Stable Isotope Variations of Deuterium and Oxygen-18 from a snow pit on Grand Mesa, Colorado

Brittlynn O'Dell

Abstract

This study examines the stable isotopic composition of deuterium (δD) and oxygen-18 ($\delta^{18}O$) in the 2024 snowpack on Grand Mesa, Colorado, to investigate how isotopic values vary with snow depth. Snow samples were collected between February and May from two primary sites, Skyway and County Line, across a range of snow depths (0 cm-125.7 cm). The original hypothesis predicted that δD and $\delta^{18}O$ values would become increasingly negative with depth, reflecting the influence of older, colder precipitation layers. However, the data revealed a distinct see-saw pattern in isotopic values rather than a gradual trend. This alternating isotopic signature with depth may suggest a snowpack composed of multiple precipitation events, each with different isotopic characteristics. On the other hand, the observed pattern may indicate that post-depositional processes such as melting, sublimation, and refreezing play a significant role in altering the isotopic composition after deposition. These processes disrupt any linear relationship between snow depth and isotopic enrichment/depletion, complicating efforts to interpret isotopic trends based solely on stratigraphic depth. Understanding these variations is important for identifying post-depositional processes, tracking seasonal changes in precipitation sources, and supporting long-term monitoring of snowmelt-driven water resources in the Upper Colorado River Basin.

Controls on the Stable Isotopes in Precipitation Across the Upper Colorado River Basin

Andrew Christianson

Abstract

Comparing the ratios of light and heavy stable Oxygen and Hydrogen isotopes in precipitation has been an effective method for tracing water flow through the hydrologic cycle. Variability in the d-excess values between meteoric waters can be explained by multiple factors, including season, elevation, and moisture source. We explored the controls on stable isotope ratios in precipitation across the Upper Colorado River Basin. Precipitation samples were collected in Cedaredge, Grand Mesa, Grand Junction, and Fruita, CO, and supplemental data from Moab, UT was collected from literature. Stable isotope data will be analyzed by season for each location because the largest variability in d-excess values occurs seasonally. We found that the primary control on the d-excess values in meteoric waters from locations in the Upper Colorado River Basin was elevation. Additionally, post-cloud evaporation plays a significant role especially during summer months. This research provides a better understanding of atmospheric water flow and hydrologic processes in the Upper Colorado River Basin. Additionally, this research provides groundwork for detecting the effects of long-term climate change on those processes.

Groundwater contributions to streamflow in the Grand Valley

Steffen Teutsch

Abstract

This study investigates the contributions of groundwater and high-altitude precipitation on surface waters in the Grand Valley region of Western Colorado using stable isotope analysis of deuterium and oxygen 18. Water samples were collected from nine sites across a 6,000-foot elevation gradient, encompassing high-elevation lakes, tributary streams, and the main stems of the Colorado and Gunnison Rivers, during the late summer/early fall to late fall/early winter of 2024. Isotopic values were compared against established precipitation trends and regional groundwater signatures. The results show the larger, higher-order river systems show distinct isotopic compositions indicative of mixing between high-altitude precipitation and groundwater, consistent with the averaging effect for large catchments. This contrasts with the local, smaller catchments which display a wider and generally lighter isotopic range, reflecting stronger influence from recent precipitation than groundwater input. Seasonal shifts in results reflect variable atmospheric moisture patterns, but the consistency in trends between these results and 2020 results for the same area imply year-round consistency in water sources. These findings show the importance of varied water sources in continued regional drought resiliency in the face of a changing climate.

Age Refinement of the Uinta Formation in the Piceance Basin, northwestern Colorado using Detrital Zircon (U-Pb) and Sanidine ($^{40}Ar/^{39}Ar$) Dating

Caitlynn Parks

Abstract

This study aims to refine the depositional age of the Uinta Formation near the center of the Piceance Basin in northwestern Colorado, approximately 1,200 feet above the Green River Formation, using integrated detrital zircon (U-Pb) and detrital sanidine ($^{40}Ar/^{39}Ar$) geochronology. The MMC-IRI-4 drill core, located in the northern Piceance Basin, reveals a vertically stacked sequence of alternating sandstone, marlstone, and mudstone that reflects shifting depositional environments. Radiometric dating on a fine-grained sandstone sample (14–15.9 feet) provided key age constraints: detrital sanidine analysis yielded a youngest single grain age of 45.3 ± 0.09 Ma and a maximum depositional age (MDA) of 46.6 ± 0.16 Ma, while detrital zircon dating produced an MDA of 45.1 ± 1.7 Ma.

