Plate 3: Explanation

SYMBOLS

strike and dip of bedding
▲ Ar/Ar date

Contacts

Fault
exposed approx. inferred

Primary contact
exposed approx. inferred

Sedimentary facies boundary
sharp
gradational

Fold axial trace
anticline
syncline

Line of Cross Section
A A′

DESCRIPTION OF MAP UNITS

PLIOCENE-QUATERNARY UNITS

Quaternary Deposits: Unconsolidated to poorly consolidated sediments representing young surficial deposits.

Qal	**Quaternary alluvium:** Unconsolidated to weakly caliche cemented alluvial gravels and fan gravels. Locally includes thick colluvial slope wash, but generally includes only deposits in channels of ephemeral streams.
Qp	**Quaternary playa:** Silty to clay rich lacustrine deposits in ephemeral playa lakes. Locally includes gypsiferous and halite bearing evaporite deposits. In the Crystal Hills evaporites and associated lacustrine clays mapped as this unit are entrenched by headward erosion of streams and are probably late Pleistocene or older in age.
Qt	**Quaternary talus:** Talus and coarse colluvial slope deposits.
Qoal	**Quaternary older alluvium:** Unconsolidated to weakly caliche cemented alluvial gravels and fan gravels. Distinguished from Qal by either well developed desert varnish surfaces, entrenchment by younger gullies, or both. Locally cut by Quaternary faults in upper Wingate Wash, but generally depositional on older bedrock.

Quaternary-Tertiary Deposits: Generally flat lying to gently tilted deposits, typically resting with angular unconformity on older, tilted units. Generally poorly consolidated and entrenched fans, but deposits in central Wingate Wash may represent older Tertiary (Miocene) deposits.

QTu	**Quaternary-Tertiary undivided:** Undifferentiated, poorly consolidated but entrenched surficial deposits.
QTg	**Quaternary-Tertiary gravels undivided:** Scattered occurrence of poorly consolidated gravels that are not clearly part of the Miocene stratigraphic sequence and appear to be younger deposits. In central Wingate Wash these deposits are faulted and gently tilted along young faults, but it is unclear if this is an age difference or due to greater Quaternary faulting in that area.
QTaf	**Quaternary/Tertiary alluvial fan:** Undeformed alluvial fan deposits exhumed by erosion and now isolated as concordant, flat-lying deposits on accordant ridge tops or mesas in lower Wingate Wash. Includes moderately sorted gravels and sands interlayed with poorly sorted debris flow deposits. The base of these deposits is locally exposed and they typically lie with angular unconformity on older tilted gravels, volcanic rocks, or pre-Tertiary basement. These deposits are primarily present in two areas. North of Wingate Wash a large older-fan complex lies atop older tilted gravels and volcanics, and slope wash from these younger alluvial fan deposits typically obscures relationships in the underlying rocks. To the south of Wingate Wash a second fan complex emanates from the mouth of Confusion Canyon and clearly overlies older deposits with angular unconformity to the west, but is entrenched by young drainages or buried in younger alluvial deposits in the east.
QTgw	**Quaternary-Tertiary gravels west:** Upper, flat-lying gravels forming accordant summits and small mesas along the south slope of the Panamint Mountains. Mostly consists of coarse, variably cemented gravels interbedded with poorly sorted sandy conglomerates that are interpreted as entrenched alluvial fan deposits.

Fault Rocks (Tertiary, Quaternary, or Both)

C	**cataclasitic rocks:** Variably hydrothermally altered fault rocks, mapped locally where cataclasite development forms a mappable unit at the northern end of the radio tower range. Most of the rocks are coarse, featureless cataclasites, but locally fine grained fault gouges occur near the center of the fault zones.

MIOCENE SEDIMENTARY, VOLCANIC, AND INTRUSIVE ROCKS

The most extensive rock units of the mapped area are Miocene in age based on geochronology reported in Golding-Luckow et al. (2005). The volcanic rocks were deposited on a profound unconformity that was a surface of significant paleo-topography. The unconformity surface in most areas is a nonconformity with volcanic rocks resting directly upon Mesozoic crystalline rocks, predominantly granitoids but locally by screens of metamorphic rock. In the southwestern Panamint Mountains, however, the contact is an angular unconformity with volcanic rocks resting on unmetamorphosed Cambrian sedimentary rocks. Similarly, in the southeastern Panamint Mountains, two angular unconformities separate unmetamorphosed Proterozoic Crystal Springs and Kingston Peak formation from volcanic rocks, and a second angular unconformity separates both of these units from Tertiary gravels (Plate 1). A few thin patches of older sedimentary rocks were observed along the Miocene unconformity (Tos), notably in the northeastern Owlshead Mountains and the southern part of the radio tower range, but elsewhere Miocene volcanic rocks lie directly on a paleosol surface at the unconformity.

The general stratigraphic relationships of the Miocene deposits are summarized in Plate 2 as partial and composite sections. The Miocene deposits can be divided into 5 assemblages that are stratigraphically distinct, but not necessarily distinct in age: (1) the Lost Lake assemblage; (2) younger sedimentary rocks of Upper Wingate Wash; (3) the Sedimentary/Volcanic assemblage of Lower Wingate Wash; (4) the Sedimentary/Volcanic assemblage of Brown Mountain/Crystal Hills; and (5) the Lower Volcanic assemblage. The first two of these assemblages are clearly younger sedimentary basins that were deposited atop the Miocene volcanic pile, and in lower Wingate Wash volcanism continued through the time of deposition constraining the age of the deposits to younger than ~13 Ma (Golding-Luckow et al., 2005). The Sedimentary/Volcanic assemblage of Lower Wingate Wash as well as the Sedimentary/Volcanic assemblage of Brown Mountain/Crystal Hills contains fanglomerate deposits that superficially are indistinguishable from the younger fanglomerate assemblages (1 and 2) but in both of these areas interbedded volcanic units constrain the gravels as older than 13-14 Ma and indistinguishable in age from the Lower Volcanic assemblage (Golding-Luckow et al., 2005).

