DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
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COMMONWEALTH OF PENNSYLVANIA
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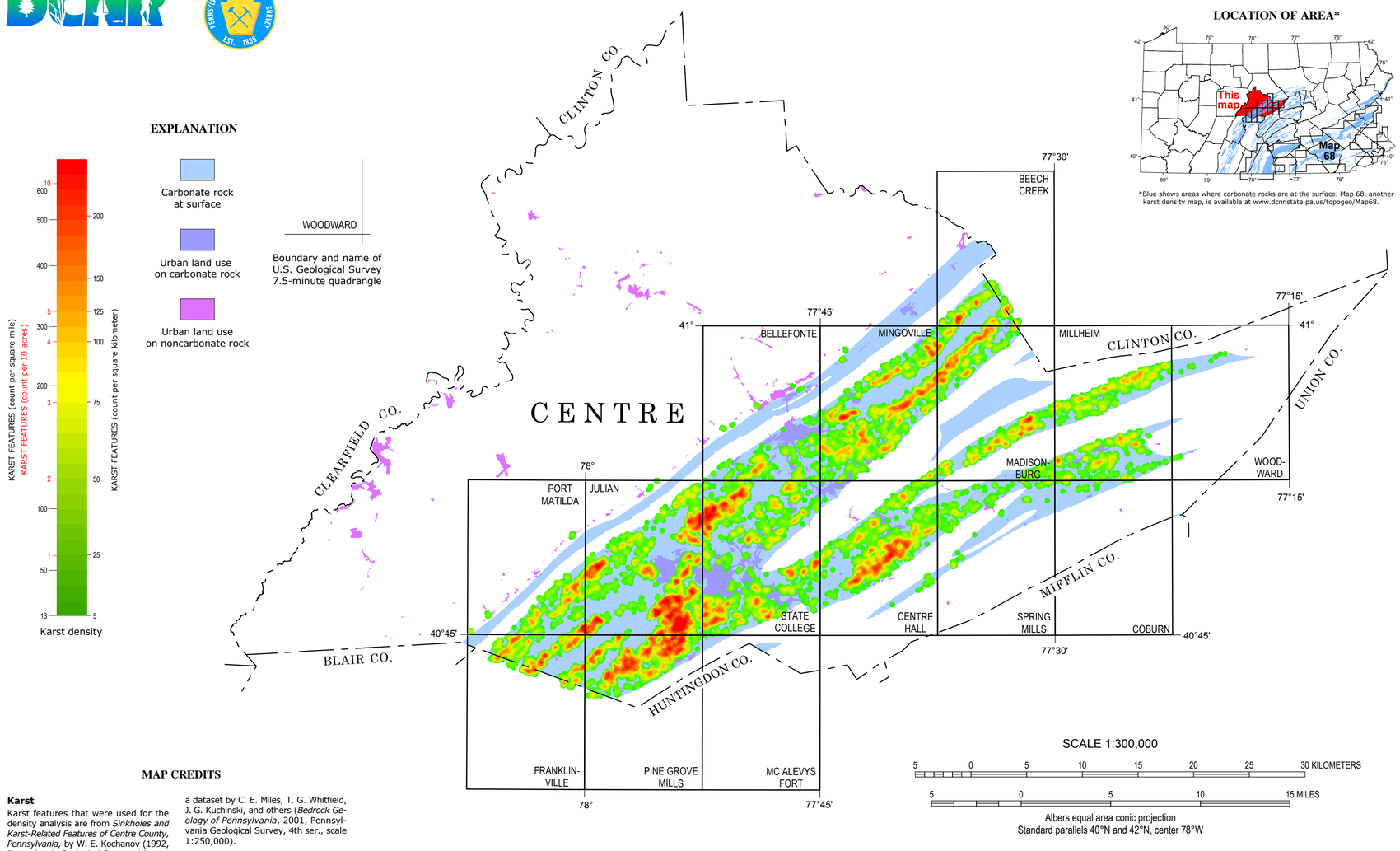
MAP 70

KARST DENSITY MAP OF CENTRE COUNTY



LOCATION OF AREA*

*Blue shows areas where carbonate rocks are at the surface. Map 68, another karst density map, is available at www.dcnr.state.pa.us/topogeo/Map68.

