

Conclusions from a numerical survey on the seismic wave propagation inside and around an underground cavity

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Motivated by the need to detect an underground cavity within the procedure of an On-Site-Inspection (OSI) of the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO), which might be caused by a nuclear explosion/weapon testing, we aim to provide a basic numerical study of the wave propagation around and inside such an underground cavity. Most techniques allowed by the Treaty have been already tested in an integrated field exercise. However, some seismic techniques referred to as “resonance seismometry” are still pending and under current development. In order to provide a proper scientific groundwork we investigate this problem on a purely numerical level and simulate these events based on recent advances in numerical modeling of wave propagation problems.

Our numerical study includes the full elastic wave field in three dimensions. We consider the effects from an incoming plane wave as well as point source located in the surrounding of the cavity at the surface. While the former can be considered as passive source like a tele-seismic earthquake, the latter represents a man-made explosion or a vibroseis as used for/in active seismic techniques. First we will discuss in detail the specific characteristics of the scattered wave field origin to a plane P-waves and plane S-wave separately. Further we will show results on the wave interaction from a point load source at the surface with a more complex subsurface structure. For our simulations in 3D we use the discontinuous Galerkin Spectral Element Code SPEED developed by MOX (The Laboratory for Modeling and Scientific Computing, Department of Mathematics) and DICA (Department of Civil and Environmental Engineering) at the Politecnico di Milano. The computations are carried out on the Vienna Scientific Cluster (VSC).

The accurate numerical modeling can facilitate the development of proper analysis techniques to detect the remnants of an underground nuclear test, help to set a rigorous scientific base of OSI and contribute to bringing the Treaty into force.