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LATEST DEVONIAN-EARLIEST CARBONIFEROUS MARINE TRANSGRESSIONS CENTRAL AND SOUTHERN APPALACHIANS, USA

by

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(6 figures)

ABSTRACT. - Lithostratigraphic and sedimentologic studies permit recognition of basin-wide sea level rises just before and just after the Devonian-Carboniferous boundary. These are the Cleveland and Sunbury transgressions, respectively, which can be traced continuously on outcrop edges of the Appalachian basin and in the subsurface beneath the Carboniferous in the deepest part of the Appalachian basin. Detailed stratigraphic mapping near the junction of Pennsylvania, Maryland, and West Virginia documents the maximum eastward extent of marine transgressions and configuration of delta lobes and embayments.

RESUME. - Des études lithostratigraphiques et sédimentologiques permettent d'identifier des remontées du niveau de la mer à l'échelle du bassin immédiatement avant et après la limite Dévonien-Carbonifère. Ce sont respectivement les transgressions de Cleveland et de Sunbury. Elles peuvent être retrouvées de manière continue dans les affleurements du bassin appalachien et en profondeur sous le Carbonifère dans les parties les plus profondes de ce bassin. Une cartographie stratigraphique détaillée aux alentours du contact des Etats de Pennsylvanie, Maryland et West Virginie illustre l'extension maximale vers l'Est des transgressions marines et la configuration des baies et des lobes de delta.

INTRODUCTION

Subsurface and outcrop work over the last eight years has clarified the latest Devonian-earliest Carboniferous marine transgressions in the Appalachian basin. These were first interpreted as sea level rises by Dennison & Head (1975). A project organized by the United States Department of Energy traced the Cleveland (Devonian) and Sunbury (Lower Carboniferous) lithofacies (Fig. 1) in the subsurface. We have followed these transgressions along the outcrop belts on the eastern edge of the basin, from Tennessee to southern Pennsylvania (Fig. 1).

The physical continuity of these two major transgressions establishes a lithostratigraphic framework which improves correlations of major Devonian-Carboniferous lithofacies. Chronostratigraphy is dependent on paleontologic and intertonguing facies control, since there are no radiometric dates for these strata in the Appalachian basin. Although there has been little recent work on the paleofaunas, there has been much paleobotanical interest in megaflora and palynomorphs. We accept the position of the Devonian-Carboniferous boundary at the Berea Sandstone-Sunbury Shale contact in northeastern Ohio, following the palynologic determinations of Eames (1974).

Our work in the Valley and Ridge and Appalachian Plateau outcrop belts is summarized as a southwest-northeast stratigraphic cross section of named strata (Fig. 2) and major lithofacies (Fig. 3). Beuthin has also conducted a three-dimensional facies analysis of about 50 wells and outcrops in an area at the northeast end of this cross section (Figs. 4, 5 and 6).

SUBSURFACE CONTROL

In outcrops of northeastern Ohio (Fig. 1) the physical stratigraphic relationships of Devonian-Carboniferous boundary strata were studied by Pepper *et al.* (1954) and by Lewis & Schwietering (1971). Using

