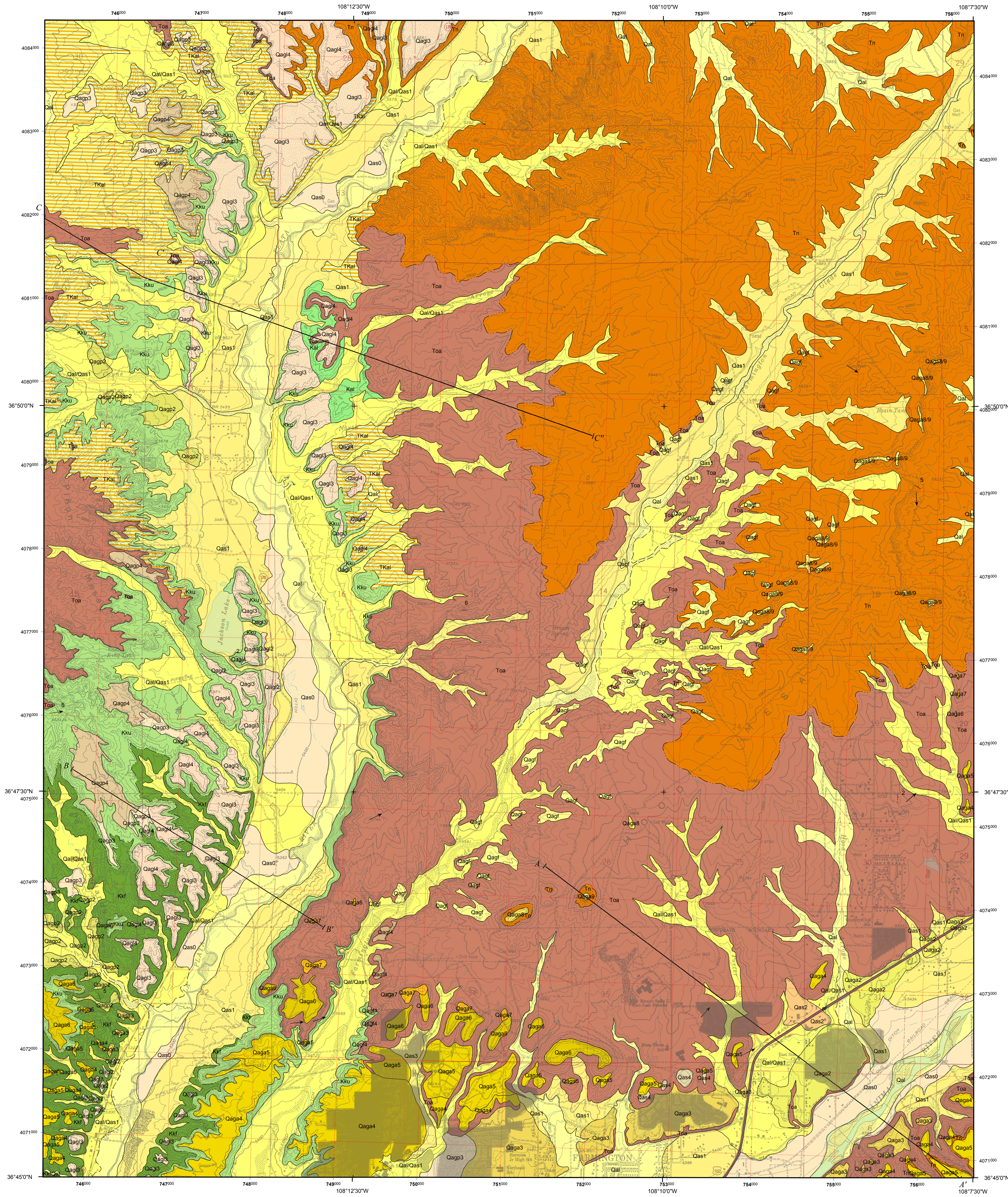
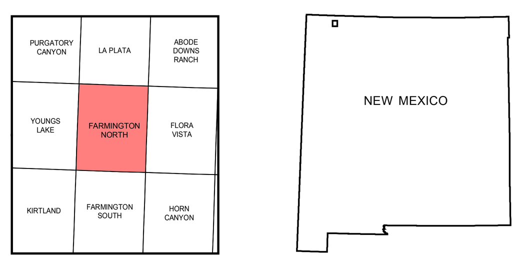
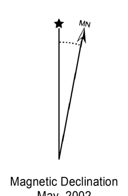
NMBGMR Open-file Map Series
OFGM 82
Last Modified 7 February 2006



