Geologic Map of the Polvadera Peak 7.5-Minute Quadrangle, Rio Arriba and Sandoval Counties, New Mexico

By

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Scale 1:24,000

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Overview

The Polvadera Peak 7.5-minute quadrangle is dominated by dacitic lavas of the Tschicoma Formation, erupted between ~ 7-3 Ma (Loeffler et al., 1988; Gardner et al, 1986) and forming some of the highest peaks in the Jemez Mountains, including Polvadera (11, 232') and Tschicoma Peaks (11,561'). These lavas were erupted as high-aspect ratio, viscous, voluminous flows with steep-sided flow lobes. Most of the vent sources for these lavas were from north-south trending structures along the eastern portion of the quadrangle. The western portion of the quadrangle is blanketed by extensive flow lobes of the Bandelier Tuff, erupted onto highly irregular surface of distal Tschicoma lava flows. This relatively low topographic region between the Polvadera Peak highlands to the east and the La Grulla plateau to the west, provided the main corridor for pyroclastic flows of the Upper and Lower Bandelier Tuffs extending northward from the Valles and Toledo Calderas. Modern Quaternary canyons dissecting the western portion of the quadrangle reveal the complex pre-Bandelier topography that preceded these eruptions. In isolated exposures within these canyons, the thin sedimentary records of the Puye Formation, Cerro Toledo Interval, and post-Bandelier Tuff alluvium are preserved.

Figure 1 below shows the location of the Polvadera Peak 7.5-minute quadrangle in relationship to the other quadrangles in the northern Jemez Mountains.

