Quaternary International 601 (2021) 143–147

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Comment on "Structural attributes and paleostress analysis of Quaternary landforms along the Vigodi Fault (VF) in Western Kachchh region [Quat. Int. https://doi.org/10.1016/j.quaint.2020.07.038]"

ARTICLE INFO

Keywords
Comments
Paleostress analysis
Vigodi fault
Kachchh
Western India

ABSTRACT

We highlight scientific blunders in the article published by Mishra et al. (2020). The authors have completely missed the location of Vigodi Fault (VF) along with misidentification of meso-scale structures. The paleostress analysis is based on insufficient field data (14 fault-slip measurements) collected along other faults and results are mutually contradictory, poor quality and highly unreliable. Two domes, not located along the VF are wrongly analyzed. We note that couple of figure captions and some parts of the paper are plagiarized from Vanik et al. (2018) and Biswas (1993). The slip history of VF inferred by Mishra et al. (2020) completely contradicts previously well-established structural facts. We reanalyzed fault-slip data of Mishra et al. (2020) and reached much different results. We conclude that the field data, paleostress analysis and interpretations in the paper by Mishra et al. (2020) are erroneous and do not belong to the VF.

1. Introduction

We comment on the paper by Mishra et al. (2020) titled "Structural Attributes and Paleostress Analysis of Quaternary Landforms along the Vigodi Fault (VF) in Western Kachchh Region" (DOI: https://doi.org/10.1016/j.quaint.2020.07.038). Our main reasons for commenting are the series of blunders, misinterpretations and self-contradictions of Mishra et al. (2020). The errors pointed out below pertain to misunderstanding and misinterpretation of local geology, erroneous approach, analytical methods and contradictory interpretations. Other inconsistencies are included in the supplementary material accompanying our comments. The study area is located in the western part of the Kachchh rift basin (KRB) on the western continental margin of India (Maurya et al., 2017, 2021; Padmalal et al., 2019, 2021; Shaikh et al., 2019, 2020). Follow Sections 1 and 2 (supplementary data) for details about the structural setup of the study area.

2. Incorrect identification of the Vigodi Fault (VF)

Mishra et al. (2020) have failed to locate the VF in field, which is a major blunder. The locations mentioned by Mishra et al. (2020) – Meghpar, Walka Mota, Walka Nana, Jadodar and the Rawapar dome are all described in detail by Biswas (1993), which is the most detailed and highly referred work based on exhaustive mapping. In spite of this, the authors failed to locate the VF in the field. In Fig. 1, we show the sites investigated by Mishra et al. (2020) along with actual location of the VF.

In section 4 of Mishra et al. (2020), it is mentioned that- "*The type section of NW-SE trending Vigodi Fault is well preserved along a road section close to the Mata-Nu-Madh, where, the fault plane is identified based on presence of slickensides.*" The actual trace of the VF is considerably far towards east of Matanomadh (as per Biswas, 1993; Shaikh et al., 2020). See Figs. 1 and 2 of this article. Follow Section 3 (supplementary data) for more information.

3. False structural information about the Vigodi Fault (VF)

In section 5.2, Mishra et al. (2020) mention that "*we identified multi directional (dip and strike parallel) slickensides within the fault zone, suggests oblique slip motion of the fault*". However, oblique-slip movement can be interpreted from striations with oblique plunge only. The striations in fact denote two different events of strike-slip and dip-slip movement along the fault. However, no striations indicating strike-slip motion are reported so far from the VF. In fact, field photograph shown by Mishra et al. (2020) in Fig. 6d is from the another fault and not from the VF (Fig. 1). Though Mishra et al. (2020) repeatedly state that oblique-slip occurred along the VF, they have not shown a single outcrop exposing oblique striations.

In section 8.4, Mishra et al. (2020) report faults related to VF, displacing the Kachchh Mainland Fault (KMF). As per the previous literature (Biswas, 1993), VF does not extend up to the KMF in the north. The faults marked on the satellite imagery in Fig. 9g of Mishra et al. (2020) seem illogical. No field photographs of faults in this zone are shown. The offsetting of KMF shown on the image is structurally implausible. KMF is shown to be displaced by cross-faults, but the cross-faults are not displaced when they cross each other. Follow Section 4 (supplementary data) for more information.

