PRELIMINARY INTERPRETATION OF CENOZOIC STRATA IN THE TAMARA NO. 1-Y WELL, SANDOVAL COUNTY, NORTH-CENTRAL NEW MEXICO

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INTRODUCTION

The Tamara #1-Y well (API 30-043-20934) is a wildcat oil-test that was drilled in northwest of Rio Rancho, New Mexico (Sec. 3, T13N. R2E., Bernalillo NW quadrangle; UTM: N: 3,916,580 m, E: 344,615 m, Zone 13, NAD83) in 1995 by Davis Petroleum Co. The Tamara well was spudded into the Ceja Member (upper Arroyo Ojito Formation of Connell et al., 1999), near the northern edge of the Llano de Albuquerque, at an elevation of about 1865 m (6120 ft) above mean sea level. The well was drilled between December 1, 1995 and January 16, 1996. According to the scout ticket, the well stopped in the Triassic Chinle Group at a depth of 8723 ft (2659 m) below land surface (bls); however, this correlation was not confirmed in this study.

Washed cuttings from this well are archived at the New Mexico Bureau of Mines and Mineral Resources (NMBMMR Library #46,891), in Socorro, New Mexico. The well was cased to 329 m bls and cuttings were collected below 360 m bls; a number of intervals were not sampled, probably due to loss of circulation during drilling. Cuttings were visually evaluated using a sample preparation microscope on available intervals between 360 and 2015 m bls. Detrital modes of sand were determined on medium-grained sand (400 points per sample) at eight sample intervals in the Cenozoic section (Appendix 1) and normalized to the modified Gazzi-Dickinson method (Table 1).

Borehole geophysical logs, archived at the NMBMMR, are available below 2103 m (6900 ft) bls. Digital borehole geophysical logs of natural gamma ray and induction resistivity of the entire well were obtained from the Denver Earth Resources Library and the U.S. Geological Survey.

The Tamara well was spudded into the Santa Fe Group near its local top on the Llano de Albuquerque, near La Ceja (Rincones de Zia of Galusha, 1966; and Tedford, 1981) and fully penetrated the Cenozoic section, thus providing an opportunity to document variations in thickness of the Santa Fe Group across intrabasinal faults of the northwestern Albuquerque Basin. This area has been mapped in detail (Fig. 1) and provides additional stratigraphic control for this well.

Table 1. Recalculated detrital mode parameters, normalized to percent, of point counts (Appendix 1) for medium-grained sand from the Tamara well using the modified Gazzi-Dickinson method (Dickinson, 1970). Volcanic grains comprise nearly all of the lithic parameters. Units are the Cerro Conejo (Tzc) and undivided Chamisa Mesa-Piedra Parada (Tzm) members of the Zia Formation, unit A and B, and Galisteo Formation (Tg). The Galisteo Formation contains volcanic grains, probably from contamination by caving of upper volcanic-bearing units.

Interval ft, bls	Unit	Modified Gazzi-Dickinson Method		
		%Q	%F	%L
1390-1420	Tzc	68	18	15
2620-2650	Tzm	67	17	16
3970-4000	B	64	22	15
4150-4180	B	72	18	10
5020-5050	A	68	19	14
5230-5260	A	70	19	11
5290-5320	Tg	63	25	12
5410-5440	Tg	67	21	12

Another purpose in studying the Tamara well was to document the presence of older or pre-Santa Fe Group Cenozoic strata near the basin margin, such as the Abiquiu, Popotosa, or Tanos formations, or the unit of Isleta #2. The Abiquiu Formation contains mostly epiclastic sediments derived from the rhyolitic Latir volcanic field in northern New Mexico (Smith, 1995; Moore, 2000). Much of the Abiquiu Formation was deposited between *ca*. 18-27 Ma (Moore, 2000; Tedford and Barghoorn, 1993) and is temporally correlative to the Piedra Parada and Chamisa Mesa members of the Zia Formation (Fig. 2). The southernmost mapped location of the Abiquiu Formation is near the town of Gilman, New Mexico,

