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THE JEMEZ MOUNTAINS REGION

Editors

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New Mexico Geological Society
Forty-Seventh Annual Field Conference
September 25–28, 1996

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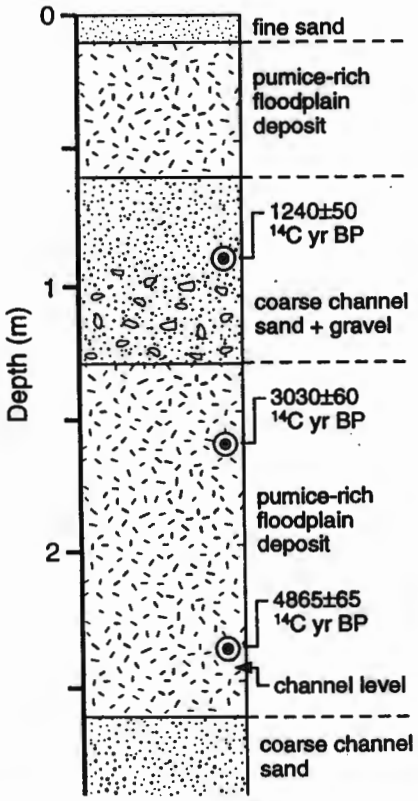

FIGURE 3.14. Stratigraphic section through Holocene alluvium in Ancho Canyon at Stop 5, showing alternating channel and floodplain deposits and locations of radiocarbon dates on disseminated charcoal fragments.

latest Pleistocene or early Holocene, presumably caused by the widespread, well documented climatic changes that occurred during this period. Beginning ca. 11,000 to 8000 yr B.P., most canyons apparently underwent extensive aggradation, and the late Pleistocene stream channels were buried by large volumes of sediment (Reneau et al., this volume). The total thickness of sediments at this site is not known, but radiocarbon dating of samples from a core hole in the north fork of Ancho Canyon 0.4 mi upstream from NM-4, revealed that a ca. 10,000 yr B.P. floodplain deposit is buried 16.5 ft deep below the present valley floor. The Holocene aggradation may have been caused by a major increase in erosion rates following enhancement of summer monsoonal rainfall, perhaps aided by a decrease in vegetation cover and/or a decrease in the ability of floods to carry the sediment out of the system (related to some combination of changes in flood magnitude, frequency, and/or duration).

Holocene sediment sections in Pajarito Plateau canyons, such as this one in Ancho Canyon, typically record alternating periods of channel aggradation and incision, particularly in the mid- to late Holocene, as has also been documented throughout the Southwest. A major question is whether the episodes of aggradation and incision are synchronous across the Plateau and across the Southwest, indicating primary climatic controls that are regional in extent, or whether the timing is variable and the episodes more local in extent. Available chronologic data from many canyons on the Plateau have not yet revealed clear synchroneity between these episodes, although this does not rule out a strong regional climatic control because the sedimentary record is fragmentary, and not all events are necessarily preserved.

Soil development in this exposure is typical of m[illegible] young valley bottom soils on the Pajarito Plateau, in t[illegible] only weak soil profile development has occurred. The strongest horizon is a cambic B (Bw) horizon, reflected by a slight increase in redness and development of weak soil structure, but translocation of clay has been minimal. Strongest soil development on the Plateau occurs at some mesa-top locations, where strong argillic (Bt) horizons have developed with up to 65% clay (unpubl. data from E. McDonald and P. Watt; see also Longmire et al., in press).

A CONCEPTUAL MODEL FOR FLOW IN THE VADOSE ZONE BENEATH THE FINGER MESAS OF THE PAJARITO PLATEAU

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Our conceptual model for flow in the vadose zone beneath the mesas of the Pajarito Plateau postulates alternating infiltration episodes and normal drying conditions. Episodic infiltration can occur either during spring snowmelts or during the intense summer thunderstorm season, when the fracture system is activated and infiltration increases moisture contents both near the surface and deeper within the mesa. In between these events, the system reverts to a more typical drying cycle. Evapotranspiration (ET) removes moisture from the surface of the mesa, while the three-dimensional network of fractures and surge beds within the Bandelier Tuff dries out the mesa from within. Superimposed on b[illegible] states is leakage down from canyon streams and alluvial aquifer s[illegible] tems.

