Geologic summary of the Abiquiu quadrangle, north-central New Mexico

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GEOLOGIC SUMMARY OF THE ABIQUIU QUADRANGLE, NORTH-CENTRAL NEW MEXICO

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ABSTRACT — We summarize the geology and present a geologic map of the Abiquiu quadrangle, report newly determined $^{40}Ar/^{39}Ar$ dates for volcanic rocks within and contiguous to the quadrangle, and describe a newly discovered low-angle fault. The Abiquiu quadrangle is located along the margin of the Colorado Plateau-Rio Grande rift in north-central New Mexico and occurs within the Abiquiu embayment, a shallow, early extensional basin of the Rio Grande rift. Rocks exposed include continental Mesozoic rocks of the Colorado Plateau, Cenozoic basin-fill deposits, and Tertiary volcanic rocks. Mesozoic units are the Upper Triassic Chinle Formation, and Middle Jurassic Entrada Sandstone and Todilto Limestone Member of the Wanakah Formation. Cenozoic rocks include the Eocene El Rito Formation, Oligocene conglomerate of Arroyo del Cobre, Oligocene-Miocene Abiquiu Formation, and Miocene Chama-El Rito and Ojo Caliente Sandstone Members of the Tesuque Formation (Santa Fe Group). Volcanic rocks include the Lobato Basalt (Miocene; ~15-8 Ma), El Alto Basalt (Pliocene; ~3 Ma), and dacite of the Tschicoma Formation (Pliocene; ~2 Ma). Quaternary deposits consist of inset ancestral axial and tributary Rio Chama deposits and landslide colluvium, and Holocene floodplain, fan and pediment alluvium. The predominant faults are Tertiary normal faults displacing rocks basinward. and minor Mesozoic thrust faults. A low-angle fault, referred to here as the Abiquiu fault, separates an upper plate composed of the transitional zone of the Ojo Caliente Sandstone and Chama-El Rito from a lower plate consisting of the Abiquiu Formation or the conglomerate of Arroyo del Cobre. The upper plate is distended into blocks that range from about 0.1 km to 3.5 km long that may represent a larger sheet that has been broken up and partly eroded.

GENERAL GEOLOGY

The Abiquiu 1:24,000-scale quadrangle (Maldonado, 2004; unpubl. 2006) is located along the Colorado Plateau-Rio Grande rift margin in north-central New Mexico (Figs. 1, 2). The map area lies within the Abiquiu embayment (Fig. 1), an early (pre-Miocene) extensional basin of the Rio Grande rift. Rocks exposed within the quadrangle include continental Mesozoic rocks of the Colorado Plateau, and Cenozoic basin-fill deposits and volcanic rocks (Fig. 3). Mesozoic units are Upper Triassic upper and lower Chinle Formation and Middle Jurassic Entrada Sandstone and Todilto Limestone Member of the Wanakah Formation. Mesozoic rocks are folded in some areas and overlain disconformably by Cenozoic rocks.

Cenozoic sedimentary rocks are composed of the Eocene El Rito Formation, Oligocene conglomerate of Arroyo del Cobre that is equivalent to Ritito Conglomerate (Barker, 1958) and lower member of Abiquiu Formation (Smith, 1995; Moore, 2000), Oligocene-Miocene Abiquiu Formation, and Miocene Chama-El Rito and Ojo Caliente Sandstone Members of the Tes-

