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New Mexico Geology, v. 38, n. 2 pp. 50-51, Online ISSN: 2837-6420.
https://doi.org/10.58799/NMG-v38n2.50

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Gallery of Geology

The Youngest Silicic Eruptions from the Valles Caldera and Volcanic Hazard Potential in North-central New Mexico

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Sporadic mafic and felsic eruptions, representing at least five major and several smaller pulses of effusive and explosive volcanic products that range in age from 25.5 Ma to 68.3 ka, crop out within the Jemez volcanic field and the surrounding areas in north-central New Mexico (Kelley et al., 2014 and references therein). The youngest pyroclastic and lava flows erupted from the southern moat of the Valles caldera. These volcanic products belong to the El Cajete Pyroclastic Beds and co-erupted Battleship Rock Ignimbrite, which are locally overlain by the Banco Bonito obsidian flow (Gardner et al, 2010). Based on detailed field mapping, Wolff et al. (2011) suggested that more than 10 km^3 of silicic magma was erupted to form the fallout and ash-flow deposits of the lower and upper units of the El Cajete Pyroclastic Beds and the Battleship Rock Ignimbrite, whereas the volume of the Banco Bonito obsidian lava flow was estimated at 4 km^3. The mostly Plinian eruptions of the El Cajete Pyroclastic Beds were distributed over much of the Valles caldera, the southern Jemez Mountains, and the Rio Grande rift, including considerable ash deposited in the Santa Fe area and in eastern New Mexico (Wolff et al., 2011). As shown in Figure 1, recent field studies identified >4 m thick of proximal and ≥1 m thick of distal primary pumice deposit near the vent (A) and in the Cerros del Rio volcanic field (B) south and west of the Santa Fe city limits, the latter being more than 30 km southeast of the eruptive center (WoldeGabriel et al., 2013). In contrast, the ash-flow tuff deposit of the Battleship Rock Ignimbrite and the Banco Bonito obsidian lava flow are confined to the southern part of the Valles caldera moat and the upper drainage basin of the Canon de San Diego, which forms the only drainage outlet from the caldera.

The El Cajete Pyroclastic Beds, the Battleship Rock Ignimbrite, and the Banco Bonito obsidian flow have long confounded geochronologists, yielding disparate results ranging from ≤40 ka to ≥1.24 Ma (Zimmerer et al., 2016). The long-standing problem with age determination was recently resolved using the latest $^{40}Ar/^{39}Ar$ and U/Th dating methods at the New Mexico Geochronology Research Laboratory and at the Stanford-USGS facility, respectively. The $^{40}Ar/^{39}Ar$ method yielded an age of 74.4±1.3 ka for the El Cajete Pyroclastic Beds and the co-erupted Battleship Rock Ignimbrite; the Banco Bonito obsidian lava flow was dated to 68.3±1.5 ka (Zimmerer et al., 2016). Petrologic and geochemical studies suggest that the youngest eruptions in the late Pleistocene represented a new cycle of volcanic activity in the Valles caldera (Wolff and Gardner, 1995).

The El Cajete Pyroclastic Beds and the co-erupted


A


B

Figure 1. Proximal (A) and distal (B) deposits of the El Cajete Pyroclastic Beds erupted from the southern moat of the Valles caldera. The proximal (>4 m thick) and distal (≥1 m thick) outcrops are located about 2.5 km and >30 km, respectively, from the vent marked red on the map in Figure 2 (labeled El Cajete Crater).

Battleship Rock Ignimbrite show minor differences in SiO_2, CaO, $Al2O_3$, TiO_2, MgO, and FeO contents (Slate et al., 2007 and references therein). The Battleship Rock Ignimbrite is more mafic with lower SiO_2 and higher CaO, FeO, MgO, and TiO_2 concentrations compared with the underlying El Cajete pumice, suggesting a mildly zoned silicic magma chamber. The Banco Bonito obsidian flow, however, generally has similar major element chemistry to the El Cajete Pyroclastic Beds.

Despite their young age, large volume of ash and lava flows, and the widespread distribution of the El Cajete Pyroclastic Beds in north-central New Mexico, the eruptive centers do not appear to pose imminent volcanic hazard concerns. Of more concern is a low-velocity zone occupying an area of 10 x 14 km beneath the western portion of the Valles caldera, ranging between ~5 and 15.5 km in depth (Steck et al., 1998). This volume contains at least 10% melt (possibly more), and represents a new pulse of magma. However, the Los Alamos Seismic Network (LASN) has not detected unusual volcano-seismic activities since the monitoring system was established in the 1970s, and sustained monitoring will provide notification of any systematic changes in the magmatic reservoir. In fact, LASN has three broadband stations installed in and around of the Valles caldera, which will monitor very small volcano-seismic events (Roberts et al., 2016).