Figure 3.15 schematically portrays the processes of the infiltration state. The mesa top soils are becoming saturated, and water is soaking into the top few meters of tuff. Some fractures become water-filled and act as preferential pathways, carrying water deeper inside the mesa. Cool temperatures and high atmospheric relative humidity minimizes ET from the mesa top, while internal drying of the mesa is low, because the wet fractures cannot carry much air, and what air is circulating through the mesa is relatively humid. Precipitation is running off the mesa top, and the streams in neighboring canyons are flowing.

Eventually, after a period of hours to days, the infiltration event comes to an end. The sun comes out and streamflow decreases (Fig. 3.15). As air temperature and plant activity increase, much of the newly infiltrated water in the soil and the top few meters of tuff on the mesa top will be drawn out by ET. Without a steady source of water, the active fractures can no longer support flow, and rapidly drain. The open fractures that had been preferential pathways for water movement now become conduits to air flow, induced by wind against the canyon walls and by natural barometric fluctuations. Air coming in from the northern New Mexico atmosphere is quite dry, but rapidly becomes saturated by evaporating water from the fracture walls. This drying of the fracture walls draws water from deeper in the matrix towards the fracture, and if the fracture density is high enough, may effectively dry out much of the mesa. Enhanced airflow through permeable volcanic surge beds may have the same drying effect.

Some canyon streams run dry while others may continue to function as an active recharge source to the relatively dry tuff below, and to some extent laterally beneath the mesas. Below the level of the canyon floors, the tuff is less fractured, and there is less opportunity for preferenti[illegible] flow paths, but this is offset to some degree by an influx of water fr[illegible] intermittent streams and/or perennial aquifers. This increased moistur[illegible] means higher hydraulic conductivities and faster flow rate, and unlike moisture within the mesa, there is little possibility of air movements drying out the tuff.

