

## ***Interactive comment on “Pull-apart basin tectonic model is structurally impossible for Kashmir basin, NW Himalaya” by A. A. Shah***

**A. A. Shah**

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Reply: Dear editor, and the reviewer: Thanks for your time in reviewing my work. I am very pleased to read the comments on my small contribution.

The comments are answered below:

Comment:

Anonymous Referee #1 Received and published: 9 February 2016 This paper almost reads like a personal diatribe.

Reply:

I have not written it to attack my colleagues but to discuss science.

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Comment:

The author is adamant that the Kashmir Basin is not a pull-apart basin as proposed by Alam et al. (2015, 2016) and the paper is essentially an earnest attempt at refutation. The author calls the pull-apart model 'impossible' 15 times (including in the title and in 110 lines of text) and also states that the pull-apart architecture 'could not exist', is 'problematic' and 'inconsistent with data'. If one of my undergraduates had written this paper, I would have sent it back with advice to remove the redundancy, improve the English, remove absolute terms like 'impossible', eliminate the undercurrents of emotion, and just stick to data-based arguments. This paper is poorly written and should not be published as is.

Reply:

I am sorry if you felt that I am forcing the reader to believe me. It is a language problem, and I am very thankful that you highlighted it. And thanks for your advice, and suggestion. I am here to learn. Modified the entire manuscript as suggested, tried my best.

Comment:

Now for the science: 1) The author has a limited understanding of oblique deformation and thinks a pull apart basin has to have the architecture of the simple cartoon shown in his figure 2. The same holds true for his model-driven views of horsetail splay termination zones (his fig. 3).

Reply:

Surely, I am a new researcher, and I always feel I am a student. I might have, what you call, limited understanding of oblique deformation but I don't think that my figure 2 represents the pull-apart settings around the world. It primarily aims to show the major problem in Alam et al. 2014. They are arguing that Kashmir basin is a pull-apart basin but the major dextral strike-slip fault that they show runs through the center of

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the Kashmir basin, which is a basic concern. And the structural orientation of horsetail structures is impossible. When I say impossible it means that such structures cannot form with that orientation (strike, and dip direction of horse tails). This is a major concern, and the evidence that they provide are very weak, and controversial, thus, based on the evidence the authors have produced it is clear that a major dextral fault in Kashmir basin is unconvincing, and wrong.

Since you have questioned my understanding about the figures 2 and 3 could you please scientifically show me how one can get those structures in a proposal dextral-pull apart model. May be I am wrongly thinking. I would greatly appreciate it. In fact you can publish your comment, the journal allows that.

Comment:

Transtensional and transpressional fault networks can be highly variable as documented all over the world. Positive and negative flower structures can have a wide variety of fault patterns. Transtensional flower structures do not have to have pull-apart geometries. The authors architectural arguments against a transtensional basin are weak.

Reply:

According to Burg, J.P “Transpression means that shortening is taking place across a dominantly strike-slip fault (oblique convergence, like along the San Andreas Fault Zone). Conversely, transtension means that extension is a deformation component of bulk strike-slip faulting (California Gulf)”. Fossan and Tikoff define it as “Transpression and transtension are broadly defined as steep strike-slip influenced deformation zones that deviate from simple shear by a component of shortening (transpression) or extension (transtension) across the zone”.

Fossen, H. and Tikoff, B., 1998. Extended models of transpression and transtension, and application to tectonic settings. Geological Society, London, Special Publications,

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135(1), pp.15-33.

Kashmir basin doesn't indicate any kind of transpression, as there is no evidence of a large dextral faulting. There is a slight oblique dextral component along with the dominant thrusting, which is very normal in an oblique convergence environment with a small component of shearing.

The recently acquired GPS data in Kashmir Himalaya (Schiffman et al., 2013) confirms these observations, and suggests an oblique faulting pattern, wherein a range-normal convergence of  $11 \pm 1$  mm/y is associated with a dextral-shear slip of  $5 \pm 1$  mm/y. They further suggest that obliquity is more towards the eastern portion of the valley. This clearly suggests that the resultant stress vector is oblique in Kashmir Himalaya, and thus the deformation is mainly absorbed by range-normal, and less so by shear components. A typical characteristic feature of oblique convergence. Fig. 1b. attached below.

