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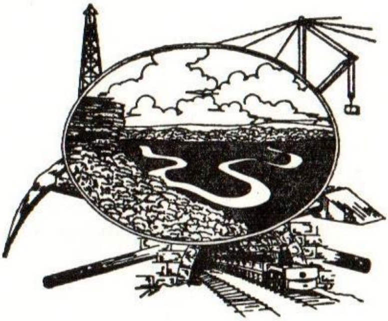
By

ROBERT D. HATCHER, JR.



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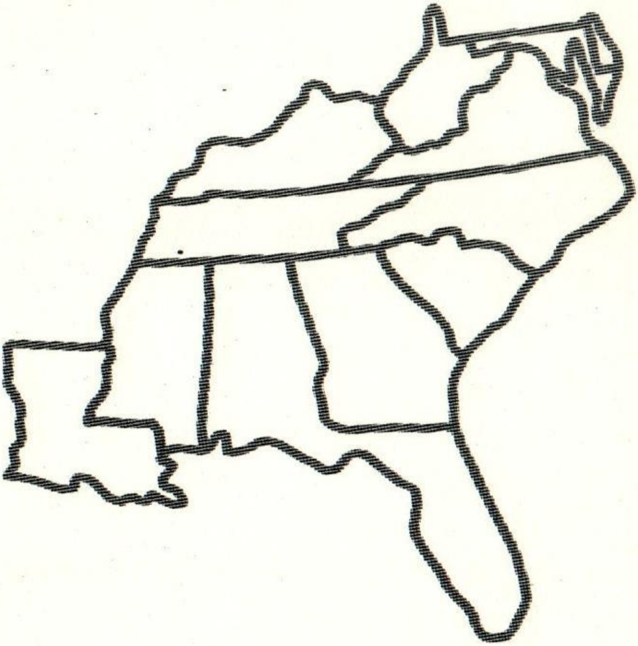

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STRUCTURE OF THE DUMPLIN VALLEY FAULT ZONE IN EAST TENNESSEE

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ABSTRACT

The Dumplin Valley fault zone extends from Morristown to Etowah, Tennessee, a distance of about 90 miles. Involved in faulting are some 10,000 feet of sedimentary rocks that range in age from Early Cambrian to Middle Ordovician. The Rome Formation, Conasauga Group, Knox Group, and part of the Chickamauga Group are represented.

Two large thrusts and their branches are traceable through most of the mapped area. They are interconnected only at one place. Toward the southwest the southeasternmost fault overrides the northwest fault. At the northeast end of the structure stratigraphic displacement on the faults diminishes and two large, open anticlinal folds are the most prominent structural features. At the southwest end of the mapped area faulting also diminishes and branches from the remaining major fault terminate in tight folds. The structure of the footwall is synclinal with rocks of the Chickamauga-Knox groups exposed over a wide area.

The Dumplin Valley fault zone is a complex of branching splay thrusts that developed in a superficial hanging wall anticline where the underlying major sole in the area changes level. The thrust presumably changes level from shales of the Rome Formation, across the competent carbonates of the Knox, into shaly limestones of the Chickamauga Group. Erosion has cut down to the ramp zone where the structure is buttressed against the Knox Group in the footwall, so that the dips of the faults at the present surface are moderate.

INTRODUCTION

At least ten major thrust faults exist in the Valley and Ridge Province of East Tennessee at the latitude of Knoxville. The present study is concerned with a portion of one of these thrust systems. The surface extent of the Dumplin Valley fault zone is from Morristown to Etowah, Tennessee, a distance of some 90 miles. About 52 miles of

