U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

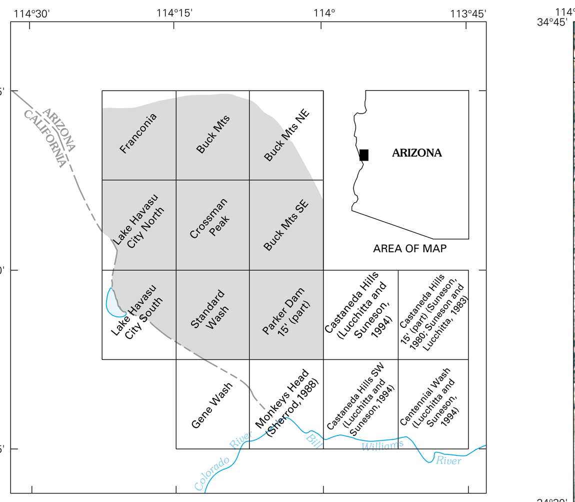

Figure 1. Index map showing location of study area (shaded), 7 1/2 minute quadrangles of area, and nearby published geologic mapping.

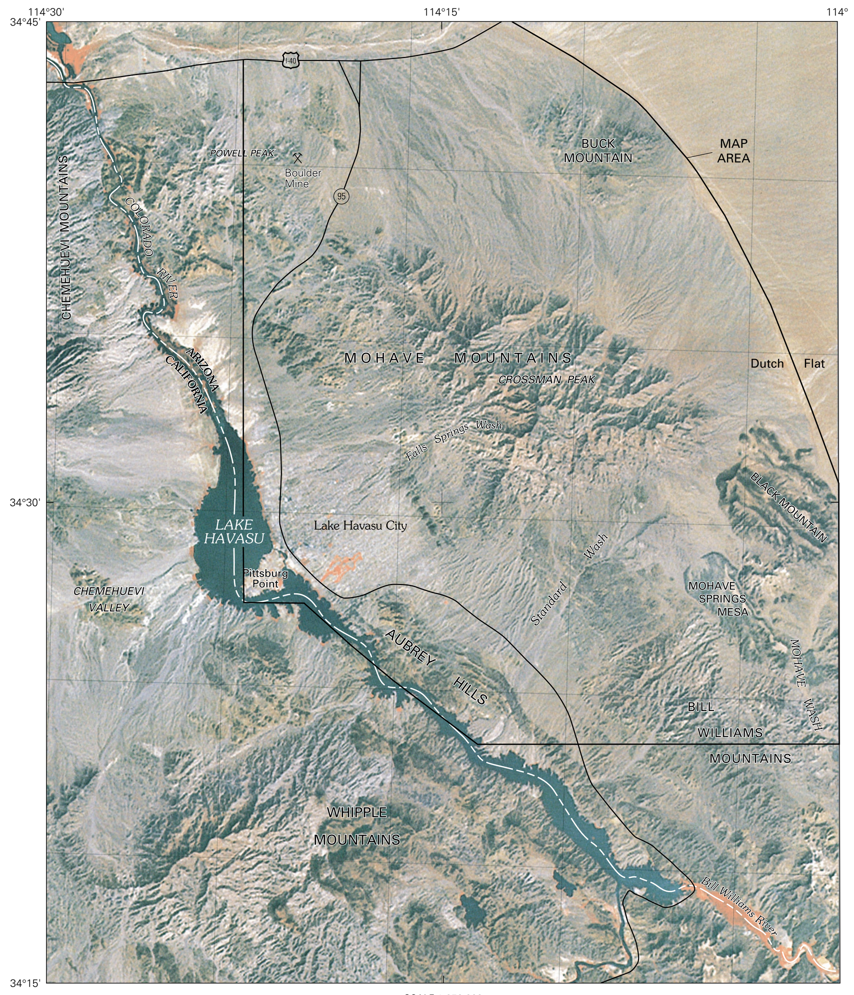

Figure 2. Landsat image showing selected geographic features.

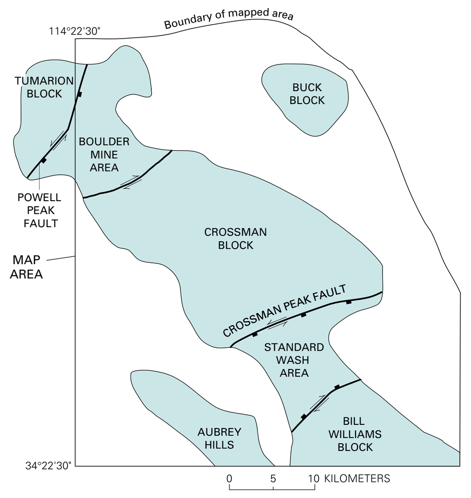

Figure 3. Generalized tectonic map showing tilt blocks and major faults. Arrows show relative direction of movement; barbs on upper plate of detachment faults.

