A Preliminary Study of Mesozoic Geology in the Southern Dome Rock Mountains, Southwestern Arizona

by

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Abstract

At least three distinct, mildly metamorphosed lithologic sequences crop out in the southern Dome Rock Mountains: a volcanic sequence, a volcaniclastic sequence, and a clastic sedimentary sequence. The sedimentary sequence, which is about 5,000 m thick, structurally overlies the volcanic and volcaniclastic sequences, which are themselves in fault contact. This sedimentary sequence records a change in the composition of source terranes through time. Its basal unit includes lithologies such as quartzite, maroon phyllite, calcareous quartz sandstone, and quartzite-clast conglomerate, whereas higher units include lithologies such as greywacke, gray phyllite, and polycomponent conglomerate. In the upper half of the sequence the conglomerate includes clasts of granitic composition. This sedimentary sequence is considered, on the basis of contact relations with dated rocks, to have been deposited sometime between mid-Jurassic and Late Cretaceous time and to be lithologically correlative with deposits that have been described in nearby ranges. Through much of the area studied, bedding and foliation planes are oriented at high angles to one another. The attitude of foliation is suggestive of regional deformation with a northwest-southeast direction for maximum shortening. Attitudes of kink folds, joints, lineations, and macroscopic intrafolial folds observed throughout the range also indicate northwest-southeast shortening.

Introduction

The Geologic Map of Arizona (Wilson, Moore, and Cooper, 1969) indicates that the southern Dome Rock Mountains are composed principally of Mesozoic sedimentary, metamorphic, and intrusive rocks (Fig. 1B). Little is known about these rocks or about rocks that have been mapped similarly elsewhere in Yuma County. This lack of description inhibits understanding of the Mesozoic tectonics of the southern North American Cordillera.

This paper reports on observations of these Mesozoic terranes made during a reconnaissance of the east flank of the Dome Rock Mountains. The traverse line ran from La Cholla Mountain (12 km southwest of the town of Quartzsite) to the boundary between the Dome Rock Mountains and the North Trigo Peaks (Fig. 1C). The purpose of this study is to characterize stratigraphic and structural elements of the terranes in the Dome Rock Mountains.

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Lithologies

Mesozoic Sedimentary Rocks

The most extensive terrane in the southern Dome Rock Mountains is labeled "Mesozoic sedimentary rocks" on the Geologic Map of Arizona (Fig. 1B). Eleven lithologies, all of which are clastic, were distinguished in the portion of this terrane traversed for this study. The field names given to these lithologies are presented, with descriptions, in Table 1. These rocks have been mildly metamorphosed (Crowl, 1979) as indicated by (1) formation of penetrative nonbedding-plane foliation, (2) transformation of shale into phyllite, (3) growth of secondary chlorite, and (4) recrystallization of quartz. The sequence of Mesozoic sedimentary rocks is characterized by repetitive interlayering of resistant coarser grained lithologies with nonresistant phyllites. Selective erosion of this sequence gives ridge crests a serrate appearance.

The sedimentary sequence, which is considered to be right side up (Crowl, 1979), is divided for the purpose of description into seven units (a through g). As there are no distinctive marker beds within the sedimentary

