THE MECHANISM OF SINKHOLE FORMATION ABOVE THE COLLAPSE OF A SMALL YIELD-PILLAR PANEL IN THE RETSOF SALT MINE

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ABSTRACT

The Retsof Salt Mine in Livingston County, New York was successfully operated for 109 years by extracting approximately 12 feet of salt from a gently dipping layer with the use of room and pillar methods. The eventual loss of the Retsof Salt Mine from flooding was initiated on March 12, 1994 with the collapse of a small yield-pillar panel. Although the collapse occurred into a room with a nominal height of 12 feet, the collapse resulted in the formation of a sinkhole at the surface with a depth of more than 15 feet. This initial sinkhole destroyed a portion of a state highway and bridge. A second sinkhole formed over an adjacent panel and resulted in 70 feet of surface subsidence. These sinkholes penetrated through 1100 feet of geologic material consisting of 600 feet of rock and 500 feet of glacial sediments. Two distinct theories were postulated for the mechanism of sinkhole formation: 1) piping of glacial sediments through open fractures in the bedrock without actual loss of bedrock support, and 2) undermining and downdropping of a bedrock block. The resolution of these theories was important in order to assess whether similar sinkholes were possible over other portions of the mine or whether the existing sinkholes would stabilize sufficiently to allow reconstruction of the state highway and bridge. Drill hole data, recorded seismic activity, subsidence measurements and seismic reflection data were analyzed. The results indicate that the sinkholes formed when the limestone, dolomite and overlying glacial sediments dropped into voids created by the dissolution of salt and the slaking of salt-bearing shale from exposure to fresh water.

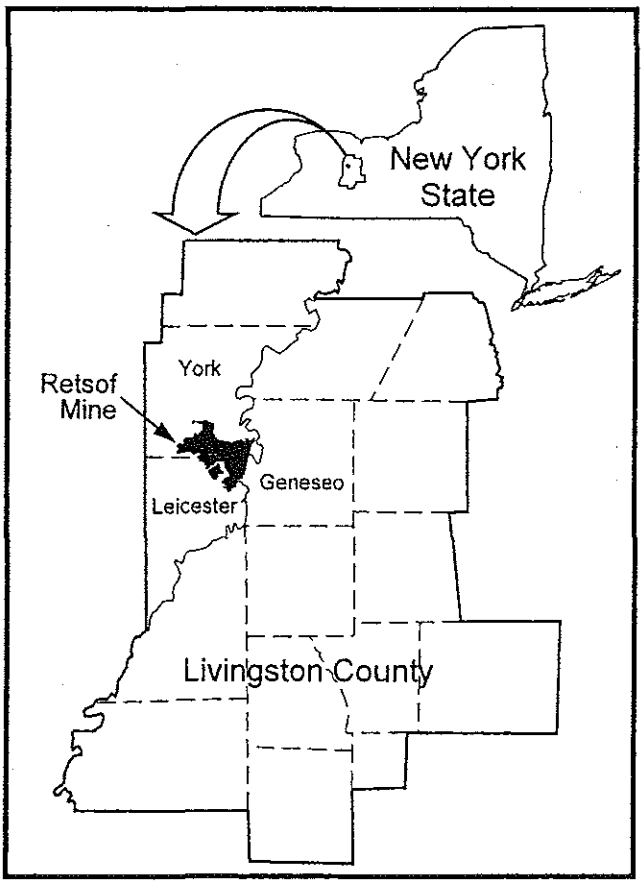

Figure 1. Location of the Retsof Salt Mine in Livingston County, New York State.

INTRODUCTION

A roof-fall occurred on March 12, 1994 in a small yield-pillar mining panel within the Retsof Salt Mine. The collapse caused a seismic event with a magnitude 3.6 (M_{bLg}) (Kelly, 1999) and formed a shallow circular depression with concentric fractures at the land surface. The mine-level collapse was coincident with a release of gas (methane) and brine into the mine. The brine inflow initially entered at a rate of 5400 gallons per minute (gpm) and eventually became fresh and increased to a rate of 20,000 gpm. The mine, which occupied 6,500 acres in Western New York (Figure 1), was completely inundated in 21 months.

The observable collapse occurred in the roof over a mine panel identified as 2 Yard South (2YS). Panel 2YS is located near the southern end of the mine and is approximately 1,100 ft beneath a deeply scoured glacial valley presently occupied by the Genesee River (Figure 2). Panel 2YS and neighboring panel 11 Yard West (11YW) were mined using a small yielding pillar method, which was adopted to solve problems with the large-pillar method that had been the normal practice in the adjacent