4. Methodology and software issues

Mishra et al. (2020) need to inform the readers how many sites are covered along the VF and how many fault-slip measurements are collected from each site. Following inconsistencies create confusion about the methods used by Mishra et al. (2020).

https://doi.org/10.1016/j.quaint.2021.04.029
Received 18 December 2020; Received in revised form 15 April 2021; Accepted 16 April 2021
Available online 15 May 2021
1040-6182/

- The abstract mentions that Win_Tensor and T-Tecto software were used
- The text mentions that Win_Tensor and FaultKin software were used
- Table 1 shows Win_Tensor and FaultKin software results
- Figures show paleostress tensors generated using Win-Tensor software only (Figs. 5, 7 and 8 of Mishra et al. (2020).
- Paleostress tensors generated using FaultKin program are not seen in the paper

The authors have not specified anywhere if they are following $\sigma_1 > \sigma_2 > \sigma_3$ convention. Some structural geologists also follow $\sigma_1 < \sigma_2 < \sigma_3$ convention. At various places in the paper, the authors have used incorrect terminologies, e.g., "SHmax σ1" and "SHmin σ2". S_{Hmax}, S_{hmin}, σ_1 and σ_2 are different quantities. As per the convention normally followed in structural geology, for normal faults- $S_{Hmax} = \sigma_2$ and $S_{hmin} = \sigma_3$; for reverse faults- $S_{Hmax} = \sigma_1$ and $S_{hmin} = \sigma_2$; for strike-slip faults- $S_{Hmax} = \sigma_1$ and $S_{hmin} = \sigma_3$ (Zoback, 2010; Vanik et al., 2018; Shaikh et al., 2020). Follow Section 5 (supplementary data) for more information.

5. Unreliable and conflicting structural data presented by Mishra et al. (2020)

Fig. 1 of this article shows that Mishra et al. (2020) have completely missed the VF in the field, which means that the fault-slip measurements included in the paper are from other faults and none from the VF. Table 1 gives basic structural data and the inferred results also, however, there is a considerable mismatch between them. It is evident from table 1 of Mishra et al. (2020) that only 14 fault-slip data are used to define the paleostress conditions of ~50 km long VF. One can perform paleostress analysis manually with such a small number of fault-slip measurements.

Mishra et al. (2020) state that they have performed Bingham distribution statistics method using FaultKin program. However, in table 1, they have mentioned 'fault plane solution'.

For all the fault-slip measurements provided in table 1 of Mishra et al. (2020), the fault type given is Normal Fault (NF). However, the slip-sense inferred by them in all the paleostress analysis methods are Inverse Sinistral (IS). The authors have not explained, how this is possible? Moreover, the inferred inverse-sinistral slip-sense contradicts with their conclusions 2 and 3, which mention essentially normal slip-sense of the VF. It can be clearly observed from table 1 of Mishra et al. (2020) that the results generated using four paleostress analysis methods contradict each other. Follow Sections 6 and 7 (supplementary data) for more information.

6. Paleostress analysis results

The results are presented in the form of paleostress tensors in Figs. 5, 7 and 8 of Mishra et al. (2020). In Fig. 5, none of the tensors show NE-SW oriented extensional stress except the one shown in Fig. 5b, which represents the discarded dataset. It means that for interpretation, the structural measurements that misfit with the resultant stress tensor are also included. The method used to generate the paleostress tensor shown in Fig. 5d is not specified. The results shown in Fig. 5d contradicts with the paleostress tensor generated by using rotational optimization method in Fig. 5a. Same program cannot generate two different results using the same structural dataset. Fig. 7a shows reverse dip-slip, Fig. 7b shows normal dip-slip and Fig. 7c shows oblique-slip of the fault. How can the same fault-slip data generate different paleostress tensors? Follow Section 5 (supplementary data) for more information.

In Figs. 7 and 8, on the left of the paleostress tensors, QRw and QRt parameters are given. QRw denotes quality ranking according to the World Stress Map project and QRt denotes quality ranking according to the TENSOR scheme. Both the parameters range from A (Best) to E (Worst). Both QRw and QRt indicate E (Worst) quality for all the tensors shown in Figs. 7 and 8 of Mishra et al. (2020). This means that the fault-slip data generated and analyzed are highly unreliable.

