

INVESTIGATION OF SUBSIDENCE EVENT OVER MULTIPLE SEAM MINING AREA

BY

KEWAL K KOHLI, Ph.D

OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT

PITTSBURGH, PENNSYLVANIA, 15220

ABSTRACT

An investigation was performed to determine the sequence of events which caused the 1987 surface subsidence and related damage to several homes in Walker County, Alabama, USA (see Figure 1). Surface affects compared to mine maps indicated the subsidence to be mine related. However, two coal seams had been worked under this area. The upper seam, the American seam, ranged from 250 to 280 feet beneath the surface in the area in question. It was mined-out before 1955 by room-and-pillar method leaving in place narrow-long pillars to support the overburden strata, and abandoned in 1955. The lower seam, the Mary Lee seam, ranged from 650 to 700 feet beneath the surface. The Mary Lee seam had been abandoned in 1966 and subsequently became flooded. The dewatering of the Mary Lee seam workings in 1985 caused the submerged pillars to be exposed to the atmosphere. Due to multiple seam mining and the fact that workings had been inundated then dewatered, a subsurface investigation ensued to determine the sequence and ultimate cause of surface subsidence. Core sample tests with fracture analysis in conjunction with "down-the-hole" TV camera inspections provided necessary information to determine that the subsidence started in the lower seam and progressed through the upper coal seam to the surface. Evidence from the investigation program established that dewatering of the lower seam workings caused the marginally stable support pillars and the roof to collapse. This failure triggered additional subsidence in the upper seam which broadened the area of influence at the surface.

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PURPOSE OF INVESTIGATION:

In 1987, an investigation was undertaken by the Office of Surface Mining Reclamation and Enforcement (OSM) to establish the source of subsidence which caused damage to four houses (Figure 2) in Walker County, Alabama, USA so that necessary remedial measures could be planned to prevent further damage.

REGIONAL GEOLOGY:

The investigation site is situated within the Warrior Coal Basin of Central Alabama. The Warrior Basin lies in the Pottsville Formation of Pennsylvanian age. The American and Mary Lee seams (Figure 3) are part of the Pottsville Formation and had been deep mined at this site.

BACKGROUND:

The American seam (upper seam) in the affected area was mined out until 1955 by room-and-pillar method leaving in place long narrow pillars (Figure 4) to support the overburden strata and was abandoned thereafter. The mining depth in the area ranged from 250 to 280 feet and the mining height was four feet.

The Mary Lee seam (lower seam) in the affected area was mined out until 1966 using room-and-pillar method leaving in place small rectangular pillars (Figure 5) to support the overburden strata. The mine was shut down in 1966 and allowed to be flooded thereafter. In 1986 it was dewatered to examine the condition of pillars in the flooded area to evaluate the possibility of doing retreat mining. But no mining was done because the conditions of roof, floor and the pillars were found bad. However, to the south of the affected area, a solid coal barrier of about 100 feet thick was left in place and retreat mining was done beyond this point along the barrier in 1986. In 1987, four houses located on the surface beneath the workings of Mary Lee seam, dewatered recently were damaged by subsidence.

The Mary Lee seam in the area was four and a half feet thick and the depth ranged from 650 to 700 feet.

DISCUSSION OF ANALYSIS:

Fresh cracks were observed in the cores of all holes from the surface up to American seam which was an indication of a recent

movement of the overburden strata above the seam in this area. But the cores from holes 6 and 7 only (see Figure 2) showed fresh cracks in the overburden strata between the American and the Mary Lee seams. That indicated recent movement of the strata above Mary Lee seam over a small area. Based on this observation, it was concluded that pillars within a small area in Mary Lee seam collapsed after these were weakened by flooding and dewatering. It caused the overburden strata lying above Mary Lee seam to bend and fracture which overloaded the pillars in the American seam. This caused the failure of the pillars over a small area in the American seam. The pillar collapse progressed in all directions due to domino effect. This was evidenced by the presence of fractures in the strata observed in the cores of all the boreholes. The failure of the pillars in the American seam caused the overburden strata to move down and finally cause surface subsidence and damage to four houses.

The cracks observed on the surface had the same orientation as the mine workings in the American seam suggesting that the surface subsidence was controlled by the American seam.