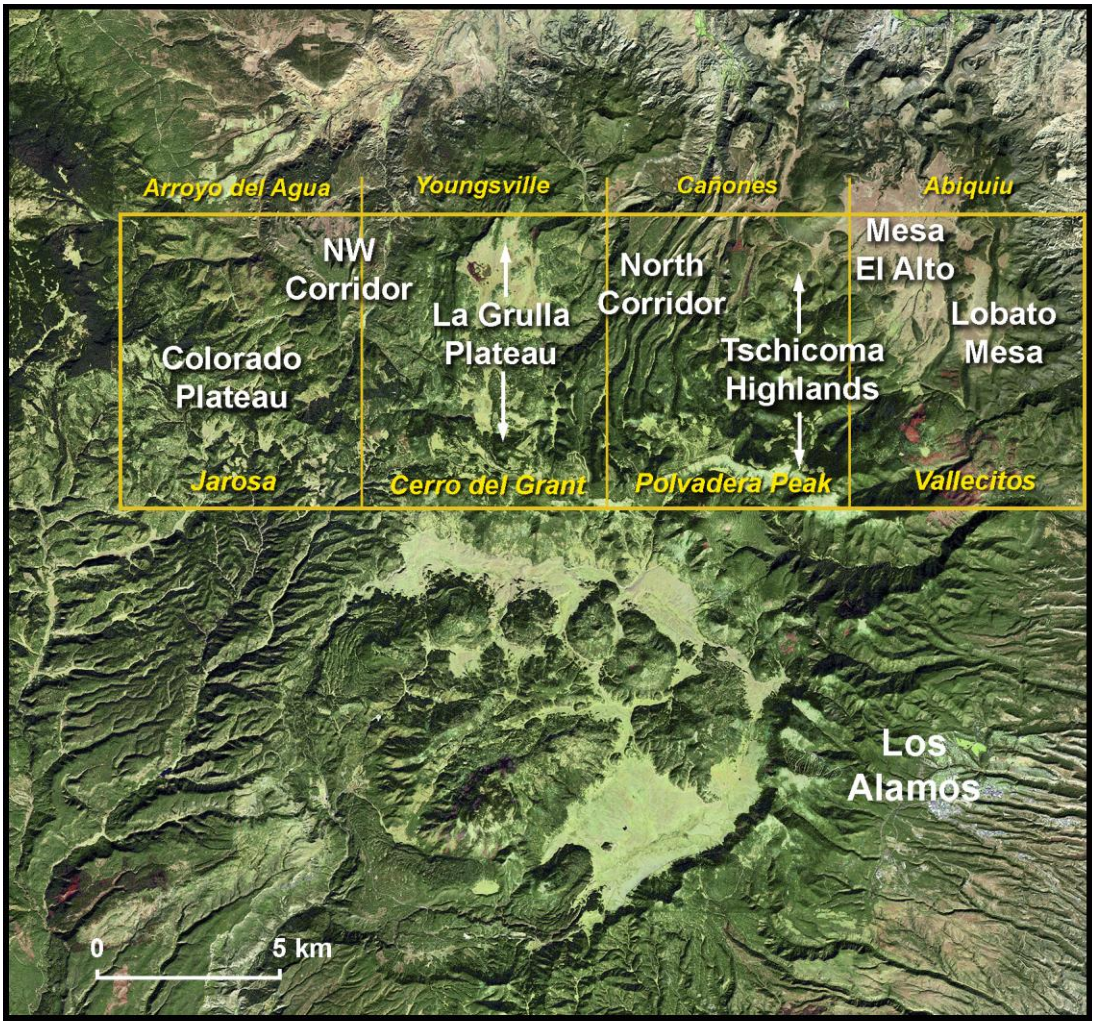

Figure 1. Satellite image of the Valles Caldera and the northern Jemez Mountains showing the location of the four 7.5-minute topograhic quadrangles north of the Valles Caldera. Geographically important divisions include the Colorado Plateau, La Grulla Plateau, Tschicoma Highlands, Mesa El Alto, and Lobato Mesa. The Bandelier Tuff was emplaced along two relatively lowland corridors, one to the NW onto the Colorado Plateau, and one to the north, between La Grulla Plateau and the Tschicoma highlands.

Geologic mapping of the Polvadera Peak quadrangle has provided several new insights into the volcanic and sedimentary history of the region, including:

1) Major volcanic centers for Tschicoma Formation lavas are recognized and separated into three age-distinctive episodes: a) an older phase (mapped as **Tt1**) that includes crystal-rich, hydrous mineralogy and dacitic lavas with

relatively non-hydrous mineralogy, b) an intermediate phase (mapped as **Tt2 and Ttpd**) that includes most of the lavas erupted along the rim of the Toledo embayment (including Chicoma, or Tschicoma, Peak), and several flows rich with cognate clots of more mafic compositions, and c) a younger eruptive episode (**Tt3**) forming the steep-sided domes of Cerro Pelon and Polvadera Peak.

2) Recognition of two distinct pulses of rhyolite lava emplacement. The older lavas, located in the southwestern portion of the quadrangle, are temporally related to the well-documented Bearhead Rhyolite phase of volcanic activity in the southern Jemez Mountains that occurred between approximately 6 to 7 Ma. The younger phase relates to Late Tertiary El Rechuelos Rhyolite, emplaced at approximately 2.0 Ma. Three rhyolite domes from this episode are aligned along a north-south trend just west of Polvadera Peak. A fourth rhyolite outcropping occurs in a crater north of Polvadera Peak. This rhyolite is mapped as a distinct El Rechuelos, since anomalies in chemistry and age indicate this rhyolite may be more closely related with older Tschicoma-phase volcanic activity.
3) Our mapping reveals a much greater extent of Lower Bandelier Tuff (Qbo) than previously known.
4) Recognition of broad exposures of the Ojo Caliente Member of the Tesuque Formation of the Santa Fe Group in Cañones Canyon. These well-sorted eolian sandstones clearly indicate a prevailing wind from the west during the time of deposition. A thin fluvial sequence belonging to the Hernadez Member of the Chamita Formation of the Santa Fe Group caps the eolian section and contains well-rounded volcaniclastic cobbles. An age of ~29 Ma for one of these cobbles suggests an origin from the San Juan volcanic field to the north, possibly as reworked Los Pinos Formation.
5) Recognition of a post-Bandelier Tuff, older alluvial deposit (Qoa) in Polvadera Creek Canyon, representing an episode of fluvial aggradation not recognized elsewhere in the region. When downcutting of the canyon resumed, incision occurred slightly eastward of the Qoa-filled paleocanyon.

Unit Descriptions

Qal – Alluvium. Late Pleistocene to Holocene. Alluvial deposits in modern drainage bottoms. Deposits include conglomerates, sands, and silts. Holocene terrace deposits less than 1 meter above drainage bottoms are included. Alluvium in canyons in the western portion of the quadrangle is dominated by weathering products of the Bandelier Tuff (primarily **Qbt**), while alluvium in eastern canyons is dominated by fluvial clasts of Tschicoma dacite (**Tt**). Obsidian fragments common. Maximum thickness can exceed 4 meters.

Qc / Qcbt – Colluvium. Late Pleistocene to Holocene. Poorly sorted talus, debris, and colluvium in wedge-shaped deposits on hill slopes. Numerous hill slopes beneath mesas of Tshirege Member, Bandelier Tuff (**Qbt**), are covered by **Qbt** colluvium (obscuring the underlying bed rock), and have been mapped as **Qcbt**. Thickness can locally exceed 5 meters.

Qt – Terraces. Late Pleistocene to Holocene. Alluvial deposits near the margins of modern streams or older perched floodplain deposits. Most are fill terrace deposits of sand, silt and gravel < 10 m above modern drainages. Maximum thickness is <5 meters.

Qtal - Undifferentiated terraces and alluvium in modern stream drainages. Obsidian fragments common. Late Pleistocene to Holocene.

Qe – Eolian deposits. Late Pleistocene to Holocene. Poorly bedded fine-grained sand and silt preserved sporadically on terraces and mesa tops. Although no sedimentary structures could be identified, these deposits appear to be primarily eolian in origin, capping older alluvial deposits. Less than 1 meter in thickness.

