AN ANALYSIS OF EXTREME DANGER PROBLEMS ASSOCIATED WITH SUBSIDENCE OF ABANDONED COAL MINE LANDS IN SOUTHWESTERN INDIANA [1]

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Abstract -- Subsidence from Abandoned Coal Mines in Indiana has resulted in 23 sites which present an Extreme Danger to individuals. The source of information for this paper is the National Inventory Update of Abandoned Mine Lands for Indiana. Three types of subsidence occur in Indiana: pit, trough, and shaft. Pit subsidence has caused the vast majority of Extreme Danger Subsidence Problems. The average depth of subsidence is 105 ft. and 78% of these problems are in areas where the overburden is less than 165 ft. thick. Topographically, 15 of the 23 sites are located in lowland areas. The mining of the Springfield and Seelyville Coal Seams accounts for more than 50% of the problems. Both seams usually have poor quality roofs of shale and poor quality clay floor materials; the Seelyville Seam has a particularly mobile underclay. Early mining techniques of irregular room configuration and insufficient pillar support have had a profound influence on subsidence. The average year that mine production began is 1909, when many of these early mining techniques were still being employed in Indiana. The outlook for subsidence in Indiana is that the problems will persist and their numbers may increase as the years put more stress on the older mines.

INTRODUCTION

Coal mining in Indiana had its beginnings in 1812 when horse-drawn scrapers were used to gain access to the shallow coal seams. In the early 1850's shaft mining became more widespread. Underground mine production rose steadily and first peaked around 1918.

All of this coal mining is not without its continued impact on the environment and individuals. Any time an area has been undermined there is the possibility of subsidence. The timing of this event is unpredictable, but "the mine is going to come down eventually and everything is going to have to adjust" (Carey 1984).

It is estimated that 10,900 acres of potential subsidence threaten urban areas alone in Indiana (Gray and Bruhn 1984). The focus of this paper is the Extreme Danger Problems associated with subsidence in Indiana. The connotation here is danger to people, but damage to property like houses and farmland is also considered as it presents an Extreme Danger to the occupants and farmers.

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RESEARCH METHODOLOGY

The data in this study are a result of a research grant from the Indiana Department of Natural Resource, Division of Reclamation and the Office of Surface Mining to conduct the National Inventory Update for Indiana. Fieldwork and interviews were a necessity in the compilation of information required on the update forms. Many sites were visited repeatedly as problems in the area changed. Additional sources of information include, but were not limited to, Preliminary Coal Maps for each county, Coal Investigation Maps for selected quadrangles, Mined maps for each topographic quadrangle, Indiana Geological Survey-Coal Section files, Indiana Department of Natural Resources-Division of Reclamation files, and newspaper and trade magazine articles.

FACTORS INFLUENCING SUBSIDENCE

Coal Geology

Fourteen coal seams have been rather extensively mined in Indiana. The Extreme Danger Subsidence Problems were associated with only seven of these coal seams. The characteristics of each have a profound effect upon the subsidence problems. The seam occupying the lowest geological position is the Pinnick Seam. Generally, the seam is thin, about 2.1 ft. thick, and rather hard to trace (Shaver et al. 1970). The roof is carbonaceous shale or massive ferruginous sandstone with an underclay floor. The second seam, the Upper Block Coal ranges in thickness from 1.5 to 5 ft. thick. The roof is usually thick-bedded shale; however, in some areas it is a soft shale overlain by massive sandstone. The floor is a hard carbonaceous underclay that becomes "plastic" when moist. The third seam, the Minshall-Buffaloville Coal is irregular in extent and thickness. The roof is clayey to silty shale and in some places it is a black sheety shale. The floor is a gray plastic underclay that may be nearly 3 ft. thick (Shaver et al. 1970). The fourth seam, the Seelyville Coal averages 6 ft. in thickness, but ranges from 1.5 to 11 ft. thick. The roof is either a gray, silty, carbonaceous shale or a brown to gray massive, friable carbonaceous sandstone. The floor is a gray underclay that may be plastic and shaley in places. This fireclay floor is a "very mobile layer" (Karpiniski 1938) that caused past active mining difficulties. The fifth seam, the Survant Coal has several shale partings that may be 20 to 30 ft. thick. The roof is usually sandstone or gray shale. The sixth seam, the Springfield Coal is the most widespread in Indiana and maintains a relatively constant thickness over these areas. The roof is usually a gray shale, but may also be sandstone or clay. The floor is a silty clay, shale, or sandstone. The final seam, the Hymera Coal ranges in thickness from 0.5 to 11 ft. The roof and floor are usually shale.

