4.3. Connecting the Dots: Sequence Stratigraphic Correlations in Devonian Black Shales of the Eastern U.S. and Relationship to Global Sealevel Variations

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Although the Late Devonian black shales of Tennessee, Kentucky, Indiana, and Ohio are known under various names depending on location, most subunits are contiguous over large areas. In Tennessee, initial sequence stratigraphic studies have shown that the Chattanooga Shale can be subdivided into as many as 14 erosion-bounded shale packages (Fig. 4.3.1).

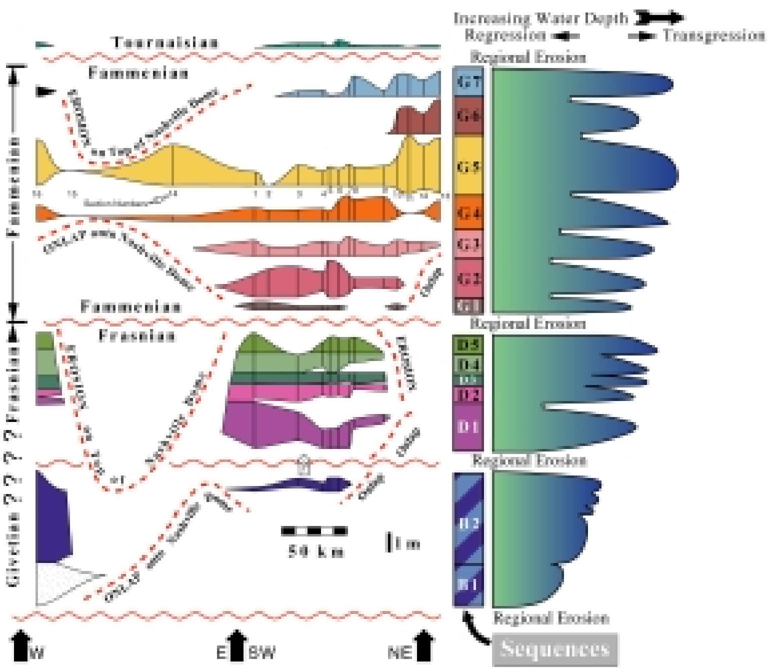

Figure 4.3.1: Sequence stratigraphic subdivision of the Chattanooga Shale (Schieber, 1998b). The succession forms three packages that are separated by regional erosion surfaces. Geometric presentation of "slices" takes into account observed amounts of erosion on top, and perceived onlap on the Cincinnati Arch/Nashville Dome. Geometry may need to be modified as more conodont data become available. The vertical dimension of "slices" is the actual thickness, and the sequences thin due to smaller rates of net deposition closer to the arch. Evaluation of currently available data led to synthetic sea-level curve at right. The question marks between the Givetian and the Frasnian indicate the current uncertainty about the age of the lowermost package. Preliminary conodont data (courtesy Dr. J. Over, SUNY Geneseo) suggest that sequence B1 may be latest Givetian, and that sequence B2 may be lower Frasnian in age. This suggests that the B1-B2 interval falls into the same age bracket as the Blocher/Trousdale interval in Kentucky and Indiana. The color coding for the sequences in this and successive figures is intended to highlight intervals that are likely correlatives across the study area.

The subdivisions in Figure 4.3.1 are based on outcrop studies in central Tennessee and south-central Kentucky that revealed extensive erosion surfaces (Schieber, 1994, 1998a, 1998b) that formed in response to sea level drop (Schieber and Riciputi, 2004) and are the basis of a sequence stratigraphic approach. In the subsurface of Indiana, sequence boundaries are identified by a combination of core studies and tracing of gamma-ray signatures from the outcrop belt (Schieber, 2000). In addition, truncation of gamma-ray motifs provides independent confirmation of sequence boundaries in the subsurface (Johri and Schieber, 2000).

How the scheme in Figure 4.3.1 carries over into areas further to the north is shown in Figure 4.3.2. What the figure also shows very clearly is the significant thickness changes of the Devonian black shale succession across the area. From less than 10 meters at locality 6 (Tennessee) it swells to more than 500 meters in northeastern Ohio (loc. 4). What also becomes apparent is that there are considerable differences in the time interval that the sections represent in different areas. For example, the Chattanooga Shale interval in Tennessee covers approximately the same time interval as the New Albany Shale in Indiana (see paper by Lazar and Schieber, this guidebook, Fig. 1.1), but the Chattanooga Shale in south-central Kentucky (loc. 5, Fig. 4.3.2) has little stratigraphic overlap with the type Chattanooga Shale in central Tennessee. All of the Dowelltown Member (Frasnian) and the lower half of the Gassaway Member are missing, and we pick up new units (*Foerstia* through Cleveland Shale interval) that are not common (though preserved locally) further south. Such disparities in the stratigraphic succession between outcrop areas have caused considerable confusion in earlier attempts at detailed correlations in the past. As long as one adhered to the (now defunct) dogma that these black shales represented condensed but by and large continuous successions, "successful" correlation was only possible through postulation of (however improbable) lateral facies changes.