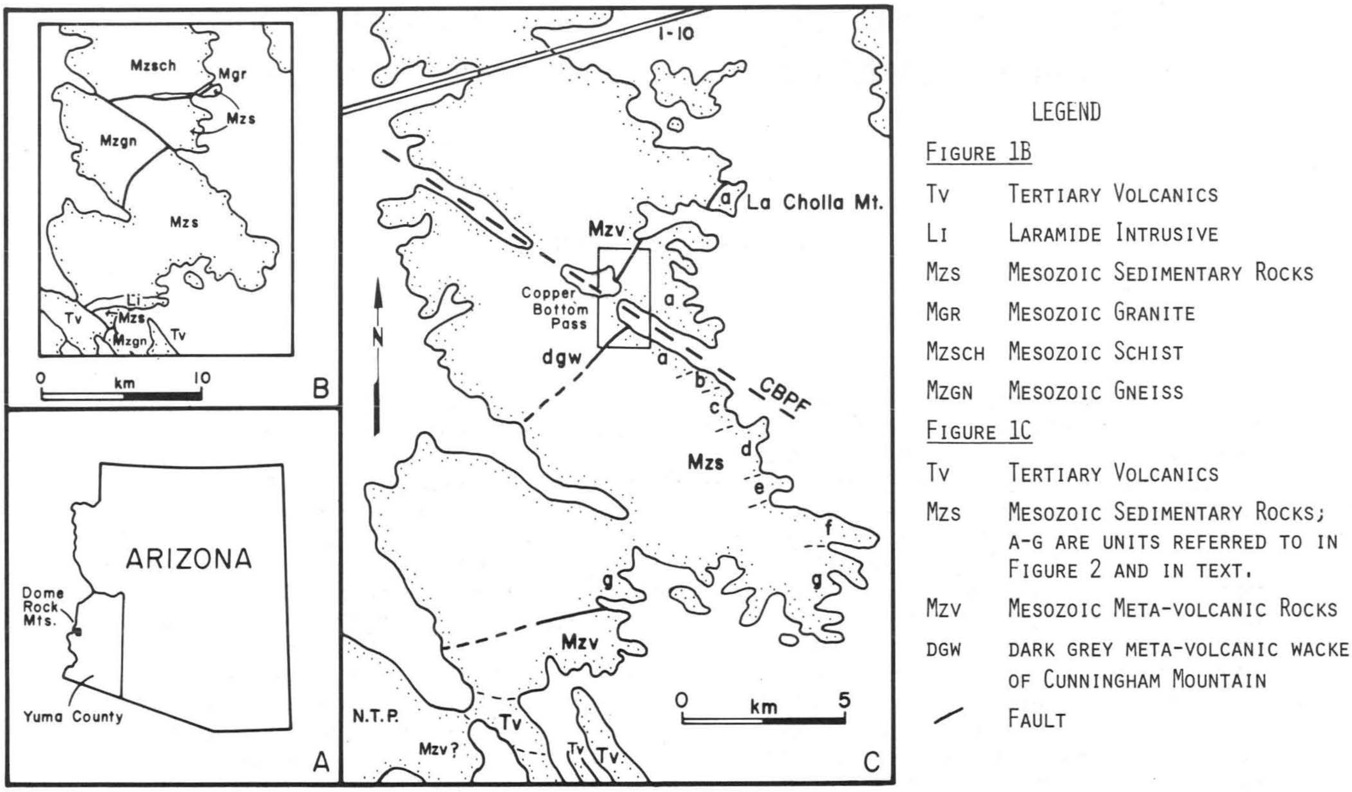

Fig. 1. (A) Location map showing the position of the Dome Rock Mountains in Yuma County, Arizona. (B) Generalized geologic map of the Dome Rock Mountains (south of Interstate Highway 10) according to Wilson, Moore, and Cooper (1969). (C) Generalized geologic map of the same portion of the Dome Rock Mountains following the present study. Boxed area is Figure 3. I-10 = Interstate Highway 10; N.T.P. = North Trigo Peaks; CPBF = Copper Bottom Pass fault.

sequence, the units are defined by their component group of lithologies. Figure 2 lists the lithologies that characterize each unit and shows the approximate thicknesses of the units. Descriptions of the lithologies listed in Figure 2 are presented in Table 1, and the ranges of individual lithologies within the sequence are indicated in Figure 3. The approximate locations of unit boundaries, as recognized on the ground, are portrayed on the map (units a-g, Figure 1C). In the interest of brevity, detailed descriptions of these units will not be presented here. Further description, accompanied by photographs and photomicrographs of component lithologies can be found in Marshak (1979). The thickness of the sequence, as estimated by measuring a traverse line perpendicular to bedding with accommodation for the dip of bedding, is 5,000 m. However, locally there is equivocal evidence for isoclinal folding and interbed shearing, which could have affected the original stratigraphic thickness (Crowl, 1979; Marshak, 1979).

There are two important lithologic transitions in the sedimentary section. These transitions are indicated by change in the proportion of feldspar found in coarser grained lithologies and by the composition of clasts in conglomerate layers (Fig. 3). The first transition is at the top of unit a, about 750 m above the base of the section. Unit a is composed of calcareous quartz sandstone, quartzite, maroon phyllite, and conglomerate (composed predominantly of quartzite cobbles and pebbles with minor limestone pebbles). By comparison, units b-e are composed in varying proportions of greywacke, granule conglomerate, maroon and gray phyllite, and complex (polycomponent) conglomerate. The conglomerate includes phyllite and volcanic(?) clasts as well as quartzite clasts. The rocks of units b-e are more feldspathic than those of unit a. The second transition is at the top of unit e, about 2,800 m from the base of the section. Units f and g include greywackes that appear to be more feldspathic than those of the underlying units. The conglomerates of units f and g contain abundant granitic pebbles and cobbles. A similar succession was recorded in the Mesozoic sedimentary rocks of the Livingston Hills (Harding, 1978).

UNIT G: Feldspathic greywacke (10) and igneous clast conglomerate (9), interbedded with siltstone-greywacke (11) and grey phyllite (6).

UNIT F: Igneous clast conglomerate (9) interbedded with feldspathic greywacke (10) and grey phyllite (6).

UNIT E: Grey phyllite (6) interbedded with complex conglomerate (5) and greywacke (7).

UNIT D: Grey phyllite (6) interbedded with complex conglomerate (5) and granule conglomerate (8).

UNIT C: Granule conglomerate (8) interbedded with maroon phyllite (3), grey phyllite (6), and greywacke (7).

UNIT B: Greywacke (7) interbedded with minor calcareous quartz sandstone (1), maroon phyllite (3), and complex conglomerate (5).

UNIT A: Lower half - calcareous quartz sandstone (1) and quartzite conglomerate (4), interbedded with maroon phyllite (3). Upper half - quartzite (2) interbedded with calcareous quartz sandstone (1) and maroon phyllite (3).