Mining Techniques and Characteristics

The most common means of coal extraction in Indiana was the Room and Pillar method. The specifics of this method vary with the characteristics of the coal seam and the time when mining occurred. Early room and pillar mining in Indiana was rather irregular (fig.1). This wandering was a failure to create or stick to a regular mining plan. This was typical of mines in this study from the late 1800's to the middle 1920's. The rooms were wide, 12 to 30 ft. The entries were narrow, only 6 to 8 ft. wide. The depth of the room varied from 165 to 600 ft. This irregular pattern resulted in many pillars of odd shapes and sizes. Many of these pillars are too narrow to support the overburden indefinitely.

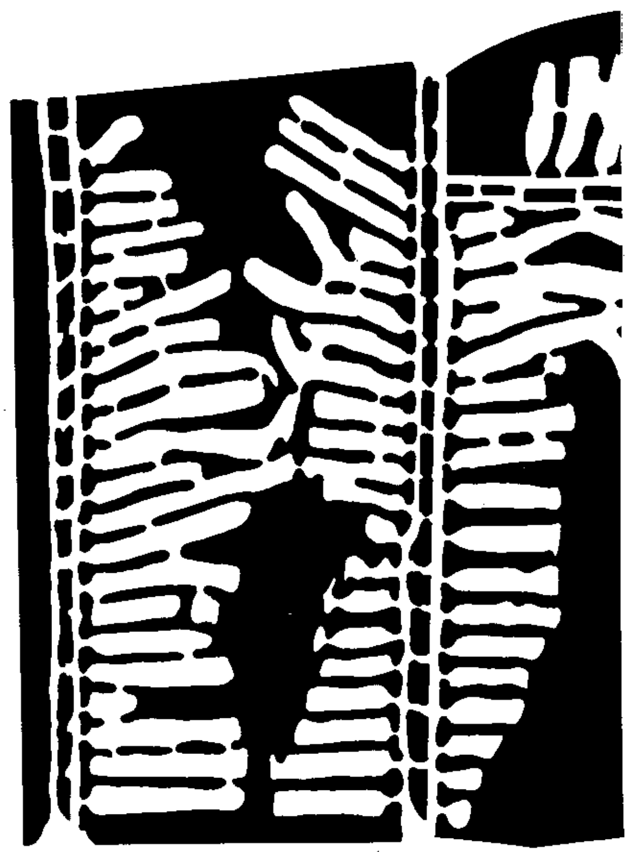

Figure 1.--Early room & Pillar method (Andros 1915).

Later the patterns of removal were more systematic (fig.2), and there was more concern over continuing mine stability. At this time the room width remained the same, the entries were twice as wide, and the length of the rooms was