The visual observations of the overburden strata from the video tapes also confirmed the fracture pattern observed in the cores from the holes. The video tapes also provided some additional information on bed separation of the overburden strata and the condition of pillars at the mine level.

The stability analysis of the pillars in the Mary Lee seam was also performed using conventional pillar design formulas and the compressive strength of coal obtained from the core samples. The pillar strength determined using these formulas was reduced by 25 percent to account for reduction in strength due to flooding. Most of the pillars within the collapsed area in the Mary Lee seam had a safety factor of one or below; which means these were marginally stable pillars before the collapse. The flooding of Mary Lee seam mine workings in 1966 and dewatering in 1986 had caused these pillars to weaken and ultimately collapse.

CONCLUSIONS:

Based on subsurface exploration and the assessment of the mine maps, it was apparent that the marginally stable pillars (50 ft X 30 ft) in a small area (see Figure 5) of Mary Lee seam collapsed after these were weakened by flooding and dewatering. The collapse of these pillars caused the overburden strata above the seam to fracture and move downward. As a result pillars in the American seam above the collapsed area were overloaded

causing them to also fail. Subsequently more pillars in the American seam failed due to the domino effect which widened the area of collapse. With the collapse of these pillars, the support to the overburden strata above the American seam was withdrawn. This caused the overburden strata above the American seam to sag, bend and fracture. The downward movement of the overburden strata progressed upward until it reached the surface and damaged the houses.