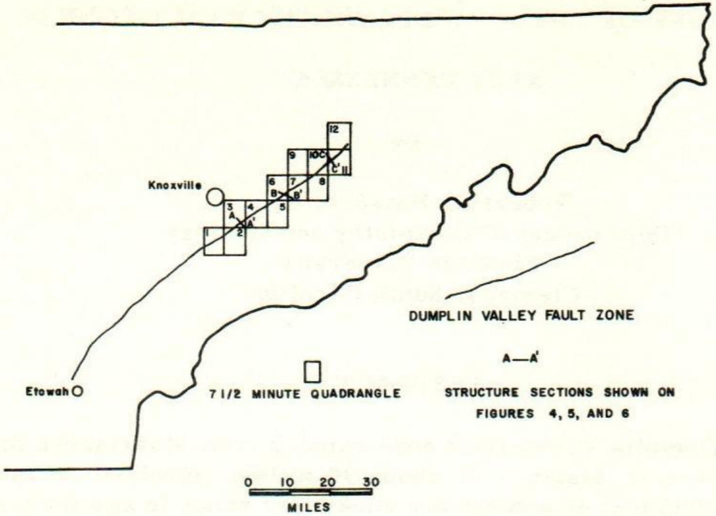

Figure 1. Location, extent, and index to mapping of the Dumplin Valley fault zone. 1. Maryville Quadrangle. Mapped by J. M. Cattermole, U.S.G.S. GQ-163. 2. Wildwood Quadrangle. Mapped by R. B. Neuman, U.S.G.S. GQ-130. 3. Shooks Gap Quadrangle. Mapped by J. M. Cattermole, U.S.G.S. GQ-76. Reconnaissance mapping by R. D. Hatcher, Jr. 4. Boyds Creek Quadrangle. Mapped by D. D. Harper, University of Tennessee Master's thesis. 5. Douglas Dam Quadrangle. Mapped by B. C. Stewart and R. D. Hatcher, Jr. 6. New Market Quadrangle. Mapped by R. D. Hatcher, Jr. 7. Jefferson City Quadrangle. Mapped by R. D. Hatcher, Jr. 8. White Pine Quadrangle. Mapped by R. D. Hatcher, Jr. 9. Talbott Quadrangle. Mapped by C. P. Finlayson, C. R. L. Oder and A. E. Coker, Tenn. Division of Geology G.M.-163NW. 10. Morristown Quadrangle. Mapped by C. R. L. Oder and R. C. Milici, Tenn. Division of Geology G.M.-163NE. 11. Springvale Quadrangle. Detailed and reconnaissance mapping by R. D. Hatcher, Jr. 12. Russellville Quadrangle. Reconnaissance mapping by R. D. Hatcher, Jr.

the northeastern portion have been mapped in detail by the writer and others and available data were compiled by the writer for this study (Figure 1).

Acknowledgments

The field work of this report was conducted under the auspices of the Tennessee Division of Geology, W. D. Hardeman, State Geologist. The manuscript was considerably improved by the criticism and comments of G. D. Swingle of the University of Tennessee and Tennessee Division of Geology, R. C. Milici of the Tennessee Division of Geology, R. G. Stearns of Vanderbilt University, R. A. Laurence and L. D. Harris of the U. S. Geological Survey, P. K. Birkhead of Clemson University, and the late V. E. Gwinn of the University of South Carolina.

PREVIOUS INVESTIGATIONS

Keith (1895, 1896a, 1896b, 1901) recognized, and mapped in part, the complex faulting that occurs in the Dumplin Valley structure. His maps are more detailed than earlier maps of this area (Safford, 1869) and show some subdivisions of the Conasauga Group.

Bridge (1945) mapped to the edge of the fault zone in his study of the Mascot-Jefferson City zinc district. Rodgers (1953a) compiled the geology of East Tennessee and made a regional interpretation of the faulting in this portion of the Valley and Ridge. The data from the quadrangles, shown in Figure 1 with some modification, has been incorporated into the present analysis.

