

APPENDIX 4. DESCRIPTIONS OF WELL CUTTINGS FROM SAN AGUSTIN PLAINS — STRATIGRAPHIC TEST #1 (SA-221) AND #2 (SA-222) WELLS.

Stratigraphic Test #1 well (SA-221). Located at Section 26, T2S, R9W. Ground elevation of 7,095 ft. Depth range interpretation considers wireline data interpretations. Common abbreviations for sand or pebble sizes are: vf (very fine), f (fine), m (medium), c (coarse), and vc (very coarse). Sand may be further subdivided according to Table 2.

Unit	Description	Depth (ft)	Thmt %	Qtz %
UPPER SANTA FE GROUP UNIT (PLIOCENE-QUATERNARY)				
Gravelly subunit (Quaternary)				
Western piedmont deposits — Qsupwc				
1	SANDY PEBBLES: Sand is pink (7.5YR 7/3) and mostly medium- to very coarse-grained. Pebbles are angular to subrounded (mostly subangular) and up to 2 cm long (most being about 1 cm). Clast count of the pebbles. @50–60 ft (n=43): 63% intermediate volcanic, 28% felsic volcanic (about half of which is Hells Mesa Tuff), 2% basaltic andesite, 2% quartz, 2% volcanoclastic pebbly sandstone, and 2% Paleozoic limestone; 1–2% rounded granite. The sand has 10% quartz and an approx. ratio of intermediate vs felsic lithic grains of 60:40.	0–90	<15%	10%
2	PEBBLY SAND: Pebbles are 2–15 mm long, subrounded (mostly) to subangular, and composed of intermediate-dominated volcanic pebbles. Sand is pinkish gray (7.5YR 6/2), mL-vcU, subangular, moderately sorted, and composed of intermediate volcanic lithics, 20–30% visually estimated felsic volcanics, 5–10% quartz, and 5–10% vitreous feldspar. ~15–20% of the detritus (sand and pebbles) is from the Hells Mesa Tuff.	90–120	15–20%	5–10%
3	SANDY PEBBLES: Pebbles are up to 20 mm long (mostly 0.8–1 cm) and subangular-subrounded (minor angular). Clast count @146–175 ft depth (n=53): 72% intermediate volcanic, 25% felsic volcanic (22% of total gravel are Hells Mesa Tuff), 2% basaltic andesite, 2% quartz. Sand is pinkish gray (7.5YR 6/2), mL-vcU, angular to subangular, and composed of 10–15% quartz grains and an intermediate vs felsic volcanic ratio of: 70–80 vs 20–30. @205–234 ft: 1 rounded chert or limestone pebble (from Tsds). Pebbles are mostly vf-m, angular to subangular, and composed of the following (based on a clast count of 55 clasts (n=55 pebbles): 60% felsic volcanics (including 5% Hells Mesa Tuff, 15% La Jencia Tuff, and 22% Vicks Peak Tuff, % of total gravel), 25% intermediate volcanic rocks, 9% basaltic andesite, and 5% siliceous clasts (quartz, quartzite, chert). The sand has 10–15% quartz and an intermediate vs felsic ratio of: 35–40% vs 60–65%.	120–234	20%	15%
4	PEBBLY SAND: Pinkish gray (7.5YR 6/2), mL-vcU sand with 15% vf-f pebbles similar in composition to pebbles at 205–233 ft. Sand is angular to subangular and composed of 10–20 quartz, 1/3 intermediate volcanic rocks, and the rest are felsic volcanic rocks (including 10–15% Vicks Peak Tuff, 1–5% La Jencia Tuff, and 10–20% Hells Mesa Tuff; % are of the total gravel number).	234–261	10–20%	10–20%

