NMBGMR Open-file Geologic Map 201
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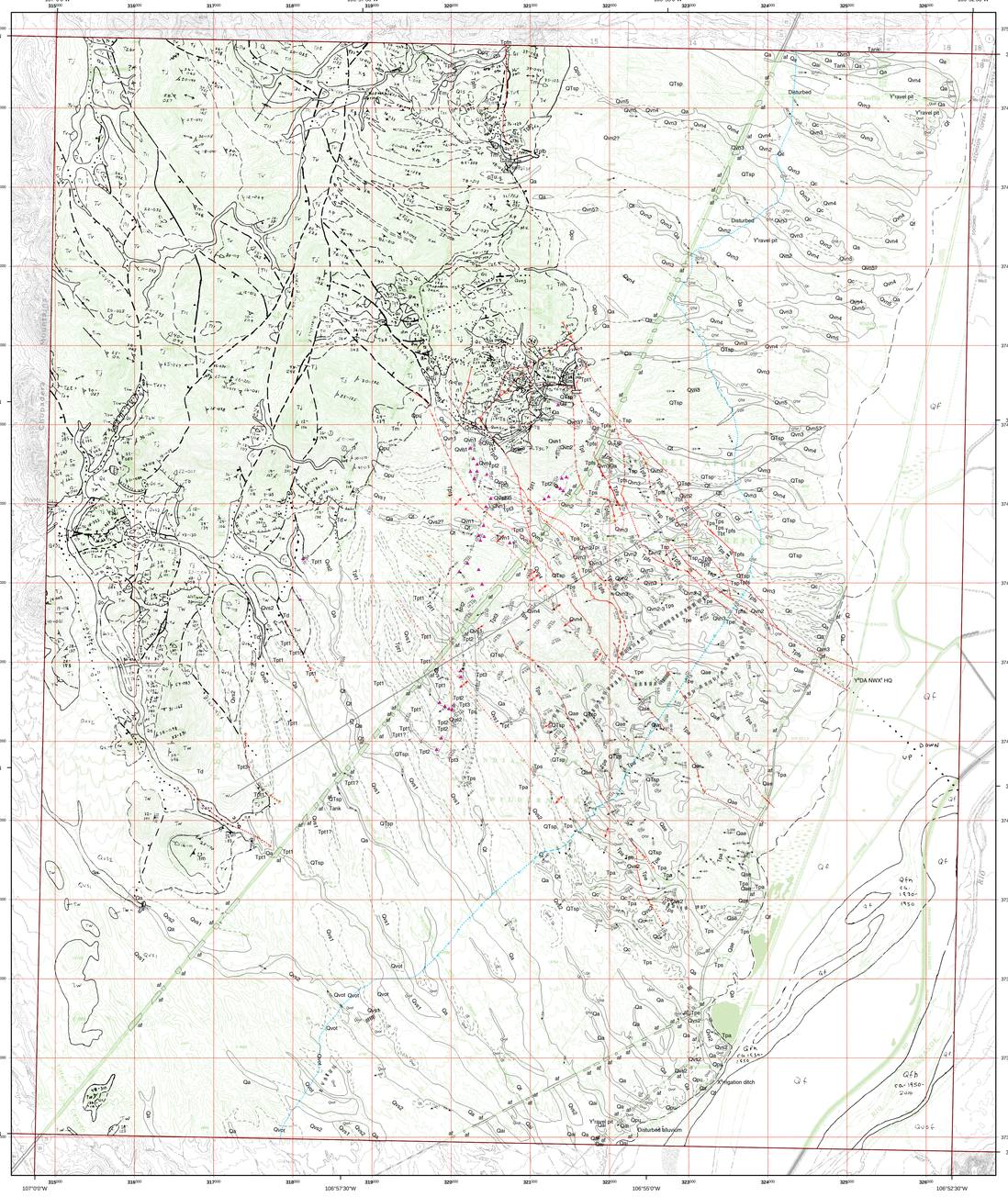
Post Santa Fe Group: Post-Santa Fe Group includes all surficial deposits inset into the Sierra Ladrones Formation and intermontane surficial deposits of middle Pleistocene to Holocene age.
af Artificial fill (Recent) — Compacted fill, as roadway subgrades along Interstate 25. Thickness ≤6 m.
Qfh Younger valley fill, axial fluvial facies, historic channels (Recent) — River channels active prior to ca. 1950 (pre-conveyance channel) flowed along the west side of the floodplain. Present-day channels are forced to flow east of the conveyance channel.
Qf Younger valley fill, axial-fluvial facies (Holocene to uppermost Pleistocene)– Floodplain and channel deposits of Rio Grande; consists mostly of clay to sand. Near San Acacia this unit grades down to well sorted gravel at basal scour surface as much as 30 m below floodplain (McGrath and Hawley, 1987). Intertongues with Qa. Thickness 0-30 m.
Qa Younger valley alluvium, piedmont facies (Holocene to uppermost Pleistocene)– Active channel, low terrace and alluvial-fan deposits of tributary arroyos; poorly sorted, non-indurated, gravel, sand, silt, and clay. Formed during last major episode of valley entrenchment and backfilling. Thickness 0–30 m.
Qae Eolian sands and alluvium undivided (Holocene to uppermost Pleistocene)– Thin, fine-grained, sand sheets locally cover, or are mixed with, young alluvium in area near Canyon Trail. Found downwind of sandstone-rich bedrock (Tpe). Eolian sands also accumulate on the lee side of ridges. Thickness is 0 to 5 meters.