STRATIGRAPHY

Some 10,000 feet of Early Cambrian to Middle Ordovician sedimentary rocks are involved in the Dumplin Valley structure (Figure 2). The oldest unit in the structure is the Lower Cambrian Rome Formation exposed in the hanging wall. Overlying the Rome are the six formations of the Middle and Upper Cambrian Conasauga Group. The Conasauga Group is overlain by the siliceous carbonates of the Upper Cambrian and Lower Ordovician Knox Group. The five formations composing the Knox Group occur principally on the southeast flank of the structure. At the present level of erosion the Middle Ordovician Lenior Limestone, Holston-Tellico Formation, and Ottosee shale of the Chickamauga Group make up the major portion of the footwall sequence and the Knox is exposed extensively along the faults in the footwall. Detailed descriptions of all the formations may be found in reports of Hatcher (1965), Bridge (1956), and Rodgers (1953a).

DESCRIPTIVE STRUCTURE

Two major thrust faults are the most prominent tectonic features in the northeastern portion of the Dumplin Valley fault zone (Hardeman, 1966). Both are traceable throughout most of this portion

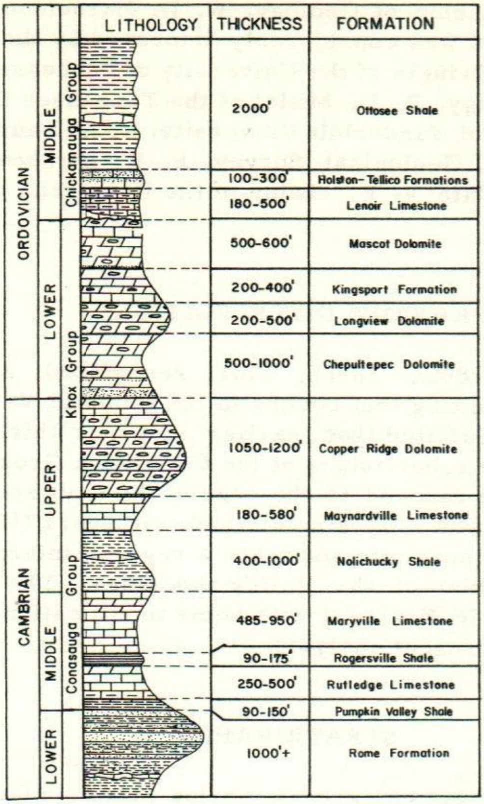

Figure 2. Stratigraphic section.

of the structure. However, to the southwest the southeasternmost fault has overridden the northwest fault producing an abnormally wide outcrop belt of the Rome Formation (Figure 3). Along the traces of both faults there are many slices of diverse sizes as well as numerous branch faults and parasitic folds (Figure 4). Faults are generally localized in incompetent zones in the Conasauga Group and Rome Formation.

The hanging wall structure of the Dumplin Valley fault zone consists of a number of minor thrusts and folds of diverse sizes. Toward the northeastern end of the structure two large northeast-plunging anticlines dominate the hanging wall structure (Figure 5). At the southwest end of the study area faulting in the hanging wall diminishes in frequency and in the Maryville quadrangle is replaced by a series of parallel trending tight folds which plunge southwesterly and diverge some 10 to 15 degrees from the strike of the structure (N35-40°E versus N50°E for the structure).