Qma – Mesa alluvium. Late Pleistocene to Holocene. Poorly sorted sand and debris composed primarily of reworked Upper Bandelier Tuff (**Qbt**). Obsidian fragments common. Though common as isolated patches on **Qbt** mesa tops, these deposits were only mapped in a few localities. Maximum thickness is less than 2 meters.

Ql – Landslides. Pleistocene to Holocene. Unsorted, chaotic debris emplaced during a single detachment event from a steep slope or cliff. Fan-shaped deposits occur where debris spread out on valley floor. Thickness highly variable.

Qav – Rock avalanche deposits. Late Pleistocene to Holocene. Chaotic, angular debris emplaced during a single detachment event from a steep slope or cliff, generally lacking a sedimentary matrix. Mapped only in a few locations. Thickness can exceed 10 meters.

Qrg – Rock glacier. Quaternary. Debris field of large, tabular Tschicoma dacite blocks along a flat ridge between Polvadera Peak and Tschicoma Peak. The deposit was possibly mobilized via interstitial ice and/or thawing alpine permafrost, providing a buoyant substrate facilitating slow creep on nearly flat topography.

Qoa – Old Alluvium. Quaternary. Older alluvial deposits of gravel, sand, and silt that were deposited after the eruption of the Tshirege Member, Bandelier Tuff. Dominant clast lithology is Tschicoma Formation dacite, with subordinate amounts of rhyolite lava and rare Tshirege Member, Bandelier Tuff. In Polvadera Canyon, a remnant of a paleocanyon filled by this unit is exposed along the western edge of the modern canyon. Aggradation of this paleocanyon may have occurred when the downcutting of the river encountered a mound of Tschicoma dacite (at the confluence of Polvadera Creek and the West Fork Polvadera Creek), impeding erosion and backfilling the canyon with sediment. The modern canyon then incised slightly to the east of this paleodrainage, preserving alluvial deposits along the canyon's western margin. Maximum thickness is approximately 30 meters.

Qbt – Upper Bandelier Tuff, Tshirege Member. Early Quaternary. White to orange non-welded to welded ash-flow tuff containing abundant phenocrysts of quartz and sanidine. Basal Tsankawi Pumice, though seldom exposed, is typically 1 meter thick and well stratified. Overlying ash-flow tuff beds consist of multiple flow units in a compound cooling unit with thin surge beds (less than 0.5 meters thick) locally exposed. Though mostly lithic poor (2-3% lithic fragments), one of the lower flow units contains > 5% of lithic fragments, appearing similar to facies of the Otowi Member, Bandelier Tuff. Erupted at approximately 1.25 Ma during the formation of the Valles caldera (Phillips et al., 2007). Maximum thickness is approximately 250 meters.

Qct – Cerro Toledo Interval. Quaternary. Rhyolitic lavas erupted within the Toledo embayment along the southern boundary of the quadrangle and poorly exposed fluvial sediments deposited between eruptions of the Bandelier Tuff. The rhyolite lavas are typically white to gray to pink and crystal poor, with sparse phenocrysts of quartz and sanidine. Lithophysal, flow banded and obsidian phases are common. Sedimentary facies are preserved in the South and West Forks of Polvadera Canyon, overlying either Tschicoma dacite or Otowi Member of the Bandelier Tuff. These fluvial facies are poorly consolidated, typically manifested as colluvial rounded cobbles of mixed lithologies (primarily Tschicoma dacite) at the surface. Fluvial cobbles of Otowi Member, Bandelier Tuff, were not recognized, so mapping of this unit was based on stratigraphic position and extrapolation. Maximum thickness is approximately 5 meters.

Qbo – Bandelier Tuff, Otowi Member. Quaternary. White to beige to orange non-welded to welded ash-flow tuff containing abundant phenocrysts of quartz and sanidine and sparse mafic phenocrysts. Moderate to abundant lithic fragments (5-12%), primarily of andesitic or mafic lavas. Though not as evident as the overlying Tshirege Member, this unit represents a compound cooling unit of multiple flows. One of the lower flow units is lithic poor (< 5%), resembling facies of the Tshirege Member. Where poorly welded this unit is also poorly exposed, often obscured by colluvium of overlying Tshirege Member. Thus, there is likely much more of this unit than indicated on the map. No exposures of the basal Guaje Pumice were observed in the quadrangle. Basal exposures preserved in the northwest corner of the quadrangle (side canyon to Cañones Canyon), however, reveal an underlying lahar deposit (**Qol**) that may indicate tumescence of the caldera region before the eruption. Erupted at approximately 1.61 Ma during the formation of the Toledo Caldera (Spell et al., 1996). Maximum thickness (exposed in Cañones Canyon) is approximately 200 meters.

