

# **Preliminary Geologic Map of the Bear Springs Peak Quadrangle, Sandoval County, New Mexico**

By

**Kirt Kempter, G. Robert Osburn, Shari Kelley, Michael  
Rampey, Charles Ferguson, and Jamie Gardner**

**May, 2003**

**New Mexico Bureau of Geology and Mineral Resources  
*Open-file Digital Geologic Map OF-GM 74***

**Scale 1:24,000**

This work was supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program (STATEMAP) under USGS Cooperative Agreement 06HQPA0003 and the New Mexico Bureau of Geology and Mineral Resources.



**New Mexico Bureau of Geology and Mineral Resources  
801 Leroy Place, Socorro, New Mexico, 87801-4796**

*The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government or the State of New Mexico.*

# **Preliminary Geology of the Bear Springs Peak 7.5-minute quadrangle, Sandoval County, New Mexico**

Kirt Kempter<sup>1</sup>, G. Robert Osburn<sup>2</sup>, Shari Kelley<sup>3</sup>, Michael Rampey<sup>4</sup>, Charles Ferguson<sup>5</sup>,  
Jamie Gardner<sup>6</sup>

(1) 2623 Via Caballero del Norte, Santa Fe, NM 87505

(2) Earth and Planetary Science Dept., Washington University, St. Louis, MO 63130

(3) New Mexico Bureau of Geology and Mineral Resources, Socorro, NM 87801

(4) Dept. of Geology, Queen's College, Cambridge University, CB39ET, United Kingdom

(5) Arizona Geological Survey, Tucson, AZ 85701

(6) Earth and Environmental Science Division, Los Alamos National Laboratory, Los Alamos,  
NM 87545

New Mexico Bureau of Geology and Mineral Resources

Open-file Geologic Map OF-GM 74

May 2003

Updated September 2004 and June 2007

## **Location**

The Bear Springs Peak quadrangle is in the heart of the older part of the 18.7 Ma to ~50 ka Jemez volcanic field in the southern Jemez Mountains. Volcanic activity in the Jemez Mountains culminated with the formation of two geographically coincident calderas, the 1.61 Ma Toledo caldera and 1.25 Ma Valles caldera, both of which lie to the north of the quadrangle. This area is on the western edge of the Española Basin, one of several basins in the northerly-trending Rio Grande rift. Small outcrops of red Triassic Chinle Group siltstone in the northwest corner of the quadrangle help define the western margin of the basin.

The rugged and heavily-forested terrain of the Bear Springs Peak quadrangle is in a remote part of the southern Jemez Mountains, accessible only by forest roads, most notably Forest Road 266. Although most of the area is part of the Santa Fe National Forest, a strip of land belonging to the Pueblo of Jemez occupies a significant portion of the middle of the map. We thank Steve Blodgett of the Department of Resource Protection at the Pueblo of Jemez for permission to work in this area.

## Previous Work

Smith et al. (1970), on their classic geologic map of the Jemez Mountains, were the first to establish the geologic framework of the Bear Springs Peak area. Guilbeau (1982) and Guilbeau and Kudo (1985) examined Ruiz Peak in detail, identified the “rhyodacite of La Jara Canyon”, and provided some of the first geochemical data for the volcanic rocks in the southern Jemez Mountains. Gardner (1985) and Gardner et al (1986) mapped the Bear Springs Peak area in more detail and refined the stratigraphy of the region by obtaining and analyzing geochronology and geochemical data from volcanic rocks throughout the Jemez Mountains, including several samples from the Bear Springs Peak quadrangle. More recent studies in the southern Jemez Mountains involved collecting geochronology and geochemical data from outcrops mainly near roads and trails (Justet, 1999; 2003; Justet and Spell, 2001, Wolff et al., 2005).

## Rock Name Terminology

We followed the rock name nomenclature of Smith et al. (1970) and Gardner et al. (1986) during the mapping of this area. More recent geochemical work in this area (Justet, 1999; 2003; Justet and Spell, 2001, Wolff et al., 2005) has revealed that many of the rocks that we called “basalt” are in fact trachyandesite. The “andesite” and “dacite” are actually the alkalic equivalents. The only true basalts are the basalt of Chamisa Mesa and the basalt of Bodega Butte.

## 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. Maximum thickness can exceed 5 meters.

**Qe – Upland alluvium, colluvium, and eolian deposits, undivided. Holocene to upper Pleistocene (?).** Poorly sorted alluvial gravel, sand, and silt interbedded with fine-grained, well-sorted eolian sand and silt. May be locally interbedded with El Cajete ash (Qec). Commonly found in flat, broad areas adjacent to major drainages on the flat tops of ridges and divides in the southwest portion of the quadrangle. Generally <1 m thick.

**Qc – Colluvium. Late Pleistocene to Holocene.** Poorly-sorted talus, debris, and colluvium in wedgeshaped deposits on hill slopes. Especially common where mesas and cuestas are capped by intermediate to mafic lavas or Tertiary gravels. 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 <10 meters.

**Qtal - Undifferentiated terraces and alluvium.** Late Pleistocene to Holocene.

**Qls – Landslides. Pleistocene to Holocene.** Slump or block slides that remain nearly intact after detaching from a steep slope or cliff, or 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. Thicknesses highly variable.

**Qec – El Cajete Member tephra (Valles Rhyolite). Quaternary.** White to beige pyroclastic fall deposits, including pumice, ash, crystals, and lithic fragments associated with the ~50 to 60 ka eruption of the El Cajete Member of the Valles Rhyolite (Reneau et al., 1996). Primary deposits are exposed in at least 2 active mines in the northwest corner of the quadrangle where the unit is poorly to moderately sorted. Typically, however, exposures of this unit are reworked, displaying few bedding features. Phenocryst content of pumices is generally less than 10% and includes quartz, sanidine, and biotite. Many of the hills in the northern portion of the quadrangle are covered with >1 meter of primary or reworked tephra. To the south the tephra thins significantly and typically is exposed as isolated patches along hillslopes or capping terrace and other alluvial deposits along drainage bottoms. Maximum thickness in primary deposits exceeds 5 meters.

