Text to accompany NBMG Map 105

STRATIGRAPHIC AND STRUCTURAL FRAMEWORK OF THE MOUNT DAVIS QUADRANGLE, NEVADA AND ARIZONA

by

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The Mt. Davis Quadrangle lies within the central part of the northern Colorado River extensional corridor (Howard and John, 1987; Faulds and others, 1990), which is a 70- to 100-km-wide region of moderately to severely extended crust situated between the unextended Colorado Plateau on the east and Spring Range on the west. The quadrangle straddles Lake Mohave along the Colorado River (fig. 1). Thick sections (generally > 3 km) of Miocene volcanic and sedimentary strata rest directly on Proterozoic and Upper Cretaceous metamorphic and plutonic rock within the extensional corridor (Longwell, 1963; Anderson, 1971, 1977, 1978; Anderson and others, 1972; Frost and Martin, 1982; Sherrod and Nielson, 1993; Faulds, 1993a, 1993b). Paleozoic and Mesozoic strata were stripped away by erosion in Late Cretaceous and early Tertiary time.

Calc-alkalic magmatism and large-magnitude extension swept northward across the northern part of the corridor in early to late Miocene time (Glazner and Bartley, 1984; Gans and others, 1989; Armstrong and Ward, 1991; Faulds and others, 1994). Magmatism began 1 to 2 million years before extension and generally continued through most of the extensional episode. Thus, the corridor is dominated by highly fragmented, thick volcanic piles contained within complex arrays of tilted fault blocks. For example, directly east of the map area, large magnitude tilting and erosion have exposed a cross sectional view of the upper several kilometers of a major volcanic complex, which includes a preextensional stratovolcano and synextensional rhyolite dome complex (Faulds and others, 1995). The predominant north-northwest strike of both normal faults and layering in tilted fault blocks, as well as slip data (Anderson, 1971; Angelier and others, 1985; Anderson and others, 1994; J. E. Faulds, unpubl. data, 1994), indicate an east-northeast (about 75°) to east-west extension direction.

In the Mount Davis Quadrangle, the Miocene volcanic and sedimentary strata rest on Early Proterozoic orthogneiss and Upper Cretaceous (?) plutonic rock. An isolated exposure of quartzite that may represent an erosional remnant of the Cambrian Tapeats Sandstone does crop out, however, about 1 km south of the map area along the eastern shore of Lake Mohave. The Proterozoic and Late Cretaceous basement is significantly dilated by early to middle Miocene mafic to silicic dikes and plutons. The Copper Mountain pluton of probable Miocene age crops out in the extreme southwestern part of the map area. Granodiorite plutons of probable Miocene age are also exposed directly south of the map area along the western shore of Lake Mohave, 1 km south of Cottonwood Cove, and to the southeast of Mount Davis directly east of the quadrangle. On the eastern flank of Opal Mountain, a garnet-bearing, two-mica granite of possible late Cretaceous age and the basal part of the Miocene section are exposed. In ascending order, the Miocene section consists of (a) the prevolcanic, 0-20 m thick, conglomerate of Cottonwood Pass; (b) 0-20 m thick, 18.5 Ma Peach Springs Tuff; (c) 600-800 m of trachydacite and trachyandesite lavas and domes of the 18.5 to 15.8 Ma volcanics of Dixie Queen Mine; (d) up to 300 m of 16.1-15.9 Ma basaltic andesite flows of the volcanics of Fire Mountain; (e) up to 900 m of rhyolite lavas and tuffaceous rocks of the volcanics of Red Gap Mine, which range from about 16.0 to 14.5 Ma, (f) basaltic andesite flows of the Upper Part of the Patsy Mine Volcanics; (g) the 10-70 m thick, 15.2 Ma Tuff of Bridge Spring; (h) up to 1.3 km of the 15.2 to 12.8 Ma Mount Davis Volcanics, which include mafic lavas, conglomerate, and monolithologic megabreccia deposits of probable rock-avalanche origin; (i) basin-filling clastic strata of the alluvium of Cottonwood basin; and (j) the Chemehuevi Formation, which incorporates well rounded gravels, sands, and mudstones deposited by the ancestral Colorado River. The thickness of the Miocene section averages 3 km, but locally exceeds 4 km. The thickest sections occur in major half grabens developed during Miocene extension.

