



Jared Bowen has always been intrigued with the world around him and found a particular interest in paleontology. After high school, Jared attended Kalamazoo Valley Community College then transferred to Western Michigan University where he achieved a B.S. in Geology with biology and chemistry minors. Jared is now attending Ohio University as a first year master's student in the department of Geological Sciences. His current research is on the paleosols and continental ichnofossils of the Pennsylvanian-Permian Dunkard Group and the neoichnology of burrowing centipedes and millipedes.

Paleosols and Ichnofossils of the Dunkard Group, Southeastern Ohio

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This study focuses on the paleosols and ichnofossils in the Upper Pennsylvanian to Lower Permian Dunkard Group of southeast Ohio in order to facilitate more robust paleoenvironmental and paleoecological interpretations of this transitional time in the Appalachian basin. While the climatic regime of the North American Midcontinent has been well studied (Joeckel, 1991; Miller et al., 1996; DiMichele et al., 2006; Tabor et al. 2008; Hartig et al., 2011; Koch & Frank, 2011) and has indicated extreme fluctuations and an overall increase in aridity (Chumakov & Zharkov, 2000; DiMichele et al., 2006), Eastern North American basins (North Central Pangea) of this time have been the subject of few paleoenvironmental reconstructions. The overall shift in global climate from ever-wet to seasonally dry by the Late Permian may be evident in the Appalachian basin but basin-scale variations may have produced different localized patterns. A thorough examination of the paleosols within the Dunkard Group of southeastern Ohio along with the continental ichnofossils that record the activities of environmentally sensitive soil-dwelling flora and fauna will allow higher resolution paleoclimatic and paleoecologic interpretations as well as allow local basin-scale comparisons between the North American Midcontinent and the Appalachian basin.

Paleosols are fossilized soils that formed in direct contact with the ancient atmosphere. They are the remains of parent materials altered by a variety of physical, chemical and biological processes (Retallack, 2001). Because soils form in terrestrial environments, their immediate contact with the ancient climatic and environmental conditions may make paleosol-based proxies the best tools for paleoenvironmental reconstructions (Sheldon & Tabor, 2009). Paleosols have been identified in strata as old as the Proterozoic (Retallack, 1984), however, traditionally paleosol studies have focused on Quaternary deposits. Recent interest in pre-Quaternary paleosols has increased due to the number, sophistication, and kinds of geologic applications (Kraus, 1999). The five modern primary soil forming factors of climate, organisms, topographic relief, parent material and time can all be assumed to have influenced the formation of ancient soils (Jenny, 1994). Previous studies have investigated the parent material, time and topographic relief related to the Dunkard Group deposits (Beerbower, 1961 & 1969;

Greenlee, 1985; Martin, 1998; Mora & Driese, 1999; Becker et al., 2006). This study will focus on the influence of climate and soil-dwelling organisms on the formation of soils in the Pennsylvanian to Permian transitional period. Ichnofossils play a pivotal role in the interpretation of the types of organisms present and how they respond to changing environmental conditions.

Ichnofossils are preserved biogenic structures that result from the life activities of an organism within or on a medium (Bromley, 1996). Due to the nature of ichnofossils, unlike body fossils, they are not likely to be transported beyond the location where they were produced. Remaining *in situ*, these structures represent the direct response of the organism to its environment (Bromley, 1996). An understanding of these relationships between organism and environment leads to more robust paleoenvironmental interpretations as the works of many ichnologists have shown (Bromley, 1996; MacEachern et al., 2005; Hasiotis, 2007). While ichnology has previously been heavily applied to marine settings, more recent work has shown that paleoenvironmental and paleoecological data can be acquired from continental traces as well, often in the absence of body fossils (Hembree et al. 2004; Hembree & Hasiotis, 2007; Hembree, 2008; Hembree et al., 2011). Trace fossils in the terrestrial realm can indicate a wide variety of environments, provided that present organisms react in a similar way to their surroundings. Rhizoliths (root traces) can be indicators of variations in soil saturation, drainage, and paleo-water table depths (Rodriguez-Aranda & Calvo, 1996; Mora & Driese, 1999; Smith et al., 2008). By using data obtained from neoichnological studies on how soil fauna respond to changes in their environments it is possible to infer past conditions including: seasonally moist to dry conditions, depth to the water table, drainage, oxygen and nutrient availability, distal floodplain to deep aquatic settings, substrate compaction, and temperature (Hasiotis, 2007; Smith et al., 2008; Hembree et al., 2011; Hembree & Nadon, 2011).