Our general interpretation of the Miocene history is that the sparse geochronology data is not sufficient to clearly resolve the depositional details of rocks that were deposited in as little as 1 m.y. and no more than 2 m.y. Specifically, although the available geochronology data has low analytical errors and the ages are very precise, the materials dated range from low-K whole rock basalts to mineral separates from high-K phases, and the paradoxical age relationships described by Golding-Luckow et al. (2005) are probably a result of variability in accuracy of dates from different materials. Thus, in this map explanation we emphasize field relationships over apparent age relationships from geochronology, and hopefully future geochronological studies will solve the unresolved age issues.

Golding-Luckow et al. (2005) showed that the Lower Volcanic assemblage is entirely 13-14 Ma in age and always depositionally underlies the younger assemblages. However, the character of these rocks varies across the region and we recognize four distinct structural/stratigraphic domains within these rocks:

Domain 1: Southern Panamint Mountains, north of the Wingate Wash fault.

Domain 2: Lower Wingate Wash and the northeastern Owlshead Mountains, between the approximate trace of the Wingate Wash fault and a NS trending high angle fault that Golding-Luckow et al. (2005) referred to as the "Filtonny fault".

Domain 3: The north-central Owlshead Mountains bounded to the north by the Wingate Wash fault, to the east by the Domain 2 boundary and with an arbitrary western edge in the central radio tower range.

Domain 4: Upper Wingate Wash south of the Wingate Wash fault, including the Brown Mountain area, Crystal Hills, and southern part of the radio tower range.

These domains are equivalent to the divisions made by Golding-Luckow et al. (2005) and the reader is referred to that paper for more details. The principal distinctions are that the deposits in Domain 1 can all be clearly linked to proximity to a large volcanic center that was located just to the east of what is now Sugarloaf Peak. Domain 2, in contrast, contains the Sedimentary/Volcanic assemblage of lower Wingate Wash and the Lost Lake assemblage with the underlying Lower Volcanic assemblage dominated by distal pyroclastic rocks—pyroclastic flows, lahars, and debris flows with few lava flows. Domain 3 is characterized by a basal section of distal to proximal facies pyroclastic rocks with interbedded flows overlain by a thick section of basanites and basalts abruptly overlain by the Lost Lake assemblage. Finally, Domain 4 is a somewhat arbitrary division separating the more poorly known volcanic assemblage of Brown Mountain and the southern radio tower range; these rocks are probably simple lateral equivalents of Domain 3, but geochronology and geochemistry are sparse in this domain, hence, we separate the rocks here.

The domain distinctions are important in analyzing the geologic map because these divisions are shown with a numerical ending to the rock label (e.g., Tvb3 is basaltic rock in Domain 3) or in the case of Domain 1, no number in the label (e.g., Tvr is a rhyolitic rock in Domain 1). For descriptive purposes, however, we have lumped equivalent lithologic types under the same rock descriptions below. Plate 2 shows an equivalency chart to clarify the lithologic units on the map. It is important to note the rock descriptions are presented in alphabetical order and there is no chronologic significance to the order of the description. Readers should refer to Plate 1 for clarification of the stratigraphic context of some of these rock units in a given locality.

Younger Tertiary Sedimentary and Volcanic Rocks of Lower Wingate Wash: The Lost Lake Assemblage

General features: A distinct sedimentary and volcanic assemblage lies at the top of the Tertiary section in lower Wingate Wash, and was referred to as the Lost Lake assemblage by Golding-Luckow et al. (2005) after well exposed sections at the northern end of the Lost Lake Valley. This basinal assemblage is dominated by coarse alluvial fan deposits but contains interbeds of Miocene volcanic and volcanogenic deposits. The base of this assemblage is well exposed throughout the northern Owlshead Mountains where it is clearly an unconformity ranging from a disconformity between sediments and older volcanics to a low-angle angular unconformity. The absence of these deposits west of the radio tower range and the close spatial association between these deposits and the entrenched northern edge of the Lost Lake Valley suggest these rocks were originally deposited in a west-tilted half-graben that extended from the Lost Lake Valley northward to at least the Wingate Wash fault. The northern edge of this basin is now truncated by younger structures along the Wingate Wash fault system, but details of this structural relationship are obscured by younger fan gravels (QTaf).