Qai Incised alluvium (Holocene to uppermost Pleistocene)– Mapped where deep gullies (~3 m) are cut in young valley fills near the mouths of tributary arroyos. Found near Elmendorf, in an area of ongoing uplift (QE'). Exposed thickness 0–4 m.
Qc Colluvium (Holocene to Pleistocene)— Talus, colluvium, rock-fall deposits and some debris-flow deposits on steep to moderate slopes in the Chupadera Mountains. A notable 25m-long train of large (3x3m) jumbled blocks derived from the Blue Canyon Tuff apparently represents a rock-avalanche deposit that must have recently crossed the Chupadera Peak trail area from north to south (train trends 350 at 0320406E/3749952N). Includes gravelly slope wash on mountain-side erosion surfaces cut in poorly consolidated upper Cenozoic deposits in Socorro Basin. Primary mass-wasting processes on hillslopes masks underlying map units. Widespread colluvial veneers on dissected piedmont slopes (QTsp) are generally not delineated. Usually 0-3 m thick, as much as 10 m thick.
Qls Landslide blocks (Holocene to Pleistocene)— Large blocks of basalt lava, down slope from and apparently derived from a basalt-capped cuesta (Tbo) east of Chupadera Spring. 0-10 m thick.
Qt Terrace alluvium, undivided (latest Pleistocene to Holocene)— Narrow terrace gravels along some larger arroyos at approximately 2, 3, and 6 meters above the active channel. Thin deposits (0-3m) consist of poorly sorted, angular to rounded, cobbly gravels to pebbly sands with clast lithologies from upstream sources.
Qvm Older valley alluvium, piedmont facies, north (middle to upper Pleistocene)– Inset terrace and alluvial-fan deposits of east flowing tributary arroyos associated with five episodes of valley entrenchment and backfilling (Qvr1 to Qvr5, oldest to youngest respectively; mapped only north of the BDA fault). Poorly sorted, angular to rounded, bouldery to pebbly gravels, gravelly sand and muddy silts were derived from the Chupadera Mountains. Sparse scholl clasts are notable east of Chupadera Spring and red rhyolite clasts are abundant east of Chupadera Peak. Mostly reddish and non-indurated, but uppermost beds are locally cemented by pedogenic carbonate horizons 0.1 m to 0.6 m thick. Thickness 0-30m.
Qvs Older valley alluvium, piedmont facies, south (middle to upper Pleistocene)– Inset terrace and alluvial-fan deposits of tributary arroyos associated with two apparent episodes of valley entrenchment and backfilling; mapped only south of the BDA fault. Poorly to moderately sorted, angular to rounded, sandy to bouldery deposits associated with gravelly sand surfaces that project west of the Rio Grande. Younger deposits scattered east of Kilmpy Tanks. Contains remains of light grey tuffs and dark grey andesites. Older fan deposits near Tiffany Canyon (Qvs1) contain crystal-rich tuff clasts from the southeastern Magdalena Mountains. Exposed thickness 0-6 m.
Qvof Older valley fill, axial fluvial facies, Rio Grande terrace deposits (middle to upper Pleistocene)– Light gray to light yellowish brown, well sorted sand and gravel. Well rounded to subrounded quartzite, most fresh chert, granite, schist and moderately abundant volcanic pebbles (latter mostly well rounded) are typical of the axial-river deposits. Locally contains rare obsidian pebbles that are generally not seen in older river beds (QTsf). 0-2m thick where unconformable on Popotosa Fm.; appears to thicken southward.
Qvot Older valley fill, piedmont to axial river transitional facies (middle to upper Pleistocene)– Reddish-orange muddy sands and sands flanking deposits of Qvof near Tiffany Canyon, locally gypsiferous. Basal contact not exposed, about 0–20m thick.
Qpu Piedmont deposits undifferentiated (upper to lower Pleistocene)— Coarse debris flows and poorly sorted gravels, sand and mud deposited on small catchment, high-gradient alluvial fans at east flank of Chupadera Mountains. Contains buried soils similar to those in QTsp; but not demonstrated to intertongue with QTsf. Probably represents locally continuous aggradation, equivalent to QTsp and older Qvn and Qvs deposits. Base not exposed; locally 30-60 m thick.
Santa Fe Group
Intermontane basin fill of the Rio Grande rift; regionally ranges from latest Oligocene to early Pleistocene (Chapin and Cather, 1994). As redefined by Machette, 1978, includes the Pliocene and Pleistocene valley fill of the Sierra Ladrones Formation (of Machette, 1978), and latest Oligocene to late Miocene bolson fill of the Popotosa Formation in the central Rio Grande rift (Denny, 1940). Intercalated volcanic units are usually given formation status (Osburn and Chapin, 1983).
Upper Santa Fe Group
QTs Sierra Ladrones Formation (lower Pleistocene to lower Pliocene)— Late-stage basin fill of the Rio Grande valley characterized by an axial-fluvial facies (ancestral Rio Grande) and intertonguing piedmont facies (large alluvial fans) derived from adjacent mountain ranges. Axial-river deposits are as much as 330 m thick in municipal water well near Socorro (Chamberlin, 1999).