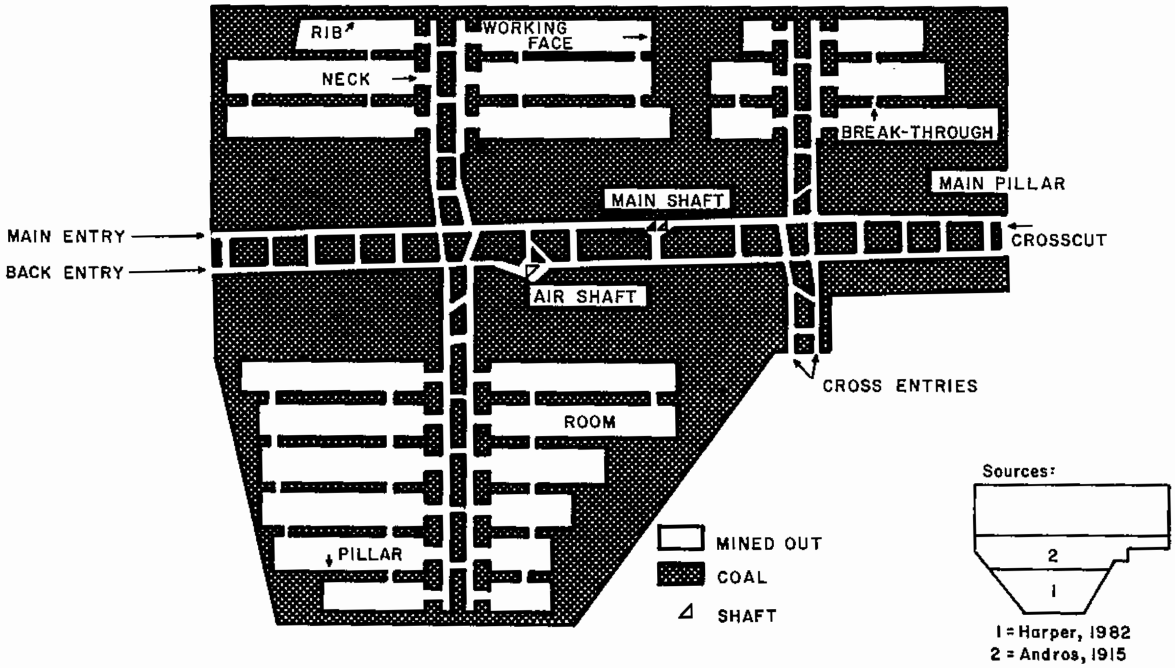

Figure 2.--Systematic room & pillar method.

much shorter - 175 to 400 ft. However, with this systematic removal of coal the pillars were consistently 6 to 23 ft wide.

In the early mines, roof supports were chiefly timbers and rather narrow coal pillars. Timbers could be quite closely spaced, but the average life of timbers in an active mine was rather short. Later metal and concrete replaced wood, however the conditions in some mines were quite corrosive (Karpiniski 1938). Since the early 1950's, roof bolting has been employed along with coal pillars.

Roof stability was affected by the types of overlying materials and the presence of any discontinuity. Faults, joints, horsebacks, or rolls all degraded the roof quality. Many of these are noted on the coal mine maps for the subsidence sites. Another common practice that affects the roof stability is "robbing pillars". This gouging of coal from the pillars was unsafe in active mining and adds greatly to the subsidence potential in abandoned mines. It was particularly unsafe when, as in some cases, this practice occurred at and around the bottom of the shaft (Harper 1982).

Some problems incurred during active mining give insight as to the types of problems that influence subsidence in the study area. In the Saxton Mine, there were notations on the mine maps of numerous areas of "bad top" (Harper 1982). There were also roof rolls and extensive clay veins and slips that thwarted efforts to adhere to mine plans. In several old mines in Clay County, coal and clay were extracted from the same mine; this gives evidence of the type of floor and roof materials which were present.

The Saxton Mine extended beneath the Wabash River. There was a very real lack of a solid overburden thickness. Roof falls and "water breaks" were common (Harper 1982). This lack of sufficient overburden thickness when mining beneath a river was also quite common in southern Indiana along the Patoka River. Sometimes distances beneath the river and the underlying coal were as little as 10 ft.

OCCURRENCES OF SUBSIDENCE

There are three main types of subsidence in Indiana; pit, trough, and shaft. Pit subsidence is responsible for more of the Extreme Danger Problems in Indiana than trough or shaft subsidence. Each of these three types of subsidence have specific movements which separate them from each other however, Eventual erosion, is a type of movement which accentuates each of these subsidence problems.