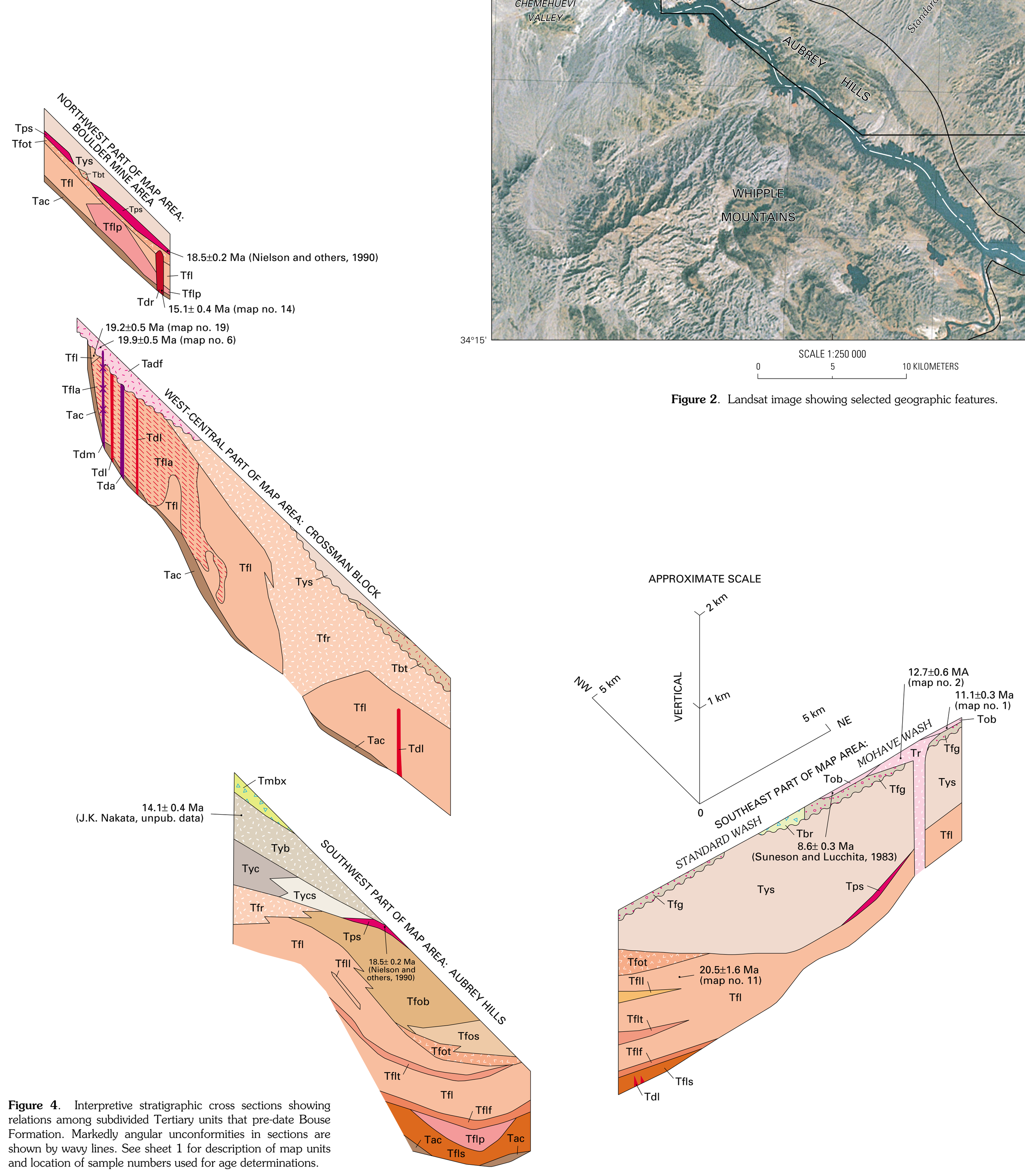

Figure 4. Interpretive stratigraphic cross sections showing relations among subdivided Tertiary units that pre-date Bouse Formation. Markedly angular unconformities in sections are shown by wavy lines. See sheet 1 for description of map units and location of sample numbers used for age determinations.

Table 1. *Potassium-argon (K-Ar), uranium-lead (U-Pb), and fission-track (FT) age determinations for selected rocks in the Mohave Mountains area, Arizona*

[K-Ar and FT numerical ages from Nakata and others (1990); U-Pb age (map no. 36) determined by Wooden and Miller (1990). *, age considered unlikely to represent crystallization age]

