Geologic Map of the New River Mesa 7.5 Quadrangle, Maricopa County, Arizona v. 2.0

by

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Digital Geologic Map (171)
Formerly AZGS Open-File Report (98-12)

November 28 2022

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Funded by the U.S. Geological Survey through the STATEMAP program agreement #1434-HQ-97-AG-01824 and the Arizona Geological Survey.

This report is part of a digital republication of a 1998 geologic map originally created by the Arizona Geological Survey with financial support from the U.S. Geological Survey STATEMAP program 1434-HQ-97-AG-01824 . Preparation for republication was conducted by students from the University of Arizona with financial support from the U.S. Geological Survey, National Geological and Geophysical Data Preservation Program (G21AP10428) and included the production of a new GIS geodatabase and a revised map layout. The following text report has not been altered and remains identical to the 1998 original, but there may be situations where unit names, ages, symbology, or other geologic information contained within this report do not match the information presented in the new map layout or GIS geodatabase.

GEOLOGIC MAP OF THE NEW RIVER MESA 7.5' QUADRANGLE, MARICOPA COUNTY, ARIZONA

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Arizona Geological Survey
Open-File Report 98-12

August, 1998

Arizona Geological Survey
416 W. Congress St., Suite 100, Tucson, AZ 85701

Includes 29 page text, and 3 sheets: 1:24,000 scale geologic map, explanation, and cross-sections.

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INTRODUCTION

The New River Mesa Quadrangle is located along the northern fringe of the Phoenix metropolitan area. The quadrangle includes several high-standing mesas, and although the rugged terrain of the New River Mesa area is undeveloped, the area to the south is becoming increasingly urbanized and is undergoing rapid population growth. Geologic mapping was related to other previous and ongoing mapping projects of urban fringe areas located to the north and northeast of the Phoenix metropolitan area. A series of color 1:24,000-scale aerial photographs (dated 11-5-79 and 6-11-88) were obtained from the U.S. Department of Interior and the Tonto National Forest office in Phoenix, and these were used by the field geologists to assist with mapping and to identify contacts in areas where access was limited due to private land holdings. This study is contiguous with geologic mapping recently completed in the Humboldt Mountain Quadrangle to the east (Gilbert and others, 1998).

Road access for most parts of the quadrangle is limited. Portions in the southwestern corner along lower Cave Creek are accessible on Forest Road 48 from Cave Creek. Grapevine Wash, in the southeast corner, is accessible along private roads that serve subdivisions north of Carefree. The northern third of the map area is accessible from a system of primitive Forest Roads that can be reached from graded Forest Roads 24, 41, and 17 from the north and east of the map area. Additional roads that provide access to inactive mines or mining claims are commonly locked and not accessible to the public. Most of the land and trails within the map area are administered by the Tonto National Forest, and areas in the east-central part of the map area were reached by walking or horseback along a well-developed trail system.

This project was funded by the U.S. Geological Survey through the STATEMAP Program, Agreement #1434-HQ-97-AG-01824, and the Arizona Geological Survey. 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 U.S. Government.

PREVIOUS STUDIES

Initial geologic investigation in the New River Mesa area was related to the geology and mining potential of the Phoenix mine along Cave Creek (Ricketts, 1887). A more detailed analysis of the general geology and mining potential of the area was performed by Lewis (1920). The regional geologic map of Maricopa County by Wilson and others (1957) includes the Cave Creek-Humboldt Mountain area. Study of Proterozoic rocks and structures in the region has concentrated in the northern Phoenix, New River, New River Mountains, and Bradshaw Mountains areas (Maynard, 1986, 1989; Reynolds and DeWitt, 1991; Bryant, 1994; DeWitt, unpublished mapping; Reynolds, unpublished mapping). Anderson (1989a) presented a simplified map of the Proterozoic geology of the Cave Creek-Humboldt Mountain area, as well as briefly summarizing the Proterozoic stratigraphy of the area. Anderson (1989b) summarized the Early Proterozoic geology of the region, including rocks of the New River Mesa area. Other geologic studies have emphasized the Tertiary rocks and structures (Gomez, 1978; Gomez and Elston, 1978; Jagiello, 1987; Leighty and others, 1995; Leighty and Reynolds, 1996; Leighty, 1997). Scarborough and Wilt (1979) described the uranium potential of the Tertiary sedimentary deposits of the region; these deposits are considered to be a potential radon hazard (Duncan and Spencer, 1993; Harris, 1997). Geologic mapping of adjacent quadrangles includes Cave Creek (Leighty and others, 1997), Wildcat Hill (Skotnicki and others, 1997), Humboldt Mountain (Gilbert and others, 1998), and Daisy Mountain (Leighty, 1998). Pearthree and Demsey (1996) prepared a map of Quaternary deposits in the southern part of the map area.

PHYSIOGRAPHIC AND GEOLOGIC SETTING

The New River Mesa Quadrangle is located along the southern boundary of the Transition Zone, just north of the Basin and Range province in central Arizona. The quadrangle lies southeast of the rugged New River Mountains and north of the alluvial basins of the Basin and Range. In general, the terrain of the Transition Zone consists of rugged mountains primarily composed of Proterozoic metamorphic and igneous rock with minor erosional remnants of Paleozoic sedimentary rocks, overlain by Tertiary volcanic and sedimentary rocks.

A diverse suite of geologic units, ranging in age from Proterozoic to Cenozoic, is exposed in the area. Moderately rugged exposures of Early Proterozoic plutonic, metavolcanic, and metasedimentary rocks form the basement for a largely flat-lying sequence of Tertiary volcanic and sedimentary strata. The most prominent landforms in the quadrangle, New River Mesa and Skull Mesa (4000 to 4600 feet elevation), are composed largely of interbedded Early and Middle Miocene basaltic rocks, fluvial-lacustrine sedimentary rocks, and minor nonwelded tuffs that probably once covered most of the region. The major drainage in the area is Cave Creek, which flows southward toward the lowlands of the nearby Basin and Range. In the northwestern part of the quadrangle, the New River flows to the southwest and provides drainage for much of the New River Mesa area.

PROTEROZOIC GEOLOGY

Regional summary

The New River Mesa area contains a diverse assemblage of Proterozoic rock types that lie near the contact between two regional tectonic provinces of central Arizona; the 1710-1692 Ma Mazatzal province to the south and east and the 1800-1755 Ma Yavapai province to the northwest (Karlstrom and others, 1987). In general, the Proterozoic succession in New River Mesa area is characterized by a predominantly mafic to intermediate volcanic-plutonic complex overlain by graywacke turbidites and fine-grained siliciclastic rocks. These rocks have been correlated with the Tonto Basin Supergroup in the Mazatzal Province, which consists of mafic to intermediate volcanic rocks (Union Hills Group), felsic volcanic rocks (Red Rock Group), and metasedimentary rocks (Alder and Union Hills Groups) intruded by several large granitic batholiths (Anderson and Guilbert, 1979; Karlstrom and others, 1987; Maynard, 1986; 1989; Anderson, 1989b; Conway and Silver, 1989). In general, the Proterozoic units within the Mazatzal Block are less intensely deformed than in adjacent areas to the northwest and southeast (Anderson, 1989b; Karlstrom and others, 1987).

If Proterozoic strata of the New River Mesa area are correlative to the Tonto Basin Supergroup, then only the lower two thirds of the sequence is preserved. The rocks are similar enough to those of the Yavapai province just to the north (Anderson, 1989a) to not exclude this correlation as a possibility, especially since none of the igneous rocks in the area have been dated by radiometric techniques. In particular, the absence of the thick felsic volcanics (Red Rock Group) and Mazatzal quartzites which make up the upper part of Tonto Basin Supergroup make correlation with Yavapai stratigraphy a distinct possibility.

Numerous workers have described the Proterozoic stratigraphic succession of central Arizona, resulting in a confusing collection of rock unit and stratigraphic names (eg. Anderson, 1989b; Conway and Silver, 1989; and Karlstrom and others, 1987). This report will not attempt to resolve nomenclature problems, and as much as possible will identify rock units solely on the basis of lithologic criteria. Likewise, this report will not attempt to interpret the structural geology of the area in terms of the regional structural models that have been proposed (eg. Anderson, 1989a; Karlstrom and others, 1987).

Supracrustal Rocks

The Early Proterozoic sequence of supracrustal rocks in the New River Mesa Quadrangle consist of subaqueous rhyolitic to basaltic volcanic rocks interbedded to varying degrees with argillaceous sandstone, conglomerate, chert, minor limestone and abundant mudstone. The sedimentary rocks are interpreted as a marine turbidite sequence, and there is abundant evidence of subaqueous deposition of the volcanic rocks in the form of pillow lavas, pillow breccias and hyaloclastites. Although the degree of tectonic fabric development varies considerably from place to place, the metamorphic grade is consistently within lower greenschist facies, and in many areas primary volcanic and sedimentary structures are well preserved. In the areas of intense fabric development, however it is very difficult to assign outcrops to lithologic units. Significant mesoscopic porphyroblastic mineral growth is restricted to the contact metamorphic aureoles associated with younger plutonic rocks.

Structurally, the supracrustal succession is folded around a major northeast-plunging upright anticline so that two essentially uninterrupted fold limbs preserve a northwest-facing section to the north and a southeast-facing section to the southeast. The hinge area of the fold is almost completely buried by Tertiary rocks. The overall geology of the area and stratigraphy of each sequence is illustrated in Figures 1,2, and 3.

Majic volcanics

Mafic volcanic rocks are the most abundant type in the New River Mesa map area. These rocks are recognized throughout the supracrustal succession, interbedded with felsic lavas towards the bottom and interbedded with argillaceous turbidite higher in the section. Two main types of sequences are recognized based on the presence or absence of abundant pyroxene phenocrysts; mafic-intermediate (Xma), and mafic (Xm). The mafic-intermediate (Xma) package is characterized by abundant plagioclase phenocrysts, whereas the mafic assemblage (Xm) contains abundant, large (0.5 to 2 cm) pyroxene phenocrysts. Both types display abundant evidence of subaqueous textures, such as pillows, pillow breccia, hyaloclastites, and interbedding with turbiditic volcaniclastic sandstones. A distinctive, crystal-rich andesitic ash-flow tuff unit (Xa) containing abundant lithic fragments and fiamme is present near the base of the supracrustal succession.