QTsf Sierra Ladrones Formation, axial fluvial facies (lower Pliocene to lower Pliocene)— Mostly well sorted, light-gray to pale yellowish brown, sand and well rounded pebbly gravel lenses; locally showing southerly paleocurrent directions. Gravel lenses contain well rounded to subrounded clasts of quartzite, mottled chert (Paleozoic type), granite, and variety of volcanic rocks. Fine- to medium-grained sands are commonly well sorted. Rare exposures of greenish mud (overbank deposits or abandoned channel fills) and reddish-orange muddy sands (distal fan deposits) are present. Poorly exposed and often mantled by thin colluvium. Near Buro Well, approximately 2 m of uppermost QTsf beds lie in slight angular unconformity on Popotosa Fm. Fault-line scarp of tectonic rift is commonly expressed in a southward thickening wedge, at about 8m /km (Sanchez, C.-C.). North of the BDA fault, QTsf may be as thick as 330 m.
QTsp Sierra Ladrones Formation, piedmont facies (lower Pleistocene to upper Pliocene)— Reddish orange to reddish brown, poorly consolidated , volcanic-rich, angular to subrounded, conglomerates, conglomeratic sandstones, muddy sandstones, silty mudstones and unconsolidated equivalents; deposited as alluvial fans and valley-floor aprons. Clasts are dominantly volcanic, derived from the Chupadera Mountains. Upturned QTsp beds form a gently south tilted veneer (0-15 m thick), unconformable on Popotosa Fm., west of Buro Well. Locally contains buried pedogenic carbonate horizons in area north of the BDA fault, where it is as much as 330m thick.
Tsp Middle Santa Fe Group, piedmont deposits, unnamed transition unit (latest Miocene to earliest Pliocene?)— Poorly exposed, pebble conglomerate, and sandstone unit of uncertain age and correlation (locally marked by a thin vitrophyre) that defines a late-stage (28.9 Ma) topographic welded tuffs mixed with rare rounded basalts and traces of vein quartz. Pebble imbrications indicate southeasterly paleocurrent directions. Sandstone and mudstone beds are reddish orange, poorly consolidated, and form recessive belt in narrow graben on the footwall of BDA fault). Basal contact exposed, but is probably an unconformity on underlying Popotosa Fm. May represent a lower Sierra Ladrones piedmont facies, recycled from older Popotosa conglomerates. Mapped separately from nearby QTsp beds due to distinctly different clast suite. Exposed thickness ~ 95 m.
Lower Santa Fe Group
Tp Popotosa Formation (locally middle Miocene to upper Miocene)— Bolson fill of the Miocene "Basque del Apache" Basin (east-tilted half graben) of the central Rio Grande rift. Locally subdivided into facies/members based on clast suites of volcanic-rich conglomerates, bulk grain size and bedforms that reflect depositional environments, general paleocurrent domains, and general stratigraphic position. Complexities in the "upper Popotosa Formation" (informally defined) contain sparse to rare rock-avalanche clasts derived from Paleozoic rocks now exposed east of the Rio Grande. Maximum total thickness in Bosque Basin is about 2 km, near the Canyon Trail (A-A'). A corresponding total thickness within Chupadera uplift (Tptu below 9.7 Ma Tbo, near Chupadera Spring) is about 250 m.
Tpfb Popotosa Formation, basaltic boulder bed (upper Miocene) —
Boulder bed contains medium-gray to black, massive to vesicular, subrounded basaltic boulders, as much as 0.5 m across, mixed with minor tuff cobbles and rare andesitic pebbles. Sparsely phyric olivine basalt boulders imply derivation from a nearby fault scarp of Miocene age that offset Tbo. Base not exposed, inferred conformable with underlying Tptu. Maximum thickness about 10m.
Tptu Popotosa Formation undivided, lower to upper, tuff-dominated facies (middle to upper Miocene)— Pebble to cobble conglomerates and sandstones within the Chupadera uplift near Chupadera Spring; locally capped by 9.7 Ma Basalt of Cerro Colorado (Tbo). Light brownish gray conglomerate and conglomeratic sandstone beds contain abundant subangular to rounded pebbles to cobbles of rhyolitic tuffs with minor andesitic porphyries. Tuff boulders are locally present. Gravel sizes generally fine upward; paleocurrent directions are westerly. Rare clasts of red siltstone (Abo type) can be found in float and poorly exposed upper Popotosa beds about 30 m below the basalt capped cuesta (Tbo) near Chupadera Spring. Basal contact is generally poorly exposed. Total thickness near Chupadera Spring (below Tbo) is about 250m.
Tpft1 Popotosa Formation, upper, tuff-dominated conglomerates and sandstones (upper Miocene)— Poorly exposed conglomerates, sandstones and rare mudstones on footwall of the BDA fault. Conglomerate beds are poorly sorted with angular to subrounded clasts predominantly rhyolitic tuff, sparse andesite porphyries and rare non-volcanic clasts. Paleocurrent directions are southwesterly. Uppermost beds are intercalated with the basalt of Broken Tank (Tbt). Exposed thickness is 280 m.
Tpft2 Popotosa Formation, upper, tuff-dominated conglomerates and conglomeratic sandstones (upper Miocene)— Similar to Tpft1, but this unit is somewhat coarser (more cobbly) with greater proportion of andesitic and non-volcanic clasts. Exposed thickness is 70 m.
