doi: 10.1130/abs/2022NC-375705

Geological Society of America *Abstracts with Programs*. Vol. 54, No. 4

For Modern Sharks To Rise, They Must First Survive An Ice Age

Daniel Cline (1), Ryan Shell, Charles Ciampaglio, and Lauren J. Fuelling

(1) Wright State University, Lake Campus
cline.74@wright.edu

Background

All modern sharks and rays form a monophyletic group, the Neoselachii. This group has its origins in the Devonian Period, and has survived the end-Devonian, Permo-Triassic, and Cretaceous-Neogene mass extinction events in order to come to dominance as the most biodiverse chondrichthyan taxon in modern seas. In the Paleozoic, the anachronistid sharks (Anachronistidae) are a frequently encountered neoselachiian group in the fossil record. This group had its origins in the early Carboniferous Period, but reached its maximum diversity as the period ended and progressed into the Permian Period. This increase in diversity coincided with a period of climatic instability often called the Late Paleozoic Ice Age, though the exact stratigraphic history of these organisms during the ice age is not well understood (see **Figures 1, 2, & 3**).

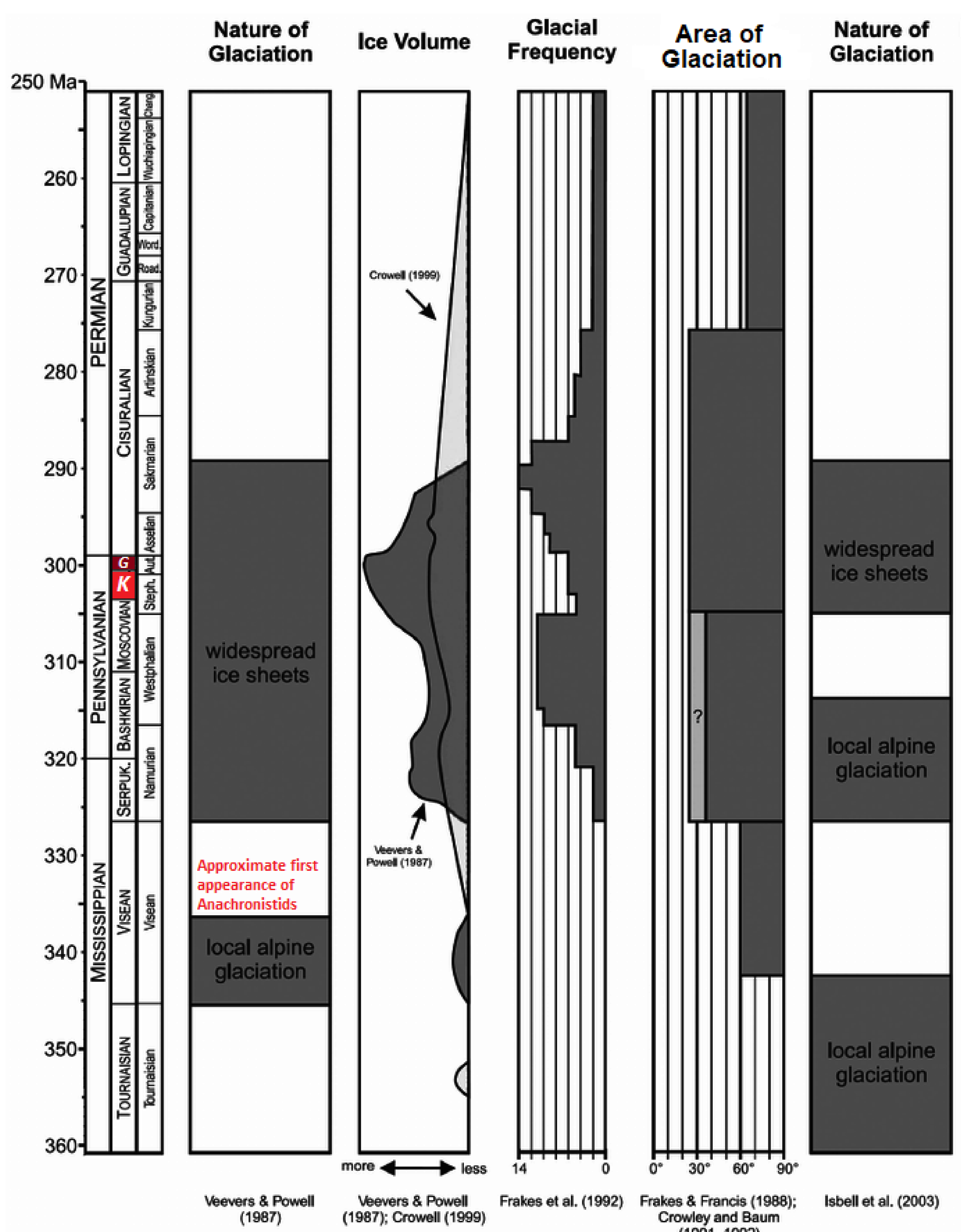

Figure 1: These charts detail global glaciation before, during, and after the Late Paleozoic Ice Age. The interval of this study (Kasimovian-Gzhelian), and the approximate appearance of anachronistid sharks in the fossil record are highlighted in shades of red. (Figure modified from Fielding et al., 2008, incorporating information from Veevers & Powell, 1987; Crowell, 1999; Frakes et al., 1992; Frakes & Francis, 1988; Crowely & Baum, 1991, 1992; and Isbell et al., 2003.)