Tgu Tg2 Tg1	**Tgu: Tertiary Gravels undivided —Tg2: upper gravel; Tg1: lower gravel:** Moderately to well cemented coarse sandstone to boulder conglomerate/diamictite interpreted as Tertiary fanglomerate deposits. Generally buff to light brown weathering, but locally reddish colored due to basaltic cinder interbeds, oxidation by fluids, or both. Mostly moderately well-sorted, moderately rounded conglomerate interbedded at 0.5-2 m intervals with poorly sorted matrix-supported conglomerate/diamictite. The latter are inferred to be debris flow intervals and the former alluvial intervals in an alluvial fan complex. Rocks are interbedded with volcanic rocks including coarse volcanic megabreccia (landslide deposits?) sheets, mudflows, and volcanic flows. Interbedded ash near the base of the unit was correlated to a 12.07 Ma tuff and is consistent with a 12.74 Ma basalt immediately beneath the deposits just north of Lost Lake Valley. However, in lower Wingate Wash, rocks mapped as the same unit (Tgu) are interbedded with a rhyolite flow and basalt flow that both yielded apparent ages >13.6 Ma. Thus, either this unit comprises two distinct assemblages or the absolute ages suffer from unknown errors. Here we preserve the map correlations and presume future studies will clarify the absolute age issues. At the northern edge of the Lost Lake Valley, Quaternary entrenchment by headward erosion from Wingate Wash allows resolution of two distinct subunits within these deposits: a lower gravel (Tg1) comprised exclusively of clasts derived from the underlying volcanic pile and an upper gravel (Tg2) containing clasts derived from the Mesozoic granitic basement complex, principally granite clasts, that increase in abundance upward within the section and record successive unroofing of the Owlshead ranges. Clasts of pre-Tertiary basement are also present in the unit north of Wingate Wash and along the base of the unit in one area south of Wingate Wash, but stratigraphic position of these sites relative to the Lost Lake section is unclear.
Tvyb	**Tvyb: younger basaltic volcanic rocks:** Olivine basalts and basaltic cinder interbedded with the Tertiary gravel deposits (Tgu). Includes dense black vessicular olivine basalt and porphyritic basalt with large plagioclase phenocrysts restricted to small flows interbedded within Tertiary gravels (Tgu) north of Wingate Wash, and a large basaltic complex faulted against, but probably in depositional continuity with, the Tertiary gravels south of Wingate Wash. One of the basalt flows from north of Wingate Wash yielded a ~13.6 Ma Ar/Ar date on a plagioclase separate and is one of the paradoxical age relationships.
Tvmfm	**Tvmfm: mudflow marker unit:** Light gray weathering pebbly mudstone interbedded within Tertiary gravels (Tgu) and interpreted as a mudflow deposit. Clasts exclusively volcanic rocks ranging from 0.05-0.3 m in diameter.
Tvmb	**Tvmb: volcanogenic megabreccia deposit:** Trachydacite to rhyolitic megabreccia interbedded with Tertiary gravels (Tgu) and interpreted as a volcanogenic rock avalanche deposit into the basinal sequence. Unit coarsens upward from matrix dominated silt to sand-size matrix materials at the base to chaotic boulder-size fragments up to 10 m at the top of the unit.
Tvrmb	**Tvrmb: rhyolitic volcanogenic megabreccia:** 2-6 m thick, white, rhyolitic megabreccia marker unit north of Wingate Wash. Monolithologic breccia derived from a distinctive white rhyolite-porphyry with larger clasts (2 cm to 50 cm) in a pulverized sandy matrix. Unit is clearly interbedded with Tgu and is interpreted as a rock avalanche into the sedimentary basin.
Tvbvu	**Tvbvu: basinal volcanic rocks undivided:** Mostly trachyandesite to rhyodacitic flows and flow-breccias in uncertain contact relationship with Tertiary gravels (Tgu). Some of these rocks are clearly interbedded with unit Tgu and one such unit yielded a 13.94 Ma Ar/Ar date on biotite consistent with the date from the stratigraphically overlying basaltic rock, but paradoxically much older than similar rocks immediately to the west. Most of these rocks, however, show depositionally overlying gravels, but do not clearly lie on gravels. Thus, because of structural complexity in the floor of Wingate Wash it is possible that some of these rocks may represent part of the older volcanic assemblage beneath the Tertiary gravel (Tgu) unit. Nonetheless, we consider this interpretation unlikely due to the general north-dip of units in the northern Owlshead Mountains, and most, if not all, of these rocks are probably flows within the sedimentary basin; presumably an older part of that basin.

Younger Sedimentary Rocks of Upper Wingate Wash

Gently south-tilted gravels and sandstones lie with weak angular unconformity on the Lower Volcanic assemblage north of upper Wingate Wash. No ash beds or interbedded volcanic rocks were observed within this unit and thus, its age is unconstrained. Nonetheless, the units are probably age equivalents to the Lost Lake assemblage based on stratigraphic position.

Tgw	**Tgw: Tertiary gravel west:** Coarse clastic deposits exposed in the southwestern Panamint Mountains. Cobble to boulder conglomerate interbedded with boulder mudstone and sandstone representing alluvial and debris flow intervals in alluvial fan deposits. Clasts in this unit are exclusively derived from underlying Miocene volcanics. Unit fines both upward and southward and shows gradational intertonguing contacts with the sandy conglomerate unit (Tsw). Thus, the basin margin for this sequence was probably located to the north or northwest of this assemblage and the center of the basin was to the south or southeast.
Tsw	**Tsw: Tertiary sandy conglomerate west:** Coarse sand to pebbly sand deposits interbedded with pebble to cobble conglomerate in the southwestern Panamint Mountains. Unit shows gradational lateral contact relationships with the gravel unit (Tgn).

Younger Tertiary Sedimentary/Volcanic Rocks of Brown Mountain/Crystal Hills

Weakly deformed to undeformed sedimentary rocks with local interbeds of volcanic rock overlie Miocene volcanic rocks in the Crystal Hills and appear to correlate with similar deposits north of Brown Mountain, just east of Wingate Pass. The base of this assemblage is only exposed in the Crystal Hills where the sedimentary assemblage clearly lies unconformably on highly altered volcanic rocks. In the Crystal Hills these sedimentary rocks are clearly Miocene in age because they are locally overlain by a trachyandesite flow dated at ~13.2 Ma by Ar/Ar (F. Monestero, personal communication, cited in Golding-Luckow et al., 2005).