Map no. (sheet 1)	Map unit	Sample no.	Latitude (34°)	Longitude (114°)	Rock type	Method	Material dated	Age (in Ma)
1	Tob	P81MH-8A	30.7'	4.5'	Basalt	K-Ar	Whole rock	11.1±0.3
2	Tr	JP82MH-23	27.7'	3.5'	Tuff	K-Ar	Sanidine	12.7±0.6
3	Tbt	H81MH-18	40.9'	18.7'	Basalt	K-Ar	Whole rock	14.6±0.4
4	Tps	JP80MH-192	37.8'	20.7'	Tuff	K-Ar	Sanidine	17.6±0.4 *
4	Tps	P81MH-2	37.8'	20.7'	Tuff	K-Ar	Sanidine	18.0±0.5
5	Tadf	JP81MH-388B	33.8'	19.5'	Tuff	K-Ar	Plagioclase	17.9±0.5
6	Tadf	JP81MH-378	35.4'	21.1'	Latite	K-Ar	Biotite	19.9±0.5
7	Tps	JP81MH-159	30.7'	5.2'	Tuff	K-Ar	Biotite	18.7±0.7
8	Tfts	JP81MH-14A	29.7'	14.6'	Basalt	K-Ar	Whole rock	17.9±0.7
9	Tfts	JP81MH-296	35.5'	22.0'	Rhyolite	K-Ar	Biotite	19.2±0.5
						K-Ar	Hornblende	16.3±0.4 *
10	Tfts	JP80MH-223	37.5'	20.0'	Perlite	K-Ar	Biotite	19.1±0.6
						K-Ar	Hornblende	17.2±0.6 *
11	Tfts	JP80MH-139	28.2'	12.0'	Perlite	K-Ar	Biotite	20.5±1.6
						K-Ar	Hornblende	18.8±0.5
12	Tfts	JP81MH-361	38.0'	18.6'	Volcanic breccia	K-Ar	Biotite	48.0±1.2 *
13	Tap	JP80MH-187	37.8'	20.5'	Latite porphyry	K-Ar	Whole rock	19.8±0.6
14	Tdr	P81MH-1	36.5'	21.2'	Rhyolite	K-Ar	Plagioclase	15.1±0.4
15	Tdm	JN81MH90-2	33.7'	6.3'	Diorite	K-Ar	Hornblende	22.6±0.7
						K-Ar	Hornblende	26.9±0.7 *
15	Tdm	JN81MH90-2A	33.7'	6.3'	Diorite	K-Ar	Hornblende	21.7±0.7
16	Tdap	BLM-139-8	34.5'	8.8'	Andesite	K-Ar	Plagioclase	42.7±1.1 *
17	Tda	BLM-163-35	35.8'	11.3'	Andesite	K-Ar	Whole rock	78.1±2.0 *
18	Tda	BLM163A	35.3'	11.6'	Andesite	K-Ar	Whole rock	42.9±1.1 *
19	Tda	P81MH-15B	33.0'	11.6'	Mircodiorite	K-Ar	Whole rock	42.0±1.3 *
20	Tda	H83MH-66	33.6'	5.8'	Mircodiorite	K-Ar	Hornblende	29.2±0.7 *
21	Tdl	BLM-190-8	32.4'	14.5'	Dacite	K-Ar	Whole rock	18.4±0.5 *
						K-Ar	Whole rock (acid)	11.3±0.5
22	Tdl	H81MH-5	36.3'	15.5'	Dacite	K-Ar	Biotite	19.8±0.5
23	Tdl	H81MH-39	32.5'	12.4'	Dacite	K-Ar	Biotite	19.2±0.5
24	Tdl	H82MH-15	36.2'	11.0'	Dacite	K-Ar	Biotite	20.8±0.5
25	Tgd	H82MH-57B	34.2'	9.1'	Quartz diorite	K-Ar	Biotite	21.5±0.5
26	TKg	H80MH-310	37.4'	16.6'	Granite	K-Ar	Biotite	18.1±0.5
						FT	zircon	16.6±1.7 *
27	TKd	H80MH-311	37.7'	16.7'	Diorite	K-Ar	Hornblende	32.0±1.0 *
28	TPd	P81MH-20	32.4'	9.8'	Rhyolite	K-Ar	Biotite	62.3±1.6
29	TPd	G81BW-167	23.6'	5.2'	Mircodiorite	K-Ar	Hornblende	332±16 *
30	Xag	P81MH-21B	31.2'	14.1'	Altered gneiss	K-Ar	Sericite	54.9±1.4 *
30	Xag	P81MH-21C	31.2'	14.1'	Altered gneiss	K-Ar	Sericite	65.0±1.6 *
						FT	Zircon	78.0±1.6 *
30	Xag	P81MH-21A	31.2'	14.1'	Altered gneiss	K-Ar	White mica	91.4±2.3
30	Xag	P81MH-21D	31.2'	14.1'	Altered gneiss	K-Ar	White mica	89.7±2.2
31	Xgl	K81MH-36	32.1'	10.2'	Altered gneiss	K-Ar	White mica	92.0±2.3
32	Xgb	K81MH-62A	34.9'	17.1'	Altered rock	K-Ar	White mica	102±3
33	Ysqn	P81MH-9	28.0'	9.1'	Granodiorite	FT	Zircon	46.4±5.4 *
34	Xag	H81BW-25	24.3'	7.2'	Gneiss	K-Ar	Biotite	130±4
						FT	Zircon	81.7±8.7 *
35	Xag	P81MH-22	29.2'	13.8'	Gneiss	K-Ar	Biotite	111±3 *
36	Xag	H81BW-174	24.0'	7.9'	Augen gneiss	U-Pb	Zircon	1642±12
37	Xagd	H82MH-16	36.2'	11.1'	Gneiss	K-Ar	Biotite	49±11 *
38	Xagd	P81MH-6	37.2'	17.3'	Augen gneiss	K-Ar	Biotite	66.7±1.7 *
						FT	Zircon	22.6±1.9
39	Xagd	P81BK-12	41.6'	8.8'	Augen gneiss	K-Ar	Biotite	120±3 *
40	Xagd	H87MH-29	33.0'	13.6'	Augen gneiss	K-Ar	Biotite	188±5 *
41	Xagd	H81BK-7A	39.6'	9.5'	Gneiss	K-Ar	Biotite	264±7 *
						FT	Zircon	81.6±8.6 *
42	Xgp	P81MH-10	38.4'	21.5'	Granite	K-Ar	Biotite	597±11 *
43	Xga	P81BK-13	41.8'	8.9'	Amphibolite	K-Ar	Hornblende	1372±41 *
44	Xga	H83MH-67	33.5'	5.9'	Amphibolite	K-Ar	Hornblende	104±3 *
45	Xgl	H87MH-30	33.2'	12.6'	Leucogneiss	K-Ar	Biotite	116±3 *