Unit	Description	Depth (ft)	Thmt %	Qtz %
5	PEBBLY SAND: Sand with 20% pebbles (up to 1.2 cm but mostly 0.7–0.8 cm). Pebbles are angular to subangular (minor subrounded). Clast count (n=45): 53% felsic tuffs (24% Vicks Peak Tuff, 4% La Jencia Tuff, 16% Hells Mesa Tuff; % is of total gravel); 36% intermediate volcanic rocks, 4% volcanic sandstone, 4% quartz, and 1% granite(?). Sand is pinkish gray to light gray (7.5YR 7/1-6/2), mL-vcU, subangular to angular, and composed of 10–15% quartz and an intermediate vs. felsic volcanic rock ratio of: 30 vs. 70. About 10% of the sand is inferred to be derived from the Hells Mesa Tuff.	261–290	10–15%	10–15%
6	PEBBLY SAND: Est 25–35% pebbles that are angular to subangular and poorly sorted. Pebble clast count (n=72) gives: 56% felsic volcanic rocks (36% Vicks Peak Tuff, 10% La Jencia Tuff, 13% Hells Mesa Tuff; % are for total number of gravel), 8% intermediate volcanic rocks, 8% basaltic andesite (La Jara Peak basalts), 1% quartz or quartzite, 1% chert, 1% volcanic sandstone, 1% granite. Sand is mL-vcU, angular to subangular, and poorly sorted. Composition of sand includes 3–5% quartz, 30% intermediate volcanics (including possible La Jara Peak “basalts”), and 60–70% felsic volcanic rocks.	290–320	10–15%	3–5%
7	@ 320–376 ft: Pebbly sand inferred to be slough from units 1–6 because both resistivity and neutron curves are relatively low. Pebbles are very fine to medium and subangular to angular. Sand is mL-vcU and subangular. Both are composed mostly of tuffs (Hells Mesa Tuff and subordinate Vicks Peak Tuff and possible Rock House Canyon Tuff).			
Gravel-poor subunit (Pliocene-Quaternary)				
Basin-floor deposits (Pliocene-Quaternary) — QTsubf				
7	CLAYEY SAND: Interpreted primarily from resistivity and neutron curves, which are low values. Cuttings are coarse, however, due to inferred slough (@320–376 ft above). Pink (7.5YR 7/4).	320–374		
8	Eastern piedmont deposits (Pliocene-Quaternary) — QTsupe SAND: Monolithic, gray (7.5YR 6/1), angular (minor subangular) sand with 5–10% very fine pebbles. Sand is composed of a phenocryst-poor (trace amounts of sanidine and plagioclase(?)) phenocrysts that are up to 2 mm long; trace to 0.5% biotite phenocrysts <1 mm) tuff that looks very much like Vicks Peak Tuff in the Strat Test #2 well and in the Southland Royalty No. 1 well. Sand is mL-cU (minor vcL-vcU) and has <1% quartz grains. @ 437–468 ft: Sand is slightly coarser (mL-vcU).	376–440	0	<1% quartz
9	Eastern piedmont slope and/or basin floor deposits with mostly eastern provenance (Pliocene-Quaternary) — QTsupe-bf CLAYEY, FINE-GRAINED SEDIMENT: Interpreted primarily from resistivity and neutron curves, which are low. Cuttings consist of gray (7.5YR 6/1), mL-vcU sand (see @437–468 ft), inferred to be slough.	440–445		
10	PEBBLY SAND: Mix of: 1) 25% vf-f, angular to subrounded, light gray pebbles, 2) 15–20% pinkish clayey vf- to m-grained sand, and 3) ~60% c-vc sand grains. The coarse sand and vf-f pebbles are composed of inferred Vicks Peak Tuff with trace to 0.5% white Hells Mesa Tuff and trace basaltic andesites. Sand is pinkish gray (5YR 7/2) and a mix of angular-subrounded grains.	450–500	<1%	<1%
11	PEBBLY SAND: Sand is white to light gray (7.5YR 7-8/1), mL-vcU; 10% very fine to fine pebbles. Both are angular to subangular (minor subrounded) and composed of tuff or tuffaceous silt-very fine sand. The tuff rock is of two types: (1) 90% light gray-light pink, inferred Vicks Peak Tuff and having 1–5% phenocrysts of hornblende, biotite, quartz, and sanidine –quartz and sanidine are up to 3 mm long, or (2) 10% reddish brown, eutaxitic tuff likely correlative to La Jencia Tuff. There is 1–5% quartz in the sand. There is a spike in the neutron and resistivity curves at 523–537 ft, consistent with a clean sand body.	500–537	<0.5%	1–5%

Unit	Description	Depth (ft)	Thmt %	Qtz %
12	<p>PEBBLY SAND: light gray (7.5YR 7/1), fL-vCU sand with 10-15% very fine to medium, pebbles; both are subangular to angular and composed of a monolithologic, light gray to pink, moderately phenocryst-rich, welded tuff (20-25% phenocrysts that are 0.5-1.5 mm long and include feldspar, quartz, and biotite)—South Canyon Tuff?; estimate 1-5% Vicks Peak Tuff fragments. 1-3% quartz sand grains.</p> <p>Pliocene-Quaternary, basin floor deposits with mixed provenance (Pliocene) — QTsubf</p>	537–573	<0.5%	1-3%
13	<p>CLAYEY SAND: Sand is light gray to pinkish gray (7.5YR 7/1-2), mL-vcU, angular-subrounded (mostly subangular), and poorly sorted; 1–10% very fine pebbles.</p> <p>@562–594 ft the sand is slightly muddy and contains minor vL-fU sand. Sand grains are composed mainly of the phenocryst-rich tuff observed in Unit 12 (some grains are eutaxitic; 25–30% phenocrysts comprised of feldspar, quartz, and biotite 0.1–2.0 mm long) in addition to ~10% phenocryst-poor, light gray tuffs, 1–5% quartz, and trace-5% intermediate volcanic grains (including possible La Jara basaltic andesite).</p> <p>@573–590: Clay body inferred from extremely low resistivity and neutron curves. Gamma ray is also low.</p> <p>@590–600 (but cuttings may be from 563–573 of unit 12): Sand is light gray to white (7.5YR 7-8/1), mU-vcU and subangular. It is composed of >80% ignimbrites with inconspicuous phenocrysts. These look different than the Vicks Peak Tuff noted above, and perhaps correlate to the South Canyon One clast has a pyroxene crystal; one sanidine crystal that is mU-cL sand-size. Gamma ray curve is extremely low.</p>	573–626	<0.5%	1-5%
14	<p>SAND: Sand is white to light gray (7.5–10YR 7-8/1), fU-cL (mL-cL in upper half, fU-mU in lower half), subrounded to subangular, and well-sorted. Sand composed of sanidine and other feldspar with 25–50% felsic tuff lithics (same phenocryst-rich tuff as in Unit 12, possibly the South Canyon Tuff), ~10% quartz, and 7–10% biotite; no intermediate volcanic grains.</p> <p>@656–689 ft: Grains contain abundant crystal-rich tuff (Hells Mesa Tuff) along with 10–20% other tuffs (including phenocryst-poor tuff probably correlative to the Vicks Peak Tuff). There is 5–10% quartz in the sand fraction.</p> <p>Pliocene-Quaternary, lower sandy unit: interfingering, distalmost western piedmont slope deposits with possible minor basin floor deposits (Pliocene) — QTsubf-pw</p>	626–680	?? May be a lot	10%
15	<p>PEBBLY SAND: Sand is light gray to white (7.5YR 7-8/1), mL-vcU sand with 20–25%, subangular to subrounded, vf-m pebbles. 97–98% of total sediment seems to be derived from Hells Mesa Tuff (as seen in Well SA-222). The tuff clasts have 15–25% phenocrysts that include quartz, sanidine, and biotite; these are 0.2–3 mm long. Sand fraction contains 1–5% quartz grains. Gamma ray log is relatively high, and is used to constrain the contacts. Coarse texture indicates local derivation from footwall, and implies a footwall scarp.</p> <p>@718–749 ft: 5-7% non Hells Mesa Tuff clasts.</p> <p>@749–781 ft: Abundant wood shavings in the cuttings; 10–15% very fine to fine pebbles that are angular to subangular; 1–5% quartz grains.</p>	680–738	>95%	5%