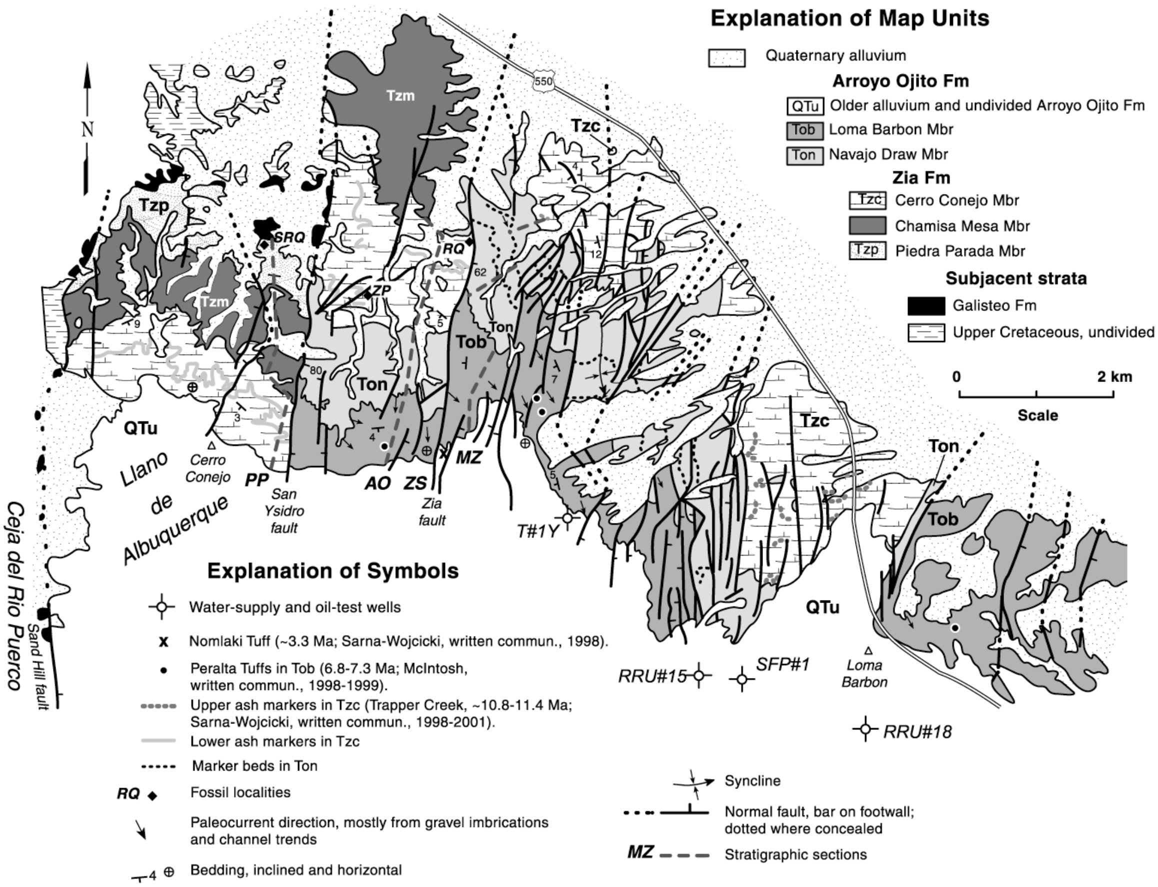

Figure 1. Generalized geologic map of the northwestern margin of the Calabacillas sub-basin (Albuquerque Basin), modified from the Cerro Conejo, Bernalillo NW, Loma Machette, and Bernalillo quadrangles (Connell, 1998; Koning and Personius, *in review*; Koning et al., 1998; and Personius et al., 2000). Stratigraphic study sites include Arroyo Piedra Parada (PP), Arroyo Ojito (AO), Zia fault (ZS), and the Marillo-Zia (MZ) sections. Unit QTu includes the Ceja Member of the Arroyo Ojito Formation of Connell et al. (1999). The Ceja Member unconformably overlies the Navajo Draw Member (not shown) on the footwall of the San Ysidro fault, but overlies the Loma Barbon Member to the east. Fossil localities of Galusha (1966; Tedford, 1981) indicated by black diamonds include the: Sanding Rock Quarry (SRQ; late Arikareean, 19-22 Ma), Rincon Quarry (RQ; late Barstovian, 12-14 Ma) and Zia Prospect (ZP; late Barstovian, 12-14 Ma). Volcanic ashes in the upper Cerro Conejo Member are correlated to the middle to late Miocene Trapper Creek tephra (Personius et al., 2000; Koning and Personius, *in review*). Water-supply and oil-test wells include the Tamara well (T#1Y), Santa Fe Pacific #1 (SFP#1), Rio Rancho Utilities #15 and #18 (RRU#15 and RRU#18, respectively).

about 40 km north of the drill site (Duchene et al., 1981). Other temporally correlative units to the Abiquiu and Zia formations include the Tanos and Blackshare formations, exposed in the Hagan embayment, along the eastern margin of the Albuquerque Basin. The Tanos Formation is as old as 25.4 Ma (Connell and Cather, *this volume*) and contains volcanic-bearing sediments derived from the Ortiz Mts., along the eastern rift margin in the Hagan embayment. To the south are exposed of the Popotosa Formation. The Popotosa Formation is a thick succession of mudstone and sandstone unit that is at least 15 Ma in the Belen sub-basin to the south (Lozinsky, 1994) and may be as old as *ca*. 25 Ma in the Abbe Springs basin, west of Socorro, New Mexico (Osburn and Chapin, 1983).

The Zia Formation (Galusha, 1966) comprises the basal part of the lower Santa Fe Group in the Calabacillas sub-basin (Fig. 2). The Zia Formation is dominated by eolian sandstone; fluviatile sandstone and mudstone beds tend to become more common upsection. The Zia Formation has been subdivided into the Piedra Parada, Chamisa Mesa, Cañada Pilares, and Cerro Conejo members (Galusha, 1966; Gawne, 1981; Connell et al., 1999). The Piedra Parada Member unconformably overlies the pre-rift Galisteo Formation (Eocene) and Menefee Formation (Cretaceous). The age of the lower Piedra Parada Member is constrained by mammalian fossils at

Standing Rock quarry (Fig. 1; Galusha, 1966), which indicate a late Arikareean North American land mammal "age." Correlations of these fossils to well dated localities in the Great Plains indicate an age of 19-22 Ma (Tedford and Barghoorn, 1999), although the biostratigraphy of the Standing Rock quarry suggests an age of *ca*. 19 Ma (R.H. Tedford, 2000, written commun.).