Results & Discussion

Figure 2: The image above, modified from Blakey (2016), details the paleogeography of marine and estuarine ecosystems during the Kasimovian (307 – 303.7 Ma) on the North American craton. The location of the sites within the Conemaugh Group used in this study is denoted by the black circle.

Figure 3: The image above, modified from Blakey (2016), details the paleogeography of marine and estuarine ecosystems during the Gzhelian (303.7 – 298.9 Ma) on the North American craton. The location of the sites within the Conemaugh Group used in this study is denoted by the black circle.

Around the time of maximum ice volume in the Late Paleozoic Ice Age (**Figure 1**), the Conemaugh Group was deposited into the Appalachian Foreland Basin (**Figures 2 & 3**). The group consists of several Late Carboniferous cyclothems which were deposited as conditions in the Conemaugh Group fluctuated between terrestrial, freshwater, and marine. A total of 7 of these marine transgressions were sampled for microvertebrates and reviewed in the literature to aid in the understanding of the marine vertebrate faunal overturn at this time (Cline et al., 2022). Remains of *Cooleyella*, a Late Paleozoic Anachronistid known from elsewhere in North America, were detected or inferred from the entire sequence of 7 transgressions and regressions.

Teeth belonging to *Cooleyella* were reported across the entire section studied, located during microsampling from the extreme top and bottom of the studied section, and inferred based on other occurrences to have existed in the Gaysport Limestone. It would appear that *Cooleyella* was able to exist in the Appalachian Foreland Basin over as many as 8 million years, as long as marine conditions existed, unlike several other marine vertebrate taxa (Cline et al., 2022). The presumed resistance displayed by anachronistids to sea-level induced extinction and extirpation may have been a factor in the ability of other members of the Neoselachii to persist across more extreme environmental changes such as the Late Paleozoic Ice Age (with its own accompanying global sea level changes) and other late Paleozoic periods of faunal overturn. While anachronistids do not appear in the early Triassic, it is clear that other neoselachiians survived the Permo-Triassic extinction event and persist to present day. However, the exact mechanism behind this persistence in the Paleozoic (be it diet, temperature, salinity, etc.) is not presently known.

Acknowledgements

We would like to express our deepest thanks to Stephen Jacquemin and David Schmidt for their guidance over part of this research. We would also like to thank Wright State University's Earth and Environmental Sciences Department, Wright State University Lake Campus (especially Dan Krane), and the Cincinnati Museum Center (especially Glenn Storrs). In the field, Jamie Cheshire and David Peterman were of significant assistance to this project. The Ohio Department of Transportation proved immensely helpful in the permitting process.

Literature Cited (in order of appearance): [1] Fielding, C., Frank, T., Birgenheier, L., Rygel, M., Jones, A., Roberts, J., 2008. Stratigraphic imprint of the Late Palaeozoic Ice Age in eastern Australia: A record of alternating glacial and nonglacial climate regime. Journal of the Geological Society. 165(1). Pg. 129 – 140. [2] Veevers, J., Powell, C., 1987. Late Paleozoic glacial episodes in Gondwanaland reflected in transgressive–regressive depositional sequences in Euramerica. Geological Society of America Bulletin. 98. Pg. 475 – 487. [3] Crowell, J., 1999. Pre-Mesozoic Ice Ages: Their Bearing on Understanding the Climate System. Geological Society of America. Memoirs. Pg. 192. [4] Frakes, L., Francis, J., Syktus, J., 1992. Climate Modes of the Phanerozoic. Cambridge University Press, Cambridge. [5] Frakes, L., Francis, J., 1988. A guide to Phanerozoic cold polar climates from high-latitude ice-rafting in the Cretaceous. Nature. 333. Pg. 547 – 549. [6] Crowley, T., Baum, S., 1991. Estimating Carboniferous sea-level fluctuations from Gondwana ice extent. Geology. 19. Pg. 975 – 977. [7] Crowley, T., Baum, S., 1992. Modeling late Paleozoic glaciation. Geology. 20. 507 – 510. [8] Isbell, J., Miller, M., Wolfe, K., Lenaker, P., 2003. Timing of late Paleozoic glaciation in Gondwana: Was glaciation responsible for the development of northern hemisphere cyclothems? In: Chan, M., Archer, A., (eds) Extreme Depositional Environments: Mega End Members in Geologic Time. Geological Society of America. Special Papers. 370. Pg. 5 – 24. [9] Blakey, 2016. North American Paleogeography. Accessed February, 2022. [10] Cline, D., Shell, R., Ciampaglio, C., Cheshire, J., Fuelling, L., 2022. Marine Vertebrate Biostratigraphy of the Conemaugh Group (Carboniferous: Kasimovian to Gzhelian). The Ohio Academy of Science. [11] Hansen, M., 1986. Microscopic chondrichthyan remains from Pennsylvanian marine rocks of Ohio and adjacent areas. Doctoral Dissertation: Ohio State University. [12] Baker, H., 1967. Geology of the Gaysport and Skelley Limestones in Athens, Meigs, Morgan and Perry Counties, Ohio. Unpublished Masters Thesis: Ohio University. [13] Ginter, M., Hampe, O., Duffin, C., Schultze, H., 2010. Handbook of Paleoichthyology. Volume 3D. Chondrichthyes. Paleozoic Elasmobranchii: Teeth.

Image Credits (in order of appearance): The Geological Society of America. Wright State University Lake Campus. Fielding et al., 2008. Accessed March, 2022. Blakey, 2016. North American Paleogeography. Accessed February, 2022.