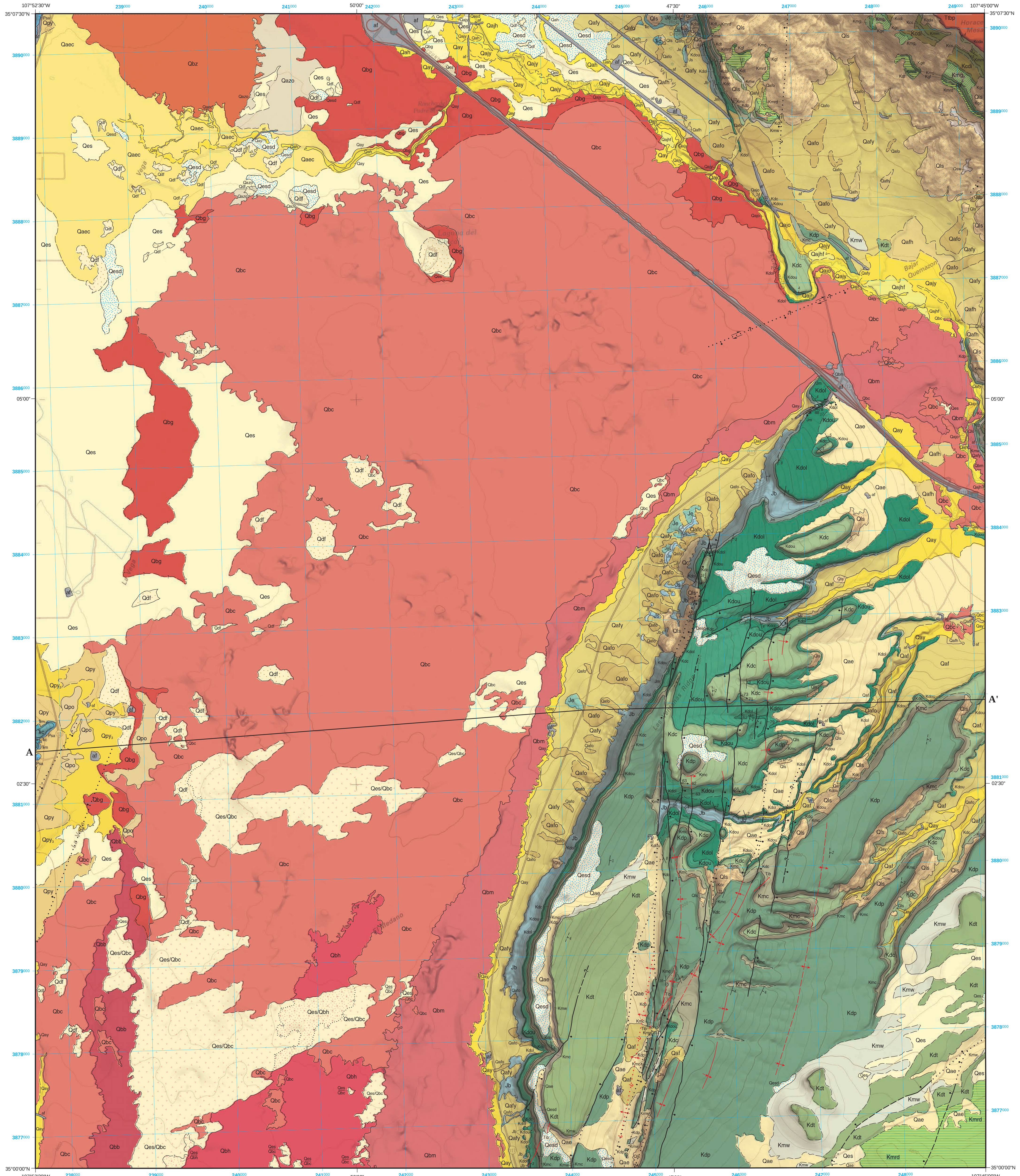


Chief elements of the Grants SE quadrangle. In the background, Horace Mesa is underlain by Pliocene basalt flows capping Mesozoic rocks from uppermost Chinle Group sediments through the Crevasse Canyon Formation. The hummocky terrain below Horace Mesa is comprised of landslides. In the foreground, pale yellowish sandstones of the Bluff Sandstone form a resistant base for the northern end of Las Ventanas Ridge, and are capped by poorly exposed Morrison Formation sediments and the basal sandstones of the Dakota Formation at the top. The Holocene McCartys lava flow is apparent in the middle ground left of center. Houses at the base of Horace Mesa lie within the eastern outskirts of the town of Grants.

DESCRIPTION OF MAP UNITS

Note: Soil descriptions after Birkeland (1999), colors after Munsell Color (1994), and all proportions are visual estimates.

Cenozoic Erathem

Anthropogenic Deposits

af — **Artificial fill** — Artificial fill. Compacted gravel, sand, and mud underlying roads, railroads, and water tanks. Up to 5 m thick.