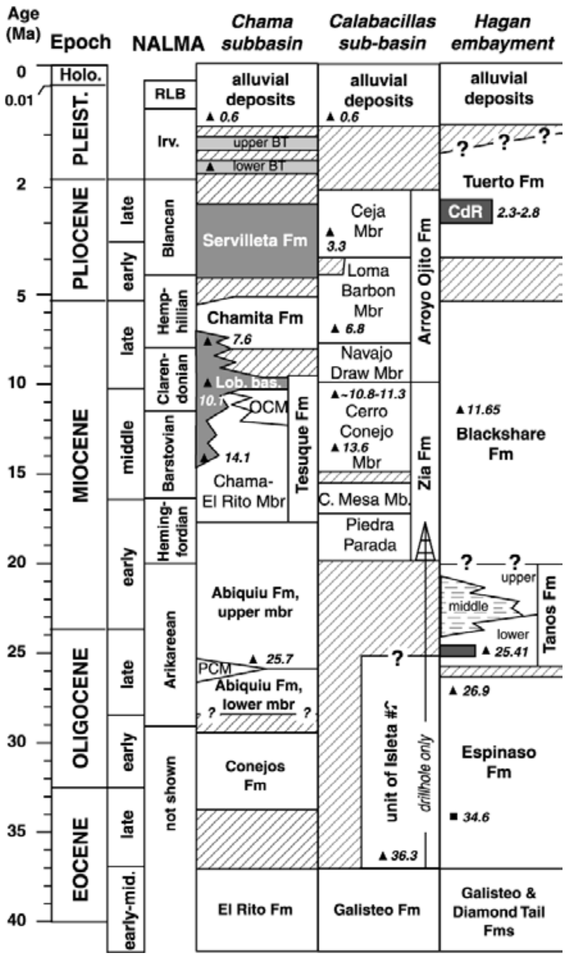

Figure 2. Correlation chart of selected Santa Fe Group units in the northwestern Calabacillas and Chama sub-basins (Connell et al., 1999; Tedford and Barghoorn, 1993; Moore, 2000; Lozinsky, 1994), and the Hagen embayment (Connell and Cather, *this volume*). Triangles denote dates (in Ma) of primary volcanic units. Shaded boxes denote basaltic flows. Abbreviations include, Lobato basalt (Lob. bas.), Ojo Caliente Member of the Tesuque Formation (OCM), and Pedernal chert Member of the Abiquiu Formation (PCM). North American Land Mammal "Ages" (NMLMA).

The Arroyo Ojito Formation (Connell et al., 1999) overlies the Zia Formation and is locally subdivided into three member units, in descending stratigraphic order: the Ceja, Loma Barbon, and Navajo Draw members. These units contain sand, gravel, and mud deposits by S-SE flowing rivers during late Miocene, Pliocene, and earliest Pleistocene times (Connell et al., 1999).

The unit of Isleta #2 (late Eocene-Oligocene) was proposed by Lozinsky (1988, 1994) for a 2 km thick succession of purplish-red to gray volcanic-bearing sandstone and mudstone recognized in deep oil test wells 25-30 km to the south; however, it is not exposed in the basin. The sand is arkose, lithic arkose, and subarkose (Lozinsky, 1994). This unit is temporally correlative to Oligocene volcanic and volcaniclastic units of the Espinaso Formation, Mogollon-Datil volcanic field, and San Juan volcanic field.

LITHOLOGY OF THE TAMARA #1-Y WELL

Cenozoic sediments examined in the Tamara well are predominantly fine- to coarse-grained sand with interbedded mud and sparse fine gravelly sand. Sand composition ranges from subarkose, lithic arkose, and feldspathic arenite. The stratigraphy of the upper part of the Tamara well is constrained by excellent exposures of the Arroyo Ojito and Zia Formations along the southern margin of the Rio Jemez valley that have been mapped by Koning (Koning and Personius, *in review*; Koning et al., 1998; Connell et al., 1999).

Geologic mapping (Koning and Personius, *in review*; Koning et al., 1998; Connell et al., 1999; Personius et al., 2000) indicates that neighboring strata of the Arroyo Ojito and Zia Formations generally dip about 3-10ºSW. A dip-meter log of strata below 2103 m (6900 ft) bls indicates that Cretaceous rocks dip as much as 20ºSW; however, it is not known whether stratal tilts in the upper part of the drillhole section progressively increase downhole, or whether they increase across unconformities. The thickness of Zia and Arroyo Ojito Formations were trigonometrically corrected using a 7º dip because of similar stratal tilts in exposures to the north. Deposit thickness was adjusted for 7º and 20º dips in lower units (Appendix 2). Lag times are not known for the samples and may contribute up to several meters of error in estimating stratigraphic boundaries, probably resulting in a slight increase in estimating apparent unit thickness. Dip-adjusted thickness of deposits correlated to the Zia and Arroyo Ojito Formations in the Tamara well is about 1138 m (Appendix 2). This is slightly thicker than estimates of about 1060 m for a composite Santa Fe Group section exposed to the west on the footwalls of the Zia and San Ysidro faults (Connell et al., 1999), and is considerably thicker than the 410 m of Zia section exposed on the footwall of the Sand Hill fault (Tedford and Barghoorn, 1999), near the structural boundary of the basin.