Felsic Volcanic rocks

Several map units of rhyolitic to intermediate composition volcanic rocks are present in the lower part of the volcanic succession. Felsic volcanic rocks are characteristically absent from the upper part (Figure 2). The felsic volcanic units consist of a crystal-poor rhyolitic lava (Xfv) and associated volcaniclastic and pyroclastic rocks (Xfs) that are interbedded with mafic volcanic rocks in the central and southern parts of the map area, and a moderately crystal-rich rhyodacitic lava (Xfx) that is found in isolated outcrops in the west-central part.

Sedimentary rocks

The sedimentary component to the supracrustal sequence is dominated by mudstone with thin sandstone or siltstone beds and laminae (Xs). A package of granodiorite boulder conglomerate interbedded with mudstones and thin-bedded sandstone (Xcg) is present near the bottom of the succession in the northeast part of the map area. Everywhere else, the sedimentary rocks are mud-rich with maximum grain-sizes in the granule to pebble range. The sedimentology of these rocks is characterized by the lack of bed-scale bedforms, and the rocks can be easily described in terms of the classic Bouma (1962) turbidite sequence. Massive or graded beds in the sandstones are ubiquitous, corresponding to the Bouma (1962) "a" and "b" divisions. Cross-beds are present only as ripple cross-laminae or cm-scale climbing ripples in thin isolated beds, or as thin capping sequences to the medium-bedded massive or graded beds. These units are typical of the Bouma (1962) "c" division. Many of the thin silty beds or laminae within the mudstones could be characterized as Bouma (1962) "d" division fallout sequences. The thick mudstones which dominate the succession are interpreted as pelagic and hemipelagic sediment or Bouma's (1962) "e" division of the turbidite sequence.

Vastly subordinate to the siliciclastic turbidite rocks of the supracrustal section are sequences of thin-bedded and rarely medium or thick-bedded light gray to red chert beds. Based on their facies association directly overlying thick volcanic sequences, the chert sequences (Xsc), and (Xe) are interpreted to by largely volcanogenic or exhalative in origin. In some areas, tabular, chert-clast intraformational conglomerates are present suggestive of disruption of hard-grounds and deposition on a submarine slope (eg. Cook and Taylor, 1977).

Rare, massive gray limestones (Xl) which appear to have been ooid packstones are present in the northern part of the map area. These beds are interpreted as Bouma "a" division turbidites. Their presence suggests that there was a nearby carbonate platform or bank.

Upward transitions from mafic volcanics to turbidites occur several times in the stratigraphic succession. the transitions are fairly rapid and characterized by intervals of green argillite (Xm), ribbon chert and mudstone (Xsc) and locally, thick individual chert beds (Xe). This facies association is present only once in the southeast limb, but at least three times in the northwest limb. It is not known which one, if any, of the northwestern chert sequences correlates with the only chert sequence of the southeast limb. It is possible that the thick turbidite sequence of the southeast limb correlates as a whole with the entire interbedded turbidite and volcanic succession of the northwest limb (Figure 2).

Plutonic rocks

Several relatively small bodies of granitoids and a series of hypabyssal concordant igneous bodies intrude the supracrustal section. The largest expanse of plutonic rock is to the northwest where the New River Mountains granite (Xgn) and a pair of dioritic stocks (YXd, YXdf) intrude the northwest edge of the supracrustal succession. A couple of discordant granitoids are present in the south; an idiomorphic granular granite at Continental Mountain (Xgc), and a fine-grained quartz monzonite along lower Cave Creek that is associated with a set of northeast-striking, fine-grained granitic dikes. These discordant bodies are probably related to the approximately 1700 Ma Verde River granite.

The mafic volcanic succession is invaded by a suite of thin, concordant, crystal-poor rhyolite sills (Xfi), the most prominent being a rib along the volcanic-turbidite contact near Bronco Butte that is informally referred to as the Chinese Wall. Although it is possible that these thin intrusive bodies are dikes emplaced after the supracrustal section was folded and tilted, the interpretation that they were emplaced as sills soon after the cessation of volcanism is favored because the bodies are locally folded and kinked along with the country rock. There is also a good analog in the Eocene of New Mexico (Atkinson, 1961) for the development of concordant, very thin and continuous sills of crystal-poor rhyolite in a hypabyssal volcanic environment.

Three other groups of granitic bodies are present within the supracrustal succession of the northern fold limb; a tabular-shaped stock of K-feldspar porphyritic quartz monzonite with abundant xenoliths of local country rocks at Grays Gulch (Xgg), a series of quartz porphyry sills farther north (Xqp), and a dacite porphyry in the northeast (Xd). The quartz monzonite (Xgg) and quartz porphyry (Xqp) form tabular bodies concordant with bedding, whereas the dacite porphyry (Xd) appears to more irregular in form.

Proterozoic structure

As mentioned in the stratigraphy section, the principal structure in the map area is a major, northeast plunging anticline (Sheet 2, cross-section A-A'). This structure is associated with a prominent axial planar cleavage or schistosity (S_1). The intensity of the fabric varies considerably over short distances, from very strong and obliterating all evidence of primary structures to very weak, but is generally weak to moderate. Rarely, a post-metamorphic, mm- to cm-scale spaced crenulation cleavage (S_2) is developed in the pelitic rocks, and in one area there is evidence of an older, north-vergent folding event. An intersection lineation (L_1) of bedding and the prominent cleavage (S_1) consistently trends NE-SW. In general, the lineation plunges moderately towards the northeast. A younger crenulation lineation (Li) is produced by the intersection of the S_1 and S_2 cleavages.

In the north limb of the major anticline, cleavage transects northwest-facing bedding and northeast-plunging z folds in a manner expected for axial planar cleavage in the upright limb of a fold. To the south, however, where the southeast-facing limb is overturned, there are many instances where the prominent cleavage is oriented at an angle greater than bedding, indicating that the cleavage is not related to the megascopic fold formation.

In the southeast corner of the map area, a major overturned to the southeast syncline is present in the turbidite sequence (Sheet 2, cross-section B-B'). This fold is part of series of folds in the turbidites that continue to the southeast into Humboldt Mountain Quadrangle (Gilbert and others, 1998). The major syncline is disrupted and intruded from below by a small granite stock at Continental Mountain. The prominent cleavage in this area is also strongly crenulated and disrupted by abundant quartz veins that contain fibers oriented normal to the crenulation hinge lines. These structures are tentatively interpreted as evidence for continued deformation and stretching parallel to the prominent cleavage plane in response to top-to-the southeast shearing in the overturned limb between the turbidites of Continental Mountain and the older volcanics to the northwest. This fold limb probably merges into a southeast-vergent thrust to the south in the Cave Creek Quadrangle where a southeast-facing homocline composed of black pelitic turbidites at Black Mountain is in contact with presumably older volcanics to the northwest. The intervening northwest-facing fold limb is interpreted to be faulted out in this area.

Along the south-face of Continental Mountain, in the upright, gently northwest-dipping southeastern limb of the aforementioned overturned syncline, a mesoscopic north-vergent fold pair is preserved that is transected by the prominent, northwest-dipping slaty cleavage that is probably axial planar to the megascopic fold structure. The mesoscopic fold is cut by a very weak, southeast-dipping axial planar cleavage, and the structure is interpreted as evidence of an older, north-vergent folding and/or shearing event.

TERTIARY GEOLOGY

Prevolcanic conglomerate

The oldest Tertiary sedimentary rock unit in the New River Mesa Quadrangle is a nonvolcaniclastic conglomerate (Tc), with subrounded and highly non-spherical clasts derived from the nearby Proterozoic rocks. Clasts of the mafic volcanic (Xm) and argillite (Xs) units are abundant and their tabular shapes accentuate pebble imbrication structures in the conglomerate. Imbrication paleocurrent data (Sheet 1) indicate that this unit was deposited by a north-flowing fluvial system. In addition, presence of abundant boulders and cobbles of the Middle Proterozoic K-feldspar porphyritic granite which is only present to the south support a northerly paleoflow for this unit.

The prevolcanic conglomerate is probably correlative with the extensive Middle Tertiary pre-volcanic fluvial units of central and southern Arizona (Eberly and Stanley, 1978; Scarborough and Wilt, 1979) such as in the eastern Gila Bend Mountains (Gilbert, 1991), the Whitetail Conglomerate (Pederson, 1969), the Bloody Basin Fanglomerate of Elston (1984), and the Cave Creek Fanglomerate (Gomez, 1979, Jagiello, 1987; and Leighty, 1997). The unit unconformably overlies the Proterozoic basement rocks, unconformably underlies all other Mid-Tertiary volcanic or sedimentary rocks, and represents the oldest post-Laramide rock unit in the Transition Zone (Gomez, 1979, Elston, 1984; Jagiello, 1987; Leighty, 1997).

Volcanics

Latite

The oldest volcanic rocks in the map area are latite lavas and lava breccias, and locally hypabyssal rocks (Tl) in the southwest corner that are probably related to a late Oligocene to Early Miocene (26.5-17.7 Ma) potassic, trachyandesite, latite, and andesite eruptive event throughout central Arizona (Krieger, 1965; McKee and Anderson, 1971; Tyner, 1979, 1984; Esperan9a, 1984; Esperan9a and Holloway, 1986; Jagiello, 1987; Esperan9a and others, 1988; Leighty, 1997). The alkaline felsic rocks of this map area are typically porphyritic with various combinations of clinopyroxene, biotite, and hornblende phenocrysts in a densely microcrystalline groundmass. Glomerocrysts of these minerals are common and xenoliths of badly altered wall rock are found locally. No mantle-derived nodules have been observed in these rocks, although crustal xenoliths are locally abundant (e.g., the Camp Creek latite). The lavas were initially described as andesites and latites (Gomez, 1978; Jagiello, 1987), but generally span a range of alkaline compositions from trachyandesite (latite and benmoreite) to trachyte (Leighty, 1997).

The latite unit of this map area had at least three vent areas. Extensive lava breccias interpreted as parts of vent facies occur just northeast of Elephant Mountain and just to the southeast of Sugarloaf Mt. A third area of dikes and hypabyssal bodies occurs to the east of Cave Creek at the southwest corner of Skull Mesa.

