U-PB DETRITAL-ZIRCON SIGNATURE OF THE CARBONIFEROUS DEEP-WATER CLASTIC DEPOSITS IN THE OUACHITA MOUNTAINS AND ITS IMPLICATIONS

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ABSTRACT:

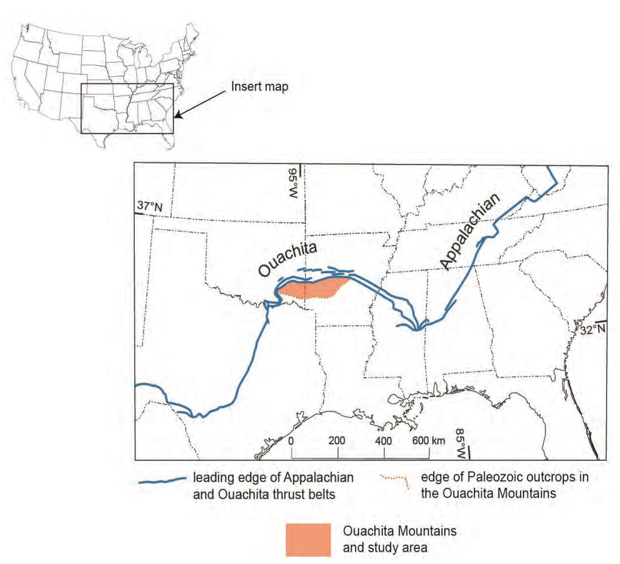
The southern margin of the North American continent transformed from a passive margin to an active margin during the Ouachita orogeny. Thick and near–continuous Paleozoic successions in the Ouachita Mountains provide a unique opportunity to document changes in both sedimentation and tectonics. In contrast to well-documented Taconic, Acadian, and Alleghenian orogenic events, limited detrital zircon studies of the Ouachita orogeny and associated successions have been published, and sediment sources of these deep-water, synorogenic clastics remain less constrained.

In this study, a total of six outcrop samples (n=617) from the Mississippian Stanley Group and Lower-Middle Pennsylvanian Jackfork and Johns Valley Groups were collected and processed for U-Pb detrital zircon geochronologic analyses to depict sediment sources and dispersal patterns during the Ouachita orogeny. Results show that the age distributions of the Carboniferous deep-water clastic deposits in the Ouachita Mountains are characterized by major peaks of the Paleozoic (~350-500 Ma), Grenville (~900-1350 Ma), and Midcontinental GraniteRhyolite (~1350-1500 Ma), minor peaks of Yavapai-Mazatzal (~1600-1800 Ma) and Superior (> ~2500 Ma) provinces. These deep water clastics share great similarities with the Appalachian sources and are likely derived from similar sources. From the Mississippian Stanley Group to the Pennsylvanian Jackfork and Johns Valley Groups, the Yavapai-Mazatzal population shows marked enrichment (up to ~12%), suggesting Precambrian basement uplifts, possibly related to the Ancestral Rockies to the northwest, might be another potential source. Compilation and comparison show the Neoproterozoic age population (~550-800 Ma), most likely associated with the peri-Gondwana terrane to the south, ranges from 3% to 35% within the Mississippian Stanley Group. The variation indicates that the Stanley Group may have strong but short-lived local contribution from the Gondwana terrane in addition to the regional Appalachian sources. Overall, despite its proximal location, these Carboniferous deep-water clastic deposits in the Ouachita Mountains received limited contribution from the Ouachita orogenic belt itself.

INTRODUCTION:

The Carboniferous stratigraphic succession of the Ouachita Mountains located in western Arkansas and southeastern Oklahoma represents a 10,000-meter interval of deep-water siliciclastics deposited into a foreland basin (Coleman, 2000). The Ouachita orogenic belt stretches from eastern Mississippi to as far west as northern Mexico. Much of the siliciclastic deposits of the Carboniferous succession in the Ouachita Mountains have been interpreted as deep-water turbidities that formed during the Ouachita Orogeny, however, its provenance remains under debate. Sediment sources for these deposits vary as either the occurrence of the southern Ouachita orogeny, the erosion of the ancestral Rockies to the north, or the occurrence of the eastern Appalachian orogeny (Morris, 1974; Graham et al., 1976; Gleason et al., 1994; Sutherland, 1998).