**Qbt –Bandelier Tuff, Tshirege Member. Quaternary.** White to beige non-welded to welded ash-flow tuff containing abundant phenocrysts of quartz and sanidine. Exposed primarily in the northwest corner of the quadrangle and as isolated outcrops in Paliza and Peralta canyons. Basal Tsankawi pumice only recognized in exposures along San Juan Canyon, overlain by multiple (at least 3) flow units. Erupted at approximately 1.22 Ma during the formation of the Valles Caldera (Spell et al., 1996). Maximum thickness is approximately 170 meters.

**Qbo – Bandelier Tuff, Otowi Member. Quaternary.** White to beige non-welded ash-flow tuff containing abundant phenocrysts of quartz and sanidine and sparse mafic phenocrysts. Moderate to abundant lithic fragments, primarily of andesitic or mafic lavas. This unit is best exposed in the northwest corner of the quadrangle where it filled a large paleocanyon, later reincised to form the modern San Juan Canyon. Isolated exposures also occur in Peralta Canyon where capped (preserved) by the Tshirege Member. Erupted at approximately 1.61 Ma during the formation of the Toledo Caldera (Spell et al., 1996). Maximum thickness is approximately 70 meters.

**Tglp - Gravel of Lookout Park.** Stratified cobble to boulder gravel almost entirely derived from upper Miocene volcanic strata. Relative proportions of basalt, basaltic andesite, andesite, dacite and rhyolite clasts vary with the bedrock lithology of the local provenance. The Gravel of Lookout Park, as mapped in the Loma Creston quadrangle to the south of the map area, is both slightly older than and slightly younger than the upper Pliocene basalts (ca. 2.5 Ma) that cap Santa Ana Mesa (Chamberlin et al., 1999).

**Tc – Tertiary Cochiti Formation, Santa Fe Group.** Upper Miocene to Pliocene. Volcaniclastic sediments with pebble to cobble-sized clasts derived primarily from Paliza Canyon, Canovas Canyon, and Bearhead rhyolite units in the study area. This unit includes conglomeratic sandstones interbedded with fine-grained sands and silts, covering much of the southern and southeastern portion of the quadrangle. Maximum thickness is approximately 100 meters.

**Tbp – Peralta Tuff Member of the Bearhead Rhyolite.** Upper Miocene. Lithic-rich tuffs and minor tuff breccias. Typically white to beige, poorly-welded with sparse phenocrysts of quartz, biotite, plagioclase, and quartz. The most voluminous and widespread tuff of this unit occurs along the footwall of the Yelo fault, extending to the NE towards Bear Peak on the Cañada quadrangle. Pumice from the tuff of Cerrito Yelo on the Cañada quadrangle is  $6.29 \pm 0.08$  Ma. At Cerrito Yelo this tuff is overlain by a younger, phenocryst-rich rhyolite lava. Preliminary correlation of this tuff on the west side of the Yelo fault is stratigraphically above dacite lavas in the vicinity of Ruiz Peak and intercalated with andesite flows on the east side of Tres Cerros. Exposures of this tuff east of Ruiz Peak are strongly bedded with large ( $> 1$  meter) and abundant lithics, suggesting a nearby source. Maximum thickness of this unit exceeds 70 meters.

**Tbr – Bearhead Rhyolite. Upper Miocene.** Light gray to white rhyolite lavas and associated pyroclastic deposits, typically crystal-poor, with sparse phenocrysts of quartz, sanidine and biotite. Lavas typically have a high-aspect ratio and erupted along N-S-trending or NE-SW-trending structures. Some rhyolites of this unit, including two domes just north and west of Tres Cerros, are moderately crystal rich, with abundant quartz and sanidine phenocrysts and lesser amounts of biotite. Most of the lavas from this episode of volcanism occur in the southeast portion of the quadrangle, possibly related to a batholithic magma chamber emplaced at approximately 6.8 Ma (Justet, 1999; Justet and Spell, 2001). The most voluminous and contiguous outcrops of this unit are exposed in Peralta Canyon, where hydrothermal alteration is locally pervasive. A rhyolite lava located east of Tres Cerros (0361690 3950778) has an  $^{40}\text{Ar}/^{39}\text{Ar}$  date of  $6.86 \pm 0.28$  Ma on sanidine and a rhyolite lava north of Paliza Canyon has an  $^{40}\text{Ar}/^{39}\text{Ar}$  age of  $6.66 \pm 0.61$  Ma on biotite. Cerrito Yelo is the youngest phase of Bearhead volcanism at  $6.04 \pm 0.06$  to  $6.16 \pm 0.03$  Ma (Justet and Spell, 2001). Maximum thickness exceeds 150 meters.

**Tpmc –Trachyandesite of Mesita Cocida. Paliza Canyon Formation. Miocene.** Medium to dark gray diktytaxitic lavas, poorly to moderately porphyritic with rare phenocrysts of plagioclase, pyroxene and trace amounts of olivine and hornblende. The weathered outcrop is platy in appearance. Massive, flow banded, and vesicular horizons are common. Chamberlin and McIntosh (2007) determined an age of  $7.09 \pm 0.21$  Ma for

this unit based on three samples on Mesita Cocida on the Loma Creston quadrangle. Maximum thickness exceeds 20 meters.

**Tpv – Volcaniclastic deposits. Paliza Canyon Formation. Miocene.** Volcaniclastic conglomerates, sandstones and silts of mixed provenance. Older sediments of this unit are primarily intercalated with thin basalt flows of the Paliza Canyon Formation and tephra of the Canovas Canyon Rhyolite, whereas the younger gravels are intercalated with andesite and dacite lavas. These gravels thicken to the southwest towards Borrego Mesa and exhibit southeast-trending imbrication. Maximum thickness is approximately 100 meters.