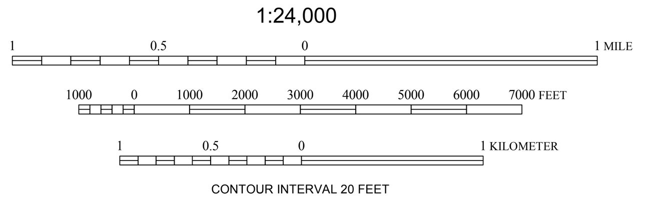
Base map from U. S.Geological Survey 1963, from photographs taken 1958 and 1962, field checked in 1963, edited in 1979.
1927 North American datum, UTM projection -- zone 13N
1000- meter Universal Transverse Mercator grid, zone 13, shown in red



QUADRANGLE LOCATION



Magnetic Declination
May, 2002
11° 18' East
At Map Center



CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

This draft geologic map is preliminary and will undergo revision. It was produced from either scans of hand-drafted originals or from digitally drafted original maps and figures using a wide variety of software, and is currently in cartographic production. It is being distributed in this draft form as part of the bureau's Open-file map series (OFGM), due to high demand for current geologic map data in these areas where STATEMAP quadrangles are located, and it is the bureau's policy to disseminate geologic data to the public as soon as possible.

After this map has undergone scientific peer review, editing, and final cartographic production adhering to bureau map standards, it will be released in our Geologic Map (GM) series. This final version will receive a new GM number and will supercede this preliminary open-file geologic map.

DRAFT

New Mexico Bureau of Geology and Mineral Resources
Open-file Map Series
OFGM 82

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, (Dr. Peter A. Scholle, *Director and State Geologist*, Dr. J. Michael Timmons, *Geologic Mapping Program Manager*).

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

[505] 835-5490
http://geoinfo.nmt.edu

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http://geoinfo.nmt.edu/publications/maps/geologic/ofgm/home.html

Geologic map of the Farmington North quadrangle, San Juan County, New Mexico.

May 2004

by
Joel L. Pederson [1] and Carol M. Dehler [1].

[1] *Utah State University Department of Geology, 4505 Old Main Hill, Logan, Utah 84322*

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 may be based on any of the following: 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.

Cross sections are constructed based upon the interpretations of the author made from geologic mapping, and available geophysical, 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.

The map has not been reviewed according to New Mexico Bureau of Geology and Mineral Resources standards. The contents of the report and map should not be considered final and complete until reviewed and published by the New Mexico Bureau of Geology 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.

Description of Map Units
Farmington North Quadrangle
Northwest New Mexico

Joel L. Pederson and Carol M. Dehler

SURFICIAL DEPOSITS

af, human disturbance

Qal-alluvium (Late Holocene)- Grayish tan to reddish tan, moderately well sorted, silt to coarse-grained sand to cobbly gravel of active channels and floodplains. Composition and texture varies with drainage.

Qas0-1, alluvial sand of Animas River, La Plata River, Farmington Glade, and piedmont (Holocene)- Grayish tan to reddish tan, bioturbated, thin-to-medium scale interbeds of laminated and dessication-cracked very fine sandy and clayey silt, and ripple-cross-stratified moderately well sorted silty fine sand. Lenticular beds of pebbles and cobbles are rare in small piedmont drainages to common in the Animas River deposits. 1-4+ m thick with base generally not exposed. Qas1 is associated with a broad fill terrace, whereas Qas0 is a lower, inset cut-fill that may be flooded at high stages and may be a continuous deposit with Qal. Qas1 locally includes hillslope deposits transported by slopewash or mass movements at the toes of bedrock escarpments. Ward (1990) reports radiocarbon ages ranging from 1400-2500 years B.P. for Qas1 to 245 years B.P. for Qas0 from samples within a couple miles of the mapping area up Thompson Arroyo (tributary to the La Plata River), Farmington Glade, and near Flora Vista.