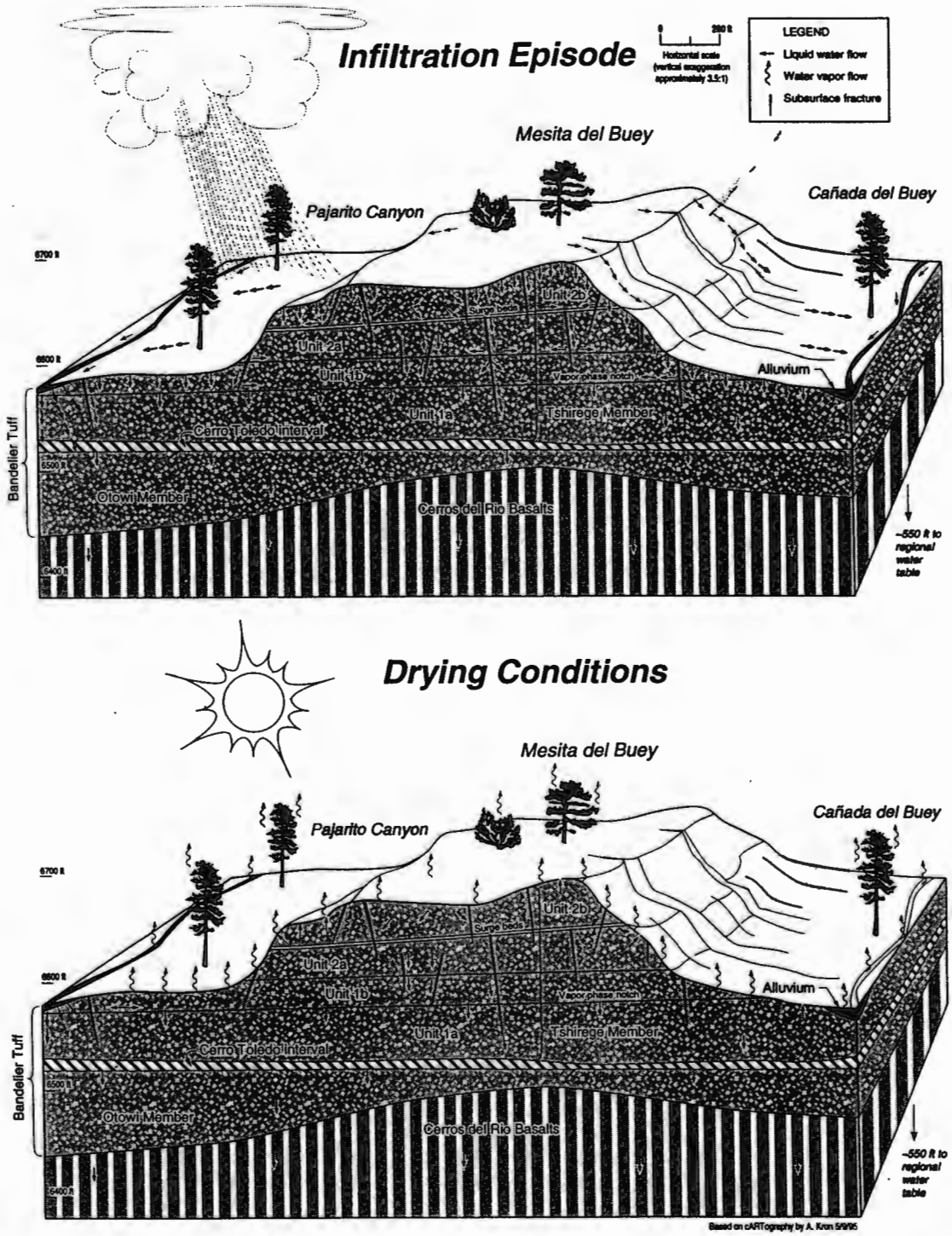

FIGURE 3.15. Conceptual model of flow beneath a typical Pajarito Plateau mesa during an infiltration episode and during drying conditions. Illustration is modeled after Mesita del Buey; details will vary at other locations.

Some key observations that support this conceptual model are listed below.

1. A series of field tracer experiments performed in 5 ft deep caissons packed with crushed tuff on Mesita del Buey showed tracer movement in bare-tuff caissons but not in ones with vegetative covers. This suggests that vegetation-induced evapotranspiration (ET) can dominate the system.

2. Moisture profiles measured in the Bandelier Tuff beneath undisturbed mesa tops show a typical pattern of near-surface moisture fluctuations and deeper stable conditions (e.g., IT Corporation, 1987). The shallow fluctuations, typically down to a depth of 6.5-13 ft, reflect episodic or seasonal infiltration events, followed by ET-driven drying. Gross measurements of deep moisture profiles generally reveal relatively dry conditions, relatively uniform both in time and space.

3. Although the degree of fracturing varies widely from unit to unit, all units within the tuff are fractured to some extent, including the Otowi Member. The fractures are an obvious *potential* pathway to flow and transport. The following observations indicate their importance.

4. A study of fracture fills in a disposal pit on one of the mesas of the Pajarito Plateau concluded that clay fracture fills were transported downward into the fractures by water movement (rather than being formed by in-situ weathering) and that the presence of calcite indicates alternating

sequences of wetting (bringing in carbonate ions in solution) and drying (precipitating calcite).

5. Geologists have reported encountering fracture coatings of evaporite minerals, including gypsum and halite. This observation indicates that the fractures at one time were the site of extensive evaporation; local waters must be concentrated by orders of magnitude before these minerals will precipitate.

6. Kearl et al. (1986) reported a local increase in moisture content associated with some, but not all, fractures at depth in intact tuff on various parts of the Plateau. More recent detailed observations, not yet published, indicate increased moisture contents associated with deep fractures following spring snowmelt events. These observations indicate that some of the fractures are acting as present conduits for water movement.

7. Living roots have been observed at depth (up to 65 ft) in fractures at several locations on the mesas of the Pajarito Plateau (Laughlin, ICF Kaiser Engineers, personal commun. 1995). These fractures are likely zones of weakness in the rock that enable roots to grow downward, extracting water from the adjacent unsaturated tuff matrix. Since plants would not survive long on ancient water in storage, this deep water must be actively replenished.