The footwall structure is synclinal. Rocks of the Chickamauga

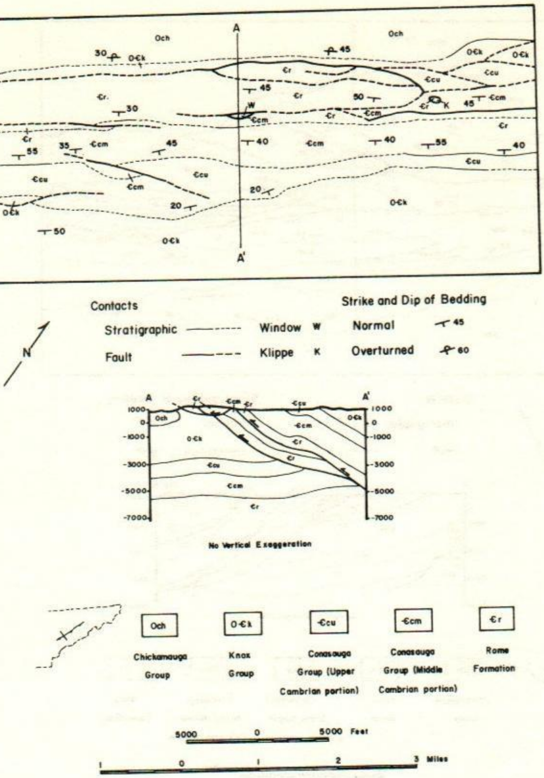

Figure 3. Geologic map and structure section of a portion of the Dumplin Valley fault zone.

Group dominate, but the Knox Group is exposed over a wide area as well. Minor faults extend from the main faults and cut footwall rocks in several places.

DEVELOPMENT OF THE MAJOR STRUCTURE

Two opposing schools of thought have evolved through the years regarding the structure of the Central and Southern Appalachians: the "thin-skinned" theory and the "thick-skinned" theory (Rodgers, 1949). The "thin-skinned", or no basement, hypothesis states that the Valley and Ridge structures are features marginal to the main area of deformation and were produced by tangential stresses that produced bedding thrusts of considerable magnitude, some having several miles of displacement in the sedimentary prism without involvement of the basement rocks (Rodgers, 1953b). Stresses were probably also applied to

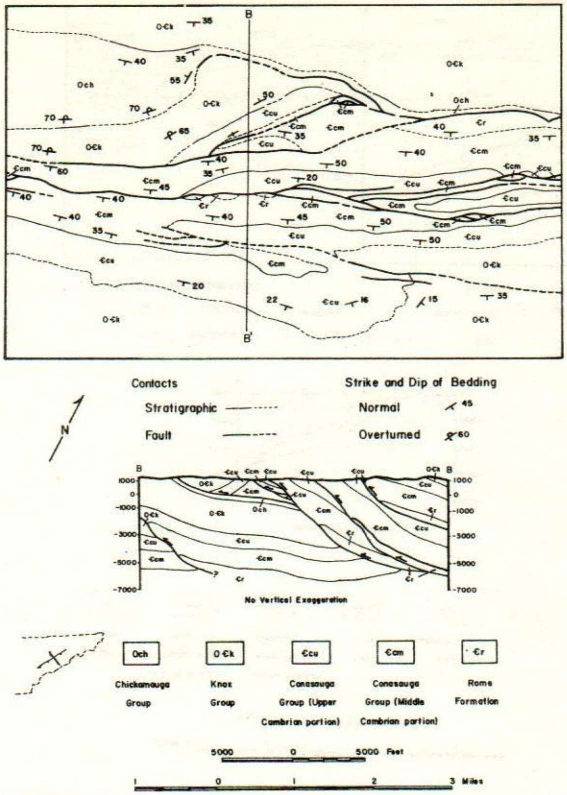

Figure 4. Geologic map and structure section of a portion of the Dumplin Valley fault zone from the New Market and Jefferson City quadrangles.

the basement rocks but their rupture strength was not exceeded. Movement of these great thrust sheets to the northwest and upward deflection of faults across competent strata produced rootless folds and associated splay thrusts in some areas. Some faults apparently originated as bedding thrusts in a particular stratigraphic interval and broke upward across competent strata from one shaly stratigraphic position to another. Thus a given fault need not everywhere have a low angle of dip, but high angle segments may exist within a given fault system. Gravity and magnetic surveys from the Valley and Ridge of Tennessee support the no basement hypothesis (Watkins, 1962).

The "thick-skinned" theory requires that the sedimentary cover adjust passively to extensive deformation in the basement. Thus, the basement is involved in faulting and the faults are assumed to have a high angle of dip (Ulrich, 1911; Cooper, 1961, 1964).