Tps Popotosa Formation, fluvial sandstone facies (middle to upper Miocene)— Moderately to poorly cemented, massive (planar?) to trough cross bedded sandstones and rare channel-shaped conglomerates. Thin mudstones, with desiccation cracks, are locally common near the south end of outcrop belt. Conglomerates contain poorly sorted, subangular to rounded pebbles with a clast suites that range between tuff-dominated (with sparse andesite) and andesite-dominated with abundant scoria (with sparse tuffs). Non-volcanic clasts are absent near the base but become notably present (~2%) in conglomeratic beds near the top. Paleocurrents are dominantly southwesterly. Locally contains a few thin eolian sandstones. Basal and upper contacts are conformable. Exposed thickness is 320 m.
Tpe Popotosa Formation, eolian sandstone facies (middle to upper Miocene)— Poorly cemented, poorly to well exposed, light gray to buff, high-angle cross bedded, fine-grained sandstones; locally interlayered with minor planar bedded, pebbly (fluvial) sandstones (Tps-type) and some channel-shaped conglomerates (Tpa-type). Eolian beds are 1-10 m thick and steepest cross beds (slip faces) generally dip easterly. Fine sand grains consist mostly of cryptocrystalline rhyolite, fine-grained porphyry and oscillatory zoned plagioclase. Exposed thickness is 100 m.
Tpa Popotosa Formation, andesite-dominated conglomeratic facies (upper Miocene)— Light- to medium-brownish gray, conglomeratic sandstones, sandstones (Tps type) and rare thin bedded mudstones; along with a few intercalated eolian sandstone beds (Tpe type). The latter are often exposed on steep sided cuestas, where difficult to show at map scale (e.g. Canyon Trail area). Conglomerates contain mostly angular to subrounded pebbles to cobbles of variicolored andesitic lavas (porphyries), with moderately abundant orangish brown, finely vesicular, andesitic scoria and sparse rhyolitic tuffs. Rare red siltstone pebbles, occasionally with white reduction spots, were almost certainly derived from exposures of the Permian Abo Formation, now found east of the Rio Grande. Andesitic boulders are locally present near Elmendorf. Paleocurrents are northwesterly. Basal contact is generally gradational into Tpe. A latest Clarendonian depositional age (ca. 9-11 Ma) for Tpa is provided by a partial fossilized skeleton of an oreodont (Merchyus major major) found embedded in this unit about 500 m north of the Canyon Trail (Morgan et al., 2009). Maximum exposed thickness is 120 m.
Tpt2 Popotosa Formation, medial tuff-dominated conglomerate facies with pumiceous sandstones (middle Miocene) — Medium to light gray and light brownish gray conglomerates, conglomeratic sandstones, and minor reddish mudstones . Four discontinuously exposed pumiceous sandstone beds locally define the top and basal depositional contacts of this facies. Pebble to cobble conglomerates are dominated by subangular to rounded, poorly to light gray, mostly crystal-poor, rhyolitic tuffs, with rare andesitic lava pebbles, rounded scoria clasts, and traces of basalt. Non-volcanic clasts are absent. Basal contact is conformable with Tpt1. Sanidine crystals from rhyolitic pumice, collected near crossing of I-25 and the Chupadera Peak trail, yield a 40Ar/39Ar age of 14.59 ± 0.06 Ma (Table 1). Field relationships and age spectra suggest this is the approximate depositional age of the pumiceous sandstone bed. Thickness ranges from 50 to 70 m .
Tpt1 Popotosa Formation, basal tuff-dominated conglomerate facies (middle Miocene) — Light gray to brownish gray pebble to boulder conglomerates with few interbedded pebbly sandstones and rare thin mudstones; generally poorly cemented and poorly exposed. Conglomerates are poorly bedded to locally massive, with rare to moderate, medium to thick bedding. Clasts are dominantly subangular to rounded, crystal-rich, light gray to grayish red, welded tuffs derived from regional ignimbrite sheets (Osburn and Chapin, 1983) dominate the clast suite. Rare clast types, such as basaltic andesite with sparse iddingsite, occur near the base of this unit and andesitic porphyry to scoria are present toward the top. Basal beds are well exposed in a gully about 300m south of the Chupadera Peak trail (0321231E/3745959N). Basal contact is generally poorly exposed and inferred to be a disconformity with tens of meters of erosional relief at the base near Chupadera Spring and the Chupadera Peak trail. Exposed thickness is 200 -380 m.
Basalt Flows in Popotosa Formation
Tbt Basalt of Broken Tank (upper Miocene)— Medium-dark gray, sparsely to moderately phyric trachybasalt flows interbedded in upper Popotosa Formation on flanks of the Chupadera Mountains. Singular flow about 1.5 km NW of the BDA visitors center ranges from black to dark reddish brown, aphyric to very phenocryst poor olivine basalt with a distinctive ophitic texture, as viewed in thin sections. Outcrops are mostly rubbly with sugary diabasic texture and local vesicular zones; some propylitic alteration occurs at south end of outcrop belt. Groundmass concentrate from this Tbt outcrop yields a 40Ar/39Ar plateau age of 8.57 ± 0.26 Ma (Table1). Thickness is 0- 8 m.
Tbo Basalt of Olney Ranch (upper Miocene). Medium to dark gray, phenocryst-poor, trachybasalt with about 4 percent, small to medium size phenocrysts (1-4 mm) of plagioclase and greenish olivine; latter is locally altered to red iddingsite. Porphyritic basal zone is 6-10 m thick and grades upward into dense core of fine-grained diabase with weak porphyritic texture and sparse phenocrysts of plagioclase. Two samples of Tbo collected in the Los Lopez quadrangle, just north of the NW quadrangle, yield 40Ar/39Ar plateau ages of 9.64 ±0.12 and 9.71 ± 0.14 Ma (Chamberlin et. al, 2002). Mean eruption age is 9.67 ± 0.09 Ma (n=2). Cuesta forming outcrop east of Chupadera Spring is about 6-18 m thick and locally underlain by red scoriaceous sandstone, suggesting the presence of a nearby vent.