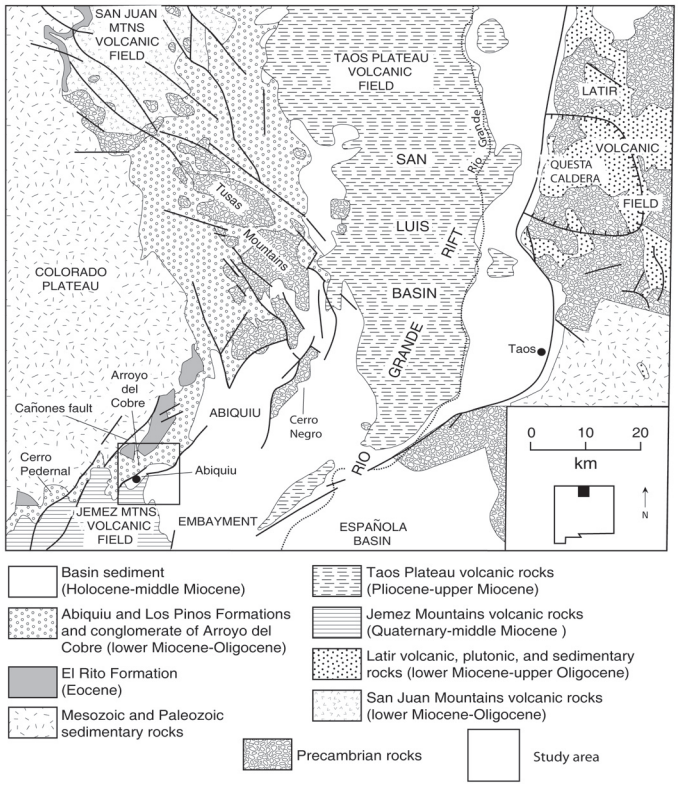

FIGURE 1. Generalized geologic map of north-central New Mexico (modified after Smith, 1995) showing study area.

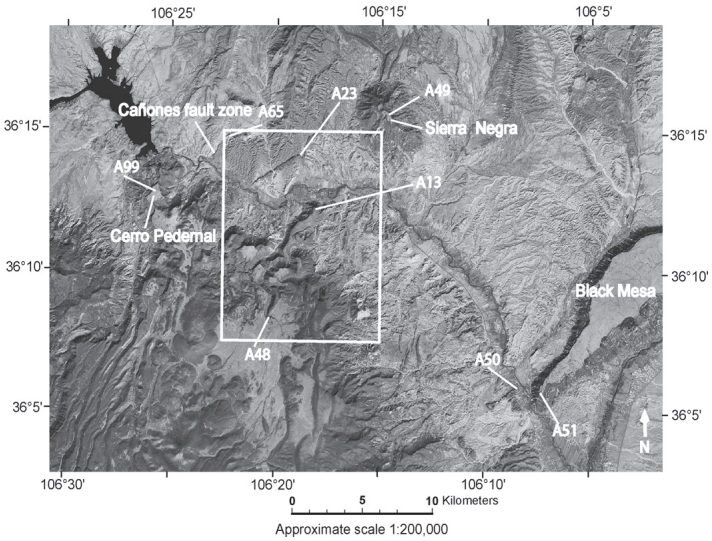

FIGURE 2. Landsat image of the Abiquiu quadrangle (shown in outlined area) and contiguous areas, showing sample locations. Some samples (e.g., A51) outside map area. Landsat image modified from Sawyer et al. (2004).

uque Formation of the Santa Fe Group. Volcanic rocks include the Miocene Lobato Basalt (~15-9 Ma, Aldrich and Dethier, 1990; ~10-8 Ma, Bachman and Mehnert, 1978; Manley and Mehnert, 1981; and 9.51±0.21 Ma, sample A48, Figs. 2, 3), the El Alto Basalt (~3 Ma, Manley and Mehnert, 1981; Baldridge et al., 1980; and 2.86±0.05 Ma, sample A13, Figs. 2, 3), and dacite of the Tschicoma Formation (~2 Ma, Gardner and Goff, 1984). Quaternary surficial deposits consist of six (F. Maldonado, unpubl., 2006) grouped Pleistocene inset ancestral axial and tributary Rio Chama deposits modified from Gonzalez (1993) and Gonzalez and Dethier (1993). Other surficial units include Pleistocene and Holocene landslide colluvium, and Holocene floodplain alluvium, fan and pediment alluvium. The Pleistocene axial terrace benches are approximately 30 to 115 m above the present Rio Chama floodplain. One set of terraces, about 115 m above the current Rio Chama floodplain, is constrained to at least 640 ka, based on the presence of the Lava Creek B ash identified in an equivalent terrace east of the map area (Dethier et al., 1990; Gonzalez and Dethier, 1991).

