segment starts at Xiling, passes through Chengdu, and ends by the Longquanshan fault, which is characterized by an EW-trending linear discontinuity of magnetic anomalies extending approximately 90-100 km (Figure S1a, c). The discontinuity can't extend to Nanchong. The eastern segment shows a small magnetic change of 20nT on the aeromagnetic image. It is clear on the first vertical derivative of the RTP aeromagnetic ΔT anomaly image (Fig. S1b, d). The small change suggests the displacement is small on both sides of the fault which may be a response to the early thrust of the LFZ under the compression of the Tibetan Plateau. The small change is

insufficient to produce an obvious gravity anomaly. The fault hasn't been reported in previous literature. We try to explain the genesis of the magnetic discontinuity and provide raw data for further discussion.

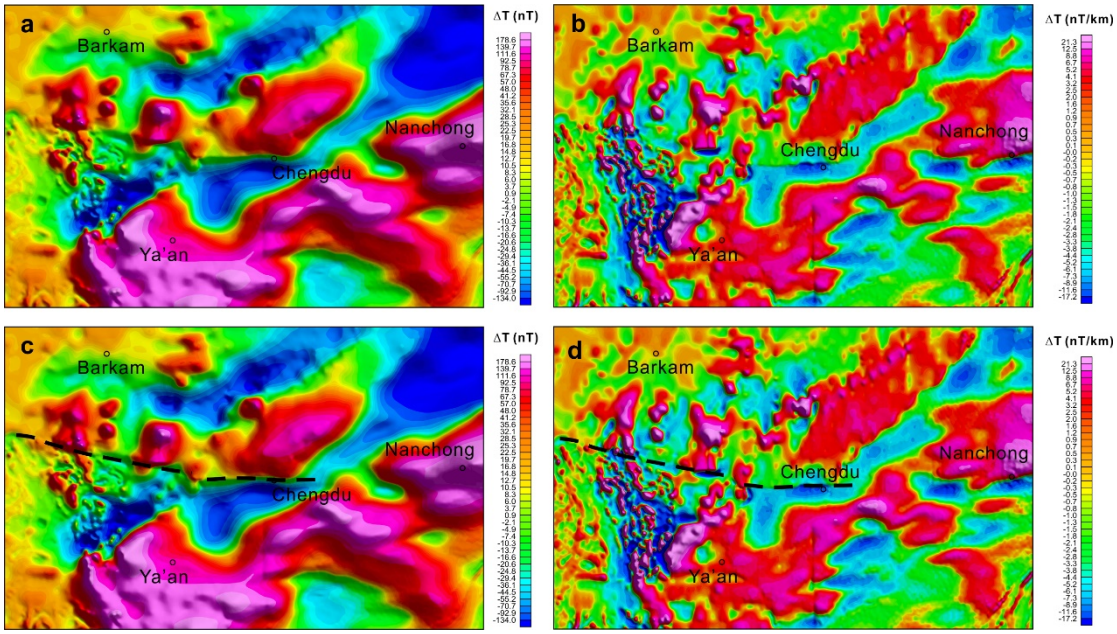

Fig. S1 Magnetic anomaly feature of inferred Daofu-Chengdu fault. (a) aeromagnetic map, (b) First vertical derivative of RTP aeromagnetic ΔT anomaly image, (c) inferred Daofu-Chengdu fault on aeromagnetic anomaly image, (d) inferred Daofu-Chengdu fault on First vertical derivative of RTP aeromagnetic ΔT anomaly image.

- Figure 4a, please add numbers to the color scale; Figure 4a and 4b, the blue boxes are seismic gap? Please describe in the caption.

  Done. The numbers are added to the color scale. The description of the blue boxes is added in the caption.

- Line 345: "Two earthquakes lie in high magnetic areas from 20 to 40 km". The depths of the two earthquakes are less than 20km. This statement could be misleading.

  Agreed. The expression changes to "Two earthquakes lie in two areas with local high magnetic susceptibility at 10 and 20km depth (Fig. 9a, b). The deep of the area shows two high magnetic blocks at 30 and 40 km depth (Fig. 9c, d). It suggests that the magnetic bodies beneath the LFZ are shallow buried and extended to deep with large scale."

- Figure 11, the HMB2 could be the Leshan-Longnvshi uplift as mentioned by Liu et al. (2021, Earth Science Review, title: Tectonic evolution of the Sichuan Basin, Southwest China).

Thank you. The strike of HMB2 is similar to the Leshan-Longnvshi uplift. It is possible that they have a genetic relationship. Actually, the genesis of two high magnetic blocks is still a hot issue. Based on the understanding of previous geological surveys, the basement is mainly composed of Neoarchean-Paleoproterozoic high-grade metamorphic rocks that are able to produce high magnetic anomaly in the Sichuan Basin, such as Kangding Group (SBGMR, 1991; Xiong et al., 2016). However, a large amount of geochronological and geochemical evidence has shown that the Kangding complex has arc signatures, representing metamorphic products of Neoproterozoic arc-related acidic plutons recently (Chen et al., 2005; Du et al., 2007; Geng et al., 2007; Kang et al., 2017; Lai et al., 2015; Liu et al., 2009; Zhou et al., 2002). According to the field observation, the quartz diorite of Kangding Complex has a high magnetic susceptibility (0.0238-0.0487 SI). Therefore, we suggest the high magnetic blocks are probably related to Meso-Neoproterozoic magmatic events. The deep seismic reflection profile found that there is a set of southeastern dipping reflectors extending from the lower crust to the upper mantle coupled with the HMB2, which revealed there are remnants of Neoproterozoic subduction (Wang et al., 2007). The Leshan-Longnvshi palaeo-uplift has an initial structure that formed at the end of the late Cambrian, which may be closely related to the Neoproterozoic event.

- The paper outlines three models on Lines54-57, then what's the difference between your model and the other three models? More specifically, what's the difference between your model and Liang et al. (2018)?

  Thank you. There are many seismic and MT models given the deep physical structure around the seismic gap, such as the ductile deformation area, fault zone, or fluid-bearing ductile flow. However, it is still unclear what genesis of the weak zone and how it controls two earthquakes. Does it have any differences in deep structure? The magnetic and gravity data are sensitive to tectonic boundaries and are good for interpreting lateral changes in the deep structure. Our model is trying to provide magnetic and density information covering a large area to explain why the two earthquakes are so different. The advance of this model is considering the basement shape of the Sichuan Basin in the geodynamic process of the two earthquakes. The structural heterogeneity of the fault zone plays an important role in geodynamics and seismogenic mechanisms of active fault.