U.S. Department of the Interior
U.S. Geological Survey

Global Prediction of Continuous Hydrocarbon Accumulations in Self-Sourced Reservoirs

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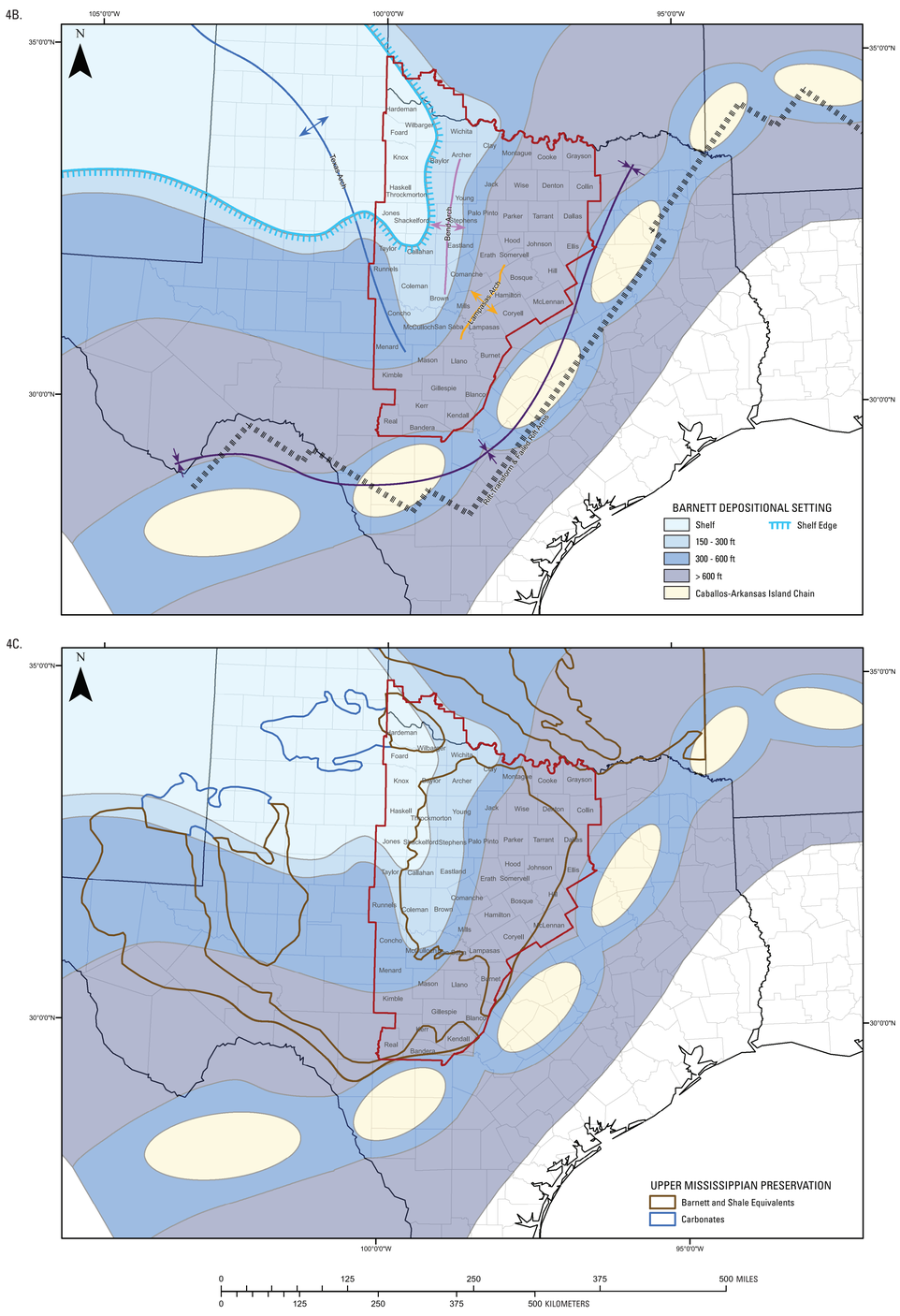
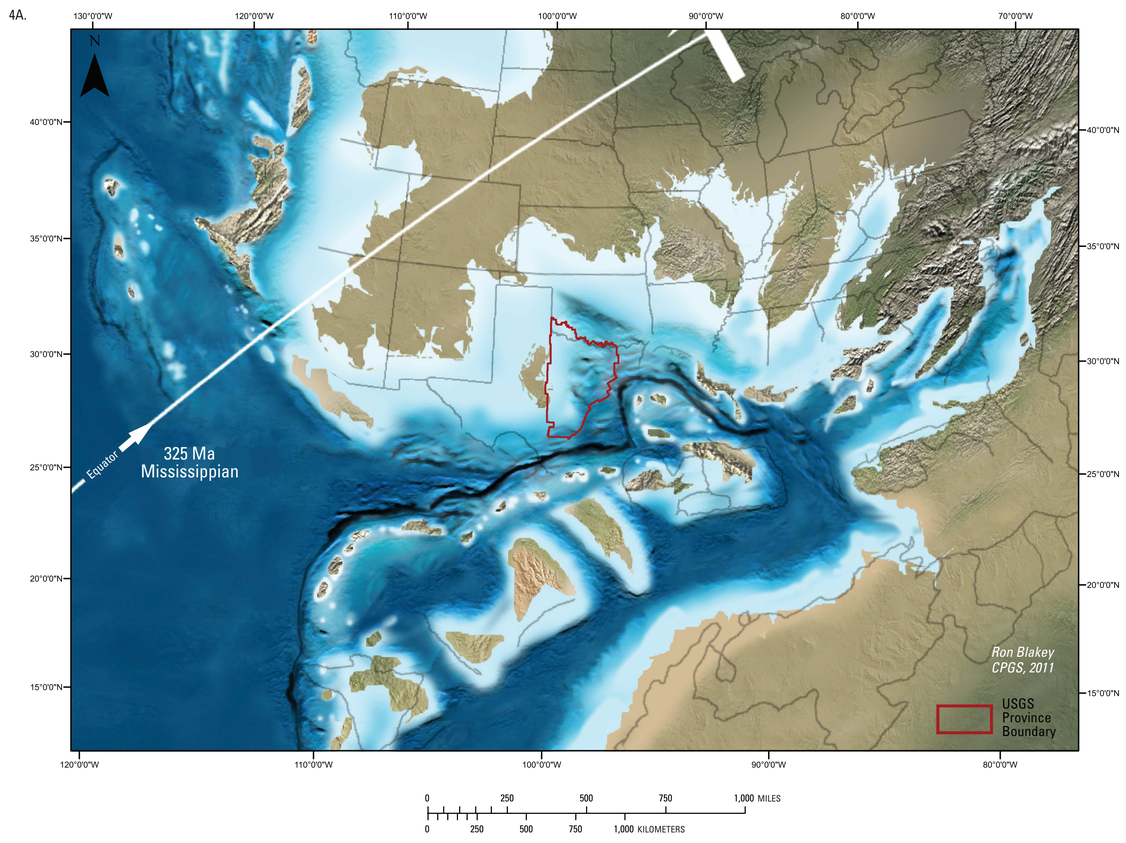
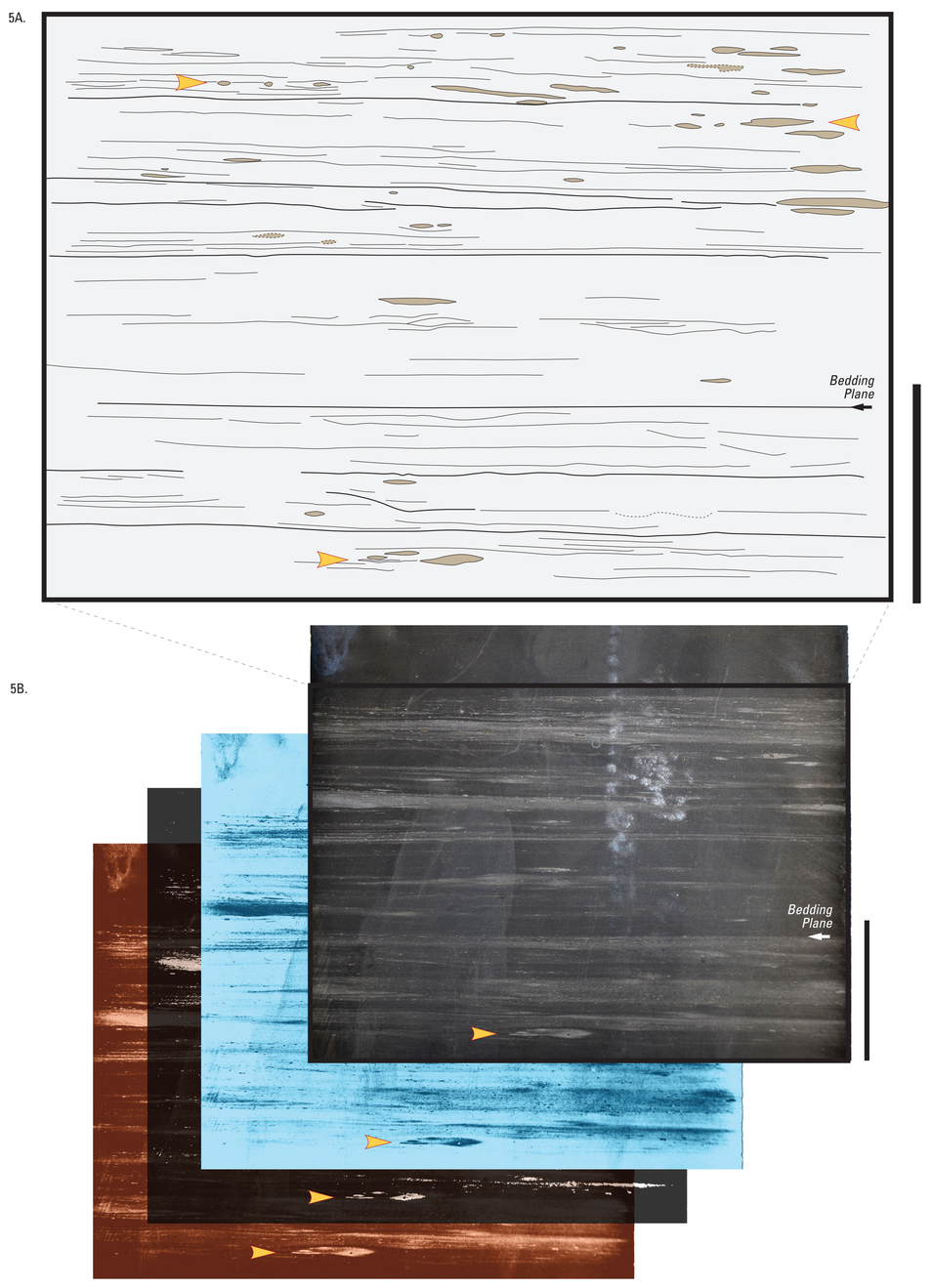
Example: Barnett Shale, Fort Worth Basin, Texas