The structural framework of the area is dominated by steeply west-tilted fault blocks, which are bounded by east-dipping normal faults. The east-dipping normal fault system terminates in a major accommodation zone about 10 km to the north of the quadrangle (Faulds and others, 1990). Most of the fault blocks are

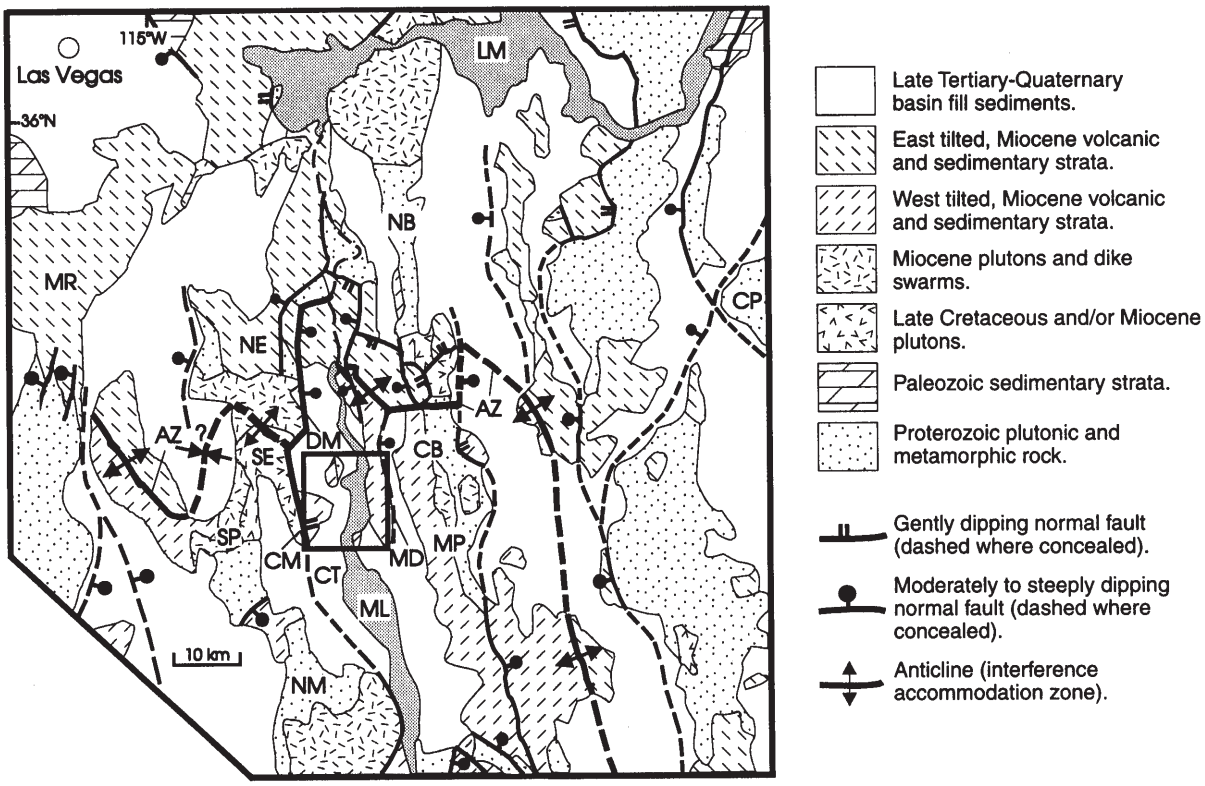

Figure 1. Generalized geologic map of the northern Colorado River extensional corridor (from Anderson, 1971, 1977, 1978; Faulds, 1993, 1995, and unpubl. data). The Mount Davis Quadrangle is blocked out in the central part of the map. AZ, Black Mountains accommodation zone; CB, central Black Mountains; CM, Copper Mountain; CP, Colorado Plateau; CT, Cottonwood basin; DM, Dupont Mountain fault zone; LM, Lake Mead; MD, Mount Davis fault; ML, Lake Mohave; MP, Mount Perkins block; MR, McCullough Range; NB, northern Black Mountains; NE, northern Eldorado Mountains; NM, Newberry Mountains; SE, southern Eldorado Mountains crystalline terrane; SP, Searchlight pluton.