MOGOLLON GROUP
Mogollon Group is all volcanic formations in upper part of the Mogollon-Datil volcanic pile that range from 29 to 24 Ma (Cather et. al., 1994). Formation nomenclature is from Osburn and Chapin, 1983.
Tlp La Jara Peak Basaltic Andesite, uppermost tongue (Oligocene)— Medium to dark gray basaltic andesite lava flows with sparse small phenocrysts of olivine altered to reddish iddingsite. Locally fills paleovalley cut in South Canyon Tuff. Tentatively correlated with the "basalt of Madera Canyon" (Osburn et.al., 1981), dated at 27.1 ± 0.2 Ma (McIntosh and Chamberlin, unpublished data). Thickness 0-20 m.
Tsc South Canyon Tuff (Oligocene)— Partially to densely welded, light gray, phenocryst-poor to moderately phenocryst-rich, pumiceous, rhyolite ignimbrite. Medium grained (1-3 mm) phenocrysts of subequal quartz and sanidine, with rare clots of phenocrysts. Forms 1-3% near partially welded base to as much as 25% near densely welded top. Moderately crystal rich upper zone is absent south of Chupadera Peak trail, where it has been removed by Miocene erosion. Erupted from Mt. Withington caldera; mean 40Ar/39Ar age of 3 bulk sanidine separates is 27.55 ± 0.14 Ma (McIntosh et al., 1991). Thickness 0-30 m.
Tlu/Tli Lemitar Tuff, upper and lower members (Oligocene) — Compositionally zoned ignimbrite (77±5 wt% SiO2) divided into a lower member (Tli) of partially to densely welded, light gray, lithic-poor, phenocryst-poor (<15%), high-silica rhyolite, and an upper member (Tlu) of densely welded, dark red, phenocryst-rich (30±5%), rhyodacite to rhyolite. Contains medium-grained (±4 mm) phenocrysts of quartz, sanidine, plagioclase and minor biotite. Small (1-3 cm) pumiceous-perlitic fragments in lower member and phenocryst-rich pumice is sparse in upper member. Lower member fills paleovalley cut through Vicks Peak Tuff and La Jencia Tuff near the Chupadera Peak trail. A thin interval (20 m) of partially exposed tuffaceous conglomerates and sandstones is present at base of Tli near Chupadera Spring. Erupted from Hardy Ridge caldera (Chamberlin et al., 2004); mean 40Ar/39Ar age of 21 new sanidine separates is 28.18 ± 0.16 Ma (McIntosh et al., 1991). Thickness 0-60 m.
Tv Vicks Peak Tuff (Oligocene) — Light gray to pale red, pumiceous, phenocryst-poor, densely welded rhyolite ignimbrite. Large, moderately abundant (5-10%), strongly flattened pumice flamme, as much as 20 cm long, are distinctive. Sugary looking vapor phase minerals also commonly present in light gray matrix around the flattened pumice fragments. Contains 8% phenocrysts of sanidine, sparse quartz, and traces of biotite. Mafic and accidental lithics are small and rare to absent. As much as 10m of tuffaceous sandstones and conglomerates are present at the base of the main cooling unit. Thickness is 30-70 m thick on footwall of the Chupadera Peak fault and at least 120 m thick on the hanging wall block, which implies fault was active prior to 28.7 Ma. Erupted from Nogal Canyon caldera; mean 40Ar/39Ar age of 3 bulk sanidine separates is 28.70 ± 0.06 Ma (McIntosh et al., 1991). 0-120 m thick.
Tj La Jencia Tuff (Oligocene) — Light gray, pale red and dusky red, phenocryst poor, densely welded to rheomorphic, rhyolite ignimbrite. Tj contains sparse (3-5%) small (1-3 mm) phenocrysts of sanidine and quartz with traces of plagioclase and rare biotite. The basal densely welded zone is characterized by medium sized (2-5cm), moderately abundant (5-10%) strongly flattened pumice flamme. The upper half of La Jencia Tuff is typically a densely welded zone of finely flow banded (rheomorphic) ignimbrite. This 1-2mm/ welded zone is characterized by streaked out pumice form a strong lineation/foliation on the foliation plane. Secondary flow folds are common in the rheomorphic zone. On some paleotopographically high blocks, laminated fall deposits (1.5 m thick) and light gray to beige partially welded zones are locally present at the base of Tj (0320182E/3745322N and 0321387E/3745602N, respectively). Erupted from Sawmill Canyon caldera; mean 40Ar/39Ar bulk sanidine age is 29.02 ± 0.08 Ma (McIntosh et al, 1991), but a precisely dated pre-La Jencia lava dome suggests eruptive age is closer to 28.89 ± 0.06 Ma (Chamberlin et al, 2004). The La Jencia Tuff is as much as 400m thick in the moat environment of a buttress unconformity (locally marked by a thin vitrophyre) that defines a late-stage (28.9 Ma) topographic wall of the Socorro caldera near Chupadera Peak and Willow Springs. On the 28.9-Ma caldera rim, southeast of the buttress unconformity, the La Jencia tuff is no more than 50-100 m thick and commonly fills narrow NW-trending paleovalleys. At Chupadera Peak and along its NW side, 60-m-high craggy cliffs mark an unusually thick and laterally restricted dusky red lithophysal zone in the basal densely welded La Jencia Tuff. The lithophysal zone occurs only where Tj overlies poorly welded moat-fill tuff (Tzt), which may have been water saturated in La Jencia time.