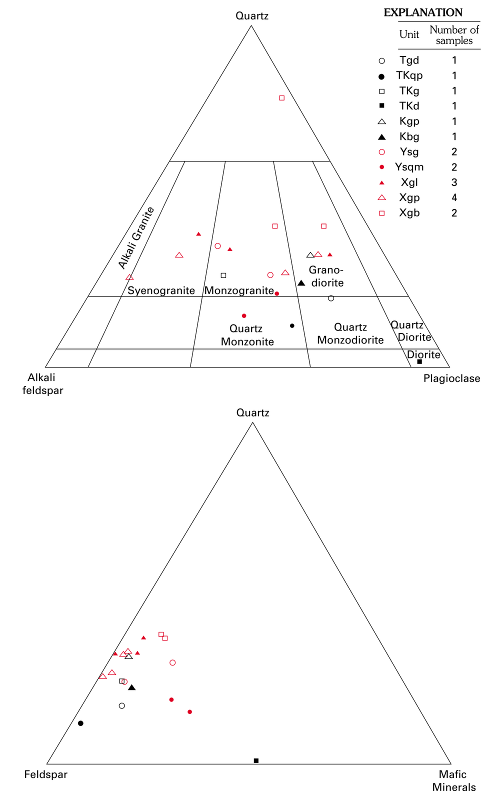

Figure 5. Modal composition of plutonic rock units, based on an average of 1000 points counted on stained slabs. See figure 6 for augen gneiss unit. International Union of Geological Sciences classification (Streckeisen, 1973)

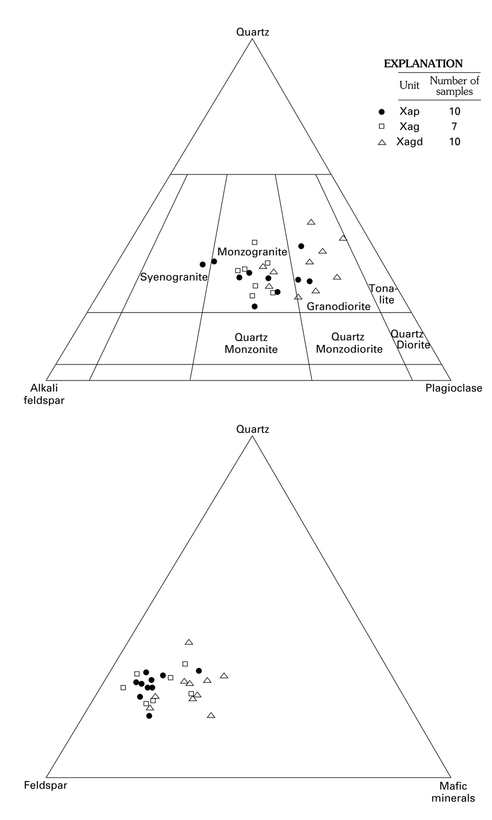

Figure 6. Modal composition of augen gneiss unit, based on an average of 1000 points counted on stained slabs. International Union of Geological Sciences classification (Streckeison, 1973).

INTRODUCTION

The Mohave Mountains area surrounds Lake Havasu City, Arizona, in the Basin and Range physiographic province (fig. 1). The Mohave Mountains and the Aubrey Hills form two northwest-trending ranges adjacent to Lake Havasu (elevation 132 m; 448 ft) on the Colorado River (fig. 2). The low Buck Mountains lie northeast of the Mohave Mountains in the alluviated valley of Dutch Flat. Lowlands at Standard Wash separate the Mohave Mountains from the Bill Williams Mountains to the southeast. The highest point in the area is Crossman Peak in the Mohave Mountains, at an elevation of 1519 m (5148 ft). Arizona Highway 95 is now rerouted in the northwestern part of the map area from its position portrayed on the base map; it now also passes through the southern edge of the map area (fig. 2).

Geologic mapping was begun in 1980 as part of a program to assess the mineral resource potential of Federal lands under the jurisdiction of the U.S. Bureau of Land Management (Light and others, 1983). Mapping responsibilities were as follows: Proterozoic and Mesozoic rocks, K.A. Howard; dikes, J.K. Nakata; Miocene section, J.E. Nielson; and surficial deposits, H.G. Wilshire.

Earlier geologic mapping includes reconnaissance mapping by Wilson and Moore (1959). The present series of investigations has resulted in reports on the crystalline rocks and structure (Howard and others, 1982a), dikes (Nakata, 1982), Tertiary stratigraphy (Pike and Hansen, 1982; Nielson, 1986; Nielson and Beratan, 1990), surficial deposits (Wilshire and Reneau, 1992), tectonics (Howard and John, 1987; Beratan and others, 1990), geophysics (Simpson and others, 1986), mineralization (Light and McDonnell, 1983; Light and others, 1983), field guides (Nielson, 1986; Howard and others, 1987), and geochronology (Nakata and others, 1990; Foster and others, 1990).