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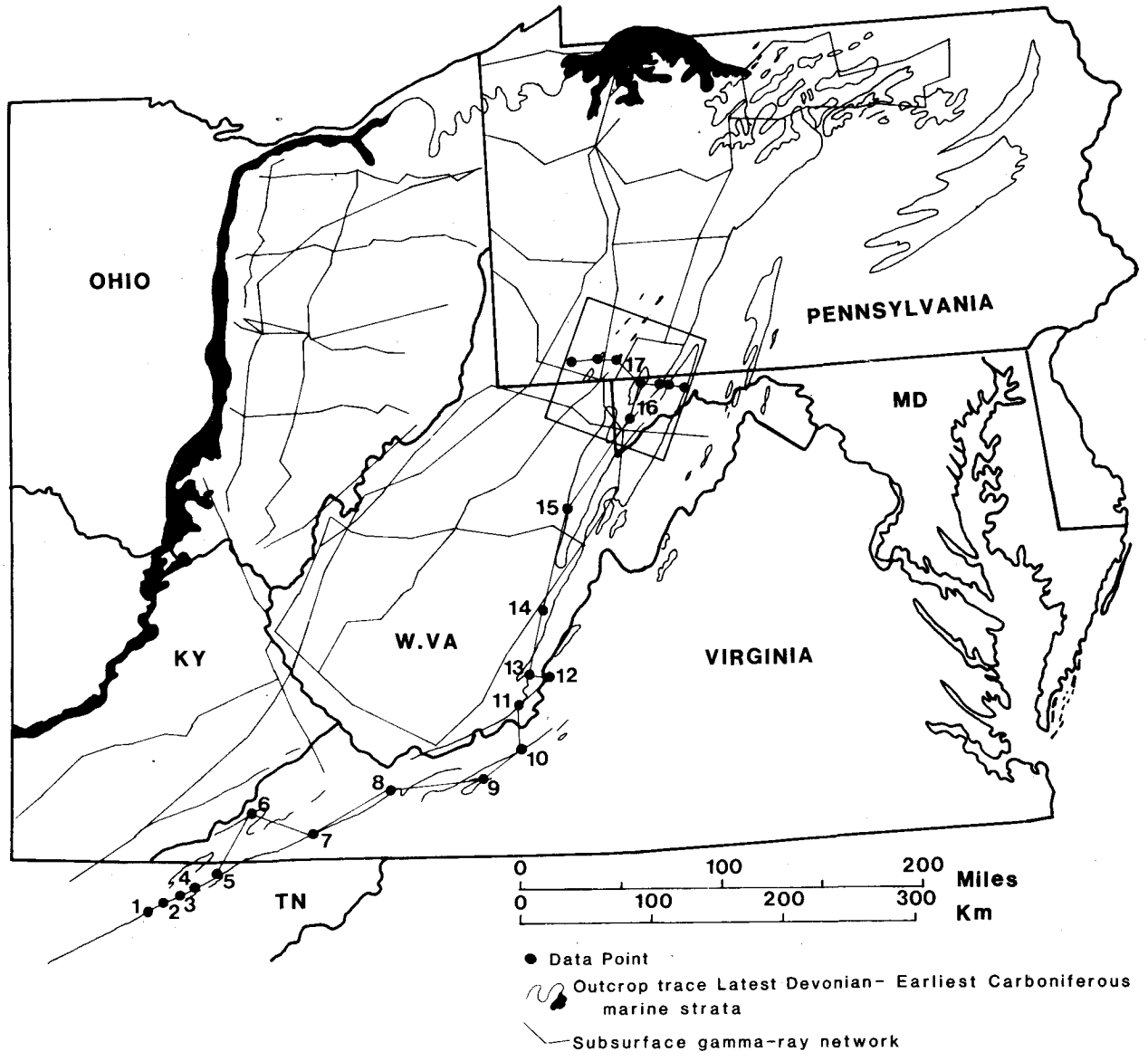

Figure 1. - Outcrops of Devonian-Carboniferous transitional strata in central part of Appalachian basin, with lines of surface and subsurface stratigraphic cross sections.

well-cuttings these relationships were traced into the nearby subsurface of northeastern Ohio, as documented in the same publications. The critical stratigraphic units are the black Cleveland Shale Member at the top of the Ohio Shale Formation, which is overlain in succession by the gray to reddish Bedford Shale Formation, the Berea Sandstone, the blackish Sunbury Shale, and the Cuyahoga Formation. DeWitt (1970) considered the Cleveland Shale as latest Devonian, and the other units as Mississippian (Early Carboniferous). More recently Eames (1974) placed the Devonian-Carboniferous boundary at the Berea-Sunbury contact.

The black shales represent obvious marine transgressions with water depths well below wave-base. The much coarser, well-sorted, cross-bedded Berea is very shallow marine or possibly partly nonmarine.

The two transgressive events can be readily traced into the Ohio subsurface, where the rocks have gamma-ray signatures characteristic of radioactive dark shales. The Sunbury is characteristically less than 10 metres thick, but more radioactive than the Cleveland Shale which is about 30 metres thick. Eastward both the Cleveland and Sunbury black shales coarsen, become lighter in colour and thicken slightly as a result of increased detrital influx. Thousands of wells penetrate the Devonian-Carboniferous boundary in the Appalachian basin, and a dense network of gamma-ray stratigraphic cross sections (Fig. 1) was developed under the auspices of the United States Department of Energy (Gray *et al.*, 1982; Neal, 1980; Piotrowski & Harper, 1979; Piotrowski & Krajewski, 1979 ; Roen *et al.*, 1978a, 1978b; Schwietering, 1980a, 1980b; Wallace *et al.*, 1977, 1979; West, 1978; Wilson *et al.*, 1981a, 1981b).