tilted in excess of 70°. The dips of the faults range from gentle to steep. The more steeply dipping faults generally cut older, more gently dipping faults. Similar magnitudes of tilting within their hanging walls and footwalls indicate that most of the gently dipping faults nucleated at steep dips and were subsequently rotated to gentle dips as the intervening fault blocks were tilted. Younger sets of steeply dipping faults were probably generated as the older faults were rotated to inclinations unsuitable for accommodating normal slip. Cross-cutting relations between major steeply and gently dipping normal faults are shown schematically on the cross sections. Similar relations are well exposed northeast of the map area (Faulds, 1993a). Fault-bedding intersection angles (as measured downward from bedding to the fault) generally range from 70 to 90° but commonly exceed 90° where younger, more steeply dipping faults cut older, highly tilted strata. These relations imply that (a) most of the faults formed at dips in excess of 70° and (b) many of the faults developed after significant tilting had already occurred.

Similar magnitudes of tilting within the hanging walls and footwalls of individual faults also indicate relatively planar to slightly curved fault geometries. Fault-block tilting was probably accommodated by displacement on east-dipping normal faults, with a slight concave upward geometry, and domino-like tilting of the intervening fault blocks (Proffett, 1977). The concave upward geometries of some of the faults probably resulted in part from the upward propagation of individual faults at steep dips as deeper, older segments were progressively rotated to shallower dips. Tilting of the fault blocks at depth may have been accommodated along a subhorizontal discontinuity imaged at about 5 km depth on seismic reflection profiles 15 km east of the map area (J.E. Faulds and D. Okaya, unpubl. data). The amount of slip on the discontinuity has not been constrained but need not be significant.

The Mount Davis, Opal Mountain, and Dupont Mountain faults are the three most important faults within the map area. The Mount Davis and Opal Mountain faults are not exposed, but offset strata

suggest that each accommodated 2-5 km of throw. The gently east-dipping, Dupont Mountain fault zone accommodated the greatest amount of displacement (>10 km) in the region. It forms the eastern boundary of the large crystalline terrane of the southern Eldorado Mountains (fig. 1). A major strand of the fault surfaces in the southwestern part of the quadrangle. Mylonitized late Cretaceous (?) and Miocene granitoids occur along the Dupont Mountain fault zone directly west of the map area and contain asymmetric microstructures indicating a top-to-the-east sense of shear (Shaw and others, 1995). The estimated magnitude of displacement on the Dupont Mountain fault is based on a tentative correlation between the Copper Mountain and Searchlight plutons. The Copper Mountain pluton is sandwiched between two splays of the Dupont Mountain fault and may represent the beheaded upper part of the 16 Ma Searchlight pluton, which crops out 10 km west of the map area. The Dupont Mountain fault may link southward with major detachment faults (Faulds and others, 1992) and eastward with the major subhorizontal discontinuity noted at 5-6 km depth on nearby seismic reflection profiles. Some of the major normal faults within the map area may sole into the Dupont Mountain fault zone.

Major extension within the region is tightly bracketed between 15.8 and 11.3 Ma by $^{40}Ar/^{39}Ar$ ages of variably tilted volcanic strata within major growth-fault basins (Faulds and others, 1995). Tilts progressively decrease up-section from about 80 to 60° in the volcanics of Red Gap Mine, 60-15° in the Mount Davis Volcanics, and 15-0° in the alluvium of Cottonwood basin. The youngest of the most steeply tilted units consistently yields $^{40}Ar/^{39}Ar$ ages of 15.7-15.8 Ma, whereas capping flat-lying basalt flows overlying the alluvium of Cottonwood basin directly west of the map area are about 11.3 Ma. Peak extension occurred between 15.2 and 14.3 Ma when tilting rates ranged from 50° to 80°/Ma.

