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Interactive comment on "Coherent diffraction imaging for enhanced fault and fracture network characterization" *by* Benjamin Schwarz and Charlotte M. Krawczyk

Anonymous Referee #1

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Coherent diffraction imaging for enhanced fault and fracture network characterization Benjamin Schwarz1 and Charlotte M. Krawczyk1,2 1GFZ German Research Centre for Geosciences, Albert-Einstein-Str. 42-46, 14473 Potsdam, Germany 2Technical University Berlin, Ernst-Reuter-Platz 1, 10589 Berlin, Germany Correspondence: Benjamin Schwarz (bschwarz@gfz-potsdam.de)

Review General: The authors present data examples of the application of diffraction imaging based on focussing with unweighted time migration including coherence measurement methods along the migration travel time surfaces without going deep into the mathematical theory. As introduction synthetic data sets illustrate the diffraction

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Discussion paper

phenomena and its relation to reflected signals. They explain the difference between focussing followed by coherency application in the image domain and coherency application in the data domain followed by projection. Coherency methods are discussed in detail in the image domain and also an application in the data domain followed by projection is compared to the same 2D synthetic dataset. A short introduction into the projection method with multiple wave front attributes is given with most relevant literature references for further reading. The real data examples are all applied by focussing followed by coherency application which is the simples form of diffraction imaging. An 2D multichannel dataset was used additionally to show the wavefield separation of reflections and diffractions in the shot-gather domain as a pre-processing stage and compared the pre-stack time migration and the migrated diffracted image. From a 2D single channel profile the diffracted image was compared to the zero-offset section and the separated diffracted zero offset section. From the same dataset additionally, a post stack time migration and the diffracted image was used to characterize the subsurface structure. A time slice of a 3D migrated land dataset data and the corresponding diffracted image time slice very nicely show additional information how diffracted images can contribute to an interpretation. The last example is an application to ground penetration radar with a zero-offset section, the separated diffracted wavefield and the diffracted image. For all data examples references are given for further reading.

Specific Comments: The comment here I make in the following could be the topics in the discussion helping people without deep theoretical understanding (application paper) when to use the focussing method and how to interpret the diffracted image although you already mentioned the topics in a broad discussion. The paper nicely shows data examples of diffracted images and how use them in conjunction with the reflective image to characterise the subsurface. But what I am missing are the uncertainties and limitations of the method. Because diffractions are generally 3D a 2D profile will also show side diffractions. The hope is that the presented coherence method will cancel most of the events, but this has not been shown, most critical I see here the single channel data. Maybe additionally a simple guideline can help nontheoretical readers to understand what of information could be expected for this kind of focussing application depending on the input information: velocity knowledge, single channel/multichannel, type of diffractions (generated by fault zones - edge wave with polarity change, point/volume diffractions without polarity change) apparent velocities, and time/depth errors from side echoes. Velocity knowledge: if multichannel data exist, the application of the velocity estimated from MCS reflections seems to be the most intuitive and hopefully the coherency will cancel the diffractor images which are generated from side echoes. A velocity estimation only from diffractions along a 2D profile would I not expect to be to accurate. I think all of the problems I mentions can be solved for 3D data with a multi-attribute analyses followed by projection which seems to get very powerful method in the future.

Individual Correction / Comment: Page 3 Line 71 Correction/Comment: . . . when a wavefield encounters a relevant property change (e.g. that has a local curvature) of or below the wave length . . . Comment: a horizontal interface with an impedance anomaly will also create diffractions.

Page 6 Figure 2 Correction/Comment: Left side: Focussing Section 3.2, Coherence measurement Section 3.1. Right side: Coherence measurement Section 3.1, Projection Section 3.3 Comment: not Section 2.x

Page 10 Figure 4 Comment: not clear what Phase-reversed semblance and augmented semblance means (I have some idea), but please reference to your equation what you did when.

Page 10 Line 219 Correction/Comment: the polarity of diffractions can change near the apex for zero offset data, which . . .. Comment: for 2D offset data the phase change occurs along the boundary ray (e.g. edge diffractions). This position can be found e.g. by a double diffraction stack (vector stack) during the migration in a shot-gather (the stationary point / tangential alignment). Side echoes may have no phase change at all.

Page 13 Line 299 Correction/Comment: which appears as a largely (transparent) body with (weak), chaotic internal structure. Comment: it does not look transparent or weak with this gain applied to the section.

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