Tvta	**Tvta: Tertiary volcanic trachyandesitic porphyry:** Distinctive andesitic porphyry with dark, glassy groundmass and light feldspar phenocrysts. Rock is exposed within the Crystal Hills and deposited within the gravels of unit Tgs which is itself deposited unconformably on the older, altered volcanic rocks. Dating by F. Monestero (personal communication, 1999) establishes a narrow age range for these volcanic rocks (see above) and the associated sedimentary deposits. Ar/Ar chronology on this unit yielded a 13.19 +/- 0.24 Ma 40Ar/39Ar date (F. Monestero, personal communication to T. Pavlis, 1999).
Tgs	**Tgs: Tertiary gravel south:** Light brown to gray pebble to cobble conglomerate interbedded with cobbly mudstone or cobbly sandstone representing alluvial fan gravels. In the Crystal Hills these rocks lie unconformably on older altered volcanic rocks, but are also interbedded with volcanic rocks including debris flows that are probably volcanogenic. In the central Crystal Hills, a trachyandesitic porphyry lies atop the exposed section and was dated at 13.19 Ma (unit Tvta, described above) whereas a rhyodacite porphyry along the base of the unit yielded an Ar/Ar date of 13.23 +/- 0.43 Ma (F. Monestero, personal communication to T. Pavlis, 1999). Thus, this unit apparently was deposited over a short time interval in the Crystal Hills. Near Wingate Pass rocks correlated with this unit depositionally overlie fine grained lacustrine(?) sediments of uncertain age. No clasts other than volcanic clasts from the underlying volcanic assemblage were observed in any of these sedimentary sections.
Trac	**Trac: rock avalanche deposit of the Crystal Hills:** Stratabound volcanic breccia horizon within Tertiary gravels (Tgs) in the Crystal Hills. Clay to sand-sized gouge layer along the base implies the rocks are a rock avalanche deposit into the sedimentary package.
Tms	**Tms: Tertiary mudstone and siltstone south:** Light brown to buff weathering mudstone and siltstone exposed along the front of Brown Mountain. The unit apparently contains montmorillonitic clays based on the characteristic popcorn weathering surfaces developed on the unit. This rock unit probably represents lacustrine deposits with clastic components derived from adjacent volcanic rocks.

Older (?) Sedimentary/Volcanic Assemblage of Lower Wingate Wash

The lower Wingate Wash assemblage represents the middle part of the stratigraphic sequence in lower Wingate Wash in that it is clearly overlain by Tertiary gravels (Tgu), but is generally in fault contact with volcanic units of the Lower Volcanic assemblage in the northern Owlshead Mountains. Thus, this unit, along with overlying rock gravels (Tgu) and associated volcanics, are part of the paradoxical association discussed by Golding-Luckow et al. (2005). This assemblage (described in this section) shows complex lateral facies changes and lack of continuity of units beneath overlying gravels producing major uncertainties in correlations of rock units across the area. Most of these rocks are probably localized basins developed within the volcanic terrain during the volcanism that produced the Owlshead and southern Panamint volcanic assemblages.

Tls	**Tertiary Limestone:** Light brown to buff weathering limestone and cherty limestone of lower Wingate Wash. Unit contains a few light brown to buff weathering limestone and cherty limestone of lower Wingate Wash. Unit contains a few imprints of terrestrial plants, algal mats, or both. The unit also grades laterally into lacustrine mudstones and overlies a mudflow unit. Very localized occurrence of this unit, together with intense veining, suggests these rocks are primarily a hot springs deposit, but initial deposition as saline lake deposits is also possible.
Ts	**Tertiary sediments:** Fine-grained sandstone to siltstone deposits interbedded locally with white volcanic ash and black basaltic tephra. Thin to medium bedding is characteristic with graded bedding common, suggesting these are predominantly lacustrine deposits. In lower Wingate Wash these deposits are white to light gray and appear to be laterally equivalent to, and interbedded with, the Tertiary limestone deposits. In central Wingate Wash at the northern end of Lost Lake Valley, rocks mapped as this unit are in an equivalent stratigraphic position but correlation is highly uncertain and available age data suggest large differences in age. This central Wingate Wash assemblage contains similar white to light-gray deposits with interbedded siliceous hot spring deposits, but also contains overlying basaltic volcanic rocks and light brown to pinkish brown weathering siltstones and sands that do not occur in lower Wingate Wash. Morever, the central Wingate Wash assemblage contains an interbedded volcanic ash within the light-gray siltstones that Wagner and Hsu (1988) reported as a 12.07 Ma ash bed based on tephrochronology correlations. Thus, in central Wingate Wash these rocks appear to be part of the Lost Lake assemblage whereas in lower Wingate Wash rocks mapped as this unit may be much older (>13.6 Ma).
Tvhs	**Tertiary volcanic hot spring deposits:** Chert and associated hydrothermal deposits primarily representing siliceous hot spring deposits. Locally includes travertine or manganiferous chert but generally these deposits are too small to map at 1:24,000.
Tvmfg	**Tertiary volcanogenic mudflow and gravel:** Distinctive mudflow marker horizon in middle Sedimentary/Volcanic assemblage. Polymict pebble to boulder size clasts in a pumice rich, muddy matrix.

