

Structural Anomalies in Black Shales of the Northern Appalachian Basin of New York State

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The framework for regional fracture sets in black shales of the northern Appalachian Basin has been well-established (e.g., Engelder, Lash). Over 100,000 fractures and other structural features identified in outcrop, well logs, and seismic reflection data demonstrate significant *local* variations in structural elements including fracture spacing and orientation (for a given lithology, bed/interbed thickness, TOC content/height above the base of the black shale). Many of these structural anomalies were influenced by local stress deviations associated with through-going fault systems that were episodically reactivated, such as reactivated intra-Grenvillian sutures and Iapetan-opening faults, and by Alleghanian thrust ramps off decollement in the Salina salt section.

Examples of the local variability include duplexing in the Union Springs Marcellus black shale outcrops in eastern NYS that indicate multiply oriented SH directions over short distances, consistent with local fault control and/or multiple phases. FMI logs show that the Marcellus at depth has, locally, open fractures that are highly oblique to contemporary SH and are parallel to local faults and folds. Cores of the Marcellus show worked surfaces indicative of low angle faulting, and seismic/well log data indicate that thrust ramps through the Onondaga deform the lower Marcellus (Union Springs) in duplexes. In the Ordovician Utica black shale outcrops in eastern NYS, WNW-striking fracture frequency increases toward Taconic NNE-striking faults, related to a compressional event across the formerly extensional faults. Seismic data reveal numerous zones of faulted Utica, but several NNE-striking Taconic faults have very narrow footprints of damage zones and drag folds in outcrop.