Typically, pit subsidence occurs from the failure of the roof (fig.3). The result is an opening from 6 to 8 ft. deep and 2 to 40 ft. in diameter (Dumontelle 1981). The main movement, at least initially, is vertical. In the Eastern United States, pit subsidence usually occurs where mines are less than 100 ft. deep and in Pennsylvania, most pit subsidence is found where the mine overburden is less than 50 ft. (Gray and Bruhn 1984). Areas where the mine is

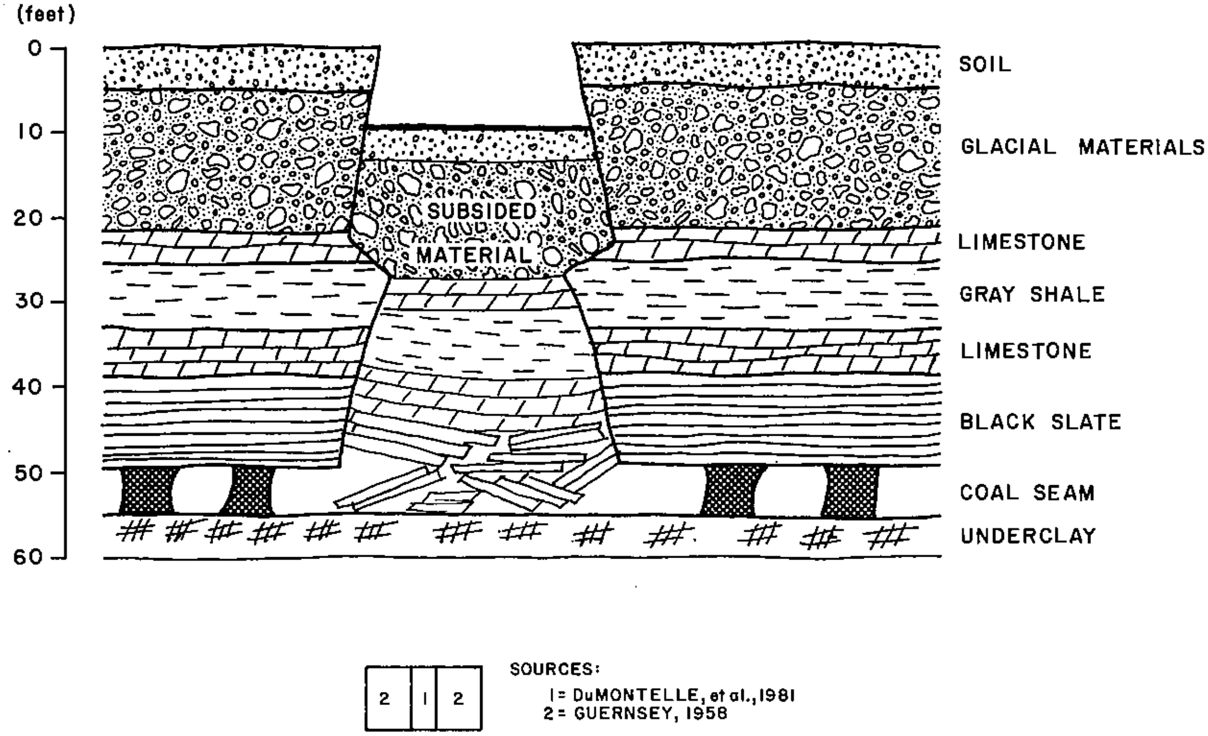

Figure 3.--Idealized pit subsidence

deeper than 150 to 165 ft. experience decreased frequencies of subsidence occurrence (DuMontelle 1981, Harper 1981). Pit subsidence usually occurs over rooms and entries resulting in a surface reflection of the mining pattern.