Lower Volcanic Assemblage

Intrusive Rocks

Tib	**basaltic intrusives:** Dark gray to black aphanitic to fine-grained porphyritic mafic intrusives. Mostly restricted to small dikes. Occurs as an extensive dike swarm in the radio tower range, but also occurs extensively in the northern Owlshead Mountains where dikes represent feeders to a thick series of basaltic to basanitic flows. Ar/Ar dating of these dikes yielded two dates 13.35 and 13.56 Ma (Guest, 2000).
Tir	**rhyodacite/trachydacite intrusives:** White to pinkish colored, variably porphyritic silicic intrusive rocks largely restricted to small to moderate size dikes cutting the intrusive center and surrounding rocks, but also occurring as larger intrusions in the northwest part of the mapped area, near Myers Ranch. Smaller silicic dikes also occur in the radio tower range and locally produce a dike swarm. Elsewhere the unit is restricted to a few small dikes and plugs. Most of the silicic intrusions are porphyritic but some are glassy, aphanitic rocks. Locally these units are difficult to distinguish from rhyolitic domes, with which they undoubtedly are gradational. One dike from the Sugarloaf volcanic center yielded an Ar/Ar age of 13.65 Ma (Luckow et al., 2005).
Tiar	**altered rhyolitic intrusives:** Highly altered rhyolitic(?) intrusive rocks within the Sugarloaf volcanic center. Alteration is sufficiently intense that original composition of the rock is uncertain due to intense silicification producing a white, bleached aphanitic rock.
Tig	**coarse-grained granite:** Restricted to a small body in the SE corner of the Sugarloaf intrusive center, this rock intrudes the fine grained granite, but is very coarse grained and resembles older Mesozoic granitoids more closely than the Tertiary assemblage, despite its clear cross-cutting relationship. Origin of the unusual grain size is unknown.
Tigp	**porphyritic biotite granite and rhyolite porphyry:** White to light gray, hypabyssal intrusive rocks ranging from holocrystalline fine-grained granite to porphyritic rhyolite cropping out in the Sugarloaf volcanic center. Variably altered by hydrothermal alteration but generally relatively unaltered compared to other intrusives in the Sugarloaf center. Within the Sugarloaf intrusive center rocks of this type are the youngest large intrusions and these intrusions are only cut by thin dikes.
Tidr	**trachydacite/rhyolitic intrusives:** Older, white to light gray, variably altered silicic intrusives. Typically fine-grained, moderately to strongly altered silicic intrusives, primarily as a large intrusive body along the western side of the Sugarloaf intrusive center. Probably the altered, fine-grained equivalent of unit Tigp.
Tia	**andesitic/trachyandesite intrusives:** Mostly highly altered intermediate plutonic rocks within the Sugarloaf intrusive center and related intermediate intrusives in surrounding rocks. A few scattered intrusions of this composition also occur throughout the mapped area. Within the Sugarloaf center the original mineralogy of these rocks is virtually obliterated by hydrothermal alteration, and most exposures are rubble covered. Where fresher rocks are present these rocks are typically either amphibole or pyroxene bearing porphyries with finer grained plagioclase phenocrysts, but grain size is highly variable. The rock appears to grade laterally into fine grained dioritic intrusives (unit Timd) suggesting these microdiorites are less altered equivalents that cooled more slowly than these andesitic porphyries.
Tiap	**andesitic/trachyandesitic porphyry:** Brown to dark gray weathering, porphyritic trachyandesitic intrusions occurring primarily in the northwest part of the mapped area as large dikes and a small stock near Myers Ranch.
Timd	**microdiorite:** Variably altered dark gray to greenish gray microdiorite and andesite porphyry within the Sugarloaf volcanic center. Generally holocrystalline with 2-3 mm amphiboles and plagioclase intergrown in a granitic texture. Grades laterally into andesitic intrusives (Tia) in the Sugarloaf volcanic center.