Comment:

2) Neither Shah nor Alam present focal mechanism solutions for earthquakes from the Kashmir Basin. If earthquake focal mechanism solutions revealed any transtensional or extensional events, then the Alam et al. pull-apart models would be more convincing. I have not been able to find any transtensional earthquake events in the Kashmir Basin from my web trawl of relevant literature.

Reply:

I have produced focal mechanism solutions in 2013 paper (Shah, 2013): Shah, A.A.: Earthquake geology of the Kashmir Basin and its implication for large earthquakes. Int. J. Earth. Sci, 102, 7, 1957-1966, 2013. These dominantly show thrust faulting (Fig. 1a). However, the data is limited as the earthquakes in and around Kashmir basin are small, and thus focal mechanism solutions are not available. How can pull-apart model become convincing when their model fails the basic definition of a dextral tectonics.

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If we start with a simple pull-apart model then the major trace of the dextral fault that forms the basin should be  $\sim$  bordering the basin, and ought not to be through the basin? Isn't that true? That is my major concern, other things are details.

Comment:

3) Both Alam et al. and Shah should look more carefully at the GPS data in Schiffman et al. (2013). Figure 13 in Alam et al. (2015) is an inaccurate representation of the actual data. It should never have been published. Some of the arrows in their figure are incorrectly oriented and the vector lengths are all the same which is misleading. The Schiffman et al. (2013) GPS data indicate that south-directed motions in Zaskar are oblique to the NW-striking Balapora Fault and Central Kashmir Fault. The obliquity suggests significant components of dextral slip. GPS velocities in Zaskar have higher S and SW velocity components than the data from the Pir Panjal Range. Thus the boundary in between - the CKF - is also under compression. Therefore, the GPS data from Schiffman et al. (2013) suggest dextral transpression within the Kashmir Basin, not transtension. Neither author raises this point correctly, nor mentions the term transpression at all.

Reply:

The actual figure from Schiffman et al., 2013 is attached (Fig. 1b), and they have concluded that "GPS measurements in Kashmir Himalaya reveal range normal convergence of  $11 \pm 1$  mm/yr with dextral shear of  $5 \pm 1$  mm/yr." This surely is not transpression? And that is why Schiffman et al, did not use the work transpression in their contribution. The GPS points near Kashmir basin dominantly show oblique convergence with a large component of thrusting. And if we imagine that Kashmir Central Fault exists then the GPS points show dominantly normal convergence not dominant shearing on it (see Fig. 2).

The reason we get more dextral slip towards SE of Kashmir basin is possibly because of the regional escape tectonics, where India acts like an indenter, and the crustal flow

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is mostly along the huge strike-slip faults ((Tapponier and Molnar, 1976). Tapponier, P. and Molnar, P., 1976. Slip-line field theory and large-scale continental tectonics. *Nature*, 264(5584), pp.319-324.

Comment:

4) Shah should point out the unconvincing images of strike-slip related features in the Alam et al. (2015) paper – e.g., their figure 8. I am not convinced of any of their visual ‘signatures’ of strike slip features and visual offsets.

Reply:

Thanks for this. As I said earlier their model lacks the basic architecture of a major dextral strike-slip fault system, thus any evidence they show is useless. Whatever they are showing is impossible, I am sorry for such strong words but it is true as per my understanding. When I say impossible I mean it. Structurally it is impossible to create a pull-apart basin the way they are showing it. That is the reason I have been very upfront about it. And I am convinced that such a structure does NOT exist at all. If someone can prove me the basic pull-apart model for Kashmir basin using the CKF structure then I might be wrong, and I will love to read such a discussion.

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Interactive comment on Solid Earth Discuss., doi:10.5194/se-2016-4, 2016.