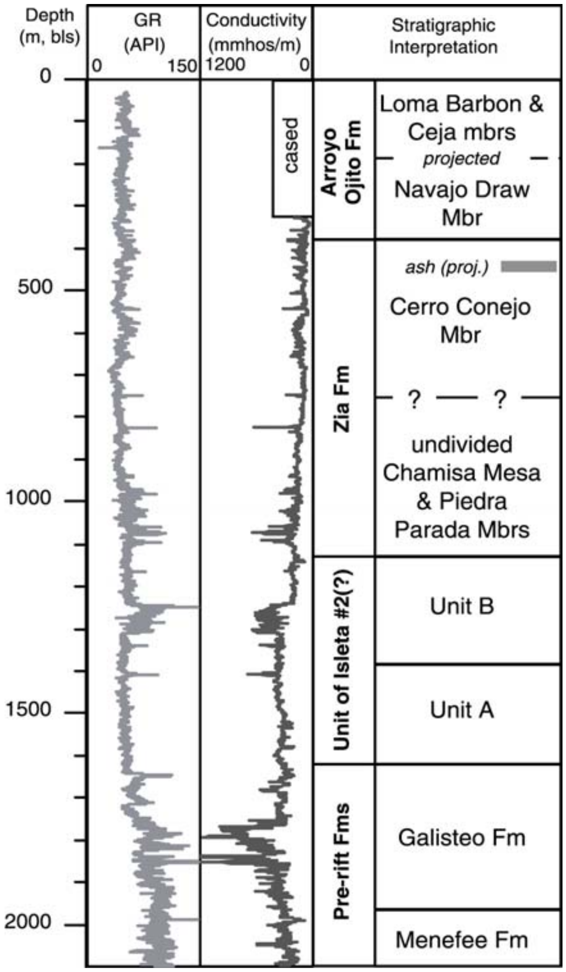

Figure 3. Interpreted stratigraphic column of Cenozoic sediments for the Tamara #1-Y well, including natural gamma ray (GR) and electrical conductivity logs (calculated from induction resistivity log) for comparison purposes. Stratigraphic interpretations are based on evaluation of cuttings and projection of contacts from geologic mapping.

Projections of mapped contacts on the Bernalillo NW quadrangle (Koning and Personius, *in review*) indicate that the base of the Loma Barbon Member of the Arroyo Ojito Formation is at 183 to 378 m bls (Fig. 3). Deposits correlated to the Ceja Member crop out along the northern rim of the Llano de Albuquerque (La Ceja) and are 30-85 m in thickness, of which ~15 m are penetrated in this well (Koning and Personius, *in review*; Personius et al., 2000). At about 180 m bls, deposits of very pale brown, fine-to medium-grained, quartz-rich sand are correlated to the Navajo Draw Member on the basis on comparisons with nearby geologic mapping (Koning and Personius, *in review*; Koning et al., 1998). At 405-424 m (1330-1390 ft) bls, traces of a gray altered tephra are recognized. This tephra-rich zone is in a similar stratigraphic position relative to ashes recognized in the upper part of the Cerro Conejo Member of the Zia Formation (usage of Connell et al., 1999) on the Bernalillo NW and Loma Machette quadrangles (Koning and Personius, *in review*; Personius et al., 2000). Some of these exposed ashes have been geochemically correlated to some of the middle to late Miocene (*ca*. 11-10 Ma) Trapper Creek tephra from Idaho (Personius et al., 2000; A. Sarna-Wojcicki, written commun., 2001; N. Dunbar, 2001, written commun., 2001). The lower part of the Cerro Conejo Member contains fossils that indicate a middle Miocene age (Tedford, 1981; Tedford and Barghoorn, 1999). The Cerro Conejo Member is 369-m thick in the Tamara well. The base of this unit is gradational with a 393-m thick succession of generally very pale brown to light gray, medium- to coarse-grained, subrounded to rounded, quartz-rich sandstone with abundant frosted quartz grains. This thick unit is correlated to the Chamisa Mesa and Piedra Parada members of the Zia Formation. The Zia Formation is composed of lithic arkose to feldspathic arenite (Beckner, 1996) and cemented zones are commonly recognized in this interval (Beckner and Mozley, 1998; Mozley and Davis, 1996).

The basal 0.5-3 m of the Zia section exposed in Arroyo Piedra Parada contains fluviatile gravel composed mostly of rounded chert pebbles derived from the Galisteo Formation with scattered cobbles of rounded, intermediate volcanic rocks (Fig. 4) deposited by southeast-flowing streams (Gawne, 1981). Elsewhere, these cobbles form a discontinuous stone pavement, where many of the volcanic clasts have been sculpted by the wind into ventifacts (Tedford and Barghoorn, 1999; Gawne, 1981). Volcanic clasts have been $^{40}Ar/^{39}Ar$ dated between 32 to 33 Ma (three dates: 31.8±1.8 Ma, 33.03±0.02 Ma, 33.24±0.24 Ma; S.M. Cather, W.C. McIntosh, unpubl. data), indicating that they were once part of the subjacent middle Tertiary volcaniclastic succession. These deposits unconformably rest upon upper Eocene sandstone and mudstone of the upper Galisteo Formation (Lucas, 1982). Thus, this gravel-bearing interval represents an unconformity that probably ranges between about 10-14 m.y. in duration between the Galisteo and Zia Formations at the northwestern margin of the Albuquerque Basin.

Between 1146-1393 m bls is unit B, an interval of pink to very pale-brown, mostly fine- to medium-grained, quartz-rich feldspathic arenite and lithic arkose recognized below strata correlated to the Piedra Parada Member in the Tamara well. Traces of a white ash and sparse scattered volcanic grains are observed between 1283-1292 m (4210-4240 ft) and 1366-1375 m (4480-4510 ft) bls, respectively. The lower 27 m of this interval contains trace amounts of purplish-gray intermediate volcanic rocks. The stratigraphic position of this unit, below the Piedra Parada Member, suggests that it might be correlative to the Abiquiu Formation. Petrographic analysis of this interval indicates that the Cenozoic portion of the Tamara well is distinct from the Abiquiu Formation, which contains considerably less quartz than Cenozoic deposits studied in the Tamara well (Fig. 5).