**Tpdb- Biotite-bearing rhyodacite, Paliza Canyon Formation. Miocene.** Light to dark gray and pink porphyritic lavas with phenocrysts of plagioclase and biotite with minor hornblende (Guilbeau, 1982; Guilbeau and Kudo, 1985). Guilbeau (1982) referred to this unit as the rhyodacite of La Jara Canyon.

**Tpa – Andesite. Paliza Canyon Formation. Miocene.** Typically medium gray to reddish purple porphyritic lavas and associated pyroclastic deposits. Phenocryst content is typically <20% and includes acicular plagioclase with less abundant pyroxenes (clinopyroxene and/or orthopyroxene). Flow banding is common, as are vesicular and brecciated horizons. Debris flow deposits, typically less than 5 meters in thickness, occur intercalated with lava flows. A thick package of these andesitic units occurs north and east of Tres Cerros, suggesting a source in this vicinity. One distinctive flow, dark gray and very fine-grained with sparse phenocrysts of plagioclase and pyroxene, occurs in numerous outcrops peripheral to Cerrito Yelo. This unit is offset by several faults that radiate from the Cerrito Yelo center and is overlain by the Peralta Tuff Member of the Bearhead Rhyolite. An  $^{40}\text{Ar}/^{39}\text{Ar}$  date for a flow near the top of this unit at Tres Cerros is  $10.8 \pm 1.5$  Ma on hornblende. Maximum thickness of this unit exceeds 200 meters.

**Tpbb – Basalt of Bodega Butte. Paliza Canyon Formation. Miocene.** Dark gray olivine basalt that is massive to vesicular and moderately porphyritic with phenocrysts of plagioclase, olivine and pyroxene. Phenocryst content is typically < 10% with olivine commonly altered to reddish-brown iddingsite. Weathered surfaces on the basalt are covered with distinctive reddish speckles. Basalt breccias and vesicular horizons are common. This widespread unit in the southeast portion of the quadrangle appears to have been emplaced during one eruptive episode, although separate flows may have overlapped. An  $^{40}\text{Ar}/^{39}\text{Ar}$  date for this unit from a sample collected at the confluence of Hondo and West Fork Canyons is  $9.10 \pm 0.13$  Ma. Chamberlin and McIntosh (2007) determined an average age of  $9.14 \pm 0.12$  Ma from four samples on the Loma Creston quadrangle to the south. Maximum thickness of unit exceeds 30 meters.

**Tpd – Dacite . Paliza Canyon Formation. Miocene.** Light to dark gray porphyritic lavas with phenocrysts of plagioclase, hornblende, and biotite. Some lavas also contain small amounts of quartz and pyroxene. Flows are typically massive but can also exhibit flow banding and brecciated horizons. An older sequence of dacites, exposed along Forest Road 266 between Bear Springs Peak and Cerrito Yelo, is stratigraphically below

most of the thick andesite package to the north. The andesite package is then capped by a younger dacitic sequence of lavas and domes. These dacitic lavas, including dome complexes at Cerro Ruiz and north of Paliza Canyon, tend to be more coarsely porphyritic, with phenocrysts of plagioclase (up to 1 cm across), pyroxene, and rare hornblende or biotite. Maximum thickness of this unit exceeds 150 meters.

**Tpbi - Basaltic dikes associated with basalts of the Paliza Canyon Formation. Miocene.**

**Tpb/Tpbs/Tpbt. Basalt. Paliza Canyon Formation. Miocene.** Medium to dark gray lavas and associated scoria deposits (**Tpbs**). Poorly to moderately porphyritic with phenocrysts of plagioclase and pyroxene. Trace amounts of olivine and/or hornblende may be present. Flows are typically flow banded and platy. Brecciated basal and top horizons of flows and vesicular horizons are also common. Most of the flows are intercalated with gravel deposits (Tpv) and appear to have originated along N-S structures related to the western Cocido fault zone, flowing to the southeast. An  $^{40}\text{Ar}/^{39}\text{Ar}$  date for a flow from the base of this unit is  $9.54 \pm 0.08$  Ma. Maximum thickness of individual flows can exceed 30 meters.

**Tcc/Tct – Canovas Canyon rhyolite lavas (Tcc) and associated pyroclastic and alluvial deposits (Tcct). Miocene.** Mostly beige to pinkish-gray, flow-banded, phenocryst-poor lavas. Dark grey to green obsidian facies common in more voluminous flows. Phenocrysts are typically small (< 2 mm) and include biotite, sanidine, and rare quartz. West of the Cocida fault zone pyroclastic deposits are intercalated with sandstones, tuff breccia, and tephra deposits. The largest contiguous flow occurs east of Bear Springs Peak and covers an area of > 6 km<sup>2</sup>. Although the thickness of this unit is unknown (the base of the flow is not exposed), the flow is widespread and appears to have a relatively low-aspect ratio more typical of lavas with a lower silica content. A similarly widespread pyroclastic flow overlies the lava and in several locations the two units appear to be intimately associated with one another, suggesting a continuum in the eruption process. Other rhyolite lavas of this unit are of limited lateral distribution (< 1 km<sup>2</sup>) and exhibit a more typical high-aspect ratio morphology. Most of the Canovas Canyon rhyolites were erupted along N-S-trending faults active during the Mid-Miocene.  $^{40}\text{Ar}/^{39}\text{Ar}$  dates for biotite from flows at 0361786 3948981 and 357602 3946081 are  $8.81 \pm 0.16$  Ma and  $9.75 \pm 0.08$  Ma, respectively. Justet (2003) determined  $^{40}\text{Ar}/^{39}\text{Ar}$  dates of  $9.30 \pm 0.05$  Ma for Borrego Dome and  $8.00 \pm 0.60$  and  $8.65 \pm 0.35$  Ma for flows from the Bear Springs Peak center. Maximum thickness exceeds 150 meters.