GEOLOGY

The area lies within a terrane characterized by major low-angle normal faults (commonly called detachment faults) of Miocene age (Davis and others, 1980; Howard and John, 1987; John, 1987a; Davis and Lister, 1988; Davis, 1988; Carr, 1991). The Whipple Mountains detachment fault is exposed 3 km (2 mi) southwest of the mapped area, and the probably equivalent Chemehuevi detachment fault is exposed 8 km (5 mi) northwest of the mapped area. Both dip gently toward the Mohave Mountains area and project beneath it at shallow depth.

Proterozoic metamorphic and igneous rocks, Cretaceous plutons, and Tertiary dikes underlie the map area. Tertiary volcanic and sedimentary rocks overlie the Proterozoic rocks. Tilting to the southwest in the Miocene along northeast-dipping normal faults resulted in steep to overturned dips of lower Miocene strata and the Proterozoic-Tertiary nonconformity. Consequently the map view restores to cross-sectional views before the tilting, in which deeper crustal levels in any tilted block are encountered to the northeast. The faulting is inferred to relate to down-to-northeast motion on the deeper Whipple Mountains-Chemehuevi fault (Howard and John, 1987). Upper Miocene to Quaternary deposits overlie the deformed rocks.

The largest of the tilted fault blocks is the Crossman block, centered in the map area (Crossman plate of Howard and others, 1982a). Other large tilt blocks are the Bill Williams, Buck, and Tumarion blocks (fig 3). Smaller tilt blocks or slices are present in the Standard Wash, Aubrey Hills, and Boulder Mine areas.

Proterozoic and Mesozoic Rocks

Granite gneisses are the predominant Early Proterozoic rocks in the map area. The gneisses are like those widely exposed elsewhere in the eastern Mojave Desert region (Wooden and Miller, 1990) and consist partly of supracrustal rocks and largely of metaplutonic rocks (Howard and others, 1982a). Scattered amphibolite bodies (**Xga**) help to define large folds in the gneiss terrane. Fold axes plunge to the southwest and restore to northeast plunge if Tertiary tilting is removed (Howard and others, 1982a).

Amphibolite is associated with white garnet-bearing gneissic pegmatite (**Xgp**) in the northwestern part of the Crossman block; it serves as a marker for fault separation to a block in the Boulder Mine area. The same assemblage also crops out along strike to the northeast in the Buck block, as well as farther southeast in the Crossman block.

Remnant metasedimentary rocks (**Xgs**) and fine-grained biotite granite gneiss (**Xgb**) and younger foliated monzogranite (**Xgp**) crop out in the northern part of the area in structurally high positions of the pre-Tertiary crustal section. Augen gneiss (**Xap**, **Xag**, and **Xagd**) occurs in structurally intermediate levels of the section and becomes more foliated and more mafic with paleodepth. Dating by the uranium-lead (U-Pb) method indicates an Early Proterozoic age (1642 Ma) for an augen gneiss body in the Bill Williams Mountains (Wooden and Miller, 1990; *table 1, No. 36). Howard and others (1982a) earlier had grouped the augen gneiss with Middle Proteozoic(?) granitoids of Standard Wash, which it resembles. The augen gneiss commonly coincides with aeromagnetic highs (Simpson and others, 1986). The deepest rocks in the exposed crustal section are dominated by garnet-spotted leucocratic gneiss (**Xgl**) in which pervasive garnets, now mostly retrograded, suggest high-grade metamorphism.

Granite and quartz monzonite in Standard Wash (**Ysg**, **Ysqm**) are tentatively correlated with rocks of Middle Proterozoic age (about 1400 Ma) described by Anderson and Bender (1989). An aeromagnetic high is associated with the quartz monzodiorite (Simpson and others, 1986). The granite is seen to intrude older gneiss just south of the map area in the southern Aubrey Hills. The Standard Wash granitoids are not mapped in the Crossman, Bill Williams, or Buck blocks.

Swarms of Middle Proterozoic ophitic diabase dikes intrude the gneiss and granitoids (see cross sections; Nakata, 1982; Howard, 1991). The dikes (**Yd**) are similar to diabase dikes distributed widely in Arizona and southeastern California and are interpreted to have an age of about 1100–1200 Ma (Wrucke and Shride, 1972; Hendricks and Lucchitta, 1974; Davis and others, 1980; Howard and others, 1982a; 1982b; Fitzgibbon, 1988). The dikes cut older folds and fabrics without deflection. Their generally northwest strikes and steep dips restore to subhorizontal when Tertiary tilting defined by the dip of lowest Tertiary strata is removed. Hence the dikes are intrerpreted as originally horizontal sheets. They are mapped to paleodepths of as great as 14 km below the Proterozoic-Tertiary nonconformity. Original depths of emplacement below the Proterozoic ground surface must have been even greater.

Cooling ages obtained on Proterozoic rocks by the fission-track (zircon) and potassium-argon (K-Ar) methods range from 46 to 1372 Ma (table 1; Nakata and others, 1990). The numerical ages tend to young downward (northeastward) in the pre-Tertiary structural sections and are consistent with younger cooling at deeper levels. Age determinations by the $^{40}Ar/^{39}Ar$ technique support this interpretation (Foster and others, 1990).

