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Interactive comment on "Abutting faults: a case study of the evolution of strain at Courthouse branch point, Moab Fault, Utah" *by* Heijn van Gent and Janos L. Urai

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The authors would like to express their thanks to the reviewer for his or her extensive review, and the helpful comments. We have implemented, most, of the changes suggested and address some of his points in detail below. In other cases we clarified our arguments. Points not addressed here section are accepted and will implemented/changed in the final document.

Reviewer's point 1) "Authors claim to deal with "thin deformation bands" (cataclastic shear bands), and then interpret their conjugate geometries according to the Navier-Coulomb-Mohr failure criterion. In order to support their interpretation, robust mi-

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crostructural evidences should be provided."

We thank the reviewer for raising this point and would like to use this opportunity to explain a little bit better. As described, and published in Johannsen et al. (2005), this outcrop contains 8 sets if “deformation band bundles”. In the following we will use the nomenclature of that paper. The bundles of “thick deformation bands” consist of deformation bands (or most likely: disaggregation bands”, sensu Fossen et al. (2007 – J Geol Soc L, vol 164 pp 755-769) consisting dominantly of undeformed grains, and 7 sets of different orientated sets of “thin deformation bands” in which the grain size is significantly reduced by cataclasis. The use of “thin” and “thick” is therefor a representation of the relative grainsize (thickness of deformation bands being roughly 3 times the grain size). These deformation bands occur in bundles, of anywhere between 2 to “dozens” of sub-parallel striking, anatomizing deformation bands. Locally within these bundles, highly polished, striated planes are found, which are interpreted by Johannsen et al. (2005) as slip planes, and the striations representing the slip direction. Other authors (Nicholas C. Davatzes et al., 2005; Eichhubl et al., 2009) have interpreted these as (sheared) joints, but the consistent nature of these slip directions, as demonstrated by the NDA analysis shown here, strongly suggest that this is not the case. Also our micrographs (fig. 2) sections show a marked increase in deformation band density towards the slip plane. In fact, the fact that the NDA analysis of the data clustered according to the sets published by Johannsen et al. (2005) into three apparently internally consistent evolutionary steps, shows that these slip planes have not formed under a single stress regime, but are part of bundle they are part of and formed as this bundle is developing. As these slip planes have formed by dominantly frictional processes, the use of the Navier-Coulomb-Mohr failure envelope is justified as first approximation.

Reviewer’s point 2) "I do not understand the reasons behind the choice of grouping together Sets 5, 6 and 7 made by the authors. According to stereoplots shown in figure 6, the forementioned failure criterion does not justify this choice. Please explain in the revised text."

We agree that the stereo plot shown in Figure 6 does not demonstrate these sets to be conjugate, like sets 1 and 2, and sets 3 and 4 are. During the analysis we found that NDA analysis of these three sets of data (5, 6 and 7) were very similar, which led us to combine these sets into one. This point is glossed over in the text, and we will change the text to include this.

Reviewer's point 3) "Since the authors report that crosscutting relationships among Sets 1&2 and Sets 3&4 were not documented in the field, their relative timing of formation should be better justified."

The cross-cutting relationships between the deformation band bundles with in the triangular Courthouse Junction outcrop were indeed not the main focus of this work. Those relationships have been published in detail by Johannsen et al. (2005), and we have only observations that confirm their work. We will clarify this in the revised text. We do however mention that we did not observe any cross-cutting relations ships, between the two sets of slip-plane data points in location I, in the canyon directly south of the outcrop. We will make the text clearer that these relative timings are based only on assumptions of what a stress axes to expect in virgin rock.

Reviewer's point 4) "Finally, I recommend to improve the quality of the field structural maps shown in Figure 3 by adding details on attitude and abutting/crosscutting relationships among the various structural elements"

We agree with this point and will include more structural detail into the map.

Specific Comments (comments not addressed here are already adopted in the final document) âĂć "Please re-write the first paragraph (too much information, and too many references)" We thank the reviewer or this point and will improve the readability of this section. We feel that all references are relevant, but will remove a number "double citations",

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âĂć "explain how you know that fractures “results from unloading or weathering close to the surface” (line 163, as well)" This is an assumption not based on data (other than some prior references that indicate “late fracturing”). We will change the text to better reflect this.

âĂć "please explain the reasons behind your interpretation of Segment A being older than Segment B (line 241)" The courthouse junction is assumed to be the result of a breached relay (Foxford et al., 1998, Fossen and Rotevatn, 2016), i.e. two initially parallel faults, where one rotates and grows towards the second until they abut (Rotevatn, 2007, 2009a). In these cases, the parallel faults often are the same age, but the abutting fault needs a pre-existing fault to abut against. Therefore we use the term “older” when describing segment A, compared to segment B but that is only valid at the location of the branch line. However, it is reasonable that further along the fault, there are sections of the faults that are active at the same time. We will adopt the text to use “pre-existing” rather than “older”.

âĂć "please explain why you assessed the formation of Sets 1&2 ahead of the of the fault tip of Segment B; " One model of fault growth in lithified rocks is by segment linkage, i.e. the coalesce of smaller, isolated deformation structures into a single through going fault plane (see for example, but not limited to Cartwright et al. (1995 , J Struc Geol, Vol. 17, No. 9, pp. 1319 -1326). One of these early isolated deformation structures in high nett/gross sandstones are deformation bands. We assume therefore that on the current trajectory of Segment B, prior to this segment becoming a fault a range of different deformation structures (fractures, faults, deformation bands) were present. As segment B grew, it incorporated more and more of these isolated structures into its tip line, and essentially freezing those structures that it passed by, as the strain was taken over by the much larger slip plane of segment B. This why we have placed the formations of sets 1&2 in front of the tip of segment B, as they need to exist, prior to being able to be incorporated into the tip line.

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