

Analysis of seismic waves generated by surface blasting at Indiana coal mines

A project pursuant to the 2002 PEPP summer workshop

Submitted by Mike Kelley, Harrison High School

The research project is to investigate the characteristics of mine blast seismic waves in southern Indiana. Coal mines are prevalent in this part of the state, and they conduct periodic blasting to open new areas for development. Mine blasts can be analyzed in much the same way as earthquakes, and such analysis would have important implications for understanding different seismic sources, earthquake structures in Indiana, and wave propagation in Indiana.

The project makes use of the data gathered by the PEPP network of Indiana, a state of the art, broadband digital seismometer network. Fourier analysis is one of the techniques used, using software such as WinQuake. Proper use of filtering software, given the broadband nature of the instruments, will also be important.

One of the difficulties in studying seismic energies is that earthquakes are unpredictable as to time and location. Because seismologists are constrained by their knowledge of local fault systems and the physical distance from the source to the recording instruments, even the best locations of earthquake hypocenters are estimates by operational definition. In addition, although earthquake wave signatures are distinctive and separable from other seismic sources on seismograms, little work has been done on other sources to investigate if there are distinguishing features of non-earthquake sources. In particular, some recent work has been done with building implosions and mine blasting to determine if there are feasible ways to identify seismic sources based solely on waveforms, and whether other information such as amplitude and frequency might be helpful in identifying unknown sources. Finally, an analysis of mine blasting in Indiana would lead to a better understanding of wave propagation characteristics, particularly in the more active southern half of the state, which would allow for better assessment of earthquake risk in the Wabash Valley and New Madrid fault systems.

Professor Brian Stump of Southern Methodist University is one of the acknowledged leaders in the research community in the area of mine blast analysis. He and members of his research group have authored numerous papers recently, using data from copper and taconite mines (deep blasting) and coal mines (surface blasting) to gain new understanding of seismic wave propagation, ground truth, and source characteristics. Much of his work has been with the active cooperation of mine operators, which allows the group to gain important information about precise times and locations of blasts, as well as the quantity and type of explosive used. The group's research has also been supported by national security concerns such as the Defense Threat Reduction Agency for its value in monitoring nuclear blasts worldwide.

The project uses Dr. Stump's research as a jumping-off point to produce new analyses of mine blasts in Indiana. From this, it is hoped that insight will be gained into several fundamental science issues, including:

1. Discrimination of different types of seismic sources (application to nuclear monitoring)
2. Better understanding of earth structure (application to understanding earthquake-generating structures in the Midwest)
3. Improved knowledge of wave propagation characteristics (application to seismic risk in Indiana)

After witnessing a live coal mine blast at Black Beauty's Somerville mine, precise information was gathered as to timing and location for blasting activities for three months in 2003. Waveforms were examined from three-component arrays at Evansville and New Harmony, Indiana, and compared. Filtering was applied to try to determine where the clearest signatures were located on the frequency spectrum.

Although Coal mine operators do not keep high-precision timing records of their blasting activities, enough information was available to identify the blasts in the data records of the two seismometer stations. Once those data were correlated and compared, other stations were examined, including Bloomington, New Albany, and Eastern Greene County to look for similarities in waveform amplitudes.

Final results of this research will be published and announced in the spring meetings of the Indiana Academy of Science (<http://www.indianaacademyofscience.org/>) in 2004.

The project made use of the Indiana PEPP network, (home page at <http://www.indiana.edu/~pepp/index.html>), which is a state-of-the-art, broadband seismometer array. It is in continuous operation in the state, and feeds data in real time to Indiana University as well as archived data to the United States Geological Survey. Contacts have been made in the past to various coal mining companies in the area, including Black Beauty Coal, and they have been cooperative in the past in facilitating research on their blasting techniques. The

project should also prove fertile ground for student research projects in both earth science and physics classes. Two student projects are already underway for the 2003-2004 school year using this project as a starting point.