Mineralized quartz veins in the Mohave Mountains contain sulfides and precious metals (Light and others, 1983). The veins cut the Proterozoic diabase and are cut by Tertiary dikes and have a minimum age of mid-Cretaceous as determined by isotopic dating: medium-grained white mica in altered gneiss associated with the veins yielded K-Ar ages of 90 to 102 Ma; numerical cooling ages on fine-grained white mica and zircon are 52 to 78 Ma (table 1, Nos. 30–32; Nakata and others, 1990).

The Mohave Mountains and adjacent ranges are near the northeastern limit of the Cretaceous magmatic arc (Burchfiel and Davis, 1981; John, 1981; John and Wooden, 1990). Granitic plutons of known and inferred Cretaceous age are widespread to the west but are rare to the northeast. Cretaceous rocks in the Mohave Mountains area may be apophyses of the deeper batholithic terrane exposed to the west in the Chemehuevi Mountains (John, 1987b). This interpretation is based on a hypothesis of Howard and John (1987) that the northern Mohave Mountains represent the displaced upper plate to rocks exposed in the Chemehuevi Mountains. Granodiorite and porphyritic granite (**Kgb**, **Kpg**) in the northern part of the map area are correlated to Late Cretaceous rocks of the Chemehuevi Mountains Plutonic Suite (John, 1987b, 1988; John and Mukasa, 1990; John and Wooden, 1990).

Rocks in the Mohave Mountains area that may be either Cretaceous or Tertiary in age include a northeast-striking rhyolite dike dated by K-Ar on biotite at 62 Ma (table 1, No. 28, unit **TYd**), northeast-striking dikes of lamprophyre and quartz porphyry (**TKl**, **TKqp**), and small stocks of granite and diorite (**TKg**, **TKd**) that yielded middle Tertiary numerical K-Ar ages on biotite and hornblende (table 1, Nos. 26, 27). Northeast-striking dikes of Laramide (Late Cretaceous to early Tertiary) age are widespread in Arizona (Rehrig and Heidrick, 1976).

Cenozoic Rocks

The lowest stratified Tertiary unit (**Tac**) is arkosic conglomerate and sandstone, locally red-bed, which is assigned an Oligocene or early Miocene age. It nonconformably overlies deeply oxidized Proterozoic rocks and forms the base of a heterogeneous, dominantly volcanic section of otherwise early and middle Miocene age (fig. 4; Pike and Hansen, 1982; Nielson, 1986; Nielson and Beratan, 1990; Beratan and others, 1990). The volcanic rocks consist of mafic and silicic lava flows, volcaniclastic flows and breccias, air-fall tuff, and tuff breccia. The Peach Springs Tuff of Young and Brennan (1974), a regional ash-flow tuff, crops out high in the lower Miocene part of the section. The sedimentary rocks include arkosic conglomerate and conglomeratic sandstones derived from Proterozoic sources, sandstone and sedimentary breccia derived solely from reworked volcanic rocks, and fanglomerate, sandstone, and claystone from mixed sources. The lower part of the Tertiary section is intruded by silicic and mafic dikes that may be feeders for some of the flows.

The dikes are part of a dense swarm of northeast-dipping Tertiary dikes that pervades the pre-Tertiary basement of the Crossman block. This Mohave Mountains dike swarm forms about 15 percent of the rock volume in the Crossman block (Nakata, 1982) and accounts for a north-east-southwest crustal dilation of 2–3 km that occurred during regional tectonic extension. The K-Ar ages considered most reliable as intrusive ages for the swarm range from 19.2±0.5 to 21.5±0.5 Ma (table 1, Nos. 21–25).

The Tertiary strata below the Peach Springs Tuff correlate broadly with the sedimentary and volcanic rocks of Fox Wash described by Sherrod (1988) from the Bill Williams Mountains. Age determinations by the K-Ar method indicate that the age of the volcanic rocks in this section is about 19 to 22 Ma (table 1, Nos. 8–11, 13; Nielson and Beratan, 1990; Nakata and others, 1990). The Peach Springs Tuff is dated from Kingman, Arizona, at 18.5+0.2 Ma (Nielson and others, 1990). The steeply dipping to overturned oldest part of the Tertiary section is overlain succesively by units of early Miocene to middle Miocene age having progressively shallower dips, in places without obvious unconformities between strata. Therefore the stratified units were deposited during tilting, and they likely record sedimentary influxes that relate to the tilting and faulting. Conglomerates low in the section are largely roundstone. Higher units include lacustrine strata deposited in closed structural basins. Fanglomerates and landslide megabreccias crop out high in the section.

North of Lake Havasu City a gently dipping latite flow (**Tadf**) dated by K-Ar at 19.9±0.5 Ma overlies more steeply tilted flows and strata (**Tfts**) from which an age of 19.2±0.5 Ma was obtained. The 30° and greater angular unconformity between the latite flow and underlying strata records the tilting of the Crossman block (Nielson and Beratan, 1988), so the age of tilting can be interpreted as near 19.5 Ma. Stratal dips indicate that tilting of other blocks ranged from before to after deposition of the 18.5–Ma Peach Springs Tuff.

A middle Miocene fanglomerate unit (**Tfg**) represents the first of two distinct periods of postdetachment alluviation. Capping it are rhyolite and olivine basalt flows (**Tr**, **Tob**) that were dated at 12.2 to 8.6 Ma (Suneson and Lucchitta, 1983; Nakata and others, 1990). They and the underlying fanglomerate are relatively undeformed compared to older strata, but in the southeastern part of the map area they are faulted and are tilted gently southwest, the same direction as older steeper tilts.