Tributary gravels beneath the Lobato Basalt and El Alto Basalt contain clasts of a fluvial system that probably represents several ancestral Tertiary Rio Chama courses. The upper contacts of these gravels with the overlying basalts are about 580 m and 395 m, respectively, above the modern Rio Chama. Clasts consist mostly of subrounded to well-rounded Paleozoic quartzite and granite, Tertiary volcanics, and traces of Pedernal Chert Member of the Abiquiu Formation (referred to as Pedernal Chert in this report). Gravels containing quartzite and Pedernal Chert also are present under the lavas capping Sierra Negra (5.56±0.12 Ma, sample A49, Fig. 2; ~5 Ma, Baldridge et al., 1980) and the Servilleta Basalt flows at Black Mesa (3.69±0.25 Ma, sample A51, Fig. 2; ~4-3 Ma; Manley, 1976; Laughlin et al., unpubl. report for Los Alamos National Laboratory, 1993), northeast and east of the map area (Fig. 2), respectively. The presence of Pedernal Chert at these two localities suggests that an ancestral Rio Chama existed approximately 3 to 5 Ma. The gravels at Black Mesa may represent a confluence of the ancestral Rio Chama and ancestral Rio Grande.

The Cañones fault zone, located in the northwest corner of map area (Figs. 1-3), separates the Abiquiu embayment from the Colorado Plateau. The Abiquiu embayment is a shallow basin that forms the western margin of the Rio Grande rift (Baldridge et al., 1994). The Cañones fault developed contemporaneous to deposition of the Abiquiu Formation, conglomerate of Arroyo del Cobre, and El Rito Formation, based on a thinner sequence of these units on the Cerro de Pedernal (Figs. 1, 2) of the Colorado Plateau (Smith, 1938; Moore, 2000; Kelley et al., 2005) and a much thicker sequence in the Abiquiu embayment. The fault appears to have remained active for a considerable time based on two observations. A dike referred to informally as the basaltic dike of Red Wash Canyon, located in the northwest corner of map area (Fig. 3), intrudes the lower part of the Chinle Formation of the Colorado Plateau Province and the conglomerate of Arroyo del Cobre unit of the Abiquiu embayment. The dike, dated at 19.63±0.40 Ma (sample A65; Figs. 2, 3) is offset right laterally approximately 2 km by the Cañones fault. The dike has the same age within analytical error as the Cerrito de la Ventana dike (19.22±0.30 Ma, sample A 23, Figs. 2, 3), which intrudes the conglomerate of Arroyo del Cobre and the Abiquiu Formation in the Abiquiu embayment, both dikes having their sources within the Abiquiu embayment (F. Maldonado, unpubl., 2006). Latest offset is constrained by the Lobato Basalt and the El Alto Basalt, on the Colorado Plateau with eruptive sources in the Abiquiu embayment (Smith et al., 1970). The Lobato Basalt is displaced across the Cañones fault, whereas the El Alto Basalt (~3 Ma) is not (Manley, 1982; Moore, 2000; Maldonado, 2004; Kelley et al., 2005).

Other faults related to rift formation and prerift formation located east of the Cañones fault are the Garcia, Cerrito Blanco, Barranca, Madera Canyon faults, and unnamed thrust faults (Fig. 3). The rift-related faults form a zone of step faults that downdrop strata to the east, toward the Española basin (Fig. 1), a deeper part of the Rio Grande rift. Prerift structures of Laramide age are preserved as folds in the Mesozoic rocks in the northwestern part of the map area (Fig. 3) and locally as small reverse faults (Fig. 4) in the upper part of the Chinle Formation in the Arroyo del Cobre area.

LOW-ANGLE FAULT OF ABIQUIU

Other important structures in the map area are blocks that are bounded by a low-angle fault zone referred to here as the Abiquiu fault (Figs. 3, 5). The zone along the fault trace is mostly concealed but characterized locally by pulverized rock and omission of strata. The Abiquiu fault separates an upper plate from a lower plate. The upper plate has been pervasively fractured and faulted with small displacements, and in some areas (Figs. 3, 5-7), dips steeply into the lower plate, forming an angular discordance.