Previous U-Pb detrital zircon analyses have concluded various sediment sources for the Carboniferous strata in the Ouachita Mountains. Interpretations from previous work indicate Carboniferous sedimentation being derived in part by tectonic recycling of the pre-Carboniferous seafloor assemblage or recycled orogenic detritus from the Appalachian foreland basin (Gleason, 2001; McGuire, 2017). Additional, U-Pb detrital zircon analyses infer changes in Carboniferous sediment sources from a southern continental arc system to multiple sources from both the Laurentian and Gondwanan (Thompson, 2017).



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Paleogeographic map showing reconstruction of the Ouachita Rifted Margin during the Cambrian (~550 Ma) (modified from Blakey, 2013). Note: Texas Christian University is granted Licensee of Key Time Slices of North America 2013 © Colorado Plateau Geosystems Inc.

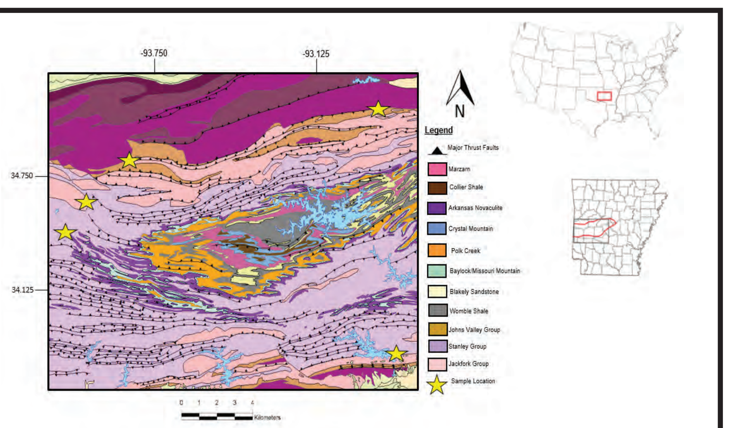
GEOLOGICAL BACKGROUND:

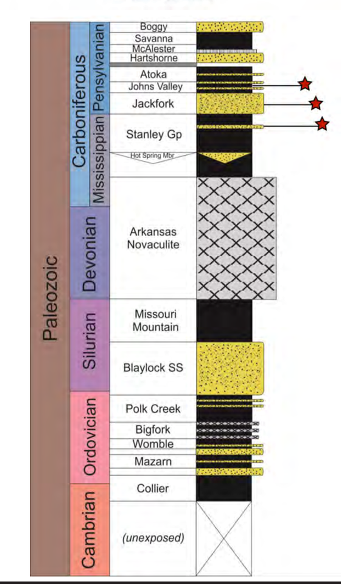
The Ouachita orogeny in the early Carboniferous period transformed the southern margin of the North American craton from a continental shelf characterized by a passive margin to a tectonically active margin (Viele and Thomas, 1989). This change resulted in the rapid deposition of clastic sediments succeeding the slow deposition of chert siliceous shale in the Ouachita orogenic belt (Morrison and McBride, 1983). These clastic sediments consist of the deep-water turbidities of the Mississippian Stanley and Pennsylvanian Jackfork Groups and the deep-marine shales of the Johns Valley Formation in the Ouachita Mountains

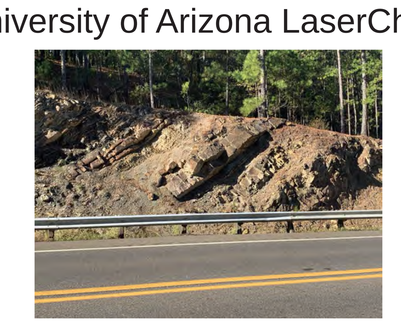
SAMPLING AND PREPARATION:

Outcrops located within the Ouachita thrust belt were used as sample locations for this study. Sampled rock units were taken from outcropping sand bodies and ranged in age from the Mississippian to the Lower-Middle Pennsylvanian. A total of six samples were collected from the Stanley and Jackfork tGroups, and the Johns Valley Shale, where its lower, middle and upper stratigraphic contacts are relatively clear. Samples have been specifically selected to provide new insights for the syn-orogenic sediment provenances and transport within the Ouachita orogenic belt spatially north to south.