**Tpcm - Basalt of Chamisa Mesa. Miocene.** Dark gray to black, aphyric to phenocryst poor basalt with rare phenocrysts of olivine and plagioclase. Chamberlin and McIntosh (2007) determined a  $^{40}\text{Ar}/^{39}\text{Ar}$  age of  $9.9 \pm 0.9$  Ma for this flow based on two samples from the Loma Creston quadrangle to the south. Justet (2003) calculated a  $^{40}\text{Ar}/^{39}\text{Ar}$  age of  $10.96 \pm 0.29$  for the flow exposed in Borrego Canyon in the southwestern corner of the quadrangle.

**Tsc** - **Cerro Conejo Formation, Santa Fe Group. Miocene.** Tan to red, moderately to well-sorted sandstone with rounded quartz sand grains. Tabular beds intercalated with the Canovas Canyon Rhyolite tuff facies. This unit becomes thicker to the south.

**Tku (on cross-section A-A') – Undivided Keres Group volcanic rocks.**

**TRc (on cross-section A-A') – Undivided Triassic Chinle Group.**

**TRcs (on cross-section A-A') –Triassic Shinarump Formation. Chinle Group.**

**TRu – Undivided upper part of Chinle Group.** Poorly exposed red siltstone in the northwestern part of the quadrangle.

**TRm(on cross-section A-A')- Triassic Moenkopi Formation.**

**Pu (on cross-section A-A') – Undivided Paleozoic sedimentary rocks.**

### **Geologic Overview**

The Bear Springs Peak (BSP) quadrangle in the southern Jemez Mountains records a significant portion of Keres-Group volcanism, the earliest phase of volcanic activity in the Jemez Mountains. Volcanism in the BSP area occurred primarily along N-S structural features during the time that this area represented the western margin of the Rio Grande rift. However, the oldest rocks in the quadrangle are poorly exposed siltstones that probably belong to the Petrified Forest Formation of the Triassic Chinle Group, a floodplain deposit associated with a 205 to 225 Ma northwesterly flowing river system. These siltstones in the northwest corner of the area likely lie on the footwall of a rift-bounding fault buried by volcanic rocks.

The next youngest rock package in the area is considerably younger. The Cerro Conejo Formation of the Santa Fe Group is a 9 to 16 Ma (Connell, 2001) eolianite deposited along the western margin of the Española Basin. Outcrops of the Cerro Conejo Formation are confined to the southern part of the area. To the west and south of the quadrangle boundaries, the Cerro Conejo Formation overlies eolian and fluvial sandstones of the Zia Formation along the edge of Borrego Mesa. Volcanism in the Jemez Mountain volcanic field began during Cerro Conejo sandstone deposition. The



relatively thin, but widespread, 9.9 Ma basalt of Chamisa Mesa is the earliest record of volcanism in this part of the Jemez Mountains.

These basalts, along with flows and tuffs of the Canovas Canyon Rhyolite, represent the earliest volcanic units in the BSP area. New and previous age data suggest that this bimodal volcanic suite was emplaced primarily between 10 – 8.5 Ma, with most of the basalts erupted west of Bear Springs Peak and rhyolites erupted primarily from N-S-trending fractures traversing the central portion of the quadrangle.

A voluminous Canovas Canyon rhyolite lava north and east of Bear Springs Peak covers an area of at least 10 (?) km<sup>2</sup>, and was likely erupted from a source along the Canovas fault zone. Overlying the lava is an crystal-poor ignimbrite (Tcct) that incorporated many lithics of the underlying lava in the lower portion of the flow. In places the lava to ignimbrite transition appears gradual, suggesting the two units were intimately associated with one another and were possibly represent a continual eruption, becoming more explosive in the later stages. No paleosols or erosional disconformities between the two units were observed in the field.

Canovas Canyon tuffs and tephras are often interbedded with thin eolian sandstones of the Cerro Conejo Formation around Bear Springs Peak, but these units are intercalated with volcanoclastic sediments and “basaltic” lava flows in the Hondo and West Fork Canyon area. A southward-dipping package of thick beds of volcanoclastic sediments and thin (1 to 5 m) “basalt” and “andesite” flows accumulated north and west of the Canovas Canyon Rhyolite domes. The “andesite” flows thicken toward the north and northeast. The area is cut by numerous N-S trending faults that were active at the time of volcanism in this part of the volcanic field, as indicated by thickening of andesitic lavas against these faults.

The last phase of Canovas Canyon silicic volcanism produced a NE-trending series of rhyodacitic lavas and domes in the vicinity of Cerrito Yelo. These dacites are porphyritic with phenocrysts of biotite and hornblende and overlie Canovas Canyon rhyolite west of Cerrito Yelo.

The Paliza Canyon Formation in the BSP quadrangle is widespread, including intercalated basalt flows and volcanoclastic sediments in the western portion of the quadrangle, a thick (> 300 meters) package of dominantly andesitic rocks exposed in the

western wall of Peralta Canyon, and a younger set of dacitic lavas exposed along the quadrangle's northern border and in the Ruiz Peak area. In general, the thick andesite package is sandwiched between the older mafic lavas and the younger dacitic lavas, with the entire sequence emplaced mostly between ~10 to 7 Ma. The youngest intermediate composition rock in the area is the 7.1 Ma trachyandesite of Bodega Butte, which was named by Chamberlin and McIntosh (2007). Flow foliations in the trachyandesite of Bodega Butte outcrop belt steepen from south to north (5° W at S to 30°W at north). The hydrothermally altered Oso Ridge fault block shows decreasing dips up section: ~ 30° in Cerro Conejo Sandstone, 15° in Tpv (Paliza Canyon volcanoclastic deposits), and 5-10° in the trachyandesite. This implies a listric geometry for the Mesita Cocida fault, which was apparently active from prior to 10 Ma to less than 7 Ma.