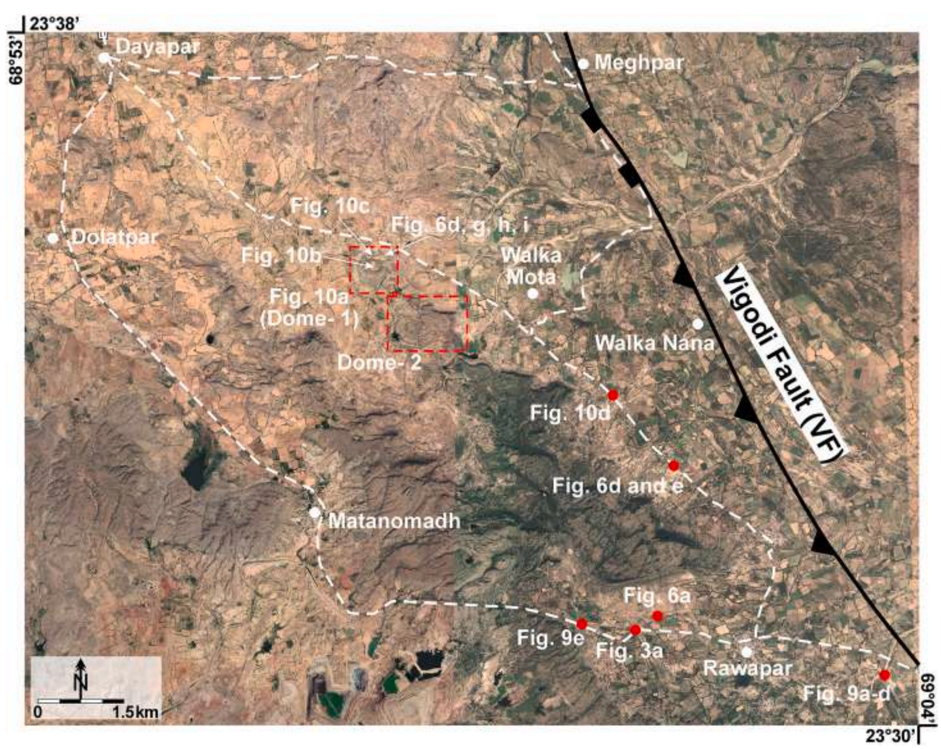

Fig. 1. Google earth image showing the location of figures of Mishra et al. (2020) marked by red circles. All locations described by Mishra et al. (2020) are away from the Vigodi Fault (VF). The black line represents NW-striking (VF) with changing slip-sense. Roads are marked by white dashed lines. Note that the dome-1 and dome-2 of Mishra et al. (2020) denoted by red squares are located away from the VF.

7. Contradictory conclusions of Mishra et al. (2020)

The conclusions of Mishra et al. (2020) are self-contradictory. The conclusion no. 2 of Mishra et al. (2020) mentions normal faulting occurred under compressional stress regime along the VF. The conclusion no. 3 of Mishra et al. (2020) refers normal, thrust and oblique-slip faulting, all in one sentence. The same conclusion says that UF is 70% and TF is 30%. The component of normal faulting is missing however, no convincing field evidence of thrust movement or oblique-slip movement is provided in the entire article. All the paleostress tensors in Fig. 8 suggest oblique-slip with major reverse dip-slip component. But the authors conclude that the VF is dominantly showing normal dip-slip movement (Conclusions no. 2 and 3). The conclusions are contradictory to the classical work of Biswas (1993) and more comprehensive recent study by Shaikh et al. (2020). The conclusions are also not acceptable as the authors have missed the location of VF in the field completely. Follow Section 10 (supplementary data) for more information.

8. Our paleostress analysis results using fault-slip data of Mishra et al. (2020)

We performed paleostress analysis using fault-slip data provided in table 1 of Mishra et al. (2020), assuming their fault-slip data were correctly documented from field. The purpose of doing so is to compare and validate the results with the results generated by Mishra et al. (2020). We implemented Improved RDM, P B T axes and Rotational Optimization Method in Win_Tensor program (Delvaux and Sperner,