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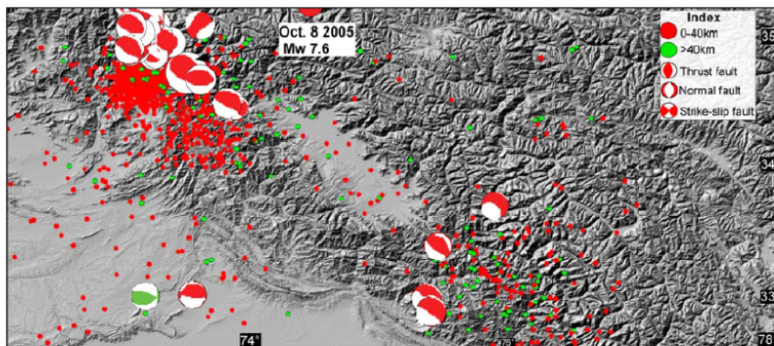


Fig. 1 a: After Shah, 2013

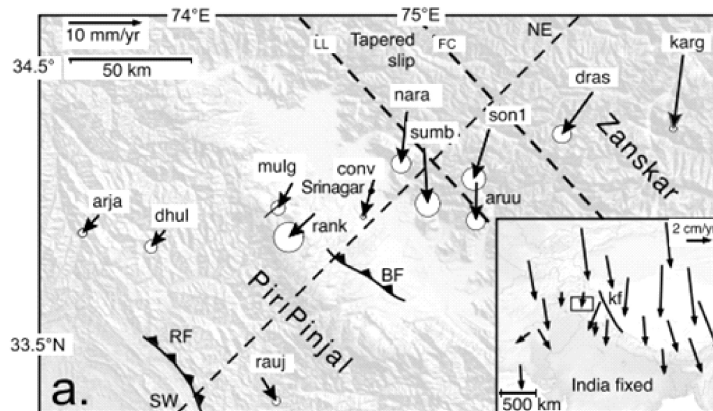


Fig. 1 b: After Schiffman, 2013

Fig. 1.

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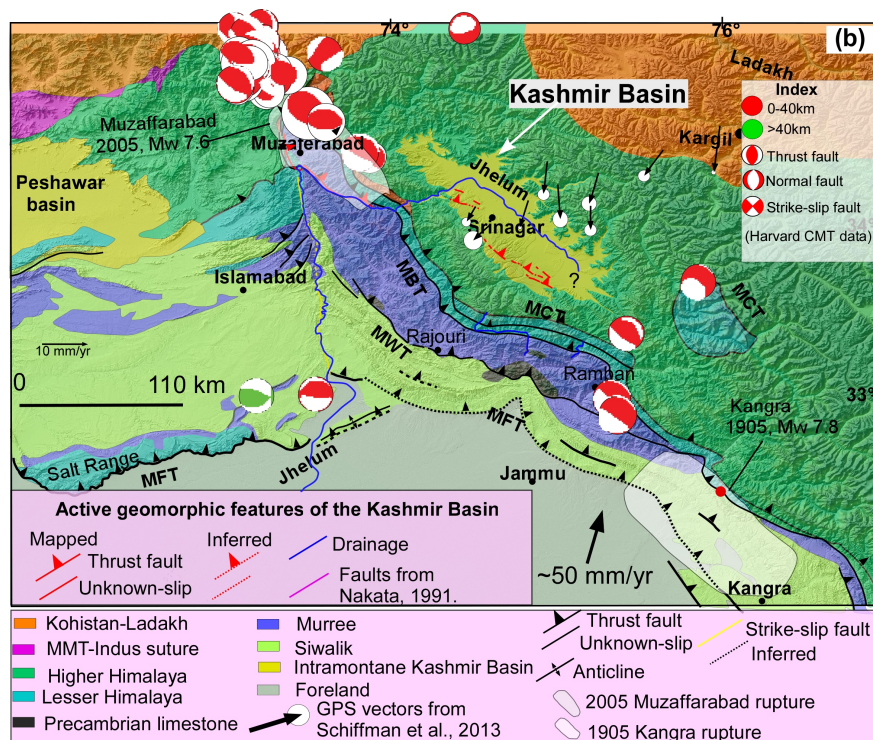


Fig. 2 (after Shah, 2016)

Shah, A., 2016, The Kashmir Basin fault and its influence on fluvial flooding in the Kashmir Basin, NW Himalaya, in Wessel, G.R., and Greenberg, J.K., eds., *Geoscience for the Public 8 Good and Global Development: Toward a Sustainable Future*: Geological Society of America 9 Special Paper 520, p. XXX-XXX, doi:10.1130/2016.2520(28).

Fig. 2.

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