Rhyolitic volcanic activity in the BSP area returned shortly after 7 Ma, as a wide variety of flows, domes (Tbr) and tuffs (Tbt) related to the Bearhead Rhyolite were emplaced between  $6.57 \pm 0.05$  and  $6.90 \pm 0.02$  Ma (Justet and Spell, 2001) along the east side of the quadrangle. Although most of these rhyolites intruded as domes and plugs along earlier N-S structural features, rhyolite dikes along the western edge of Peralta canyon trend NE-SW. Rift-related structural activity continued after emplacement of the Peralta tuff member, as > 60 meters of displacement of this unit is observed along the Cerrito Yelo fault south of Cerrito Yelo. We identified a previously unrecognized Bearhead Rhyolite center in the northwest corner of the quadrangle (355600 3955800, NAD 27,  $6.66 \pm 0.61$  Ma).

The Peralta Tuff member of the Bear Springs Rhyolite, which includes at least 12 ignimbrites interbedded with volcanoclastic sediments (Smith and Lavine, ???), is well exposed in the quadrangle and frequently caps older basalts, andesites, and dacites of the Paliza Canyon Formation. A particularly voluminous ignimbrite of the Peralta Tuff member covers much of the SW corner of the quadrangle and is overlain by fan conglomerate gravels of the Cochiti Formation.

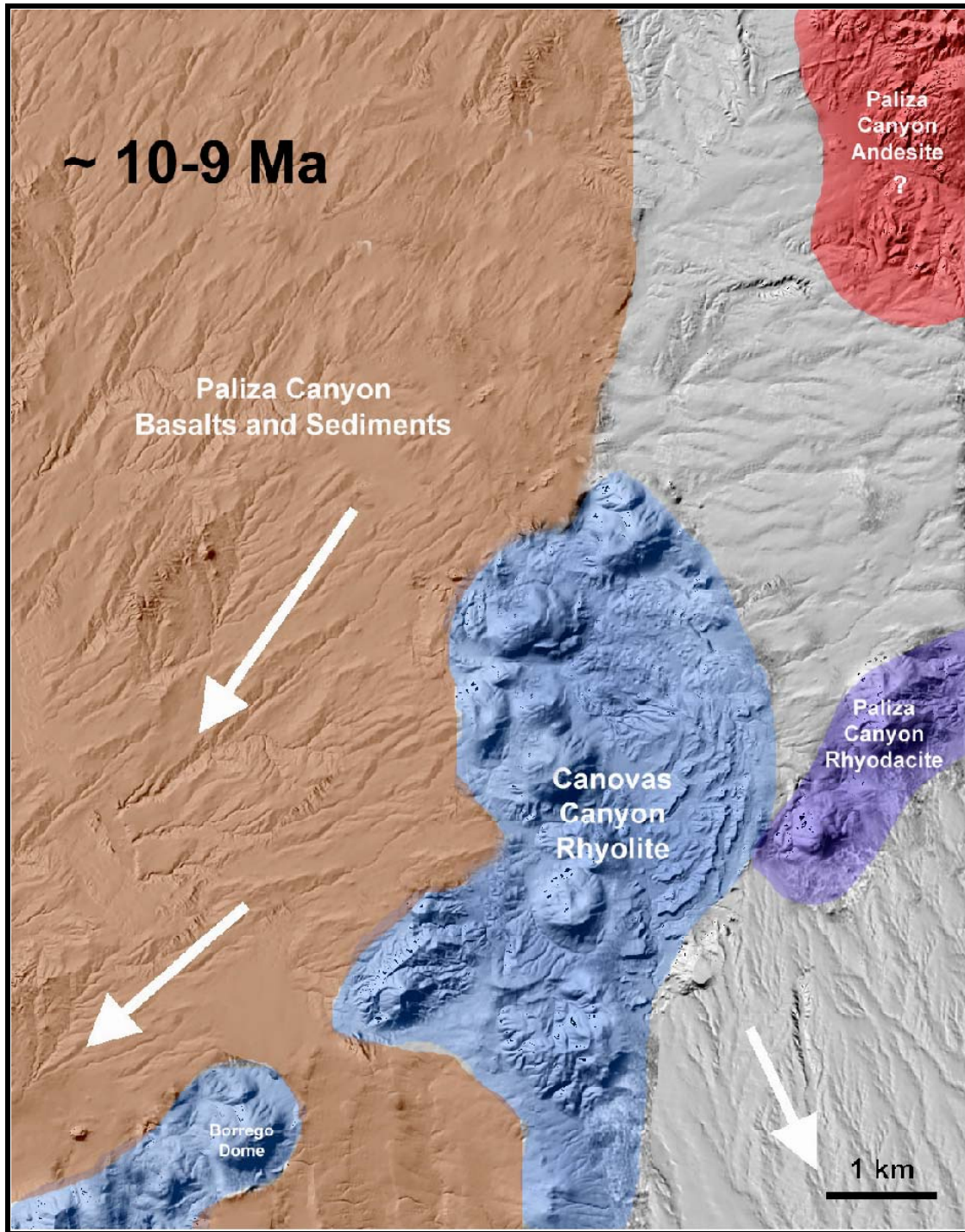
Following the Bearhead Rhyolite episode of volcanic activity, volcanism in the Jemez Mountains shifted northward while late Miocene to early Pliocene volcanoclastic sediments of the Cochiti Formation were deposited in the southeast portion of the BSP quadrangle. After ~ 5 Ma of volcanic quiescence in the BSP area, primary volcanic

deposits reappeared in the Quaternary, as distal flows of the Bandelier Tuff (both Otowi and Tshirege members) partially filled paleocanyons where the modern Peralta, Paliza and San Juan canyons now exist. Bandelier Tuff deposits preserved in patches along the walls of Peralta Canyon record a complex record of canyon filling and erosion. A rare exposure in Peralta Canyon near the quadrangle boundary (Cañada quadrangle) reveals pre-Bandelier Tuff colluvium, overlain by Guaje tephra, lower Bandelier Tuff, Cerro Toledo Formation, Tsankawi tephra, and upper Bandelier Tuff (photo below).