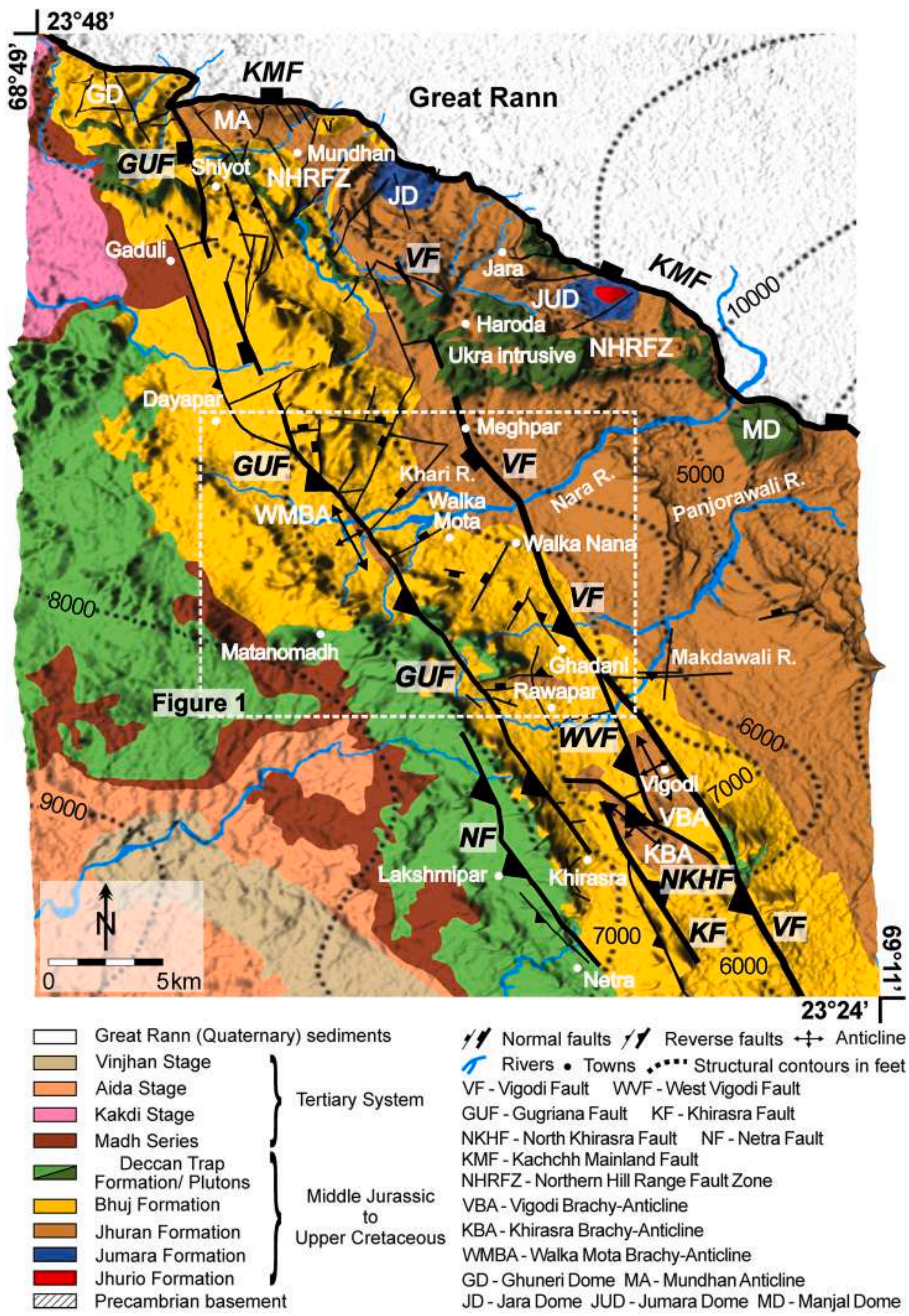

Fig. 2. Structural map of the Vigodi-Gugriana-Khirasra-Netra Fault System (VGKNFS) (after Shaikh et al., 2020). White box shows the location of Fig. 1.

