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# The Suffield Fault, Stark County, Ohio<sup>1</sup>

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**ABSTRACT.** A ground-derived total intensity magnetic map of the Suffield fault, a western extension of the Transylvania fault zone, suggests a fault with a southwest dip of 80° or greater. Displacement history is uncertain, but may involve significant right-lateral wrenching at the time of early fault development. Subsequent movements may include normal faulting. Although principal fault movement is Permo-Pennsylvanian, displacement at the level of the Precambrian surface, inferred from the magnetic map, suggests significant Cambro-Ordovician faulting. Subsurface distribution patterns of Silurian to Mississippian units define minor syndepositional fault movements during accumulation of the Silurian Salina salts and again during deposition of the Mississippian Berea sands.

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## INTRODUCTION

Studies of basement tectonics define a major fault zone in the continental plate near latitude 40°N extending from the Early Mesozoic Gettysburg basin in Pennsylvania westward into Ohio (Root and Hoskins 1977). It is mapped as a series of large, subvertical east-west trending faults in the Blue Ridge, Great Valley, and Valley and Ridge. Westward on the Appalachian Plateau it is recognized from subsurface mapping and geophysical studies. This feature, the Transylvania fault, is believed to have originated in the Precambrian and to have reactivated during the Middle Ordovician Taconic orogeny, to a major degree during the terminal Paleozoic Alleghenian orogeny (Root and Hoskins 1977), and to a lesser degree during Early Jurassic faulting of the Atlantic Cycle rift basins (Root 1985).

The Transylvania fault zone has been extended across Ohio by Gray (1982). Structure contour maps on top of the Mississippian Berea and Devonian Onondaga Formations and unpublished maps on the Silurian Packer Shell (Gray 1982) define five, high-angle faults that extend northwestward from East Liverpool, Columbiana County, to Berea, Cuyahoga County (Fig. 1). At the level of the Onondaga, maximum vertical displacement across the Akron-Suffield faults is 60 m (200 ft) and across the Highlandtown fault is 72 m (240 ft), with the northeast blocks upthrown (Gray 1982). Although the structures are well defined by subsurface structural mapping, they are only moderately manifested on the aeromagnetic maps of Ohio (Hildenbrand and Kucks 1984).

This study maps the eastern half of the Suffield fault zone by detailed magnetic investigation and examines the Paleozoic stratigraphic sequence for indications of recurrent movement during deposition.

## MAGNETIC INVESTIGATIONS

Traverses were made across the region of the Suffield fault, as defined by Gray (1982), with a portable E. G. & G. Geometrics Memory-Mag Proton Precession magnetometer. Stations were located every 30 m (100 ft) along north-south lines, supplemented by reconnaissance stations, where required for coverage. Data were reduced

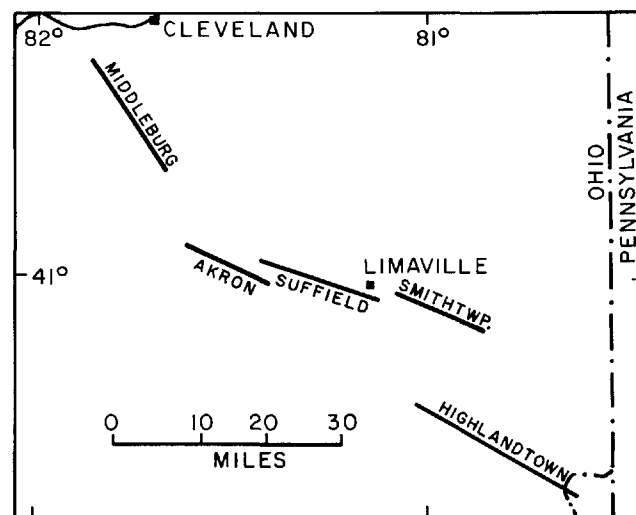


FIGURE 1. Index map showing Higlandtown fault zone mapped by Gray (1982). Town of Limaville, Stark County is in the area of this study.

for diurnal variation. An area of 64.7 km<sup>2</sup> (25 mi<sup>2</sup>) was covered with 325 stations (MacWilliams 1985).