The bulk of the extensional episode is recorded by the Mount Davis Volcanics. Growth-fault relations, including fanning dips and westward thickening wedges of volcanic and sedimentary rock, are well developed throughout the entire section (see cross sections). In addition, clastic deposits within the Mount Davis Volcanics record the unroofing of the southern Eldorado Mountains crystalline terrane. For example, the abundance of clasts of plutonic and metamorphic rock derived from the southern Eldorado Mountains increases appreciably both to the west and up-section within the Mount Davis Volcanics. Each unit of poorly sorted, matrix supported conglomerate containing large amounts of plutonic and metamorphic clasts probably represents an alluvial fan deposit shed from the southern Eldorado Mountains. The crystalline terrane had clearly been exposed by approximately 14 Ma. In addition, large sheets of monolithologic breccia composed primarily of plutonic and metamorphic rock are intercalated within the Mount Davis Volcanics. These sheets of megabreccia probably represent rock-avalanche deposits (cf., Yarnold and Lombard, 1989) derived from oversteepened slopes in the rapidly rising crystalline terrane. Both the conglomerates and megabreccia sheets thicken significantly westward toward the crystalline terrane. It is noteworthy that megabreccias and abundant clasts of plutonic and metamorphic rock have not been observed east of the Colorado River within the Mount Davis Volcanics. The topographic depression currently utilized by the Colorado River, here referred to as the Cottonwood basin (cf., Fauld, 1995), had apparently developed relatively early during the episode of middle Miocene extension. Integration of the Cottonwood basin into the Colorado River drainage did not occur, however, until after extension had ceased, probably during late Miocene to early Pliocene time.

The evolution of the Colorado River is nicely recorded by the Chemehuevi Formation (cf., Longwell, 1963), which consists of interfingering rounded gravels, sands, silts, and mudstones. Within the map area, these deposits are flat-lying and unfaulted (with one exception). They are thickest near the present-day river, but do crop out as much as 135 m above and 4.2 km to either side of the river. The gravels and sands commonly have well developed primary structures, including pebble imbrication and cross beds. Although not studied systematically, these structures appear to indicate a southerly flow direction. The gravels are generally dominated by pebbles and cobbles of Paleozoic limestone, chert, and sandstone. The Grand Canyon is the most likely source for these clasts. Thus, the Chemehuevi Formation probably records much of the excavation of the Grand Canyon. Mudstones within the Chemehuevi Formation grade laterally into rounded gravels and sands, which suggests that they represent paleo-floodplain deposits of the Colorado River rather than either lacustrine deposits (Longwell, 1963) or possible marine sediments of the late Miocene to early Pliocene Bouse Formation (Buising, 1990).

The Chemehuevi Formation interfingers with locally derived fanglomerates of the alluvium of Cottonwood basin. In some cases, rounded gravels within the Chemehuevi Formation fill channels cut into the fanglomerates, whereas some of the fanglomerates fill channels cut into the river gravels. In many areas, two sequences of river gravels are separated by a thin layer of fanglomerate. The intervening sequence of fanglomerates generally pinches out near Lake Mohave such that the two sequences of river deposits merge into one. In a few cases, however, individual sheets of the intercalated fanglomerate crop out on both sides of Lake Mohave. For example, thin sheets of fanglomerate, which are dominated by clasts of plutonic rock derived from the southern Eldorado Mountains, are sandwiched between sequences of river gravels along

the eastern shore of Lake Mohave and clearly correlate with similar fanglomerates to the west of the lake. A possible interpretation for these relations is that an early vigorous river system nearly died out allowing alluvial fans to prograde across the basin. This may have been induced by climatic changes or possibly by damming of the Colorado River by Quaternary basalt flows in the Toroweap area of the Grand Canyon. Alternatively, such relations may have been produced by progradation of individual alluvial fans across the central part of the basin while the Colorado River flowed through a now abandoned channel east of its present-day course.

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