The upper plate is composed of the transitional zone of the Ojo Caliente Sandstone and Chama-El Rito Members (Fig. 5) and is stratigraphically out of place with some of the stratigraphic section missing. In the southern part of the Cerrito Blanco area (Fig. 3), the upper plate overlies the Abiquiu Formation and to the north, it overlies the conglomerate of Arroyo del Cobre (Fig. 5). The scattered blocks of the upper plate may have originally formed a sheet that has subsequently been broken and eroded into smaller blocks ranging in length from about 0.1 km to 3.5 km (Figs. 6, 8). In the Cerrito Blanco area (Fig. 6), referred to as "Battleship Rock" by Smith (1938), the upper and lower plates and Abiquiu fault have been offset by movement on the Cerrito Blanco fault, resulting in cementation of the upper plate. The upper plate was probably first fractured, possibly by the Abiquiu fault, followed by solutions migrating up along the Cerrito Blanco fault zone and cementing the upper plate. In the southwestern part of the map area, south of the Rio Chama and south of the village of Barranca (Fig. 3), smaller blocks are present that may have been part of the larger sheet. There, the upper plate is composed of the Ojo Caliente transitional zone and intruded by basaltic dikes (Fig. 7) referred to as dikes of Barranca. The dikes are truncated by the Abiquiu fault (Fig. 7), suggesting that intrusion of the dikes preceded detachment of the upper plate. These dikes may be related to Lobato Basalt volcanism. This is suggested by the presence of

FIGURE 3. Generalized geologic map of the Abiquiu quadrangle, north-central New Mexico. See Plates 6 and 7, page 136 and 137, for a color version of this map and explanation.

LIST OF MAP UNITS

Qrc	Main stream channel of the modern Rio Chama (historic)
Qa	Alluvium and colluvium (Holocene). Includes present side stream, floodplain, and pockets of alluvium and colluvium
Qcb	Colluvium deposit predominately of basaltic clasts of Tlb and Teb (Holocene)
Qcb/Tto	Colluvium deposit predominately of basaltic clasts and Ojo Caliente Sandstone Member of Tesuque Formation, undivided (Holocene and upper to middle Miocene)
Qcb/Ttc	Colluvium deposit predominately of basaltic clasts and Chama-El Rito Member of Tesuque Formation, undivided (Holocene and middle to lower Miocene)
Qcb/Ta	Colluvium deposit predominately of basaltic clasts and Abiquiu Formation, undivided (Holocene and lower Miocene to upper Oligocene)
Qls	Landslide deposits (Holocene and Pleistocene)
Qt	Axial channel and side stream channel deposits (Qt1 thru Qt6) of the ancestral Rio Chama, undivided (Pleistocene)
Ttd	Dacite of Tschicoma Formation (Pliocene)
Ttda	Dacite of Tschicoma Formation and Abiquiu Formation, undivided (Pliocene and lower Miocene to upper Oligocene)
Teb	Basalt of El Alto (Pliocene)
Tlb	Lobato Basalt (Miocene)
Tcd	Cerrito de la Ventana dike (early Miocene)
Tbr	Basaltic dike of Red Wash Canyon (early Miocene)
Tbb	Basaltic dike of Barranca (Miocene?)
Tto	Ojo Caliente Sandstone Member of Tesuque Formation (upper and middle Miocene)
Ttoc	Transitional zone of the Ojo Caliente Sandstone and Chama-El Rito Members of Tesuque Formation (middle Miocene)
Ttc	Chama-El Rito Members of Tesuque Formation (middle and lower Miocene)
Ttcv	Volcaniclastic unit of the Chama-El Rito Member of Tesuque Formation (middle and lower Miocene)
Ta	Abiquiu Formation (lower Miocene and upper Oligocene)
Tca	Conglomerate of Arroyo del Cobre (Oligocene)
Te	El Rito Formation (Eocene)
Mz	Mesozoic rocks, undivided (Middle Jurassic to Upper Triassic)

EXPLANATION

Contact—Queried where uncertain; contacts between bedrock and surficial deposits approximately located

Normal fault—Bar and ball on downthrown side; dashed where approximately located; dotted where concealed; queried where uncertain; arrows indicate amount and direction of motion