QTt – Terrace gravels and conglomerates of uncertain age. Late Tertiary – Early Quaternary. Isolated exposures of older alluvium preserved adjacent to large Tschicoma flow boundaries. May be equivalent to the Puye Formation (Griggs, 1964; Gardner et al., 1986). Mostly coarse boulder conglomerate of Tschicoma dacite with minor amounts of andesite and rhyolite. No clasts of Bandelier Tuff. Maximum thickness is approximately 30 meters.

Ter1 / Ter2 – El Rechuelos Rhyolite. Late Tertiary. **Ter1** is represented by three eruptive centers of white to pink rhyolite with subordinate amounts of dark, glassy, and sometimes sugary-textured obsidian, emplaced along an arcuate fracture along the western margin of Polvadera Peak at ~ 2 Ma (Goff et al., 1989). Another rhyolite eruptive center, mapped as **Ter2**, is located approximately 2.5 miles north of Polvadera Peak, and is defined by a small crater termed El Lagunito de Palo Quemador. Geochemical analyses of this rhyolite suggest that it may be more closely related to older Tschicoma-related volcanism (Loeffler, 1984). Rhyolite fragments are typically pumiceous with < 5% phenocrysts of plagioclase, quartz, biotite and hornblende. The three remaining eruptive centers occur along a north-south fracture west of Polvadera Peak. Two large centers occur at the head of Cañada del Ojitos and consist of intrusive and extrusive dome facies with sparse phenocrysts of plagioclase and biotite. The margins of both of these domes include autobrecciated and vesicular horizons with minor obsidian facies. The northernmost of these two domes has apparent landslide scarps on its NW flank, which may explain the two small satellite exposures of this unit in the Cañada del Ojitos valley floor. Lastly, at approximately 1.2 miles SW of Polvadera Peak is a small rhyolite center with abundant obsidian facies, though poorly exposed. Maximum thickness is approximately 150 meters.

Tp – Puye Formation. Pliocene to Early Pleistocene. Poorly exposed alluvial gravels composed almost entirely of Tschicoma lava clasts. Mapped only in the West Fork of

Polvadera Canyon where overlain by the Otowi Member of the Bandelier Tuff. May also include older terrace deposits (**QTt**) mapped adjacent to Tschicoma domes in the northeast quadrant of the quadrangle. Maximum thickness is approximately 25 meters.

Ttd / Tt1 / Tt2 / Ttpd/Tt3 – Tschicoma Formation. Late Miocene to Pliocene. Light gray to dark gray coarsely porphyritic lavas, primarily of dacitic composition but also including andesites and rhyodacites. This episode of volcanism includes thick, superimposed flows and high-aspect ratio domes. No pyroclastic facies of this unit were observed in the quadrangle (but do occur on the Vallecitos quadrangle to the east). The first and third highest peaks in the Jemez Mountains, Tschicoma Peak and Polvadera Peak, are dacitic domes of this unit located within the quadrangle. Age dates for this unit in the northeastern Jemez Mountains range from ~ 7 to 3 Ma with most domes/flows emplaced between 5 to 3 Ma. These domes and flows were subdivided into three general age relationships based on field relationships, age data, and geomorphology of the dome flows:

1) an older sequence of domes and flows (**Tt1**), including plagioclase-dominated flows with both hydrous (biotite + hornblende) and non hydrous mineralogy. Age dates from these flows imply ages greater than 4.5 Ma, including a dome immediately southwest of Polvadera Peak. In the NE quadrant these older flows and domes are mostly dacitic to rhyodacitic, with abundant phenocrysts of plagioclase, biotite and hornblende with minor amounts of pyroxene.

2) **Tt2** deposits include dacites commonly containing cognate clots of more mafic magmas (vesicular basaltic andesite) ranging in size from 2 to 25 cm. These flows represent an age span between 4.5 to 3.2 Ma.

3) **Ttpd** flows include dacite and rhyodacite (undivided) in the Tschicoma Peak area including the northern rim rocks of the Toledo embayment and Chicoma (or Tschicoma) Peak**.** These massive to sheeted, coarse porphyritic lavas have abundant phenocrysts of plagioclase, and variable quantities of phenocrysts of biotite, hornblende, and rare clinopyroxene. The younger lavas may contain of sanidine and quartz and 2 to 25 cm, elliptically-shaped inclusions of mafic composition; $^{40}Ar/^{39}Ar$ dates are 4.29 to 4.46 Ma (Kempter et al., 2007); maximum exposed thickness >500 m.

3) The youngest lavas and domes (**Tt3**) formed Polvadera Peak and Cerro Pelon, both porphyritic dacites with plagioclase the dominant phenocyrst. Cerro Pelon contains both clinopyroxene and orthopyroxene, with minor biotite and hornblende.

Undifferentiated Tschicoma biotite-bearing dacite lavas are represented by the symbol **Ttd**. Maximum thickness exceeds 600 meters.