In Ohio the Paleozoic strata are generally magnetically transparent. A few red bed units may have significant magnetic susceptibility but, because of the small area studied, any facies changes are considered negligible. Therefore, associated magnetic variations will be minimal and their contribution to the total magnetic field, both vertically and laterally, will be negligible. Any magnetic anomalies are, therefore, ascribed to Precambrian igneous basement properties. Again, because of the small area, corrections for datum and the geomagnetic reference field are not critical. For this study only the total magnetic field intensity was mapped.

A map of the total magnetic field at a 10-gamma contour interval (Fig. 2) shows patterns that are interpreted as the result of displacement in the basement. The Suffield fault mapped by Gray (1982) is located astride a steep magnetic gradient which is a common magnetic signature of faults. South of the fault the trend of magnetic contours is WNW-ESE and generalized maximum values are about 56,380 gammas. On the upthrown block, north of the fault, the trend of magnetic contours is N-S, with a second trend E-W, and generalized maximum values are about 56,430 gammas. These values

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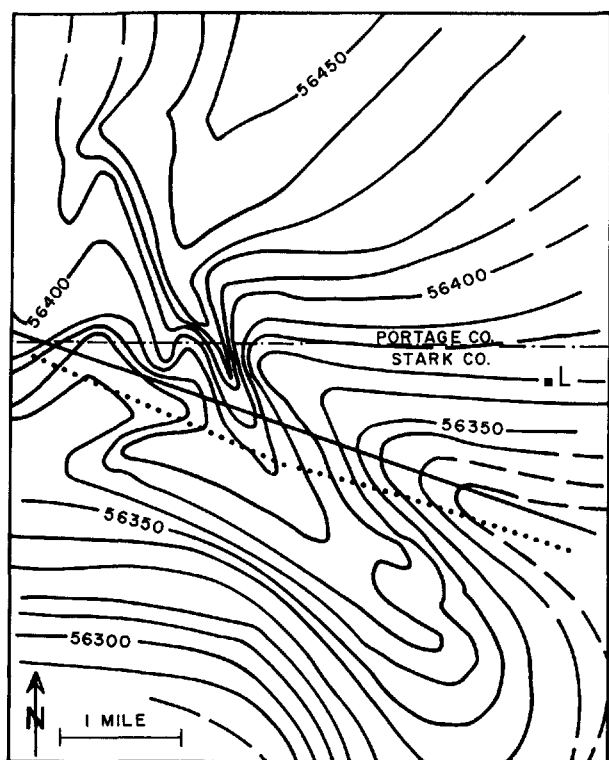


FIGURE 2. Total magnetic intensity map of Limaville area (designated by "L"). Contour interval 10 gammas. Solid line is position of Suffield fault at level of the Onondaga, mapped by Gray (1982). Dotted line is position of fault on top of basement as inferred from magnetic values.

suggest that at the level of the basement the northerly block is upfaulted, which was demonstrated for the younger units by Gray (1982).

Depth to basement was computed to determine if the anomalies are at the top of the Precambrian basement or are deeper intra-basement features. The area mapped is not sufficiently large to permit reliable calculations, but a regional aeromagnetic study by Popenoe et al. (1964) does permit a rough calculation. A basement depth of 3,030 m (10,100 ft) ( $-2,700$  m subsea) was computed with the maximum slope method of magnetic profiles and an index value of 0.7 (Sheriff 1978). The index value was generated from two long magnetic profiles in Wayne County that tied to wells penetrating basement. This rapid method of estimating depth to basement anomalies has a 25 percent margin of error. The nearest wells penetrating basement are approximately 30 miles to the northwest (Summerson 1962) and 20 miles to the southeast (Owens 1967). Extrapolation to this region indicates basement at about  $-2,460$  m ( $-8,200$  ft). Congruence of depth to basement from magnetics and subsurface data suggests that the magnetic anomalies are at the top of basement and not intrabasement effects. From differences in the total magnetic field relative to anomaly depth on either side of the fault, it is inferred that vertical displacement at the level of the basement is possibly twice the 200 feet measured by Gray (1982) on the Berea horizon, suggesting an initial Precambrian, or certainly pre-Silurian age for this fault. This conclusion is speculative because it assumes that basement composition is relatively uniform across the fault, despite the complex deformational history of the basement.

