During a transgression of the McKenzie sea, areas of thicker Keefer sand stood as submerged topographic highs. The local relief provided optimum sites for the patch reefs to develop and offered better protection to the fauna from being overwhelmed by incoming terrestrial clays. Conversely, the shaly interreef deposits of the McKenzie are present in areas of thinner Keefer Sandstone; they were laid down in turbid, relatively deep water between highs. A minor regression followed as represented by middle McKenzie intertidal sediments, and growth of the patch reefs ceased when the area emerged above the level of low tide.

Two southwest-northeast tracts of thicker McKenzie Formation and Keefer Sandstone mark the trends of Keefer topographic highs and associated McKenzie patch reefs. These trends now offer the best potential gas in the Middle Silurian of western West Virginia.

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Mauch Chunk Alluvial Plain and Mud-Flat Sediments in Northern West Virginia

Regional subsurface analysis of red beds of the Mauch Chunk Group (Upper Mississippian) in northern West Virginia, using oil and gas well logs and cuttings, suggests that deposition was in alluvial-plain environments grading basinward into mud flats.

Thickest net sandstone in the Mauch Chunk Group is in Barbour, Tucker, and Preston Counties in a belt 10 to 15 mi (16 to 20 km) wide striking north-northeast parallel with and just west of major fold axes of the Appalachian Plateau. This belt comprises numerous dip-oriented (west to northwest), vertically stacked, anastomosing subbelts and dendroids. Belt position reflects a gradient change from what were higher elevations on the east onto more level and tectonically stable areas of northwestern West Virginia. Lithofacies interpreted for the area include (1) channel fill–levee deposits as gray-green sandstone, siltstone, or non-red shale, and (2) flood-basin (overbank-levee) sediments as red and green shale. Streams carried a large suspended load and very fine to fine-grained sand. To the northwest, sandstone percentage decreases, and alluvial-plain facies interfinger with mud flats. Distal mud facies include laterally persistent limestone beds, and tidal-channel units with massive sandstone fill.

The overall genetic aspect of Mauch Chunk stratigraphy is a general regressive facies shift to the northwest. The boundary between Mauch Chunk red beds and coarse clastic alluvial sediments of the overlying Pottsville Group reflects changes in gradient, supply, and source area relief.

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Dilation Brecciation—Proposed Mechanism of Fracturing, Petroleum Expulsion, and Dolomitization in Monterey Formation, California

The Monterey Formation has been selectively replaced by dolomite and subsequently fractured, brecciated, and relithified with several generations of dolomite cement. The two dolomite types are distinctive in morphology, color, stoichiometry, δC^{13}, δO^{18}, and insoluble and trace-element content.

Dilation breccias evidently originate in embrittled rocks through a distinctive sequence of steps induced by tectonism: dilatancy, fluid expulsion, natural hydraulic fracturing, brecciation, hydroplastic flow, injection, and dolomite precipitation. Development is most abundant in, but not restricted to, areas of strike-slip faulting.

Initially, breccia clasts are angular, large, and closely fitted. In advanced development, smaller clasts appear unsupported and volumetrically subordinate to fracture-filling dolomites. Complex examples contain a very wide range of unsorted clasts and cement, similar to a slurry. They appear to be injected under pressure into swollen bedding planes and terminal fractures.

Tectonic stresses cause an initial compression and subsequent dilation (elastic) of rock microcracks and imperfections. With continued stress, the cracks are propagated inelastically and develop into major fracture networks. Fracturing associated with excess pore-fluid pressures triggers an instantaneous flow of connate fluids across several hundred feet of newly fractured strata. The resulting sharp drop in fluid pressure and temperature causes rapid precipitation of fracture-healing dolomite. The relithified rock is then subject to renewed dilatancy and rupture.

The dilatancy is pervasive and sufficient in magnitude to cause the expulsion of indigenous petroleum held initially in the organic matrices of the relatively impervious Monterey Shale. Several periods of petroleum migration are recorded in breccia paragenesis.

Dilation breccia is a distinct form of nondepositional breccia. It probably occurs in many tectonic provinces.

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Constraints and Problems in Producing Gas from Eastern Shales

The enormous gas resources locked in the various Mississippian and Devonian shale layers of the major eastern geologic basins naturally attracts the interest of energy policy makers and commercial entrepreneurs who are motivated to see and participate in the exploitation of that fraction which can be easily recovered. To succeed in this endeavor, however, certain constraints have to be faced, and other nagging problems have to be resolved. This paper classifies the constraints and the problems so that they can be dealt with systematically, and so that the expectations will not overtake the prospects and the realities.

The fact that the shale gas resource is widespread, and indeed reasonably evenly spaced, must be weighed against the observation that so far very few ways have been found to achieve high levels of prolonged production even from the historic reservoir locations. The obstacle that most appears to limit recovery is the fact that the shale matrix which holds much of the gas has the character of a molecular sieve. This means that somehow transport paths must be induced (especially when they do not naturally preexist) so that gas can easily move toward the wellbore sinks. Completing shale wells with stimulations that induce fractures and other types