

Pervasive Strain the Marcellus Gas Shale of the Appalachian Plateau as Revealed by CAT-scan Analyses of Core

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The Devonian Marcellus gas shale fairway sweeps in an oroclinal bend from the New York State, through Pennsylvania, and into West Virginia. The oroclinal bend reflects Alleghanian tectonics driven by the collision of the margin of Gondwana against Laurentia in Pennsylvania through Middle Permian time. During the Alleghanian the Appalachian Plateau detachment sheet slipped toward the North American craton on a décollement of Silurian salt. The décollement is blind at its toe which means that slip was accommodated by a combination of fault imbrications, folding, and pervasive strain exceeding 10% layer parallel shortening. While the Marcellus is nearly devoid of strain markers, there is little doubt that it suffered the same pervasive strain as those gray shales and siltstones with obvious strain markers. Well developed pencil cleavage in weathered outcrops is a manifestation of layer-parallel shortening. CAT-scan analyses of cores taken by Penn State's Appalachian Basin Black Shale Group (ABBSG) shows extensive evidence for layer-parallel shortening not visible on the external boundary of cores. These cores were recovered from the flanks of second-order anticlines in the PA Valley and Ridge where flexural slip folding is manifest by both bedding-parallel slickenside surfaces and drag folds of silt lamina several mm thick. The interior of these samples show the development of a spaced cleavage emanating from the silt laminae with a regular spacing of about double the thickness of the laminae. This disjunctive cleavage initiates normal to the planes of the laminae but grow outward into the adjacent mudstone as axial planar cleavage remaining vertical as beds are rotated on the flank the host fold. As the cleavage grows into the bounding mudstone layers, it splays and gradually dissipates. Development is best in quartz rich silt layers relative to clay-rich muds, a behavior consistent with other examples of cleavage development in foreland settings.