Pyroclastic Rocks

Tvpu	**Tvpu, Tvpu2, Tvpu3, Tvpu4: proximal facies pyroclastic rocks undivided:** Coarse pyroclastic rocks representing various combinations of pyroclastic flows, rock avalanches, and debris flows. In the Sugarloaf volcanic center the unit is conspicuously layered due to interbedding of pyroclastic units with flows, but elsewhere the unit is generally a distinct layer of coarse pyroclastic rocks, typically clast supported breccias or poorly sorted matrix supported breccias.
Tvav4	**Tvav4: altered volcanic rocks:** Intensely hydrothermally altered volcanic rocks of the Crystal Hills and western radio tower range (or RTR—informal name, see map). White, buff, and pink weathering rocks of unknown original composition, but clearly of volcanic protolith are characteristic. Large selenite crystals are common within this and the associated sedimentary(?) unit (Tvs4) and appear to be derived from hydrothermal veins, although poor exposure precludes a clear inference of the origin of the gypsum. Silicified zones are common within the complex and are relatively well exposed, but most rocks are poorly exposed, montmorillonitic-rich clays that weather to a thick surface-weathered layer that handicaps recognition of the major features of the rock.
Tvbb	**Tvbb, Tvbb3: basaltic breccia:** Poorly sorted, commonly partially to entirely clast supported breccia with clasts and matrix developed exclusively from basalt to basaltic andesitic compositions. Angular to weakly rounded clasts range to boulder size. Most rocks mapped as this unit probably represent proximal debris flow deposits or rock avalanche deposits, but some may represent flow breccias or AA lava flows.
Tvpbc3	**Tvpbc3: pyroclastic basaltic cinder:** Red to dark reddish brown to black scoriaceous, fragmental basalt; fragments from sand size to pebble, with dominance of pebble size fragments; locally contains basaltic "bombs" cemented into the matrix. Map pattern and presence of bombs clearly indicates these deposits are lithified basaltic cinder cone deposits. Primary deposits are within a large basanitic basalt volcanic pile at the northern edge of the Owlsbeak range (informal name, see map) where they form two approximately circular features interpreted as buried cinder cones and a sheet-like deposit just below gravel deposits of the Lost Lake assemblage.
Tvbdf	**Tvbdf, Tvbdf2, Tvbdf3: volcanogenic basaltic debris flows:** Volcanogenic diamictite containing 30-50% muddy to sandy matrix of variable composition and subrounded to rounded clasts of trachybasalt to trachyandesitic composition. Matrix contains abundant ash in some debris flows, but generally the matrix is polymict where clast sizes are large enough to distinguish composition. Reverse grading common with moderate clast supported rocks near base and matrix supported diamictite near the top of individual units.
Tvdf	**Tvdf, Tvdf2, Tvdf3, Tvdf4: volcanogenic debris flow:** Volcanogenic diamictite with 30-50% muddy to sandy matrix and moderately rounded polymict volcanic clasts, typically ranging in size from pebble to boulder sizes. Matrix variable in composition with ash common as a dominant component in many debris flows, particularly in the northern Owlshead Mountains. Reverse grading common with moderate clast supported rocks near base and matrix supported diamictite near the top of individual units.
Tvl	**Tvl, Tvl2, Tvl3, Tvl4: lahar deposits:** Volcanic diamictite with >50% muddy matrix supporting polymict clasts of other volcanic lithologies. Most show a gray to grayish brown muddy-sand matrix with clast sizes ranging from a few centimeters to ~1 m typical. Distinguished from debris flows by dominance of matrix over clasts.
Tvlt	**Tvlt, Tvlt2, Tvlt3, Tvlt4: white rhyolitic lithic tuff:** White pumice rich, lithic tuff, and associated rocks. Map unit contains a variety of ash layers ranging from reworked, water-lain ash deposits, ashfall-tuff, and tuffaceous matrix debris flows lumped together based on easy mapping of white, pumice rich layers. Many of these deposits occur in distinct channels and are discontinuous. One thick unit occurs throughout most of the area away from the Sugarloaf volcanic center ~100 m from the base of the section and forms a regional tuff that is prominent in the Owlshead Mountains.
Tvrdf	**Tvrdf: volcanogenic rhyodacitic debris flow:** Volcanogenic diamictite similar to unit Tvdf except clast types are entirely rhyolitic to dacitic in composition. Glassy clasts are typical in these units. Most probably represent pyroclastic flows, but some are probably low-temperature debris flows.
Tvrb	**Tvrb, Tvrb3, Tvrb4: rhyolitic breccia:** Pebble to boulder sized, clast supported monolithologic breccia comprised of rhyolite to dacite clasts. The unit near Brown Mountain is in close proximity to a subcircular rhyolite area that probably represents a rhyolite dome, and brecciation of this unit probably is related to the dome. Elsewhere most of these breccias are probably predominantly rock avalanche deposits.
Tvs	**Tvs, Tvs4: volcanogenic sedimentary rocks:** Well bedded volcanogenic sedimentary rocks including water-lain tuffs, volcanic sandstone and volcanic conglomerate. Tvs is distinguished by well-developed stratification, commonly in distinct channels, and sorting indicative of water-lain deposits. In the Crystal Hills this unit (Tvs4) includes poorly exposed buff to brown clay-rich rocks that are possibly equivalent to unit Tms along the Brown Mountain front, but correlation is unclear. This unit (Tvs4) superficially is similar to Tvav4, but rocks either appear to be stratified, contain no obvious volcanic materials, or both. Rocks of Tvs4 probably represent secondary sedimentary deposits near surface hydrothermal systems, that is, local lacustrine deposits within a hydrothermal field with clays derived from adjacent altered volcanic rocks.
Tvtl3	**Tvtl3: tuffaceous lahar:** Volcanic diamictite with muddy matrix dominated by white to light gray pumice. Typically contains polymict clasts but clasts represent <50% of the rock.

Volcanic Flow and Undifferentiated Units

Tvu	**Tvu, Tvu2, Tvu3, Tvu4: volcanic rocks undivided**
Tva	**Tva: andesitic rocks:** Aphanitic gray to brownish gray andesite and trachyandesite.
Tvab	**Tvab2, Tvab3: trachyandesitic to basaltic trachyandesite:** Aphanitic dark gray to dark brown, commonly vesicular flows; commonly with brecciated margins or flow tops.
Tvb	**Tvb, Tvb2, Tvb3: basalt:** Dark gray to black, typically vesicular basalt, basanite, and trachybasalt. Thick flows in Domain 3 just below Tgu are dominantly basanites and alkali basalts, many with distinctive olivine phenocrysts. Elsewhere rocks mapped as this unit are typically more silicic, and are basaltic trachyandesites.
Tvbp	**Tvbp: basaltic porphyry:** Dark gray to black porphyritic basalt and basaltic andesite with 1-3 mm phenocrysts, typically feldspar. Chemical analyses indicate that most of these basalts are trachybasalts and basaltic trachyandesites.
Tvbr	**Tvbr, Tvbr2, Tvbr3, Tvbr4: flow-banded rhyolite:** Generally glassy, strongly foliated rhyolite and trachyte with foliation produced by conspicuous flow-banding. Commonly flow-banding is also folded into tight to isoclinal folds, and commonly lies at the base of flows or along the margins of large bodies inferred to be rhyolitic domes. One massive body of banded rhyolite north of Long Hills in upper Wingate Wash is almost certainly a rhyolite dome, as are similar deposits just to the east. Similarly, north of Brown Mountain a large rhyodacite body forms a roughly circular outcrop trace and has flow-banded rhyolites along is margins. Although many flow-banded rhyolites represent ash-flow tuffs, none of these deposits seem to fit characteristics for ash-flow deposits.
Tvr	**Tvr; Tvr3, Tvr4: rhyolite porphry: rhyolitic to dacitic/trachytic flows:** Locally may include flow breccias, but typically massive gray to purplish gray felsic porphyries with K-spar and quartz phenocrysts. One large mass west of Sugarloaf Peak is largely black to red obsidian, but generally partial devitrification is conspicuous. This unit is mostly restricted to large masses that probably represent rhyolitic dome complexes built on the flanks of the larger volcanic edifice.
Tvt	**Tvt, Tvt2, Tvt3: dacite/trachyte:** Massive to glassy, light gray to purplish gray flows, commonly with significant brecciation near tops, bases, or both. Geochemically all of these units appear to be trachytes, but some could be dacitic. Not all units were analyzed and some of these units are probably rhyolitic.
Tvad3	**Tvad3: andesitic/dacitic rock:** Andesitic to dacitic rocks undivided.

