

High-density bioturbated sandstones in the Mississippian Mauch Chunk Formation, eastern Pennsylvania, USA: Implications for continental ecospace exploitation

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ABSTRACT

Continental communities represented by complex, rapidly evolving invertebrate ecosystems first appeared during the Early Palaeozoic Era and are recorded in surface and subsurface bioturbation. The Mississippian-age Mauch Chunk Formation contains several high-density bioturbated, fine-grained sandstones that are preserved as erosively based fluvial channel fills. Several of these channel sandstone bodies are almost completely homogenized by subsequent bioturbation throughout their entire thickness, up to a maximum depth of 1.6 m.

The Mauch Chunk ichnofossil record demonstrates that high-density bioturbation occurred at least 30 my prior to the Permian and well before its widespread distribution in the Triassic. Hence, the Late Mississippian high-density bioturbated sandstones demonstrate a much earlier high-density exploitation of the continental subsurface ecospace than previously known.

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1. Introduction

Marine strata of various ages have yielded important insights into the evolutionary history of bioturbation depth and the paleoenvironmental distribution of invertebrate burrowing (Sepkoski and Miller, 1985; Droser and Bottjer, 1987, 1988, 1989; Sepkoski, 1991; Droser and Li, 2001). Successful discoveries in the marine record spurred the examination of bioturbation in continental settings in order to glean similar insights into how substrate exploitation varied through time (Buatois and Mángano, 1993; Buatois et al., 1998; Miller and Labandeira, 2002; Miller et al., 2002). Applying semiquantitative indices to fluvial and lacustrine Permian and younger strata, high-density bioturbation was shown to occur on bedding planes before the vertical exploitation of substrate ecospace took place (Miller et al., 2002), supporting earlier observations that penetrative burrowing was rare, if not absent in Palaeozoic continental strata (Miller, 1984; Maples and Archer, 1989). As an example, the ichnogenus *Beaconites* has been reported to burrow to 20 cm depth in the Devonian to Lower Carboniferous strata (Graham and Pollard, 1982; Morrissey and Braddy, 2004).

The Mississippian Mauch Chunk Formation of eastern Pennsylvania has recently proven to be a rich source for understanding vertebrate and invertebrate ichnofossils yielding important insights into continental ichnodiversity during the Mississippian (Fillmore et al., 2010, 2011, 2012; Lucas et al., 2010a,b; Storm et al., 2010). This paper reports on recently discovered, high-density, bioturbated fluvial channel deposits, discusses the conditions of their formation, and explains the implications

for ecosystem development in the Mississippian-age Indian Run Member of the Mauch Chunk Formation of eastern Pennsylvania (Fig. 1).

2. Geological setting

Recently, the Mauch Chunk Formation has been divided into three formally named members, from oldest to youngest, Lavelle (lower), Indian Run (middle), and Hometown (upper) members (Figs. 1 and 2; Wood et al., 1969; Wood, 1973; Edmunds et al., 1979; Fillmore et al., 2012). The Lavelle Member consists of interbedded red shales and sandstones, and lithic fine-grained sandstones that are gradational with those of the underlying Pocono Formation (Wood et al., 1969; Wood, 1973; Edmunds et al., 1979; Fillmore et al., 2012). Red sandstones and mudstones and minor gray-to-green sandstones compose the Indian Run Member. The first appearance of olive-colored sandstones and conglomerates, typical of the Tumbling Run Member of the Pottsville Formation, delimits the upper boundary of the Hometown Member. The youngest red bed marks the top of the Hometown Member and the start of the Tumbling Run Member of the Pottsville Formation at its type locality at Jim Thorpe, Pennsylvania (Fig. 2; Wood et al., 1969; Wood, 1973; Edmunds et al., 1979; Fillmore et al., 2012). Regional stratigraphic relationships (Fig. 2; Brezinski, 1999), the Mauch Chunk paleoflora, in particular *Anduantes antiquus* (Jennings, 1985), and Carboniferous footprint biostratigraphy (Lucas, 2001, 2007; Fillmore et al., 2012) all indicate that the Mauch Chunk Formation of eastern Pennsylvania is Early Namurian (Chesterian) in age. Opdyke and DiVenere (2004) subdivided the Mauch Chunk Formation into 5 magnetozones that can potentially correlate this