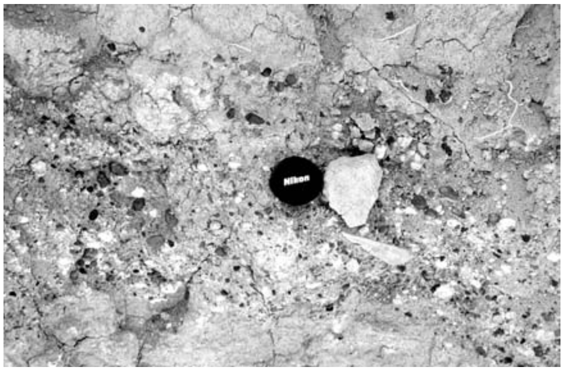

Figure 4. Pebbly sandstone at contact between Galisteo Formation (below gravel) and Piedra Parada Member of the Zia Formation (above gravel). Most of the gravel is composed of rounded and polished chert and quartzite derived from the Galisteo Formation and Oligocene volcanic deposits. Note the Oligocene volcanic pebble near lens cap.

Below 1393 m bls is unit A, a 223-236-m-thick interval of cemented, reddish-yellow, fine- to coarse-grained, subrounded to rounded, subarkose and lithic arkose. Lithic fragments from this unit contain abundant chert with minor gray intermediate volcanic grains containing hornblende. The lower 55 m of this unit contains slightly more intermediate to felsic intrusive and volcanic grains. This interval is compositionally similar to unit B, but is distinguished by a change in color and a slight increase in volcanic grains as seen in the sample preparation microscope.

Units A and B are petrographically similar to the lower Santa Fe Group as described by Large and Ingersoll (1997), but are more quartz-rich than Zia deposits described by Beckner (1996). The stratigraphic position of these intervals below deposits correlated to the Piedra Parada Member suggests a correlation to pre-Santa Fe Group strata in the basin. One such deposit is the Oligocene-upper Eocene unit of Isleta #2 of Lozinsky (1988, 1994), which overlies the Galisteo Formation in drillholes in the northern part of the Albuquerque Basin. Comparison of this small petrographic dataset indicates slight overlap among Santa Fe Group strata and the subjacent unit of Isleta #2 and Galisteo Formation (Fig. 5), thus hampering a definitive correlation to the unit of Isleta #2. The Tamara sand petrography, however, is similar to the unit of Isleta #2, suggesting that this unit is compositionally a close correlative. We provisionally assign units A and B to the unit of Isleta #2, because of the lack of older, pre-Piedra Parada Member strata in the NW Calabacillas sub-basin. Units A and B are slightly more quartzose than Santa Fe Group strata described by Large and Ingersoll (1997). Lozinsky (1994) documents the presence of up to 2185 m of the unit of Isleta #2 in oil test wells to the south (Fig. 6). The interval of units A and B could represent the northwestern limit of preservation of the unit of Isleta #2. This correlation is provisional, mainly because of the similarity in sand composition and lack of age control. The presence of a slightly more volcanic-rich interval near the bottom of this interval suggests that this volcanic activity was occurring during deposition of part of this unit. The color and slightly greater abundance of volcanic grains in unit A suggests a somewhat closer match to the unit of Isleta #2.

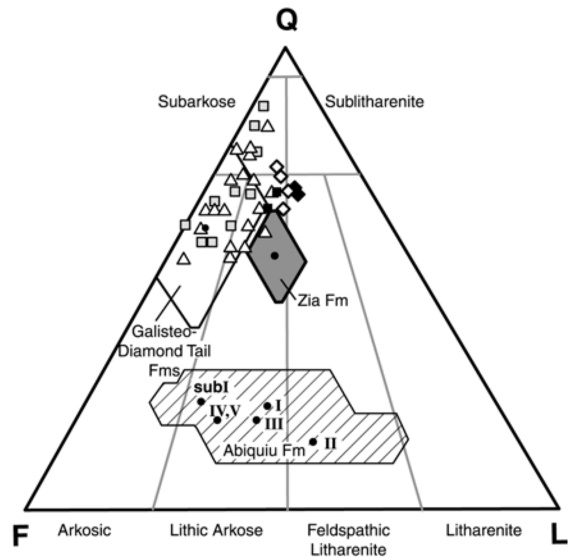

Figure 5. Detrital modes of sand from the Tamara #1-Y well (Table 1), illustrating comparisons of the Zia Formation (black diamonds), unit A and B (white diamonds), and Galisteo Formation (black squares) in the Tamara well to the Abiquiu Formation (Moore, 2000), Galisteo Formation (white boxes; Lozinsky, 1994), Zia Formation (shaded; Large and Ingersoll, 1997), unit of Isleta #2 (triangles), and Galisteo Formation (boxes). Black circles and boxes delineate means and fields of variations (based on standard deviation) of the Abiquiu, Zia, and Galisteo Formations, including Galisteo Formation deposits exposed along the east side of the rift (Gorham, 1979). The means of lithofacies of the Abiquiu Formation (Moore, 2000) are denoted by roman numerals.