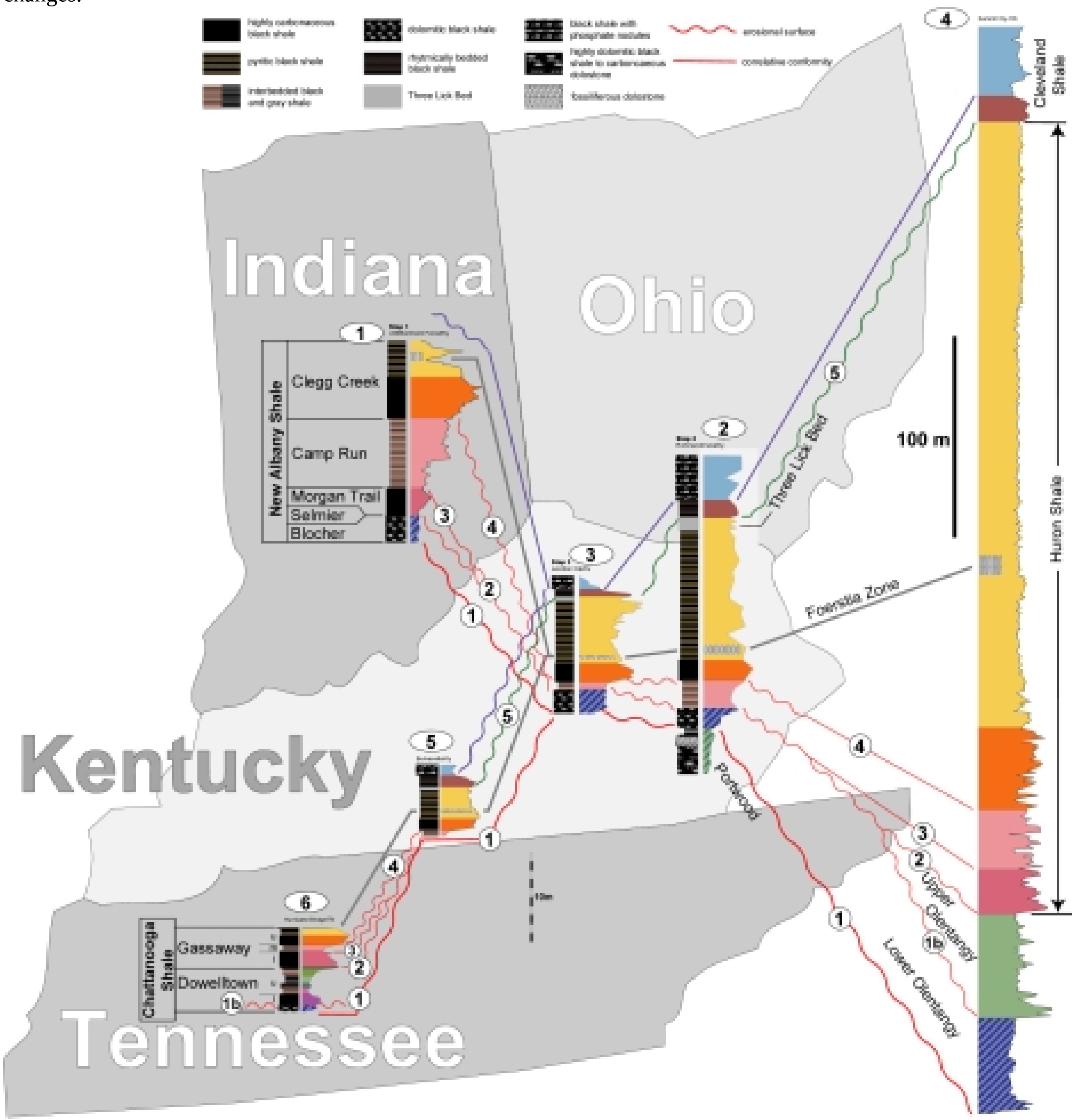

Figure 4.3.2: Stratigraphic overview for Tennessee, Kentucky, Indiana, and Ohio. Numbers in white ovals are localities of sections, placed in their approximate geographic position on the underlying map. Localities 1 through 3 are the stops discussed in the road log (Section 2, this guidebook). Locality 4 is an interpreted gamma-ray log from a well in northeastern Ohio, and is not at the same scale as the other sections (it would need to be expanded by a factor of 4.5 to be the same scale). The section for locality 1 has been moved NW (into Indiana) in order to allow space for