Low-angle fault (Abiquiu fault), mostly concealed and approximately located

Incipient fissure (scarp) of gravity-slide block at Mesa de Abiquiu

X A48 Sample location

Strike and dip of sedimentary beds

Inclined

Horizontal

Syncline

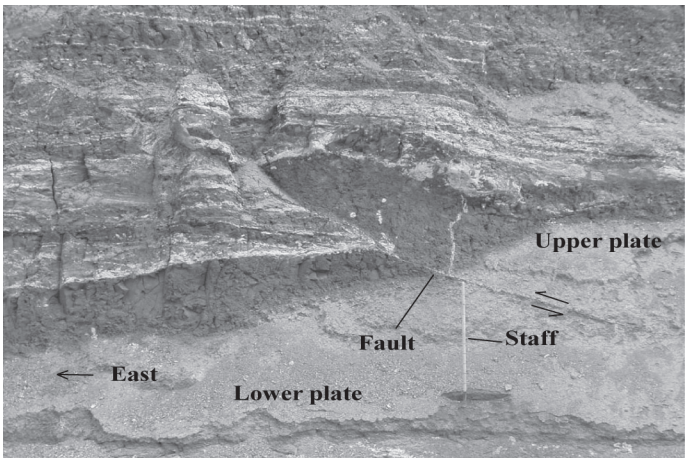

FIGURE 4. View looking east in Arroyo del Cobre area. Laramide reverse fault in mudstones and siltstones of the upper part of the Chinle Formation. Upper plate has moved to the east. Arrows indicate direction of movement. Staff is 2 m high.

equivalent dikes mapped by Dethier and Manley (1985) in the Chili quadrangle, east of map area, that also intrude the Chama-El Rito and Ojo Caliente Sandstone. A sample (A50, Fig. 2) from one of those dikes yielded in a $^{40}Ar/^{39}Ar$ date of 10.11±0.13 Ma.

ACKNOWLEDGMENTS

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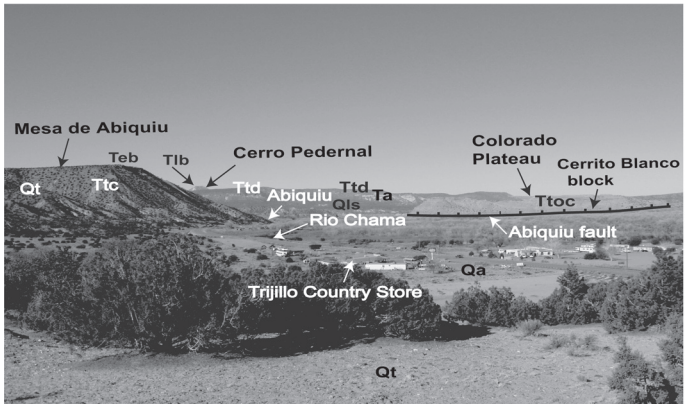

FIGURE 5. Panoramic view looking west towards Rio Chama and Cerro Pedernal (Colorado Plateau) from east of Trujillos County Store. Fault with hachure indicates block of Ttoc overlying unit Ta. Ta, Abiquiu Formation; Ttoc, transitional zone of the Ojo Caliente Sandstone and Chama-El Rito Members of Tesuque Formation; Tlb, Lobato Basalt; Teb, El Alto Basalt; Ttd, dacite of Tschicoma Formation; Qls, landslide deposits; Qt, axial channel and side stream channel deposits of the ancestral Rio Chama, undivided; Qa, floodplain of the modern Rio Chama.

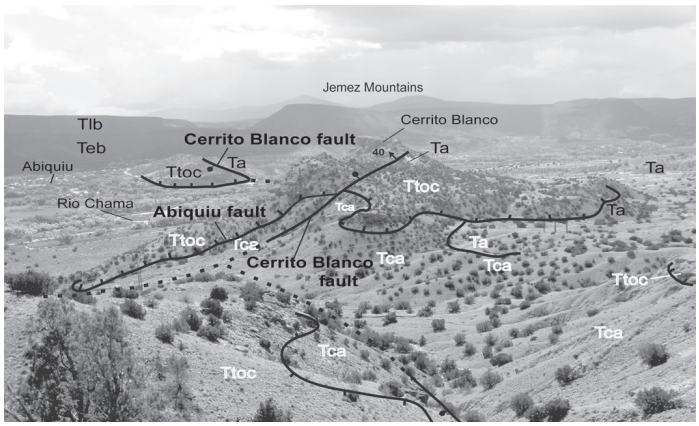

FIGURE 6. Panoramic view looking south towards Cerrito Blanco, Abiquiu, and peaks of the Jemez Mountains from the northern part of Cerrito Blanco. Fault with hachure indicates block of Ttoc. Tca, conglomerate of Arroyo del Cobre; Ta, Abiquiu Formation; Ttoc, Transitional zone of the Ojo Caliente Sandstone and Chama-El Rito Members of Tesuque Formation; Tlb, Lobato Basalt; Teb, El Alto Basalt.