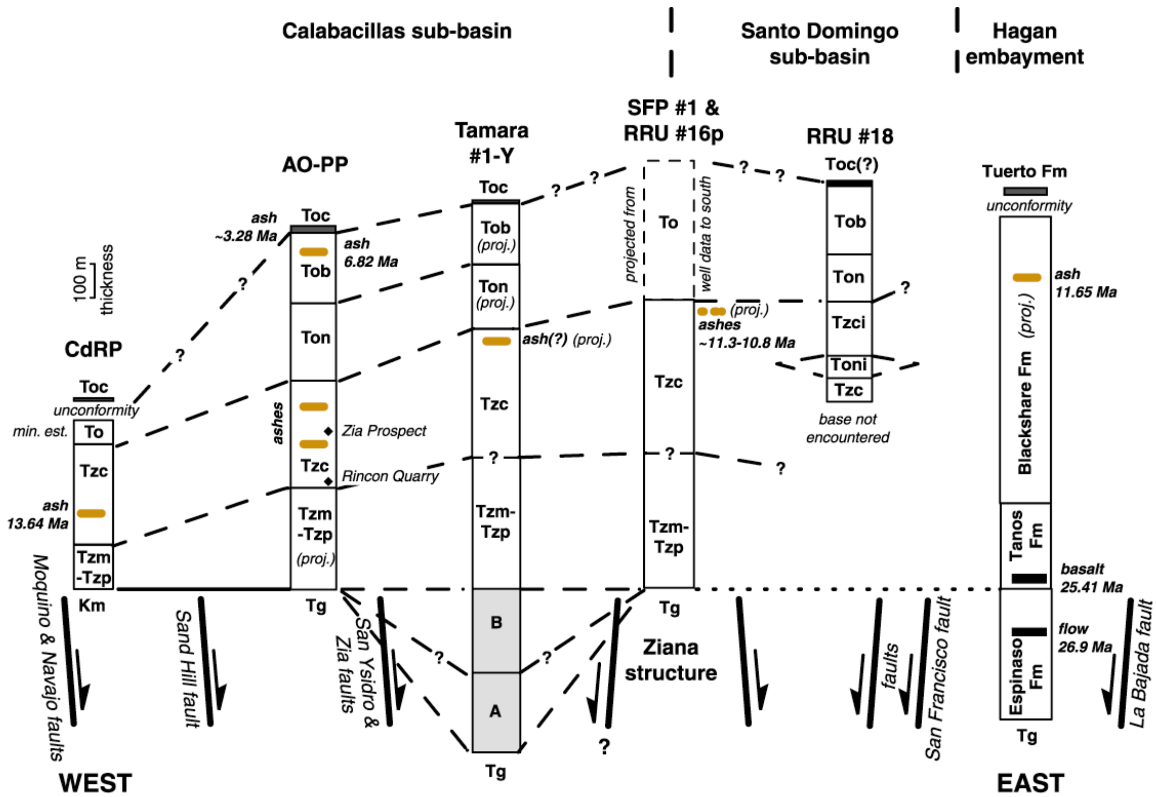

Figure 6. Comparison Santa Fe Group units along the Ceja del Rio Puerco (CdRP; Tedford and Barghoorn, 1999), a composite section in Arroyo Ojito and Arroyo Piedra Parada (AO-PP; Connell et al., 1999; Tedford and Barghoorn, 1999), Davis Tamara well, Santa Fe Pacific #1 (SFP#1; Lozinsky, 1988,. 1994; Black and Hiss, 1974), Rio Rancho Utilities #18 (RRU#18; Connell and Hawley, unpubl. data), and similarly aged strata in the Hagan embayment (Connell and Cather, *this volume*). Additional stratigraphic constraints are from unpublished data from Rio Rancho Utilities #16p (RRU 16p, J.W. Hawley, unpubl. data). The CdRP site is about 20 km southwest of AO-PP, and the Hagan locality is about 35 km to the east; other localities are <10 km of each other. The AO-PP section contains middle Miocene fossils from the Rincon quarry and Zia prospect (Galusha, 1966). Units Tzci and Toni are interfingering Cerro Conejo and Navajo Draw members, respectively. These interfingering relationships are recognized in the Bernalillo NW quadrangle (Koning and Personius, *in review*). Unit Toc in the Tamara and AO-PP sections contains both strata of the Pantadeleon Formation and Ceja Member of Connell et al. (1999). It is likely that the Santa Fe Group succession is thicker beneath RRU#18, however, the correlation tie lines are horizontal at the Ton/Tzc contact because of the lack of subsurface data.

Unit A rests upon a 327-345 m-thick succession of reddish-yellow, pink, very pale-brown, and light-gray sand and gravelly sand containing abundant granite. Volcanic grains were observed in thin section (Appendix 1), but probably represent contamination by caving from overlying deposits in the drillhole. From a visual examination of cuttings, this unit is lithologically similar to exposures of the Galisteo Formation (Koning et al., 1998). This unit is interpreted to be correlative to the Galisteo Formation, principally because of its stratigraphic position above the shale- and coal-bearing Menefee Formation (discussed below) and the similarity in color to nearby mapped units of the Galisteo Formation (Koning et al. 1998).

The interpreted base of the Cenozoic section in the Tamara well is at 1978 m bls. Cuttings from this well were not evaluated below 2015 m (6610 ft) bls. This lowest interval studied here contains gray siltstone with interbeds of coal that comprise about 5-10% of the described unit. These are interpreted to be the Cretaceous Menefee Formation based on stratigraphic position, and similarity in lithologic character to mapped units to the west and northwest (Koning et al., 1998).

