The Hydroclimate and Environmental Response to Warming in the Southwestern US: A Study Across the Mid-Miocene Climate Optimum

Sianin Spaur, Jeremy Caves Rugenstein, Daniel J. Koning and Scott Aby

1 New Mexico Bureau of Geology & Mineral Resources, 519 Western Ave, Socorro, NM, 87801, sianin.spaur@nmt.edu
2 Colorado State University, Fort Collins, CO, 80521
3 New Mexico Bureau of Geology & Mineral Resources, New Mexico Institute of Mining & Technology, Socorro, NM, 87801
4 Muddy Spring Geology, NM

Predictions for the effects of modern climate change on the southwestern US tend to suggest increased aridity, which is incompatible with paleoclimate data from other warm, high pCO₂ periods. The Mid-Miocene Climate Optimum (MMCO; ~17-14 Ma) represents a period of warm global temperatures and high pCO₂ with estimates similar to the projected pCO₂ for future decades. We present new stable isotope records of mid-Miocene terrestrial carbonates from the Española basin in northern NM, with δ¹⁸O and δ¹³C records recording the extent of the MMCO and the beginning of late Miocene cooling. New ⁴⁰Ar/³⁹Ar ages establish an updated, high-resolution age model for the Tesuque Fm of the Santa Fe Group. We use δ¹⁸O as a measure of the balance between summertime and wintertime precipitation and δ¹³C as a reflection of soil productivity. We find evidence for an increasingly winter-wet climate in the southwest US during the MMCO; when compared to modern precipitation δ¹⁸O, the carbonate δ¹⁸O record suggests that the region received more westerly-derived, cool-season precipitation than it does today. This indicates that El Niño Southern Oscillation (ENSO) was operating during the MMCO and may have been stronger than today; it seems to have been particularly strong during cooler periods during the MMCO, suggesting that cooler temperatures and high pCO₂ may be favorable to ENSO. The δ¹⁸O and δ¹³C records are highly correlated, indicating seasonality of precipitation as a main control on soil productivity; increases in soil productivity coincide with increases in cool-season precipitation and with faunal fossils that indicate a wetter environment with large vegetation. Changes in the seasonal hydroclimate and soil productivity agree well with the paleontological record at the site, which show a diverse and dynamic faunal assemblage that evolved with the hydroclimate. During the global cooling immediately following the MMCO Española carbonates display decreasing soil productivity and a more summer-dominant hydroclimate similar to that of the region today, with paleontological records indicating a drier faunal and floral assemblage very different from those that occupied the region during the MMCO. Collectively our data do not support increased aridity in the southwest US during warm, high pCO₂ periods, instead suggesting a shift in the hydroclimate towards cool-season, westerly-derived precipitation, driving higher soil productivity and supporting larger vegetation and dynamic faunal assemblages in the region.


2023 New Mexico Geological Society Annual Spring Meeting
April 21, 2023, Macey Center, Socorro, NM
Online ISSN: 2834-5800