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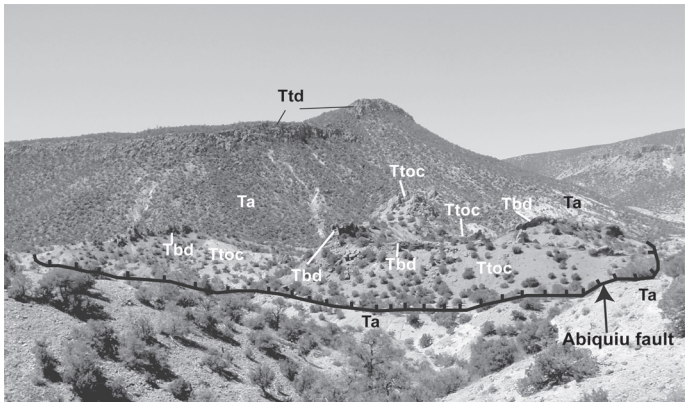

FIGURE 7. Panoramic view looking southwest from an area south of the Rio Chama and the village of Barranca towards blocks of Ttoc intruded by Tbd. Hachure indicates block of Ttoc. Ta, Abiquiu Formation; Ttoc, transitional zone of the Ojo Caliente Sandstone and Chama-El Rito Members of Tesuque Formation; Tbd, basaltic dikes of Barranca; Ttd, dacite of Tschicoma Formation.

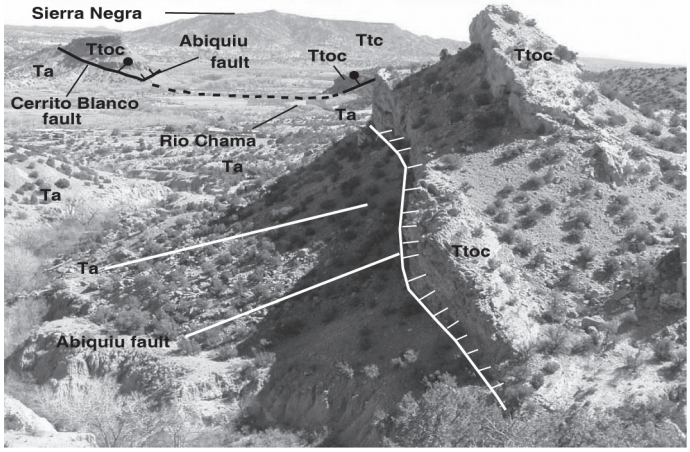

FIGURE 8. Panoramic view looking northeast towards Sierra Negra (Fig. 2) from an area south of Rio Chama towards blocks of Ttoc. Hachure indicates block of Ttoc. Ta, Abiquiu Formation; Ttc, Chama-El Rito Member of Tesuque Formation; Ttoc, transitional zone of the Ojo Caliente Sandstone and Chama-El Rito Members of Tesuque Formation.

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PLATE 6: GENERALIZED GEOLOGIC MAP OF THE ABIQUIU QUADRANGLE, NORTH-CENTRAL NEW MEXICO