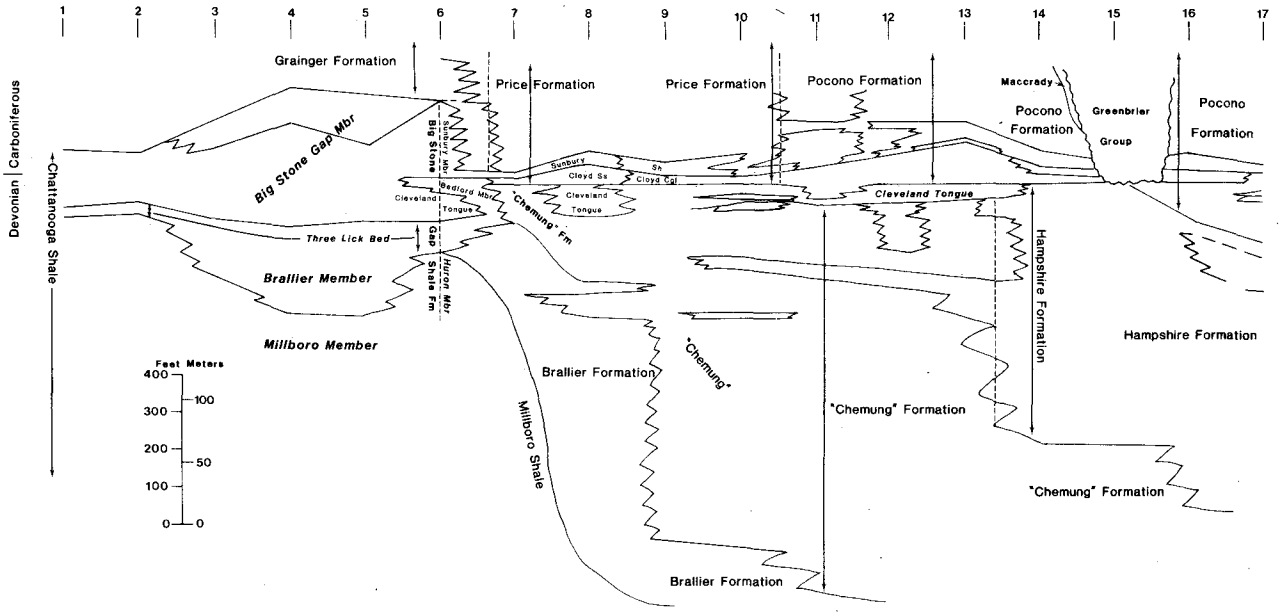

Figure 2. - Southwest-northeast stratigraphic cross section of named strata adjacent to Devonian-Carboniferous boundary in eastern Appalachian basin.

Numbered locations at top of diagram correspond to numbered data points on Fig. 1. Locations of numbered data points are as follows : 1. Joppa, 2. Bunches Trace, 3. U.S. Route 25E, 4. TN Route 31, 5. TN Route 70, 6. Big Stone Gap, 7. Wooten Gap, 8. VA Route 16, 9. U.S. Route 11 at Pulaski, 10. U.S. Route 460 at Brush Mountain, 11. Gap Mills, 12, Alleghany, 13. Caldwell, 14. Stonewall Gas, Sinking Springs No. 1 well, 15. Beverly, 16. Altamont, 17. Negro Mountain No. 1 well.