Position of the fault on top of basement from the magnetic map is best defined in the eastern part of the area where it occurs about 300 m (1,000 ft) south of the trace of the fault on the Onondaga as mapped by Gray (1982). Elevation difference between the Onondaga (Gray 1982) and generalized basement (Summerson 1962) is about 1,950 m (6,500 ft) indicating a fault dipping south more than  $80^\circ$ . Displacement sense of the fault is uncertain. Typically, subvertical faults are associated with lateral motion. Geometry of the Akron-Suffield-Smithtownship faults suggests that they originated as en echelon synthetic faults produced by right-lateral wrenching. Inferred displacement, from anomaly off-sets on the map of Popenoe et al. (1964), is arguably a minimum of 21 km (13 mi). This displacement would have occurred early in the development of the fault. Subsequent movements of the fault, however, may involve normal faulting of small displacement rather than wrench tectonics.

### RECURRENT FAULTING

Where first recognized in Pennsylvania, the Transylvania fault zone has a history of reactivation during the Ordovician, Permo-Pennsylvanian, and Jurassic (Root and Hoskins 1977, Root 1985). In the study area, it is impossible to recognize post-Permo-Pennsylvanian faulting because the youngest bedrock in the area is Lower Pennsylvanian. From regional relations it is clear that much of the displacement shown on the Silurian and younger horizons (Gray 1982) occurred during terminal Paleozoic Alleghenian deformation. However, small displacement increments may be attributable to syn-depositional movement. Abundant oil and gas well data are available that may be used to determine recurrent fault activity from formational thickness variations restricted to an area where the fault is now recognized. Geophysical logs start at the top of the Berea, the first potential producing unit, and terminate at the base of the Medina, the deepest producer. Hence, information is available for all the Silurian and Devonian, and Lower Mississippian strata.

Isopach maps were prepared for seven key driller's units, spanning this time interval. These units are shown from oldest to youngest in Figure 3. The isopach map of the Lower Silurian Clinton/Medina sequence (Fig. 3a) shows a NE-SW thickening, probably an offshore bar, extending without interruption across the site of the Suffield fault. The isopach of the Middle Silurian Packer Shell, shows narrow zones of thickness variation extending across the fault (Fig. 3b). The Middle Silurian Casing Shell is a thin unit (4.5-6.0 m) showing a distribution similar to the Packer Shell and is not illustrated. The overlying Middle Silurian Rochester Shale shows a subtle northwest thinning and contours trend uniformly across the fault (Fig. 3c). The very thick Upper Devonian Ohio Shale, which is mapped here to include shales from below the Berea to the top of the Onondaga, shows constant westward thinning, with contours passing uniformly across the site of the Suffield fault (Fig. 3e). The Lower Mississippian, second Berea sandstone, defines a N-S trending thin area passing across the fault site (Fig. 3f). In aggregate, these units demonstrate that their distribution was not noticeably influenced by syndepositional movement of the Suffield fault. Therefore, during much

