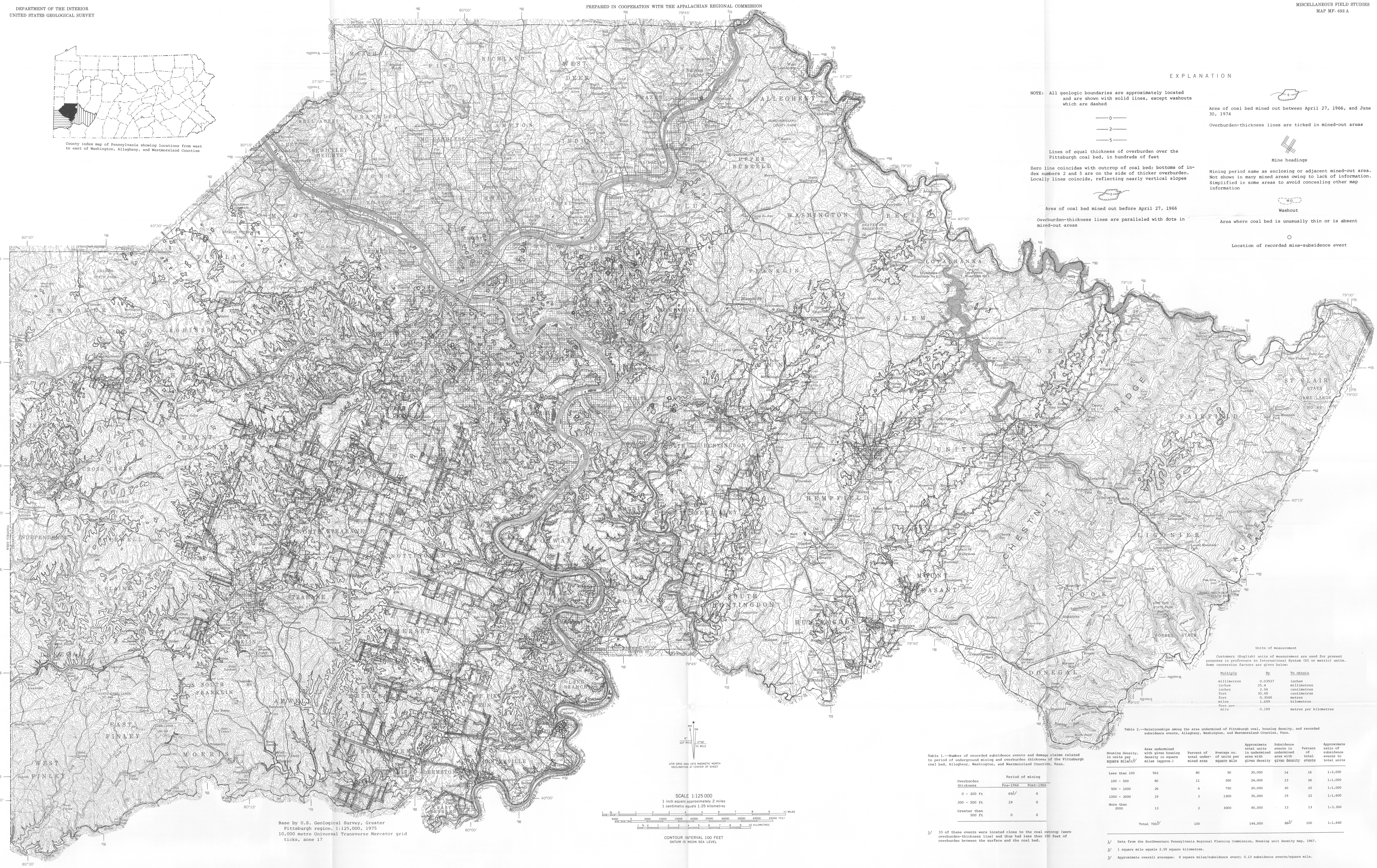
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE APPALACHIAN REGIONAL COMMISSION

MISCELLANEOUS FIELD STUDIES
MAP MF-693 A



Base by U.S. Geological Survey, Greater Pittsburgh region, 1:125,000, 1975
10,000 metre Universal Transverse Mercator grid ticks, zone 17

Units of measurement

Customary (English) units of measurement are used for present purposes in preference to International System (SI or metric) units. Some conversion factors are given below:

Multiply	By	To obtain
millimetres	0.03937	inches
inches	25.4	millimetres
inches	2.54	centimetres
feet	30.48	centimetres
feet	0.3048	metres
miles	1.609	kilometres
feet per mile	0.189	metres per kilometres

Table 1.--Number of recorded subsidence events and damage claims related to period of underground mining and overburden thickness of the Pittsburgh coal bed, Allegheny, Washington, and Westmoreland Counties, Penn.