Unit	Description	Depth (ft)	Thmt %	Qtz %
16	SAND: Sand is white to light gray (7.5YR 7-8/1), mL-cU, angular to subangular (mostly subangular), and relatively well-sorted. Composed of tuffs (substantial Hells Mesa Tuff detritus) with 10–15% feldspar (including sanidine), 10% quartz, 3–5% phenocryst-rich tuff observed in Unit 123 (South Canyon?), 3–5% intermediate grains, and 3% biotite grains. @750–782: Sediment is cl. to vcU sand and vf-f pebbles composed of angular Hells Mesa Tuff. 3–5% quartz grains. @896–937 ft: fU-cU sand and 3% for-sure intermediate volcanic grains; felsic grains are consistent with derivation from mainly the Hells Mesa Tuff.	738–937	>50%	10%
17	SAND: Sand is gray and slightly reddish (5-7.5YR 6/1) mL-vcU, angular-subangular, and relatively well-sorted. Composed of Hells Mesa Tuff with 10–15% vitreous feldspars (including likely sanidine), 10–15% quartz, and 5% intermediate volcanic grains. Much wood shavings. @969–1,000 ft: fU-cU sand; composition as above and containing 10–15% vitreous feldspar (including likely sanidine), 10% quartz, and 3% intermediate volcanic grains. @1,000–1,032: ml-cU sand; as above but with 7–10% intermediate volcanic grains. @1,032–1,063 ft: 10–15% vf-m pebbles that are mostly intermediate volcanic in composition. Sand contains 10–15% quartz, 10–15% vitreous feldspar, and the rest are felsic volcanic rocks (mostly Hells Mesa Tuff); 15–20% intermediate clasts. @1,092–1,100 ft: Clayey interval inferred from geophysical logs. Cuttings at 1,063–1,126 ft sample interval are a muddy vfL-vcU sand. The sand at 1,094–1,126 ft consists of orangish, quartz- and sanidine-phyric felsic volcanic lithic grains (10–20% phenocrysts) with 10–15% feldspar, 5% quartz, and 3% biotite.	937–1,100	<50%	5–15%
18	SAND: Sand is white to pinkish white (7.5YR 8/1-2), mL-vcU, subangular, sand composed of light-orange to light-gray, quartz-sanidine-phyric tuff fragments (20% phenocrysts, so likely still derived primarily from the Hells Mesa Tuff), 10% quartz, 10% vitreous feldspar, and 1–3% intermediate volcanic grains. Steady coarsening-upward trend in lower 45 ft may suggest progradation of the White House fan.	1,100–1,210	>50%	10%
<p>MIDDLE SANTA FE GROUP UNIT Basin floor deposits (late Miocene) — Tsmbf <i>Inferred Miocene-Pliocene boundary at 1,210 ft. Sediment is less gravely and more red below this contact, consistent with Santa Fe Group observed in the south-central Rio Grande rift.</i></p>				
19	CLAYEY-SILTY SAND: Much more fines than above. Sand is white to pinkish white (7.5YR 8/1-2), mL-cU (10% vf-f & 5% vc), subangular, low-well to high-moderate sorted, and more heterolithic than above; estimated composition of undetermined felsic tuff, 10–20% intermediate volcanic grains, 5–10% vitreous feldspar, 5–10% quartz. Much of the tuff grains could be Hells Mesa Tuff, but the small grain size hampers conclusive ID. @1,283–1,314 ft: mL-cU sand with 1–2% mud; 15% vf-f sand and 1–5% vc sand; sand is subangular and composed of quartz-sanidine-biotite tuff (probably mostly Hells Mesa Tuff), 10–15% vitreous feldspar (including sanidine), 10–13% quartz, 3% biotite, 1–3% intermediate volcanic rocks.	1,210–1,315	Probably >50%	5–10% 10-13%