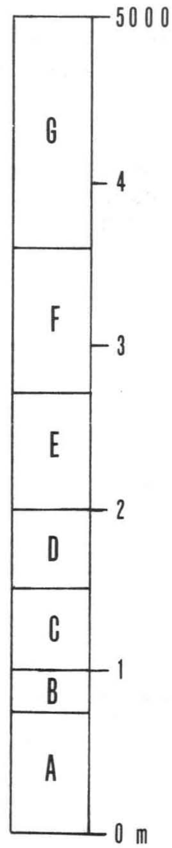

Fig. 2. The sedimentary section of the Dome Rock Mountains. Numbers refer to lithologies described in Table 1. Schematic column shows the relative thicknesses of the units.

Meta-volcanic and Meta-volcaniclastic Rocks

On the Geologic Map of Arizona by Wilson and others (1969) the Mesozoic sedimentary rocks of the Dome Rock Mountains are shown to be in contact with units labeled "Mesozoic Gneiss" and "Mesozoic Schist" (Fig. 1B). This study considers only those portions of these units that crop out immediately adjacent to the terrane of Mesozoic sedimentary rocks; for further discussion of these units, see Crowl (1979). The low metamorphic grade of these units allowed protoliths to be recognized. Crowl (1979) stated that these rocks display mineralogy characteristic of lower greenschist facies. These units were found to be composed of volcanic and volcaniclastic lithologies (Crowl, 1979; Marshak, 1979). The field names given to the lithologies (and used in the text below) are presented with descriptions in Table 2.

The distribution of lithologies in the Copper Bottom Pass area, as mapped in the present study, is shown in Figure 4. Unit Mzvt, north of the Copper Bottom Pass fault (an area labeled "Mesozoic Schist" on the Geologic Map of Arizona) is composed of well-stratified meta-crystalline tuff and volcanic agglomerate, interlayered locally with meta-andesite(?). Unit Mzvw is composed of light-tan meta-volcanic wacke in which, locally, are cobble-sized fragments of andesite or dacite porphyry. Unit dgw, south of the Copper Bottom Pass fault (an area labeled "Mesozoic Gneiss" on the Geologic Map of Arizona) is composed of dark-gray meta-volcanic wacke. This lithology can be distinguished from the wacke of unit Mzvw by its color and by the fact that it has a very uniform grain size and no large igneous cobbles. No volcanic flows were found within the mapped area of unit dgw, and the unit does not display stratification.

At the southern end of the Dome Rock Mountains (Fig. 1C), the Mesozoic sedimentary rocks contact a volcanic terrane (an area labeled "Mesozoic Gneiss" on the Geologic Map of Arizona) that is composed principally of meta-basalt, meta-andesite(?), and meta-crystalline tuff (see descriptions in Table 2). The meta-crystalline tuff was mapped on the Geologic Map of Arizona as "Laramide Intrusive." In contact with these volcanic rocks is a body of altered granite or granodiorite that is cut by thin aplite dikes. The extent of this body was not determined.

Table 1. Field lithologic names with descriptions for the section of Mesozoic sedimentary rocks