Traditional zircon extraction methods were performed on each of the six samples by crushing and grinding until reduced to a fine powder. Each sample was separated using a Wilfley table, Frantz magnetic separator, and heavy liquids. Following that processing, zircons were identified and selected by hand under a microscope. The selected zircons underwent U-Pb geochronology testing conducted by laser ablation multicollector inductively coupled plasma spectrometry (LA-MC-ICPMS) at the University of Arizona LaserChron Center.

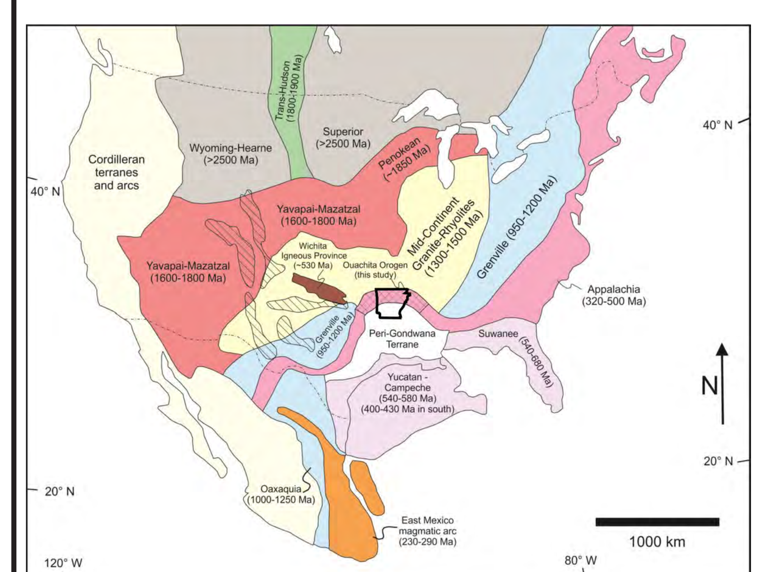


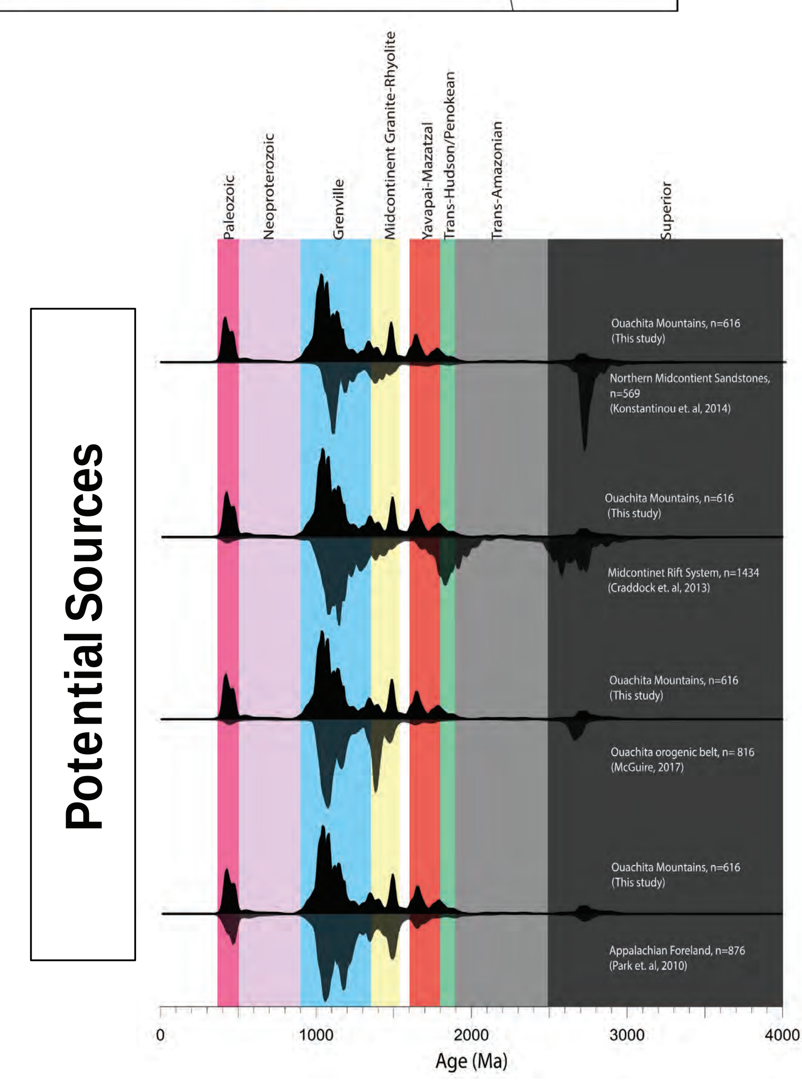


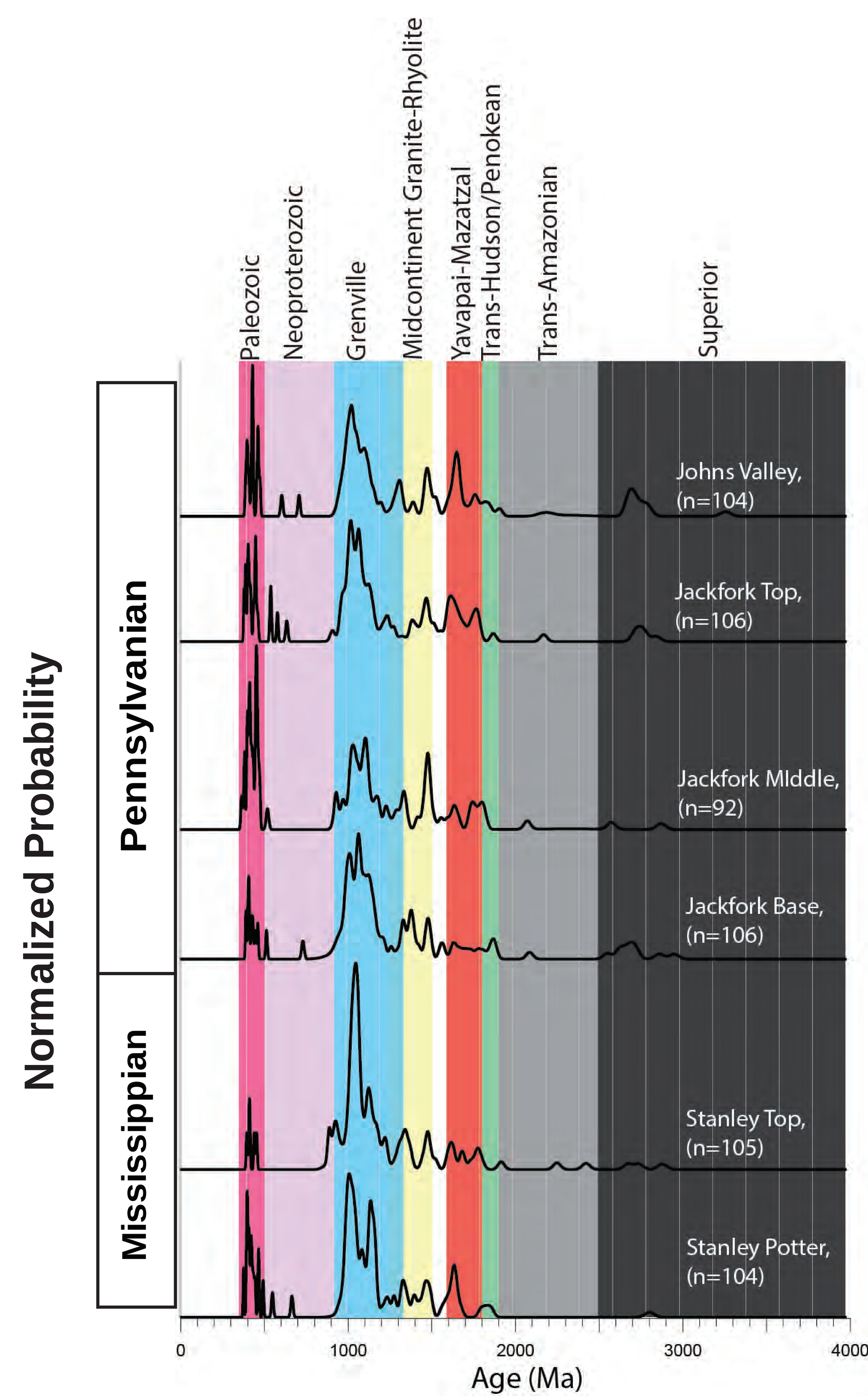


RESULTS :

Major source terranes include Paleozoic (~350-500 Ma), Grenville (~900-1300 Ma), and Midcontinental Granite-Rhyolite (~1350-1500 Ma) with minor source terranes including Yavapai-Mazatzal (~1600-1800 Ma), and Superior Provinces (~2500 Ma)





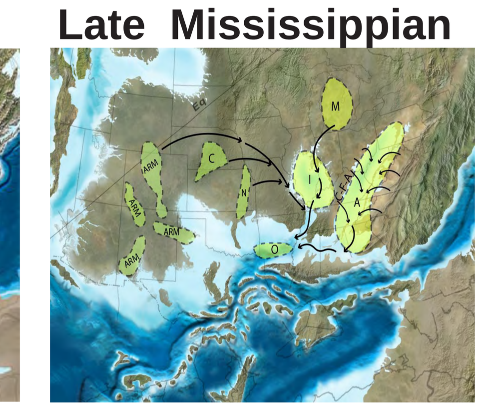


INTERPREATIONS:

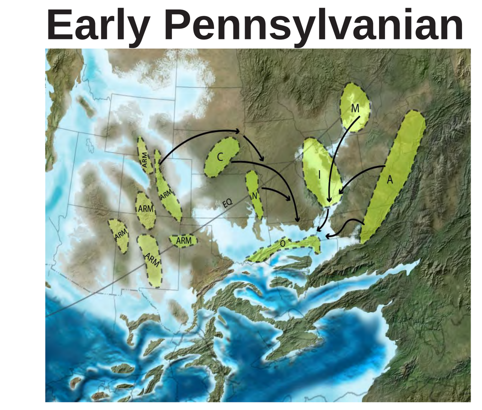
We conclude the detrital zircon signatures of the Carboniferous strata of the Ouachita Mountains are relatively similar, and were sourced from recycled sediment from the eastern Appalachian orogenic belt with minor contributions from the northern Midcontinent region, Ouachita orogenic belt, and western Laurentia. We also propose new sediment transport pathways to the southern Midcontient in the Carboniferous.