Unit	Description	Depth (ft)	Thmt %	Qtz %
20	SLIGHTLY SILTY-CLAYEY SAND: Redder than above (pinkish gray to pink, 5YR 7/2-3) and has less clay and silt than above. Sand is fU-cU, subangular (minor subrounded), high-moderately sorted, and composed of 10–15% quartz, 10–15% vitreous grains, 5-10% intermediate volcanic grains, and the rest is a felsic tuff consistent with Hells Mesa Tuff or the orangish tuff described in 1,470–1,501 ft. @1,345–1,377 ft: 1% vf pebbles; 10% cU sand. @1,377–1,408 ft: 5% mud with fU-vcU sand (mostly mL-cU); sand is subangular and contains 7-10% quartz, 7–10% vitreous feldspar, and 10% intermediate volcanic grains. @1,408–1,438 ft: In washed cuttings, I observe felsic tuffs, 20–25% vitreous feldspar + quartz (subequal), 10% intermediate volcanic rocks, and 3% biotite. There is one grain of quartz that is 2 mm long. Abundant red staining (discoloration) of sand grains.	1,315–1,440	~50%?	10–15%
21	SAND: Sand is light gray to pinkish gray (5YR 7/1-6/2), medium- to very coarse-grained, subangular to subrounded, and moderately sorted. Composition is relatively monolithic: pink, biotite-hornblende dacite with 0.1–1.0 mm-size crystals. 1–5% quartz grains. Seen only on chip tray.	1,440–1,452	<5%	1–5%
22	CLAYEY SAND: Sand is fU-vcU, clean, angular to subangular, and low-moderately sorted. Washed cuttings indicate an orangish tuff (15% phenocrysts of subequal quartz, sanidine, biotite; 0.2 to 2 mm long – South Canyon Tuff?), 25% feldspar (minor vitreous grains; most are orange and tabular), 7–10% quartz, 1–3% biotite. Very low resistivity and neutron signatures, but high gamma ray, so I interpret a clayey sand although evidence of mud in the cuttings is lacking. @1,501–1,533 ft: mU-vcU sand that is still clean; low-well sorted. Composition includes 30–40% felsic tuff, 30–40% intermediate volcanic rocks, 15% pink feldspar, 5–10% vitreous feldspar, and 5% quartz. Probably White House Canyon provenance. NOTABLY REDDISH ABOVE 1,533 FT UP TO 1,210 FT. Eastern piedmont deposits derived from crystal-poor tuff (Late Miocene?) — Tsmip [Note that this could possibly be a western piedmont deposit from a drainage sourced in Vicks Peak Tuff-dominated bedrock, during a time when this tuff may have occupied much more of the eastern Datil Mountains]	1,452–1,555	<10%	7–10%
23	SAND: Sand is whitish, mU-vcU, angular-subangular, and composed of a monolithic tuff with 20% intermediate volcanic grains, and 15% [subequal quartz and vitreous feldspar]. The tuff is biotite-phyric and relatively crystal-poor; a coarse sanidine phenocryst seen in a sand grain and <5% quartz or sanidine phenocrysts. Lots of wood chips. @1,555–1,565: Sand is mU-vcU and composed of tuffs with 10–20% intermediate volcanic rocks and 10–20% quartz. Intermediate-rich detritus may be slough.	1,555–1,595	<1%	5–10%
24	SAND: Sediment is light gray (5–7.5YR 7/1), mL-cU, subangular (minor subrounded), well-sorted, clean sand composed of a heterolithic mixture of fine-grained tuffs (orange, pink, light gray), 15–20% intermediate volcanic grains, 5% quartz, and 5% vitreous feldspar. This is inferred to be slough because the gamma ray is very high, similar to what is associated with Vicks Peak Tuff. It may also be a heterolithic mixture of Mogollon Group tuff grains deposited on a basin floor. SLIGHTLY REDDISH BETWEEN 1,625–1,533 FT. SLIGHTLY REDDISH ABOVE 1,628 FT	1,595–1,625	??	5%