Name	Description
calcareous quartz sandstone (1)	light buff to green or maroon, weathering to dark brown or black (desert varnish); grains are fine to medium sand sized, moderately well sorted, angular with high sphericity, composed of quartz (60-90%), chert (20-30%), calcite (10-40%), feldspar (5-10%), clay (<10%), with accessory zircon, magnetite, epidote, and biotite (altered to chlorite); locally there are pebbles of pink quartzite; cement is calcite; calcite which constitutes up to 50% of the rock is partly detrital in origin; layers are 1-5 m thick, with bedding-plane partings at intervals of 0.1-1 m, foliation planes crosscut bedding planes, layers are continuous on a scale of 0.5 km but pinch and swell along strike; locally, dark, heavy minerals are concentrated in streaks, which may define large-scale cross-beds, resistant ledge former.
quartzite (2)	vitreous, maroon to green or gray, weathering to dark brown or black; grains are fine sand sized or not visible, vitreous, well sorted, angular, with ragged intergrown edges, composed of quartz (80-95%), chert (0-10%), feldspar (0-10%), with accessory magnetite and epidote and minor clay; layers are 2-10 m with bedding-plane partings at intervals of 0.1-1 m, layers are continous on the scale of 0.5 km, foliation planes crosscut bedding planes; resistant ledge former. Alternative name, quartz arenite.
maroon phyllite (3)	lustrous maroon, locally green or gray, weathering to similar color with good phyllitic luster; grains are fine silt sized or not visible, composed of clay (30-60%) and quartz (40-70%); widespread abundant 0.1-0.5 mm grains of pyrite or limonite after pyrite, locally pyrite crystals exceed 10 cm in length, locally, abundant elongate 1-2 cm long lenses of chlorite; layers are 1-4 m thick with bedding-plane partings at intervals of 1-10 cm, foliation planes crosscut bedding planes; nonresistant trough former.
quartzite conglomerate (4)	maroon to green or gray, weathers to dark brown or black; large clasts/matrix = 80/20; large clasts are pebble and small cobble sized, composed of pink quartzite (80-100%) and limestone (10-20%), matrix is medium- to coarse-grained sand sized, composed predominantly of quartz and chert; occurs as restricted lenses within lithologies 1 and 2, and as massive layers up to 30 m thick, foliation planes crosscut bedding planes; resistant ledge former.
complex conglomerate (5)	gray, weathering to dark brown; large clasts are composed of quartzite, greywacke(?), phyllite, and possibly volcanic rock; matrix composed of phyllite or greywacke; occurs as restricted lenses or as beds. Alternative name, polycomponent conglomerate.
gray phyllite (6)	light to dark gray, weathering to same color with good phyllitic luster; grains are fine silt sized or not visible, composed of clay, sericite, quartz, and carbonaceous material(?), possibly tuffaceous; layers 2-10 m., bedding-plane parting is very close, locally has pencil cleavage; very soft, erodes into shimmery troughs.
greywacke (7)	light bluish or greenish gray, weathering to black or brown (desert varnish), large grains/matrix = 70/30; large grains are medium sand sized (0.05-0.5 mm), poorly sorted, angular, composed of quartz (60-80%), chert (15-25%), feldspar (5-15%); matrix composed of sericite (70-90%), quartz (5-15%), chlorite, with accessory magnetite; layers are 0.5-5 m thick, bedding-plane partings more closely spaced; both resistant ledge former and nonresistant trough former; pebbly; lithology is highly variable; matrix in many samples is probably derived from feldspar and devitrified glass, and some matrix may actually be aphanitic lithic fragments, if so, greywacke field name is inappropriate, and a preferable name is tuffaceous litho-feldspathic quartz arenite.
granule conglomerate (8)	very light greenish gray to white, with phyllitic luster, weathering to light tan; grains/matrix = 80/20; grains are coarse sand to granule sized (0.5-3 mm), poorly sorted, angular to subangular, composed of quartz (50-70%), chert (10-20%), and phyllite (20-30%), embedded in a matrix of phyllite (sericite-clay?) and chert; matrix is possibly tuffaceous; cement is composed of silica and, locally, calcite;

Table 1. Field lithologic names, Mesozoic sedimentary rocks—*Continued*

Name	Description
	layers are 2-20 m thick with bedding--plane partings at 0.5-2 cm; foliation planes are not parallel to bedding, forms rubbly nonresistant outcrops; widely interbedded with phyllite.
igneous clast conglomerate (9)	dark greenish gray, weathering to dark brown or black (desert varnish); large clasts/matrix = 40/60, large clasts pebble to cobble sized, well rounded, composed of medium-grained quartz monzonite (feldspar 50%, quartz 40%, muscovite 4%, biotite 3%, chlorite 3%) (30-40%), quartzite (40-50%), sandstone or volcanic(?) (5-10%), phyllite (50-10%); matrix coarse sand sized, composition similar to lithology 9; layers are 2-10 m thick, bedding parting is poorly developed; moderately resistant ledge former.
feldspathic greywacke (10)	light greenish gray, weathering to dark brown or black (desert varnish); grains/matrix = 60/40; large grains are medium to very coarse sand sized (0.02-1 mm), poorly sorted, angular, composed of quartz (30-40%), chert (20-30%), feldspar (30-40%); matrix composed of sericite (80%), quartz (10%), chlorite (10%); possibly tuffaceous; layers are 0.5-2 m thick, bedding-plane partings more closely spaced; rubbly moderately resistant ledges.
siltstone greywacke (11)	dark grayish tan, weathering to black or brown (desert varnish); composed of silt-sized grains with aphanitic matrix; grains/matrix = 80/20; grains composed of quartz (50-70%), feldspar (30-50%); matrix composed of sericite (70%), chlorite (20%), and quartz (10%); possibly tuffaceous; beds 0.5-3 m, layers 1-3 m thick, bedding-plane parting is closely spaced; crops out as very tough resistant ledges.

Contact Relations

The northern contact between the Mesozoic sedimentary rocks and the meta-volcanic and meta-volcaniclastic terranes is here considered to be a sheared unconformity (henceforth called the Cunningham Mountain fault; abbreviated CMF on Figure 4). The location of this contact is slightly different from that indicated for the contact between the sedimentary rocks and the "Mesozoic Schist" on the Geologic Map of Arizona, as demonstrated by comparison of Figures 1B and 1C. The Cunningham Mountain fault juxtaposes rocks of quite contrasting appearances and generally occurs in topographic shelves or saddles (Fig. 5). It is marked widely by a 1-5 m-thick band of mylonite schist. This mylonite schist is recognized in the field by its reduced grain size, phyllitic sheen, and very closely spaced foliation (see description in Table 2).