Tbr – Miocene Bearhead Rhyolite. Rhyolite domes and intrusions exposed at three vent sources in the southwestern corner of the quadrangle. They include flow banded, vitrophyric lava with vesicular horizons with phenocrysts of plagioclase and minor biotite. Ages for this group of rhyolites range from 5.8 – 7.5 Ma (Kempter et al., 2007; Loeffler et al., 1988). These lavas were previously mapped as El Rechuelos Rhyolite, but age considerations and similar exposures along the northern rim of the Valles Caldera (Goff et al., 2006) suggest these lavas correlate with the widespread pulse of Bearhead volcanic activity recognized in the southern Jemez Mountains (Justet and Spell, 2001; Justet, 2003).

Tgbhd – Dacite lava of La Grulla Plateau. Light gray porphyritic dacite with phenocrysts of plagioclase, biotite, and hornblende. Overlies more mafic rocks (Tge) in the walls of Cañones Canyon. Maximum thickness is approximately 80 meters.

Tge – Lavas of Encino Point, La Grulla Plateau. Miocene. Dark gray, fine grained basaltic andesite to andesite lavas with phenocrysts of plagioclase, clinopyroxene, orthopyroxene and olivine. This unit is only exposed in the northwest quadrant of the quadrangle, with most exposures along the eastern edge of Cañones Canyon. Here the major flow thins and thickens dramatically, clearly filling in paleotopography at the time of its eruption. The base of the unit is typically hidden by colluvium, although where exposed, the lava overlies fluvial deposits of the Hernandez Member of the Chamita Formation. Presumably, these lavas underlie the thick Tschicoma dacite sequence in the quadrangle. Maximum thickness is approximately 100 meters.

Tst/Tstb – Santa Fe Group, Tesuque Formation, Ojo Caliente Sandstone. Miocene. Primarily buff to tan, cross-bedded eolian sandstones of the Ojo Caliente Member. Exposures of this unit are limited to Cañones Canyon and Chihuahueños Creek along the northern boundary of the quadrangle. These eolian sandstones are composed primarily of quartz and indicate and clearly indicate a prevailing wind from the west. In Cañones Canyon some exposures of the Ojo Caliente Member are consolidated, outcropping as subdued cliffs. Most of the unit, however, is poorly consolidated, forming buff-colored sand and silt on the canyon slope. At the base of the eolian sequence in Cañones Canyon are isolated exposures of thin basalt flows (**Tstb**), presumably intercalated with the sedimentary sequence. These lavas may correlate with the Lobato basalt in the northeastern Jemez Mountains.

Tsc - Santa Fe Group, Tesuque Formation, Ojo Caliente Sandstone. Poorly exposed fluvial sandstones with rounded cobbles (2 to 12 cm across) of volcanic origin overlying the eolian sandstones along the eastern rim of Cañones Canyon, possibly representing the Hernandez Member of the Chamita Formation as mapped by Koning and Aby (2005). These gravels contain cobbles of andesite with lesser amounts of rhyolite and basaltic andesite, possibly originating from the San Juan or Latir volcanic fields. Maximum thickness exceeds 200 meters.

Structure

Few major structures were recognized in the course of mapping this quadrangle. Although numerous steep-sided contacts between volcanic units occur throughout the area, the majority of these relationships were interpreted as depositional, especially those between flow lobe boundaries of Tschicoma lavas and overlying (valley-fill) Bandelier Tuff. Although it is likely that faults within the Tschicoma Formation exist, more detailed mapping of individual flow units would be needed to help identify these structures.

Two volcanic collapse features occur in the quadrangle. To the south, the topographic rim of the Toledo Embayment represents a major collapse feature that likely occurred during the formation of the Toledo Caldera at approximately 1.6 Ma (Gardner and Goff, 1996). The actual structure, however, is obscured by voluminous flows of Cerro Toledo rhyolite lavas (Qct) and modern colluvium (Qc) from the Tschicoma rim rocks. A second, much smaller collapse feature occurs at El Lagunito de Palo Quemador in the northeast portion of the quadrangle. This feature is approximately 1/4 x 1/2 km in size and is filled by obsidian and devitrified El Rechuelos rhyolite. This crater likely formed after an explosive eruption of the rhyolite, as no lava flows of the rhyolite are recognized outside of the crater.

In Cañones Canyon, NE-SW-trending faults are exposed that offset Bandelier Tuff and older rocks. Possibly, a major fault extends along the axis of the canyon but is concealed by the thick deposits of Bandelier Tuff. Samples of basalt exposed along the canyon floor may correlate with Lobato basalt along the canyon's eastern rim, and samples of both lavas have been submitted for geochronological analyses. Exposures of Santa Fe Group Ojo Caliente sandstones along the eastern side of Cañones Canyon are consistently tilted to the east at approximately 7-10 degrees, suggesting a proximity to a large structure. Early faulting and canyon formation in the area is suggested by rapidly-thickening deposits of intermediate composition lavas exposed along the eastern wall of the modern canyon. Faulting in Cañones Canyon repeatedly facilitated erosion and canyon formation, as a deep paleocanyon existed prior to the eruption of the Lower Bandelier Tuff (Otowi Member), evidenced by steep-sided contacts of the tuff with older Ojo Caliente Member sandstones (Tst) and intermediate lavas of Encino Point (Tge). A deep canyon formed again prior to the emplacement of the Upper Bandelier Tuff (Tshirege Member). Finally, the modern Cañones Canyon formed, representing one of the major drainages exiting the northern Jemez Mountains.

