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Effects of charge design features on parameters of acoustic and seismic waves and cratering, for SMR chemical surface explosions

Y. Gitterman
The Geophysical Institute of Israel, Seismology, Lod, Israel (yefim@seis.mni.gov.il)

A series of experimental on-surface shots was designed and conducted by the Geophysical Institute of Israel at Sayarim Military Range (SMR) in Negev desert, including two large calibration explosions: about 82 tons of strong IMI explosives in August 2009, and about 100 tons of ANFO explosives in January 2011. It was a collaborative effort between Israel, CTBTO, USA and several European countries, with the main goal to provide fully controlled ground truth (GT0) infrasound sources in different weather/wind conditions, for calibration of IMS infrasound stations in Europe, Middle East and Asia.
Strong boosters and the upward charge detonation scheme were applied to provide a reduced energy release to the ground and an enlarged energy radiation to the atmosphere, producing enhanced infrasound signals, for better observation at far-regional stations. The following observations and results indicate on the required explosives energy partition for this charge design: 1) crater size and local seismic (duration) magnitudes were found smaller than expected for these large surface explosions; 2) small test shots of the same charge (1 ton) conducted at SMR with different detonation directions showed clearly lower seismic amplitudes/energy and smaller crater size for the upward detonation; 3) many infrasound stations at local and regional distances showed higher than expected peak amplitudes, even after application of a wind-correction procedure.
For the large-scale explosions, high-pressure gauges were deployed at 100-600 m to record air-blast properties, evaluate the efficiency of the charge design and energy generation, and provide a reliable estimation of the charge yield. Empirical relations for air-blast parameters - peak pressure, impulse and the Secondary Shock (SS) time delay - depending on distance, were developed and analyzed. The parameters, scaled by the cubic root of estimated TNT equivalent charges, were found consistent for all analyzed explosions, except of SS time delays clearly separated for the shot of IMI explosives (characterized by much higher detonation velocity than ANFO). Additionally acoustic records at close distances from WSMR explosions Distant Image (2440 tons of ANFO) and Minor Uncle (2725 tons of ANFO) were used to extend the charge and distance range for the SS delay scaled relationship, that showed consistency with SMR ANFO shots.
The developed specific charge design contributed to the success of this unique dual Sayarim explosion experiment, providing the strongest GT0 sources since the establishment of the IMS network, that demonstrated clearly the most favorable westward/ eastward infrasound propagation up to 3400/6250 km according to appropriate summer/winter weather pattern and stratospheric wind directions, respectively, and thus verified empirically common models of infrasound propagation in the atmosphere.
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