Provenance interpretations suggest that the youngest sanidine grains (53–44 Ma) were likely deposited via direct volcanic ashfall, not fluvial transport. Their ages align closely with mid-Eocene eruptions of the Absaroka and Challis volcanic provinces, supporting an atmospheric delivery mechanism. At the time of deposition, limited sediment supply from traditional fluvial sources likely resulted in diminished input into the basin. The dominance of fine-grained marlstones and silty sandstones, minimal coarse fluvial deposits, and the presence of volcanic ashfall in the core reflect this sedimentary regime.

This sediment starvation may have led to reworking of underlying Green River Formation deposits, recycling older zircons and lacustrine material into the Uinta Formation. These findings highlight the complex interplay of volcanism, sediment supply, and basin dynamics during the middle Eocene. The combination of ashfall and intra-basin recycling marks a key transition from lacustrine to fluvial deposition, preserving a detailed record of environmental change during the final phases of the Laramide Orogeny.

Detrital Sanidine ^{40}Ar-^{39}Ar and Detrital Zircon U-Pb Dating of the Poverty Mesa Conglomerate in the Black Canyon of the Gunnison, Colorado: New insights on post-Laramide uplift and Late Oligocene Paleotopography

Morgan Sholes

ABSTRACT

The Black Canyon of the Gunnison preserves a complex geologic history shaped by both Laramide and post-Laramide uplift and late Eocene to Oligocene volcanism and erosion. However, the relative influence of these processes on the modern landscape development remains uncertain. This study uses new dates and provenance of ancient river deposits of the Poverty Mesa Conglomerate to evaluate whether paleotopography or post-Laramide uplift and erosion-controlled sediment distribution and subsequent canyon incision.

Detrital zircon U-Pb and detrital sanidine 40Ar/39Ar ages indicate deposition occurred in the late Eocene and early Oligocene, closely following regional volcanic activity. Additionally, provenance analysis reveals a mixed assemblage of clasts sourced from both local Precambrian basement rock and recycled sedimentary and volcanic rocks.

These findings support the interpretation that sediment distribution of the Poverty Mesa Conglomerate was primarily controlled by post-Laramide uplift and erosion, while paleotography's role was smaller. This study strengths the temporal and stratigraphic framework of the Black Canyon region and underscores the role of different tectonic factors in driving the landscape evolution.

FIRST-ORDER ESTIMATES OF HIGH-FLOW STREAM FLOODING DISCHARGE FROM COMPETENCE MEASUREMENTS USING DRONE (SUAS) LIDAR IMAGERY IN AN EPHEMERAL STREAM, MESA COUNTY, COLORADO USA.

Graceanne Hanson

Abstract

This project presents first-order estimates of high-flow flooding discharge in Ladder Creek, an ephemeral stream in Grand Junction, Colorado, using drone-derived orthomosaic and LiDAR imagery. Structure-from-Motion (SfM) models from 2024 and 2025 were compared to identify cobble displacement across six field sites. Using the sixth-power law and cross-sectional measurements based on strand lines, peak discharge (Q) values were calculated. Discharge values ranged from 25.73 to 58.72 m^3/s across all sites, with an average of 39.51 m^3/s and a standard deviation of 9.68. The highest competence occurred upstream (Site 1, 52.34 m^3/s average), corresponding with steeper bank profiles and confined flow. Downstream sites showed reduced competence (Site 7, 27.99 m^3/s), reflecting broader channels and braided morphology.

Qualitative analysis revealed sediment accumulation and undercutting consistent with flood-driven fluvial processes. Longitudinal profiles indicated net deposition between 2022 and 2025, particularly in middle reaches. Results validate drone-based competence analysis as a reliable proxy for flood discharge estimation in ungauged, ephemeral stream networks and demonstrate its potential for repeatable, high-resolution geomorphic monitoring in these complex systems.