The Cunningham Mountain fault dips on the average 30° SW., generally subparallel to bedding attitudes of both the Mesozoic sedimentary rocks and the meta-volcanic rocks. The composition of the underlying rocks varies along the strike of this contact. On La Cholla Mountain, the Mesozoic rocks are juxtaposed with meta-basalt. North of the Copper Bottom Pass fault, in the map area of Figure 4, the footwall unit is meta-crystalline tuff (map unit Mzvt), whereas south of the Copper Bottom Pass fault, the footwall unit is dark-gray meta-volcanic wacke (map unit dgw). Locally (see the northern edge of the map in Fig. 4), the foliation of the underlying terranes is bent into parallelism with the fault. A stereographically determined hinge of one of these flexures strikes northeast. Lineations and overturned kink folds within the mylonite schist band suggest that where movement has occurred there has been transport of the overlying Mesozoic strata from northwest to southeast with respect to the underlying rocks. Milky quartz veins have been injected into the contact area widely, and many of these veins have been prospected. The amount of offset on this contact is not known, but the fact that foliation of the footwall is not affected everywhere and that the mylonite is locally very thin or absent suggests that displacement is small. As stated earlier, this contact is most likely a locally sheared unconformity. Crowl (1979) considered the contact to be depositional, but the presence of sheared rock and deformation of foliation in the contact area suggests that there has been some movement.

The contact between the Mesozoic sedimentary rocks and the meta-volcanic terrane at the southern end of the Dome Rock Mountains

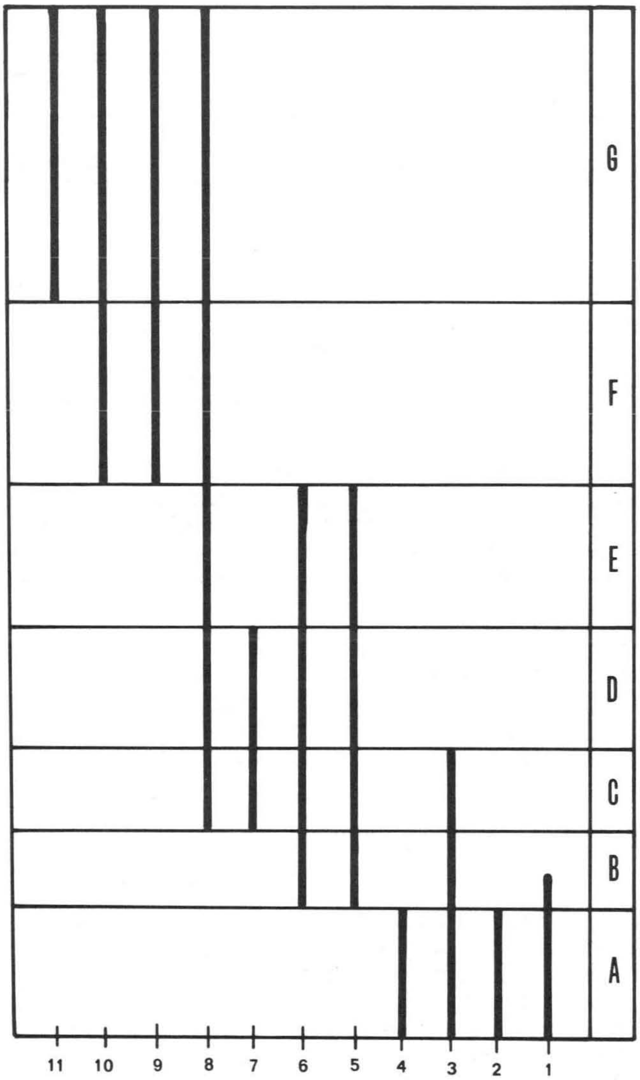

Fig. 3. Schematic chart showing the ranges of lithologies described in Table 1 in the sedimentary sequence of the Dome Rock Mountains. Numbers refer to numbered lithologies in Table 1.

The major fault that cuts northwest through the range in the Copper Bottom Pass is about 2.5 km north of the contact between Mesozoic sedimentary rocks and "Mesozoic gneiss" shown on the Geologic Map of Arizona (compare Figs. 1B and 1C). This contact is not well exposed, but hematite-stained breccia is present in three prospect shafts in the contact area, suggesting that the contact is a fault. The "Laramide intrusive" indicated as "Li" on the Geologic Map of Arizona (Fig. 1B), as mentioned earlier, is a highly foliated, light-colored meta-crystalline tuff that appears to be interlayered with meta-basalt and meta-andesite(?).

Structural Features

Throughout the northern two-thirds of the mapped area in Figure 1C, stratification dips east or southeast. In contrast, metamorphic foliation dips toward the north; thus, foliation is oriented at a high angle to bedding. This pattern, which is illustrated by the stereonets of Figure 6, is probably indicative of regional large-scale folding with a northwest-southeast direction of maximum shortening. Bedding-foliation relations at the southern end of the range are highly variable and could not be interpreted with available data.