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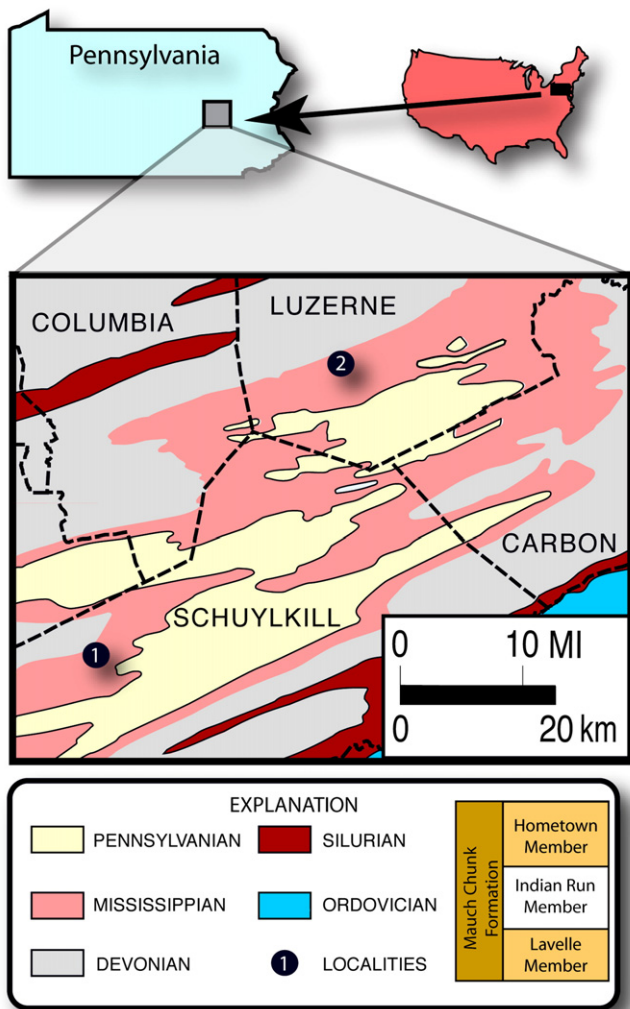


Fig. 1. Location of sample localities, which are road cuts developed in the Mississippian Mauch Chunk Formation in eastern Pennsylvania. Locality 1: (Lavelle) = $N40^{\circ} 43' 21.70''$; $W76^{\circ} 22' 27.74''$. Locality 2: I-80 (West of Whitehaven) = $N41^{\circ} 03' 43.23''$; $W75^{\circ} 52' 05.49''$. Geologic map modified from Berg (1980).

red bed sequence at a finer-scale of resolution than is currently possible from biostratigraphy alone.

The interpretation of the depositional environment of the interfingering Loyalhanna Limestone of the Mauch Chunk Formation was problematic until recently (Fig. 2). The distinctive feature of wind-ripple strata indicates an aeolian origin for most of the Loyalhanna Limestone (Ahlbrandt, 1996; Krezoski et al., 2005). The interbedded assemblage of articulated brachiopods indicates that a complex set of sub-environments may be present (Brezinski and Kollar, 2006). Elsewhere in the Illinois Basin, aeolianites and associated calcretes are recognized within the Ste. Genevieve Limestone, suggesting a semi-arid setting prevalent throughout the eastern US during Mississippian time (Hunter, 1989, 1993; Smith and Read, 1999). This is consistent with Parrish (1993), who argued that Pangaeian tropical climates were characterized by mega-monsoons, promoting the development of low-latitude desert-like settings.