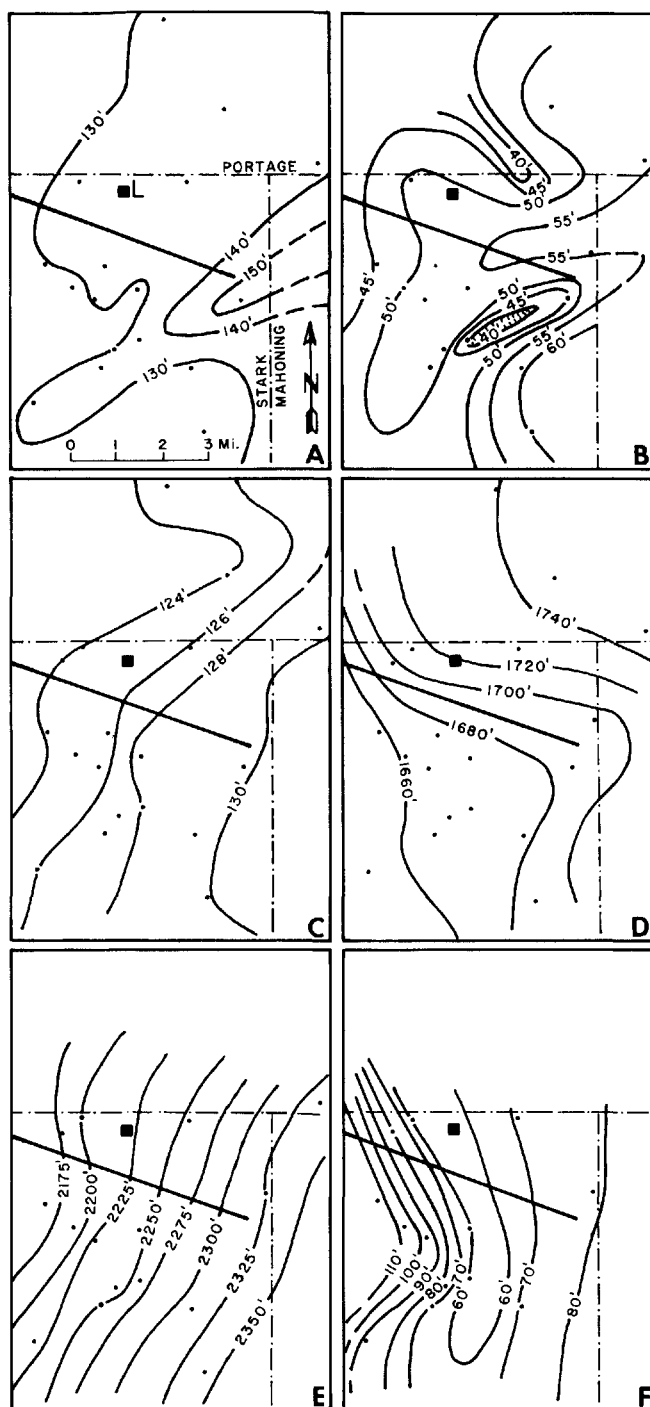


FIGURE 3. Isopach maps of key subsurface units from wire line logs. Dots indicate control wells. 3A. Lower Silurian Clinton, 3B. Middle Silurian Packer Shell, 3C. Middle Silurian Rochester shale, 3D. Silurian-Devonian Big Lime, 3E. Upper Devonian Ohio shale, 3F. Lower Mississippian Second Berea. Solid line is position of the Suffield fault on top of the Onondaga (Gray, 1982). Square marked "L" = Limaville.

of the Silurian to Lower Mississippian this area was principally a tectonically quiescent area.

Evidence of syndepositional activity on the Suffield fault is found in the thick Silurian-Devonian carbonate

sequence, the driller's Big Lime whose top is the Onondaga. Contours parallel the trace of the fault suggesting depositional control by reactivation of the fault (Fig. 3d). This control is confirmed by detailed studies of Silurian salt horizons in this interval (Clifford 1973), which show that salts F1 and F3 thin over the site of the fault, and that salt F4 is absent here. These appear to be primary depositional patterns and not the product of halokinesis. In addition, although the fault may have been inactive in the area studied, elsewhere along its extent movement could have occurred. Apparently, Lower Mississippian syndepositional movement occurred on the western half of the Suffield fault, as Pepper et al. (1954) show marked thinning of an extensive thick lobe of Berea sandstone as it crosses the present site of the fault. On the eastern half of the fault, however, there seems to be no syndepositional activity (Fig. 3f).

Presently, little is published concerning the tectonic history during deposition of the older Cambro-Ordovician units or the younger Pennsylvanian units. Both are periods of recognized regional tectonism in the Appalachian Orogen during which reactivation of the Suffield fault could occur. For example, the greater vertical fault displacement on top of the basement than on the Berea, inferred from magnetic data, arguably suggests pre-Clinton movement on the fault.

Basement faulting along the Suffield fault has an extended deformational history throughout the Paleozoic. Both geologic and geophysical data must be used for full understanding of such features.

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