The major fault which cuts northwest through the range in the Copper Bottom Pass area has been referred to in this paper as the Copper Bottom Pass fault. A deep alluviated valley follows the trace of this fault, so the fault is widely covered. In an exposure at the base of Cunningham Mountain, this fault is exposed as a wide shear zone. The Copper Bottom Pass fault offsets the Cunningham Mountain fault with about 1 km left-lateral separation and thus must have been active after the Cunningham Mountain fault. However, the observed 1-km offset cannot account for the juxtaposition of the dark-gray meta-volcanic wacke (unit dgw) south of the fault with the meta-volcanic terrane (units Mzvt and Mzvw) on the north, thus implying that the Copper Bottom Pass fault was also active prior to slip on the Cunningham Mountain fault. The northwest-trending faults of the Dome Rock Mountains have been studied by Balderman and La Violette (1977).

Preliminary measurements made in the Copper Bottom Pass area indicate that

1. Intrafolial folds at the Copper Bottom mine have hinge lines oriented approximately 35°, N. 60°-80° E.

2. Kink folds within the meta-volcanic terrane have hinges oriented 10°-20°, N. 70°-80° E.

3. A set of conjugate joints cuts the meta-volcanic terrane with one set oriented N. 80°-90° E, 30°-40° N., and another set oriented approximately horizontal. The average pole-to-foliation plane bisects the angle between the two joint sets.

4. Lineations locally observable on foliation planes in the meta-volcanic terrane strike northwest-southeast. All these data suggest a deformation field with maximum shortening in the northwest-southeast direction, consistent with that indicated by the bedding-foliation relation. However, it must be noted that late Tertiary tilting of the range as evidenced by the 40° E. dip of mid-Tertiary deposits at

Table 2. Field lithologic names with descriptions for the portions of the meta-volcanic and meta-volcaniclastic areas examined for this report

Name	Description
meta-basalt	black to dark maroon; aphanitic, locally with 0.5-2 cm long amygdules filled with chert; composed of outcrops in thick layers, parts on irregular foliation surfaces spaced at 1-2 cm intervals.
meta-crystalline tuff	very light greenish-gray to white with phyllitic luster, weathering to similar color with dark-brown and green crystals standing out of the weathered surfaces; large crystals/matrix = 20/80; large grains are coarse sand sized, angular, composed of quartz (60-70%), feldspar (30-40%); matrix is aphanitic, composed of chert (60-70%), sericite (30-40%), chlorite (5-10%); locally there are brown pumice(?) fragments; beds are defined by contrast in grain coarseness, beds 0.5-3 m(?) thick.
meta-andesite(?)	light to dark olive green, weathering to similar color or dark black or brown; porphyritic aphanitic (phenocrysts account for 10-20%); phenocrysts composed of sericitized feldspar, matrix composed of chlorite (10-60%), sericitized feldspar (30-50%), quartz (10-30%), calcite (0-20%), magnetite (5-15%); original texture largely altered; occurs in layers 0.5-2 m thick with blocky splitting; moderately resistant ledge former.
light-tan meta-volcanic wacke	light pinkish tan, weathering to dark brown or black (desert varnish); grains/matrix = 60/40, grains are coarse sand sized (0.2-1 mm), composed of angular (sub-euhedral) feldspar (predominantly plagioclase) (50-60%), quartz (40-50%); matrix is aphanitic, composed of sericite (60-70%), quartz (20-30%), chlorite (10-20%); locally there are pebbles and cobbles of hypabyssal intrusive rock; bedding not apparent; resistant cliff former.
dark-gray meta-volcanic wacke	dark greenish gray, weathering to dark brown or black (desert varnish) with prominent white grains; grains/matrix = 60/40; grains are 0.5-3 mm (locally up to 1.5 cm), angular, composed of feldspar (mainly plagioclase) (60-80%) (feldspar has well-developed cleavage, is locally euhedral, and widely sericitized), quartz (15-25%); matrix composed of fine-grained sericite (60-80%), quartz (10-30%), chlorite (10-20%); bedding not apparent, outcrops are moderately resistant; *Actinocelia* fossil associated with this unit.
quartz monzonite	dark greenish gray and pink, weathering to dark brown and black; medium-grained equigranular; composed of feldspar (mostly plagioclase) (50-60%), quartz (30-40%), chlorite (10-20%).
aplite	light tan, weathering to dark black or brown; fine-grained, equigranular, sugary appearance; composed of quartz (60-70%), alkali feldspar (30-40%), biotite (0-10%); occurs as narrow dikes cutting the quartz monzonite (lithology 17).

the southern end of the range may have altered the original orientation of the structures.

Age Constraints and Correlation

The meta-volcanic terrane, not including the dark-gray meta-volcanic wacke of Cunningham Mountain, whose relation to the meta-volcanic terrane (units Mzvt and Mzvw) is as yet uncertain and whose age is problematic (Robison, 1979; Marshak, 1979), has been radiometrically dated as Early to Middle Jurassic (L. T. Silver, cited in Crowl, 1979). These rocks probably formed as part of an early to mid-Mesozoic subduction-related volcanic arc (Crowl, 1979), which has been documented elsewhere in Arizona, California, and Sonora (Coney, 1978; Rangin, 1978; Cooper, 1971).