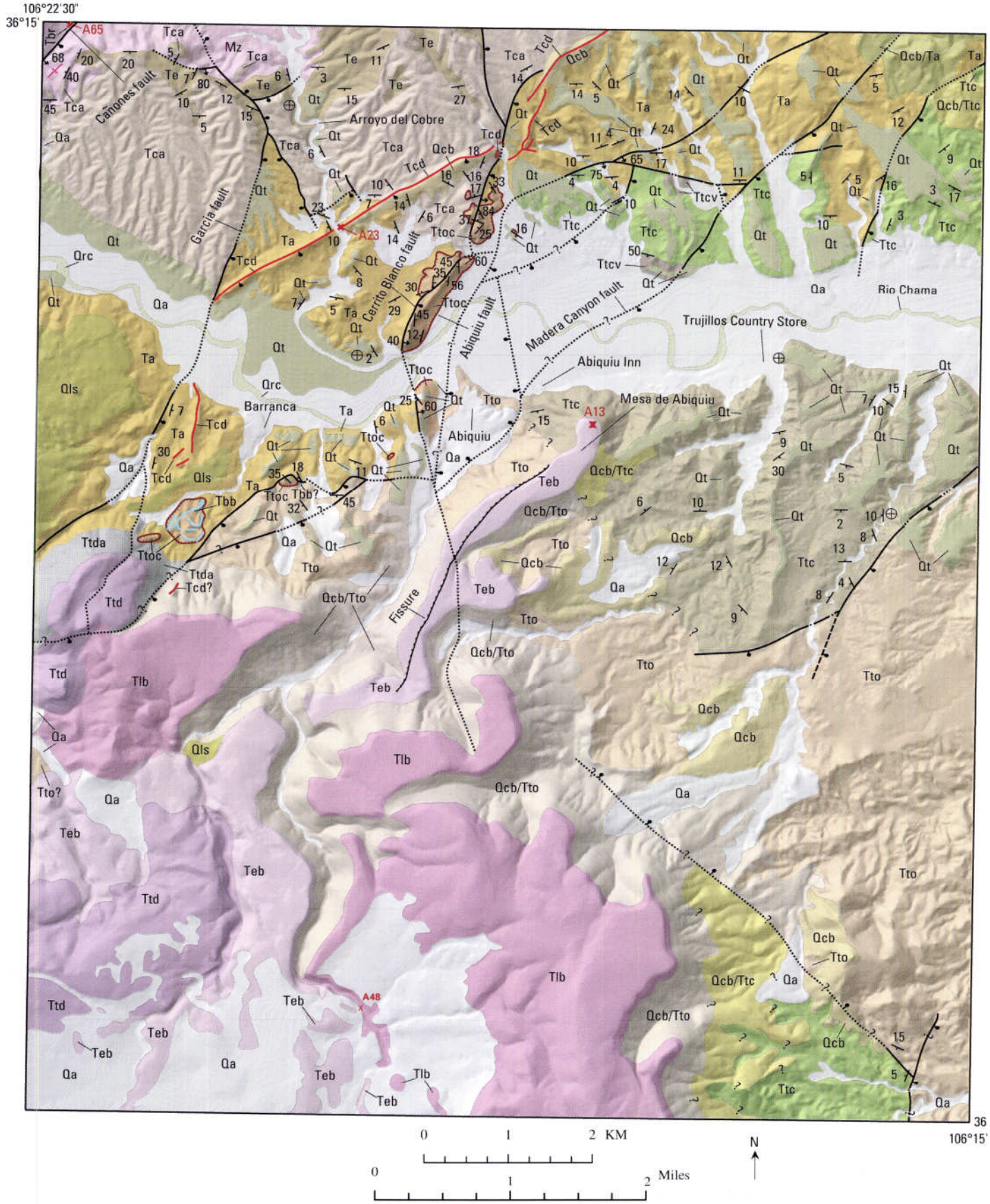

PLATE 7: EXPLANATION FOR THE ABIQUIU QUADRANGLE GEOLOGIC MAP

LIST OF MAP UNITS

Qrc	Main stream channel of the modern Rio Chama (historic)
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Ted	Cerrito de la Ventana dike (early Miocene)
Tbr	Basaltic dike of Red Wash Canyon (early Miocene)
Tbb	Basaltic dike of Barranca (Miocene?)
Tto	Ojo Caliente Sandstone Member of Tesuque Formation (upper and middle Miocene)
Ttoc	Transitional zone of the Ojo Caliente Sandstone and Chama-El Rito Members of Tesuque Formation (middle Miocene)
Ttc	Chama-El Rito Members of Tesuque Formation (middle and lower Miocene)
Ttcv	Volcaniclastic unit of the Chama-El Rito Member of Tesuque Formation (middle and lower Miocene)
Ta	Abiquiu Formation (lower Miocene and upper Oligocene)
Tca	Conglomerate of Arroyo del Cobre (Oligocene)
Te	El Rito Formation (Eocene)
Mz	Mesozoic rocks, undivided (Middle Jurassic to Upper Triassic)

EXPLANATION

Contact—Queried where uncertain; contacts between bedrock and surficial deposits approximately located

Normal fault—Bar and ball on downthrown side; dashed where approximately located; dotted where concealed; queried where uncertain; arrows indicate amount and direction of motion

Low-angle fault (Abiquiu fault), mostly concealed and approximately located

Incipient fissure (scarp) of gravity-slide block at Mesa de Abiquiu

X A48 Sample location

Strike and dip of sedimentary beds

Inclined

Horizontal

Syncline

See the article by Maldonaldo and Miggins on page 182 for more details concerning the geology of the Abiquiu quadrangle.