Chalk Canyon Fonnation

Overlying the latite lavas in the southwest and prevolcanic conglomerate or Proterozoic crystalline rocks throughout the rest of the map area is a package of basaltic lava (Tb), pumiceous sandstone and volcaniclastic conglomerate (Tvs) and thin, non-welded felsic tuffs (Tt) that ranges in thickness from 100 to 500 meters. The unit was named informally by Gomez (1978) for exposures in Chalk Canyon of this map area along the west slope of Skull Mesa. In general, the unit thickens to the south. The basalts are typically porphyritic olivine ± clinopyroxene lavas that commonly contain modal biotite, and have alkaline compositions. The lavas are also generally poorly preserved, commonly with abundant calcite veins and calcite-filled amygdules presumably because they are interbedded with abundant fluvial and lacustrine sandstones.

Regionally, the Chalk Canyon Formation represents a sequence of Early Miocene alkaline basalts, fluvial-lacustrine sediments, and felsic tuffs exposed across the Basin and Range and southern Transition Zone. Lithologic sequences within the Chalk Canyon Formation are distinctive (Leighty, 1997) and have been recognized at locations across the region (e.g., eastern Lake Pleasant, north Phoenix, New River, Black Canyon City, Cave Creek, etc.). An unconformity within the formation allows it to be subdivided locally into lower and upper members (Gomez, 1978; Bryant, 1994; Leighty, 1997). The unit was not divided in this map area, and its contact with Hickey Formation basalts is defined simply as the top of the uppermost occurrence of the Tvs (volcaniclastic sedimentary rocks) unit.

South of Sugarloaf Mt. near the base of Chalk Canyon Formation, basalts have yielded K-Ar whole rock dates of 21.3 ± 0.5 Ma (Scarborough and Wilt, 1979) and 23.3 ± 2.7 Ma (Shafiqullah and others, 1980). A high-precision, single crystal, laser-fusion, sanidine $^{40}Ar/^{39}Ar$ date of 20.98 ± 0.06 Ma (McIntosh and Ferguson, in preparation) was obtained from a pumice-rich non-welded ash-fall tuff at the base of the Chalk Canyon Formation (about 3 meters above the unconformity with Proterozoic rocks) in the northern part of the map area where the unit is relatively thin. Another sanidine $^{40}Ar/^{39}Ar$ date of a pumice-rich non-welded tuff at the base of the much thicker section south of Sugarloaf Mt is in progress, and should indicate whether or not the unit has the same age at its base to the north. This date in progress is also important because the tuff layer underlies or is equivalent in age to a volcaniclastic sandstone or nonwelded tuff that contains an oreodont fossil (Lindsay and Lundin, 1972; Leighty, 1997) which has been reported as the oldest mammal fossil in Arizona.

The thin tuffs and pumice clasts in the volcaniclastic rocks of Chalk Canyon Formation change composition upwards from high-silica, sanidine and quartz-bearing phenocryst assemblages to more dacitic, plagioclase and biotite-bearing assemblages. Some of the dacitic tuffs are welded (Tdt) and in the easterly adjacent Humboldt Mountain Quadrangle(Gilbert and others, 1998) these welded tuffs can be traced to a dacite lava dome that is preserved in the middle of the Chalk Canyon Formation. Other dacite lava domes occur to the west of the study area (Leighty, 1998) which are probable sources for the welded dacite tuffs (Tdt) near Elephant Mountain, and a small dacite plug and lava breccia (Td, Tdb) along the southern edge of this quadrangle may also be correlative with the dacitic tuffs within Chalk Canyon Formation. Unfortunately, attempts to date the uppermost tuffs with the highly-precise and very accurate sanidine $^{40}Ar/^{39}Ar$ technique have proved unsuccessful because these tuffs do not contain sanidine crystals. Dating of biotite or plagioclase crystal is possible, but the lack of accuracy and problems calibrating dates with these minerals with those from sanidine crystals would make interpretation of the results equivocal.

The top of the Chalk Canyon Formation has been dated as young as 15.4 Ma (Doorn and Pewe, 1991, no error data available) based on a whole-rock K-Ar date of a basalt that overlies a sequence of lacustrine, thin-bedded mudstone, fine-grained sandstone, siliceous to dolomitic limestone and marl, and minor tuff near Lone Mountain in the southerly adjacent Cave Creek Quadrangle (Leighty and others, 1997). However, the utility of this age is questionable in terms of dating the sequence in the New River Mesa map area, because there is no indication of the quality of the geochronology data and because the lacustrine lithofacies described at Lone Mountain may not be time correlative to those in New River Mesa map area.

Hickey Formation

Basaltic volcanism during the Middle Miocene was widespread across the Basin and Range and Transition Zone and is represented by dominantly subalkaline lavas of the Hickey Formation and correlative rocks (Anderson and Creasey, 1958; McKee and Anderson, 1971; Eberly and Stanley, 1978; Gomez, 1978; Elston, 1984; Jagiello, 1987; Leighty and Glascock, 1994; Leighty, 1997). In the New River Mesa Quadrangle, a series of cliff-forming early Middle Miocene (14.8 $\pm$ 0.8 Ma, 14.7 $\pm$ 0.4 Ma, Scarborough and Wilt, 1979) Hickey Formation basaltic flows cap Skull Mesa and New River Mesa, and probably extended aGross most of the area with a very slight regional dip to the south. These lavas have been referred to as the New River Mesa basalt (Gomez, 1978; Jagiello, 1987), but almost certainly represent the southern Transition Zone equivalent of the Hickey Formation (Leighty, 1997). The tilted basalt overlying the Chalk Canyon Formation section north of Carefree at Lone Mountain has been dated at 13.4 ± 0.4 Ma (Doorn and Pewe, 1991). Basaltic rocks of similar age (15.4 ± 0.4 Ma, Scarborough and Wilt, 1979), petrography, and geochemistry are exposed atop several fault-block remnants (e.g., Shaw Butte, Deem Hills, Hedgpeth Hills, Carefree Highway range) in the Basin and Range of northern Phoenix (Scarborough and Wilt, 1979; Jagiello, 1987; Leighty, 1997).

In the Skull Mesa and New River Mesa areas, as many as 8-10 flow units are present in the sequence that has a maximum exposed thickness that ranges from 200 to 500 feet. These subalkaline lavas are basaltic andesites having characteristic intergranular textures, with. clinopyroxene and altered olivine phenocrysts within a framework of plagioclase crystals (Leighty, 1997). A paleosol (2-5 meters thick) typically separates the Hickey Formation lavas from the underlying Chalk Canyon Formation; thin sediment and soil horizons also separate individual Hickey Formation flow units. Columnar jointing and zones of vesicles trains are common in outcrop. These lavas are distinctively different in outcrop color (grayish brown) compared to the underlying Chalk Canyon Formation alkaline flows (typically dark gray to bluish gray).

Tertiary Structure

East-west oriented extension

The most prominent Tertiary normal fault in the region is a north-striking, east-side-down, structure that parallels the south-flowing segment of Cave Creek and has between 60 and 300 meters of displacement (Sheet 1). Block rotation related to this fault and a series of others to the east are responsible for the regional, gentle (5°-15°) westerly dips of the Miocene strata that prevail throughout most of the map area. The main fault of this generation (with about 800 meters of east-side-down displacement) lies about 10 km to the east of the map area along the western edge of the Verde Valley (Gilbert and others, 1998; Wrucke and Conway, 1987). Just to the east of the map area, another zone of east-side-down normal faulting is expressed near the mouth of Rackensack Canyon as an east-side down fault with over 100 meters of displacement that cuts and is buried by volcaniclastic conglomerate that probably correlates with the younger conglomerates of this map area (Tcy). These north-striking faults probably correlate with the Late Miocene east-west extension of the Basin and Range disturbance discussed by Leighty and Reynolds (1996).

Northeast-southwest oriented extension

South-dipping faults

Two major west to northwest-striking, south-side-down normal faults are present along the southern edge of the map area (Sheet 1). These structures form the southern edge of the Transition Zone physiographic province, and extension resulting from these faults may be related to one or more tectonic phases, including waning metamorphic core complex extension, block faulting of the Basin and Range disturbance, or an even younger extensional event (Menges and Pearthree, 1989; Leighty and Reynolds, 1996; Leighty, 1997).

The northern fault of this style in the map area (herein named Continental Mountain fault) is relatively well exposed along the south flank of Continental Mountain. Based on the apparent right-lateral offset of steeply west-dipping Proterozoic contacts across the fault, Leighty and others (1997) and Skotnicki and others (1997) interpreted it as north-side-down and north-dipping. We found no evidence of northerly dips, and interpreted it as south-side-down because the basal Tertiary unconformity occurs in its hangingwall (south side) and only Early Proterozoic rocks are found to the north. We suggest that the apparent right-lateral offset is due to a dextral, strike-slip component of motion. The unconformity in its hangingwall is overlain by nonvolcaniclastic conglomerate (Tc) containing clasts of the Early Proterozoic argillite unit (Xs), mafic volcanics (Xma), and of a distinctive Middle Proterozoic, K-feldspar porphyritic granite which could only have come from the south or southeast Gust like other exposures of the nonvolcaniclastic conglomerate farther south). The same conglomerate unit was mapped as younger, volcaniclastic conglomerate in the southerly adjacent Cave Creek Quadrangle(Leighty and others, 1997) correlative to the Tcy unit of this report, and the fault at Continental Mountain interpreted as a north-side-down structure by Leighty and others (1997) and Skotnicki and others (1997). However, the presence of pre-volcanic conglomerate to the south of the fault argues for south-side-down offset of at least 250 meters. To the west, the fault appears to die out, but westerly continuation of south-side-down offset may transfer to a zone of apparent south-side-down faulting (buried by even the oldest Tertiary volcanics if it exists and not shown on Sheet 1) that strikes east-west through the saddle north of Elephant Mountain.