Unit	Description	Depth (ft)	Thmt %	Qtz %
25	SAND Gray (5YR 6/1), mL-vcU, angular-subangular sand composed of light gray tuff that looks similar to the Vicks Peak Tuff, 1–3% quartz, and 1–3% vitreous feldspar grains. Biotite phenocrysts on the light gray tuff are more abundant than quartz or sanidine phenocrysts. 15–20% pink-orange, sanidine-biotite-quartz phyrlic felsic rock that may possibly be South Canyon Tuff. No signs of cementation. Resistivity and neutron curves show a steady coarsening-upward trend. Gamma ray curve is high. @1,723–1,755 ft: 0.5% very fine pebbles. In washed cuttings, the light gray tuff contains the following phenocryst assemblage: trace quartz (one is up to 2 mm long), trace sanidine (0.5–2 mm), 0.5% biotite (0.2–1 mm). When wetted, this tuff looks reddish.	1,625–1,855	<1%	1–3%
26	SAND AND MINOR PEBBLES: Sand is light gray (5YR 6/1), cL-vcU and angular. Pebbles are very fine and angular. Both are composed of crystal-poor tuff correlated to the Vicks Peak Tuff; this tuff has 1–3% quartz and 1–3% sanidine phenocrysts (both are mostly <1 mm, locally up to 2 mm). In sand, there is 1–3% quartz grains, 1–3% sanidine, and 0.5% biotite. Still a light gray color (5YR 6/1). Gamma ray curve is high but neutron and resistivity curves are relatively low. ABOVE HERE, THE NEUTRON AND RESISTIVITY CURVES SHOW A COARSENING UPWARD TO THE TOP OF THE UNIT. Inferred interfingering with basin-floor facies.	1,855–1,925	<1%	1–3%
27	INTERBEDDED SAND AND SILTY SAND: Sand is light gray (5YR 6/1) and mostly mL (lesser fL-fU and lesser mU-vcU). Sand is angular to subangular, high-moderate to low-well sorted, clean, and composed of a crystal-poor tuff, Detritus correlated to Vicks Peak Tuff. Gamma ray curve is high-value.	1,925–2,075	1%	<1%
LOWER SANTA FE GROUP, UNIT				
Upper Subunit (middle Miocene?)				
Basin floor deposits—Tslbf				
28	CLAYEY-SILTY FINE SAND: Sand is pinkish gray (7.5YR 7/2), fL-cU (mostly mL-mU), angular to subangular, and composed of an orangish-gray, felsic volcanic rock (15–20% phenocrysts of quartz, feldspar, and biotite up to 1 mm long) – possible South Canyon tuff, but the overall formation has a low gamma-ray signature—with minor intermediate-volcanic grains; also 3–7% grains of vitreous feldspar and 1–3% quartz. @2,069–2,132 ft: fU-mU sand. 15–20% light gray, relatively aphyric intermediate grains; ~5% opaque feldspar. @2,132–2,164 ft: mL-cU sand (minor fL-fU sand); 20% aphyric, light gray, intermediate grains. @2,196–2,227 ft: 5–10% aphyric, lt gray intermediate grains.	2,075–2,226	<1%	1–3%
29	SILTY SAND INTERBEDDED WITH SUBEQUAL COARSER SANDS: Sand is pinkish gray (7.5YR 7/2), fL-mU, and composed of felsic volcanic rocks with ~20% dark intermediate volcanic rocks ; 3–10% subequal quartz and vitreous feldspar. 1% clay seen in the cuttings. Three relatively clean sand bodies at 2,227–2,235 ft, 2,242–2,247 ft, and 2,257–2,265 ft; these lack notable fining- or coarsening-upward trends. Coarser sand on cuttings board is mU-vcU.	2,226–2,265	<1%	5%
30	CLAYEY-SILTY SAND: Sand is pinkish gray (5-7.5YR 7/2), mL-cL, and angular to subrounded (mostly subangular), well sorted, and has ~1% clay in the cuttings. Inspection of washed cuttings: orangish gray felsic volcanic rock [10–20% phenocrysts composed of quartz and sanidine (0.1-1 mm, minor 2 mm) and lesser biotite], 10% vitreous feldspar, 10–20% opaque feldspar, 1–5% quartz, 10–25% intermediate volcanic grains (mostly non-phyric), 3% biotite grains Particularly clayey intervals at 2,265–2,285 ft, and 2,328–2,338 ft based on wireline logs. @2,354–2,384 ft: fL-cU sand that is subangular, moderately sorted, and similar in composition to the sand at 2,291–2,323 ft.	2,265–2,416	<1%	1–5%

Unit	Description	Depth (ft)	Thmt %	Qtz %
31	CLAYEY-SILTY SAND: Sand is pinkish gray (7.5YR 7/2), fU-mU (5% cL-cU), angular to subangular (mostly subangular), and well sorted. Washed cuttings consist of orangish felsic volcanic rock [15% phenocrysts dominated by quartz and vitreous feldspar; usually <1 mm but locally up to 2 mm long], 10% light gray, biotite-phyric volcanic rock, 3% quartz, and 10% vitreous feldspar. Particularly clayey intervals at 2,455–2,465 ft. @2,540–2,635 ft: Sand is mL-vcU and subangular to angular. Inspection of washed cuttings indicate a composition of: orange-gray felsic rock [15% phenocrysts comprised of quartz, vitreous feldspar, and biotite; usually <1 mm but locally up to 2 mm long—South Canyon Tuff?], 20–25% light gray, biotite-phyric volcanic rock (probably a dacite), 3–5% subrounded quartz, and ~20% vitreous feldspar.	2,416–2,635	<1%	5%
32	CLAYEY-SILTY SAND: Sand is gray to light gray to pinkish gray (7.5YR 6-7/1, 7/2), fU-cU (minor vL-vcU), subangular to angular, and well sorted. Inspection of washed cuttings indicate the following sand composition: orangish-gray felsic volcanic rock (as described in Unit 31), 15–20% light gray intermediate rock (3–10% biotite and 1% hornblende phenocrysts), 10% vitreous feldspar, 1–3% quartz, 1–3% biotite. On cuttings board, this sand type extends to 2,793 ft.	2,635–2,775	<1%	<1–3%

Lower Subunit (middle Miocene?)

Sandy basin floor and fluvial deposits — TsIs

33	CLAYEY-SILTY FINE SAND INTERBEDDED WITH 15–30% SAND INTERVALS: Sand is mU-vcU (mostly cU), subangular (minor angular and subrounded), and has 1% very fine pebbles. Inspection of washed cuttings indicate the following sand composition: orangish gray felsic volcanic rock (as described in Unit 31; mostly quartz-sanidine-phyric, lesser biotite and hornblende, and phenocrysts <1 mm long) with 10–20% light gray intermediate rock, 10% vitreous feldspar, 10% opaque feldspar, 1–3% quartz, trace-2% biotite.	2,775–3,108	0%	1–3%
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On wireline logs: Sand body thicknesses typically are 3–10 ft. Two thicker bodies, displaying fining-upward trends, are present at 2,864–2,860 ft and at 2,942–3,000 ft.

