Nuclear Explosion Monitoring Research and Engineering (NEMR&E) Program
Quarterly Report DOE DE-FC52-06NA27319

Research Title: "Advanced Waveform Simulation for Seismic Monitoring Events"

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Reporting Period: August 1, 2007-October 31, 2007

Technical Progress:

A. Description of Activities

This quarter involved continued efforts in helping people at AFTAC and LLNL. We are also preparing a paper on the role of rupture directivity in generating high-frequency signals, see ***Abstract.***

Rupture Directivities of the 2003 Big Bear Sequence

Abstract

We have developed a forward modeling technique to retrieve rupture characteristics of small earthquakes (3<M<5), including rupture propagation direction, fault dimension, and rupture speed. The technique is based on an empirical Green's function (EGF) approach, where we use data from co-located smaller events with fault parameters as Green's functions to study the bigger events. Compared to deconvolution, this forward modeling approach allows full use of both the shape and amplitude information produced by rupture propagation. Assuming simple 1D Haskell source model (*Haskell*, 1964), we parameterize the source time function of a target event as the convolution of two boxcars, featuring the rise time τ_r and the rupture time τ_c, and we solve for τ_r and τ_c in a grid search manner by minimizing the waveform misfit between the three-component data and the "synthetics" from the EGFs. By fitting the observed azimuthal pattern of τ_c with the

predictions from the model for both P and S-waves, we obtain estimates of fault length and rupture velocity. We have applied the approach to the 11 strike-slip events with magnitude greater than 3 from the 2003 Big Bear sequence in Southern California. We generally chose smaller events with similar focal mechanisms for EGFs, however, we show that the smaller events with different focal mechanisms can work equally well when corrected for radiation pattern effects. The studied events show rupture propagation in all azimuths with a wide-range of rupture speeds (1.5-3.5 km/sec), implying the complexities introduced by a multi-fault-plane fracture zone. Events propagating along the mainshock strike (Mode II) tend to have lower stress drops and faster rupture velocities than those involved in cross-faultings, but with many exceptions.

B. Progress - on track.

C. Progress is following the stated Work Statement.