Project Proposal

*Background:*

Rivers have long provided human beings with drinking water, irrigation, transportation, recreation, and power. Our proximity to these systems, however, can also prove hazardous, especially as the global climate changes and river hydrology becomes more unpredictable.

Recent mathematical modeling of modern river response to climate warming tend to inundate present systems with increasingly large floods1,2. Ancient river deposits, however, suggest that a warming climate will trigger more complex, system-wide changes in river and floodplain hydrodynamics3,4. While modeling of modern systems may be helpful for projecting near-future flood hazards, these system-wide changes have been largely ignored, and **we still lack a fundamental understanding of how river systems physically respond to climate warming**.

Unlike their modern counterparts, ancient fluvial deposits provide a large timescale of observable data from river systems throughout earth history, including during periods of past rapid global warming (hyperthermals). Abundant, repeated hyperthermals during the Paleogene warm period (~60-50 Ma), make fluvial sediments deposited during this time an ideal subject of study for understanding how river systems respond to and record changes in climate. Previous work on fluvial deposits that span the Paleocene-Eocene Thermal Maximum (PETM) and/or Early Eocene Climatic Optimum (EECO) use widely varied sedimentary characteristics as proxies for hydrological or environmental change, making cross-study comparison difficult3,4,5,6. This complication, paired with the fact that these studies tend to narrow their focus to the PETM, make it nearly impossible to determine whether sedimentological changes occur at a consistent timescale and magnitude across different warming events. Instead of studying isolated hyperthermal events or focusing on one or two sedimentological proxies, my project analyzes varied sedimentological data from multiple fluvial subenvironments across the entire Paleogene warm period. This dataset will allow me to directly compare multiple paleoenvironmental and hydrological proxy changes with preexisting climate proxy data3,7 and develop a framework for understanding how climate changes are preserved in fluvial stratigraphy.

*Research plan and available resources:*

My project addresses two questions related to preservation of climate signals in fluvial sediments: **1) What sedimentological changes can be observed in fluvial sediments from the early Paleogene?** and **2) Do these changes coincide with early Paleogene hyperthermals?** To answer these questions, I am conducting a detailed sedimentological analysis of the Wasatch and Green River Formations of the Uinta Basin, Utah, which record the entire Paleogene warm period through a thick succession of fluvial/lacustrine deposits. Previous magnetostratigraphy, biostratigraphy, and absolute age dating provide high time resolution in this basin and will allow me to correlate sedimentological data from my outcrop analysis and preexisting paleoclimate data with a high degree of precision. My advisor is Dr. Piret Plink Björklund, an expert in fluvial sedimentology with years of experience both conducting and advising Uinta Basin research.

My project utilizes previous work from the Uinta Basin, comparing and combining preexisting data to construct a detailed record of sedimentological changes across the entire Paleogene warm period. Where previously collected data are scarce or missing, I will conduct

my own field work during the summers of 2023 and 2024, starting with a summer 2023 field season in Nine Mile Canyon, Utah. Drawing on methods from an extensive literature review of early Paleogene fluvial sedimentological studies from around the world, my field work will consist of recording bar heights and thicknesses, degree of channel amalgamation, maximum grain sizes, degree of macroform preservation, and, where exposures allow, channel width to serve as proxies for changes in paleochannel dimensions, bed shear stress, and degree of reworked sediment in this system. I will use lithofacies proportion data to track changes in sediment supply and distribution. Finally, proportions of supercritical to subcritical flow structures, bioturbation of channel deposits, and well-drained paleosol features such as caliche nodules will be used to quantify increases in flood flashiness or transitions to variable discharge. Each of these specific, quantifiable parameters allow me to interpret and track hydrologic and geomorphologic changes in this ancient system through multiple hyperthermal events. Once these data are collected, I plan to use correlation analyses to determine which observed changes are related to changes in paleoclimate. Compared with the other skills required for my project, I have the least experience with data science and statistical analyses. To offset this gap in my background and develop a network of data science experts, I am enrolled in Colorado School of Mines' Data Science certificate program.

*Preliminary timeline:*

Spring/Summer '23: Continued literature review, field season in Nine Mile Canyon, Utah. Fall '23/Spring '24: Data organization/statistical analyses, working toward publication.

Spring/Summer '24: Field season, location TBD (dependent on gaps in previous work). Fall '24/Spring '25: Data organization/ statistical analyses, working toward publication.

*Disciplinary importance:*

While there has been previous research on broad changes in river systems during the onset of the PETM and some major EECO hyperthermals, a study that tracks changes in a single fluvial system through the entire Paleogene warm period has yet to be published. Additionally, instead of relying on the response of one sedimentological parameter (i.e. channel size), this study will record and analyze changes in numerous sedimentological features that serve as proxies for both channel and floodplain processes, allowing me to determine whether observed changes are consistent both across multiple hyperthermal events and multiple fluvial subenvironments. This approach will produce quantifiable results that contribute to our fundamental understanding of how river systems respond to and preserve a changing climate.

**References: [1]** Bell et al., 2012. *Journal of Hydrology*, 442-443: 89-104. **[2]** Schneider et al.,

2013. *Hydrol. Earth Syst. Sci*, 17: 325-339. **[3]** Birgenheier et al., 2020. *GSA Bulletin*, 132(3-4):

562-587. **[4]** Foreman et al., 2012. *Nature*, 491: 92-95. **[5]** Zellman et al., 2020. *Journal of*

*Sedimentary Research*, 90(12): 1770-1801. **[6]** Schmitz and Pujalte, 2007. *Geology*, 35(3): 215-

218. **[7]** Westerhold et al., 2018. *Paleoceanography and Paleoclimatology*, 33(6): 626-642.