Tz Luis Lopez Formation (Oligocene) — Heterogeneous post-collapse intracaldera fill of the Socorro caldera consisting of volcaniclastic sedimentary rocks, pumiceous rhyolitic ignimbrites, basaltic to intermediate lavas and rhyolitic lava domes. Locally erupted volcanic units range from 30.2 Ma to 28.9 Ma (Chamberlin et al, 2004).
Tzbr Luis Lopez Formation, upper rhyolite member (Oligocene) — Light brown, phenocryst-poor, flow-banded, lithoidal rhyolite lava with minor spherulitic zones. Contains spare phenocrysts of plagioclase, sanidine and minor biotite with traces of hornblende and pyroxene. Steep flow foliations suggest a local vent near Table Mountain Tank. Exposed thickness is 100 m. A similar lava dome at Nogal Canyon is dated at 28.9 Ma (Chamberlin et al, 2004).
Tzt Luis Lopez Formation, medial pumiceous tuff member (Oligocene)— Light gray, poorly welded, pumiceous, phenocryst-poor, rhyolite ignimbrite. Contains lithic-rich lenses dominated by andesitic fragments. Small rare fragments of crystal-rich quartz-rich Hells Mesa Tuff are also locally present. Small (1–3 cm) aphyric to very crystal poor, white pumice lapilli form 15 to 30 % of rock. Pumice contains rare phenocrysts of plagioclase, sanidine and quartz and is commonly altered to clay. Medial Luis Lopez tuffs were erupted from Black Canyon vent area in northern Chupadera Mountains (Chamberlin et al, 2004). Mean 40Ar/39Ar age from two "single-crystal" sanidine determinations is 30.23 ± 0.05 Ma (Chamberlin et al, 2004). As much as 60m thick under Chupadera Peak; Tzt appears to wedge out against north-facing topographic wall (intermediate-age caldera wall) about 1 km south of Chupadera Peak. Small outcrop of Tzt, 3 km NW of Willow Springs, marks southern limit of Luis Lopez moat-fill deposits, which may represent a moderately permeable local aquifer (M. J. Darr, oral commun., 2007). Tzt is absent south of 28.9 Ma buttress unconformity.
Tzs Luis Lopez Formation, basal sedimentary member (Oligocene) —Purplish gray to medium gray andesitic debris flow deposits, andesite-rich conglomerates, sandstones and reddish mudstones derived from the southern topographic wall of the Socorro caldera. Rare sanidine-rhyolite clasts in Tzs conglomerates help distinguish them from andesitic conglomerates of the Spears Formation. Near Nogal Canyon, conglomeratic sandstones at the top of this unit contain spheroidal sanidine-rhyolite cobbles that yield 40Ar/39Ar ages of 33.96 ± 0.10 and 33.90 ± 0.15 Ma (Chamberlin et. al, 2004), demonstrating they are age equivalent to the Blue Canyon Tuff. Spheruilic clasts were previously interpreted as derived from rhyolite lavas (Chamberlin et al, 2004). However, new map data imply they are actually clasts of densely welded Blue Canyon Tuff derived from the caldera wall and rim, as now delineated southeast of Chupadera Peak. Andesitic conglomerates SW of Chupadera Peak contain rare clasts of Hells Mesa Tuff. Pebble imbrications in andesitic conglomeratic sandstones about 3 km NW of Willow Springs indicate northerly paleocurrents, suggesting correlation with Tzs. Near Chupadera Spring, Tzs wedges out southward against Proterozoic schists at the inner (oldest) topographic wall of the Socorro caldera (Eggleston, 1982). The top of Tzs is also truncated by a Miocene erosional unconformity here (base of Tptu). East of Chupadera Spring, the maximum preserved thickness is 180m.
Tze Luiz Lopez Formation, exotic blocks of Blue Canyon Tuff (Oligocene)— Stratigraphically incoherent blocks of Blue Canyon Tuff at the 33.9 Ma caldera wall, near the Chupadera Peak trail, are interpreted as ancient landslide deposits coeval with the upper Luis Lopez Formation. South of the trail, a 60 x 70 m wide slab (0320920E/ 3745440N) and 3x4 m block of Blue Canyon Tuff rest on andesite porphyry lavas (Tw). The stratigraphically misplaced (anomalously above Tc) slab and block of Blue Canyon ignimbrite also clearly occur stratigraphically below a thin sheet of La Jencia Tuff , which marks the 28.9-Ma caldera rim. Slab is about 10 -20 m thick.
DATIL GROUP
Datil Group is all volcanic formations in lower part of the Mogollon-Datil volcanic pile that range from 32 to about 37 Ma (Cather et. al., 1994). Formation nomenclature is from Osburn and Chapin, 1983.