@2,793–2,825 ft: Light gray (5YR 7/1), mL-cU (5% vL-vcU sand) and clayey-silty sand in the cuttings. Grains are angular to subangular and moderately sorted. 15–20% intermediate volcanic detritus (biotite-hornblende phyric, mostly biotite), with rest (~80%) being orangish-gray, feldspar-quartz phyric felsic rock whose phenocrysts include biotite, hornblende, sanidine(?), and plagioclase phenocrysts. Sand has 3–5% quartz and 15% feldspar (subequal vitreous and opaque).

3,019–3,077 ft: Light gray (5YR 7/1), mL-cU sand and clayey-silty sand in the cuttings. Grains are angular to subangular and moderately sorted. Sand has trace-1% quartz.

@3,044–3,076: mU-vcU sand. Washed cuttings indicates a sand composition of: orangish felsic volcanic rock (phenocrysts include biotite, hornblende, and vitreous feldspar), 25% light gray biotite-phyric intermediate volcanic rock, 5–10% opaque feldspar, 5–7% vitreous feldspar, 1–2% biotite.

@3,077–3,108 ft: Greenish cL-vcU, angular sand and clayey-silty sand mostly composed of propylitically altered, intermediate volcanic grains that are mostly biotite-phyric. Trace quartz. Subordinate creamy quartz-poor tuff with hornblende and sanidine(?) phenocrysts. Seen only on the cuttings board.

Unit	Description	Depth (ft)	Thmt %	Qtz %
34	<p>CLAYEY-SILTY FINE SAND INTERBEDDED WITH ~20% SAND INTERVALS: Clayey-silty, pinkish gray to light gray, fine- to coarse-grained sand (mostly mL-mU) composed of the orangish gray felsic rock and 20–35% intermediate volcanic detritus with ≤3% quartz.</p> <p>@3,108–3,138: Pinkish gray (5–7.5YR 7/2), slightly clayey, mL-cU, angular-subangular, moderately sorted sand. Washed cuttings indicate a sand composition of: orangish gray felsic volcanic rock with 15% plagioclase-biotite dacite, 20% feldspar, 10% bronzy biotite, and 3% quartz sand.</p> <p>@3,138–3,170 ft: Pinkish gray (7.5YR 6-7/2), clayey fU-cU (1–3% vL-vU), angular to subangular, moderately sorted sand. Inspection of washed cuttings indicates: orangish quartz-feldspar-phyric felsic volcanic rock with 30–35% biotite-phyric, light gray dacite, 3–5% vitreous feldspar, 10% opaque feldspar, and 3–5% quartz.</p> <p>@3,170–3,266 ft: Light gray (5YR 7/1), fL-cU sand (mostly mL-mU; fine sand more common down-section) and clayey-silty sand that is angular-subangular and moderately to well-sorted. Inspection of washed cuttings indicates biotite-phyric dacite with 30–50% orangish felsic rock, 5–15% feldspar (vitreous and opaque grains), and 1–2% quartz grains. Only 10–15% greenish grains seen on the cuttings board.</p> <p>@3,266–3,370: Sand composition is like that described in Unit 35.</p>	3,108–3,370	0%	3%
				3–5%
				1–2%
35	<p>INTERBEDDED SAND AND SILTY SAND: Sand is gray (7.5YR 6/1-10YR 5/1), fL-cL (minor vU), angular (mostly) to subangular, and moderately sorted. Washed cuttings exhibit the following sand composition: Orangish feldspar-quartz felsic volcanic (also aphyric) with 35–50% light gray, biotite-phyric dacite, 15% feldspar (mostly orangish, but up to 10% of total sand is vitreous feldspar), 1–2% biotite, 0.5–1% quartz. Much greenish grains seen on cuttings board. Intermediate volcanic rocks are mostly biotite-phyric, with only minor hornblende(?). Trace quartz grains. Sand body thicknesses typically are 3–6 ft. Two thicker bodies are at 3,432–3,446 ft and 3,457-TD; these sands lack vertical trends. Top contact based on geophysical curves, since lithologically similar sand extends up-section to ~3,266 ft.</p>	3,370–3,495	0	0.5–1%

Stratigraphic Test #2 well (SA-222). Located at SE1/4 SE1/4 NW1/4 NE1/4 Section 13, T1S, R9W.