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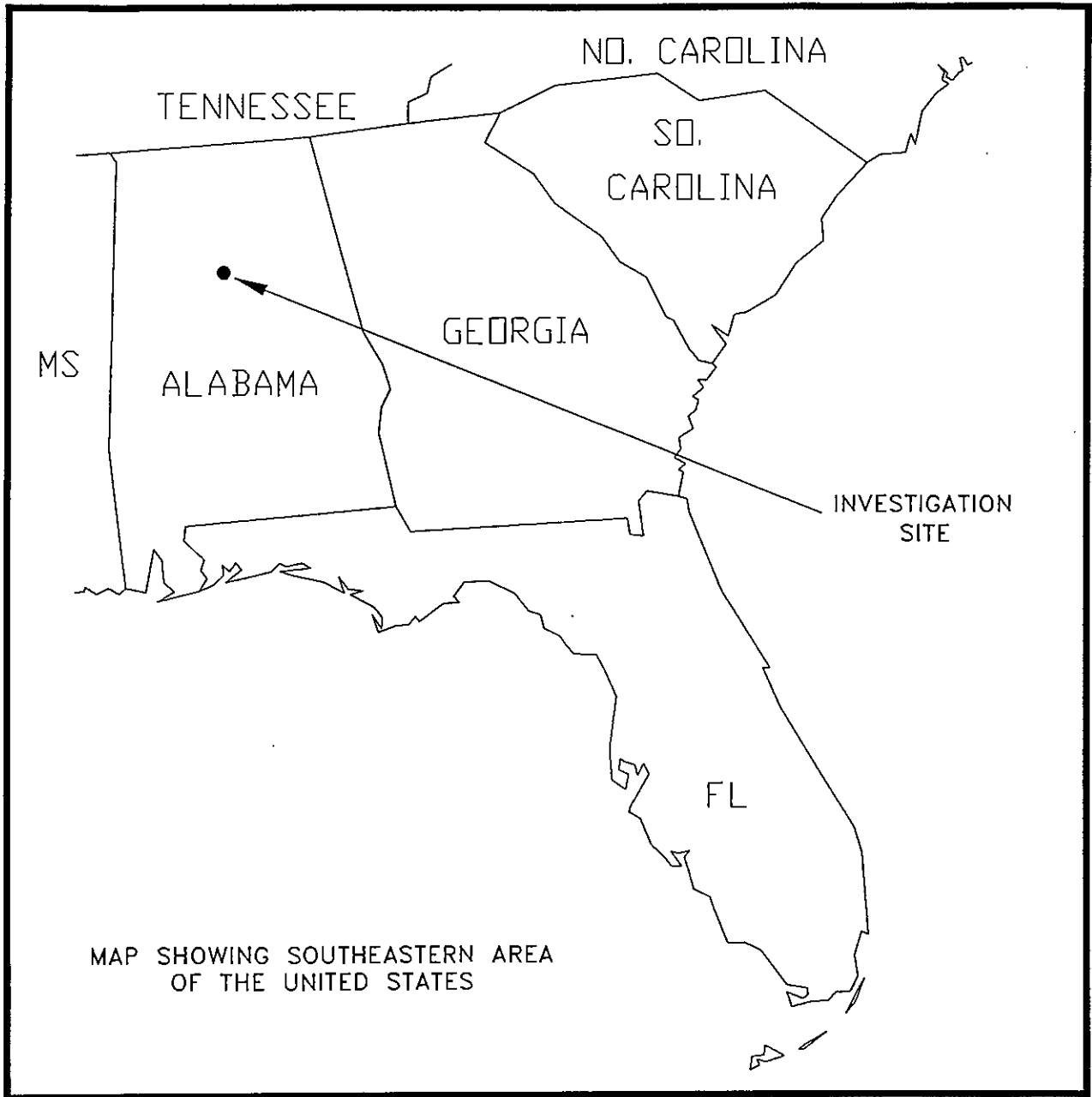
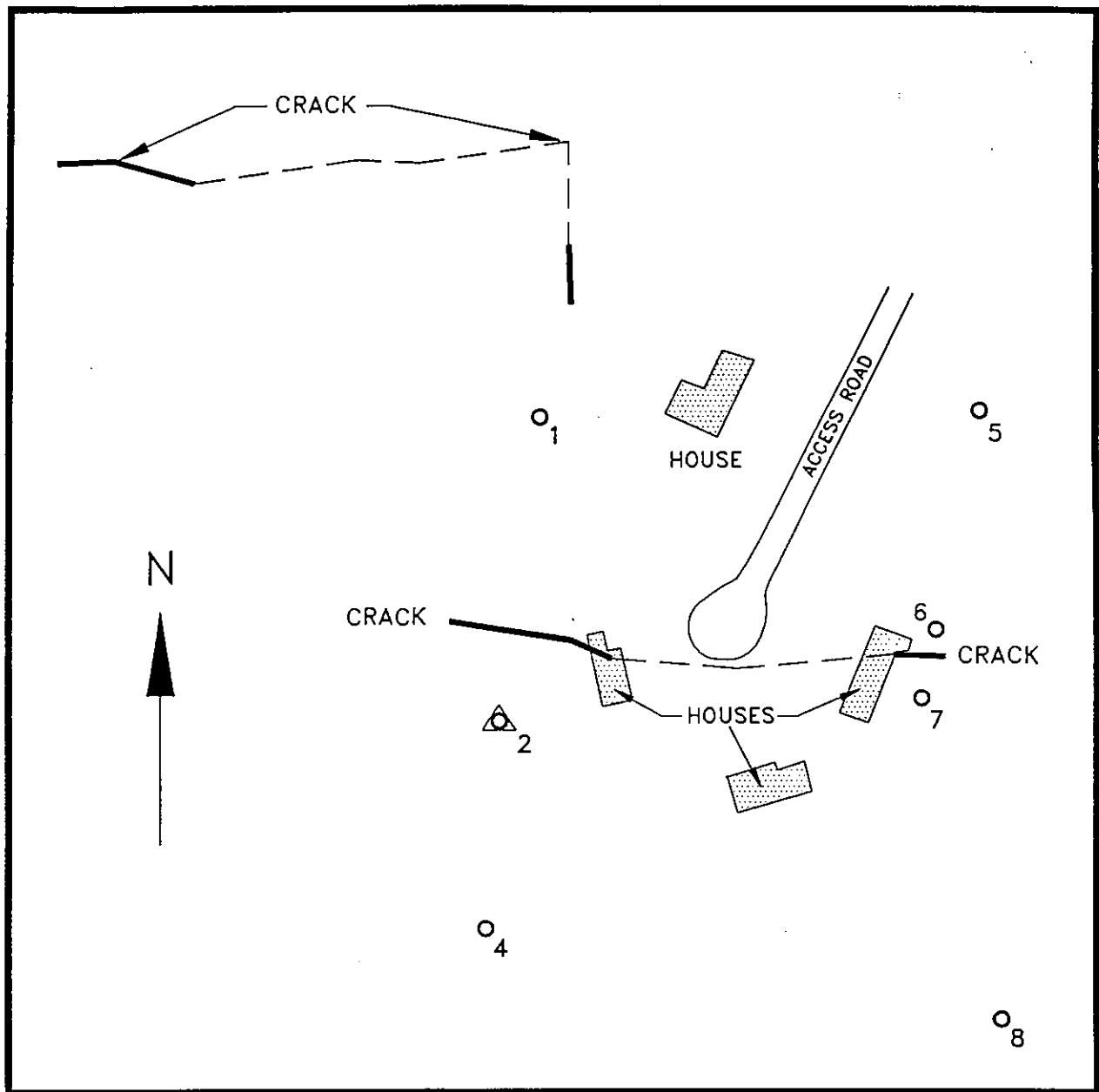