INTRODUCTION

Approximately one quarter of Centre County, Pa., is underlain by carbonate bedrock in the form of limestone and dolomite. However, about 80 percent of the urban areas and a majority of the population of the county are located in the valleys formed by these carbonate rocks.

Carbonate rocks are unique in that they weather more readily than other types of rocks. The dissolution or dissolving away of the carbonate bedrock by water over long periods of time results in a landscape called karst topography. It is characterized by features such as sinkholes, surface depressions, and caves. The dissolution of the carbonate rock also develops the subsurface drainage network for water along widened cracks or fractures within the bedrock layers. The majority of water in karst areas does not occur as surface streams but is primarily in the subsurface as groundwater.

Sinkholes and surface depressions are subsidence features. The surface expression of these features is a result of water transporting residual material and soil through subsurface pathways established by the dissolution process. Both features are typically circular in shape and can vary in size. Sinkholes exhibit an actual break or hole on the land surface, whereas surface depressions are generally bowl-shaped hollows that do not show this land-surface break. Caves are formed as fractures widen by dissolution, creating large openings in the rocks.

Karst features often impact public safety and health. Subsidence and water-quality problems have been associated with karst topography for many years. Gradual subsidence or the sudden collapse of the land surface can cause serious damage to urban structures, utilities, and roadways. In addition, karst features serve as direct recharge zones to local and regional aquifers, making these areas highly vulnerable to groundwater contamination.

DATA COLLECTION

In 1985, the Pennsylvania Geological Survey began investigations to map karst features throughout the commonwealth. Results of these investigations were released as a series of county-based open-file reports. For Centre County, karst surface features were located through an extensive review of aerial photographs from 1949, 1957, 1963, and 1971, and a subsequent field survey. Identified features were then transferred to scale-stable, 7.5-minute topographic base maps. Additional karst features were compiled from municipal questionnaires and published and unpublished data sources. Although not karst related, small surface mines may be similar in appearance to karst subsidence features. This is most apparent where such a mine has been abandoned for a long period of time. For this reason, surface mines were identified and added to the open-file maps.

After completion of the open-file reports, karst features and surface mines were digitized as point data from the topographic base maps using GSMAP software from the U.S. Geological Survey. Points were positioned in the best-determined centers of surface depressions, sinkholes, and surface mines, and at the entrance points of caves. Coordinates and feature types were saved in ASCII files, which were later converted to Microsoft Excel 2000 spreadsheet files. Shapefiles were created from the inventoried data, and point locations and feature attributes were spot-checked against the corresponding features on the original maps. Corrections to the data were made where applicable. The resultant data file served as the basis for the density layer calculations.

As a result of the inventory, 24,657 individual points were compiled for 15 7.5-minute quadrangles. Only karst-feature points (surface-mine points were excluded) in Centre County and those outside but within 500 meters of the county boundary were used for the density layer calculation. Of these 23,418 points, 97.4 percent are surface depressions, 2.3 percent are sinkholes, and 0.3 percent are cave entrances.

DENSITY LAYER CALCULATION

To create the digital density surface, ESRI ArcMap 8.3 software was used to divide the study area into 25- by 25-meter (82- by 82-foot) grid cells and to count the karst data points that fell within the area of a 250-meter (820-foot) search radius from the center of each cell. The number of points divided by the search area (approximately 0.2 square kilometer [0.08 square mile or 49 acres]) represents the karst density value of a cell. After the density value was calculated for the first cell, the search area was shifted to the next 25-square-meter grid cell, and the floating process was repeated until all of the cells were assigned a density value. This process smoothed the density data over the study area. Grid cells were then assigned a color using an ESRI ArcMap 8.3 "quantile" gradation of density values. On the map, red represents nearly 200 karst features per square kilometer (over 500 per square mile). The darkest green color indicates that at least one karst feature falls within the 250-meter search radius of the cell.