The second type of subsidence is trough. Usually, this is a gradual disintegration of the pillars or squeezing of floor materials into the mine voids. The disintegration and squeezing may also occur simultaneously (fig.4). Troughs may occur in areas of mining at any depth, but most frequently associated with deeper mines than those where pit subsidence occurs. Troughs are usually 2 to 4 ft. deep and cover larger areas than pit sub-

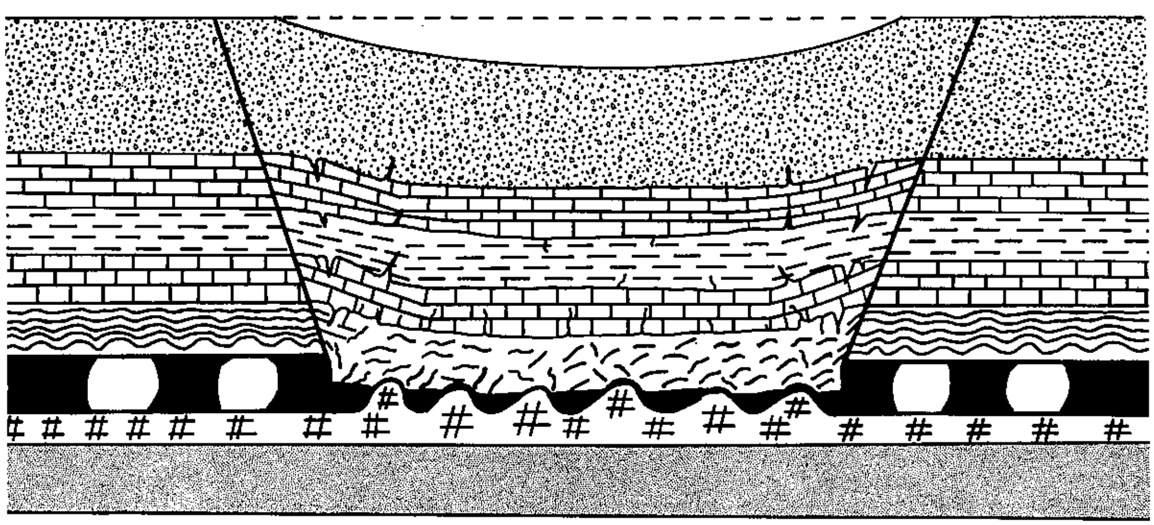

Figure 4.--Idealized trough subsidence (modified from DuMontelle 1981).

sidence. The movements are both vertical and horizontal (DuMontelle 1981) as the whole area is depressed. The horizontal areas may extend over a broader area than is undermined. For a 160-ft-deep mine, the area affected may be 75 ft. beyond the mined out areas (DuMontelle 1981). This is an important point as many individual homeowners in Indiana feel that they and their property are safe if the mine does not extend beneath their house.

The third type of subsidence is associated with the shaft itself. This is commonly associated with older mines, especially those in Clay County (Harper 1982). The older shafts were not supported well when active mining was occurring. Frequently the added weight of the buildings and equipment near the shaft was not considered in the required support. Decades later the supports fail and erosion widens the original shaft opening (fig.5). New subsidence sites in Indiana "will pose continuous problems because they are a result of collapsing shafts and tunnels" (Honea and Baxter 1983). In the Western United States, subsidence occurs around mine shafts. This subsidence is similar in appearance to pit subsidence, except the pits are much deeper (Dunrud 1984). Similar conditions to these are present in Indiana.

RESULTS

Extreme Danger Situations

A total of 77 occurrences of subsidence present an Extreme Danger to individuals in certain areas in Indiana. Some examples of the recent problems in Indiana are noted here. One air shaft subsided to a depth of 20 ft. in a corn field, just a few weeks after harvest. A child in Clay County was in the backyard playing when the ground beneath his feet gave way and he dropped down 15 ft. Near that same site, a road collapsed on Christmas. Several sites are near the foundations of houses, one is near a trailor, and others are located in backyards.

Some subsidence is active. One trough has increased in size by approximately 20% in the last 2 years. One shaft has increased in size from the original size of a 10 by 15 ft. rectangular shaft to an area 75 ft. in diameter in the last 15 years. This particular shaft contains a combine, three old cars, and 60 years worth of household garbage. Most of the occurrences average 20 ft. in diameter and have an average estimated depth of 25 ft. One trough is 225 ft. long, 100 ft. wide, and 30 ft. deep. The Miami #1 Mine, an area of active sub-