Pre-Miocene Sedimentary and Volcanic Rocks

Tos	**Tos: older sedimentary rocks:** Two older sedimentary rock localities were observed along the unconformity at the base of the Miocene section: in the northeastern Owlshead Mountains, and in the south-central part of the radio tower range. The Owlshead section is the most distinctive of the two with 1-20 m of red sandstone and conglomerate. These deposits appear to be fluvial conglomerate and sandstone based on moderate sorting, rounding, and development of moderate scale cross-stratification and channelized layering. The clasts in the conglomerate are diverse but are notable in the lack of significant volcanic components, with a predominance of polished, typically broken, quartzite clasts. The rock is very similar in appearance to the Titus Canyon Formation (see photos in accompanying geodatabase) with the unusual broken and polished clasts, and we tentatively correlate the unit with the Titus Canyon Formation. The other exposure of older material is poorly exposed and less distinctive, with a 2-3 m thick laminated silty to porcellanitic deposit. This rock unit is probably an early volcanic unit, but its origin is unclear and it could also represent a lacustrine deposit.
MzTv	**MzTv: Mesozoic or older Tertiary distal volcaniclastic rocks:** This suite of volcaniclastic sedimentary rocks includes: very fine grained one to two meter thick, white, cross-bedded, water-lain ash beds; thin to decimeter scale beds of interbedded purple, red and green, pebble conglomerate, sandstone, siltstone, and shale layers. All of these rocks have undergone contact metamorphism and are limited to small, laterally discontinuous exposures at the southern end of the radio tower range. A Mesozoic age is implied by the discordant contacts suggesting the rocks may be older than adjacent intrusives. Exposure is poor, however, and it is possible these rocks are fault bounded exposures of Tertiary volcanic rocks.

PRE-TERTIARY ROCKS

Mesozoic Intrusive Rocks

Kg	**Kg: granite undivided:** Pink to light gray biotite granite of the eastern Owlshead Mountains. Commonly medium to coarse grained megacrystic granite comprised of 20-30% quartz, 20-40% K-feldspar, 20-30% plagioclase, and ~10% biotite. **Kgr1:** Generally referred to as "Owlshead granite", crops out at the northernmost end of the radio tower range (RTR). This rock is a light gray to white, holocrystalline, fine to medium grained, subautomorphic granite. It is composed of 30% quartz, 40% plagioclase, 20% K-spar, 10% biotite mica and minor amounts of other accessory minerals such as magnetite, and zircon. This unit is probably equivalent to unit Kg in the eastern Owlshead Mountains based on general appearance in the field and on satellite imagery. **Kgr2:** Referred to here as "RTR granite", crops out in the lower lying regions along the flanks of the RTR occurring as stocks, and dikes that intrude both diorite and Paleozoic sedimentary rocks. These rocks range from granite to granodiorite compositions. They are generally gray to blue gray (depending on composition), holocrystalline, fine to medium grained, and subautomorphic in nature. These granites, and granodiorites are dominantly composed of plagioclase (35% or more) with lesser amounts of quartz (30% or less) and K-spar (25% or less). In some cases the K-spar is an interstitial phase. Common accessory minerals are biotite, hornblende, and pyroxene. Kgr2 is interpreted to be, moderately to highly, hydrothermally altered RTR granite. **Kgr3: Cretaceous(?) granite 3:** Pink holocrystalline, medium to coarse-grained, subhedral-granular pink granite. The rock is dominantly composed of plagioclase (20%), K-spar (45%), and quartz (25%) with minor amounts of accessory minerals. Accessory minerals include zircon or monazite, possibly oxidized magnetite, and some unidentified mm scale xenoblasts. Micas are notably absent. This granite has a distinctive red to pink color in outcrop and is distinctive on satellite images. The intrusive body appears to have the structural form of a flat-bottomed sill that caps the RTR from the range crest, near the middle of the RTR, to the southern end of the range.
Jd	**Jd: dioritic rocks:** A series of Jurassic (?) diorite, and lesser amounts of associated granodiorite intrusives (Jd) locally intrude the marbles along the southeast flank of the radio tower range. This rock is a gray, dark greenish gray to black, holocrystalline, fine to medium grained, automorphic, altered diorite. The diorite consists of approximately 60% plagioclase, >10% K-spar, and 40% mafics (hornblende, and biotite mica, both highly altered). Associated granodiorites are gray to dark gray, holocrystalline, fine to medium grained, granodiorite. The granodiorite consists of 30% quartz, 20% K-spar, and 40% plagioclase, with 10% mafics, typically biotite and hornblende. The diorites generally crop out in lower elevations and appear to have acted as screens through which later intrusives have passed. A Jurassic age is indicated by a 141 Ma hornblende Ar/Ar isochron date for a sample collected in this study (Guest, 2000). The age is a cooling age, however, and the igneous age of the rocks could be older.
Mzg	**Mzg: Mesozoic granitoid undivided**

Metamorphic Rocks

Pzm	**Pzm: Paleozoic(?) marble:** Highly fractured, and discontinuous, cherty, calcite marble that occurs as a roof pendant in the Mesozoic granitoids on the southeast flank of the radio tower range. Similar rocks also occur in the southern Owlshead Mountains. Based on the fact that these marbles are calcite marbles instead of dolomitic marbles, and given the lack of associated clastic rocks (the Precambrian dolomites are always associated with thick clastic sequences) they are interpreted as metamorphosed Paleozoic limestones. However the size and lateral extent of this unit in the RTR is too limited to provide the definitive data that would allow an unequivocal correlation.