Quaternary Colluvium, Slopewash, and Eolian Deposits

Qsw — **Slopewash (Holocene)** — Sandy silt and silty sand accumulating in depressions in landslide areas. Likely up to 2 m thick.

Qdf — **Deflationary pits (upper Pleistocene to Holocene)** — Gray to brown (7.5YR 7/2 and 5YR 4/2 measured), generally well-laminated silt and lesser clay with 5-15% fine sand, subangular to subrounded, accumulating in depressions. Likely up to 2 m thick.

Qc — **Colluvium (upper Pleistocene to Holocene)** — Gravel, sand, and silt transported by mass wasting and sheet flow. Likely up to 2 m thick.

Qls — **Landslides (upper Pleistocene to Holocene)** — Slumps, slides, debris-flow deposits, and associated fine-grained material underlying hummocky terrain along slopes below basalt-capped mesas.

Qes — **Quaternary eolian sand (upper Pleistocene to Holocene)** — Silty fine sand and fine sandy silt forming sand sheets and low dunes. Pale brown colors typical, with colors of 7.5YR 7/3 to 7/6 and N 9 measured. Little evidence of soil development. Likely up to 2 m thick.

Qes/Qbc, Qes/Qbh — **Eolian sand overlying basalt (upper Pleistocene to Holocene)** — Hybrid unit that locates areas of either the Hoya de Cibola (*Qbc*) or El Calderon (*Qbh*) basalt flows largely buried by thin (0-1 m thick) eolian sand cover.

Qesd — **Dune sand (upper Pleistocene to Holocene)** — Clean to silty fine sand and fine sandy silt forming dune forms of variable development and sandsheets with mounded microrelief. Variably vegetated, with the more vegetated dunes displaying weak soil development such as Stage I gypsum accumulation. As much as 5 m thick.

Qae — **Alluvial and eolian sand, undivided (upper Pleistocene to Holocene)** — Silty sand and sandy silt transported by wind, slopewash, and confined water flow. Variably vegetated, typically does not exhibit signs of soil development. <1/2 to 2 m thick.

Quaternary Alluvial Deposits

Qah — **Historic alluvium, undivided (Holocene)** — Boulders to fine sand along active stream channels exhibiting evidence of historic transport. Deposits are typically poorly to moderately sorted angular to rounded silt/sand grains and fine pebbles. Likely up to 1 m thick.

Rio San Jose alluvium

Qajh — **Historic alluvium associated with the Rio San Jose, undivided (Holocene)** — Sand and silt with lesser gravel and rare clays found along the current floodplain of the Rio San Jose. No sign of soil development. Deposits are typically poorly to moderately sorted angular to rounded silt/sand grains and fine pebbles. Likely up to 1 m thick.

Qajhf — **Historic fan alluvium with the Rio San Jose floodplain (Holocene)** — Historic alluvium associated with thin alluvial fans from the termini of gullies and channels along the Rio San Jose floodplain. Likely up to 1 m thick.

Qajy — **Younger alluvium associated with the Rio San Jose (upper Pleistocene to Holocene)** — Alluvium underlying terrace treads up to 2 m above the active channel, with typical soil development including a weak reddened Bw horizon and up to Stage I Bk development. Colors of 10YR 5/4 to 5/6, 7.5YR 5/3 to 5/4, and locally 5YR 4/4 and 7/4, measured. Likely not more than 3 m thick.

Qajo — **Older alluvium associated with the Rio San Jose (upper Pleistocene)** — Thin deposits of sand and gravel associated with the Rio San Jose at relatively high elevations along the active channel. Largely only identifiable by the presence of sparse granitic and siliceous pebbles that do not occur in underlying strata. No signs of soil development observed. 0-1 m thick.

Las Ventanas Ridge and Horace Mesa alluvium

Qaf — **Alluvial fan material from Mezosoic-cored highlands, undivided (upper Pleistocene to Holocene)** — Pebbly sand and silt derived from small drainages in the flanks of Las Ventanas Ridge and Horace Mesa. Typically subdivided based on age inferred from geomorphology and soil development.

Qafh — **Youngest alluvial fan material from Mesozoic-cored highlands (middle to upper Holocene)** — Likely up to 1 m thick.

Qafy — **Younger alluvial fan material from Mezosoic-cored highlands (upper Pleistocene to Holocene)** — Alluvium underlying fan surfaces inset upon those of *Qafo* and bearing weak soils (A/Bw at most), with colors of 10YR 6/3 measured. Likely up to 6 m thick.

Qafo — **Older alluvial fan material from Mezosoic-cored highlands (upper Pleistocene)** — Alluvium underlying fan surfaces inset upon by those of Qafy and bearing buried soils and evidence of a strong active soil. Buried soils have Bt and up to Stage II Bk horizons and colors of 10YR 6/3-6/4 and 2.5Y 7/4. Evidence for a Stage III K horizon at the top of these deposits, but this was not observed in outcrop. Likely up to 10 m thick.