Thw/Thb Hells Mesa Tuff, caldera wall facies (Thw) with megabreccia slabs (Thb) (Oligocene)— Thw is comprised by densely to partially welded, light-gray to pale red, locally xenolith-rich to xenolith-poor, phenocryst-rich, quartz-rich, rhyolite ignimbrite. It locally contains abundant andesite, schist and granite xenoliths. Spears-type conglomeratic megabreccia slabs (Thb), as much as 20 m thick, are present at the base. Lower half is strongly bleached and hydrothermally altered. Just north of the quadrangle boundary, a slightly altered, lithic-poor zone at the top of the unit yields a single-crystal laser-fusion 40Ar/39Ar sanidine age of 32.06 ± 0.17 Ma (Chamberlin et al, 2004), which agrees (within analytical precision) with a mean 40Ar/39Ar age of 32.27 ± 0.20 Ma from 4 bulk sanidine determinations of the Hells Mesa Tuff (McIntosh et al., 1991). Thw unconformably overlies Proterozoic schists and felsic porphyry at Chupadera Spring. Thw is interpreted as relatively thin (270 m) intracaldera Hells Mesa Tuff that overlapped an inner collar of the caldera formed by large volume removal and scarp retreat of precaldera rocks, through mass wasting, during eruption and collapse of the Socorro caldera. Thw wedges out against Proterozoic schist at the inner (32.3 Ma) caldera wall, about 1 km south of Chupadera Spring. South of the 32.3-Ma caldera wall, the Hells Mesa Tuff is absent throughout the southern Chupadera Mountains.
Tlaf Willow Springs Formation (Eocene)— A 200-300 m-thick pile of moderate to dark gray, grayish red and dusky red, pumiceous-andesite porphyry lavas (Tw) and locally interlayered, compositionally similar, volcaniclastic rocks (Tvs) exposed near Willow Springs are here informally named the "andesite of Willow Springs". The volcaniclastic rocks are dominantly minor volcaniclastic sedimentary facies (Tws) includes boulder monolithic laharic breccias, varicolored debris flows, yellowish brown lithic-rich arenites and reddish argillized ash beds. As mapped, Tw consists entirely of porphyritic lava flows and Tws is comprised by porphyritic volcaniclastic rocks, with or without interbedded lava flows. Together these facies (and a nearby andesite dike, Tia) suggest the "andesite of Willow Springs" was emplaced on the intermediate to distal slopes an andesitic volcanic center (e.g. composite volcano). Two reference sections are recommended for Tw . At 1.2-km west of Willow Springs, about 60 m of porphyritic lavas conformably overlie fluviatile andesitic epiclastic sandstones of the Spears Formation (Ts) and conformably underlie the Blue Canyon Tuff (Tb) with another 5 m of lavas above Tb, then truncated by a fault (from 0321850E/3742540N to 0315940E/3742960N) . At 1.7 km SSE of Chupadera Peak approximately 230m of SE dipping andesitic porphyry lavas are well exposed along a north-facing hillside and drainage line from 0320570E/3745290N to 0320990E/3745250N. Here Tw lavas conformably overlie Chupadera Wilderness Tuff and are paraconformably to disconformably overlain by the La Jencia Tuff. In both reference sections the andesitic lavas tend to become more phenocryst rich and coarser grained up section. Coarse grained porphyries near the top of the section contain up to 20-phenocrysts dominated by clear to whitish tabular plagioclase (3-7mm) and moderately abundant prismatic black pyroxene of similar size. Flows are about 3-20m thick and locally vesicular (or amygdaloidal). A reference area for Tws is located along both sides of a drainage and subsidiary road about 2.4 km NW of Willow Springs (from 0345880E/3744850N to 0316040E/3745360N). Lacustrine breccias, debris flows and thin tuffs are well exposed here and unconformably overlain by La Jencia Tuff, and the base of Tws is not exposed here. The andesite of Willow Springs contains the 33.9 Ma Blue Canyon Tuff, suggesting it is mostly of upper Eocene age (ca. 35-33 Ma). Age determinations that are pending may provide additional constraints. The andesite of Willow Springs may be coeval with the lithologically similar Rubio Peak Formation in the Hillsboro area (Clemons, 1979) or the andesite of Dry Legget Canyon near Reserve (Rattè, 1989), but lateral continuity with these remote lava piles seems unlikely
Tc tuff of Chupadera Wilderness (new name) (Eocene) — A 20-30m thick, pale red, poorly to moderately welded, moderately phenocrystic, relatively biotite rich, moderately lithic rich, dacitic ignimbrite is here informally named for key marker ecposures in the Chupadera Wilderness about 2 km SE of Chupadera Peak. A reference section, about 500m north of the Chupadera Peak trail (0321418E/3745694N), exposes about 25 m of medium reddish brown weathering dacitic ignimbrite conformably overlying a pale orandish gray, poorly welded tuff zone in the top of the Blue Canyon Tuff (Tb) and conformably underlying a massive, grayish red, phenocryst-rich andesite porphyry lava flow of the andesite of Willow Springs (Tlaf). About 3-4 m of section below the dacitic tuff is covered. Tc is characterized by moderately abundant phenocrysts (5-10%) of whitish plagioclase (1-4mm) and 2-3% black biotite (1-2mm) with a trace of very few (<0.5 mm) sanidine in a well indurated, partially welded, pale red matrix mantled with sparse varicolored small andesitic lithics and scoria fragments. Sparse (2-3%) slightly to moderately flattened, phenocryst poor pink pumice flamme define a subtle compaction foliation. South of the Chupadera Peak trail, Tc is locally truncated by overlying andesite lavas and also locally truncated by the 28.9 Ma buttress unconformity associated with the late-stage wall of the Socorro caldera. Tc is discontinuously exposed above the Blue Canyon Tuff in the area west of Willow Springs, Tc is presently undated, but must be somewhat younger than the 33.9 Ma Blue Canyon Tuff; thus suggesting it is of late Eocene age. The Tuff of Chupadera Wilderness is probably a minor volume local ash-flow tuff; it is not presently recognized outside the southern Chupadera Mountains. Thickness is 0-30m.