Figure 1 Location of Investigation Site



LEGEND

- ₁ Borehole
- △₂ Angle hole

Figure 2 Location of Houses, Surface Cracks and Boreholes

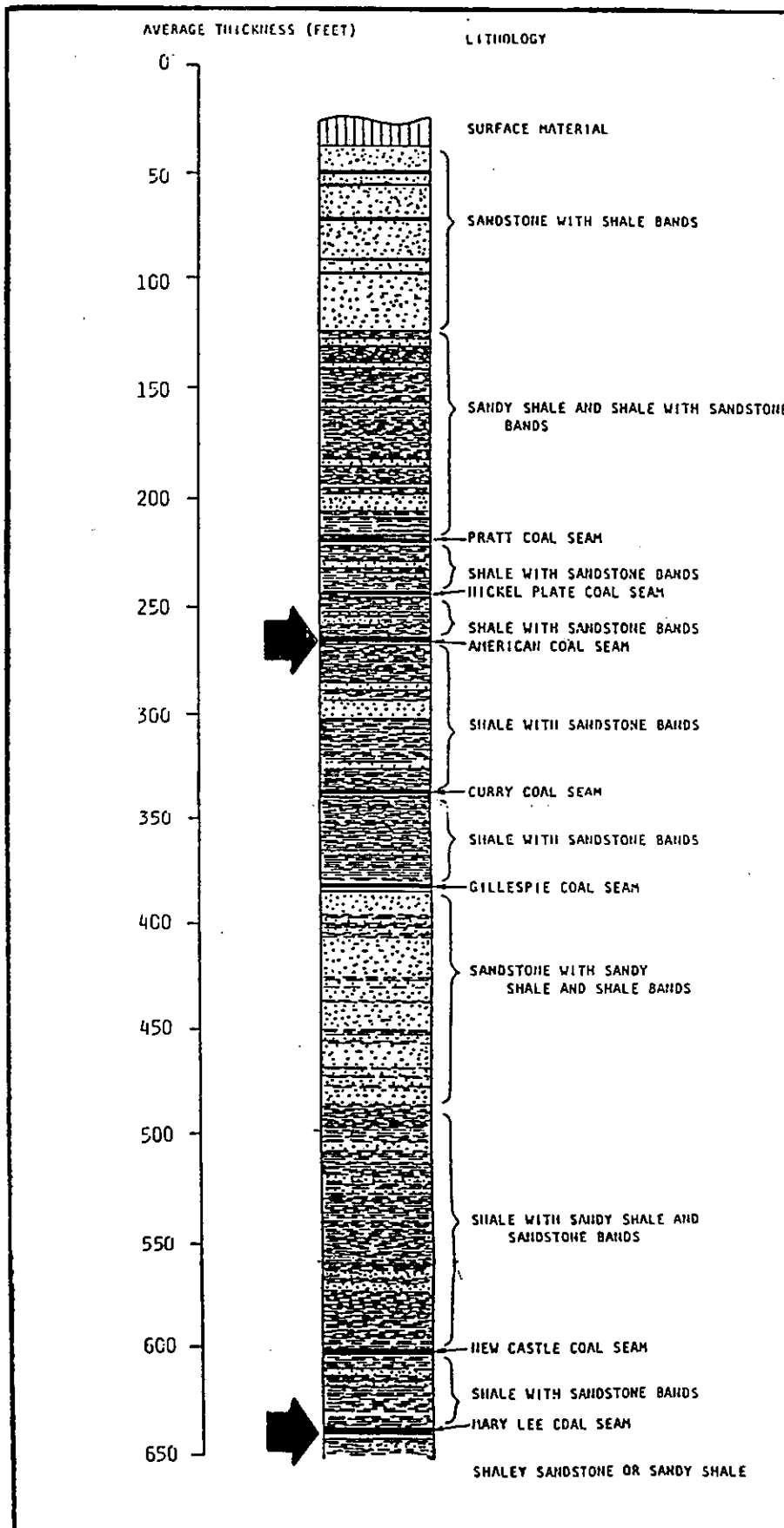
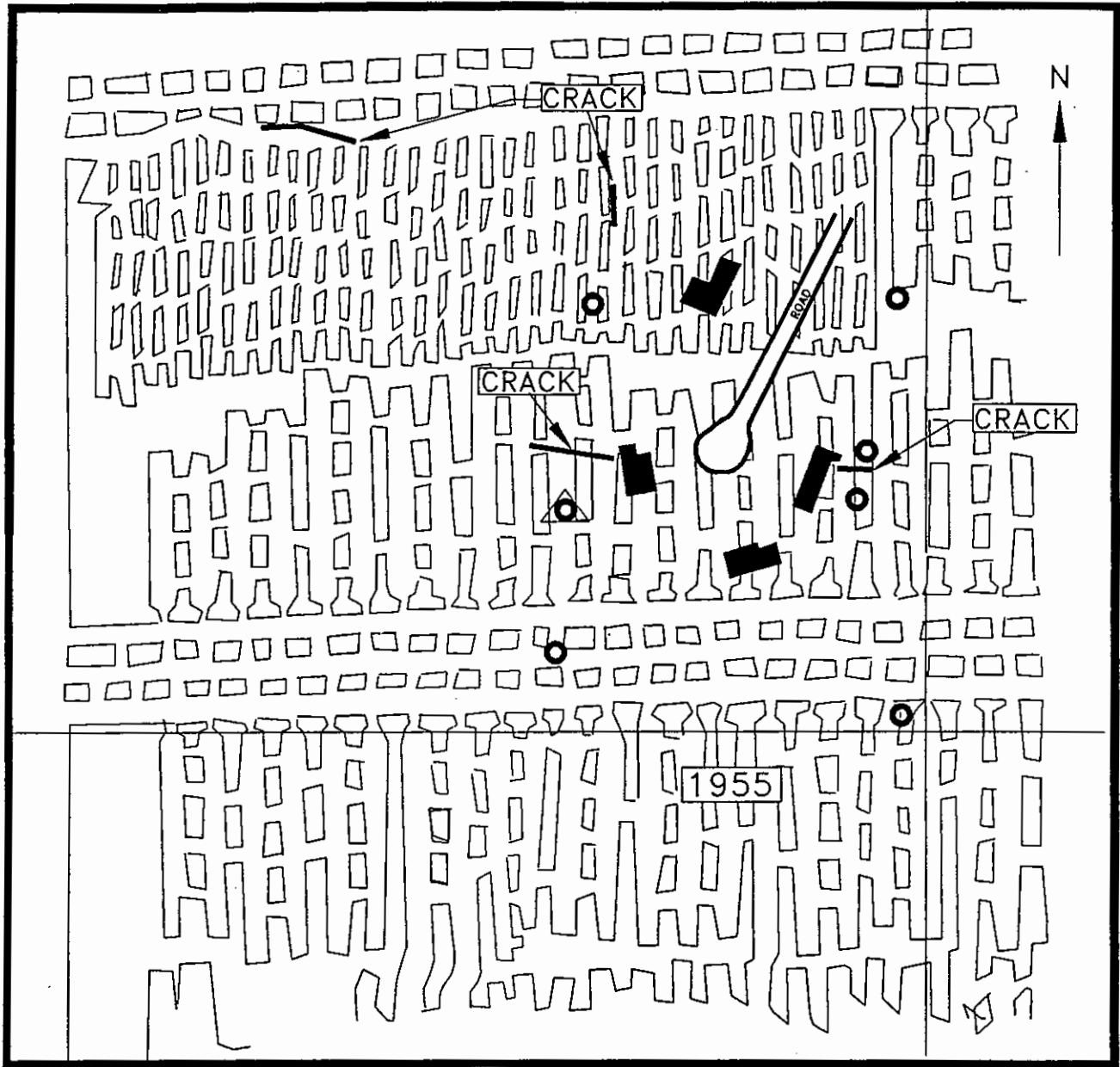