The Bouse Formation of late Miocene and Pliocene age was deposited mostly in quiet water along the valley that was later to be followed by the Colorado River. A sandy subaerial facies of the Bouse was deposited in the northern part of the Mohave Mountains area; a similar facies was mapped south of the Whipple Mountains by Dickey and others (1980).

Undeformed upper Miocene to Quaternary piedmont sedimentary deposits record a second period of alluviation. These deposits are fanglomerates composed of unsorted to poorly sorted, coarse, angular to subangular clastic debris derived from the exposed pre-Tertiary and Tertiary rocks. The fanglomerates interfinger with river-laid sand and gravel along the Colorado River west of the study area. Most of the fanglomerate deposits are at least as old as Pleistocene and probably formed a series of large, coalescing alluvial fans (unit QTs_1). The depositional surface later was nearly completely dissected, with levels of erosion generally below the soil profile, on the west side of the mountains where drainages flow directly into the Colorado River. Dissection, planation, and reworking is largely responsible for a series of inset terraces and washes veneered by succesively younger parts of the piedmont unit. Soils are progressively less well developed on younger units (Wilshire and Reneau, 1992).

Tertiary Structure

Structural relations in the Crossman block indicate that it was tilted as a largely coherent block. The lower part of the Tertiary section dips steeply to overturned. The tilt persists at deeper structural levels in the block, as shown by the consistent steep orientations of rotated Proterozoic diabase sheets, subparallel to the lower Tertiary section. The Tertiary Mohave Mountains dike swarm maintains a moderate northeast dip all across the block and is unbroken by faults except in a few places.

The evidence for tilting of the Crossman block implies that it exposes a cross section that represents progressively greater crustal depths from southwest to northeast. This section represents 10 to 15 km of crustal thickness if the Crossman block is unbroken and tilted at least 75° (Howard and John, 1987). Amphibolite bodies within the block trace cryptic Proterozoic folds that argue against much internal disruption of the block by Tertiary faulting, except where faults are mapped. The Crossman block may have been translated 40 km from Chemehuevi Valley, where the western Whipple Mountains below the Whipple Mountains detachment fault expose a footwall of similar dike swarms and Proterozoic gneisses (Carr and others, 1980; Dickey and others 1980; Davis and others, 1980, 1982; Howard and others, 1982a; Davis, 1988; Lister and Davis, 1989).

The Whipple Mountains-Chemehuevi detachment fault projects eastward beneath the Crossman block and is inferred to juxtapose it against deeper mid-crustal mylonitic gneisses (see cross sections). In the eastern Chemehuevi Mountains and eastern Whipple Mountains the footwall of the detachment exposes mylonitic gneisses derived from Proterozoic to Tertiary protoliths and mylonitized in the Cretaceous and Tertiary (Anderson and Rowley, 1981; Davis and others, 1982; Anderson and others, 1988; Davis, 1988; John and Mukasa, 1990).

An abrupt northeast termination of the Crossman block at its originally deep end is proposed on cross section ***A–A'*** in order to help explain a steep gravity gradient at this position. The gravity gradient led Simpson and others (1986) to model a steep boundary between denser rocks underlying the exposed Crossman block against less dense (lacking dikes?) bedrock to the northeast, under a thin sedimentary cover. The gravity model requires a greater density contrast (0.12 to 0.15 g/cm^3) between bedrock terranes than would be expected from the largely granitic bedrock exposed in the region and from density measurements of rocks in the Crossman block (Simpson and others, 1986). Hence the interpretation portrayed on cross section ***A–A'*** must be considered tentative and uncertain.

A curving family of northwest-striking faults including the Wing fault cut the northwestern part of the Crossman block. These faults are steep, they cut the Mohave Mountains dike swarm, and they appear to have significant pre-dike-swarm displacements of gneiss units. Based on the generalized crustal section inferred for unbroken parts of the Crossman block, each fault of the Wing-fault family appears to attenuate crustal section, juxtaposing originally shallower rocks against originally deeper rocks to the north. Chloritized rock is present on the "deep" northeast side of the Wing fault but not on the "shallow" side, a pattern reminiscent of chloritized footwalls of low-angle normal faults in the region. Based on the resemblances to low-angle normal faults in the region, the steep Wing fault perhaps was rotated from an originally smaller dip.

The Boulder Mine and Standard Wash areas expose numerous fault slices in synformal arrays structurally over the Crossman, Bill Williams, and Tumarion blocks. The faults in the Aubrey Hills and the Boulder Mine area mostly dip at low angles, and those in the Standard Wash area are inferred to also. Fault traces concave to the northeast in the Standard Wash area are consistent with synformal shapes and low northeast dips for the faults. Cross sections ***B–B'*** and ***C–C'*** interpret a shallow depth to the underlying footwall of the Whipple Mountains detachment fault. The depth is consistent not only with the geology but with the depth to a seismic-velocity increase interpreted as the base of the highly faulted allochthons (John and others, 1987; McCarthy and others, 1987).

