Geology Field Report

Stratigraphic and Structural Survey of the
Red Rock Canyon Escarpment, Mojave Desert, California

Site	Red Rock Canyon State Park, Kern County, CA (UTM 11S 388 450 E, 3 941 700 N)
Survey Dates	14–16 July 2024
Geologist	Dr. Elena Vasquez, Department of Earth Sciences, University of Nevada, Las Vegas
Field Party	Dr. Vasquez (lead), M. Chen (MSc candidate), R. Okafor (field technician)
Weather	Sunny; high 38 °C; wind calm to light NW
Permit	CA State Parks Scientific Collection Permit #SCP-2024-0412

Abstract

A three-day stratigraphic and structural reconnaissance was conducted along the western escarpment of Red Rock Canyon State Park to characterise Neogene sedimentary sequences and document associated normal-fault geometry. Seven distinct lithostratigraphic units were identified, ranging from Miocene lacustrine diatomite (Unit I) through fluvial conglomerates (Unit VII) of probable Pleistocene age. Net stratigraphic thickness across the measured section is approximately 285 m. Two conjugate normal-fault sets striking N 10–25°E and N 70–85°W were mapped; maximum measured offset on the primary fault is 42 m (dip-slip). Twelve rock samples were collected for thin-section petrography and XRF geochemistry. Results are consistent with progressive basin subsidence during the opening of the Mojave Extensional Province in the late Miocene.

Location & Geologic Setting

Red Rock Canyon lies at the southern margin of the El Paso Mountains, where Neogene basin-fill sediments of the Mojave Desert are exposed in colourful badland escarpments up to 120 m high. The study area occupies a half-graben bounded to the east by the *Ricardo Fault Zone*, a series of NNE-trending normal faults with cumulative Miocene extension of 8–12 km [1]. The regional stratigraphic framework is dominated by the *Ricardo Group* (Miocene) and overlying *Dove Spring Formation* (late Miocene–Pliocene), which together constitute the basin-fill sequence examined in this study [2]. Average dip of preserved strata is 6–14° eastward, reflecting progressive half-graben rotation.

Field Methods

- **Measured section:** A 285 m composite section was measured along three sub-parallel traverses using a Jacob staff (2 m) and Brunton compass; beds thinner than 5 cm were lumped.
- **Strike & dip:** Planar attitudes were recorded at >120 stations with a Brunton compass (right-hand rule); data georeferenced with a Garmin GPSMAP 66i (±3 m horizontal accuracy).
- **Sampling:** Fresh rock chips (~300 g) were collected with a geologic hammer, labelled, and double-bagged in Ziploc pouches. Sample locations were photographed and GPS-logged.
- **Photography:** A Canon EOS R7 with 24–105 mm lens was used; a 30 cm scale bar was placed in all outcrop photographs.
- **Safety:** Heat-mitigation protocol followed; all personnel carried 4 L water minimum; no personnel worked alone.

Stratigraphy & Observations

Measured Stratigraphic Section

The composite measured section runs from the base of the exposed escarpment (Unit I) to the uppermost preserved horizon (Unit VII). Thicknesses are corrected for bedding dip.