Qaga2-9, gravels of Animas River (Pleistocene-Early Holocene)- Up to 4 m of clast-supported, subrounded, pebble-to-mostly cobble gravel with few boulders and poorly sorted sand matrix, with relatively minor interbeds of moderately-poorly sorted, weakly carbonate cemented, sand lenses with small-medium scale, low-angle crossbedding. Deposits are associated with well-developed strath terraces to thin fill terraces. Imbrication consistent with flow direction of modern Animas River, and lower 1-1.5 m commonly carbonate cemented. Representative clast composition (Qaga4) is 46% porphyry, 32% quartzite, 18% granite or metamorphic rock, and 4% sedimentary rocks; and mean clast size is 7 cm.

Qagl2-4, gravels of La Plata River(Pleistocene-Early Holocene)- Up to 5 m of clast-supported, subangular-to-subrounded, pebble-and-some-cobble gravel with moderately-poorly sorted sand matrix, with few interbeds of moderately-poorly sorted, weakly carbonate cemented, sand lenses with small-medium scale, low-angle crossbedding. Deposits are associated with well-developed strath terraces to thin fill terraces. Imbrication consistent with flow direction of modern La Plata River, and lower 0.5 m may have weak carbonate or iron-oxide cement. Representative clast composition (Qagl4) is 52% porphyry, 30% sedimentary rocks, 16% quartzite, and 2% granite or metamorphic rock; and mean clast size is 3 cm.

Qagf, gravels of Farmington Glade (Pleistocene-Early Holocene)- <4 m-thick or erosional lag of subangular-to-subrounded, pebbles and cobbles from reworked Animas terrace gravels of Hood Mesa and pebbles weathered out of conglomeratic Ojo Alamo bedrock. Deposits are not readily distinguished or correlated in terms of landscape position, except for near the mouth of the drainage and are both deposits of Farmington Glade itself and of small piedmont (tributary drainage and hillslope) systems. Deposits are associated with preserved terraces in a few cases, and field relations indicate all Farmington Glade gravels are younger than Animas gravel Qaga4.

Qagp2-4, piedmont gravels (Pleistocene-Early Holocene)- <4 m-thick, immature pebbly sand to clast-supported pebble gravel with poorly sorted sand matrix of small tributary drainage and hillslope systems. Composition varies with bedrock exposed in drainages, with subrounded pebbles from reworked conglomeratic Ojo Alamo bedrock or older terrace gravels and subangular clasts of weak sandstone bedrock. These are typically stream deposits that can be associated with strath terraces to thin fill terraces, notably to the west of the La Plata valley, and grade to stream gravels of major drainages. But deposits locally include sediment transported by hillslope processes and, in any case, often are not be readily distinguished or correlated in terms of landscape position.

Correlation and age of Pleistocene gravels

From younger to older: Qag2 probably correlates to unit 6 of Ward (1990) and the T6a and/or T7 of Gillam (1998), interpreted to be late Pleistocene in age via correlation to terminal moraines in the headwaters of the Animas River. Qag3 is unit 5 of Ward (1990) and T5 and/or T6a of Gillam (1998), which Gillam interpreted to be middle Pleistocene in age based on extrapolation from incision rates and amino-acid dating. Though the Correlation of Map Units reflects these conservative age estimates for Qag2 and Qag3, there are two specific, equivocal correlation possibilities. Qag2 may correlate specifically to Gillam's T7 and the late and(?) early Pinedale glaciation (25-15, 70-50 ka), with Qag3 deposited during the Bull Lake glaciation and deglaciation (150-100 ka). The other possibility is that both the Pinedale and Bull Lake glaciations are represented by Qag2, with Qag3 being older, which is the interpretation of Gillam (1998)

Qag4 is unit 4 of Ward (1990) and T4d of Gillam (1998), are middle Pleistocene in age and estimated by Gillam to be 430-500 ka. Qag5 is unit 3c of Ward (1990) and T4b of Gillam (1998), and is dated to just before 640 ka because it is locally overlain by colluvial-alluvial deposits containing the Lava Creek B tephra, including at a locality near Flora Vista (Gillam, 1998). Qag6 is unit 3b of Ward (1990) and T3a or T3b of Gillam (1998), estimated by Gillam to be ~740-800 ka by extrapolation from incision rates. Qag7 was not distinguished from unit 3b by Ward (1990), was mapped as T3a by Gillam (1998), and is early Pleistocene in age. Qag8 and Qag9 are separate gravels, but not easily correlated or distinguished in the map area. They were mapped by Ward (1990) as unit 2 and mapped as T2i and T2h, respectively, by Gillam (1998), who estimated their age at >1.3 Ma.