El Malpais valley alluvium

Qay — **Younger alluvium of the El Malpais valley (upper Pleistocene to Holocene)** — Fine sand and mud with local fine pebbles, mainly along shallow, low gradient drainages. Active soils and buried soils are typically weak, A/Bw to A/Bt/Bk (Stage I), with clay as fine films on ped faces and bridging grains. Likely up to 2 m thick.

Qaec — **Calcareous alluvium and eolian material (upper Pleistocene to Holocene)** — Fossiliferous sand, mud, and sparse fine pebbles with rare dark gray organic material accumulations. Soil analyzes by White (1989) indicate deposits are up to 100% carbonate. Fossils are mollusk shells, and carbonate casts of grasses and roots are also locally common. Likely up to 3 m thick.

Qazo — **Older alluvial fan material from Zuni Canyon (Pleistocene)** — Gravel, sand, and silt bearing clasts indicative of derivation from the Zuni Mountain interior, specifically fine pebbles of granite, red siltstone, quartz sandstone, siliceous material, and arkosic sandstone. Distribution suggests transport from Zuni Canyon into the El Malpais valley prior to the eruption of *Qbz* but probably after eruption of *Qbc*. Thickness unknown, possibly tens of meters in the El Malpais graben.

Quaternary Piedmont Alluvial Deposits

Zuni Mountains

Alluvium of the Zuni Mountains piedmont, undivided. Typically subdivided based on age inferred from geomorphology and soil development. Units are extended from work to the west by Timmons and Cikoski (2012).

Qpy — **Younger alluvium of the Zuni Mountains piedmont, undivided (upper Pleistocene to Holocene)** — Combined unit of Qpy_1, Qpy_2, and Qpy_3 of Timmons and Cikoski (2012), mapped where finer subdivision is not readily possible at this scale. Likely up to 3 m thick.

Qpy_3 — **Youngest alluvium of the Zuni Mountains piedmont (Holocene)** — Brown silty fine to coarse sand with little soil development. Contains sparse very fine carbonate nodules (Stage I carbonate horizon morphology). Colors of 5YR 6/4 to 7.5YR 5/3 measured. 0-1 m thick.

Qpo — **Older alluvium of the Zuni Mountains piedmont (upper Pleistocene)** — Pale to medium reddish brown pebbles to boulders and silty sands with strong soil development. Stage III carbonate horizon morphology common in outcrop. Colors of 5YR 5/4 to 8.5/2 measured, with color controlled by abundance of carbonate. Likely up to 10 m or more thick.

Quaternary and Tertiary Lava Flows and Intrusive Rocks

Qbm — **McCartys flow (Holocene)** — Dark gray basalt flow largely unconcealed by eolian material or vegetation. Variably porphyritic, from <1% to 20% phenocrysts, principally of subhedral, <1 mm across pyroxene, but also rare (<3%) plagioclase as subhedral, clear, <1 mm across prismatic crystals. Age estimates range from 2.4 to 3.9 ka (Table 1). Likely 0 to 6 m thick.

Qbb — **Bandera flow alluvium (lower Holocene)** — Lithologically similar to *Qbm*, though with more fine-grained eolian cover. Consistent age estimates range from 9.17 to 12.5 ka (Table 1). Likely 0 to 6 m thick.

Qbz — **Zuni Canyon flow (upper Pleistocene)** — Dark gray to black, generally phenocryst-poor basalt. Up to 3% phenocrysts of translucent greenish pyroxene and olivine, both <1/2 mm across, typically anhedral, and variably degraded to translucent reddish iddingsite(?). Likely 0 to 4 m thick.

Qbh — **Hoya de Cibola flow (upper Pleistocene)** — Basalt flows burying *Qbc*, and buried by *Qbm* and *Qbb*, locally concealed by eolian material and vegetation though typically only partially concealed. Likely 0 to 5 m thick.

Qbc — **El Calderon flow (upper Pleistocene)** — Dark gray to black basalt with rare fine phenocrysts. Up to 5% phenocrysts <1/2 mm across of mainly subhedral translucent greenish pyroxene and lesser (up to 1% of rock) anhedral translucent greenish olivine. Basalt surface is often largely concealed by eolian material and vegetation, with actual basalt cropping out mainly at breaks in slope, areas of erosion, and areas with relatively high microrelief. Age of eruption uncertain due to a wide spread in results, from 34 to 130 ka (Table 1). Likely 0 to 7 m thick.

Qbg — **Grants flow (upper Pleistocene)** — Dark gray to black generally phenocryst-poor basalt underlying and largely concealed by *Qbc*. To date, only conclusively distinguished as a separate flow by the paleomagnetic work of Cascadden *et al.* (1997). Here, the contact is placed on a well-defined flow break along the Rio San Jose, and an inferred flow break along the western margin of the El Malpais valley; only the former contact is verified by paleomagnetic work. Rock mass is up to 4% phenocrysts of pyroxene (up to 1 mm across, subhedral, translucent greenish) and <1-2% olivine (euhedral, <1 mm across, translucent greenish). Likely 0 to 7 m thick.