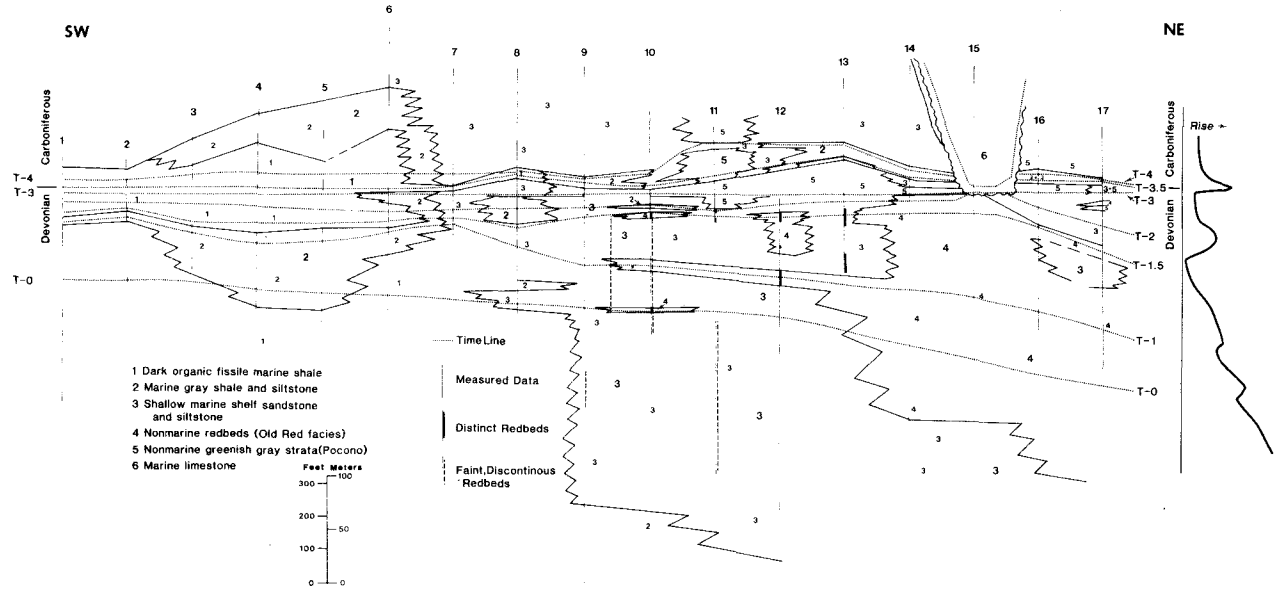

Figure 3. - Southwest-northeast cross section of lithologic facies represented by named units shown in Figure 2. Numbered locations at top of diagram correspond to numbered data points in Figure 1. Dotted lines labeled T-0 through T-4 are estimates of time lines.

The physical continuity of these two transgressions, coupled with the unique pattern of a thick, transgressive wedge (Cleveland) and a younger, thin, transgressive wedge (Sunbury), permits correlation of outcrops without detailed paleobotanical control. Recent palynologic work near Bowden, West Virginia (Gillespie, Rothwell & Scheckler, 1981) tends to confirm this lithostratigraphic and gamma-ray grid of correlations.

Gamma-ray correlations also extend the Cleveland and Sunbury time-markers southward across Ohio and Kentucky as the Berea Sandstone and Bedford Shale disappear and change facies into the upper part of the Ohio Shale of southeastern Kentucky and the upper part of the Chattanooga Shale of northeastern Tennessee and the southwestern tip of Virginia. Conodont and palynologic studies generally place the uppermost few meters of the Chattanooga Shale in the earliest Carboniferous and the remainder of the Chattanooga in the Late Devonian.

SOUTHWEST-NORTHEAST CROSS SECTION

The stratigraphic cross sections of Figures 2 and 3 diagram the stratigraphic name and facies changes associated with the Cleveland and Sunbury transgressions along the outcrop belts on the east side of the Appalachian basin. In Tennessee Hasson (1982) identified a turbidite siltstone marker in the Chattanooga Shale which corresponds to the gamma-ray position of the Three Lick Bed in the outcrop and subsurface of Ohio and Kentucky (Provo *et al.*, 1978). This is the sea level drop which produced the abrupt maximum progradation of the Catskill delta shoreline (Dennison, 1985a, 1985b). At Big Stone Gap, Virginia (Locality 6 in Figs. 2 and 3), the black shales of the upper Chattanooga show intertongues of gray silty shale of the Bedford (Kepferle *et al.*, 1981), and from there northeastward (interpreted from Bartlett, 1974) it is possible to trace the Cleveland and Sunbury transgressions as separate events.

