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Active seismic imaging using microseismic events

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The analysis and interpretation of microseismic data sets are receiving increased attention, both in the exploration industry for the characterization of hydrocarbon and geothermal reservoirs as well as in academia for the general understanding of seismogenic processes at plate boundaries. The gain in data quality due to e.g. the deployment of borehole-receiver-arrays and the meanwhile common practice of recording the full waveform of the seismic events allows the processing of these data sets using modern seismic imaging and inversion algorithms. We have developed a passive seismic imaging approach which consists of two steps. Firstly, the hypocenter of the microseismic event is precisely located. Secondly, this event is treated as pseudo-active seismic source and we process the reflections within the recorded wavefield using a directional migration algorithm in order to construct a high-resolution image in the close vicinity of the located hypocenter. Here we describe this approach and demonstrate the application to several microseismic events recorded by a borehole array in the SAFOD (San-Andreas-Fault-Observatory-at-Depth) main hole. The results are high-resolution images of different fault branches related to the San-Andreas-Fault (SAF) system in the close vicinity of the borehole. The comparison of these findings with existing surface seismic reflection images as well as additional borehole information demonstrates some interesting features. In summary our results allow a spatial characterization of the complex internal structure of the SAF and can certainly be helpful for other studies which rely on this knowledge.