The southernmost fault of this type and the most significant in the map area is located in the extreme southwestern corner. It is entirely covered by post-faulting sedimentary rocks, and its location in the subsurface is constrained from geometrical relationships and well-log data in the Carefree area (Doorn and Pewe, 1991; Leighty and others, 1997). This buried structure is related to the Carefree fault system, located in the Wildcat Hill Quadrangle to the east (Pearthree and Scarborough, 1984; Skotnicki and others, 1997) and Cave Creek Quadrangle to the south (Leighty and others, 1997). Tilted Hickey Formation sheet lavas (14.8-13.4 Ma) to the south of the fault constrain the earliest timing of faulting to the late Middle Miocene.

Other major southwest-dipping normal faults are present in the basins south of the New River Mesa Quadrangle. Regionally, movement along this suite of faults involved fault-block rotation in the north Phoenix are, a style of faulting more akin to core-complex rotational faulting than classic "Basin and Range" style block-faulting. Movement on these normal faults occurred after 13.4 Ma and produced depositional basins that filled with large quantities of elastic sediments of Late Miocene to Pliocene(?) age. Thus, the south- to southwest-dipping faults were coeval with the 13-$<$10 Ma Basin and Range disturbance and probably post-dated a cryptic northeast-dipping faulting episode.

North-dipping faults

Although structures along the southern edge of the Transition Zone are dominated by south-side-down faults, there is also evidence of a slightly older phase of northeast-side-down faulting in the form of southwesterly tilting at Lone Mountain in the southerly adjacent Cave Creek Quadrangle(Leighty and others, 1997; Leighty, 1998). In the southwest corner of the New River Mesa Quadrangle this southerly tilting can be observed where the gently northwest-dipping (5°) Tertiary strata of New River Mesa changes gradually to a slightly south-dipping orientation at Black Mesa, and eventually to greater southerly dips (~ 15°) at Elephant Mountain.

Similar relationships are evident to the south in the Cave Creek Quadrangle (e.g., Lone Mountain) where the southwest-dipping Tertiary rocks are cut by several west- to northwest-striking secondary faults having relatively small northeast-side-down displacements (Leighty and others, 1997). These relatively small faults at Lone Mountain were probably related to a larger, northeast-dipping, somewhat listric normal fault (the Lone Mountain fault) that is buried beneath younger sedimentary cover along the northeastern margin of the Carefree Basin. The Lone Mountain fault may have had as much as 1000 to 1400 meters of northeast-side-down displacement (Leighty and others, 1997).

The north- to northeast-dipping fault responsible for lrotation of the New River Mesa-Elephant Mountain Tertiary sequence in the New River Mesa Quadrangle is probably the western projection of the Lone Mountain fault, but since the fault is buried and apparently cut by the Carefree fault its trace is not shown on the map (Sheet 1). As in the Cave Creek Quadrangle, this fault is buried by Late Miocene basin-fill and younger surficial deposits. It may project beneath the high mesas of the southern Transition Zone, and its orientation synthetic to the northeast-dipping South Mountain-White Tank detachment fault system suggests that it might be associated with metamorphic core complex development in the nearby Basin and Range (Leighty and others, 1997). However, since the fault is related to the tectonic rotation of 13.4 Ma basalts, its association with core-complex development (with approximately 19 Ma biotite cooling ages [Reynolds and others, 1986]) is questionable.

The northeast-dipping Lone Mountain fault might also be related to another style of breakaway faulting in which the rotation of the fault block is not related to a through-going listric master fault. The Lone Mountain fault may simply terminate against the south-dipping Continental Mt fault in a style similar to the breakaway faults described within the Superstition Cauldron (Skotnicki and Ferguson, 1995) and along the western margin of Rio Grande Rift of New Mexico within the Mt. Withington Cauldron (Ferguson, 1991). In both instances, this style of breakaway faulting occurs along the "anticlinal" boundary between a flat-lying stable block and a relatively steeply tilted domain. The two different structural interpretations for Continental Mountain fault are depicted in Figure 4.

GEOLOGIC HAZARDS

A variety of potential geologic hazards exist in the study area. The primary geologic hazards that may affect this area are flooding, debris flows, and rockfalls. Radon, a radioactive gas that is a decay product of uranium, may also be a potential hazard in areas that include the deposits of the Chalk Canyon Formation. The general character of these hazards and the areas that may be affected by them are summarized below.

Flooding

Flooding is a serious geologic hazard in the New River Mesa Quadrangle. Potential flood hazards consist of inundation and erosion along Cave Creek and its larger tributaries, and flash-flooding associated with the smaller tributary streams that flow across the piedmonts of the area. Cave Creek is a moderately large drainage that heads in the Transition Zone north of the New River Mesa Quadrangle. Its drainage area is about 80 mi^2

at the northern edge of the quadrangle and about 130 mi^2 at the southwestern edge of the quadrangle. Thus, it is capable of generating large floods. The flood with a 1 percent chance of being exceeded annually (the 100-year flood) has been estimated at about 23,000 cubic feet per second (cfs) to 36,000 cfs (Kenny, 1986). Such large floods involve deep, high-velocity flow in channels, inundation of overbank areas, and may cause substantial bank erosion along the channels.

Flood hazards associated with smaller tributaries may be subdivided into (1) localized flooding along well-defined drainages, where there is substantial topographic confinement of the wash; and (2) widespread inundation in areas of minimal topographic confinement (i.e., active alluvial fans). Delineation of flood-prone areas along well-defined drainages is fairly straightforward, and avoiding building in or immediately adjacent to washes may mitigate these hazards. Floods leave behind physical evidence of their occurrence in the form of deposits. Therefore, the extent of young deposits on piedmonts is an accurate indicator of areas that have been flooded in the past few thousand years. These are the areas that are most likely to experience flooding in the future. Following this logic, the extent of potentially flood-prone areas on a piedmont may be evaluated based on the extent of young deposits (Qa).

Rockfalls and Debris Flows

Rockfalls, small landslides, and debris flows are potential hazards on and immediately adjacent to steep slopes. The mass movement of material on steep slopes is typically triggered by intense or prolonged periods of precipitation (Christenson and others, 1978). Debris flows are viscous slurries of sediment and water that can transport large boulders substantial distances downslope. In southern and central Arizona, nearly all of the documented historical debris flows have been restricted to mountain slopes and valleys. Rockfalls and landslides are potential hazards below bedrock cliffs and where bedrock outcrops exist at or near the top of steep mountain hillslopes. The existence of large boulders near the base of a steep slope should be considered evidence of potential rockfall hazard in most cases.

Potential rockfall hazards in the New River Mesa Quadrangle are greatest on or near the slopes of the steep mesa escarpments and bedrock hills and low mountains formed on various metamorphic rocks. Debris flows may be a hazard along the steep upper reaches of the streams that drain the mountainous portions of the quadrangle. Mass movements on hillslopes or within steep stream valleys typically generate debris flows. Larger debris flows in some environments may continue downslope out of the mountains and impact piedmont areas. In this environment, however, it is more likely that debris flows will impact only hillslopes and channels within steep-walled mountain valleys.

Radon

Uranium is present in all geologic materials, generally in concentrations of 1 to 10 parts per million (ppm). When a uranium atom undergoes radioactive decay it begins a long string of decays through a series of isotopes that make up the uranium decay series.

Radioactive decay ends at stable lead-206. Radon, a colorless, odorless gas, is a member of the uranium decay series. Radon produced in the ground as part of the uranium decay series can escape into overlying homes and other buildings, and can result in elevated radiation exposure, and associated risk of cancer to human lungs. Areas with higher uranium concentrations present greater risk of elevated indoor radon levels (Spencer, 1992). Chalk Canyon Formation pumiceous sedimentary rocks in the New River Mesa area may be a significant potential radon hazard. This is because silicic volcanic rocks contain relatively high concentrations of Uranium, and this element is commonly concentrated to even higher degrees in associated sedimentary rocks. Similar rocks in the northern part of the Cave Creek Quadrangle contain anomalous uranium levels (50 ppm; Duncan and Spencer, 1993; Harris, 1997).