correlation lines. The displacement is permissible because this section (with the Selmier Member missing) is also representative of New Albany sections one might encounter along the outcrop belt in SE Indiana. Numbers in circles correspond to erosion surfaces examined in the road log stops. The Dowelltown Member of Tennessee (Frasnian), the temporal equivalent of the Selmier Member of Indiana, can be subdivided into several subunits (see also Fig. 4.3.1), that have yet to be recognized in other Frasnian intervals of the study area. In Ohio, the Frasnian equivalent of Selmier and Dowelltown is known as the Upper Olentangy Shale, and the Trousdale/Blocher equivalent is known as the Lower Olentangy Shale. In Tennessee, strata that are age-equivalent to the Blocher/Trousdale interval occur only locally as erosional remnants (below surface 1b). The thickest-developed Blocher equivalent sections outcrop near Olive Hill/Tennessee (east of Savannah/TN), in the western vicinity of Nashville/TN, and in the Flynn Creek impact crater (south of Gainesboro/TN). In many other areas no Blocher age strata are preserved. Color coding matches Figure 4.3.1. The base of the Cleveland Shale (erosion surface 5) is clearly an erosion surface in NE Ohio (locality 4), yet how much erosion occurred elsewhere in the basin and what its relationship is with regard to the Three Lick Bed is not as clear-cut. This still requires a careful determination of the origin of the Three Lick Bed (as indicated in the description of Stop 2, this guidebook). There is also an upper portion of the Cleveland Shale that contains phosphate nodules in black shale matrix, and in places in Tennessee and Kentucky this portion is in erosional contact with underlying shales. How consistent this erosional contact is still must be determined. Reworking of these phosphate nodule-bearing shales during the terminal Devonian to Kinderhookian regression probably provided the raw material for the Falling Run Bed, the erosional lag that separates Devonian from Mississippian strata in many areas.

Black shales may have been deposited in comparatively shallow water, within wave base of strong storms (Schieber, 1994, 1998a) in the vicinity of the Cincinnati Arch, as well as in the deeper water of basins adjacent to the Cincinnati Arch (Illinois and Appalachian Basins). Sequences may diminish in thickness or disappear completely as we approach the Cincinnati Arch, reflecting onlap as well as erosion during emergence of the arch (Fig. 4.3.1). Using available biostratigraphic data, detailed lithostratigraphic correlations, and matching of transgressive-regressive cycles, it is possible to link the sequences in the study area to equivalent Devonian strata in Iowa, New York, and to the global Devonian sea-level curve. Figure 4.3.3 shows the global TR cycles proposed by Johnson et al. (1985), starting with the Taghanic onlap, the base of TR cyle IIb and also the base of the Portwood interval (see contribution by Brett et al., this guidebook).

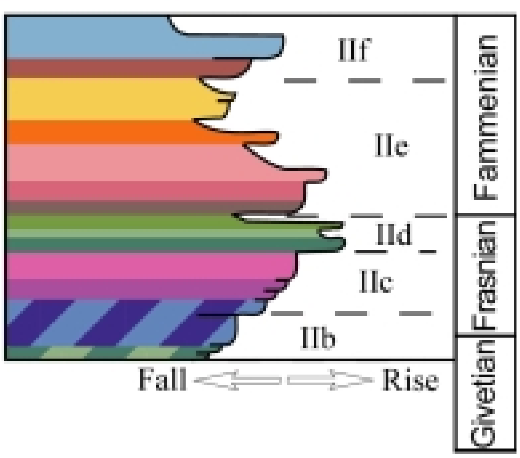

Figure 4.3.3: Tentative correlation of the global TR cycles of Johnson et al. (1985) with the sequences (color stripes) recognized in the Late Devonian black shales of the eastern U.S. Color coding matches Figures 4.3.1 and 4.3.2. Note that the Blocher/Trousdale interval straddles TR cycles IIb and IIc. Improved conodont data and tracing of lags/erosion surfaces should allow reproducible subdivision of this interval in the future, permitting the placement of the TR IIb/IIc boundary. Correlation of sequences to the bases of TR cycles agrees with available conodont data (Sandberg et al., 1994; Over, 2002). Matching of sequences to subsidiary transgressions within TR cycles is consistent with available conodont data, but additional confirmation is highly desirable. Overall, the match-up suggests that currently recognized sequences largely reflect eustasy.

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