Tb Blue Canyon Tuff (Eocene)— Basal zone about 30 m thick consists of light gray to light brownish gray, densely welded, moderately lithic rich (1-5%), moderately phenocryst rich (15-20%) sanidine-rich, very quartz poor, rhyolite ignimbrite typically with sparse coppery biotite and cleaved glassy sanidine crystal faces as much as 5 mm long. Soft scoria fragments in the ledge-forming densely welded zone commonly weather out to form 2-3cm wide "swiss-cheese" holes that lead to the false impression of poor welding. Small (3 mm) strongly flattened crystal-rich pumice are difficult to see in the densely welded basal zone, especially where it has weathered to a dark brown to black patina, which can give the false appearance of a mafic lava outcrop. Where only poorly welded upper zone is absent 30 m thick and weathers to a medium grayish orange; here it contains about 5-7% phenocrysts of sanidine (also up to 5 mm across) and sparse coppery biotite in a pinkish gray matrix mottled with rare small andesitic lithics and medium gray aphyric pumice (or densely welded zone is generally absent near Willow Springs. Tentative correlation here is based on distinctive size and abundance of sanidine phenocrysts (Rattè et al, 1990) and lithologic similarity to well dated 33.9 Ma sanidine-rhyolite clasts in the Los Lopez Formation moat fill about 5 km north of Chupadera Peak (Chamberlin et al., 2004). Source of widespread Blue Canyon Tuff is unknown; mean 40Ar/39Ar age of 2 bulk sanidine separates is 33.88 ± 0.06 Ma (McIntosh et al., 1991). Thickness 0-60m; appears to be absent in southernmost Chupadera Mountains (south of 0374100N).
Ts Spears Formation (Eocene) — Light to greenish gray andesitic rhyolitic conglomerates and conglomeratic sandstones dominated by varicolored andesitic clasts. Sparse but widespread, light-gray crystal-rich hornblende-plagioclase-dacitic clasts, with abundant large (2-4 mm) black hornblende crystals, are distinctive of Spears conglomerate beds in the southern Chupadera Mountains. Imbricated clasts indicate northeasterly to southeasterly paleocurrent directions. Thin to thick beds are dominantly clast supported, in contrast to the matrix supported debris flows and laharic breccias in the volcaniclastic sedimentary facies in the andesite of Willow Springs. Rare red laminated siltstone clasts in lower 5m of Coyote Springs suggest unit may unconformably overlie the Permian Abo Formation near here. Spears sandstones unconformably overlie Pennsylvanian Madera Group limestones near Chupadera Peak, and may conformably overlie a thin limestone cobble conglomerate unit tentatively correlated with the Baca Formation. Maximum exposed thickness south of Coyote Springs is 190m. Age of Ts is locally bracketed between 33.9 Ma Blue Canyon Tuff and middle Eocene (?) Baca conglomerate beds.
Cenozoic Intrusive Rocks
Tim Mafic dikes (Oligocene) — Mostly dark gray to greenish gray, phenocryst-poor basaltic andesite dikes with sparse small phenocrysts of plagioclase laths and sparse large (4-5 mm) black pyroxene crystals in a very fine grained lithoidal (cryptocrystalline) matrix. Near-vent dike is 15-20m wide and strikes ENE (080). Dike cuts Spears conglomeratic sandstone beds (Ts). Andesite porphyry dike is very similar to phenocryst-rich andesite porphyry lavas in the andesite of Willow Springs, which suggests they are coeval.
Laramide Orogenic Deposit
Tba Baca Formation (Eocene?) — Gray limestone cobble conglomerates about 20 m thick; locally well exposed about 600m SW of Chupadera Peak. Unconformably overlie Madera Group limestones. Tentative correlation with Baca Formation suggests Chupadera Peak area was a Laramide highland in early Tertiary time. 0-20m thick.
PALEOZOIC STRATA
IPm Madera Group (Pennsylvanian)– Gray, micritic, cherty limestone and minor shale beds; fossiliferous thin to thick bedded limestones are Derryian (Kottlowski,1960). Beds SE of Chupadera Peak are hydrothermally altered (silicified) and appear to be folded. 0-60m thick.
Mkc Kelly and Caloso Formations, undivided (Mississipian) — Basal pale red arkosic sandstones of Caloso formation (~ 10m thick) overlain by gray to buff, micritic to bioclastic limestones and shales of the Kelly Formation (~10-20m thick). Basal sandstones are locally silicified.
PROTEROZOIC ROCKS
Proterozoic schists, amphibolites, felsic porphyry and granite are shown as mapped by S.C. Kent, 1982, with minor modifications. Thin aplite, pegmatite and carbonatite(?) dikes are not shown. Transposed lithologic units are highly variable in apparent thickness, and original bedding is not preserved (Bowring et al., 1983). Feldspathic and pelitic schists are interpreted to represent regionally metamorphosed (and essentially coeval) arkosic sandstones and muddy siltstones, with minor interbedded mafic to silicic volcanics or shallow intrusives; all of which predate the locally foliated granite porphyry (Bowring et al., 1983).
Xgn Gneiss (Proterozoic)— Quartz-m