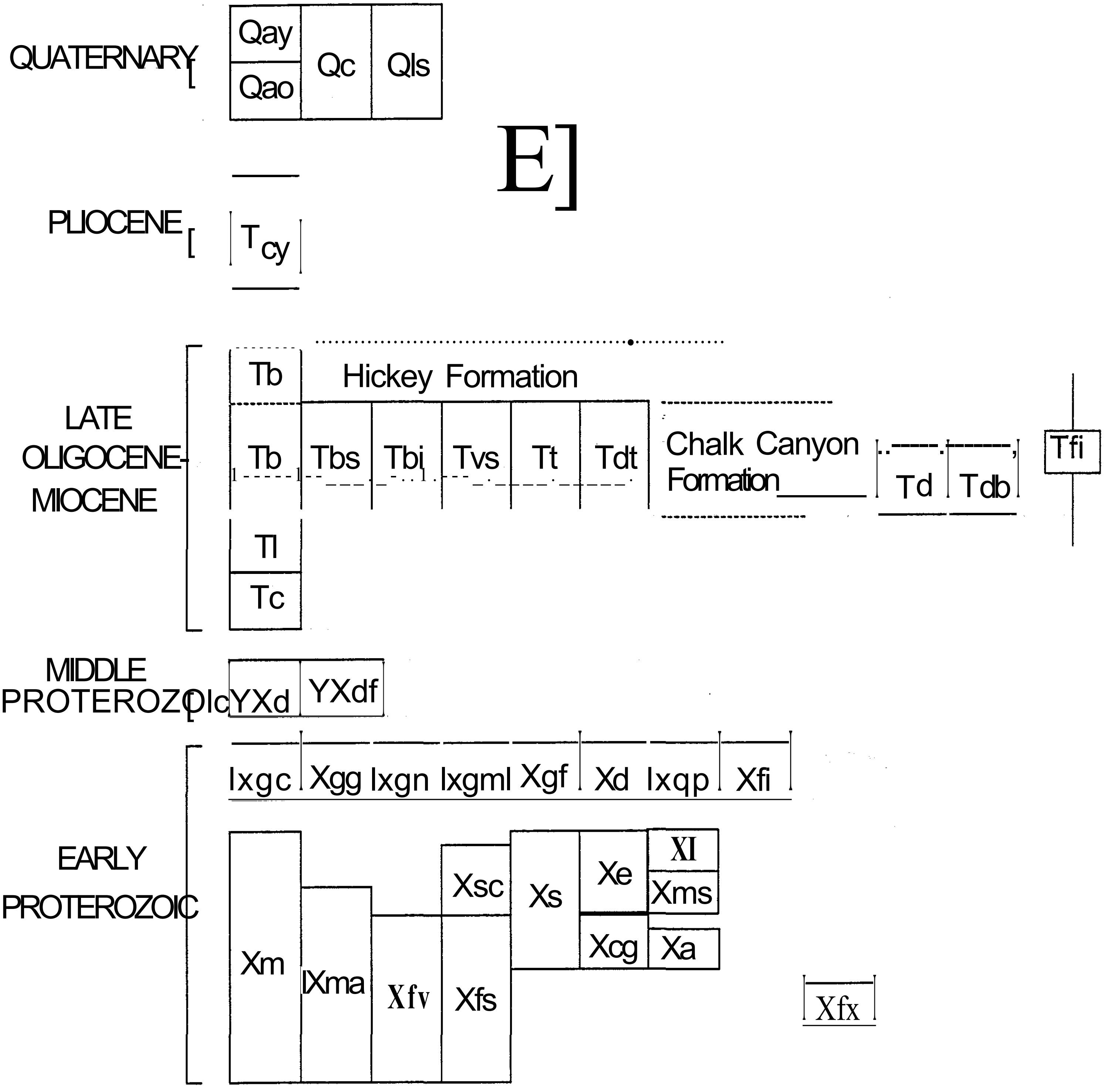

Figure 1 Correlation diagram for map units of the New River Mesa 7.5' quadrangle.

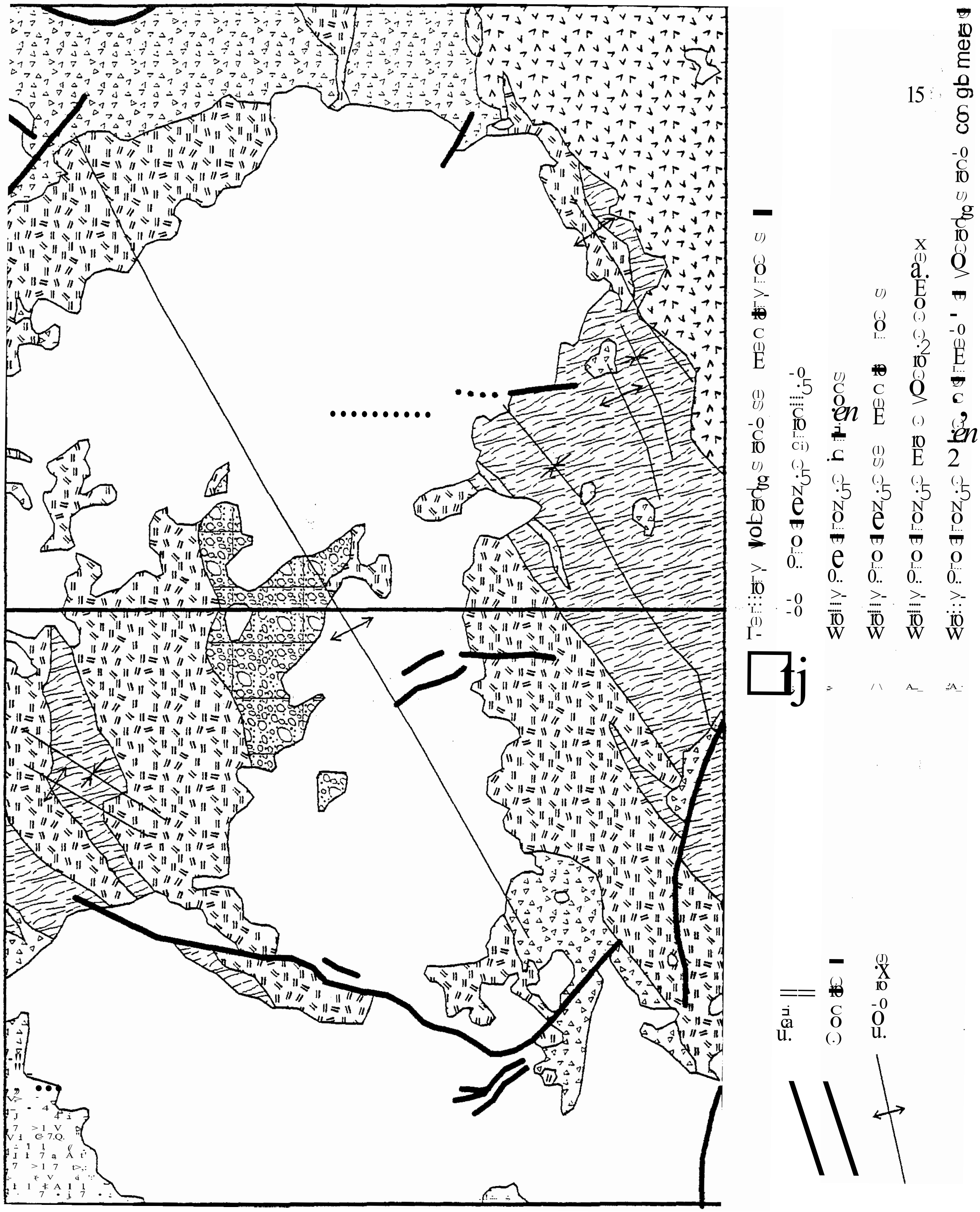

Figure 2 Generalized geology of the New River Mesa (left) and Humboldt Mountain (right) 7.5' quadrangles.

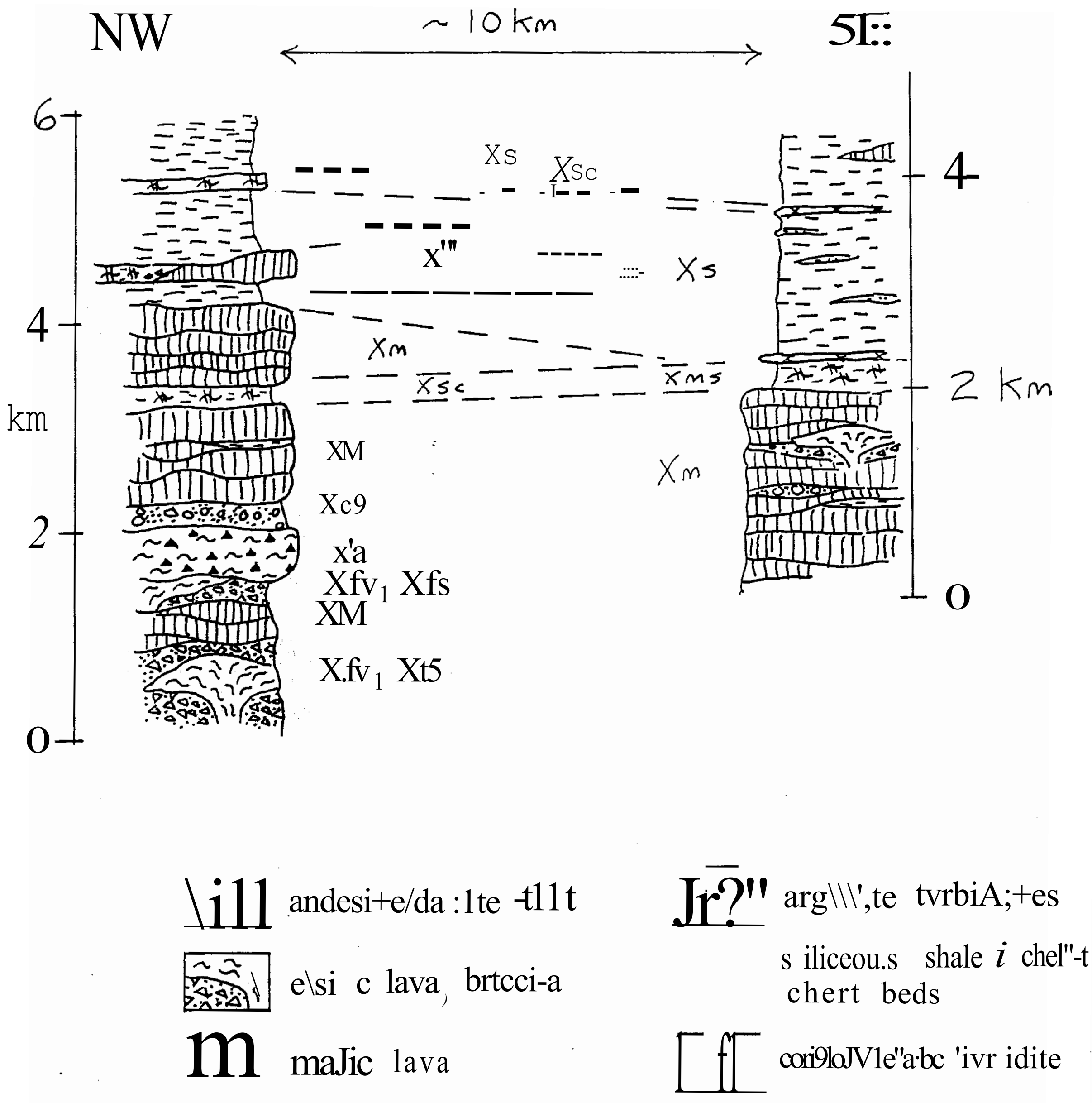

Figure 3 Stratigraphic correlation diagram for Early Proterozoic supracrustal rocks exposed on the northwest (NW) and southeast (SE) limbs of the major anticline which transects the Humboldt Mountain and New River Mesa quadrangles. Unit symbols correspond to units described in the unit descriptions section and on the geologic map (Sheet 1).