Table 1. Summary of geochronologic data for the Grants SE basalt flows.

Unit	Age[1] (ka)	±2σ[2]	Type[3]	Ref.[4]	Latitude	Longitude	Comments
Qbm	2.97	0.12	^{14}C	L94	34°56.01'N	107°50.33'W	
	3.01	0.14					
	2.5	1.1	^{3}He	L94	35°05.16'N	107°46.52'W	
	2.4	0.6					
	3.9	1.2	^{36}Cl	DP04	34°55.97'N	107°50.45'W	Weighted mean of 0 mm/kyr and 5 mm/kyr erosion rate assumptions
Qbb	9.17	0.14	^{14}C	L94	35°00.32'N	108°04.35'W	
	9.81	0.12					
	11.0	1.1	^{3}He	L94	34°59.64'N	108°05.22'W	
	10.0	1.8					
	12.5	1.4	^{3}He	L94	34°59.57'N	108°05.48'W	
	11.2	0.6	^{36}Cl	DP04	34°59.55'N	108°05.30'W	Weighted mean of 0 mm/kyr and 5 mm/kyr erosion rate assumptions
	41	7	Ar/Ar	M94			Inconsistent age, possibly from excess argon
Qbh	50	14	Ar/Ar	LWup			Uncertain age, possibly suffers from excess argon
Qbc	128	33	K-Ar	CL88			
	54	50	K-Ar	L93	35°07.52'N	107°20.55'W	
	34.7	3.0	^{36}Cl	DP04	35°04.49'N	107°45.29'W	Weighted mean of 0 mm/kyr and 5 mm/kyr erosion rate assumptions
	115-120	--	PM	C97			Suggested to have erupted during the Blake geomagnetic polarity event
Ttbp	3238	85	K-Ar	L93	35°05.17'N	107°42.50'W	Lower lava flow from southeastern tip of Horace Mesa

[1]: Age as published; no attempt made to normalize values. ^{14}C ages are not calibrated calendar ages.
[2]: Uncertainty as published.
[3]: PM – age from comparison of radiometric ages and paleomagnetic data to established paleomagnetic sequence; ^{14}C ages date material from buried soils immediately underlying the flows; ^{3}He and ^{36}Cl are cosmogenic surface exposure ages; $^{40}Ar/^{39}Ar$ and K-Ar are crystallization ages.
[4]: C97 – Cascadden et al., 1997; CL88 – Champion and Lanphere, 1988; DP04 – Dunbar and Phillips, 2004; L93 – Laughlin et al., 1993; L94 – Laughlin et al., 1994; LWup – Laughlin and WoldeGabriel, unpublished data, cited in Laughlin and WoldeGabriel., 1997; M94 – McIntosh, 1994.

Ttbp — **Porphyritic trachybasalt capping Horace Mesa (Pliocene)** — Medium gray basalt with up to 5% phenocrysts of mainly plagioclase (up to 6 mm across, translucent white to chalky white, lathe-like subhedral or fractured anhedral shapes, 2-4% of rock mass) and pyroxene (<1-6 mm across, black to dark translucent green, anhedral to subhedral, <1-2% of rock mass). K-Ar age of 3.24 ± 0.09 Ma from Laughlin et al. (1993) thought to be from this flow. 15-25 m thick.

Tid — **Intrusive basalt (Pliocene)** — Dark gray to dark brownish gray and black pyroxene-plagioclase basaltic porphyry dikes. Rock mass is up to 10% greenish-translucent subhedral pyroxene, 1-3% clear to white subhedral plagioclase, and sparse reddish translucent crystals, possibly iddingsite replacing olivine. All phenocrysts <1 mm across. Dikes are 0 to 1 m wide.

Mesozoic Erathem

Late Cretaceous Rocks

Crevasse Canyon Formation (including associated tongue of the Mancos Shale)

Kcda — **Dalton Sandstone Member** — White to pale brown quartz-rich, variably silty fine to medium sandstone. Thin bedding, typically 10-60 cm thick, with common 1-5 mm thick cross-laminae. Colors of 2.5Y 8.5/1 and 2.5Y 7/2 measured for fresh faces. 34-40 m thick.

Kmm — **Mulatto Tongue of the Mancos Shale** — Yellowish brown mudstone, mostly siltstone. Strongly planar laminated/bedded mudstone, with wavy beds 2 to 30 mm thick. Colors of 2.5Y 7/4 to 8/3 measured for fresh surfaces, 10YR 7/6 measured for weathered surface. Includes a thin quartz-rich very fine sandstone interval. 50-60 m thick.

Kcs — **"Stray" Sandstone Member** — Pale brown quartz-rich clean fine sandstone. Thinly bedded, 10-40 cm thick, and massive to weakly internally cross-stratified. Colors of 2.5Y 8/3 to 7/4 measured on fresh surfaces. Includes a 2-3 m thick shale interval, as well as local mudstone interbeds (<5% of exposures). 20-25 m thick.