Precise dating of the Mesozoic sedimentary rocks in the Dome Rock Mountains is difficult, for as yet no identifiable fossils have been recovered from these rocks. These rocks are lithologically similar to sedimentary deposits of the Plomosa Mountains and the Livingston Hills, 10 km to the east, which have been described by Miller (1970) and Harding (1978). Miller divided these deposits into two units. The lower unit, which he named "continental red bed deposits," is described in detail by Robison (1979) and is here considered to correspond to unit a of the Dome Rock Mountains.

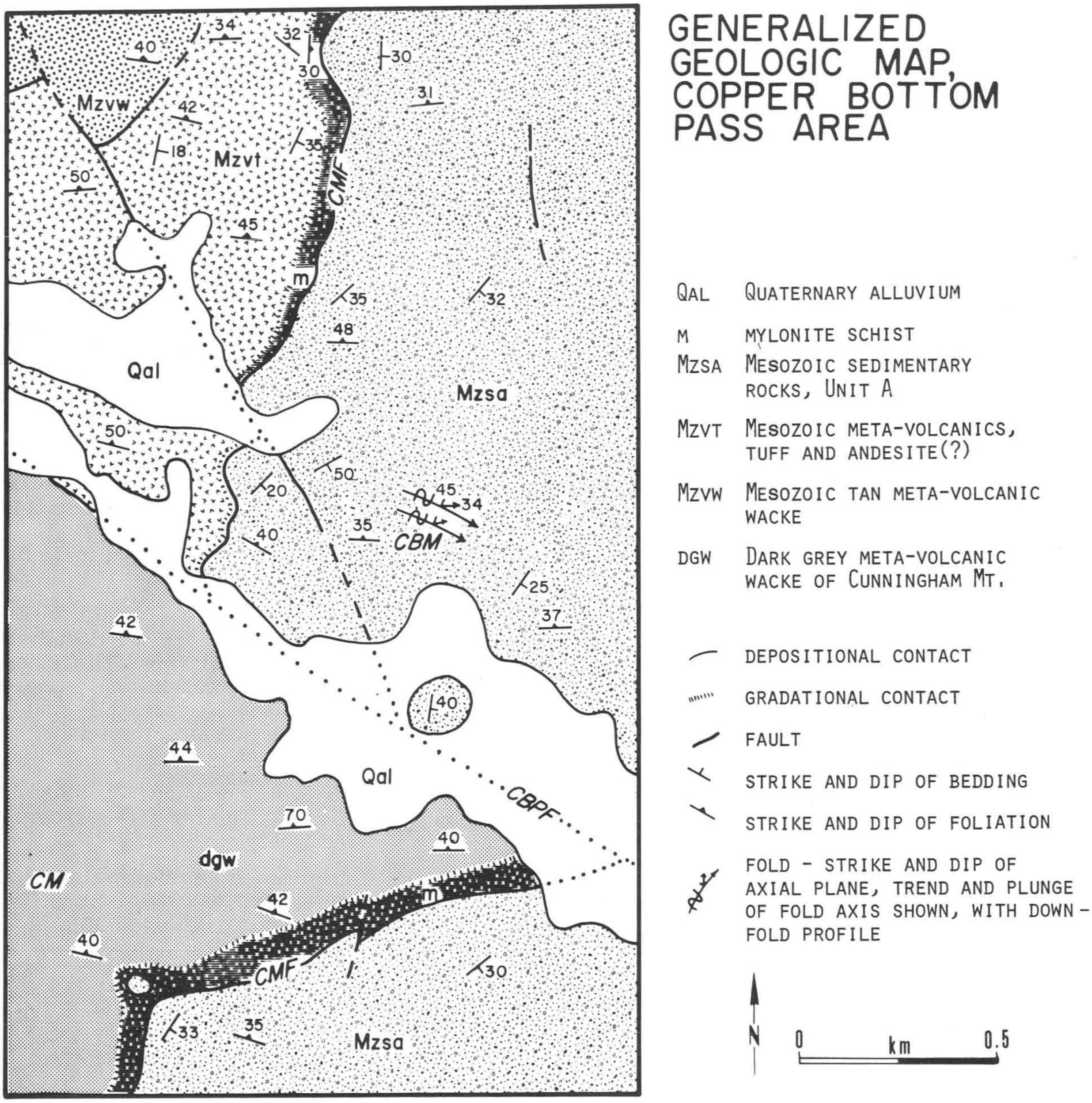

Fig. 4. Generalized geologic map of the Copper Bottom Pass area, Dome Rock Mountains, CMF = Cunningham Mountain fault; CBPF = Copper Bottom Pass fault; CBM = Copper Bottom mine.

Fig. 5. View of the Cunningham Mountain fault, looking south from Cunningham Mountain. Mzsa = Mesozoic sedimentary rocks, unit a; dgw = dark-gray meta-volcanic wacke.

The upper unit, a 3,600-m-thick section of conglomerate, greywacke, and siltstone, Miller named the "Livingston Hills Formation." The Livingston Hills Formation is here considered to correspond to units b-g of the Dome Rock Mountains (Fig. 1C). Sedimentary rocks similar in composition to those of the Dome Rock Mountains and Livingston Hills also crop out in the McCoy Mountains of southeastern California (Pelka, 1973) and possibly in the Granite Wash, Plomosa, Castle Dome, Kofa, Middle, and Buckskin Mountains of Yuma County (Wilson, 1933; Marshak, 1979).