Volcanic History

The oldest deposits in the quadrangle, exposed along the northern boundary in Chihuahueños Canyon, belong to the Tesuque Formation, including the Miocene Chama El Rito and Ojo Caliente members (Manley, 1979). These oldest sedimentary deposits indicate a relatively flat basin-like topography during their deposition. Capping the Ojo Caliente sandstone is a thin fluvial sandstone and gravel (< 5 m thick) that includes rounded volcanic clasts of unknown origin. This deposit may correlate with the

Hernandez Member of the Chamita Formation as described by Koning and Aby (2005). A clast of andesite from a conglomerate horizon yielded yielded an age of ~29 Ma, indicating a volcanic source much older than the Jemez Mountains (Kempter et al., 2007). Possible sources include the San Juan volcanic field (a remobilized clast from the Esquibel Member?), or the Latir volcanic field (pre-Amalia Tuff).

Intercalated with these thin fluvial deposits are intermediate to mafic rocks of the La Grulla volcanic plateau and Encino Point, dated at approximately 7-8 Ma (Kempter et al., 2007) and representing the oldest primary volcanic rocks exposed in the quadrangle. Presumably, these widespread more mafic volcanic rocks underlie the thick package of Tschicoma Formation lavas that cover the eastern portion of the quadrangle.

Between ~ 7-3 Ma, volcanic activity in the area was dominated by dacitic lava and dome eruptions of the Tschicoma Formation, forming highlands along the western half of the quadrangle (Figure 2). During the early part of this interval, however, small-volume eruptions of rhyolite occurred in the southwestern portion of the quadrangle, representing Bearhead Rhyolite volcanic activity in the northern Jemez Mountains. As Tschicoma-related volcanic activity continued, high-aspect ratio flows extending from eruptive sources produced steep-walled flow lobes that are still recognizable in the modern topography. The major dacitic domes erupted during this episode occur along a north-south trend extending from Chicoma Mountain in the south to Cerro Pelon to the north. Puye Formation fanglomerate deposits, contemporaneous with Tschicoma-age volcanism in the eastern Jemez Mountains (Waresback, 1986), are poorly represented in the northern Jemez Mountains. Only one identifiable outcrop of Puye Formation was observed in the quadrangle, underlying Lower Bandelier Tuff in the West Fork of Polvadera Creek, containing rounded to subangular clasts of Tschicoma Formation dacite lavas.