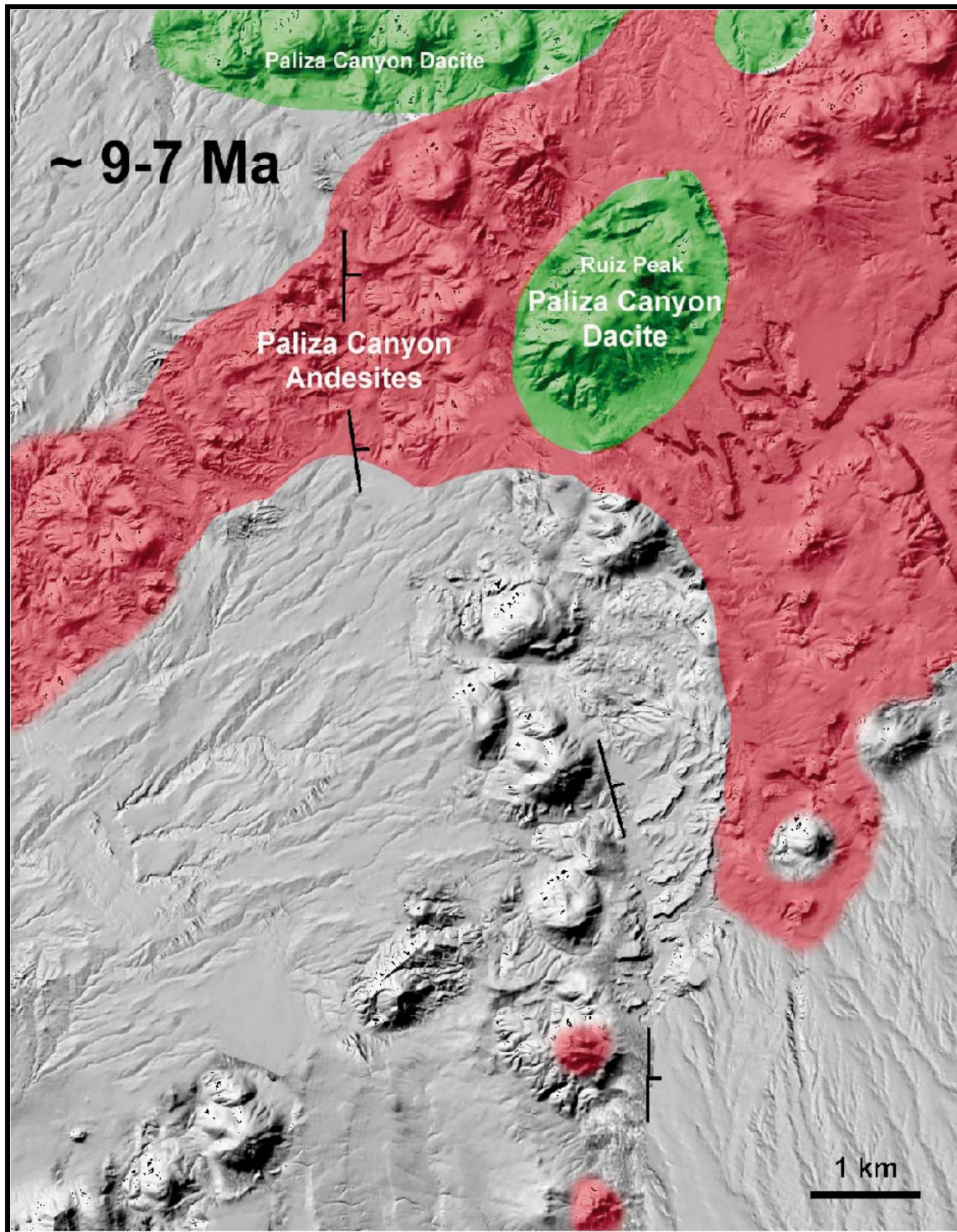
Capping the volcanic sequence is the ~50 ka El Cajete tephra, which blanketed most of the BSP area in pumice, with > 5 meters of primary deposits exposed in pumice mines north of Paliza Canyon. The distribution and thickness of the El Cajete in the BSP quadrangle, clearly indicates a strong SSE axis of dispersal from the main vent, located at the El Cajete Crater along the southern base of Redondo Peak, ~ 9 km north of the quadrangle's northern boundary.

Three paleogeographic reconstructions are provided below that show the progression of volcanic activity and sedimentation in the Bear Springs Peak area between 10 to 6 Ma. The images represent volcanic and geographic settings at three periods: 10 to 9 Ma, 9 to 7 Ma, and 7 to 6 Ma.