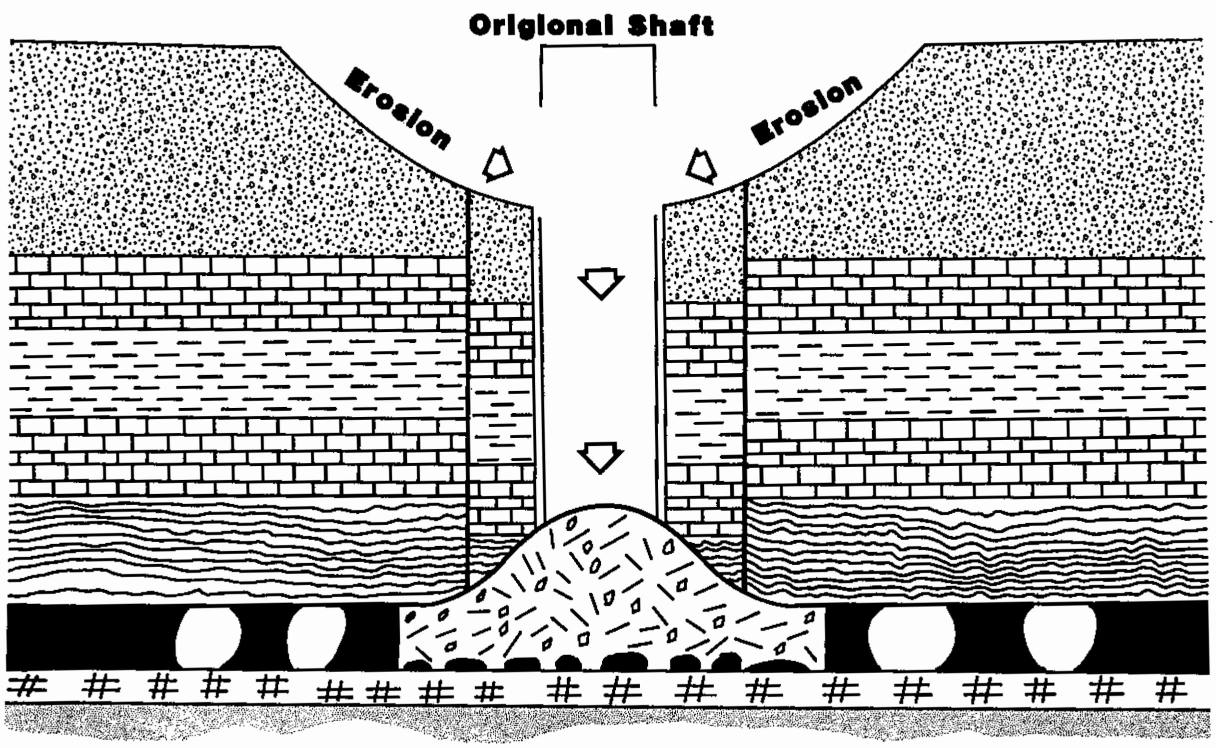

Figure 5.--Idealized shaft subsidence (modified from Dunrud 1984).

sidence near two houses, is typical of the small old mines. Medium size trough areas are particularly in evidence in the Clay County area, where robbing pillars was routinely practiced.

Discussion

There are 23 sites in Indiana where subsidence presents an Extreme Danger to people (fig.6). Clay, Green, Vigo, and Warrick are the four counties with 74% of the sites. Most had more than one occurrence of subsidence. There are 77 individual occurrences associated with the 23 sites of Extreme Danger Problems.