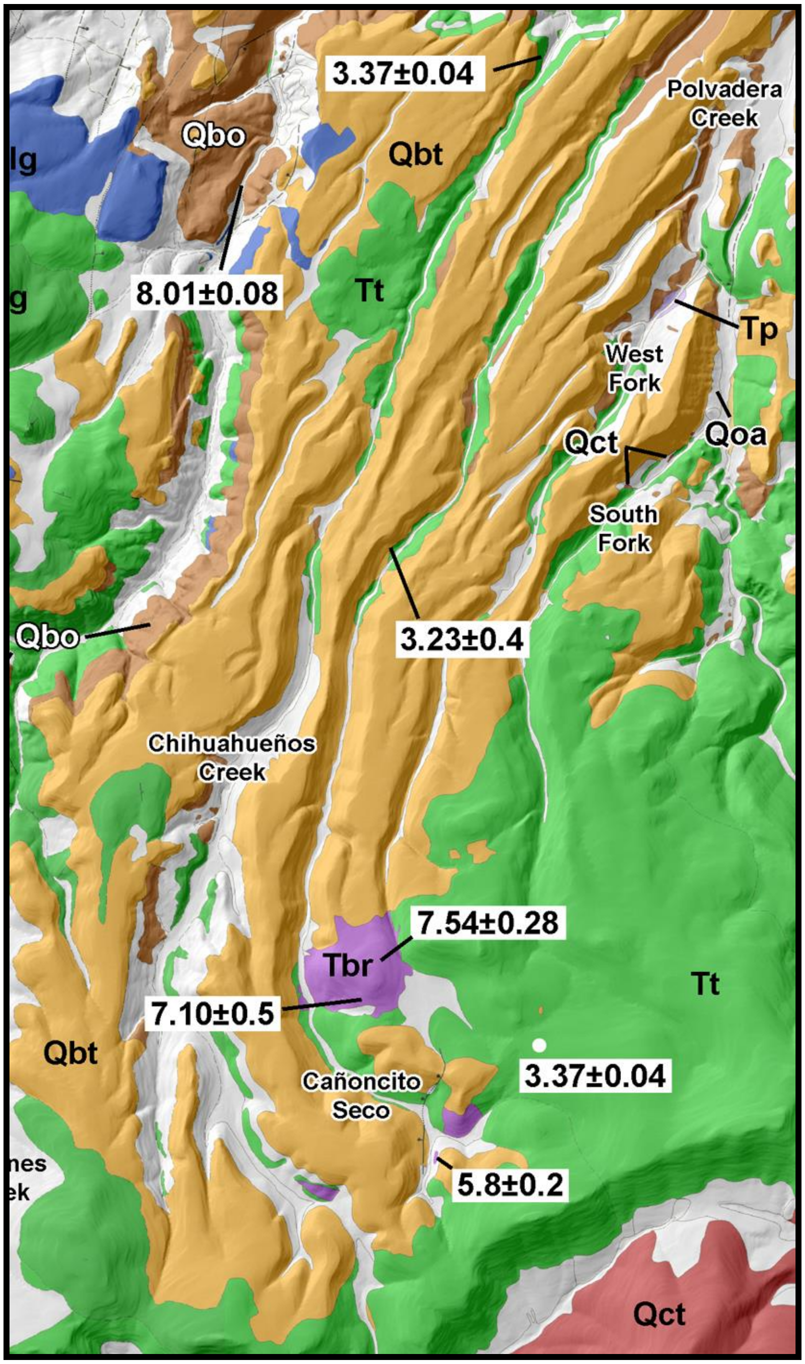

Figure 2. Simplified geologic map of the western portion of the Polvadera Peak quadrangle, including the northwest portion of the Toledo embayment. Lavas west of Cañones Creek belong to the La Grulla plateau. Thick Otowi Tuff (Qbo) filled a major paleo-Cañones Canyon to the north, capped by thin Tshirege Tuff (Qbt). Ages of Tschicoma dacite lavas (Tt) from the rim of the Toledo embayment to the northern part of the quadrangle are virtually identical (3.23 to 3.37 Ma), possibly representing a single flow. Several outcrops of Bearhead Rhyolite are exposed in the vicinity of Cañoncito Seco, giving ages of 5.8 to 7.5 Ma. Rare sediments of Puye Formation (Tp), Cerro Toledo (Qct),

post-Bandelier Tuff alluvium (Qoa) are exposed in the South Fork and West Fork of Polvadera Creek. Cerro Toledo lavas (Qct) are in the Toledo embayment.

At approximately 2.0 Ma (Loeffler, 1984; Goff, pers. comm) El Rechuelos Rhyolite activity occurred along a north-south trending fracture along the western margin of Polvadera Peak. Three eruptive centers are recognized, as viscous domes and short-traveled flows were superimposed on the underlying Tschicoma highland surface. The largest dome, approximately 1.5 km northwest of Polvadera Peak, exhibits landslide scarps along its northwestern flank. Two satellite outcrops of El Rechuelos Rhyolite in Cañada de Ojitos Creek may represent the detached flanks from the original dome, emplaced prior to the eruption of the Bandelier Tuff.

The next major volcanic event was the eruption of the Toledo Caldera and the emplacement of the Otowi Member, Lower Bandelier Tuff at approximately 1.6 Ma (Izett and Obradovich, 1994).. Rare exposures of the base of the Otowi in a side canyon to Cañones Canyon in the northwestern corner of the quadrangle reveal the eruption was preceded by a lahar deposit (Qol) that includes large boulders of mafic lava and Tschicoma dacite (Tt). Possibly, tumescence of the region shortly prior to the eruption triggered this lahar deposit. No deposits of Guaje Pumice were observed at the base of the Otowi in the field area. The Toledo embayment along the southern margin of the quadrangle is believed to have formed during this event (Gardner and Goff, 1996). Thick deposits (> 100 meters) of moderately to welded Otowi are preserved in the Cañones and Chihuaheños canyon walls (Figure 3).