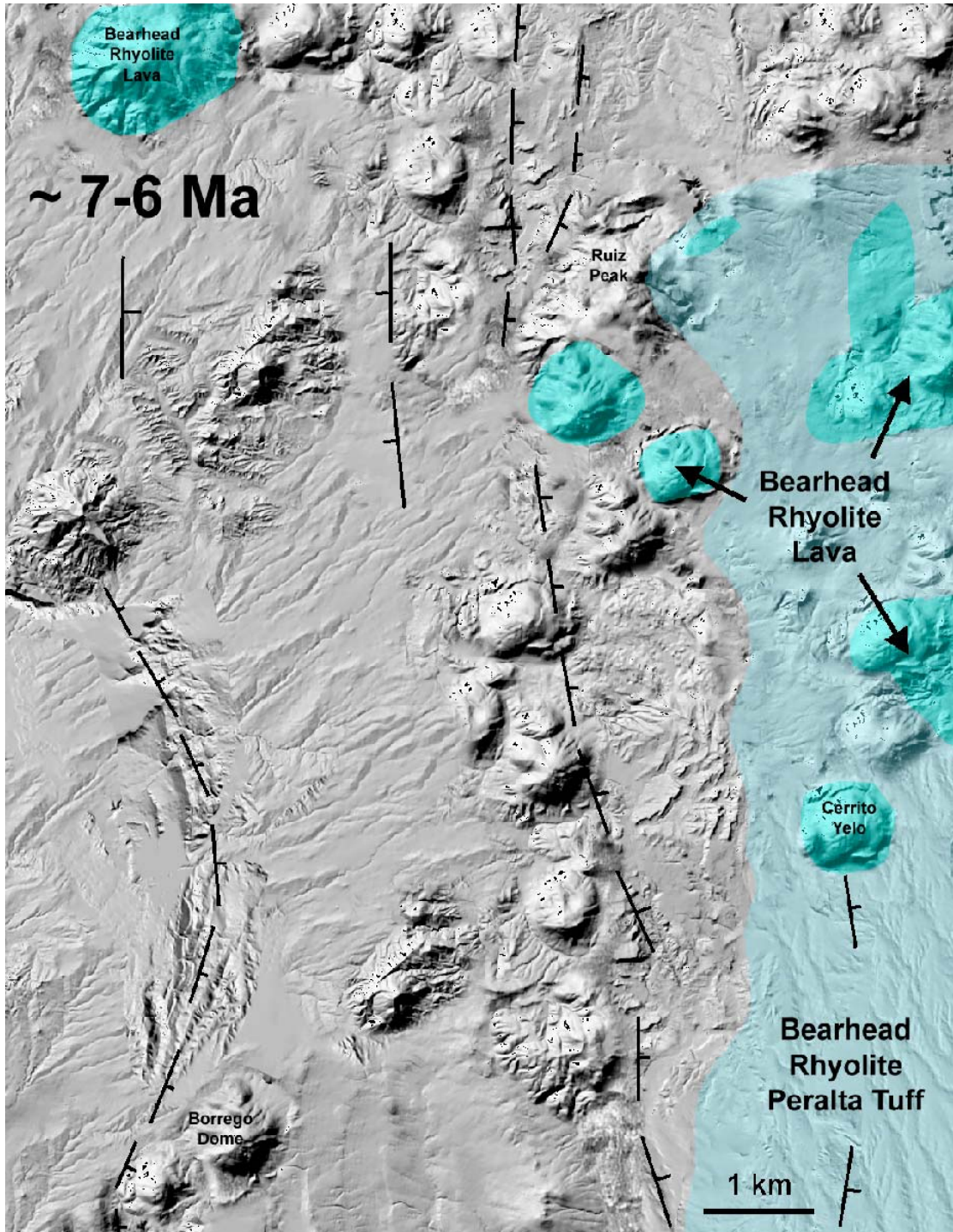




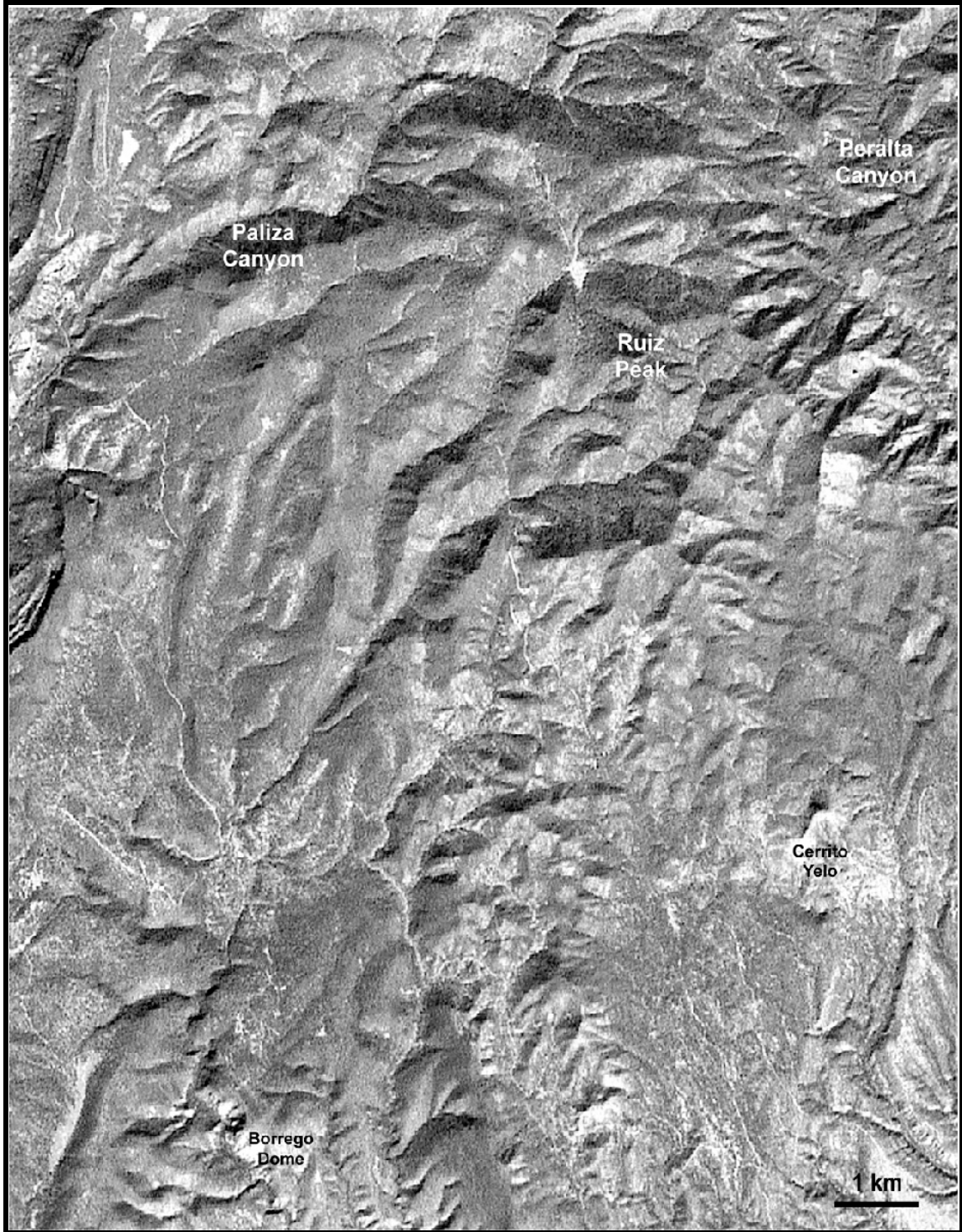
~ 10-9 Ma. In the western half of the BSP quadrangle, SW-dipping, low topography accommodated volcanoclastic sediments and basalt flows (brown). Meanwhile, voluminous outpourings of Canovas Canyon Rhyolite (blue - lavas and tuffs) created volcanic highlands in the central BSP area and a large dome to the SW (Borrego dome). Less voluminous Paliza Canyon rhyodacite (purple) and andesite (red) were also emplaced during this interval.