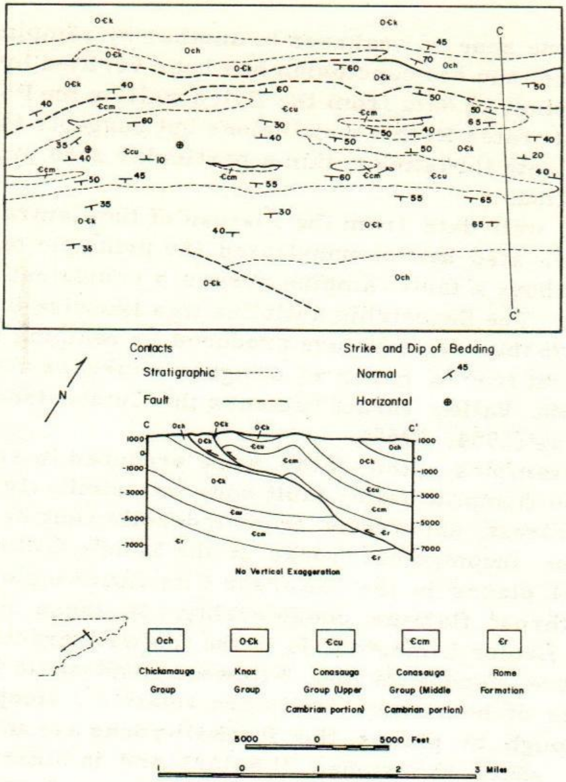

Figure 5. Geologic map and structure section from a portion of the Dumplin Valley fault zone near the northeast end.

More features of the Dumplin Valley structure seem compatible with the "thin-skinned" theory than with the "thick-skinned" theory. Faults follow zones of weakness and are parallel or subparallel to bedding, but at the same time generally have moderate to steep attitudes, at least at the present surface.

The hanging wall structure is for the most part anticlinal and that of the footwall synclinal (see Figures 3 and 4). The core of the structure in the hanging wall is a complex of overriding thrusts (Figures 3 and 4). The simplest interpretation of the structure would be a faulted fold with a complexly deformed core. However, with this intimate association of faults and folds there arises the question of the respective origins of each element and of whether faulting preceeded folding or vice versa. Rich (1934), in his study of the Pine Mountain fault, concluded that the Powell Valley anticline was produced by a thrust rising from one zone of weakness to another by ramping across a competent sequence, and his conclusion has been verified by drilling. Harris (1967), in a study of data from the Bales well on the Powell Valley anticline, corroborates Rich's conclusions but suggests that ramping along with imbricate thrusting within a particular zone produced the Powell Valley anticline.

In a study of well data from the Plateau of the Central Appalachians, Gwinn (1964) also has demonstrated the principle of rootless anticlines forming above a fault ramping across a competent zone to a higher decollement. The Sequatchie anticline was likewise interpreted by Milici (1963a, 1963b) as a structure produced by ramping of the Sequatchie Valley thrust from a lower to a higher weakness zone; in the latter the Sequatchie Valley thrust becomes the Cumberland Plateau overthrust of Stearns (1954, 1955).

In all the examples cited, folds were produced in association with thrusting. The Dumplin Valley fault zone was similarly produced by ramping of a thrust, apparently from a decollement in the Rome Formation, into the incompetent rocks of the Middle Ordovician sequence. At several places in the Jefferson City Quadrangle the dip of the northwestern thrust flattens considerably. In these places the Middle Ordovician Lenior Limestone is in the footwall directly beneath the fault. Elsewhere, except in the Wildwood Quadrangle (Newman, 1960), the attitudes of both major faults are relatively steep (40 to 60 degrees), even though in places the footwall rocks are incompetent Middle Ordovician shaly limestones (Lenior) and in others they are massive dolomites and limestones of the Knox Group. Buttressing of the hanging wall against the Knox in the footwall sequence is the probable cause of the steep dips on the faults in the structure, because the portion of the structure observed at the present level of erosion is the "ramp level" while that portion that flattened into the younger incompetent zone is now largely eroded away.

