Miller, R.D., J. Xia, and C.B. Park, 2001, Detecting fracture related voids and abandoned lead/zinc mines near Baxter Springs, Kansas: Proceedings of the National Association of Abandoned Mine Lands Annual Conference, August 19-22, Athens, Ohio, proceedings published on CD.

Historical lead/zinc mining activities have left surface scars and underground hazards across a portion of southeastern Kansas, southwestern Missouri, and northeastern Oklahoma, known as the Tri-State Lead/Zinc Mining District. Fractures and voids in otherwise competent near-surface rock layers can pose a stability risk to overlying surface structure. Confident detection and delineation of voids or open fractures prior to surface expression permits the evaluation and possible reduction in risk such features pose to people and property. Surface growth associated with a sinkhole located within 100 ft of State Line Road and a gas metering station south of Baxter Springs, Kansas, raised concerns for public safety and prompted an extensive drilling and geophysical investigation. The mine workings of interest ranged in depth from 100 to over 150 ft below ground surface and are in an area where Mississippian Limestone acts as both host and roof rock. Overlying the limestone is a soil and clay layer varying in thickness from 10 to 20 ft. Subsidence in this area has a historical precedent dating back prior to the mid-twentieth century.Abandoned lead/zinc mines (drifts) known from mine maps to pass beneath State Line Road and generally coincident with the sinkhole of concern were the primary targets of this study and were suggested to embody a risk to surface structures in this area. Extensive drilling in the immediate area provided excellent 1-D ground truth but lacked the lateral resolution necessary to map the subsurface extent of fracture zones and voids. Surface wave imaging detected lateral variations in rock rigidity at depths and locations generally consistent with mine maps and drillencountered sediment-filled and open fractures. Stable voids, regardless of origin, represent no risk to public safety; however, if stable voids begin to grow and surpass a size or roof span that can be supported by its roof rock, subsidence will occur. At the present time, science provides no method to confidently predict subsidence rates, extent, and volume. However, by using geophysical methods such as surface wave imaging as a monitoring tool, iterative “snap shots” of the subsurface allow discrimination of change and estimates of current subsidence rates. Surface wave analysis using MASW allowed relatively quick and accurate (in relation to other geophysical methods) acoustic images to be produced of the upper 50 ft to 150 ft. Considering the sensitivity of surface wave propagation to shear wave properties, changes in the phase velocity of surface waves is directly proportional to changes in rock stiffness or rigidity. Abrupt changes in shear wave velocity will occur at the boundary between voids (water or rubble filled) and consolidated rock. As well, fractured or highly altered zones where competent rock is broken up and replaced by unconsolidated sediments and/or fluids will produce distinctive changes in the shear wave velocity field. Very localized anomalous features detected at depths of over 100 ft in two locations at this site were generally consistent with the geometry of drifts suspected to pass under the lines. Images produced as a result of this study clearly indicate that rock layers beneath the profile lines possess localized lateral discontinuities in rock properties. With no obvious connectivity existing between these structurally weak zones, it is not feasible to suggest the orientation and potential commonality of these features. Interpretation of surface wave and drill data was complementary in depth and extent of void areas, but unique in terms of resolution. The single snap shot in time provided by the surface wave technique provides a relatively clear picture of subsurface rock strengths, but without a prolonged study evaluating change over time it is not possible with either data set (drilling or subsurface) to confidently discern the long-term risk of collapse at a specific spot. It is reasonable to suggest, based on both data sets, that a sizeable thickness (> 10 ft) of competent limestone separates the bedrock surface and the shallowest of the void/fracture areas encountered by either study. Two areas have been identified on surface wave data where some strain exists above void/fracture zones. It is not clear in this setting how much of a strain gradient is indicative of failure versus being consistent with a long-term sustainable load. An analogy would be the strain present between bridge pillars. A bridge is designed to span a specific distance and support a given load. This load will manifest itself as increased strain between the bridge supports. Based on the data presently available, there is no way to confidently predict long-term subsidence rates or location along these profiles. With only a single snap shot in time, it is not possible to detect vertical migration. Considering the small size of the anomalous features and the thickness of overlying competent rock, returning to the site in six to nine months and acquiring identical surface wave data will provide a measure of change in rock properties (if any exists). This study was successful in developing an accurate shallow subsurface image consistent with the ground truth provided by drill data. The feasibility of this technique to delineate lateral changes in shear wave velocity and its relationship to drill data was evaluated.