3. Fluvial setting

Bioturbated samples for this study were collected in eastern Pennsylvania in the Indian Run Member of the Mauch Chunk Formation along a road cut on Pennsylvania State Route 901, near Lavelle, Pennsylvania

(locality 1 – Fig. 1) and also near Whitehaven, Pennsylvania (locality 2 – Fig. 1) on Interstate Route 80 (Figs. 1 and 3). The Mauch Chunk Formation has not been explored in other areas for additional examples of high-density bioturbated sandstones. The high-density bioturbated sandstone is identifiable by the mottled appearance of freshly exposed rock outcrop (Fig. 3C and D).

3.1. Description

Near Lavelle, Pennsylvania, a specific, 1.6-m-thick erosively based sandstone deposit in the Indian Run Member was sampled at ~10 cm intervals for slabbing, polishing, and thin sections (Figs. 3A, and 4). This channel deposit grades from a medium-grained sandstone at the base to fine- to medium-grained sandstone at the top. Little variation in grain size (fine- to medium-grained sandstone) is present throughout most of the channel deposit; the most rapid change in grain size takes place at the base and in the uppermost 15 cm. Capping the crude fining-upward sequences are interbedded fine-grained sandstones capped by mud-draped current ripple bedforms followed by mudstones with mudcracks, roots, and raindrop impressions (Fig. 5B and C). Other mudstone-draped rippled bedforms have yielded tracks and trackways attributed to the track *Palaeosauropus*, produced by an

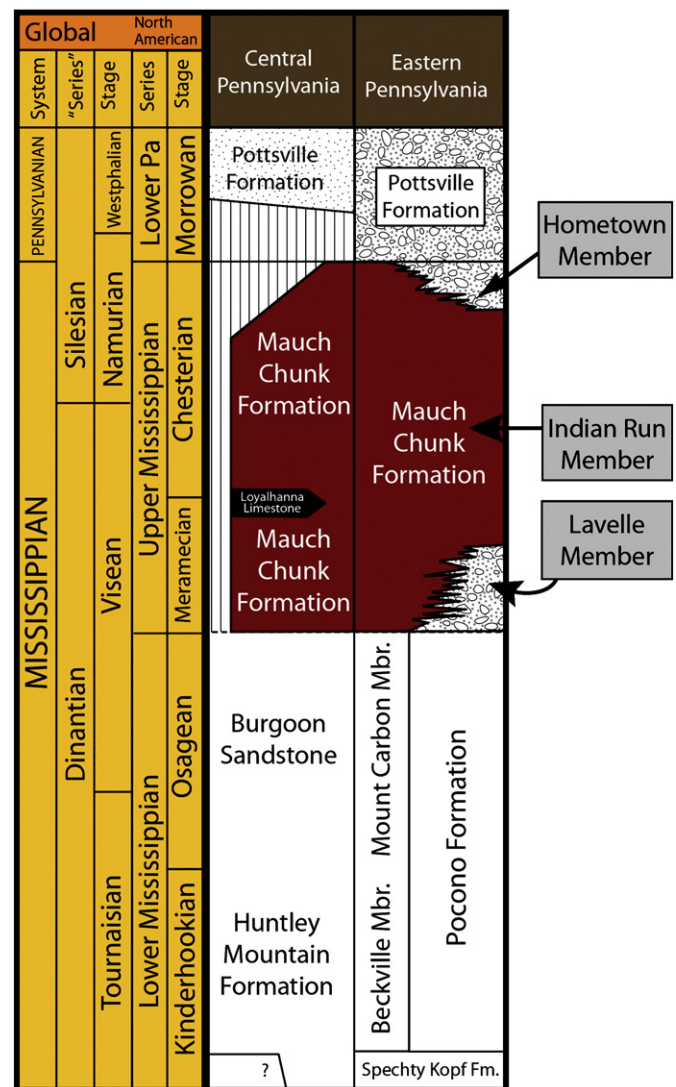


Fig. 2. Stratigraphic correlation of Mississippian age strata in central and eastern Pennsylvania. The high-density bioturbation reported here is in strata of the Indian Run Member of the Mauch Chunk Formation. The chart is modified from Brezinski (1999).

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