Near the boundary of Virginia and West Virginia (Dally, 1956; White, 1984; Parker, 1984; McDonnell, 1981; Potter *et al.*, 1984 : unpublished field data by Dennison), the Cleveland-age transgression is separated by the Cloyd-Berea conglomeratic sandstone from the Sunbury transgression.

Farther north in West Virginia, near Beverly (Locality 15 in Figs. 2 and 3) and Bowden uplift produced erosion at the top of the Pocono Formation, (Lewis, 1983), and locally erosion cut into the Devonian Hampshire Formation (Yielding, 1984). Consequently the Cleveland and Sunbury transgressions cannot be physically traced through outcrops in the Beverly area. The principal uplift was during the Osagian or earliest Meramecian (late Tournaisian or early Visean) so the Sunbury Shale was probably more extensively eroded than the Cleveland Shale horizon.

The coals near the top of the Hampshire Formation near Bowden, West Virginia (described by Gillespie, Rothwell & Scheckler, 1981) possibly represent coastal swamps during the Cleveland eustatic highstand of sea level. Farther north, in Maryland and southern Pennsylvania, Cleveland and Sunbury sea level rises are recognized in the lower part of the Pocono Group.

STRATIGRAPHIC MAPPING AT THE JUNCTION OF MARYLAND, PENNSYLVANIA, AND WEST VIRGINIA

Lower Pocono Group strata in this area record a facies change from the dominantly marine Oswayo through Shenango Formations in the west to the dominantly nonmarine Rockwell Formation in the east (Figs. 4 and 5). This area was a coastal plain that was

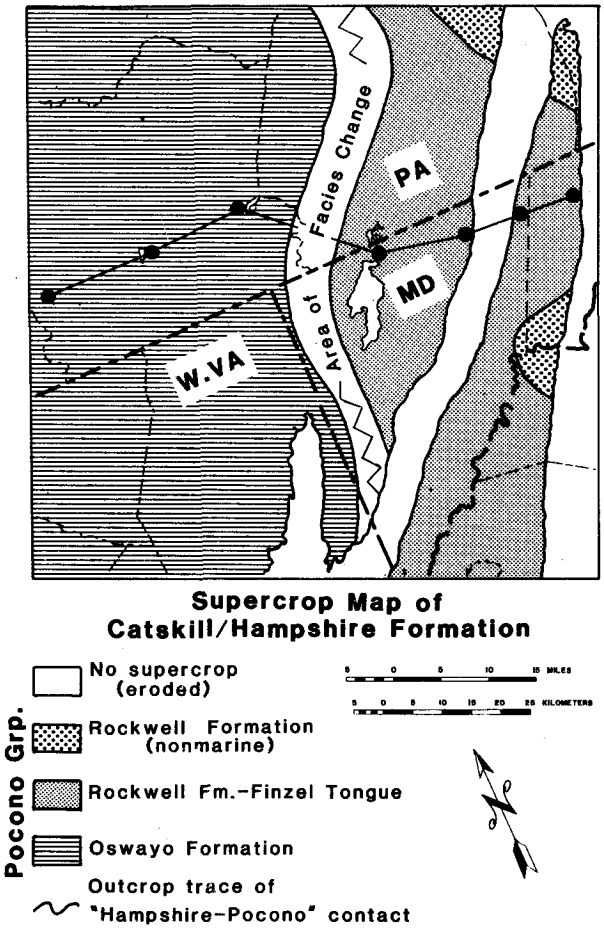

Figure 4. - Supercrop map of Catskill/Hampshire Formation, showing types of Pocono Group strata directly overlying nonmarine Catskill delta near the Pennsylvania-Maryland-West Virginia junction. Connected data points show location of Figure 5 stratigraphic cross section.