Soil development in study area reaches steady-state on Qag4-9. That is, soils developed in terraces of Qag4 through Qag9 have apparently equivalent development, having a total thickness of 1.5-2 m and weak stage III calcic horizon, with soils being exhumed by surficial erosion. Qag3 is associated with stage II calcic horizons, and the soil of the minor Qag2 is not well exposed in the study area but the correlative unit of Ward (1990) regionally has stage I calcic horzon development. Surface terrain and vegetation characteristics of terraces are likewise uniform, and cannot be used to distinguish or correlate gravels. Weathering rinds may be useful, and intermediate or felsic porphyritic clasts have rinds that are 1-2 mm thick in the soil of Qag3 and rinds that are 1-5 mm in the soil of Qag4.

BEDROCK UNITS

Tn—Nacimiento Formation (Paleocene)- White, yellow, tan, maroon, and green tuffaceous shales with gray, green, red, and tan sandstones. Soft sandstones and reworked tuffs present in m-scale intervals within the slope-forming shale intervals, are interbedded with ledgy sandstone beds. Sandstones are fine- to coarse-grained, moderately to poorly sorted, and angular to rounded. Larger clasts are typically composed of petrified wood, chalcedony, many varieties of chert, schist, and granite. Smaller grains are composed of quartz, chert, plagioclase, orthoclase, and biotite. Sandstone are porous and are weakly to moderately cemented with silica, calcite, hematite, and (or) clay. Sandstones exhibit ripple laminations, planar-tabular crossbeds, and trough crossbeds in thin to thick, lenticular to tabular beds. Paleocurrent flow directions from trough crossbeds show flow to south, southwest and southeast (140°, n=9). Poorly consolidated, slope-forming unit that weathers into badlands, and exhibits "popcorn" weathering and extensive piping. Sandstones are less common upsection and laterally to the north along eastern side of the La Plata river. Grades southward into Toa in Twin Arroyo area. No upper contact exposed in field area. Thickness in field area is ≤~130 m.

Toa-Ojo Alamo Formation (UpperCretaceous (?) to Paleocene)-Orange, yellow, and tan weathered, and yellow to tan fresh, medium to coarse-grained, locally tuffaceous sandstone with granule- to pebble-sized clasts (≤20 cm dia. (long axis), 1-2 cm dia. ave.). Coarsest grains found in lowermost 2 meters of unit and along south end of ridge between Farmington Glade and the La Plata drainage and in Jackson Lake area. Grains are poorly sorted, angular to subangular grains, and granules and pebbles commonly show better rounding. Grains are composed of quartz, quartzite, sandstone, red chert, rhyolite, andesite, plagioclase, orthoclase, petrified wood, and bone. Cemented weakly with silica, clay, and hematite. Trough crossbeds are in medium to massive sets that are amalgamated into channels 10's of meters wide and thick. Soft-sediment deformation features are common and plane beds are rare. Paleocurrent flow directions from trough crossbeds show flow dominantly to the southeast (104°, n=32). Iron concretions and secondary gypsum common. Sandstones are interbedded with green to gray to maroon shale and thinly bedded fine-grained sandy intervals 0.25 to several meters thick (Tn or shale facies). Weakly to moderately consolidated. Forms rounded cliffs, spires, hoo doos, and caves. This unit undergoes a gradational facies change laterally northward into Tn (shale facies) in the Twin Creeks area and the Barker Arroyo areas of the La Plata drainage. Contact with Tn is approximated above the last set of substantial (10's of meters thick) sandstone cliffs. Equivalent to the Kimbeto Member (Cather, 2003). Thickness ~0-140 m.