Figure 3 Geology of the Area

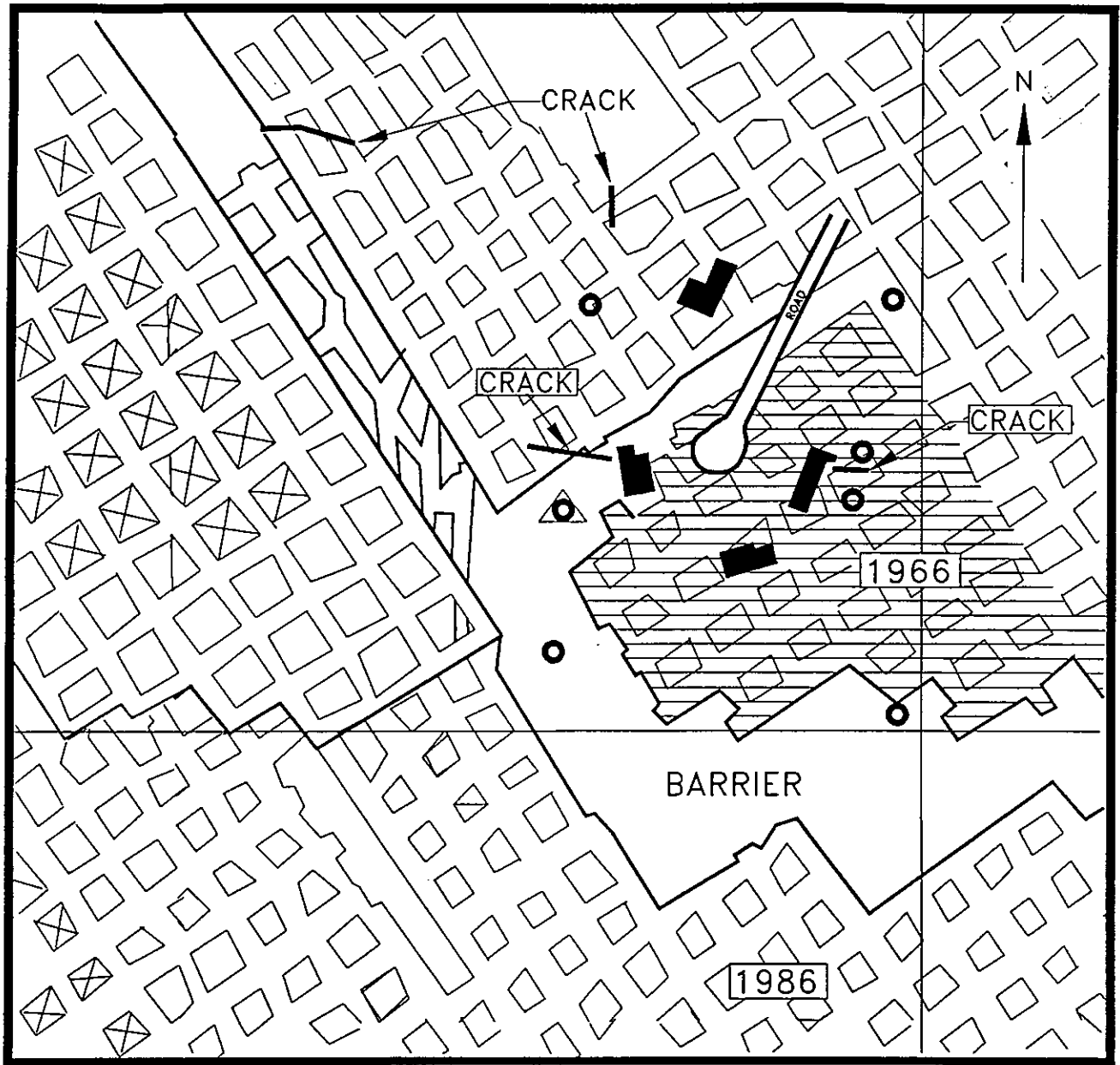


NOT TO SCALE

LEGEND

Mining height	4 feet
Depth	250 feet
Borehole	○
Angle hole	△
Structures	■

Figure 4 American Seam Workings



NOT TO SCALE

LEGEND



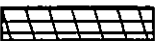

- Mining height 4.5 feet
- Depth 650 feet
- Borehole 
- Angle hole 
- Collapsed area 
- Structures 

Figure 5 Mary Lee Seam Workings