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

Global Prediction of Continuous Hydrocarbon Accumulations in Self-Sourced Reservoirs

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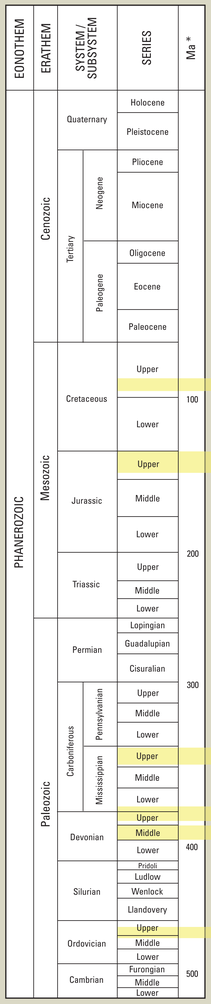
Open-File Report 2012–1091
Sheet 2 of 4

Continuous Hydrocarbons



Eagle Ford Shale
Haynesville - Bossier Fms.
Barnett Shale
Bakken Formation
Marcellus Shale
Utica Shale

*Ages are approximate; Ma, millions of years before present.

Note: Numbers 1–12 in figures 3A–3D refer to numbered references in list of selected references.

Eustasy

Figure 3A. SEA LEVEL — Most North American self-sourced shale reservoirs correlate with geologic periods characterized by rapid reconfiguration of tectonic plates, specifically during the assembly and breakup of Pangea. Rising and high sea levels flooded marginal-marine and cratonic basins. Marine metazoan diversity reflects many changes to the paleoenvironment, such as changing sea level and increasing terrestrial runoff and nutrients.

Climate

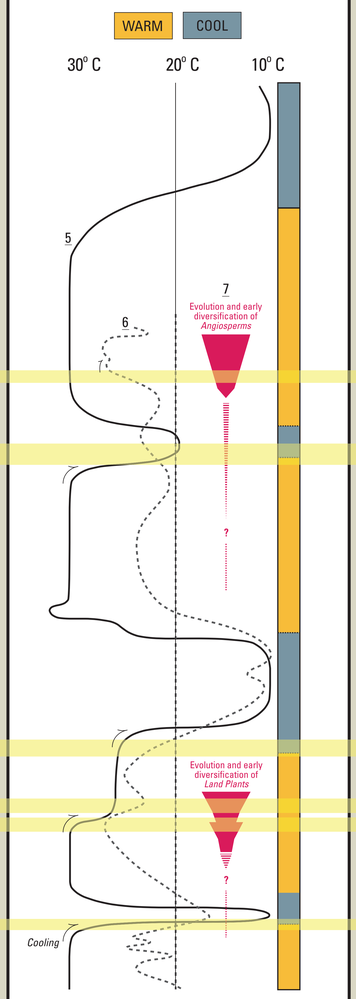


Figure 3B. CLIMATE — Volcanogenic release of carbon dioxide (CO_2) and methane during global tectonic-plate reconfiguration contributed to global warming, and with little to no glaciation, induced flooding of cratonic interiors. In addition, higher levels of CO_2 correspond to periods of land-plant diversification and high marine primary productivity. Rapid burial of organic material in marine environments sequestered carbon and reduced CO_2, which induced cooling (arrows).

Seawater Chemistry [8–9]