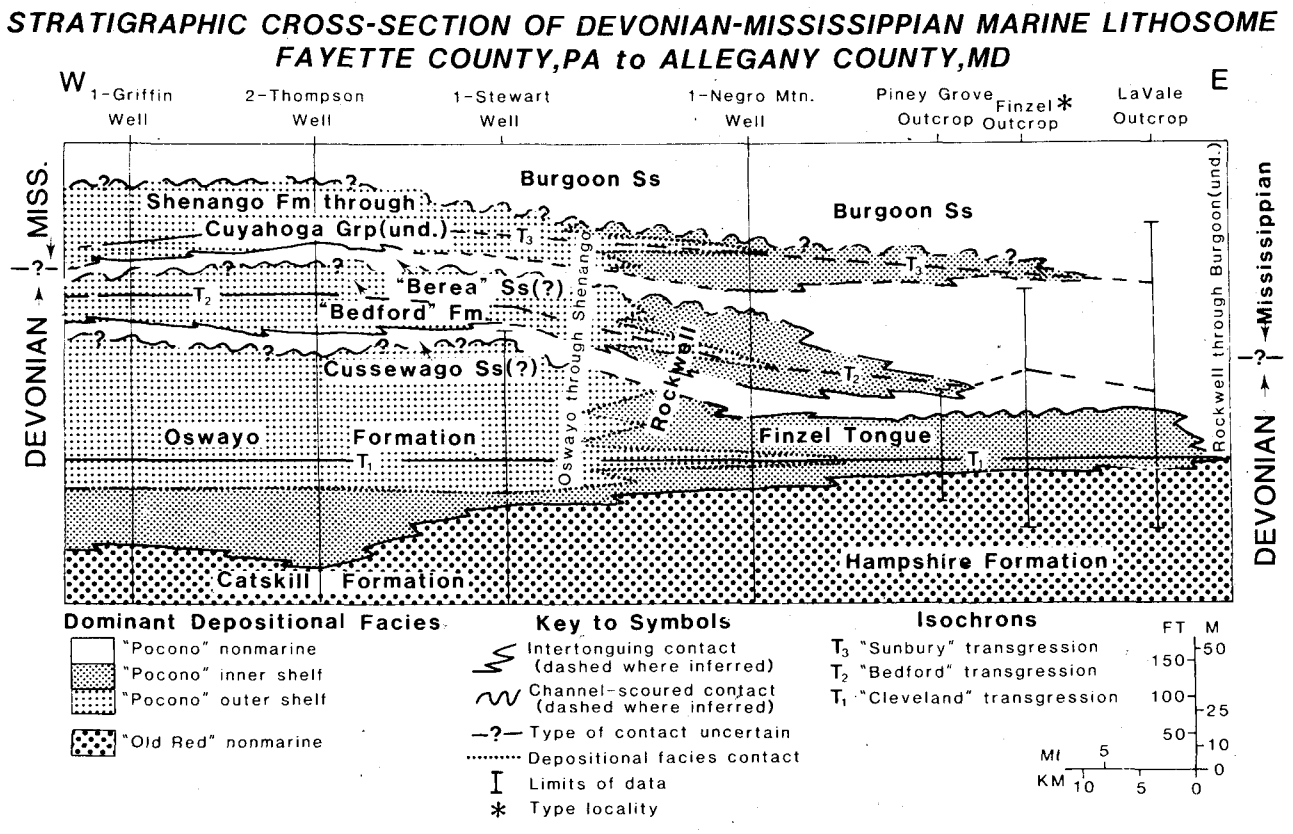

Figure 5. - East-west stratigraphic cross section across middle of Figure 4.
Time-line T_3 of Figure 5 corresponds to time-line T-4 of Figure 3.
Time-line T_1 of Figure 5 corresponds to time-line T-2 of Figure 3.