The Dumplin Valley fault zone consists of a complex of branching splay thrusts as defined by Gwinn (1964, p. 890). These thrusts are thought to have developed along the zone of inflection of the superficial fold which formed in the subsurface in the area where the major decollement changes level from the Rome to the Chickamauga rocks (Figure 6).

DEVELOPMENT OF STRUCTURES WITHIN THE HANGING WALL

The splay thrusts which form the Dumplin Valley structure behave mechanically in the same manner as the larger thrusts that come to the surface farther to the west, i.e., by ramping across a competent sequence from one weakness zone to another. The folds which are present on the hanging wall of the structure formed above the splay thrusts in response to the ramping process.

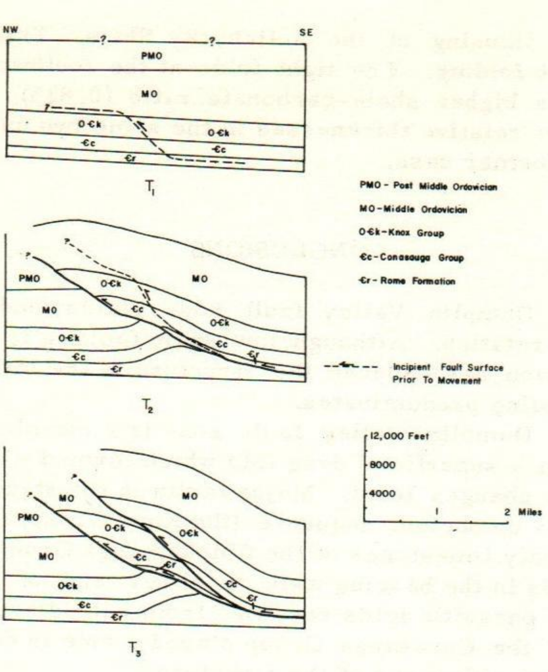

Figure 6. Interpretive sequential sections across the Dumplin Valley fault zone showing the development of the structure as interpreted by the writer. Depth to basement was estimated to be between 15,000 and 18,000 feet from the present surface by Watkins (1964).

The northwest fault and associated structures probably formed first, then the southeast fault ramped over the hanging wall of the northwest fault as a backlimb thrust (Figure 6). Toward the southwest end of the study area the northwest fault was completely overridden by the southeast fault (Figure 3).

The axes of two major anticlinal folds, which are present in the hanging wall assemblage at the northeast end of the structure, have been cut off by the southeast fault (Figure 5). These folds probably originated in association with the northwest fault and were then truncated as the southeast fault ramped up over the hanging wall of the other major fault.

The style of folding at either end of the structure appears to be somewhat controlled by differences in the stratigraphy of the Conasauga Group. At the northeast end there is a significantly lower shale-carbonate ratio (0.467), caused by relative thickening of the Maryville

Limestone and thinning of the Nolichucky Shale. This gave rise to more competent folding. The tight folds at the southwest end, which are caused by a higher shale-carbonate ratio (0.825), probably also are attributed to relative thicknesses in the same two units, but in the reverse of the former case.

CONCLUSIONS

1. The Dumplin Valley fault zone yields readily to a "thin-skinned" interpretation. Although low angle faulting is present in the structure, erosion has reduced the structure to the ramp zone where high angle thrusting predominates.

2. The Dumplin Valley fault zone is a complex of branching splay thrusts in a superficial drag fold which formed where the major sole in the area changes level. Major faults in the structure have refracted across a competent sequence (the Knox Group) from the Rome shales to the shaly limestones of the Chickamauga Group.

3. Folds in the hanging wall at either end of the study area have formed as parasitic folds resulting from subsidiary faulting. The stratigraphy of the Conasauga Group played a role in determining the style of folding at either end of the structure.

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