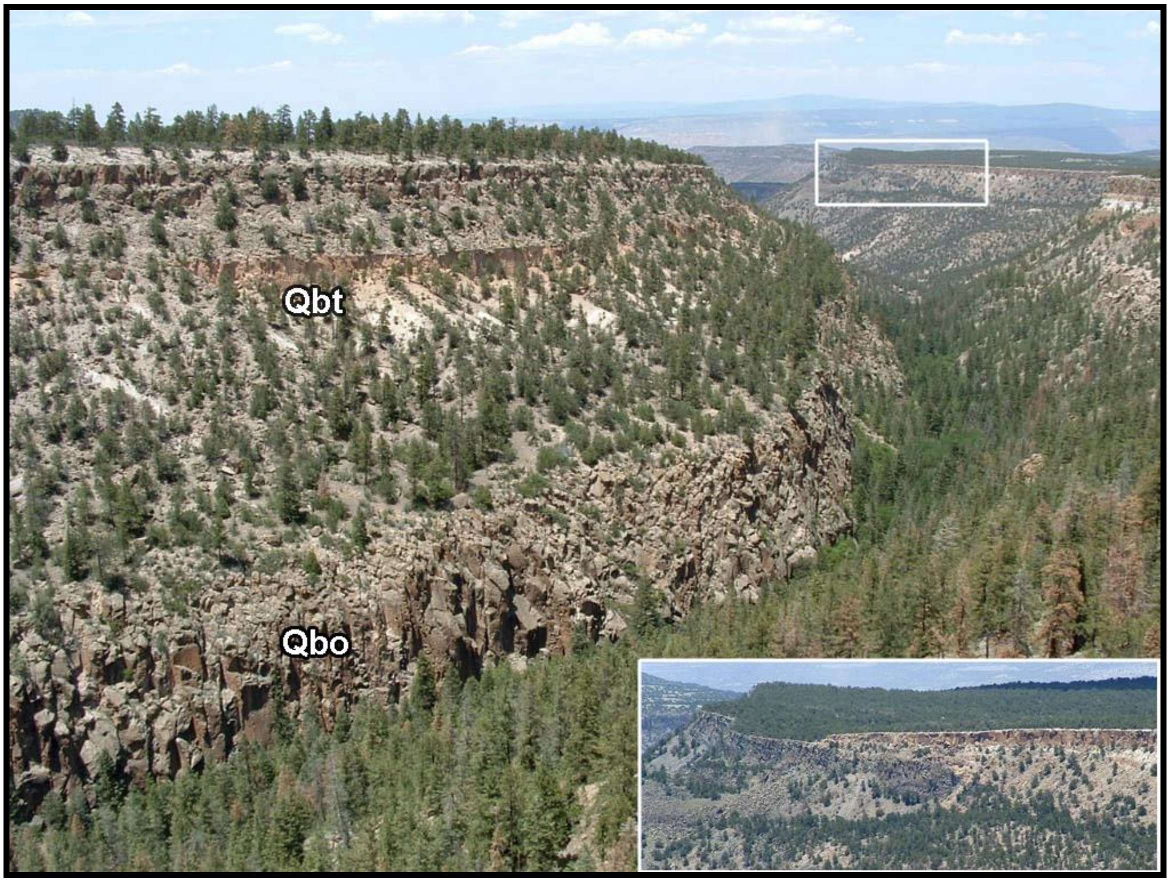

Figure 3. Cañoncito Seco heading into the Cañones quadrangle showing layered Upper Bandelier Tuff (Tshirege member, Qbt) above massive, moderately to densely welded Lower Bandelier Tuff (Otowi member, Qbo). In general the Otowi member is more welded than the Tshirege Tuff in the northern Jemez Mountains. Note onlap of Tshirege Tuff on basalts of Polvadera Mesa down canyon.

Between major Bandelier Tuff eruptions the Cerro Toledo interval was emplaced. In the Polvadera Peak quadrangle this includes voluminous rhyolitic lavas that filled the Toledo embayment, and thin fluvial sediments preserved in rare exposures along the South Fork of Polvadera Creek. These sediments are dominantly composed of Tschicoma-related clasts, but also include obsidian and El Rechuelos Rhyolite clasts.

Eruption of the Tshirege Member, Upper Bandelier Tuff at approximately 1.25 Ma (Phillips et al., 2007) capped the volcanic sequence in the Polvadera Peak region. The underlying Tsankawi Pumice deposit is exposed in several locations and is typically > 1 meter in thickness (Figure 4). Although of similar volume to the earlier Otowi Member, the Tshirege Member eruption was slightly more extensive in the region, lapping onto the Tschicoma and El Rechuelos highland topography in the middle of the quadrangle.

Figure 4. Shari Kelley providing scale for Bandelier Tuff deposits. The Otowi Member tuff is gray, reaching her head level. Two meters of overlying Tsankawi tephra are then overlain by pyroclastic flow deposits of the Tshirege Member tuff.

Erosion of the area has been the dominant process in the region in the past million years. Besides Late Quaternary alluvial and colluvial deposits, few sediments appear to have been deposited following the Upper Bandelier Tuff eruption. An exception is an old alluvial channel preserved along the western margin of Polvadera Creek Canyon (Qoa). This deposit, which exceeds 30 meters in thickness, includes clasts of Upper Bandelier Tuff, but is dominated by clasts of Tschicoma dacite and El Rechuelos rhyolite. We interpret a Polvadera Creek paleocanyon backfilled with alluvium when a resistant mound of Tschicoma dacite was exhumed downstream. Eventually, downcutting resumed, with the new canyon offset slightly eastward of the paleovalley.

Figure 5. Unusual debris field of tabular Tschicoma dacite blocks along a flat ridge between Polvadera Peak and Tschicoma Peak. The deposit has been mapped as a Quaternary rock glacier (Qrg), and possibly mobilized via interstitial ice and/or thawing alpine permafrost, providing a buoyant substrate facilitating slow creep on nearly flat topography.

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