8. Using chilled-mirror psychrometry, Los Alamos personnel measured in-situ matric potential profiles on Mesita del Buey in 1994 (D. Rogers, LANL, personal commun. 1994). In almost every measured profile, an extremely strong peak in matric potential was observed at a depth of 40 to 60 ft, corresponding to the surge beds at the base of Tshirege Unit 2b. These data suggest that moisture both above and below the surge bed horizon is moving towards that horizon, which is therefore acting as a drying horizon.

Since many of Los Alamos National Laboratory's waste disposal sites are located on the mesa tops of the Pajarito Plateau, there is concern about the potential for contamination migration from these mesa tops. The natural alternation of wetting and drying cycles described above greatly limits the potential downward movement of water, and therefore contaminants, under undisturbed conditions; human activities associated with waste disposal activities will complicate the situation.

Two main aspects of disposal activities that may alter subsurface flow are increased paving of the mesa surface and replacement of intact Bandelier Tuff with waste and crushed tuff fill. Our conceptual model emphasizes the importance of ET and airflow in drying the mesas and thus reducing net infiltration; since asphalt paving eliminates or greatly decreases both processes, we expect and have observed higher moisture contents in the vicinity of paved areas (B. Martinez, LANL, personal commun., 1994). Neutron probe measurements within and beneath waste disposal pits atop Mesita del Buey have revealed increased moisture contents (S. McLin, LANL, personal commun., 1994; Loaiza and Vold, 1995). This additional moisture may be due in part to moisture coming in with waste for disposal, but is more likely attributable to local precipitation, run-on, and ponding during the active lifetime of the pit.

Increased moisture, whether due to paving or fill, will have two major effects. First, in an unsaturated setting hydraulic conductivity is a strong function of moisture content. Increased moisture will dramatically increase the hydraulic conductivity of the medium and the potential for transport. Second, the increased moisture creates a moisture gradient away from the waste by increasing saturation and decreasing matric potential. These effects suggest that waste disposal activities may lead to increased contaminant transport potential compared to undisturbed conditions.

Continue straight ahead on NM-4. **0.4**

26.0 Ascend south wall of Ancho Canyon. **0.7**

26.7 Technical Area 33 on left of roundhouse turn. A late Pliocene cinder cone and flow composed of quartz-bearing olivine basalt of the Cerros del Rio volcanic field is exposed about 300 ft to the southeast (on restricted DOE land). Many mafic flows in the Cerros del Rio field contain quartz and other upper crustal xenolithic fragments (Iddings, 1890). The cinder cone was almost completely overtopped by the Tshirege Member of the Bandelier Tuff, and has only a slight topographic expression today (Broxton and Reneau, this volume).

Roads branching from the site lead to other experimental areas that were used to develop weapons such as the atomic cannon of the 1950s. From about 1975 to 19[illegible] most of the Laboratory's geosciences groups were hou[illegible] here. **0.2**

26.9 St. Peter's Dome, an uplifted block of Keres Group volcanic and volcaniclastic rocks of Miocene age surrounded by the Bandelier Tuff, is exposed at 10:00. Dates at St. Peter's Dome proper range from 8.7 to 11.3 Ma (Goff et al., 1990). A thick sequence of poorly bedded volcaniclastic rocks of the Keres Group occurs within the St. Peter's Dome complex (Lavine et al, this volume). The east rim of Valles caldera occurs at 12:00. St. Peter's Dome provided the name for the "Dome Fire" of 1996 that burned over 15,000 acres of Santa Fe National Forest and Bandelier National Monument. **1.2**

28.1 Entrance to Bandelier National Monument on left; continue straight ahead. Road ascends long grade going through Tshirege units D and E. In a borrow pit on this mesa, north of the highway (on restricted DOE land) is exposed the thickest section of El Cajete pumice yet reported on the Pajarito Plateau, 7.2 ft in total thickness (Longmire et al., in press). This is significantly greater than the <3 ft thickness shown on the isopach maps of Self et al. (1991), suggesting that the isopach maps greatly underestimate the original thickness and distribution of the fallout deposit. This underestimation is likely due to substantial erosion of the pumice over the past 50–60 ka. Notably, thin ash beds are interlayered with pumice at the top of the section, a feature that has only been observed at one other site on the Plateau, and further indicate that [illegible] borrow pit displays an exceptionally complete sectio[illegible] the more distal El Cajete fall deposit.