Kcdi — **Dilco Coal Member** — Heterolithic unit of interbedded pale brown to gray siltstone, pale brown to tan sandstone, and black coal. Thin bedding to thick laminae; sandstone beds are typically 5-25 cm thick and massive or internally cross-laminated with 1-4 mm thick laminae, while mudstone beds are 3 mm to 3 cm thick, and coal beds are up to 1 cm thick and discontinuous. Sandstone color of 2.5Y 8/4 measured on a fresh face. 35-45 m thick.

Gallup Sandstone (including associated tongues of the Mancos Shale)

Kgc — **Gallup Sandstone tongue "C"** — Pale brown to light yellowish gray quartz-rich silty fine sandstone. Thinly bedded (5-30 cm thick) with common internal cross-laminae 1 mm to 1 cm thick. Color of 10YR 8/4 measured for a fresh face. Designation as unit "C" after Molenaar (1983), previously referred to as "Gallup, main body" by Thaden *et al.* (1967) and Zeigler *et al.* (2012). 12-20 m thick.

Kgm_2 — **Upper tongue of Mancos Shale intercalated with the Gallup Sandstone** — Poorly exposed, thinly laminated mudstone and siltstone located stratigraphically between *Kge* and *Kgc*. 30-36 m thick.

Kge — **Gallup Sandstone tongue "E"** — Pale brown to light yellowish brown, quartz-rich silty-clayey fine sandstone. Thinly bedded (3-50 cm thick), massive with vertical tubular burrows to well cross-laminated, with 1-3 mm thick laminae. Color of 2.5Y 8/4 measured for a fresh face. Unit is capped by a distinctive brown, well indurated, calcite-cemented, muddy fine sandstone, with colors of 10YR 5/4 to 6/3. Designation as unit "E" after Molenaar (1983), previously referred to as "Gallup, upper tongue" by Thaden *et al.* (1967) and Zeigler *et al.* (2012). 15-25 m thick.

Kgm_1 — **Lower tongue of Mancos Shale intercalated with the Gallup Sandstone** — Poorly exposed, thinly laminated mudstone and siltstone located stratigraphically between *Kgf* and *Kge*. 10-15 m thick.

Kgf — **Gallup Sandstone tongue "F"** — Pale brown to pale yellow to gray quartz-rich silty fine sandstone and fine sandy siltstone. Thinly bedded (4-30 cm thick), commonly massive with burrows at the base, grading up into cross-laminated (1-4 mm thick laminae). Colors of 2.5Y 7/1-8/3 measured. Designation as unit "F" after Molenaar (1983), previously referred to as "Gallup, lower tongue" by Thaden *et al.* (1967) and Zeigler *et al.* (2012). 12-15 m thick.

Kmrd — **Mancos Shale, equivalent to the Rio Salado and D-Cross Tongues** — Light gray to medium gray to pale brownish gray, well-laminated gypsiferous siltstone to claystone and rare sparry gypsum beds. Thinly bedded, with beds up to 6 cm thick, commonly internally laminated, with laminae <1 to 1 mm thick. 45-55 m thick.

Dakota Sandstone (including associated tongues of the Mancos Shale)

Kdt — **Dakota Sandstone, Two Wells Tongue** — Light yellow to white, quartz-rich, variably silty fine sandstone and local siltstone. Typically more massive and thicker bedded base, and more cross-bedded and thinner bedded top. Beds from 1 m thick at base to 25-40 cm thick at top. Color of 2.5Y 7/4 measured on a fresh face. Gradational basal contact. 9-11 m thick.

Kmw — **Mancos Shale, Whitewater Arroyo Tongue** — Light gray to dark gray siltstone to claystone. Generally very poorly exposed. Color of 2.5Y 7/2 measured. 4-6 m thick

Kdp — **Dakota Sandstone, Paguate Tongue** — Light yellow to pale brown, variably silty fine to medium sandstone. A massive base grades up into a bedded but internally massive middle, followed by a bedded and internally cross-stratified top. Beds are 4-20 cm thick, cross-strata 1-12 mm thick. Unit tends to coarsen upsection, from silty very fine to clean fine-medium sandstone. Colors of 2.5Y 7/3-8/3 measured on fresh faces. 9-12 m thick.

Kmc — **Mancos Shale, Clay Mesa Tongue** — Black to brown claystone to siltstone. Brown color of 10YR 5/4 measured; brown color may be an iron oxide stain. 18-24 m thick.

Kdc — **Dakota Sandstone, Cubero Tongue** — Pale brown to light yellow variably silty fine sandstone. Thinly bedded, particularly where not bioturbated (30-50 cm thick where massive, 2-12 cm thick where cross-bedded). Vertical and subhorizontal burrows common. Unit includes a ~2 m thick medial section of mudstone, separating two sandstone intervals. 9-12 m thick.