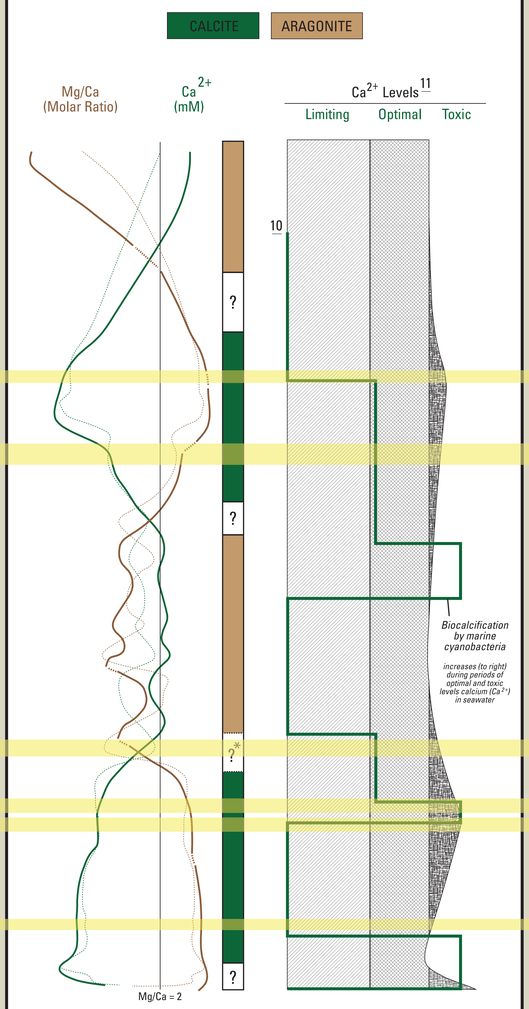


Figure 3C. SEAWATER CHEMISTRY — Oceans were primarily calcitic (green curves) during deposition of self-sourced shale reservoirs. Seawater chemistry correlates broadly with changes in biodiversity (fig. 3D), and it may also have affected the success of reservoir stimulations. Shallowing of the carbonate compensation depth during global warmth likely affected which microfossils and macrofossils were preserved, adding an additional bias that complicates understanding of the deposition of organic-carbon-rich shales. Understanding the distribution of the preservation of calcitic and siliceous tests may help explain variable production trends of these plays. (*Carboniferous uncertain, Stanley, S. M., written commun., Feb. 2012).

Biodiversity [12]

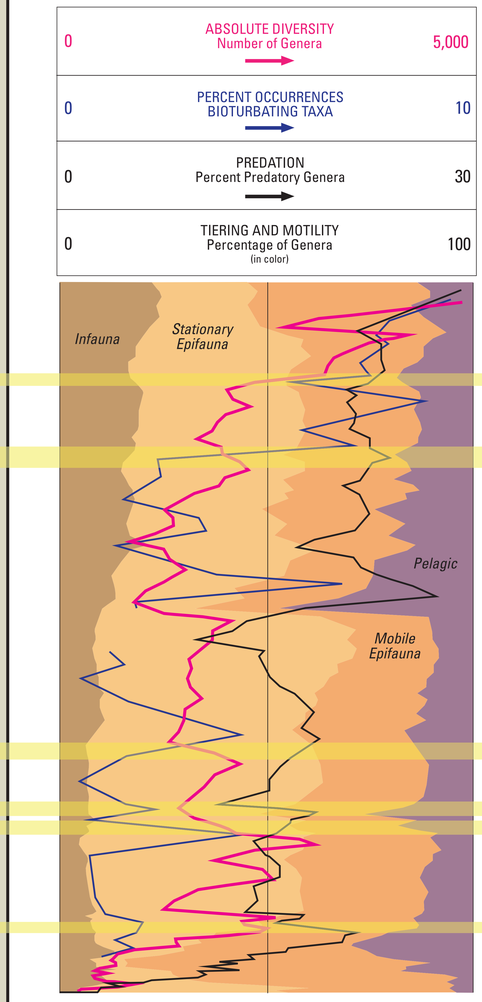
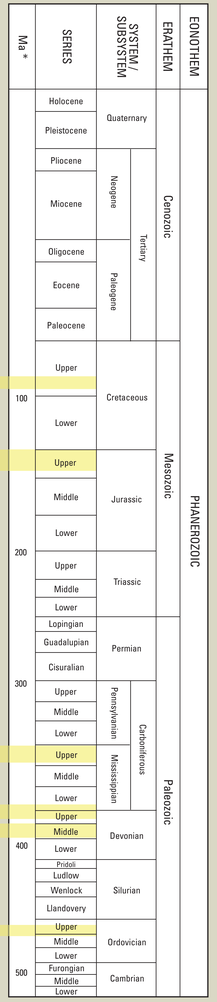


Figure 3D. BIODIVERSITY — Self-sourced shale reservoirs hosting continuous accumulations of oil and (or) gas correlate broadly with several trends in *marine metazoan diversity.* For the most part, each North American play is correlative with a geologic interval characterized by: (1) declining absolute diversity of marine metazoan genera; (2) higher percentage of predators; (3) lower diversity of infaunal and epifaunal taxa; and (4) waning percent occurrences of rapidly bioturbating taxa. Ultimately, higher primary productivity and reduced consumption of organic matter, as the benthos faltered, promoted the deposition and preservation, respectively, of thick accumulations of organic carbon.



Model — The correlation of large-scale changes among several geological, paleoenvironmental, and paleobiological/ecological parameters explains why organic-carbon-rich, self-sourced shale reservoirs appear to be limited to discrete periods in geological history (fig. 3). Optimal settings: Rapidly subsiding, semi-restricted basins during periods of high sea level, warm climates, calcitic seas, and reductions in absolute metazoan diversity due primarily to "origination failure." (See Eoff, 2012, and references therein).

Eoff, J.D., 2012, Global prediction of continuous hydrocarbon accumulations in self-sourced reservoirs: U.S. Geological Survey Open-File Report 2012–1091, 4 sheets.

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