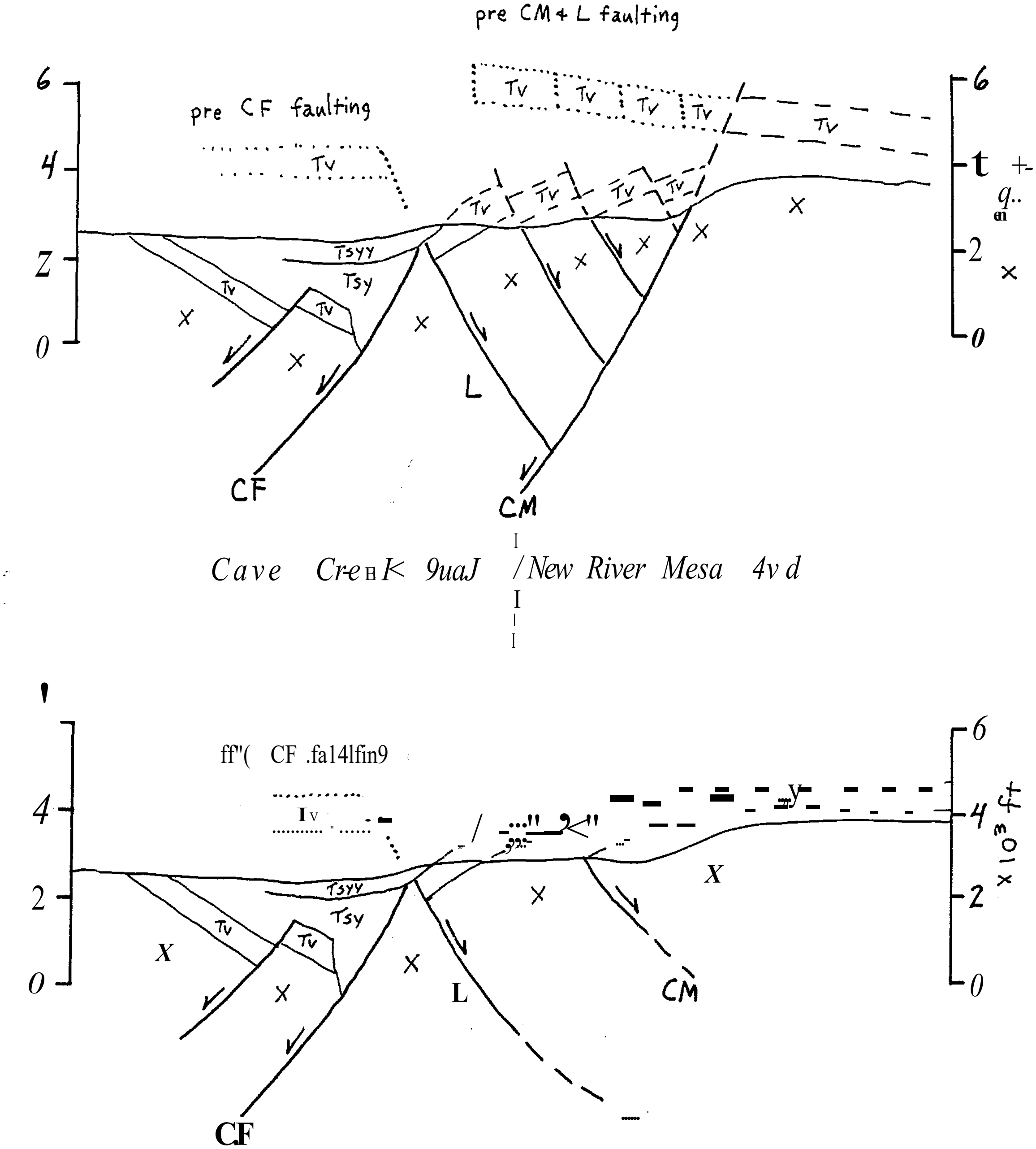

Figure 4 Generalized· structural cross-sections showing two possible interpretations for the evolution of the Basin and Range - Transition Zone boundary fault zone along the southern edge of the New River Mesa quadrangle. Cross-sections are oriented with north-northeast to the right and the quadrangle boundary lying in the middle of each section. Dashed lines indicate eroded geological relationships. Dotted lines indicate pre-deformational configurations of the Tertiary volcanic sequence and location of important faults. Top cross-section shows Continental Mountain fault as south-side-down structure (this report) and low.er cross-section shows it as a north-dipping fault synthetic with the Lone Mountain fault. Both sections show Carefree fault as youngest structure. Tsyy = youngest younger conglomerate, Tsy = younger conglomerate, Tv = Tertiary volcanics, X=Proterozoic undifferentiated, CF = Carefree fault, CM = Continental Mountain fault, and L=Lone Mountain fault.

REFERENCES

Anderson, Phillip, 1989a, Stratigraphic framework, volcanic-plutonic evolution, and vertical deformation of the Proterozoic volcanic belts of central Arizona, in Jenney, J.P., and Reynolds, S.J., eds., Geologic evolution of Arizona: Arizona Geological Society Digest 17, p. 57-147.

Anderson, Phillip, 1989b, Proterozoic plate tectonic evolution of Arizona, in Jenney, J.P., and Reynolds, S.J., eds., Geologic evolution of Arizona: Arizona Geological Society Digest 17, p. 17-55.

Anderson, C.A., and Creasey, S.C., 1958, Geology and ore deposits of the Jerome area, Yavapai County, Arizona: U.S. Geological Survey Professional Paper 308, 185 p., 9 sheets, scale 1:24,000.

Anderson, P., and Guilbert, J.M., 1979, The Precambrian massive-sulfide deposits of Arizona, a distinct metallogenic epoch and province, *in* Ridge, J.D., ed., Papers on mineral deposits of western North America (IAGOD Fifth Quadrennial Symposium Proceedings, V. 2): Nevada Bureau of Mines and Geology Report 33, p. 39-48.

Atkinson, W. W., 1961 Geology of the San Pedro Mountains, Santa Fe County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 77, 50 pp.

Bryant, B., 1994, Preliminary geologic map of the New River quadrangle, Maricopa and Yavapai Counties, Arizona: U. S. Geological Survey Open-File Report 94-153, scale 1:24,000.

Bouma, A. H., 1962, Sedimentology of some flysch deposits: Elsevier, Amsterdam, 168 pp.

Christenson, G. E., Welsch, D. G., and Pewe, T. L., 1978, Geology, McDowell Mountains area, Maricopa County, Arizona, *in* Christenson, G. E., Welsch, D. G., and Pewe, T. L. (eds.), Environmental Geology of the McDowell Mountains area, Maricopa County, Arizona: Arizona Bureau of Geology and Mineral Technology Geologic Investigation Series Map GI-1-A, 1 sheet, 1:24,000 scale.

Conway, C.M., and Silver, L.T., 1989, Early Proterozoic rocks (1710-1615 Ma) in central to southeastern Arizona, *in* Jenney, J.P., and Reynolds, S.J., eds., Geologic evolution of Arizona: Arizona Geological Society Digest 17, p. 165-186.

Conway, C.M., and Wrucke, C.T., 1986, Proterozoic geology of the Sierra Ancha-Tonto Basin-Mazatzal Mountains area, road log and field trip guide, *in* Beatty, B., and Wilkinson, P.A.K., eds., Frontiers in geology and ore deposits of Arizona and the Southwest: Arizona Geological Society Digest, v. 16, p. 227-247.

Cook, H. E., and Taylor, M. E., 1977, Comparison of Continental slope and shelf environments in the Upper Cambrian and lowest Devonian of Nevada, *in,* Cook, H. E., and Enos, P. (eds.), Deep-water carbonate environments: Society of Economic Paleontologists and Mineralogists Special Publication 25, p. 51-82.

Doorn, P.L., and Pewe, T.L., 1991, Geologic and gravimetric investigations of the Carefree Basin, Maricopa County, Arizona: Arizona Geological Survey Special Paper 8, 187 p., 10 plates, scale 1:24,000.

Duncan, J.T., and Spencer, J.E., 1993, A survey of uranium concentrations in rocks and soils in populated areas of Arizona: Methods, *in* Spencer, J.E., ed., Radon in Arizona: Arizona Geological Survey Bulletin 199, p. 93-96.

Eberly, L.D., and Stanley, T.B., Jr., 1978, Cenozoic stratigraphy and geologic history of southwestern Arizona: Geological Society of America Bulletin, v. 89, no. 6, p. 921-940.

Elston, D.P., 1984, Rocks, landforms, and landscape development in central Arizona, *in* Smiley, T.L., Nations, D.J., Pewe, T.L., and Schafer, J.P., eds., Landscapes of Arizona: the geological story: Lanham, Maryland, University Press of America, Inc., p. 151-173.

Esperanc;a, S., 1984, An experimental and geochemical study of the high-K latites and associated nodules from Camp Creek, Arizona: Tempe, Arizona State University, unpublished Ph.D. dissertation, 204 p.

Esperanc;a, S., and Holloway, J.R., 1986, The origin of the high-K latites from Camp Creek, Arizona; constraints from experiments with variable fO_2 and aH_2O: Contributions to Mineralogy and Petrology, v. 93, p. 504-512.

Esperanc;a, S., Carlson, R.W., and Shirey, S.B., 1988, Lower crustal evolution under central Arizona; Sr, Nd and Pb isotopic and geochemical evidence from the mafic xenoliths of Ramp Creek: Earth and Planetary Science Letters, 90, p. 26-40.

Ferguson, C. A., 1991, Stratigraphic and structural studies in the Mt. Withington Cauldron, Grassy Lookout quadrangle, Socorro County, New Mexico: New Mexico Geology, v. 13, p. *50-54.*

Gilbert, W. G., 1991, Bedrock geology of the eastern Gila Bend Mountains, Maricopa County, Arizona: Arizona Geological Survey Open-file Report 91-5, 13 pp., 1:24,000 sheet.

Gilbert, W. G., Ferguson, C. A., and Leighty, R. S., 1998, Geology of the Humboldt Mountain 7.5' quadrangle, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 98-11, 17 pp., 3 sheets, 1:24,000 scale.

Gomez, E., 1978, Geology of the south-central part of the New River Mesa quadrangle, Cave Creek area, Maricopa County, Arizona: Flagstaff, Northern Arizona University, unpublished M. S. thesis, 144 p.

Gomez, E., 1979, Geology of the south-central part of the New River Mesa Quadrangle, Cave Creek area, Maricopa County, Arizona: U.S. Geological Survey Open-File Report 79-1312, 144 p., 1 sheet, scale 1:12,000.

