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SEISMIC DETECTION OF VOIDS IN COAL SEAMS

by

Daniel M. Larson

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Golden, Colorado

Date Aug 24, 1987

Signed: Daniel M. Larson
Daniel M. Larson

Approved: Thomas L. Dobecki
Dr. Thomas L. Dobecki
Thesis Advisor

Golden, Colorado

Date 24 Aug 1987

P R Romig
Dr. Phillip R. Romig
Department Head
Geophysics

ABSTRACT

Void detection is an important application for the shallow seismic reflection method as abandoned, unmapped coal mines may result in a hazard to life and property. This study examines the use of the seismic method to locate subsidence hazards near Gillette, Wyoming and determine the extent of previous coal mining at the U.S. Mid-continent site. Three different sites were surveyed near Gillette and five sites in the U.S. Mid-continent. Seismic reflection field testing was performed to obtain the best data, and common offset shooting was used as an inexpensive and effective means for locating anomalies which could indicate voids.

Three seismic indicators were found to be especially effective for locating voids. These include: early first breaks, seismic doublet formation and seismic resonance. Early first breaks result from a velocity field disturbance above the void due to its presence which actually speeds first arrivals rather than delays them. The seismic doublet is also formed by a velocity effect; however, it is a reflection effect caused by the near total collapse of the void resulting in a large rubble and disturbed zone. Seismic resonance is caused by the source being directly above a fairly shallow void and the void then acting as a secondary source which generates high amplitude mono-frequency seismic energy, dominating the seismic section. In an effort to better understand the above effects, seismic modeling was performed for the early arrival and doublet models.

At the Wyoming Site, early first arrivals and seismic doublet formation were the most successful for locating voids. These two indicators occurred in together at the Peerless Mine, where 80% of the drill holes encountered voids. Confidence in void prediction

is very high whenever early first breaks and seismic doublet formation are observed together. Seismic resonance was not observed except on Lakeway Line 1 where one trace appeared to resonate. The absence of resonance at the Wyoming Site may be explained that at Peerless Mine the voids were filled with water and at a 100 ft depth, too distant from the source to resonante, while at Lakeway Drive and Laur Mine, the voids may have been collapsed and could not resonate. At the Mid-continent Site, all indicators were used to locate voids with seismic doublet formation being the most reliable. Early first breaks and seismic doublets were seen at Sites 1 and 2 and occurred together as at the Peerless Mine however, they were more subtle at Sites 1 and 2. Resonance was used very successfully at Site 5, with a 75% success ratio and I feel that with thorough analysis, using the techniques described in the thesis, similar consistent results should be attainable. Resonance was also observed at Sites 2 and 3 but at that time we did not understand enough about the causes of resonance to make void predictions. Geologic noise was also a problem on the seismic records as several missed voids had coals or limestones missing, thick parting or other unusual characteristics that may have caused the seismic anomalies which were drilled.

Color attribute processing of the common offset trace data was also used to accentuate the subtle features which are more difficult to observe on a conventional variable area seismic display. Instantaneous phase was used to detect doublets and continuity of seismic events. Instantaneous frequency was used to detect changes in the wavelet frequency content which may help to confirm the presence of a void. Seismic doublet formation shows up very well on instantaneous phase plots as an additional color bar. Sometimes the frequency plot shows higher frequency content surrounding the doublet. Early arrivals show no frequency content change when compared to normal first arrivals however, the color display shows arching of the color bands, as expected. Seismic resonance shows up well

as continuous bands of energy on conventional and phase plots. On frequency plots, consistent frequencies are shown in the resonance portion of the record.

The shallow reflection technique, combined with confirmation drilling, is a good tool which can speed the detection of voids and aid in the appraisal of the hazards involved.

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