Unit	Description	Depth (ft)	Thmt %	Qtz %
UPPER SANTA FE GROUP UNIT (Pliocene-Quaternary)				
Gravelly subunit				
Western piedmont (Quaternary) – Qsupwc				
1	SANDY PEBBLES: Pink to gray (7.5YR 7/4 to 6/1). Gravel are vf-c, subangular to subrounded, and composed of tuffs (mostly crystal-rich, but quartz-poor, Datil Well Tuff) with 20–35% intermediate volcanic rocks. Largest pebble is a 26 mm long, vesicular basalt. Sand is mU-vcU and subangular to subrounded, and similar in composition to the pebbles. About 5% of sand is quartz. About 5% of detritus is Hells Mesa Tuff.	0–50	5%	5%
2	INTERBEDDED SANDY PEBBLES AND CLAYEY-SILTY SAND: Sand is pink to light gray (7.5YR 7/1-3) and mostly very fine- to fine-grained. @80–90 ft, pebbles are up to 2 cm long and subangular. Pebbles composed of a crystal-poor and and crystal-rich (but quartz-poor) tuffs correlated with Rockhouse Canyon and Datil Well Tuffs, respectively. ~20% intermediate volcanic rocks. Sand is mU-vcU, subangular to subrounded, and similar in composition as the pebbles.	50–100	<5%	<5%
3	COARSE SAND AND PEBBLES: Sand is mostly cL-vcU, pinkish white to gray (7.5YR 8/2 to 5/1), and subrounded to subangular. Pebbles are mostly vf-m, subangular to subrounded, and composed of about subequal intermediate volcanic rocks vs tuffs. The tuffs are mainly Datil Well, with lesser Rockhouse Canyon and Hells Mesa. Est 3% of detritus is Hells Mesa Tuff. Est 2–5% of sand is quartz. Resistivity and neutron peaks are relatively symmetrical. @150–153 ft: Clayey fine sand bed.	100–162	3%	2–5%
4	CLAYEY FINE SAND: Top half is light brown (7.5YR 6/4), and lower half is white (10YR 8/1). 10–20% of sand is medium to very coarse, rest is very fine- to fine-grained.	162–175		
5	SANDY PEBBLES: Gray (7.5YR 6/1). Pebbles are subangular and up to 23 mm long. Pebbles composed of intermediate volcanic rocks with 30–40% tuffs (mainly Datil Well, minor Rockhouse); <3% Hells Mesa Tuff. <2% quartz. Sand is cL-vcU, subangular to subrounded, moderately sorted, and composed of intermediate volcanic rocks with 20% tuffs (primarily Datil Well Tuff). @180–182 Ft: Clayey sand bed.	175–200	<3%	<2%
6	SUBEQUAL SANDY PEBBLES AND CLAYEY SAND BEDS: Bedding thicknesses are 1–3 ft thick. Clayey sand is very pale brown (10YR 7/3), and sand is primarily vf-f, with 1–25% m-vc sand. Pebbles are subangular and up to 17 mm long. <3% quartz in sand. No Hells Mesa Tuff seen. @200–209 ft: Thick clayey sand interval. @239–245 ft: Thick clayey sand interval.	200–245	<1%	<3%
7	SANDY PEBBLES, VERY LOW CLAY PROPORTION IN MATRIX: Gray to white. Pebbles are vf-m (one is up to 18 mm), subangular to subrounded, and composed of intermediate volcanic rocks with 30–40% tuffs (mainly Datil Well and Rockhouse Canyon Tuffs). No Thmt seen. Sand is cL-vcU, subangular to subrounded, and composed of subequal intermediate volcanics vs. tuffs. No quartz grains.	245–262	<1%	<1%

Unit	Description	Depth (ft)	Thmt %	Qtz %
8	INTERBEDDED CLAYEY SAND AND SAND: Sand on cuttings board is pink (7.5YR 7/4), vL-fU w/ <10% coarser grains. @262–279 ft: Slightly clayey-silty sand.	262–305		
9	SANDY PEBBLES, VERY LOW CLAY PROPORTION IN MATRIX: Gray to white. Pebbles are up to 23 mm long and subangular. Pebbles composed of subequal intermediate int volc and tuffs (+/- 1/3). Sand is cL-vcU and subangular, and has 3–5% quartz. Overall, <3% Hells Mesa Tuff. Upper sandy subunit (Pliocene-Quaternary) Western piedmont (Quaternary) – Qsupw	305–340	<3%	3–5%
10	SAND WITH MINOR CLAYEY SAND: Pink to light brown (7.5YR 6-7/4), vL-cU (mostly finer sand). @340–350 ft: Clayey fine sand interval.	340–367		
11	INTERBEDDED CLAYEY FINE SAND AND SUBORDINATE SAND: Pink to light brown (7.5YR 6-7/4), vL-cU (mostly finer sand); subangular to subrounded. @384–392 FT: SLIGHTLY CLAYEY, SAND-DOMINATED INTERVAL: Mostly mL-cL, based on 370–380 ft in chip board.	367–398		
12	THICKER-BEDDED COARSE SANDS INTERBEDDED WITH SUBORDINATE CLAYEY-SILTY SAND: Pink to light brown (7.5YR 6-7/4), Coarser sands likely mU-vcU.	398–434		
13	CLAYEY FINE SAND AND A MIDDLE SAND: Light brown (7.5YR 6/3-4). Coarser sand is mL-vcU.	434–452		
14	COARSE SANDS AND PEBBLY SANDS INTERBEDDED WITH SUBORDINATE CLAYEY-SILTY SAND: Pink to pinkish white (7.5YR 8/2-7/3). Pebbles are vf-m, subangular-subrounded, and intermediate volcanic rocks w/ 35–40% tuffs (mainly Datil Well and Rock House). Sand is mostly mL-cU (minor vL-vcU) and subangular to subrounded. MIDDLE-LOWER SANTA FE GROUP UNIT Western piedmont deposits, upper subunit (late Miocene) – Tsm1pw2 Inferred Mio-Pliocene boundary at 507 ft (6,806 ft elev)	452–507	<1%	<3%
15	CLAYEY-SILTY SAND: Pinkish white (7.5YR 8/2), vL-cL sand (<=10% coarser sand); 1–3 ft-thick bedding.	507–588		
16	INTERBEDDED SILTY-CLAYEY SAND AND SAND: Pinkish white (7.5YR 8/2), vL-cU, subangular to sub-rounded sand (<=15% coarser sand). @606–666: Higher resistivity values. Western piedmont deposits, lower subunit (Middle to late Miocene?) – Tsm1pw1	588–694		
17	INTERBEDDED SILTY-CLAYEY SAND AND SAND, SLIGHTLY SANDIER THAN ABOVE: Pinkish white (7.5YR 8/2), vL-vcU, subangular to subrounded sand. @600–620: Subequal tuffs vs intermediate volcanics. Tuffs are inferred to be mostly from the Datil Well Tuff.	694–724	<1%	2–5%
BEDROCK: INTERBEDDED MOGOLLON-SPEARS GROUP				
Basalt or basaltic andesite (Tba)				
18	BASALT OR BASALTIC ANDESITE: Subangular-angular, monolithic basalt fragments (vc sand to f pebble size), one pebble is 35 cm long and angular.	724–742		