KTal—Lower Animas Formation (UpperCretaceous (?) to Paleocene)—Gray, green, yellow-tan, and maroon shales and soft sandstones interbedded with subordinate resistant ledges of thin to thick beds of tuffaceous sandstone. Sandstone grains are fine to pebble in size, typically angular to subangular with granules and pebbles (4-5 cm dia. max) showing better rounding, moderately to very well sorted, and composed of quartz, micas, plagioclase, orthoclase, chert, volcanic lithics, and intraclasts, depending on individual bed. Weakly to moderately cemented with silica, hematite, and clay. Ripple cross-laminated, trough-crossbedded to massive in thin to thick beds. Paleocurrent flow directions from trough crossbeds show flow to the northeast (38°, n=3). Local horizontal burrows in shale. Contact with overlying Koa is sharp, scoured, and a slight angular discordance may be present. Yellow sandstones of this unit are very similar to KToa. Variegated shales of this unit are very similar to the upper Kirtland Member shales and the Nacimiento Formation shales. Medium bed of pepperite at base of hill X5648 in Section 9 at mouth of South Twin Creek wash. Facies change (?) to Kku southward across Piñon Mesa to south. This unit is likely equivalent to the McDermott Member og the Animas Formation or the Naashobito Member of the Ojo Alamo Formation (e.g., Cather, 2003). Thickness 0-~35 m.

Kku Upper Member of the Kirtland Formation (Upper Cretaceous)- Tan, yellow, orange, purple, maroon, and green shale with resistant ledges of green, red, and tan-yellow sandstone and slope forming soft sandy intervals. Tuffaceous. Sandstones are fine- to coarse-grained, well to moderately sorted, angular to subangular, and are composed of quartz, orthoclase, plagioclase, chert, chlorite, volcanic lithics, and biotite, depending on individual bed. Weakly cemented with silica, hematite, and (or) clay, and porous. Sandstones are massive to ripple laminated in thin beds. Poorly consolidated slope forming unit that weathers into badlands, and exhibits "popcorn" weathering and extensive piping. Forms badlands around Jackson Lake. Grades laterally and vertically with underlying Farmington Sandstone. This unit is very similar to the shales of the Lower Member of the Animas Formation and the shales of the Nacimiento Formation. Age of upper Kirtland Member is 73.04± 0.25 Ma ($^{40}Ar/^{39}Ar$ age, Fassett and Steiner, 1997), although this age is form the southern San Juan Basin. Equivalent to thr De-na-zin Member of the Kirtland Formation (Anderson et al, 1997). Thickness--~46 m.

Kkf-Farmington Member (or Middle Member) of the Kirtland Formation (Upper Cretaceous)-Tan and yellow cliffy sandstone interbedded with slope-forming gray, brown, green, and tan shale and thin interbeds of gray sandstone. Tan and yellow sandstones are medium to coarser-grained with lesser pebbles, moderately sorted, angular to subangular, composed of quartz, chlorite, sandstone, chert, and trough crossbedded in medium to thick tabular sets in tabular to lenticular beds. Local soft sediment deformation. The variegated shales are in decimeter to meter-scale intervals punctuated by ledges of thin, tabular to lenticular, fine- to medium-grained sandstone beds. Sandstones are moderately cemented by silica and hematite. Paleocurrent directions from trough crossbeds show flow dominantly to the east (80°, n=7). Moderately indurated and forms rounded to blocky cliffs, and can be ledgy. Yellow sandstones of this unit are very similar to KToa sandstone, and shales are similar to other shales in the map area, except are not as colorful. Laterally and vertically gradational with Kku. Equivalent to the Farmington Member of the Kirtland Formation (Anderson et al., 1997). Thickness of ~137 m (Baltz et al., 1966, Hunt and Lucas, 1992).

MAP SYMBOLS

contact (solid line where approximate, dot-dash where gradational)

strike and dip of bedding

paleocurrent direction

DISCUSSION
QUATERNARY GEOLOGY:

The surficial deposits of the Farmington North Quadrangle are dominated by stream sand and gravel. There are only one or two mappable and distinct eolian or hillslope deposits, and they were, in fact, not considered significant enough to justify their own map units. Qag2 is relatively minor in the map area, found along the Animas River valley, but only rarely along the La Plata drainage. The higher and older Qag5-Qag9 are preserved only along the broad Animas-San Juan River valley in the southern part of the map area. The La Plata and Farmington Glade drainages preserve only Qag4 and younger deposits in valleys that are lower in landscape position than, and even inset into, the older Animas River terraces.