DISCUSSION

Stratigraphic relationships near the Tamara well near the northwestern margin of the Albuquerque Basin suggest a tectonic control on the thickness distribution of lower Santa Fe Group strata (Figs. 6-7). The basal contact of the Piedra Parada Member near its type locality contains scattered Oligocene volcanic gravel as well as abundant rounded pebbles reworked from the Eocene Galisteo Formation (Tedford and Barghoorn, 1999), indicating the presence of formerly extensive Paleogene deposits prior to deposition of the Piedra Parada Member. The Zia Formation thickens slightly between exposures along the Ceja del Rio Puerco, on the footwall of the Sand Hill fault (Tedford and Barghoorn, 1999), and a composite section for Arroyo Piedra Parada and Arroyo Ojito on the hanging wall. To the east, in the Shell Santa Fe Pacific #1 well (Lozinsky, 1994), is a comparable succession of Zia Formation sediments that directly overlies the Galisteo Formation on the Ziana structure (Fig. 6). The Ziana structure was interpreted as an anticline by earlier workers (Black and Hiss, 1974; Kelley, 1977), and later as a horst (Personius et al., 2000, cross section), and as an anticlinal accommodation zone (Stewart et al., 1998) that forms the boundary between the Santo Domingo and Calabacillas sub-basins of the Albuquerque Basin (Grauch et al., 1999).

Between 455-482 of units A and B is preserved between Arroyo Ojito and the Shell Santa Fe Pacific #1 well (Fig. 6), which was drilled about 6 km southeast of the Tamara well on the Ziana structure. The absence of units A and B in nearby exposures and in the Shell Santa Fe Pacific #1 well indicates significant stratal thickening into the basin and non-deposition or erosion on the Ziana structure. At the Santa Fe Pacific #1, the Zia section is 853-905 m thick (Black and Hiss, 1974; Lozinsky, 1994). Thus, nearly 500 m of pre-Piedra Parada deposits are preserved within about 3 km from the Zia fault and the Ziana structure. Such variations in thickness near the Ziana structure and nearby faults suggest that these sub-basin accommodation zone and intrabasinal faults were active prior to deposition of the well dated Piedra Parada beds at Standing Rock quarry.

Faults associated with the Ziana structure cut deposits correlated to the Arroyo Ojito Formation (Personius et al., 2000), indicating that this structural zone was active after deposition of the Zia Formation. Preservation of units A and B between the Zia fault and Ziana structure suggests that block faulting preserved these units and that correlative units were likely stripped on adjacent uplifted fault blocks prior to deposition of the Zia Formation. On the other hand, the additional section could have been preserved by broad tectonic subsidence or down-warping. Neither interpretation can be definitively demonstrated with the data presented here.

Petrographic studies, albeit using a rather small dataset, indicate that the Tamara data is compositionally different than reported data for the Santa Fe Group, unit of Isleta #2, and Galisteo Formation. Because no core was available for this well, cuttings were used in the analysis. The Tamara data overlaps slightly with other constituents, making definitive petrographic comparisons among these units ambiguous. Petrographic comparisons of detrital modes are also hampered by compositional variations in the size of analyzed sand-fraction, which are sensitive to grain size (Ingersoll et al., 1984). Lozinsky (1994) did not discriminate sand size. Large and Ingersoll (1997), and Gorham (1979) used medium- and coarse-grained constituents.

Geologic mapping (Personius et al., 2000) and examination of drillhole data in the Rio Rancho area indicates that the stratigraphic section encountered in the Santa Fe Pacific #1 represents a minimum thickness. An examination of lithologic notes and borehole geophysics for Rio Rancho Utilities #16p (Rio Rancho #16 in Personius et al., 2000) indicate the presence of a 3-m thick white ash at about 433-439 m bls (J.W. Hawley, unpubl. data). This ash is near the top of a thick sandy interval that is overlain by interbedded sand and mud above 347-433 m bls. The ash in Rio Rancho Utilities #16p is in a similar stratigraphic position relative to exposures of Trapper Creek ashes exposed to the north (Personius et al., 2000; Koning and Personius, *in review*), suggesting a correlation to the Cerro Conejo Member. The top of the Santa Fe Group section is probably not preserved at this well, so this estimate represents a minimum thickness of Arroyo Ojito strata. If this estimate is correct, then more than 347-430 m of Arroyo Ojito Formation section may have been deposited over the Cerro Conejo Member near the Santa Fe Pacific #1 well (Fig. 6).

Alternatively units A or B may not be correlative to the unit of Isleta #2 and could represent a previously unrecognized lower member of the Zia Formation, which would nearly double the known thickness of the Zia Formation at the type area, <10 km west of the Tamara well. The existence of older Santa Fe Group deposits would be supported by the presence of the Oligo-Miocene Tanos Formation at the eastern margin of the basin (Connell and Cather, *this volume*). The Zia section tends to thicken eastward, suggesting westward onlap, which would result in the deposition of younger sediments along the basin margin. However, the presence of a major unconformity at the base of the Zia Formation and the absence of a significantly thick Zia section on the Ziana structure suggests that units A and B were likely eroded prior to deposition of the Piedra Parada Member, and therefore, are more likely part of the pre-Santa Fe Group stratigraphic succession.