Overburden thickness	Period of mining: Pre-1966	Period of mining: Post-1966
0 - 200 ft	69 1/	0
200 - 500 ft	19	0
Greater than 500 ft	0	0

1/ 33 of these events were located close to the coal outcrop (zero overburden-thickness line) and thus had less than 100 feet of overburden between the surface and the coal bed.

Table 2.--Relationships among the area undermined of Pittsburgh coal, housing density, and recorded subsidence events, Allegheny, Washington, and Westmoreland Counties, Penn.

Housing density, in units per square mile 1/, 2/	Area undermined with given housing density in square miles (approx.)	Percent of total undermined area	Average no. of units per square mile	Approximate total units in undermined area with given density	Subsidence events in undermined area with given density	Percent of total events	Approximate ratio of subsidence events to total units
Less than 100	562	80	50	30,000	14	16	1:2,000
100 - 500	80	11	300	24,000	23	26	1:1,000
500 - 1000	26	4	750	20,000	20	23	1:1,000
1000 - 2000	19	3	1500	30,000	19	22	1:1,600
More than 2000	13	2	3000	40,000	12	13	1:3,300
Total	700 3/	100		144,000	88 3/	100	1:1,640

1/ Data from the Southwestern Pennsylvania Regional Planning Commission, Housing unit density map, 1967.

2/ 1 square mile equals 2.59 square kilometres.

3/ Approximate overall averages: 8 square miles/subsidence event; 0.13 subsidence events/square mile.

INTRODUCTION

This map was prepared as part of a study of underground coal mining activity as it relates to surface subsidence. The premise of the study was that geologic and other mappable factors would correlate with known subsidence events and thereby either increase the predictability of subsidence events or, at the least, enable a general classification of land relative to its potential for subsidence. This map and another (Bushnell and Peak, 1975) combine published and newly developed information, from which an interpretive classification was made showing areas that correlate with high, moderate, and minor numbers of subsidence events (Bushnell, 1975). The sources of information used in compiling the map are indicated by asterisks in the list of selected references.

The Division of Mine Subsidence Regulation, Pennsylvania Department of Environmental Resources, provided access to mine maps and related information. A. W. Martin Associates, Inc., King of Prussia, Penn. (W. W. Beck, Jr., written commun., 1974), furnished locations of damaging surface subsidence events (structures damaged by mine subsidence). Their compilation is from insurance claims, newspaper articles, the Allegheny County government, and the Division of Mine Subsidence Regulation. This record probably is very incomplete, for only in the last few years have there been regulatory safeguards that yield records of most subsidence events. In earlier times only relatively spectacular events received notice and were recorded in the press or elsewhere. Because of the varied sources of map information, some detailed but others very general, as well as the relatively small-map scale, this map is intended for general planning purposes and not as a basis for decisions on the use of specific tracts.

The study was sponsored by the Appalachian Regional Commission as one element of a regional program of environmental analysis conducted by the U.S. Geological Survey.

MINING ACTIVITY

The Pittsburgh coal bed is the best known bituminous coal bed in Pennsylvania. It is a high volatile, low ash, relatively low sulfur, bituminous coal with an average mineable thickness of about five and a half feet throughout its area of occurrence. It lies at the base of the Pittsburgh Formation in the Monongahela Group of Pennsylvanian age (Wagner and others, 1970, p. 46, fig. 25).

Settlers in southwestern Pennsylvania began mining the Pittsburgh bed about 1760 (Heyman in Wagner and others, p. 108-111, 1970; Edmunds and Koppe, 1968), and mining has continued to the present with one active mine in Allegheny County, seven in Westmoreland County, 13 in Washington County, and others in adjacent counties. Only a small proportion of the Pittsburgh remains unmined in Allegheny and Westmoreland Counties, however, and some of this never will be mined owing to technical problems of reentering old mines and other factors.

In Washington County, current mining is largely in the north and east. Activity probably will spread southward eventually to undermine most of the county. As mining moves southward, it will also go deeper, because most of the unmined Pittsburgh coal lies under 500 feet or more of cover.

Elsewhere, in northern Allegheny County, northwestern Washington County, and much of Westmoreland County, the Pittsburgh coal is absent because of erosion and strip mining.