The Dunkard Group has been studied since at least the late 1850s (Greenlee, 1985) and is currently described as an up to 360m thick, mixed clastic and carbonate unit consisting of sandstone, siltstone, shale, mudstone, limestone and coal (Martin, 1998). The Dunkard Group occurs in southeastern Ohio, northwest West Virginia and southwest Pennsylvania. The 12,800 km² Dunkard Basin is approximately parallel to the Appalachian fold belt and formed during the Allegheny orogeny with all source rocks to the southeast (Martin, 1998; Becker et al., 2006). These strata have been interpreted as the deposits of a lower and upper fluvial plain as well as a fluvial-lacustrine-deltaic plain with many freshwater lakes and swamp basins (Martin, 1998). An 11-member cyclothem has been observed for the upper Monongehela and lower Dunkard while an 8-member cycle has been identified in the upper Dunkard. These cycles have been attributed to alluvial mechanisms (Beerbower, 1961; Beerbower, 1969). Although there have been extensive studies concerning the age of the Dunkard Group no conclusive data has been found; therefore most studies consider the Dunkard to represent a transitional period from Pennsylvanian to Permian. Mudstone and shale comprise 65% of measured stratigraphic sections of the Dunkard and range in color from red and maroon to green-gray reflecting environmental conditions (Martin, 1998). The red mudstone units have previously been interpreted as paleosols (Martin, 1998) and preliminary field work supports this conclusion with the observation of rhizoliths preserved within these units. It is likely that many of the green-grey mudstone units are also paleosols that formed under different environmental conditions. Since such a large portion of exposed sections are made up of these lithologies, the Dunkard Group is ideal for studying the paleosols in order

to interpret the paleoenvironmental, paleoclimatic and paleoecological conditions in this part of the Appalachian basin during the Pennsylvanian-Permian transition.

Field work for this project will be conducted in eastern Athens County, Ohio. Three equally spaced, 20-40m sections of outcrop will be excavated along the east bound James A. Rhodes Appalachian Highway approximately 2.5 km southwest from Coolville (39°12'45.74"N 81°49'35.28"W). For each trench, general stratigraphic columns will be constructed to identify major lithologic changes and to identify paleosol units. Once identified each paleosol will be described and sampled in 10 cm intervals. Where possible, trenches in paleosols will be laterally extended in order to expose a larger fresh surface for description and sampling. Stratigraphic columns detailing lithology, color, texture, structure, nodules, rhizoliths, and ichnofossils will be made for all paleosols. The color of wet samples will be determined using a Munsell Rock-Color chart (Munsell, 1991). Vertical variations in these paleosol features will relate to different soil horizons allowing a soil type to be determined. The lateral continuity of the horizons, the sharpness of horizon boundaries and the composition and distribution of nodules will be used to interpret the relative seasonality of precipitation and local drainage conditions. Paleosol samples will be used to make thin sections (5 per paleosol unit) as well as tested with X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD) to determine bulk geochemistry and clay mineralogy respectively. The thin sections will be used to identify and describe grain size, mineralogy, micro-texture, clay fabrics, and small-scale trace fossil content. The XRF and XRD data will provide crucial information relating to paleoclimatic conditions including the type and intensity of physical and chemical weathering processes and soil water content. Thin sections, XRF, and XRD analyses will be completed by commercial laboratories.

Ichnofossils found in the paleosols will analyzed for branching, fill type, morphology (size, shape, orientation, and general architecture), abundance, and the structure of linings if present. This information will be used to assign a proper ichnogenus and ichnospecies designation to all ichnofossils found if possible. For any large, well-defined burrows thin sections will be made in order to determine the presence and type of lining, type of fill (active or passive) and lithology of filling material. Ichnofossil distribution and abundance will be used to establish ichnocoenoses. Type, orientation, and abundance of the burrows and rhizoliths present will be used as important indicators of climatic and paleoecologic conditions and the location of the water table. The identified ichnofossils and ichnocoenoses will provide important information for the reconstruction of the paleofauna and flora, their behaviors (e.g. dwelling, feeding, locomotion) and the soil environment that they inhabited. These interpretations will be based on published studies of modern soil ecosystems. This thorough study of the paleosols and ichnofossils of the Dunkard Group will provide vital information for the interpretation of the paleoclimatic and paleoecologic conditions for local basin-scale comparisons and may be of use to refine the age of these Permo-Pennsylvanian deposits.

Preliminary fieldwork has been conducted at the proposed field site in eastern Athens County, Ohio. Within the Dunkard Group deposits several paleosols have been identified with the presence of rhizoliths and some large slickenside surfaces suggestive of a vertisol soil type. There are four distinct cumulative paleosols separated by small beds of sandstone and freshwater limestone. Green-gray mudstone units are incorporated into the red mudstone and may be paleosols that indicate a local

change in drainage conditions or a regional-scale change in precipitation. Fossils of a tree fern and an as yet unidentified plant have been found within the interbedded sandstone units.

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