The southeast-dipping Powell Peak fault bounds the Tumarion block against higher blocks of the Boulder Mine area, and the southeast-dipping Crossman Peak fault similarly bounds the exposed Crossman block against higher blocks of the Standard Wash area. Measured striae on the latter fault strike northeast in a direction parallel to the direction of extension and regional fault slips, including slip on the deeper Whipple Mountains and Chemehuevi detachment faults (Davis and others, 1980; Howard and John, 1987; John, 1987a).

Cross sections ***B–B'*** and ***C–C'*** portray the Powell Peak and Crossman Peak faults as bottoming at shallow depth, so that the Crossman block is connected at depth below the Standard Wash area and the Boulder Mine area with the Bill Williams and Tumarion blocks. This interpretation is based on (1) the alignment of Tertiary strata in the three big upended blocks; (2) the moderate (30–40°) dip of the exposed Powell Peak and Crossman Peak faults; and (3) the synformal array of higher blocks in the Boulder Mine and Standard Wash areas (Howard and others, 1982a; Howard and John, 1987). An alternate interpretation is that the Crossman Peak and Powell Peak faults are syndepositional transfer faults, and that the Crossman block does not intervene between the Standard Wash area and the Aubrey Hills as portrayed on the cross sections. This latter interpretation is based on stratigraphic coherence in the Tertiary section of the Aubrey Hills and Standard Wash areas and stratigraphic contrasts to the Crossman block (Beratan and others, 1990; Nielson and Beratan, 1990).

Relatively mild tilting and step faulting in upper Miocene strata (northeastern part of cross section ***B–B'***) may postdate active extension accomodated on the Whipple Mountains and Crossman Peak faults. The late Miocene tilting may relate to rebound of the detachment faults and later adjustments of tilted blocks following the end of movement on the Whipple Mountains fault.

ACKNOWLEDGMENTS

Mapping of the Mohave Mountains area was a team effort. J.S. Noller, K.K. Beratan, D.M. Peterson, and D.V. Prose mapped parts of the area. R.D. Knox and M.A. Pernokas participated in sampling and field and laboratory study. We benefited from discussions with R.W. Simpson, W.A. Rehrig, T.D. Light, G.A. Davis, and J.L. Anderson. Critical reviews by D.R. Sherrod, R.W. Tabor, and J.G. Evans led to many improvements.

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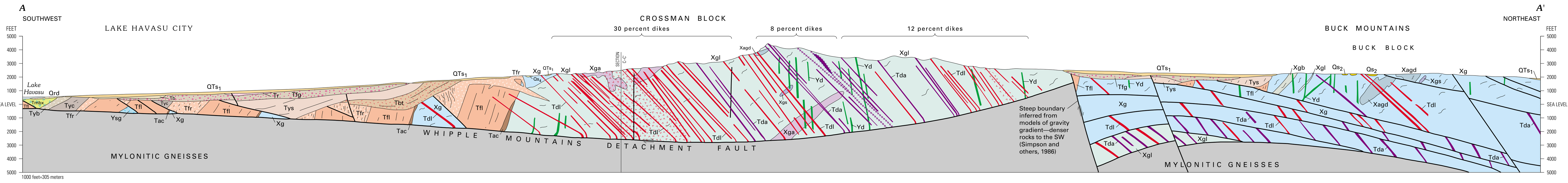
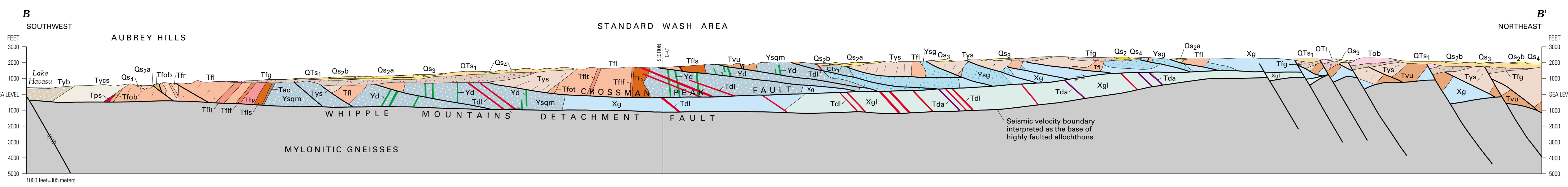
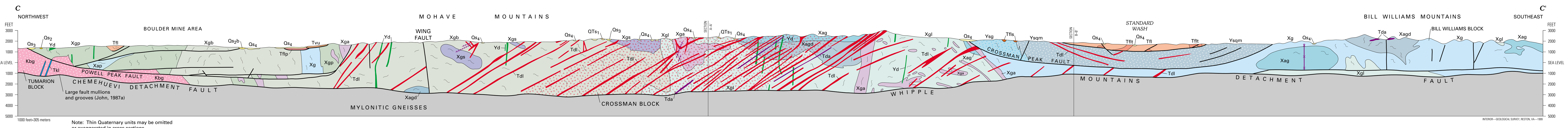
*Some ages listed in table 1 record cooling younger than age of rock (especially for Proterozoic rocks); other ages are anomalously older than probable rock age (especially for dikes) and may result from excess argon (Nakata and others, 1990). Description of Map Units mentions ages that are believed to reflect crystallizaion age of sampled rock units.







Note: Thin Quaternary units may be omitted or exaggerated in cross sections.

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1999

GEOLOGIC MAP OF THE MOHAVE MOUNTAINS AREA, MOHAVE COUNTY, WESTERN ARIZONA

By
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1999

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