IMAGING QUASI VERTICAL GEOLOGIC FAULTS WITH EARTHQUAKE DATA

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ABSTRACT

In this thesis we present a method for imaging quasi vertically dipping faults with surface records of reflected P waves from small earthquakes. These faults are boundaries between geologic structures, such as tectonic plates and are located in earthquake active regions such as Parkfield, California. The high degree of activity enables the use of multiple seismic recordings in our fault identification algorithm. Major challenges occur because of the quasi vertical orientation of the fault and the fact that the wave reflected by the fault and recorded by the surface receivers is not well modeled by the direct arrival of the propagating wave generated by the earthquake source.

Our method uses the 2D acoustic wave equation as the model for P wave propagation. We assume that the approximate wave speed map on the reflection side of the fault and the source location are known, e.g. from travel time tomography. We also assume that the source time function is known. The new features of our method arise because the earthquake sources are located very close to the fault. This has two implications: (1) the direct arrival and the reflected wave arrive almost simultaneously, so that it is impossible to separate them, using standard techniques, on a seismogram, and (2) most of the reflections occur above the critical angle which introduces the distortion in the reflected wave. To overcome these difficulties we use a modeled incident wave to: (1) remove the direct arrival from the data, and (2) remove the post-critical distortion from the reflected wave. We justify the distortion removal using the leading order term of an asymptotic expansion, for which exact estimates are made of the error, and an optimization procedure. To complete our algorithm we utilize some features of reverse time migration: (1) the use of full acoustic wave equation for modeling and back propagation, and (2) zero lag correlation of the back propagated time reversed reflected and incident waves.

We present numerical examples of fault reconstructions with synthetic data where faults of two different shapes are reconstructed: (1) the straight vertical fault, and (2) the fault that shifts horizontally as it dips, in the media where the

regions separated by the fault have constant and depth dependent P wave speed profiles.