Determination of Mesoscopic Fracture Kinematics from Drone-based Remote Sensing in Unaweep Canyon, Western Colorado, USA

Cole Beyer

Abstract

Advancements in drone-based photogrammetry has transformed structural geology by enabling efficient, high-resolution mapping of fracture networks, particularly in areas that are remote or difficult to access. This study evaluates the effectiveness of drone-based methods for analyzing surface fractures near Unaweep Canyon, Colorado, where there are exposed fractures within the Kayenta Fm. A DJI M350 RTK drone equipped with a high-resolution RGB camera was used to generate detailed digital elevation models (DEMs) and orthomosaics. Fracture traces were digitized and will be analyzed using MATLAB-based FracPaQ software and transect line methodologies were performed to quantify orientation, density, length, and spatial distribution. Results revealed two dominant fracture sets trending NNW–SSE and NE–SW, with near-vertical dips, consistent with regional tectonic stress fields. Fracture densities were highest in weathered sandstone units, with average spacing as low as 0.66 m, while more competent lithologies exhibited wider spacing averaging 3.02 m. The strong agreement between remote sensing and traditional field results confirms the reliability of UAV-based methods for structural mapping. The integration of high-resolution LiDAR and photogrammetry provides a comprehensive and efficient approach to fracture analysis, capturing both fine-scale features and broader spatial trends. These findings demonstrate the value of combining drone technology with field validation in structural geology.

Preliminary Structural Investigation of Laramide Deformation, South Shale Ridge, DeBeque, Colorado, USA

Zachary Shomers

Abstract

The timing and origin of structural deformation in strata of the Upper Mesaverde Group (Williams Fork Formation, Ohio Creek interval) as well as in overlying Cenozoic formations near De Beque, Colorado, have not been well studied. New information on the origin and timing of deformation has implications for improving our understanding of the regional tectonic history. This study aims to determine whether the observed deformation primarily originated during the Late Cretaceous (early phase of the Laramide Orogeny), or at a separate time. The research area is located along the western flank of the Piceance Basin and spans the Cretaceous-Paleogene boundary. Field investigations include ground-based structural measurements of joints, clastic dikes, and faults, supplemented by high-resolution RGB and LiDAR imagery acquired from drone-based technologies. By analyzing stress orientation patterns across the area, this study will determine whether structures align with the known Late Cretaceous stress field or indicate later tectonic influences. Stereonets, as well as further kinematic analysis, will provide insights on the deformation history. The results of this study will contribute to the understanding of possible Laramide-aged tectonic activity in western Colorado.

Multispectral UAS-Based Analysis of Fluvial Sandstones and Stratigraphic Architecture of the Upper Cretaceous Williams Fork Formation, CO

Maddie Bishop

Abstract

Fluvial deposits exhibit complex stratigraphic architectures that influence sediment connectivity, reservoir quality, and subsurface interpretations. This study develops a workflow to evaluate these characteristics in the lower Williams Fork Formation using an unmanned aerial system (UAS) analysis, photogrammetry, geostatistics and object-based 3D modeling. High-resolution stratigraphic and lithological models were generated from outcrop data in the Main Canyon in the Piceance Basin, Colorado. The Upper Cretaceous lower Williams Fork Formation consists of heterogeneous sandstones interbedded with mudstones, deposited by meandering and low sinuosity rivers in a coastal plain setting. These deposits exhibit significant lateral and vertical heterogeneity, impacting connectivity and lateral continuity. Traditional field methods are valuable but have limitations when it comes to steep, large-scale outcrops with limited, safe human accessibility. UAS-based analysis and photogrammetry allows for the creation of high resolution and object-based 3D models. Results indicate the connectivity of all sandstone bodies in the outcrop is 29.2% and is controlled by the stratigraphic architecture of the sandstone facies as well as impermeable lithologies like mudstone in the Williams Fork Formation. This project demonstrates the value of using a combination of traditional and nontraditional field methods in defining facies, fluvial modeling, and geostatistical analysis, with applications in sedimentology, geophysics, mineral exploration, subsurface geology and environmental sciences.