**~ 9-7 Ma.** Paliza Canyon andesite (red) dominated this interval of volcanism in the BSP-area, with the thickest deposits preserved to the northeast. Capping the andesitic sequence are dacitic domes and flows (green) forming Ruiz Peak and an east-west chain of domes along the northern border of the quadrangle. Ponding of andesite flows along fault escarpments indicate some N-S faults were active during this interval.



**~ 7-6 Ma.** Bearhead Rhyolite volcanism affected much of the eastern portion of the BSP area, as viscous domes (medium blue), flows and tuffs (light blue - Peralta Tuff Member), were emplaced along N-S or NE-trending structures. Cerrito Yelo, a small rhyolite dome erupted at ~ 6.0 Ma, was the last pulse of Bearhead Rhyolite activity in the area. Although many of the major faults in the BSP area were active during this interval, the most significant displacement along these faults occurred in the Pliocene.



**Modern Topography.** An ~ 5 Ma lull in volcanic activity followed the Bearhead Rhyolite interval, as volcanism in the Jemez Mountains migrated northwards. During the Pliocene, volcanoclastic sediments of the Cochiti Formation were deposited to the SE. Since the late Pliocene, widespread erosion and canyon formation of the BSP area has occurred.



## References

- Chamberlin, R.M., and McIntosh, W.C., 2007, Chronology and structural control of Late Cenozoic volcanism in the Loma Creston quadrangle, southern Jemez volcanic field, New Mexico: New Mexico Geological Society Guidebook 58, in press.
- Chamberlin, R.M., Pazzaglia, F.J., Wegmann, and Smith, G.A., 1999, Preliminary geologic map of Loma Creston quadrangle, Sandoval county, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open file report OF-DM-25: scale 1:24,000.
- Connell, S.D., 2001, Stratigraphy of the Albuquerque Basin, Rio Grande rift, New Mexico: A progress report: in Stratigraphy and tectonic development of the Albuquerque Basin, central Rio Grande rift New Mexico Bureau of Geology and Mineral Resources Open File Report 454b, p. A1-A27.
- Gardner, J.N., 1985, Tectonic and petrologic evolution of the Keres Group: Implications for the development of the Jemez volcanic field, New Mexico: Ph.D. dissertation, University of California at Davis, 172 pp.
- Gardner, J.N., Goff, E, Garcia, S., and Hagan, R.C., 1986, Stratigraphic relations and lithologic variations in the Jemez volcanic field, New Mexico: Journal of Geophysical Research, v. 91, p. 1763-1778.
- Guilbeau, K.P., 1982, Geology, geochemistry, and petrogenesis of the Upper Keres Group, Ruiz Peak area, Jemez Mountains, New Mexico: Albuquerque, University of New Mexico, M.S. thesis, 132 p.
- Guilbeau, K. P.; and Kudo, A. M., 1985, Petrology and geochemistry of the Paliza Canyon Formation and the Bearhead Rhyolite, Keres Group, Jemez Mountains, New Mexico: GSA Bulletin, Volume: 96 p. 108-113.
- Justet, L., 1999, The geochronology and geochemistry of the Bearhead Rhyolite, Jemez volcanic field, New Mexico [M.S. thesis]: Las Vegas, University of Nevada, 110 p.
- Justet, L., 2003, Effects of basalt intrusion on the multi-phase evolution of the Jemez volcanic field, NM [Ph.D. dissertation]: Las Vegas, University of Nevada, 248 p.
- Justet, L., and Spell, T.L., 2001, Effusive eruptions from a large silicic magma chamber: The Bearhead Rhyolite, Jemez volcanic field, N.M.: Journal of Volcanology and Geothermal Research, v.107, p. 241-264.
- Reneau, S.L., Gardner, J.N. and Forman, S.L., 1996, New evidence for the age of the youngest eruptions in the Valles caldera, New Mexico: Geology, v. 24, p. 7-10.

- Smith, G.A., and Lavine, A., 1996, What is the Cochiti Formation?: New Mexico Geological Society, 47th Field Conference, Guidebook, p. 219-224.
- Smith, R.L., Bailey, R.A., and Ross, C.S., 1970, Geologic map of the Jemez Mountains, New Mexico: U.S. Geological Survey Miscellaneous Investigation Series Map I-571, scale 1:125,000.
- Spell, T.L., McDougall, I. and Doulgeris, A.P., 1996, The Cerro Toledo Rhyolite, Jemez Volcanic Field, New Mexico:  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology of eruptions between two caldera-forming events. *Bulletin Geological Society America*, 108, 1549-1566.
- Wolff, J.A., Rowe, M.C., Teasdale, R., Gardner, J.N., Ramos, F.C. and Heikoop, C.E., 2005, Petrogenesis of pre-caldera mafic lavas, Jemez Mountains volcanic field (New Mexico, U.S.A.): *Journal of Petrology*, v.46, p. 407-439.