DISCLAIMER

While this map is useful for planning and preliminary site studies, it is not a substitute for site-specific subsurface investigations.

The occurrence of a sinkhole or surface depression depends on numerous factors, including rock type, geologic structure (e.g., fractures, joints, and faults), surface and subsurface hydrology, surficial materials, and land use. On the map, color shows the density of karst features over a given area. Although orange and red indicate areas where karst features are interpreted to be more abundant, it does not guarantee that new sinkholes will occur in these areas. Conversely, sinkholes can occur in carbonate areas where no karst features have been observed. The occurrence of sinkholes, therefore, is not restricted to the high-density areas delineated on the map.

On the map, a few karst density values are shown outside the mapped limits of carbonate bedrock. There are several possible reasons for this. Unconsolidated surficial material, such as colluvium, can conceal the contact between noncarbonate and carbonate bedrock. In addition, due to the nature of the compilation of the 1980 "Geologic Map of Pennsylvania," on which the digital formation contacts were based, some limits of carbonate areas could be off by several hundred feet, and small areas of carbonate rocks may not be shown. Undetected faults may also account for karst density values occurring outside the areas of carbonate rocks.

A type of land use that affected the density and distribution of the karst data points used in constructing this map is urbanization. Urbanization can mask the surface expression of karst features, thereby impacting the interpretation of aerial photographs and the locating of features during subsequent field surveys. Thus some karst features, especially surface depressions, are commonly underrepresented in urban settings. Sinkholes may be skewed in distribution toward urban areas because of a greater likelihood of being recorded when they cause problems.

Because of the factors mentioned above, the scale of compilation, and the conversion of areal features to point data, this map should not be used to predict the location of future sinkholes or to correlate numbers of karst features to specific formations.

MAP CREDITS

Karst

Karst features that were used for the density analysis are from *Sinkholes and Karst-Related Features of Centre County, Pennsylvania*, by W. E. Kochanov (1992, Pennsylvania Geological Survey, 4th ser., Open-File Report 92–01, scale 1:24,000, 15 maps plus 8-page text).

Karst features were digitized by Survey interns and Kochanov, 1992, and coordinates and other attributes were imported into Microsoft Excel files by Kochanov, 1994–95.

Karst density analysis was done by S. O. Reese, 2004, based on shapefiles generated from the Excel files. ESRI ArcGIS 8.3 software was used to do the analysis and to create the shapefiles.

Geology

Locations of carbonate rocks are slightly modified from *Geologic Map of Pennsylvania*, compiled by T. M. Berg, W. E. Edmunds, A. R. Geyer, and others (1980, Pennsylvania Geological Survey, 4th ser., Map 1, 2nd ed., scale 1:250,000, 3 sheets). This map was prepared as a dataset by C. E. Miles, T. G. Whitfield, J. G. Kuchinski, and others (*Bedrock Geology of Pennsylvania*, 2001, Pennsylvania Geological Survey, 4th ser., scale 1:250,000).

Base Map

Urban areas are from the dataset *Urban areas of Pennsylvania—PA Explorer CD-ROM edition* by Joe Bishop (1998, University Park, Gap Analysis Program, Environmental Resources Research Institute, Pennsylvania State University).

County lines are slightly modified from an unpublished municipality dataset (Pennsylvania Department of Environmental Protection, 1998, 1:24,000-scale accuracy).

Quadrangle lines are from shapefiles created by M. E. Moore of the Pennsylvania Geological Survey (1990, unpublished), using ESRI Atlas GIS software.

Other

Map layout and design by S. O. Reese and C. E. O'Neil of the Pennsylvania Geological Survey, 2005.

DENSITY OF MAPPED KARST FEATURES IN CENTRE COUNTY, PENNSYLVANIA

BY

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