Unit	Description	Depth (ft)	Thmt %	Qtz %
Upper Spears Group				
19	CLAYEY SAND: White (10YR 8/1), clayey very fine- to very coarse-grained sand. Upper 10 ft is pink (5-7.5YR 7/4).	742-778		
20	HETEROLITHIC, COARSE SAND AND FINE PEBBLES: White to light gray (10YR 7-8/1), tuffaceous, coarse to very coarse-grained sand and very fine- to medium pebbles. Detritus is subangular and of mixed composition.	778-794		
21	MONOLITHIC, SANDY PEBBLES: Light gray (7.5YR 7/1), very coarse-grained sand and very fine- to fine pebbles. Detritus is angular-subangular and composed of Vicks Peak Tuff (very sparse phenocrysts).	794-826		
Vicks Peak Tuff (Tvpt)				
22	IGNIMBRITE: Gray (5YR 6/1), angular pebbles of a phenocryst-poor tuff. ≤3% phenocrysts that include sanidine, plagioclase, biotite or hornblende.	826-919		
Upper Spears Group (Tsu)				
23	SAND: Gray (5YR 6/1), medium to very coarse, subangular sand grains composed of heterolithic (but intermediate-dominated) volcanic rocks.	919-940		
La Jara basaltic andesite (Tba)				
24	MAFIC LAVA: Black, vesicular basalt; calcite fills amygdules.	940-969		
Upper Spears Group (Tsu)				
25	SANDY PEBBLES: Reddish brown (2.5YR 5/3), monolithic, angular to subangular, very fine to medium pebbles composed of a finely-vesicular, crystal-poor tuff. One cL-cU size sanidine crystal seen in the tuff. Possibly from erosion of an upper, non-welded part of the La Jencia Tuff.	969-998		
26	SAND: Gray (7.5YR 5-6/1), subrounded to subangular, mU-vcU sand composed of heterolithic volcanic grains.	~998-1,016		
La Jencia Tuff (Tljt)				
27	IGNIMBRITE: Reddish brown (5YR 4-5/3), angular, fine to medium pebbles of a eutaxitic, strongly welded, crystal-poor tuff.	1,016-1,040		
Upper Spears Group, Crosby Peak Formation (Tcsp)				
28	SAND: Light gray (5YR 7/1), tuffaceous and very fine- to medium-grained; volcanoclastic. Well-cemented and appears as subrounded chunks.	1,040-1,058		
29	SANDY CLAY: Light reddish brown (2.5-5YR 6/4). Sand size is very fine to very coarse.	1,058-1,066		
30	CLAYEY SAND: White to pinkish white (7.5YR 8/1-2), clayey vf-vc sand. Slight fining-upward trend on neutron and resistivity curves. Larger grains are subrounded and composed of quartz plus purplish gray, biotite-hornblende-phyric dacite.	1,066-1,185		
31	SLIGHTLY CLAYEY, COARSE SAND: Pinkish gray (5YR 7/2), medium- to very coarse-grained, subrounded to subangular sand. Sand mostly composed of heterolithic, intermediate volcanic grains.	1,185-1,240		

Unit	Description	Depth (ft)	Thmt %	Qtz %
32	SANDY PEBBLES AND SAND: Pinkish gray (5YR 7/2), medium- to very coarse-grained, subrounded to subangular sand composed of heterolithic, intermediate volcanic grains. Pebbles are very fine to medium, angular to subangular, and composed of heterolithic andesites-dacites (one with a biotite phenocryst, but most are phenocryst-poor). Hells Mesa Tuff (Thmt)	1,240–1,278		
33	LESS-CONSOLIDATED COARSE GRAINED TUFF: Cuttings are vitric-gray, cU-vcU sand composed primarily of quartz. In lower half, grains of consolidated tuff (as described below) become increasingly more abundant (up to 50%).	1,278–1,444		
34	CONSOLIDATED COARSE-GRAINED TUFF: Cuttings are white (7.5YR 8/1-2), >90% of cemented/consolidated tuff in chunks up to 3 cm long. Crystals are fU to vcU sand-size and consist of quartz, plagioclase or sanidine, biotite, and very minor hornblende. No foliation seen.	1,444–1,564		



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