Early Mississippian

Late Mississippian

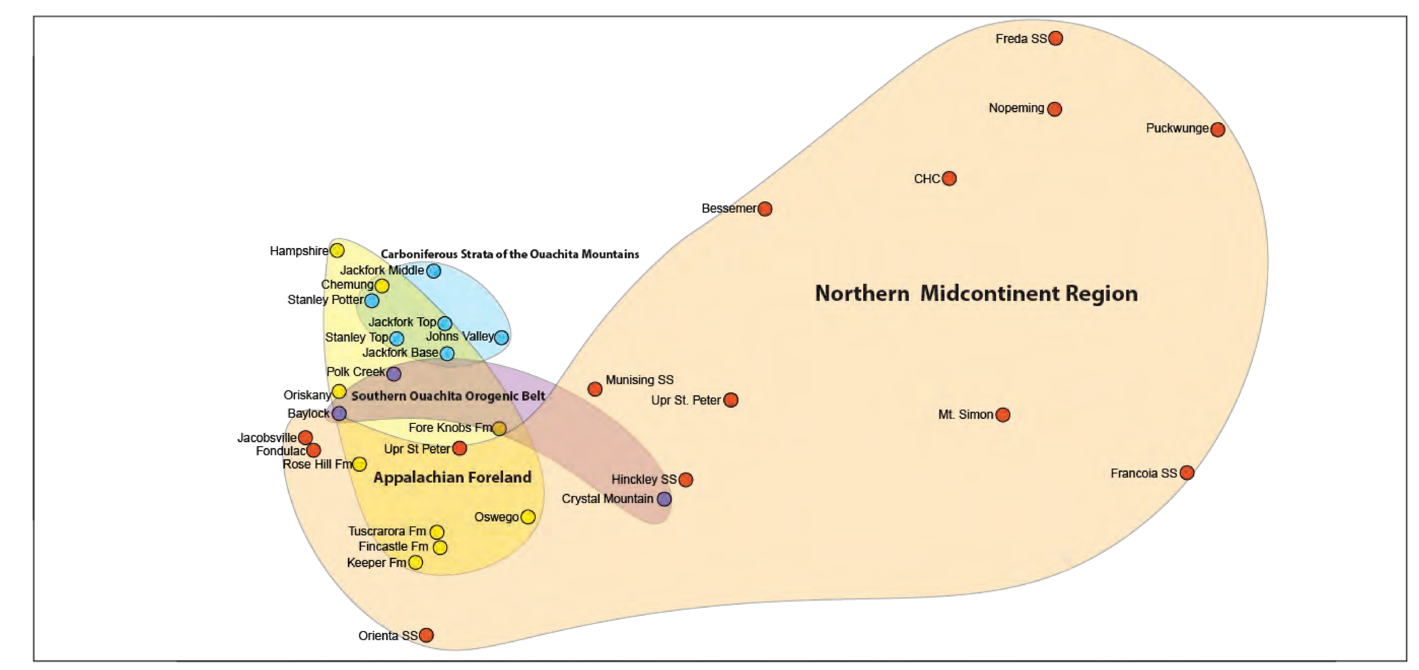


Early Pennsylvanian



Sediment delivery pathway during the deposition of the Carboniferous strata of the Ouachita Mountains in the southern Midcontinent (~360-299 Ma) (Blakey, 2013). Arrows denote proposed sediment transport network to the remnant Ouachita ocean basin. M, Michigan Basin; I, Illinois Basin; remnant Ouachita ocean basin; Appalachian Basin, A; C-F-A, Cincinnati Findlay-Algonquin; ARM, Ancestral Rockies Mountains; C, Cambridge Uplift; N, Nemaha Ridge; Eq, Equator. Note: Texas Christian University is granted Licensee of Key Time Slices of North America 2013 Colorado Plateau Geosystem Inc.

MDS Analysis



Conclusions:

In this study, a total of six samples from the syn-orogenic Carboniferous deep-water succesion of the Ouachita Mountains were collected and processed for U-Pb detrital zircon Geochronological analysis. The results from this study conclude: (1) Overall, the detrital signatures of the Carboniferous strata of the Ouachita Mountains are relatively similar which suggests they were deposited by similar sources. (2) The provenance of the of Carboniferous succession of the Ouachita Mountains was primarily derived from recycled detritus of the distal Appalachian orogenic belt. (3) Minor variations in signatures suggest there was intermixed ranging influences from northern Midcontinent region, Ouachita orogenic belt, and western Laurentian sources. Theses changes suggest the remnant Ouachita ocean basin acted as a terminal sink for various sediment sources. (4) Carboniferous sediment dispersal in the Southern Midcontinent was controlled by paleogeographic, paleoclimate, and paleotectonic factors. Sediment transport was controlled by longshore currents, and transcontinental and longitudinal systems from the Appalachian forelands or Michigan Basin.

Acknowledgements:

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