SURFACE SUBSIDENCE

The extensive mining has created a serious mine subsidence problem. "Mine subsidence" is a customary and useful term equivalent in Pennsylvania to subsidence of the ground surface as a result of underground mining. The Commonwealth of Pennsylvania responded to this situation with the passage of the Bituminous Mine Subsidence and Land Conservation Act of 1966. This act required that mine operators leave coal in place beneath certain structures in existence on the effective date of the Act, April 27, 1966; cemeteries are also protected. In addition, structures that postdate the act may be protected by the purchase of unmined coal, which is then left in place to support the surface. Details of this act and its operation may be acquired from:

Division of Mine Subsidence Regulation
Department of Environmental Resources
Donaldsons Crossroads
203 South Washington Road
McMurray, Penn. 15317

Surface subsidence is controlled by the nature of the coal and its enclosing rocks, the nature of the mining operations, the depth of mining (that is, thickness of overburden), cultural development of the ground surface, the ground-water regime, and the period of mining operations--before or after April 27, 1966. Locally, subsidence has occurred long (30 or more years) after cessation of mining. This suggests that the old coal pillars are failing as the results of ground-water action, weathering, surface loading, or plastic failure of the mine floor, with accompanying overextension of the bridging capacity of the mine roof and overburden. Overburden data and the time of mining are most amenable for map presentation, considering available information.

Locally, the Pittsburgh coal is replaced by sandstone or shale, a feature termed "washouts" or "faults". These are the results of scour and channel fill by Pennsylvanian age streams after the coaly material was deposited. Most large washouts are not mined, but avoided, and they thus underlie areas that are not subject to surface subsidence (Noel N. Moebs, U.S. Bureau of Mines, and James Tilton, Equitable Gas Co., oral commun., 1974).

It is readily apparent from table 1 that areas with 0 to 200 feet of overburden, mined out prior to 1966, have the greatest number of subsidence events. A close examination of these factors suggests why the correlation exists. Prior to 1966, most of the mining was under areas with only 0 to 200 feet of overburden. Post-1966 mining, when certain surface structures were protected by the Act of 1966, mainly has been in areas of 200 to 500 feet of overburden. Only in the future will coal be extracted from large areas with more than 500 feet of overburden over the Pittsburgh coal bed. With these conditions, the lack of documented subsidence events after 1966 suggests that the problem of mine subsidence is related as closely to older unregulated mining practice as it is to overburden thickness.

Moreover, the map shows that the distribution of recorded events coincides generally with urbanized areas. Many subsidence events are not recorded unless a building is damaged or the results of the event so impinge on the population that the event is memorable. Probably, therefore, more events are reported from urban areas than from less populated areas.

In fact, subsidence occurs in rural areas, where full retreat mining now is practiced (James Tilton, oral commun., 1974), but generally this subsidence is not recorded because relatively few surface structures are present.

In table 2, recorded subsidence events are tabulated according to the housing density of their locations. The table shows that, indeed, the incidence of recorded events is a function of urban versus rural location. The 20 percent of the undermined area that contains more than 100 housing units per square mile yielded 84 percent of the events.

The last column of table 2 is an attempt to remove the housing-density factor from the analysis by relating the number of events recorded in an area to the number of housing units in that area. The resulting ratios average 1:1,640, with an irregular range from 1:1,000 to 1:3,300, differences that may not be significant in light of the probable incompleteness of the subsidence-event record and the fact that the numbers of housing units and the areas involved are not exact numbers. A tentative conclusion can be drawn that the chance of any one undermined structure being damaged by subsidence is about the same whether it is in a rural or urban area, all else being equal.

In some parts of Allegheny and Washington Counties, the problem of subsidence over old mines is being remedied with modern mining methods, because in these areas underground mining apparently left enough coal to make surface (strip) mining profitable, thus converting areas with relatively high subsidence risk into areas of zero risk.

SELECTED REFERENCES

(Asterisk indicates reference used in map compilation)