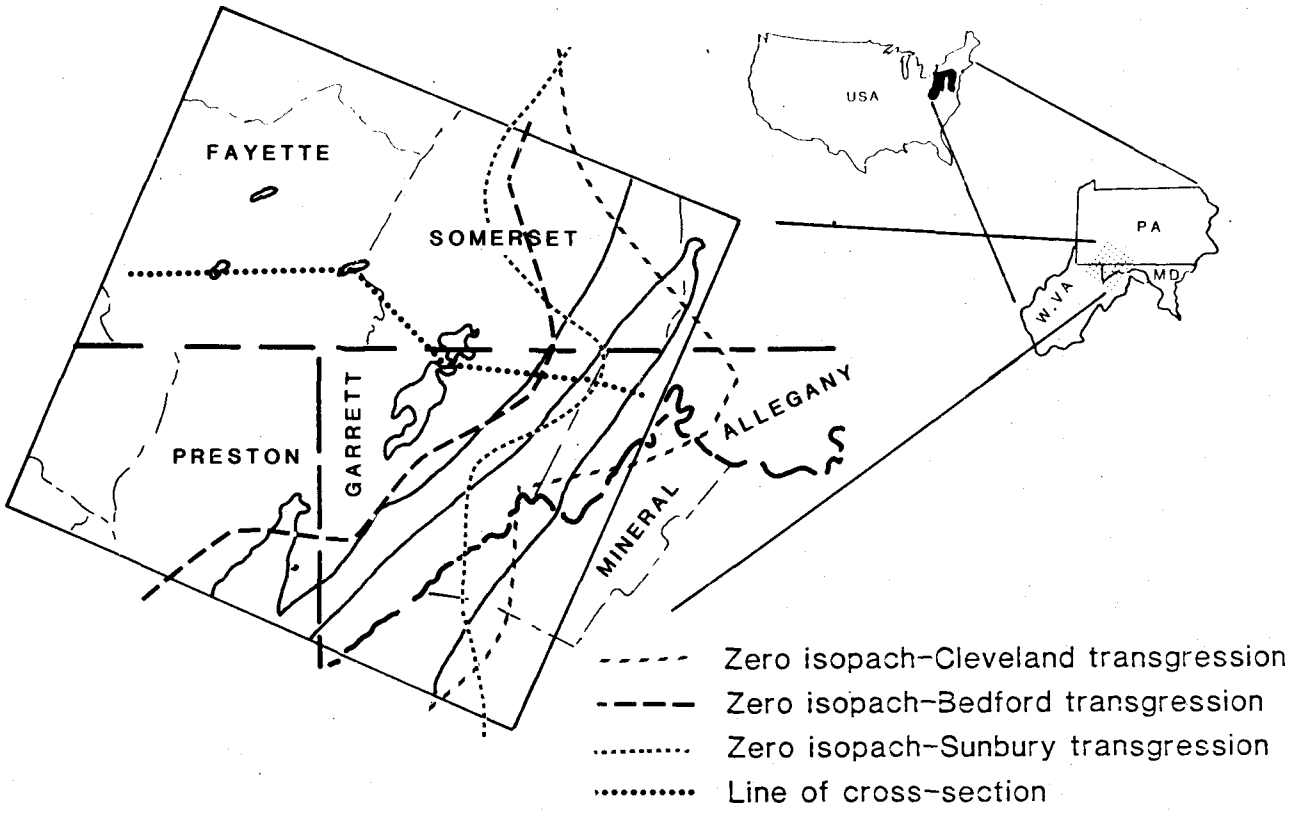

Figure 6. - Eastern limit of marine beds of transgressions T_1, T_2 and T_3 as shown in Figure 5.

alternately submergent and emergent, largely in response to changes in sea level.

The Finzel tongue of the Rockwell Formation consists of dark shales and siltstones bearing a brackish-water fauna and greenish-gray *Skolithos*-burrowed sandstones. These beds were deposited in coastal embayments created by submergence of the Hampshire coastal plain during the Cleveland sea level rise. Another dark shale above the Finzel tongue contains Early Carboniferous mega-invertebrates and is a submergent facies of the Sunbury sea level rise. A submergent facies intermediate between the Finzel tongue and the Early Carboniferous shale is weakly developed and apparently represents a brief transgression during deposition of the upper Bedford Shale (possibly this brief transgression was not eustatic). Complex facies relations and erratic thickness patterns in this area suggest that during emergence (Cussewago and Berea regressions) there was stream incision and some subaerial erosion. These processes produced numerous diastemic surfaces that punctuate the rock-stratigraphic record.

The zero-isopachs on Figure 6 represent stratigraphic thinning of marine beds as a result of facies change to nonmarine beds. The three transgressive indentations indicate that delta lobes persisted in the northeastern and southeastern corners of the study area with an intervening bay. During high-stand, water was deepest over the bay, and thicker sedimentation occurred there than over the drowned delta lobes. Base level infilling of drowned lobes and interlobate bays was followed by rapid progradation/regression with deposition of thin sand bodies (Cussewago and Berea). These transgressions were probably coupled with sea level drops, but the data are not conclusive.

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