Figure 4. Barnett Shale (Upper Mississippian), Fort Worth Basin, Texas. Province Boundary (red), USGS Fact Sheet 2004–3022: (*http://pubs.usgs.gov/fs/2004/3022/fs-2004-3022.html*).
A. Deposition at low latitudes in Ouachita "interior orogen" of assembling Pangea. Map Scale 1:20,000,000.
B-C. Depositional model within incipient foreland basin setting. Modified from Loucks and Ruppel (2007). Map Scale 1:5,000,000.
B. With structural elements of Barnett self-sourced shale play (Walper, 1982).
C. Preserved Upper Mississippian strata, controlling exploration and development efforts for mature hydrocarbons. Modified from Loucks and others (2009).







Anoxia — Source-rock deposition is commonly attributed to upwelling and (or) anoxia, but faint laminations and evidence of bioturbation by "sediment swimmers" in thixotropic muds suggest a grain-size control behind previous (mis)interpretations. Minimally, low variance in grain size would have: (1) limited inhabitation by benthic organisms that required structured dwelling or feeding burrows, and (2) hindered recognition of traces within seemingly homogeneous sediments.

Cryptobioturbate texture in source rocks and self-sourced shale reservoirs should be expected to have affected diagenesis, influenced the migration of hydrocarbons, and exert an additional control on the recovery of oil and gas when stimulation production techniques are used. Although self-sourced shales have been modeled as "dual porosity" systems that include matrix and fracture porosities, the effects of cryptobioturbation are in need of evaluation.

Ongoing microstratigraphic characterization of the Barnett Shale permits development of a framework with which to discriminate among potential source rocks and potential self-sourcing shale reservoirs.

Figure 5. Scale bars 1 in. Pyrite replacement of burrows (yellow arrows).
A. Laminations and bioturbation in an otherwise "black shale" facies, suggesting that the depositional setting was more complex than is generally assumed. Lack of silt-sized and coarser grains may limit: (1) the type of benthos and, therefore, biogenic traces; and (2) the ability to recognize depositional fabrics. B. Layering of core photograph used to generate drawing above. Photograph modified digitally in multiple stages, and individual images stacked as needed to enhance microstratigraphy.

Conclusions

A conceptual model is proposed to aid in the global exploration of continuous hydrocarbon accumulations in self-sourced shale reservoirs. Tectonics was the initial driver behind a myriad of changes that promoted the accumulation of organic matter (Mackenzie and Pigott, 1981; Sandberg, 1983; Waples, 1983). As data resolution increases, improved models will be used to predict the distribution of these self-sourced shales reservoirs more readily than current understanding permits.

(1) Whereas the deposition of thick, organic-rich shales in rapidly subsiding foreland basins was archetypal of the Paleozoic, self-sourced shales of the Mesozoic were deposited primarily in low-latitude, semi-restricted basins of rifted passive margin settings along the U.S. Gulf Coast.

(2) In addition to creating basins with favorable geometries, rapid reconfiguration of tectonic plates induced a number of other global changes that were necessary for the accumulation of (Type II) organic matter in these resources:

(a) Production of new oceanic crust elevated the seafloor and resulted in the flooding of cratonic interiors.
(b) Associated volcanism released carbon dioxide, which triggered global warming and encouraged higher rates of productivity on land and in shallow-marine waters.

(3) Bush and Bambach (2011) detailed a number of macroevolutionary changes in marine metazoan communities throughout the Phanerozoic, many of which were responses to these geological drivers. Reduction of absolute generic diversity due to changing rates of origination and (or) extinction reflects the paleoenvironmental effects of cratonic flooding that typified supercontinent assembly and subsequent breakup. Diminished consumption of accumulating biomass may have resulted from the increased proportion of pelagic taxa with respect to infaunal and epifaunal taxa.

(4) For Paleozoic shale reservoirs deposited in foreland basins, subsequent loading by "flysch"-like deposits contributed to their preservation and later maturation (fig. 1). Overlying, thick, siliciclastic sections, such as the Cotton Valley and Travis Peak/Hosston Formations, encouraged maturation of shale reservoirs deposited in passive marine settings along parts of the Gulf Coast.

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