Joint hypocenter-velocity inversion of surface wave arrival times to locate hypocenter of unexploded ordnance munition (UXO)

Issam Bakari, Institut National de la recherche scientifique (INRS-ETE), Canada, Québec.
Bernard Giroux, Institut National de la recherche scientifique (INRS-ETE), Canada, Quebec.
Sonia Thiboutot, Defence Research and Development Canada, Canada, Quebec.

Unexploded ordnances (UXO) in training ranges cause a significant risk to the environment and human activity after the abandonment of training fields. It was recently proposed (VanDeMark et al., 2012; VanDeMark et al., 2013) to detect and locate the occurrence of OXUs during firing exercise through microseismic monitoring, to allow their rapid removal. In this contribution, the location problem is addressed. The proposed method is based on the inversion of surface wave arrival times recorded by seismic sensors buried around the range. The method consists in minimizing, by the least-squares method, the difference between observed and predicted arrival times of the surface wave generated from UXO impacts. Due to the non-linearity of the problem, the velocity model and the initial hypocenters are iteratively updated until the residuals between predicted and observed arrival times fall within a prescribed limit. The location algorithm is based on the approach of Block (1994) and Giroux (2001) but with surface waves traveltimes computed on triangular meshes instead P and S waves on rectangular grids. The algorithm was tested with synthetic data which consist of the arrival times of surfaces waves generated by the ray tracing code under heterogeneous velocity. Each source of arrival time has thus a known coordinate hypocentre and origin time. The velocity model was estimated by 20 calibrations shots whose origin time and locations at the free surface are known. Tests were conducted but applying varying quantities of noise on the synthetic arrival times in each seismic sensor. The results obtained show that the previous approach is feasible; it is possible to locate the UXO's hypocenters with good accuracy (error of the hypocenter location reached 1-2 meter) under low noise condition (3%). However, under strong noise (15%) the accuracy of localisation decreases significantly (error of the hypocenter location reached 40 m). This notwithstanding, error of location depends on the ray-station coverage within the grid and the initial velocity model depend upon the number of calibration shot.