Kdou — **Dakota Sandstone, upper Oak Canyon Member** — Black to pale brown gypsiferous claystone to siltstone. Strongly laminated mudstone, commonly wavy, up to 4 mm thick. Local very fine sandstone beds up to 3 cm thick. Colors of 2.5Y 5/3, 7/2, and black (value <2.5, chroma ~1) measured. Unit includes a ~2 m thick sandstone interval dividing two mudstone intervals. 26-30 m thick.

Kdol — **Dakota Sandstone, lower Oak Canyon Member** — Pale brown to white, variably silty fine to medium sandstone and lesser pebbly sandstone and siltstone. Thin beds (1-10 cm thick beds) that are typically more massive at the base and internally planar and cross-laminated toward the top. Vertical and subhorizontal burrows are common. Locally carbonaceous. Pebbles at the base are up to ½ cm across, poorly sorted, generally well rounded, and principally of light to medium brown siliceous material with rare quartzite and sparse granite. 8-10 m thick.

Jurassic Rocks

Jm — **Morrison Formation, undivided** — Interbedded pale yellow to light brown sandstone, varicolored mudstone, and lesser conglomerate. Lower sandstones are of silty fine sand, typically pale yellow in color (2.5Y 8/3 measured), and are indistinctly bedded with cross-laminae. Upper sandstones and conglomerates are pale brown to white, of quartz-rich silty fine to coarse sand, generally in thin beds (5-8 cm thick) with common, well-expressed cross-laminae. Pebbles, only observed in the upper part of the unit, are up to 1 cm across, moderately sorted, subrounded to rounded, and mainly of siliceous material with rare granites (up to 2% of beds) and sparse white to gray quartzites (<<1%). Mudstones are clay to silt, with colors of 5YR 5/3, 5GY 8/1, and 5Y 8/2 measured. Use of *Jm* here differs from the previous maps of Thaden *et al.* (1967) and Maxwell (1986) in that the strongly cross-bedded sandstones and conglomerates between the varicolored mudstones and bioturbated lower Dakota sandstones are included in the Morrison and not considered a part of the Oak Canyon Member of the Dakota. Pinches out to the south. 0-30 m thick.

Jb — **Bluff Sandstone** — Light gray to strong olive colored, strongly cross-bedded, dominantly eolian sandstone with local fluvial sandstone. Variably silty fine to medium sands, mainly of quartz. Thin to medium beds (up to 1.5 m thick observed), tabular and wedge-shaped, with steep, large-scale, eolian cross-laminae. Local fluvial beds are thinner, up to 20 cm thick, with low-angle, small-scale cross-laminae. Colors of 5Y 8/2 and 2.5Y 6/6 measured. Forms bold cliffs. 85-90 m thick.

Js — **Summerville Formation** — White to pale yellow, very poorly exposed sandstone, mudstone, and limestone conglomerate(?). One poor exposure suggests the presence of limestone pebble conglomerate channels, with subrounded to rounded, poorly sorted fine to medium pebbles in a silty fine to coarse sand matrix; given the poor exposure, however, it is possible this conglomerate is actually a caliche-cemented Quaternary deposit inset upon the Summerville sandstones. Colors of 2.5Y 8/1 to 7/3 measured. 13-16 m thick.

Jt — **Todilto Formation** — Gypsiferous light to dark gray fine-grained limestone. Typically <5% of fresh faces is visible grains (locally up to 20%), with <1-2% fine (<1 mm across) circular fossils. Thinly bedded, 0.5 to 10 cm thick. Colors of 2.5Y 6/1 to 7/1 measured. 5-7 m thick.

Je — **Entrada Sandstone** — Pink to light reddish brown silty fine sandstone and siltstone. Grains are moderately to poorly sorted, very silty with rare medium sand grains. Indistinctly thinly bedded (2-10 cm thick), but well cross-bedded. Color of 2.5YR 7/4 measured. 45-50 m thick.

Triassic Rocks

Ȓu — **Triassic rocks, undivided** — Cross section only. Includes both Ȓc and Ȓm. 540-550 m thick.

Ȓc — **Chinle Formation, undivided** — Poorly exposed red mudstone at the top, reddish brown sandstone and pebble conglomerate at the base; middle of unit is not exposed. Basal contact placed on the first pebble conglomerate.

Ȓm — **Moenkopi Formation** — Slope-forming red to reddish brown mudstone along the eastern edge of the quadrangle. Poorly exposed. Less than 5 m thick.

Paleozoic Erathem

Permian Rocks

Psa — **San Andres Formation** — Light to dark gray limestone and dolomite. Exposed only along the eastern margin of the quadrangle. 75-80 m thick.

Pg — **Glorieta Sandstone** — Cross section only. 40-45 m thick.

Py — **Yeso Formation** — Cross section only. 380-385 m thick.

Pa — **Abo Formation** — Cross section only. 285-290 m thick.