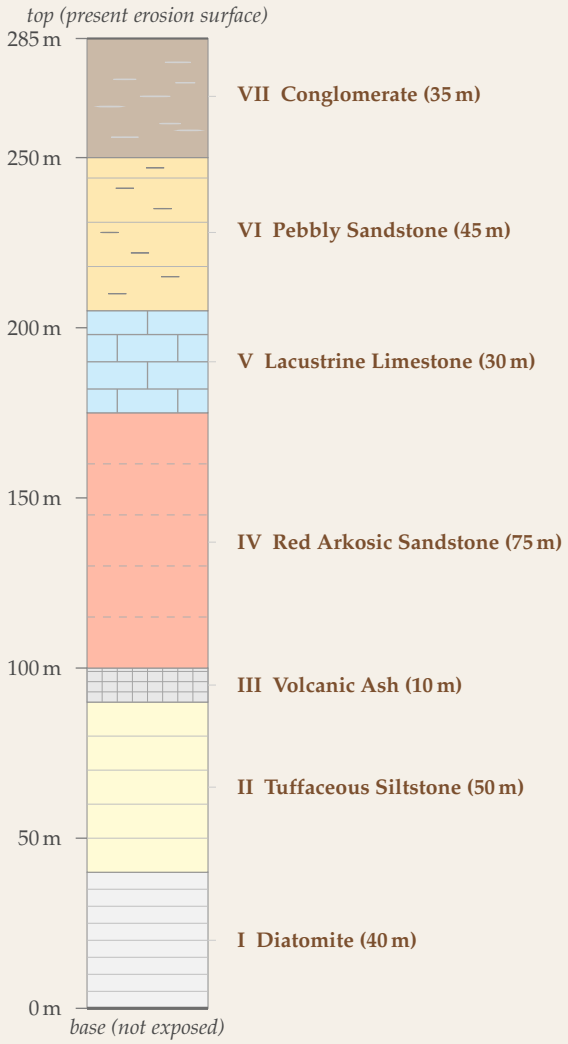

Figure 1. Composite measured stratigraphic section, Red Rock Canyon escarpment. Column width is schematic; thickness to scale on left axis.

Lithology Description Table

Unit	Age (approx.)	Lithology & Key Features
I	Miocene (11–10 Ma)	White to cream massive diatomite; chalky texture; rare mollusc fragments indicating fresh-water lacustrine origin; sub-horizontal lamination.
II	Miocene (10–9 Ma)	Pale yellow tuffaceous siltstone; abundant glass shards (optical microscopy); occasional plant-leaf impressions; even parallel bedding.
III	Miocene (9.2 Ma)	White-grey compact volcanic ash (airfall tuff); sharp basal contact; pumice clasts up to 2 cm; K-feldspar phenocrysts visible; potential radiometric marker bed.
IV	Miocene (9–7.5 Ma)	Red to brick-orange arkosic sandstone; medium–coarse grain; sub-angular to sub-rounded; cross-bedding sets 20–40 cm; K-feldspar and quartz dominant; plagioclase partially altered to sericite.
V	Miocene (7.5–7 Ma)	Light grey to buff micrite and wackestone; discrete algal laminae; vugs with calcite spar; minor dolomitisation near top; represents return to lacustrine conditions.
VI	Pliocene (5–3 Ma)	Yellow-brown pebbly sandstone; clasts 0.5–3 cm subangular quartzite and granite; fining-upward cycles 1–2 m thick; fluvial channel facies.
VII	Pleistocene (2–1 Ma)	Clast-supported polymict conglomerate; cobbles to 20 cm; poorly sorted; sub-angular clasts of granite, gneiss, quartzite; sandy matrix; alluvial fan interpretation.

Table 1. Lithostratigraphic units, Red Rock Canyon escarpment.

Structural Features

Normal fault (primary): A well-exposed, east-dipping normal fault was traced for 1.4 km along the northern escarpment face. Fault plane attitude: 082°/62° (strike/dip, right-hand rule). Slickenlines rake 82° (near down-dip), indicating predominantly dip-slip motion. Maximum measured stratigraphic offset: **42 m**; gouge zone 15–30 cm thick; breccia zone up to 0.8 m wide. The hanging-wall block is rotated 8–12° relative to the footwall.

Conjugate fault set: A secondary NW-trending normal fault set (mean attitude 322°/45°) produces graben blocks 80–200 m wide in the central section. Offsets 2–15 m.

Bedding attitudes: Mean attitude of Units I–V: 094°/08° (shallow eastward dip, consistent with half-graben rotation). Units VI–VII: sub-horizontal (002°/03°), unconformably overlying tilted lower units; angular unconformity well-exposed at Station 6.

Joints: Two prominent joint sets: Set A (N 10°E, near-vertical); Set B (N 75°W, vertical). Spacing 0.3–1.5 m; open fractures filled with calcite veins up to 8 mm.

