Geophysical Research Abstracts
Vol. 18, EGU2016-8735-1, 2016
EGU General Assembly 2016

Seismic wave interaction with underground cavities

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Realization of the future Comprehensive Nuclear Test Ban Treaty (CTBT) will require ensuring its compliance, making the CTBT a prime example of forensic seismology. Following indications of a nuclear explosion obtained on the basis of the (IMS) monitoring network further evidence needs to be sought at the location of the suspicious event. For such an On-Site Inspection (OSI) at a possible nuclear test site the treaty lists several techniques that can be carried out by the inspection team, including aftershock monitoring and the conduction of active seismic surveys. While those techniques are already well established, a third group of methods labeled as "resonance seismometry" is less well defined and needs further elaboration.

A prime structural target that is expected to be present as a remnant of an underground nuclear explosion is a cavity at the location and depth the bomb was fired. Originally "resonance seismometry" referred to resonant seismic emission of the cavity within the medium that could be stimulated by an incident seismic wave of the right frequency and observed as peaks in the spectrum of seismic stations in the vicinity of the cavity. However, it is not yet clear which are the conditions for which resonant emissions of the cavity could be observed. In order to define distance-, frequency- and amplitude ranges at which resonant emissions could be observed we study the interaction of seismic waves with underground cavities. As a generic model for possible resonances we use a spherical acoustic cavity in an elastic full-space. To solve the forward problem for the full elastic wave field around acoustic spherical inclusions, we implemented an analytical solution (Korneev, 1993). This yields the possibility of generating scattering cross-sections, amplitude spectrums and synthetic seismograms for plane incident waves. Here, we focus on the questions whether or not we can expect resonant responses in the wave field scattered from the cavity. We show results for varying input parameters such as dimensions, densities, and seismic velocities in and around the cavity, in order to discuss the applicability of such observations during an OSI.