The pattern of deposits near the confluence of the Animas River and the La Plata River or Farmington Glade indicates that the Animas River, over Pleistocene time, has incrementally shifted its channel to the south by perhaps 2-3 miles. This may be influenced by bedrock control of the upper Kirtland Formation underlying the Ojo Alamo. The rivers of the study are seem to be creating strike valleys of upper Kirtland shale with valley walls formed in the overlying Ojo Alamo Sandstone. This is the case for the La Plata River and its south-oriented strike valley along the western half of the map, as well as the Animas River in the southeast corner of the map. Related to this, the La Plata River in the northern end of the quadrangle takes a notable jog to the right (west) and breaks through the Ojo Alamo escarpment before continuing south along this strike valley. This turn in the channel coincides with a location where the Ojo Alamo Sandstone locally grades into the predominantly mudstones of the Nacimiento Formation in the north-central part of the quadrangle. Thus during incision, the superimposed La Plata River appears to have taken advantage of a location where the more resistant Ojo Alamo Sandstone essentially does not exist.

Bedrock incision rates in the area, based on heights and age estimates of strath terraces, are consistent with the 100-150 m/m.y. rates of regional studies. The terraces on the Qag2, Qas1, and Qas2 deposits of the La Plata River and Farmington Glade appear to diverge downstream relative to Qal, accompanied by knickpoints or knickzones along those drainages. Qag2 could be interpreted to emerge from beneath younger deposits in the lower few miles of the La Plata drainage, and the terraces of Qas1 and Qas0 become more distinct and higher off Qal in the downstream direction of both the La Plata and Farmington Glade. Gillam (1998) describes a general pattern of Pleistocene outwash terraces converging downstream in the reach below the glacial moraines in the Animas River valley in Colorado, but then, consistent with our mapping, she notes that this changes to terraces diverging downstream in the area of Farmington.

BEDROCK GEOLOGY:

The bedrock units of the map area are interbedded variegated shales and sandstones representing meandering and braided fluvial systems flowing in a generally easterly direction. The channel environment is represented by the Farmington Canyon Sandstone, the Lower Member of the Animas Formation, and the Ojo Alamo Formation, as well as the subordinate sandstone bodies in the Nacimiento Formation. Floodplain environments are represented by the Upper Member of the Kirtland Formation, the Lower Member of the Animas Formation, and the Nacimiento Formation, as well as subordinate shale intervals in the other sandier units.

Facies changes are common in the map area and show genetic relationships among many of the units. The Farmington Canyon Sandstone changes laterally and vertically into the Upper Member of the Kirtland Formation, and the Upper Member of the Kirtland Formation grades (?) vertically and laterally into the Lower Member of the Animas Formation. Although there is a sharp, mappable contact between the Ojo Alamo Formation and subjacent units, it is unclear whether this contact represents an unconformity in the map area. The Ojo Alamo Formation changes laterally and vertically into the Nacimiento Formation, and the Lower Member of the Animas Formation and the Nacimiento Formation are very similar units. In fact, Ward (1990) mapped much of what we mapped as the underlying Lower Member of the Animas Formation as the Nacimiento Formation. These latter units appear to be genetically related, as do all bedrock units in the map area. If there is an unconformity beneath the Ojo Alamo Formation, it may not represent a significant amount of time. In fact, it is possible that the Cretaceous-Tertiary boundary is preserved in the northwest part of the field area. These observations lean towards Ayer et al's (1994) model that there was minor erosion prior to Ojo Alamo deposition. Preliminary paleocurrent data suggest east-northeast flow during depostion of the Farmington Sandstone through lower member of the Animas Formation and east-southeast flow during Ojo Alamo and Nacimiento time. This change in flow direction could suggest slight basin reorganization related to movement on the Hogback monocline, as was recognized by other workers (Cather, 2003, and references therein).

Bedding in the map area is dominantly horizontal to subhorizontal in orientation, with northerly strikes and easterly dips. Bedding is difficult to measure in the map area due to the predominance of shale units and the fact that most sandstone bedding plans do not exhibit planar beds representative of true dip (i.e., trough crossbeds in channels). The gentle dips reflect the distal folding related to the Hogback monocline to the west. A N-NW-trending, east-facing flexure is present along the La Plata River in the northwestern part of the map area. This flexure is expressed by the Ojo Alamo and Nacimiento formations rolling down to the northeast. This flexure coincides with the pinching out of the Ojo Alamo Formation and also an easterly bed in the Hogback monocline.

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Farmington North Quadrangle

CORRELATION OF MAP UNITS