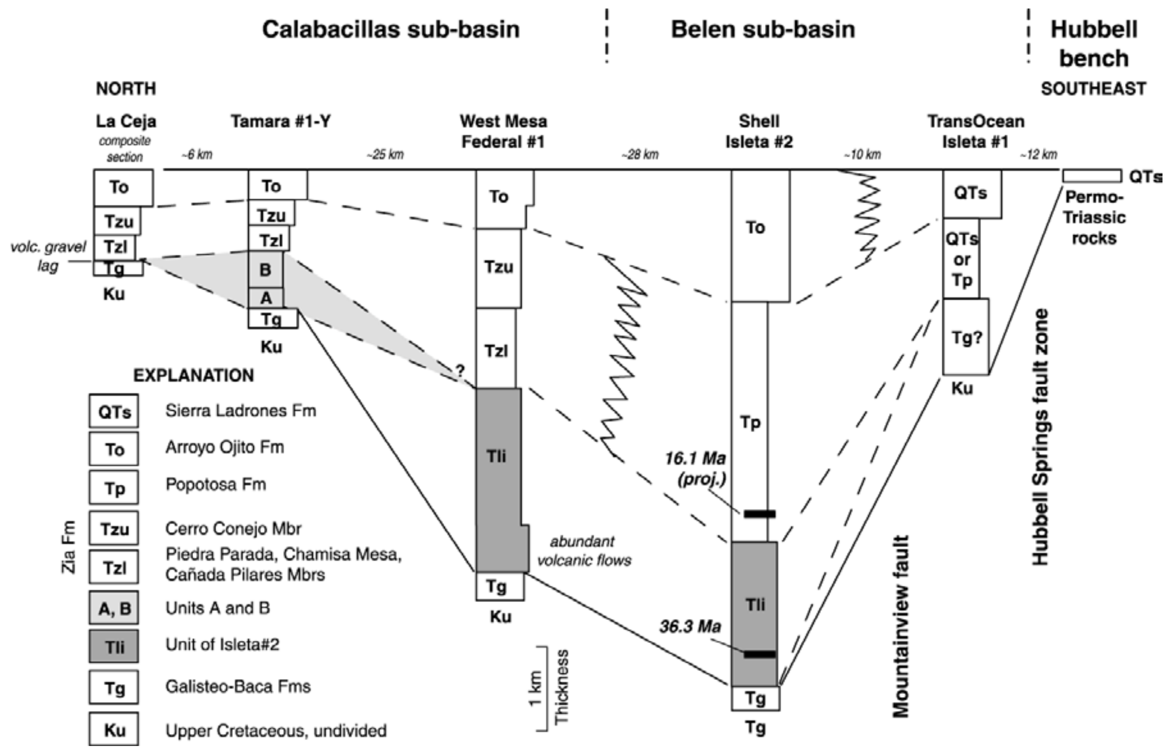

Figure 7. Stratigraphic fence of Cenozoic deposits in the Calabacillas sub-basin. Data from oil test wells (Lozinsky, 1988, 1994; Connell et al., 1999; Tedford and Barghoorn, 1999; Maldonado et al., 1999; Black and Hiss, 1974).

Nonetheless, the assignment of 455-482 m of units A and B to either the Santa Fe Group or the subjacent unit of Isleta #2 indicates that tectonic activity and local erosion occurred along the northwestern margin of the Albuquerque Basin, either during Oligocene or early Miocene time.

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Appendix 1. Point-count petrographic data of medium-grained sand (250-500 µm) from washed cuttings from Davis Tamara #1-Y. Abbreviations include: monocrystalline quartz (Qm), polycrystalline quartz (Qp), plagioclase (P), potassium feldspar (K), granitic or gneissic (gn), quartz phenocryst within volcanic fragment (Qv), plagioclase phenocryst within volcanic fragment (Pv), volcanic groundmass (Vg), quartz within sedimentary fragment (Qs), chert (Qc), feldspar within sedimentary fragment (Fs), mica (M), opaque (O), unknown (U), and total grains counted (N). The interval is depth range, in feet bls, where cuttings samples were taken. Volcanic detritus in the Galisteo Formation is probably the result of caving from stratigraphically higher, volcanic-bearing strata in the drillhole.

Interval	Unit	Qm	Qp	P	K	gn	Qv	Pv	Vg	Qs	Qc	Fs	M	O	U	N
1390-1420	Tzc	244	12	29	32	7	0	2	59	1	13	0	0	0	1	400
2620-2650	Tzm	230	10	28	28	9	1	2	61	1	21	1	1	5	2	400
3970-4000	B	227	10	44	29	11	0	2	58	2	15	0	0	1	1	400
4150-4180	B	260	6	28	37	7	0	1	35	0	21	0	0	2	3	400
5020-5050	A	244	7	31	34	8	1	1	54	0	18	0	0	0	2	400
5230-5260	A	252	8	36	32	4	0	3	43	1	17	0	1	2	1	400
5290-5320	Tg	232	10	46	45	6	0	2	45	0	11	0	0	1	2	400
5410-5440	Tg	238	6	34	41	7	1	2	46	2	21	0	0	0	2	400

Appendix 2. Summary of interpreted stratigraphic boundaries in Davis Tamara #1-Y. The Ceja (Toc), Loma Barbon (Tob) members of the Arroyo Ojito Formation are projected into the drillhole from neighboring outcrops. Units encountered in the include the Navajo Draw Member (Ton) of the Arroyo Ojito Formation, The Cerro Conejo (Tzc), and the undivided Chamisa Mesa and Piedra Parada members of the Zia Formation (Tzm-Tzp). Units A and B are stratigraphically lower than the Piedra Parada Member and represent, either a lower member of the Zia Formation, or the subjacent unit of Isleta #2. The Galisteo (Tg) and Menefee (Km) Formations were also encountered, but not studied in detail. Thickness estimates for these units were adjusted for stratal tilts based on a dip-meter log and correlation to geologic maps (Koning and Personius, *in review*; Koning et al., 1998).

Unit	Depth to top (m, bls)	Drilled thickness (m)	Inferred Dip	Dip adjusted Thickness (m)
Toc	0 *(proj.)*	15	7º	15
Tob	15 *(proj.)*	168	7º	167
Ton	183	195	7º	194
Tzc	378	372	7º	369
Tzm-Tzp	750	396	7º	393
B	1146	247	7º (20º)	245 (232)
A	1393	237	7º (20º)	236 (223)
Tg	1630	348	7º (20º)	345 (327)
Km	1978	---	---	---