Gomez, E., and Elston, D.P., 1978, Oligocene and Miocene development of the mountain-desert region boundary, Cave Creek, Arizona [abs.] : Geological Society of America Abstracts with Programs, v. 10. no. 3, p. 107.

Harris, R.C., 1997, Uranium distribution in the Cave Creek-Carefree area, central Arizona: Arizona Geological Survey Open-File Report 97-6, 11 p., scale 1: 100,000.

Jagiello, K.J., 1987, Structural evolution of the Phoenix Basin, Arizona: Tempe, Arizona State University, unpublished M.S. thesis, 156 p., scale 1:24,000.

Karlstrom, K.E., Bowring, S.A., and Conway, C.M., 1987, Tectonic significance of an Early Proterozoic two-province boundary in central Arizona: Geological Society of America Bulletin, v. 99, no. 4, p. 529-538.

Kenny R., 1986, Reconnaissance environmental geology of the Tonto Foothills, Scottsdale, Arizona: Tempe, Arizona State University, unpublished M. S. thesis, 158 pp., 1:24,000 scale map.

Krieger, M.H., 1965, Geology of the Prescott and Paulden quadrangles: U.S. Geological Survey Professional Paper 467, 127 p., 5 sheets, scales 1:48,000 and 1:96,000.

Lewis, A.S., 1920, Ore deposits of the Cave Creek district in Arizona: Engineering and Mining Journal, v. 110, p. 713-716.

Leighty, R. S. , 1997, Evolution of tectonism and magmatism across the Basin and Range-Colorado Plateau boundary, central Arizona: Tempe, Arizona State University, unpublished Ph.D. dissertation, 1019 p.

Leighty, R. S., 1998, Tertiary volcanism, sedimentation, and tectonics of the central Arizona Transition Zone, *in* Duebendorfer, E. M., (ed.), Geologic Excursions in northern and central Arizona: Northern Arizona University Press, p. 59-96.

Leighty, R.S., and Glascock, M.D., 1994, A Middle Miocene Magmatic Transition in central Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 26, no. 7, p. A354.

Leighty, R.S. and Reynolds, S.J., 1996, Dynamics of Neogene faulting across the Colorado Plateau-Basin and Range boundary in central Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 28, no. 7, p. A451.

Leighty, R.S., Skotnicki, S.J., and Pearthree, P.A., 1997a, Geologic map of the Cave Creek quadrangle, Maricopa County, Arizona

Lindsay, E.H., and Lundin, R.F., 1972, An Oligocene oreodont *(Mammalia artiodaciylia)* from central Arizona: Journal of Paleontology, v. 46, p.115-119.

Maynard, S.R., 1986, Precambrian geology and mineralization of the southwestern part of the New River Mountains, Maricopa and Yavapai Counties, Arizona: Albuquerque, University of New Mexico, M.S. thesis, 155 p.

Maynard, S.R., 1989, Geologic map and cross-sections of the southwestern part of the New River Mountains, Arizona: Arizona Geological Survey Contributed Map CM-89-E, 2 sheets, scale 1: 12,000.

McKee, E.H., and Anderson, C.A., 1971, Age and chemistry of Tertiary volcanic rocks in north-central Arizona and relation of the rocks to the Colorado Plateaus: Geological Society of America Bulletin, v. 82, no. 10, p. 2767-2782.

Menges, C.M., and Pearthree, P.A., 1989, Late Cenozoic tectonism and landscape evolution in Arizona, *in* Jenney, J., and Reynolds, S.J., eds., Geologic Evolution of Arizona: Arizona Geological Society Digest 17, p. 649-680.

Pearthree, P. A., and Scarborough, R. B., 1984, Reconnaissance analysis of possible Quaternary faulting in central Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 85-4, 27 pp.

Pearthree, P.A., and Demsey, K.A., 1996, Surficial geologic map of the southern parts of the New River Mesa and Humboldt Mountain quadrangles, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 96-26, 13 p., 1 sheet, scale 1:24,000.

Pedersen, E.P., 1969, Sedimentology and stratigraphy of basin-fill sediments of the Payson Basin, Gila County, Arizona: Tempe, Arizona State University, M.S. thesis, 136 p., 1 sheet, scale 1:32,000.

Reynolds, S. J., Safiqullah, M., Damon, P. E., and DeWitt, E., 1986, Early Miocene mylonitization and detachment faulting, South Mountains, central Arizona: Geology, v. 14, p. 283-286.

Reynolds, S.J., and DeWitt, E., 1991, Proterozoic geology of the Phoenix region, central Arizona, in Karlstrom, K.E., ed., Proterozoic geology and ore deposits of Arizona: Arizona Geological Society Digest 19, p. 237-250.

Ricketts, P.P., 1887, Phoenix mine, Arizona: Engineering and Mining Journal, v. 43, p. 309.

Scarborough, R.B., and Wilt, J.C., 1979, A study of the uranium favorability of Cenozoic sedimentary rocks, Basin and Range Province, Arizona; Part 1, General geology and chronology of pre-late-Miocene Cenozoic sedimentary rocks: Arizona Bureau of Geology and Mineral Technology Open-File Report 79-1, 101 p.

Shafiqullah, M., Damon, P. E., Lynch, D. J., Reynolds, S. J., Rehrig, W. A., and Raymond, R. H., 1980, K-Ar geochronology and geologic history of southwestern Arizona and adjacent areas, *in* Jenney, J.P., Stone, C., (eds.), Studies in western Arizona: Arizona Geological Society Digest 12, p. 201-242.

Skotnicki, S. J., and Ferguson, C. A., 1995 Geologic map of the Goldfield and northern portion of the Superstition Mountains SW 7.5' quadrangles, Pinal County, Arizona: Arizona Geological Survey Open-File Report 95-9, scale 1:24,000.

Skotnicki, S.J., Leighty, R.S., and Pearthree, P.A., 1997, Geologic Map of the Wildcat Hill Quadrangle, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 97-2, 17 p., scale 1:24,000.

Spencer, J. E., 1992, Radon gas: A geologic hazard in Arizona: Arizona Geological Survey, Down-to-Earth Series, no. 2, 17 p.

Tyner, G. N., 1979, Field geology, petrology and trace element geochemistry of the Sullivan Buttes latite, Yavapai County, Arizona, Arizona: unpublished M.S. thesis, University of Texas, Austin, 136 pp.

Tyner, G. N., 1984, Geology and petrogenesis of the Sullivan Buttes latite, Yavapai County, Arizona, Arizona: Field and geochemical evidence: unpublished Ph.D. dissertation, University of Texas, Austin, 248 pp.

Wilson, E.D., Moore, R.T., and Peirce, H.W., 1957, Geologic map of Maricopa County, Arizona: Arizona Bureau of Mines, 1 sheet, scale 1:375,000 (now available as Arizona Geological Survey Map M-3-5).

Wrucke, C.T., and Conway, C.M., 1987, Geologic map of the Mazatzal Wilderness and contiguous roadless area, Gila, Maricopa, and Yavapai counties, Arizona: U.S. Geological Survey Open-File Report 87-0664, 22 p., 1 sheet, scale 1:48,000.

Unit Descriptions
New River Mesa 7.5 ' Quadrangle
Maricopa County, Arizona

Quaternary

Qay **Younger alluvium:** Unconsolidated alluvial sediment along active channels and fans. May locally include some low-lying, sparsely vegetated terraces.

Qao **Older alluvium:** Unconsolidated alluvial sediment along relatively high-standing, heavily vegetated terraces.

Qls **Landslides and mass movement deposits:** Large areas along lower Cave Creek Canyon of extremely coarse-grained, boulder to sandy matrix diamictite consisting of blocks up to *50* meters of volcaniclastic sandstone, nonwelded tuff and basalt lava. Deposit is interpreted as a mixture of landslides and slumps derived from the slopes of New River and Skull mesas.

Qc **Talus and colluvial slope deposits:** Unvegetated talus deposits and soil covered slope deposits found chiefly along the steeper slopes of New River Mesa and Skull Mesas.

QTs **Conglomerate:** Partially indurated, locally derived conglomerate found along the southern slopes of the New River Mountains in the extreme northwest corner of the map area.

Tertiary

Tcy **Younger conglomerate:** Sandy conglomerate and pebbly sandstone composed of a mixture of Proterozoic and Tertiary clasts. The unit is found only along the southwestern corner of the map area, and it is considered equivalent to Carefree Formation (Dorn and Pewe, 1991) of the southerly adjacent Cave Creek quadrangle (Leighty and Skotnicki, 1997), and possibly equivalent with the Younger Conglomerate (Tcyu, Tcyl) unit of the easterly adjacent Humboldt Mountain quadrangle (Gilbert and others, 1998).

Tdt **Dacitic tuff (Chalk Canyon Formation):** Welded to nonwelded predominately air-fall tuffs, typically thin- to medium-bedded. Phenocrysts of plagioclase and biotite $\pm$ quartz make up 10-15 % of the tuffs which occur as one and locally two units interleaved with basalt flows south of Quien Sabe Peak, and also as a single unit along the north slope of Elephant Mountain. The eastern tuffs were probably derived from a single plug near the head of Rackensack Canyon in the easterly adjacent Humboldt Mountain quadrangle (Gilbert and others, 1998). The western tuffs were probably dervied from nearby dacite plugs either along the southern margin of the map area or plugs to the southwest (Leighty, 1998). These tuffs are part of the Chalk Canyon Formation (Gomez, 1978).

Tvs **Volcaniclastic sandstone, conglomerate, mudstone, and marl (Chalk Canyon Formation):** Thin to medium-bedded pumiceous and basaltic volcaniclastic sandstone with minor amounts of conglomerate, mudstone, and marl, and nonwelded tuff. The unit is intimately interleaved with the basalt lava (Tb) unit, and is locally gradational with the nonwelded tuff (Tt) map unit. Nonwelded tuffs are ubiquitous, comprising up to 10 % of the unit, but are too thin to map separately. The conglomerates contain mostly Tertiary basalt, but also Proterozoic crystalline clasts. Mudstones and marls occur chiefly in the southwest, high in the Tertiary section along Elephant Mountain and Black Mesa. Locally, the finer grained sediments are heavily bioturbated with vertical and horizontal cm-scale burrows and root casts. These sedimentary rocks are part of an interbedded sequence of tuffs, sandstones and basaltic lavas which make up the Chalk Canyon Formation (Gomez, 1978).