Bandelier National Monument is named for Adolph Bandelier, a Swiss-born (though naturalized US citizen) anthropologist, who made the canyon and its prehistoric Indian ruins famous in the late 1890s with his book "The Delight Makers." It was made a national monument by presidential proclamation in 1916, with administration transferred to the National Park Service in 1932. The major work of stabilizing the ruins and constructing visitor facilities was carried out between 1934 and 1937 as Civilian Conservation Corps (CCC) projects. During WWII, the lodge in Frijoles Canyon was appropriated by the U.S. Army in connection with the Manhattan Project as additional housing for project workers.

The Indians who lived here probably came from the Four-corners region in about 1075 A.D. and moved down to today's modern pueblos along the Rio Grande by about 1550. According to Hoard (1983), the Anasazi on the Pajarito Plateau had reached a zenith in population and cultural advancement by 1400 A.D. The Plateau was an important developing area for many of the traits associated with the New Mexico Indians of the past and present. But by the 1500s, these Indians began to gather into fewer, yet larger sites to provide mutual defense against nomadic Indian raiders. The main ruin near the Bandelier Visitors' Center is a multi-room and multi-level structure built in a great circular shape on the canyon floor. The ruins co[illegible] a central plaza and underground kivas for religious ceremonies. Nearby, cliff dwellings line the canyon walls. About a mile west of the visitor center is a kiva in a cave some 150 ft above the canyon floor which can be reached

SUBJECT: INSTRUCTIONS FOR UPDATING THE TECHNICAL AREA 54 REFERENCE SET

The attached materials are an update to "Reference Set for Material Disposal Areas, Technical Area 54," of the Los Alamos National Laboratory Environmental Restoration Project reference library. The attached materials include a revised table of contents and tabbed references for Volumes 6 and 8. These references correspond to "Voluntary Corrective Action Plan for Potential Release Sites 51-001 and 54-007(d)" and "Voluntary Corrective Action Plan for Potential Release Site 54-007(c)-99," which have been submitted.

To update the Technical Area 54 reference set, perform the following:

1. To update Volume 6, remove the old table of contents page (dated April 27, 2000) and replace it with the attached revised table of contents page (dated November 8, 2000). Insert tab and reference 57916 into Volume 6 in proper numerical sequence.
2. To update Volume 8, remove the old table of contents page (dated April 27, 2000) and replace it with the attached revised table of contents page (dated November 8, 2000). Insert tab and reference 66410 into Volume 8 in proper numerical sequence.

If you have questions regarding these instructions, please contact Marcy Backsen at 505-665-3787.

REFERENCE SET FOR TECHNICAL AREA 54
VOLUME 8

This reference set is provided to facilitate review of Laboratory Environmental Restoration (ER) Project documents and is organized by ER identification (ER ID) number.

ER Project documents use ER ID numbers to track reference items through its Records-Processing Facility. Because ER ID numbers are issued on an ongoing basis throughout the entire ER Project, gaps may be present in the numbers included in this table of contents.

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63868 Quadrel Services, September 30, 1993. "EMFLUX Soil-Gas Survey of Technical Area 54 Los Alamos National Laboratory New Mexico," Quadrel report number QS1135 prepared under subcontract 1490L0013-91, Ijamsville, MD. (Quadrel Services 1993, 63868)

63869 Quadrel Services, September 9, 1994, "EMFLUX Soil-Gas Survey of Technical Area 54 Los Alamos National Laboratory New Mexico," Quadrel report number QS1190 prepared under subcontract 1490L0014, Clarksburg, MD. (Quadrel Services 1994, 63869)

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63901 Neleigh, D., September 28, 1995. "Modification to Phase I Material Disposal Area G Los Alamos National Laboratory (NM0890010515)," Environmental Protection Agency memorandum to T. Taylor, Dallas, Texas. (Neleigh 1995, 63901)

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