Available online at www.sciencedirect.com
ScienceDirect
International Journal of Coal Geology 71 (2007) 72–84
International Journal of COAL GEOLOGY
www.elsevier.com/locate/ijcoalgeo

Palynological and bulk geochemical constraints on the paleoceanographic conditions across the Frasnian–Famennian boundary, New Albany Shale, Indiana

Sarah R. de la Rue [a,*], Harold D. Rowe [b], Susan M. Rimmer [b]

[a] Department of Geology and Geophysics, Louisiana State University, Baton Rouge, Louisiana 70803-4101, USA
[b] Department of Earth and Environmental Sciences, Slone Research Building, University of Kentucky, Lexington KY 40506-0053, USA

Received 9 January 2006; received in revised form 2 June 2006; accepted 5 June 2006
Available online 28 July 2006

Abstract

A down-core record of stable isotope and geochemical results is integrated with palynofacies (kerogen) data from the New Albany Shale (Indiana) to reconstruct environmental changes that occurred across the Frasnian–Famennian boundary. Preliminary interpretations are focused on developing several multiproxy linkages that will potentially lead toward a more robust understanding of the occurrence and significance of phytoplankton assemblage variations during the Late Devonian, a time of widespread black shale formation. Development of such linkages will potentially provide a more comprehensive assessment of the various controls on 1) primary production, and 2) carbon sequestration in a large, low-paleolatitude intracratonic basin.

An abrupt change in the geochemical and biotic proxies for particulate organic matter across the Frasnian–Famennian boundary coincides with a distinct lithological change, characterized by laminated, brownish-black Famennian mudstones unconformably overlying alternating bioturbated, greenish-gray and non-bioturbated, dark-gray Frasnian mudstones. Elemental and isotopic profiles reflect different patterns of production, degradation, and removal of organic carbon in the two shale facies. A shift from acritarch- to prasinophyte-dominated waters across the boundary indicates the overall importance of bathymetric fluctuations, chemico-physical conditions, and nutrient availability related to eustatic sea-level change. A positive $\delta^{13}C_{V\text{-}PDB}$ shift of 1.1‰ across the boundary is interpreted to be correlative with the global Upper Kellwasser Event. A preliminary model is proposed to explain the sustainable primary production during times of maximum flooding, thereby enhancing organic preservation during black shale formation.

Keywords: Late Devonian; Illinois Basin; New Albany Shale; *Tasmanites*; Palynomorphs; Stable isotopes

1. Introduction and geological setting

Deposition of organic carbon-rich muds is thought to depend upon the relationship of two end-member factors: high primary production of marine phytoplankton and low clastic input (Pedersen and Calvert, 1990; Calvert et al., 1996), or anoxic conditions at the water–sediment

* Corresponding author. Tel.: +1 225 578 5999; fax: +1 225 578 2302.
E-mail address: sdelarue@geol.lsu.edu (S.R. de la Rue).

0166-5162/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.coal.2006.06.003

interface enhancing carbon accumulation and preservation (Demaison and Moore, 1980). Estimation of phytoplankton productivity during times of black shale formation has been evaluated usually using down-core bulk organic elemental (C/N/P) and isotopic ($\delta^{13}C$, $\delta^{15}N$) signatures (e.g., Sageman et al., 2003), or whole-rock geochemistry and palynology (Bucefalo Palliani et al., 2002; Filipiak, 2002). A thorough synthesis of the problems and aspects associated with black shale studies can be found in Wignall (1994) and Katz (2005).

Previous studies of Upper Devonian rocks of the Illinois, Michigan, and Appalachian basins have concentrated on organic matter (OM) accumulation, and have employed organic petrology (e.g., Robl et al., 1992; Rimmer et al., 1993, 2004), authigenic clay minerals (e.g., Hover et al., 1996), metal enrichment (e.g., Ripley and Shaffer, 2000; Rimmer, 2004), and geochemistry (e.g., Frost et al., 1985; Brown and Kenig, 2004) as tools for determining the source, type, and degree of degradation of OM. Additionally, while the palynological content of chronostratigraphically equivalent shales from various areas of these basins has been investigated (e.g., Wicander and Loeblich, 1977; Wicander and Playford, 1985; Huysken et al., 1992), no known palynologic studies have been undertaken to ascertain the distribution patterns of particulate organic matter (POM) in the Selmier and Morgan Trail Members of the New Albany Shale of Indiana.

The main objective of the present study is to investigate the ecological and general environmental controls on primary biomass production and black shale formation during the Late Devonian, utilizing various chemical, sedimentological, and biotic proxies. To this end, 30 preliminary samples from a core drilled in the low-paleolatitude Illinois Basin were chosen in order to evaluate the potential for a high-resolution, multiproxy investigation that integrates palynological, sedimentological, geochemical, and

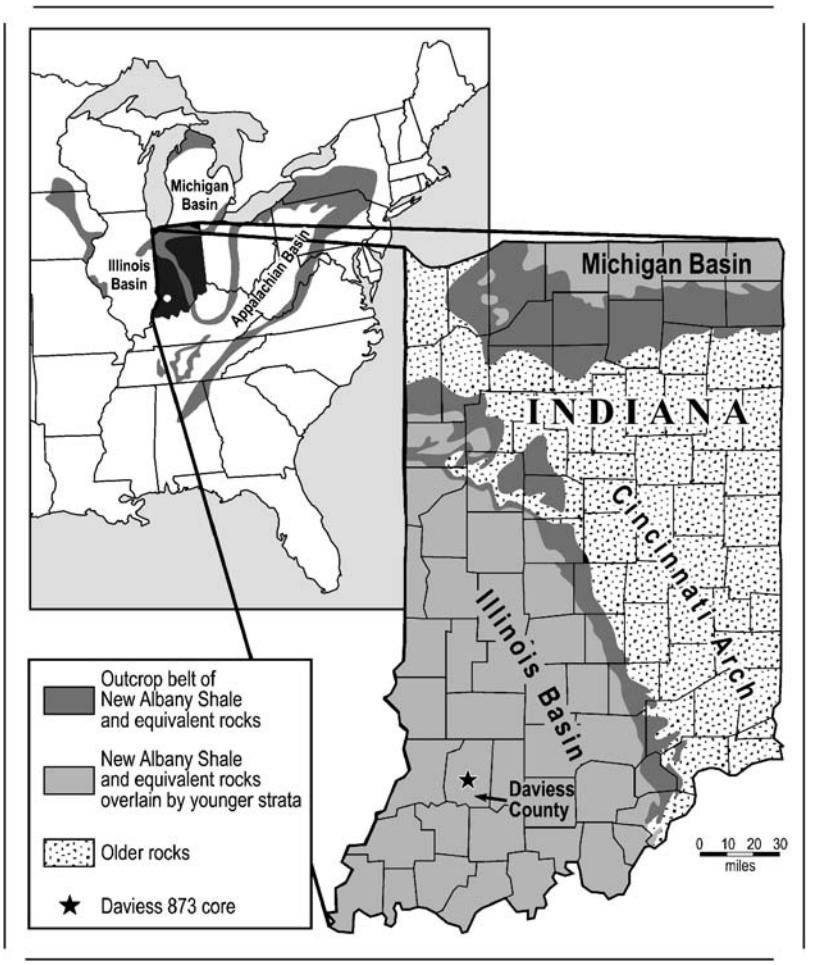

Fig. 1. Location of the studied core (Daviess 873) recovered from the outer perimeter of the Illinois Basin, southwestern Indiana, USA (adapted from Lineback, 1970, and Brown and Kenig, 2004).