Tt **Nonwelded tuff (Chalk Canyon Formation):** Thin to medium-bedded air fall tuff, ash-flow tuff and rare surge deposits, locally interbedded with subordinate volcaniclastic rocks. The tuffs are generally light-colored and crystal-poor. In general the older tuffs are sanidine and quartz bearing, whereas the youger tuffs are more dacitic in composition, containing only plagioclase and biotite phenocrysts. The tuffs are part of an interbedded sequence of tuffs, sandstones and basaltic lavas which make up the Chalk Canyon Formation (Gomez, 1978).

Td **Dacite lava (Chalk Canyon Formation?):** Intermediate composition (10-20% plagioclase and biotite phenocrysts) medium-gray dacitic lava.

Tdb **Dacite lava breccia (Chalk Canyon Formation?):** Autobreccia or vent breccia of the dacite lava (Td).

Tb **Basaltic lava (Chalk Canyon and Hickey formations):** A thick succession of basaltic lavas interleaved with volcaniclastic sedimentary rocks (Tvs), welded (Tdt), and nonwelded tuffs (Tt). The flows range in thickness from a few meters to over 50 meters, but average about 10 meters. The sequence is divided into two formations based petrologic differences and their association or lack of association with interbedded tuffaceous rocks. The lower unit's (Chalk Canyon Formation) basalts are interleaved with abundant tuffaceous rocks, whereas the upper unit (Hickey Formation) occurs as a single, unbroken, amalgamated sequence. Texturally, the Chalk Canyon Formation lavas are olivine and clinopyroxene porphyritic, with intergranular biotite in a generally fine-grained matrix. Matrix of the Hickey Formation lavas tend to be more interganular with coarser-grained plagioclase, finer-grained clinopyroxene and an overall more diktytaxitic texture. The Chalk Canyon basalts are largely alkaline to transitional in composition, whereas the Hickey Formation basalts are subalkaline (olivine subalkali basalt and basaltic andesite).

Tbs **Basaltic lava scoria (Chalk Canyon Formation):** Bedded scoria associated with Chalk Canyon Formation basalt lava flows. The scoria deposits have sharp contacts with adjacent, subjacent and superadjacent lavas and gradational contacts with laterally adjacent nonwelded tuff (Tt) and volcaniclastic sedimentary rocks (Tvs). The scoria deposits are interpreted as part of cinder cones around vents, located on Sheet 1.

Thi **Intrusive basalt:** Dikes of basaltic lava feeding lava flows of the Chalk Canyon Formation.

Tfi **Felsic intrusive rocks:** Undifferentiated felsic composition igneous dikes.

Tl **Hornblende latite or andesite lava:** Hornblende porphyritic, light to dark gray latite or andesite lava, locally including lava breccia and minor hypabyssal rocks.

Tc **Nonvolcaniclastic conglomerate and sandstone:** Pebble-cobble to boulder conglomerate and pebbly sandstone containing clasts of Proterozoic granitoid and metamorphic rocks exclusively. Generally thick-bedded but also medium-bedded. The conglomerates are chiefly clast-supported, and locally display well-developed clast imbrication. The unit consists almost exclusively of conglomerate in the south, while pebbly sandstones are more abundant to the north.

MIDDLE PROTEROZOIC

YXd **Medium-grained, equigranular diorite:** Crumbly weathering, biotite-rich dioritic granitiod.

YXdf **Fine-grained diorite:** A finer grained variety of the diorite (YXd) map unit.

EARLY PROTEROZOIC

Xgc **Granitoid of Continental Mountain (Verde River Granite?):** Leucocratic, pink-weathering, medium-grained, equigranular to slightly K-spar porphyritic quartz monzonite. This pluton is completely post-kinematic with respect to the host rocks in the area, but it is considered Early Proterozoic because of its similarity to the Verde Valley granites of the easterly adjacent Humboldt Mt. quadrangle (Gilbert and others, 1998), and other granitoids of this map area (Grays Gulch) which are clearly concordant with respect to bedding.

Xgg **Granitoid of Grays Gulch:** K-spar porphyritic, pink weathering quartz monzonite to quartz monzosyenite with abundant xenoliths. This tabular pluton occurs in the north-central part of the map area. It is petrographically more similar to the granitiod of Continental Mountain than to the other nearby, tabular, concordant plutons (Xqp). Because of its concordant, sill-like nature, it is considered to be only slightly younger than its Early Proterozoic host rocks.

Xgn **Granitoid of New River Mountains:** Nonfoliated, medium to coarse-grained granite. Probably related to the New River felsic complex (1700Ma).

Xgm **Quartz Monzonite:** Nonfoliated, fine-grained quartz monzonite. Pluton occurs in the lower Cave Creek drainage basin.

Xgf **Fine-grained granitic dikes:** Dikes associated with the fine-grained quartz monzonite pluton (Xgd). The dikes cut both adjacent country rocks and the pluton.

Xqp **Quartz porphyry:** Dark-colored, nonfoliated, concordant sills of quartz porphyry. Porphyry contains phenocrysts of plagioclase and biotite, ?????

Xd **Dacite porphyry:** Pink- to lavender-weathering, lavender to medium gray dacite in northeast part of map area. Commonly porphyritic with coarse-grained phenocrysts of quartz and plagioclase (20-50 %) set in a fine-grained to aphanitic groundmass, but locally fine-grained.

Xfi **Crystal-poor rhyolite sills:** Light-colored, crystal-poor, locally flow-banded rhyolite sills. The sills occur as thin (less than 20 meters and typically less than 5 meters) concordant bodies within the mafic lava complex. The unit forms a prominent sill, currently oriented as if it were a vertical dike in the southeast corner of the map area along the contact between the turbidite (Xs) unit and the mafic lava complex (Xm). The dike-like feature in this area is locally referred to as the Chinese wall.

Xl **Limestone:** A thin band of massive gray limestone (probably a turbiditic packstone), along upper Grays Gulch in the north central part of the map area.

Xs **Argillite, siltite, and argillaceous sandstone:** Dark-colored (gray to greenish gray and purple) mudstone and siltstone interbedded with between 5 % and 25 % gray, fine- to medium-grained and rare granule sandstones. The sandstones are thin- to medium-bedded with argillaceous matrix and they commonly display classic Bouma sequence sedimentary structures. Massive, gradded beds are commmonly capped by parallel to ripple cross-laminated, fine-grained sandstone or siltstone. Flame structures, ball and pillow structures, and sharp erosive bases are common. Locally, mud-chip intraformational cobble-pebble conglomerate is present. The sand is generally quartzose with a few percent feldspar. Some of the granule sandstones are arkosic. The argillaceous strata commonly contain a few percent thin-bedded laminated or ripple cross-laminated siltstones. The unit is interbedded with both silceous (cherty) and calcareous intervals some of which were too thin or discontinuous to be mapped separately.

Xe **Chert:** Individual chert beds.

Xsc **Siliceous shale and chert:** Greenish gray argillite interbedded with thin- to medium-bedded chert (typically jasperoid), and tabular-clast, chert pebble to cobble argillite matrix conglomerates. Some of the argillites contain rusty brown weathering intervals suggestive of carbonate. Unit is strongly associated with the contact zones between the argillite (Xs) and mafic volcanic complex (Xm or Xma) units.

Xms **Green argillite** Dark green argillite, probably derived from fine-grained mafic tuffaceous or volcaniclastic rocks. Associated with the siliceous shale and chert (Xsc) unit and the mafic volcanic complex (Xm).

Xcg **Granitoid boulder to cobble conglomerate, argillaceous sandstone, and mudstone:** Conglomerate with distinctive, medium-grained, equigranular granodiorite clasts along with abundant mafic volcanic clasts. Conglomerates are interbedded with pebbly, granule sandstones and dark green mudstones similar to strata of the argillite (Xs) unit.

Xa **Andesite tuff and tuff breccia:** Massive, light gray- to brown-weathering porphyritic andesite with abundant plagioclase phenocrysts. The unit also contains abundant lithic fragments and possible pumice fragments and is interpreted as a subaqueous ash-flow tuff.

Xfv **Felsic lava and lava breccia:** Light gray- to light pink-weathering, crystal-poor (quartz and feldspar) felsite. Flow-banding and autoclastic primary textures are commonly preserved, indicating origin as lava flows.

Xfs **Felsic volcaniclastic and pyroclastic rocks:** Felsic to intermediate composition elastic rocks displaying a wide variety of textures, ranging from pyroclastic to volcaniclastic conglomerate. The more pyroclastic and volcaniclastic varieties contain mostly angular to subangular volcanic clasts, and abundant crystal clasts that could be phenocrysts. The unit also includes minor mudstone and rounded plutonic boulder-cobble clast conglomerate with variable amounts of volcanic detritus.

Xfx **Crystal-rich felsic to felsic intermediate volcanics:** Light pink to tan, feldspar- and quartz-phyric, porphyritic volcanic rock with approximately 30% phenocrysts. Occurs west of Black Mesa where its relationship to the other supracrustal rocks of the area could not be determined, however its position suggests that it lies near the bottom of the volcanic sequence.

Xma **Mafic (andesite-basalt) subaqueous lava complex:** Brown- to light green-weathering, medium to dark gray basaltic andesite or andesite that characteristically display coarse-grained plagioclase phenocrysts. Locally displays pillow structures and hyalocalstites. Differs from Xm in that Xma is generally lighter-colored and lacks pyroxene phenocrysts. Interbedded locally with tuffaceous, conglomeratic, and argillaceous turbidite sedimentary rocks.

Xm **Mafic (basalt-ultramafic) subaqueous lava complex:** Dark brown- to light green-weathering, dark green to black basalt and basaltic andesite. Commonly massive or composed of volcanic breccia. Locally displays pillow structures and hyaloclastites. The unit is rarely amygdaloidal, and locally porphyritic, with coarse-grained plagioclase or pyroxene phenocrysts. Generally displays greenschist-grade metamorphic recrystallization, and is locally interbedded with volcaniclastic sandstone and mudstone. May locally include intervals of Xma.