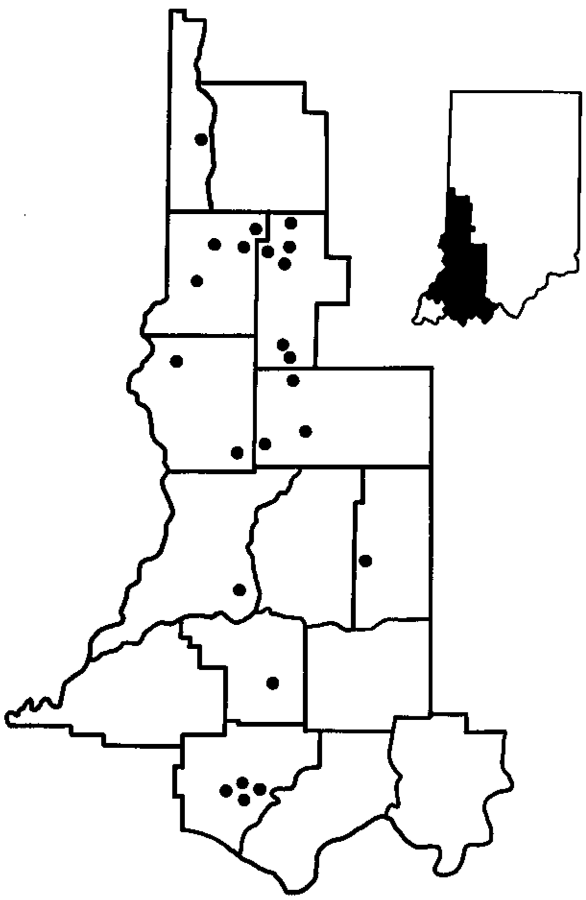

Figure 6.--Twenty-three Subsidence Sites in Indiana.

In addition to these, there are at least 200 acres affected by subsidence that present a danger problem or are affecting the land surface in less-inhabited areas. It should also be noted that many subsidence problems that demand immediate action fall under the auspices of the Office of Surface Mining Emergency Program.

The seams where most of the problems occur are the Springfield with 8, Seelyville 5, Survant 4 and Hymera 3. The three remaining seams have one problem site each. The Seelyville Coal seems to have an inordinately higher percentage of subsidence occurrence than appears to be warranted given its relatively low percentage of coal production.

In Indiana, the Extreme Danger Problems were mainly associated with pit subsidence. There were 70 occurrences of pit subsidence, 3 of trough, and 4 of shaft subsidence. Most of the subsidence occurred in areas of shallow overburden. Areas less than 165 ft deep accounted for 78% of the problems. This was reduced to 70% in areas less than 100 ft deep and 43% in areas less than 50 ft deep. The depths ranged from 25 ft to 550 ft; the average depth was 105.6 ft.

Topographically, 15 of these mines were located in lowland areas, 6 in upland areas, and 1 on a floodplain. One site was in the Wisconsin glaciation region, 16 were in the Illinoian glacial areas, and the remaining 6 were in the non-glaciated areas of Indiana.

There were strong relationships between the total number of Extreme Danger Problems in Indiana and the beginning and ending years of coal production (Elbert 1987). There were more problems associated with the older mines. The beginning year of production was more characteristic of the types of mining techniques employed at the mine than did the ending year of production. Usually the methods and techniques used in mining the coal at a particular mine did not change much over the duration of production. Also, many mines with Extreme Danger Problems were relatively shortlived with 30% remaining in operation less than 5 years, and 50% less than 10 years (Elbert 1987).

Of the 23 subsidence sites, the range of the beginning year of production was 1884 to 1950. Five began production before 1900, and twenty began before 1920. The average year production began was 1909. The years production ended ranged from 1897 to 1960. Seven ended production before 1920, and sixteen had ended production by 1930. The average year production ended was 1923.

CONCLUSIONS

The subsidence problems in this study have occurred from abandoned mines which were abandoned between 1897 and 1960. Most of these mines were abandoned in the early 1920's. More than 50% of the areas were undermined 60 years ago, and 40% were undermined 30 years ago (Harper 1982). In Indiana, mines associated with all

Extreme Danger Problems were abandoned approximately 5 to 7 years behind the production peaks for coal in the state of Indiana (Elbert 1987). Therefore, since peak underground production occurred in 1918 and the mean of the date of abandonment is 1923, it would be expected that subsidence in Indiana will continue at least at the present rate, if not increase.

The most prevalent type of coal removal in underground mining in Indiana was the room and pillar method. When coal has been extracted, there is always the possibility that subsidence can occur. More research into all types of subsidence problems in Indiana would facilitate the prediction of future subsidence.

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