Detecting explosion-induced dynamic phenomena using time-lapse seismic surveying

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Characterization of seismic events as underground nuclear explosions is a challenging task. Geophysical methods such as seismic monitoring systems are used by CTBTO to link post-explosion phenomena to potential sources. The main challenges in seismic monitoring involve accurately locating of sources and separating underground variations in seismic properties due to the explosion from naturally occurring variations. Underground detonations result in an immense change in pressure and temperature concentrated around the source origin. This results in the formation of characteristic static and dynamic phenomena. This study highlights the potential of using time-lapse seismic to identify ground zero by monitoring post-explosion dynamic phenomena. Time-lapse seismic, also known as 4D seismic, is successfully employed in the oil and gas industry for petroleum production monitoring and management. It involves taking more than one 2D/3D seismic at different calendar times over the same reservoir and studying the difference in seismic attributes.

Following an underground explosion, dynamic changes in rock and fluid properties are observable for a prolonged period, even up to several decades. This is prominent near to source origin, and it is a result of the redistribution of residual energy, such as pressure, temperature, and saturation. Frequent seismic monitoring surveys (time-lapse seismic) enables one to monitor the changes in rock and fluid properties. This study presents the characteristics of the time-lapse seismic signature observed in a heterogeneous medium (or heterogeneous cavity). We will look into the impact of factors affecting land 4D repeatability on the 4D signature. The significance of identifying the 4D signature related to the explosion in a seismic section, and the feasibility of detecting it during the OSI with resource and time constraints in place will be discussed. We present a fast detection method using machine learning for the detection of explosion related time-lapse signature, which could be an identifier of the source location or ground zero.

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