Sample Catalog

Sample ID	Unit	Easting	Northing	Requested Analyses
RRC-24-01	I	388 412	3 941 688	Thin section, XRF
RRC-24-02	I	388 418	3 941 694	SEM-EDS (diatom taxonomy)
RRC-24-03	II	388 433	3 941 702	Thin section, XRF, stable isotopes
RRC-24-04	III	388 440	3 941 710	^{40}Ar/^{39}Ar dating, XRF
RRC-24-05	III	388 445	3 941 715	Duplicate for ^{40}Ar/^{39}Ar
RRC-24-06	IV	388 460	3 941 728	Thin section, point count, XRF
RRC-24-07	IV	388 471	3 941 735	Thin section (cross-bedding orientation)
RRC-24-08	V	388 485	3 941 748	Thin section, stable C/O isotopes
RRC-24-09	V	388 490	3 941 753	XRD (mineralogy, dolomite quantification)
RRC-24-10	VI	388 510	3 941 770	Thin section, clast count
RRC-24-11	VII	388 528	3 941 786	Clast lithology count, roundness analysis
RRC-24-12	VII	388 535	3 941 791	XRF (provenance, major + trace elements)

Table 2. Sample catalog with UTM coordinates (WGS84, Zone 11S) and requested analyses.

Interpretation

The Red Rock Canyon stratigraphy records a coherent basin-fill history spanning approximately 10 Ma of Mojave extensional tectonism:

- **Early lacustrine phase (Units I–II, 11–9 Ma):** Calm, closed-basin conditions produced thick diatomite and tuffaceous siltstone, suggesting a perennial, nutrient-rich freshwater lake analogous to modern Walker Lake, Nevada.
- **Volcaniclastic influx (Unit III, ∼9.2 Ma):** The sharp-based volcanic ash likely correlates with the widespread Peach Springs Tuff or a co-magmatic eruption; radiometric dating (samples RRC-24-04/05) will test this. The marker bed provides a critical chronostratigraphic anchor.
- **Alluvial-fluvial progradation (Unit IV, 9–7.5 Ma):** Basin subsidence outpaced sediment supply initially, but footwall erosion of granite and gneiss source terrain delivered coarse arkosic sand via braided-river systems. Cross-bedding paleocurrent data (pending) will constrain transport direction.
- **Lake renewal and carbonate precipitation (Unit V, 7.5–7 Ma):** A second lacustrine pulse precipitated limestone, possibly linked to regional drainage reorganisation and reduced clastic input. Stable isotopes (sample RRC-24-08) will assess salinity and temperature conditions.
- **Angular unconformity and late-stage alluvial fans (Units VI–VII, 5–1 Ma):** Post-tectonic

erosion created the angular unconformity at Station 6; subsequent fan and fluvial systems prograded over the tilted block, recording exhumation of mixed crystalline basement sources.

The conjugate normal-fault pattern is consistent with NW–SE σ_3 extension, in agreement with regional GPS vectors and Basin-and-Range kinematics. Preliminary fault-heave estimates suggest $\sim$6 km of cumulative extension since 11 Ma, overlapping with Loomis & Glazner's [1] estimate of 8–12 km.

References

[1] **Loomis, D. P., & Glazner, A. F.** (1984). Structural geology and tectonics of the Ricardo Group, Red Rock Canyon, Mojave Desert, California. *Geological Society of America Abstracts with Programs*, 16(6), 580.

[2] **Whistler, D. P.** (1989). Biostratigraphy of the Ricardo Group (Miocene), Red Rock Canyon, California, and the mammalian fauna from the Cudahy Mine locality. *Natural History Museum of Los Angeles County, Contributions in Science*, 409, 1–34.

[3] **Dokka, R. K., & Travis, C. J.** (1993). Late Cenozoic strike-slip faulting in the Mojave Desert, California. *Tectonics*, 12(6), 1381–1415. doi:10.1029/92TC02586

[4] **Spittler, T. E., & Arthur, M. A.** (1982). The Ricardo Formation and other Cenozoic rocks of the Red Rock Canyon area, Kern County, California. *California Division of Mines and Geology, Open-File Report* 82-27, 30 pp.

Report compiled: July 2024 · Red Rock Canyon State Park, CA · All data subject to revision pending laboratory results.