If the contact between the Mesozoic sedimentary rocks and the underlying meta-volcanic terrane in the Dome Rock Mountains is a sheared unconformity, then the Mesozoic sedimentary rocks are stratigraphically above the Early to mid-Jurassic volcanic terrane (as considered by Crowl, 1979). If these sedimentary rocks are correlative with lithologically similar deposits in the Granite Wash Mountains, then they must be pre-Late Cretaceous, for the deposits of the Granite Wash Mountains are intruded (Reynolds, this volume) by radiometrically dated Late Cretaceous plutons (Eberly and Stanley, 1978; Reynolds, this volume). These contact relations suggest that the sedimentary rocks were deposited at some time between mid-Jurassic and Late Cretaceous time. More data are necessary before this assignment can be refined further.

Interpretation

This preliminary study suggests that southwestern Arizona has a complex Mesozoic history. Part of the region was the locus of volcanic activity during Early and mid-Jurassic time. When the volcanism ceased, the region subsided and the area of Yuma County became a locus for sedimentary deposition. This depositional basin appears to have received detri-

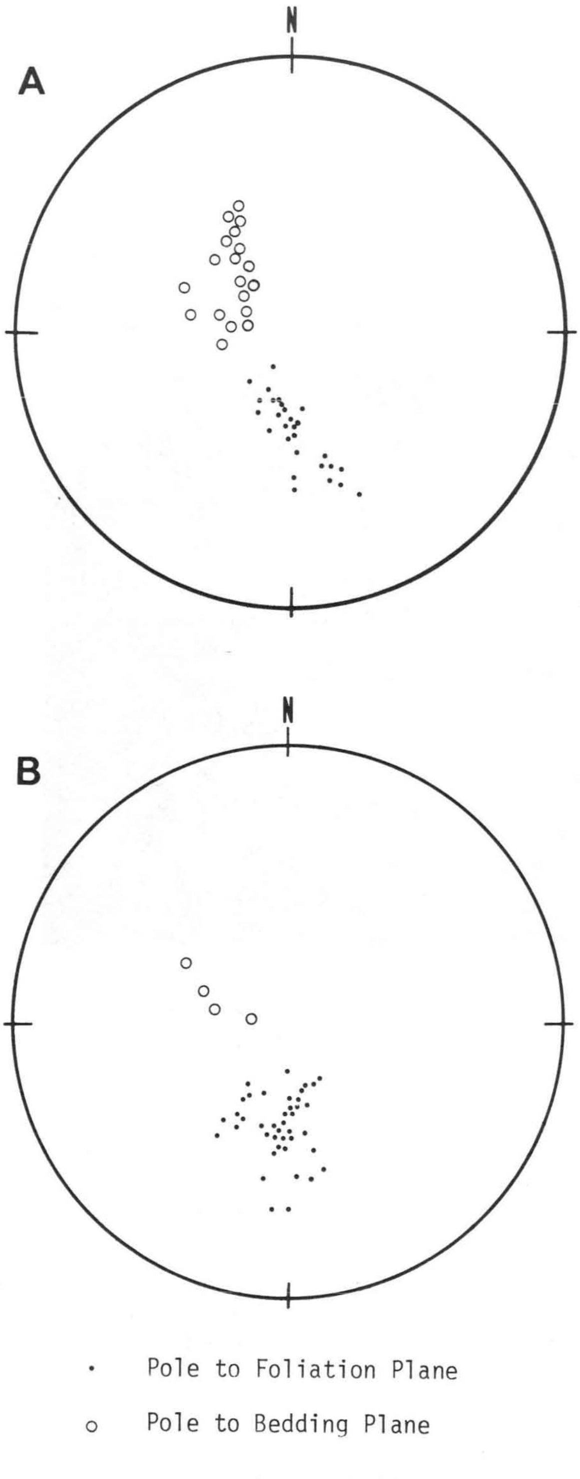

Fig. 6. Equal-angle projections of poles to bedding and foliation planes in (A) the Mesozoic sedimentary rocks and (B) the meta-volcanic terrane. Measurements were made in the Copper Bottom Pass area (boxed area in Fig. 1C).

tus first from a highland that included Paleozoic sedimentary lithologies and later from a volcanic terrane. A similar suggestion has been made concerning the deposits of the Livingston Hills (Harding, 1978). The earlier highland was perhaps the Mogollon Highlands (Cooley and Davidson, 1963) and the latter was perhaps the great Cretaceous volcanic arc that developed to the west of Yuma County (Armstrong and Suppe, 1973). Robison (1979) made a similar suggestion based on his work in the Livingston Hills. Following deposition, the Mesozoic rocks of Yuma County were subjected to deformation and metamorphism, probably as a consequence of Late Cretaceous through early Tertiary tectonism (Marshak, 1979; Reynolds, this volume).

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