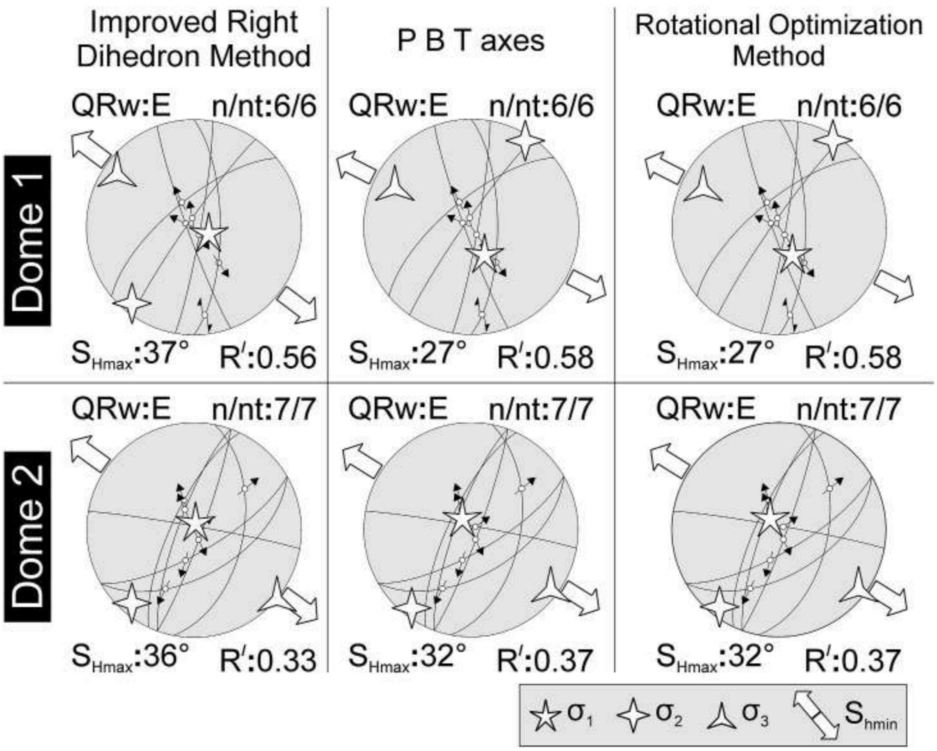

Fig. 3. Paleostress analysis carried out by us using fault-slip data presented by Mishra et al. (2020). The paleostress tensors (lower hemisphere, equal area projection) were generated by implementing Improved Right Dihedron Method, P B T axes and Rotational Optimization Method in Win_Tensor program (Delvaux and Sperner, 2003). Six fault-slip data from dome-1 and seven from dome-2 are taken from table 1 of Mishra et al. (2020). Black lines are fault planes with slip vectors, marked by open circles with black arrows. White, outward-pointed double arrows at the periphery of each paleostress tensors indicate orientation of minimum horizontal principal stress (S_{hmin}). $\sigma_1 \geq \sigma_2 \geq \sigma_3$. Note that for normal faults, $S_{hmin} = \sigma_3$. R′: stress index (Delvaux et al., 1997).

2003) using six fault-slip data from dome-1 and seven from dome-2 given in table 1 of Mishra et al. (2020).

The paleostress tensors generated by us (Fig. 3) show high discrepancy with those deduced by Mishra et al. (2020). The S_{Hmax} orientation ranges N027–037° E for dome-1. Whereas, Mishra et al. (2020) obtained S_{Hmax} orientation ranging N024–179° E for dome-1. The R′ranges 0.56–0.58 which suggests pure extensional stress regime. Whereas Mishra et al. (2020) obtained R′= 2.52, which actually indicates pure compressive stress regime but transpressive stress regime is mentioned in table 1 of Mishra et al. (2020). Similarly, our paleostress analysis results generated for dome-2 are also inconsistent with that of Mishra et al. (2020). Follow Section 8 (supplementary data) for more information. Follow Section 9 (supplementary data) for details about Quaternary landform development and tectonic implications.

9. Concluding remarks

The title is misleading as Mishra et al. (2020) have actually tried to investigate the structural characteristics of the fault and not of any geomorphic landforms. Section 7 of Mishra et al. (2020) on Quaternary landform development and tectonic implications describes structural attributes only. The authors have completely missed the trace of the Vigodi Fault (Fig. 1). The database comprises only 14 fault-slip measurements. The authors have copied verbatim the lengthy captions of their Figs. 7 and 8 from Vanik et al. (2018) (see Section 11 of supplementary data). Our reanalysis of data show wide mismatch with those of Mishra et al. (2020). We conclude the fault-slip data collected by Mishra et al. (2020) are of poor quality, highly unreliable and do not belong to the VF.

Declaration of competing interest

The authors declare that they have no known competing financialinterestsor personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Financial assistance from the Ministry of Earth Sciences (MoES), Government of India in the form of a research project (Project No. MoES/P.O. (Seismo)/1(170)/2013) to DMM is gratefully acknowledged. Council of Scientific & Industrial Research (CSIR) - Senior Research Fellowship (SRF), India (No. 09/114(0223)/19-EMR-I) to MHS is thankfully acknowledged. Three rounds of in-depth reviews by the Editor and two reviewers have considerably improved the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.quaint.2021.04.029.

Conflict of interest and authorship conformation form

Please check the following as appropriate:

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