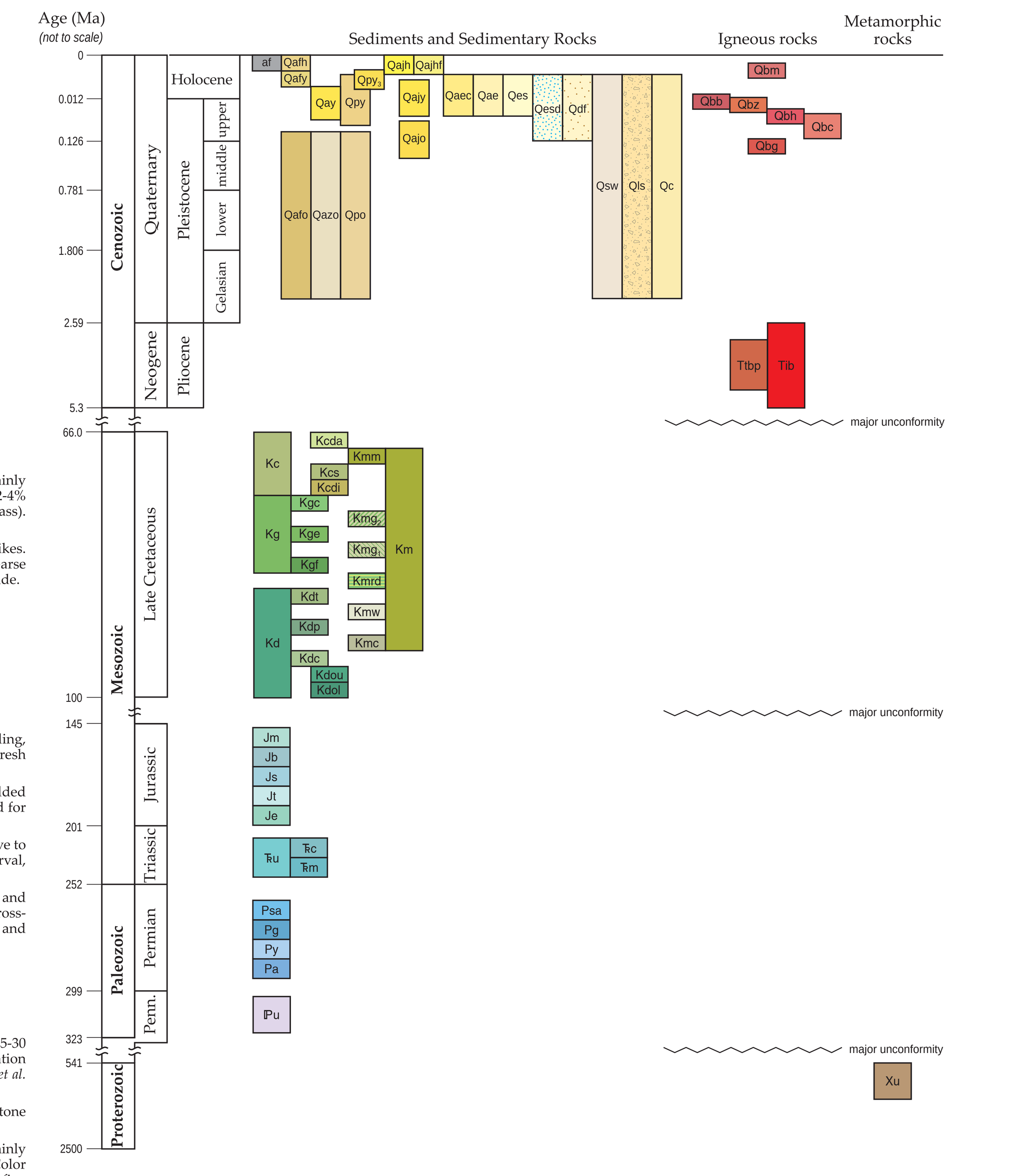
Pennsylvanian Rocks

IPu — **Pennsylvanian rocks, undivided** — Cross section only. Only locally present in the Zuni Mountains, ~150 m thick in the Gottlieb #1 lithologic log.