*Ackenheil, A. C., and Associates, Inc., 1968, Mining and physiographic study, Allegheny County, Pennsylvania: Pittsburgh, Pennsylvania, A. C. Ackenheil and Associates, Inc., 52 p.
*Berryhill, H. L., Jr., 1964, Geology of the Amity quadrangle, Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ-296.
*Berryhill, H. L., Jr., and Schweinfurth, S. P., 1964, Geology of the Ellsworth quadrangle, Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ-333.
Berryhill, H. L., Jr., Schweinfurth, S. P., and Kent, B. H., 1971, Coal-bearing Upper Pennsylvanian and Lower Permian rocks, Washington area, Pennsylvania: U.S. Geol. Survey Prof. Paper 621, 47 p.
*Berryhill, H. L., Jr., and Swanson, V. E., 1964, Geology of the Washington West quadrangle, Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ-283.
Bushnell, K. O., 1975, Map showing areas that correlate with subsidence events due to underground mining of the Pittsburgh and Upper Freeport coal beds, Allegheny, Washington, and Westmoreland Counties, Pennsylvania: U.S. Geol. Survey Misc. Field Studies Map MF-693C [in press].
Bushnell, K. O., and Peak, J. R., 1975, Map showing depths to the Upper Freeport coal bed, mining activity, and related surface subsidence, and The Redstone coal bed mines, Allegheny, Washington, and Westmoreland Counties, Pennsylvania: U.S. Geol. Survey Misc. Field Studies Map MF-693B [in press].
*Cortis, S. E., Alexander, T. B., and Edmunds, W. E., 1973, Mined out areas of Pittsburgh coal: Pennsylvania Geol. Survey open-file map.
*Craft, J. L., 1974, Preliminary overburden-thickness map on the Pittsburgh coal: Pennsylvania Geol. Survey open-file map.
*Edmunds, W. E., 1974a, Preliminary structure contour map of Allegheny County, Pennsylvania: Pennsylvania Geol. Survey open-file map.
*______ 1974b, Preliminary structure contour map of Washington County, Pennsylvania: Pennsylvania Geol. Survey open-file map.
*______ 1974c, Preliminary structure contour map of Westmoreland County, Pennsylvania: Pennsylvania Geol. Survey open-file map.
Edmunds, W. E., and Koppe, E. F., 1968, Coal in Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Educ. Ser. ES 7, 28 p.
*Hughes, H. H., 1933, Freeport quadrangle--Geology and mineral resources: Pennsylvania Geol. Survey, 4th ser., Topog. and Geol. Atlas A 36, 272 p.
*Johnson, M. E., 1929, Pittsburgh quadrangle, [Pennsylvania] geology and mineral resources: Pennsylvania Geol. Survey, 4th ser., Topog. and Geol. Atlas A 27, 236 p.
*Kent, B. H., 1967, Geologic map of the Hackett quadrangle, Washington County, Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ-630.
*______ 1971, Geologic map of the Prosperity quadrangle, southwestern Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ-1003.
*Kent, G. H., Schweinfurth, S. P., and Roen, J. B., 1969, Geology and land use in eastern Washington County, Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Gen. Geol. Rept. G 56, 31 p.
O'Neill, B. J., Jr., 1974, Greater Pittsburgh region construction aggregates: Pennsylvania Geol. Survey, 4th ser., Mineral Resources Rept. M 67, 60 p.
*Roen, J. B., 1973, Geologic map of the Midway quadrangle, Washington County, southwestern Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ-1067.
*Roen, J. B., Kent, B. H., and Schweinfurth, S. P., 1968, Geologic map of the Monongahela quadrangle, southwestern Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ-743.
Roen, J. B., and Kreimeyer, D. F., 1973, Preliminary map showing the distribution and thickness of sandstone in the lower member of the Pittsburgh Formation, southwestern Pennsylvania and northern West Virginia: U.S. Geol. Survey Misc. Field Studies Map MF-529.
*Schweinfurth, S. P., 1967, Geologic map of the California quadrangle, Washington and Fayette Counties, Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ-648.
*Schweinfurth, S. P., Roen, J. B., and Kent, B. H., 1971, Geology and land use in eastern Washington County, Pennsylvania, California and Monongahela 7 1/2' quadrangles: Pennsylvania Geol. Survey, 4th ser., Gen. Geol. Rept. G 56A.
*Swanson, V. E., and Berryhill, H. L., Jr., 1964, Geology of the Washington East quadrangle, Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ-334.
Wagner, W. R., Heyman, Louis, Gray, R. E., Belz, D. J., Lund, Richard, Cate, A. S., and Edgerton, C. D., 1970, Geology of the Pittsburgh area: Pennsylvania Geol. Survey, 4th ser., Gen. Geol. Rept. G 59, 145 p.
*Wagner, W. R., Craft, J. L., Heyman, Louis, and Harper, J. A., 1974, Greater Pittsburgh region preliminary geologic map: Pennsylvania Geol. Survey open-file map.
Wagner, W. R., Kelley, D. R., and Lytle, W. S., 1971, Stratigraphic framework of greater Pittsburgh area, Pt. 1, Allegheny, Washington, Beaver, and southern Butler Counties: Pennsylvania Geol. Survey open-file rept.
Wagner, W. R., and Lytle, W. S., 1972, Stratigraphic framework of greater Pittsburgh area, Pt. 2, Westmoreland, Armstrong, northern Butler, and western Indiana Counties: Pennsylvania Geol. Survey open-file rept.

MAP SHOWING DEPTHS TO THE PITTSBURGH COAL BED, MINING ACTIVITY, AND RELATED SURFACE SUBSIDENCE, ALLEGHENY, WASHINGTON, AND WESTMORELAND COUNTIES, PENNSYLVANIA

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