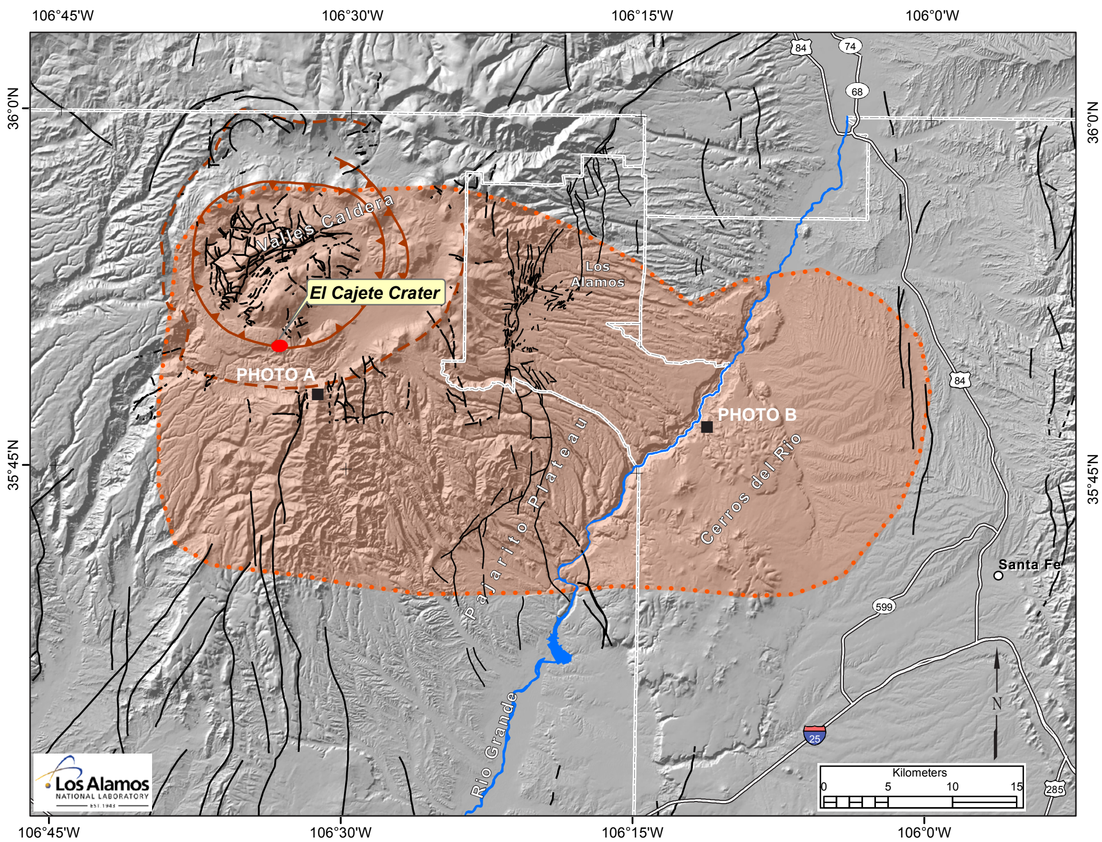

Figure 2. Map of the area between the Valles Caldera and Santa Fe. The outcrop extent of El Cajete Pyroclastic Beds is shown in orange shading (from WoldeGabriel et al., 2013). Locations of photos A and B in Figure 1 are shown by the solid squares. Thick black lines represent unconcealed faults.

References

Gardner, J.N., Goff, F., Kelley, S., and Jacobs, E., 2010, Rhyolites and associated deposits of the Valles-Toledo caldera complex, New Mexico Geology, v. 32, no. 1, p. 3–18.

Kelley, S.A., McIntosh, W.C., Fraser, G., Kempter, K.A., Wolff, J.A., Esser, R. Braschayko, S., Love, D., and Gardner, J.N., 2013, Spatial and temporal trends in pre-caldera Jemez Mountains volcanic and fault activity, Geosphere, v. 9, no. 3, p. 614–646.

Roberts, P.M., Jacobs, E.P., Ten Cate, J.A., and House, L.S., 2016, The Los Alamos Seismic Network (LASN): Current network status and updated north-central New Mexico seismicity, New Mexico Geological Society, Proceedings Volume, 2016 Annual Spring Meeting, Macey Center, New Mexico Tech, Socorro, NM, p. 57.

Slate, J.L., Sarna-Wojcicki, A.M., Wan, E., Dethier, D.P., Wahl, D.B., and Lavine, A., 2007, A chronostratigraphic reference set of tephra layers from the Jemez Mountains volcanic source, New Mexico, in Kues, B.S., Kelley, S.A., and Lueth, V.W., eds., Geology of the Jemez Region II: New Mexico Geological Society, 58th Annual Field Conference, Guidebook, p. 239–247.

Steck, L.K., Thuber, C.H., Fehler, M.C., Luther, W.J., Roberts, P.M., Baldridge, W., Stafford, D. G., and Sessions, R., 1998, Journal of Geophysical Research-Solid Earth, v. 103, issue: B10, p. 24301–24320.

WoldeGabriel, G., Kelley, R., Miller, and Schultz-Fellenz, E., 2013, Geochemistry, extent, signatures, and chronology of basaltic and young silicic pyroclastic eruptions: refining existing data to support a future volcanic hazard assessment of Los Alamos National Laboratory, Los Alamos National Laboratory Report LA-UR-13-23431, 92 p.

Wolff, J.A., and Gardner, J.A., 1995, Is the Valles caldera entering a new cycle of activity?: Geology, v. 23, p. 411–414.

Wolff, J.A., Brunstad, K.A., and Gardner, J.N., 2011, Reconstruction of the most recent volcanic eruptions from the Valles caldera, New Mexico, Journal of Volcanology and Geothermal Research, v. 199, no. 1–2, p. 53–68.

Zimmerer, M.J., Lafferty, J., and Coble, M.A., 2016, The eruptive and magmatic history of the youngest pulse of volcanism at the Valles caldera: Implications for successfully dating late Quaternary eruptions: Journal of Volcanology and Geothermal Research, v. 310, p. 50–57.