Cliff Retreat Monitoring at
Technical Area 54

Los Alamos National Laboratory

Presented by Elizabeth Miller
In collaboration with Kay Birdsell, Phil Stauffer, Adam Atchley, Sean French, and Brent Goehring

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Located on the Pajarito Plateau, which is capped by volcanic rocks.
Mesas are lined with near-vertical cliffs and incised drainages.
Slope and Vegetation Differences

Slope and vegetation differences affect cliff retreat rates and hazards.
Geologic Differences

Degree of welding in geologic units causes differential weathering.
Some pits and shafts lie within 30m of the TA-54 southern cliff edge.
Importance of Studying Cliff Retreat

Continued cliff retreat threatens to expose disposal pits and shafts.
Phase I Assessments

- Mapping and characterization of fractures
- Block fall characterization
- Rock surface hardness measurements
- Repeat photodocumentation surveys
- Slope and topographic relief measurements
- Rock mass ratings
- Canyon width measurements
- Preliminary seismic hazard analysis
- Cliff face aging using rock art

Mostly qualitative in nature.
Average Rates of Cliff Retreat

- North side (Cañada del Buey) 220m/1.256 Ma ≈ 0.175 m/1,000 years

- South side (Pajarito Canyon) 210m/1.256 Ma ≈ 0.167m/1,000 years

Average rate ≈ 0.17m/1,000 years
Faulting and Seismicity

- Small earthquakes are common in the LANL area
- Severe seismic activity can trigger fracturing or failure

~M4.5 = failure on shallow slopes
~M6.8 = failure on steep slopes

*Earthquakes can cause larger cliff retreat events.*
Rock art provides evidence of active fracturing.
Archaeological Evidence for Cliff Retreat, cont.

- Top half of the rock art figure is still present
- Lower half has been eroded away (black arrow)
- Erosion occurred in the last 500 to 700 years, after the rock art was created

Erosion is occurring!
The most recent disturbances are anthropogenic in nature.
Phase II Assessments

- Cosmogenic nuclide dating
- Repeat LiDAR surveys
- Fracture monitoring using crack gauges

Current and proposed work is more quantitative in nature.
Cliff Retreat Quantification via Cosmogenic Nuclide Dating

Cosmogenic Isotopes are Produced In Situ by the Interaction of Cosmic Rays with a Variety of Target Atoms

Used to estimate how long a rock has been exposed to the surface.
Age dates are used in conjunction with joint spacing to generate episodic cliff retreat rates.
What is the relationship between seismic events and cliff retreat?
Cyclic thermal forcing and diurnal temperature swings trigger rockfalls!
High resolution elevation data is essential for small-scale change detection.
Repeat Lidar surveys highlight regions of change.
Conclusions

• Rock art erosion/fracturing and anthropogenic disturbances are evidence that cliff retreat is occurring
• Continued cliff retreat threatens to expose pits and shafts
• Phase I studies provided an initial assessment and estimation of cliff retreat rates
• Phase II studies will provide additional data for quantification of cliff retreat rates
• Continued monitoring is essential for change detection and identification of areas with potentially higher cliff retreat rates.