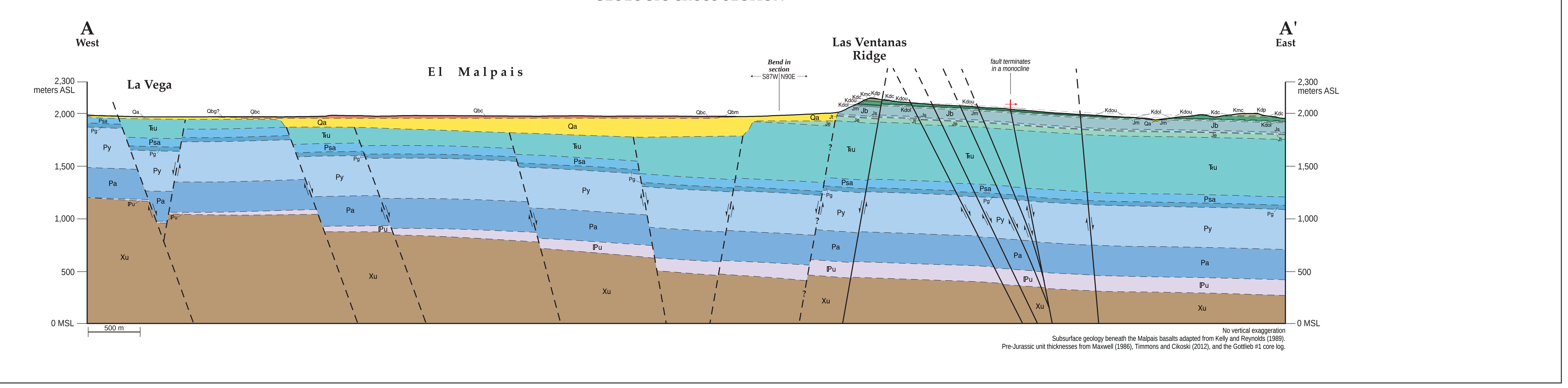
Proterozoic Eonothem

Xu — **Proterozoic rocks, undivided** — Cross section only.

CORRELATION OF MAP UNITS



GEOLOGIC CROSS SECTION



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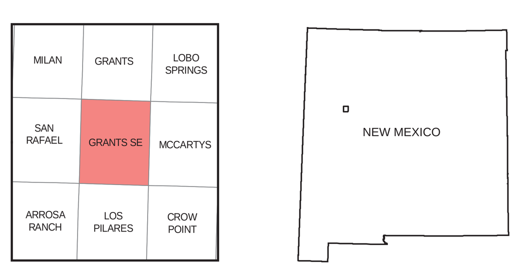
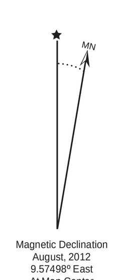
Base map from U.S. Geological Survey 2010.
North American Datum of 1983 (NAD83) World Geodetic System of 1984 (WGS84).
Reprojected to NAD27, UTM Zone 13S.
Projection and 1000-meter grid: Universal Transverse Mercator, Zone 13S
10 000-foot ticks: New Mexico Coordinate System of 1983(west zone), shown in blue.

Roads....©2006-2010 Tele Atlas
Names....GNIS, 2008
Hydrography....National Hydrography Dataset, 2005
Contours....National Elevation Dataset, 2000



QUADRANGLE LOCATION



Magnetic Declination
August, 2012
9.57498º East
At Map Center

1:24,000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

New Mexico Bureau of Geology and Mineral Resources
Open-file Geologic Map 241

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act, administered by the U. S. Geological Survey, and by the New Mexico Bureau of Geology and Mineral Resources, (L. Greer Price, *Director and State Geologist*, Dr. J. Michael Timmons, *Associate Director for Mapping Programs*).

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This and other STATEMAP quadrangles are available for free download in both PDF and ArcGIS formats at:

http://geoinfo.nmt.edu

Geologic map of the Grants SE quadrangle, Cibola County, New Mexico

June, 2013

by

Colin T. Cikoski

New Mexico Bureau of Geology and Mineral Resources, 801 Leroy Place, Socorro, NM 87801

MAP SYMBOLS

A——A' Location of geologic cross section.

Geologic contact. Solid where exposed or known, dashed where approximately known, dotted where concealed; queried where uncertain.

Normal fault, ball-and-bar on downthrown side, shear arrows show strike slip movement where interpretation suggests. Solid where exposed, dashed where approximately known, dotted where concealed. Tick gives attitude of fault plane, showing dip magnitude, arrow gives trend of fault plane lineations, showing plunge magnitude.

Exposed monocline, showing direction of plunge.

Anticlinal bend of a monocline, Solid where exposed, dashed where approximately known, dotted where concealed, queried where existence uncertain.

Synclinal bend of a monocline, Solid where exposed, dashed where approximately known, dotted where concealed, queried where existence uncertain.

Tib — Basaltic dike, unit Tib.

Strike and dip of inclined bedding.

Strike and dip of inclined bedding, remotely determined.

Horizontal bedding.

COMMENTS TO MAP USERS

A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map are based on reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation. Locations of contacts are not surveyed, but are plotted by interpretation of the position of a given contact onto a topographic base map; therefore, the accuracy of contact locations depends on the scale of mapping and the interpretation of the geologist(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site-specific conditions should be verified by detailed surface mapping or subsurface exploration. Topographic and cultural changes associated with recent development may not be shown.

The map has not been reviewed according to New Mexico Bureau of Geology and Mineral Resources standards. Revision of the map is likely because of the on-going nature of work in the region. The contents of the report and map should not be considered final and complete until reviewed and published by the New Mexico Bureau of Mines and Mineral Resources. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the State of New Mexico, or the U.S. Government. Cross-sections are constructed based upon the interpretations of the authors made from geologic mapping, and available geophysical (regional gravity and aeromagnetic surveys), and subsurface (drillhole) data.

Cross-sections should be used as an aid to understanding the general geologic framework of the map area, and not be the sole source of information for use in locating or designing wells, buildings, roads, or other man-made structures.