Unmetamorphosed Pre-Tertiary Sedimentary Rocks

Pre-Mesozoic sedimentary rocks crop out at three localities in the mapped area: the northwest part of the mapped area, just north of Wingate Pass; the northeastern part of the mapped area in an unnamed wash between Anvil Springs Canyon and Wingate Wash; and a large exposure in the northeast corner of the Owlshead Mountains. These exposures contain local, well known stratigraphic units. For detailed descriptions of these rocks units, and their divisions, see Wright and Troxel (1984). Pre-Tertiary sedimentary units in the mapping area include the following.

Cambrian Rocks

Cbk	**Cbk: Cambrian Bonanza King Formation**
Cc	**Cc: Cambrian Carrera Formation**
Cz	**Cz: Cambrian Zabriski Quartzite**

Precambrian Rocks

pCs?	**pCs?: Stirling Quartzite?:** Small exposure of white, brecciated quartzite may represent the Stirling Quartzite.
pCkp3 pCkp2 pCkp1	**pCkp1, pCkp2, pCkp3: Kingston Peak Formation:** Three subunits separated are two distinct diamictites (1 and 3) and a limestone that probably is a slice of the Sourdough Limestone member of the Kingston Peak Formation.
pCd	**pCd: Crystal Springs Diabase**
pCmcs	**pCmcs: middle Crystal Springs Formation**
pClcs	**pClcs: lower Crystal Springs Formation**

Metamorphic Rocks

PCg	**pCg: Proterozoic basement gneiss**

STRUCTURE

The general structural relationships of the Wingate Wash area have been described in detail elsewhere (Golding-Luckow et al., 2005) and a partial tectonic interpretation for the region (Guest et al., 2003). Thus, descriptions in this explanation are limited to first order features. The reader is referred to these published works for more general information; and for detailed observations, station notes accompany this map as part of the geodatabase, as well as field photographs tied to those stations. In addition, most faults carry an attribute field in the GIS files indicating any known slip information. We also include cross sections presented by Golding-Luckow et al. (2005) with this map for completeness. For structural descriptions accompanying this map, we describe the structures in terms of the same structural/stratigraphic domains that are used to subdivide the rock units.

Domain 1: Southern Panamint Mountains Block

The structurally simplest part of the mapped area is the southern part of the Panamint Mountains, north of the Wingate Wash fault. The southern Panamint block (Domain 1) is essentially an intact, modestly south-tilted block cut by only a few minor faults. Indeed, the principal evidence for the existence of a through-going Wingate Wash fault lies in the contrast between this essentially intact block and the adjacent, complexly deformed domains.

The conclusion that this block is essentially intact is seen easily on this map by turning off all layers except the fault layer, and the contrast between the complex fault pattern to the southeast with the Panamint block is striking. Evidence for south tilting is less obvious, but arises from two observations:

1) Although the volcanic deposits surrounding the Sugarloaf volcanic center were not deposited horizontally, the spatial variations in layering clearly show that the volcanic rocks have been tilted southeastward, presumably along the Wingate Wash fault. Specifically, layering south of the volcanic center has steep dips to the south whereas layers to the east and west dip east and west respectively at a modest angle, probably near their original depositional angle, and layers to the north are virtually flat lying. On a stereographic projection these layers form a conic distribution, consistent with original deposition on the slopes of a volcanic cone, but the axis of the cone is inclined to the north ~30°; consistent with north or northwest tilting of the section as a whole.

2) The younger sedimentary section in upper Wingate Wash (units Tgw and Tsw) dips uniformly toward the southeast at ~10-15°. Although these gravels were probably deposited with some initial dip to the south, the initial dip was probably less than 5 degrees. Thus, like the volcanic center, these beds indicate a regional southeast tilt to the range, and the lack of disruption on the unconformity beneath them illustrates the lack of significant faulting.

The most significant complications in Domain 1 occur along the southern boundary of the block where contractional structures are prominent, and sinistral strike-slip also is evident. Specifically, to the southwest a fold-thrust system along the Brown Mountain front and the Crystal Hills (Domain 4) is an active feature, and a prominent fault scarp with south-side up and sinistral slip occurs north of the Long Hills. These oblique contractional features suggest the present topographic depression between Wingate Pass and the radio tower range is probably related to thrust loading from the south.

In the lower half of Wingate Wash, the Wingate Wash fault is more cryptic as a young structure with the only evidence for Quaternary deformation in low hills north of the northern tip of the radio tower range. In that area sinistrally offset drainages and a small south-side up offset of an old fan surface record Quaternary slip, but the scarp is deeply eroded and is probably relatively old. Evidence for older motion on the Wingate Wash fault is cryptic in upper and central Wingate Wash, but is very prominent in lower Wingate Wash. In that area, the gravels of the Lost Lake assemblage appear to be truncated in the subsurface by the Wingate Wash fault (cross sections A-A' and B-B'). However, the upper part of the assemblage overlaps the fault, crossing a major unconformity that appears to cut out most of the volcanic section, yet these gravels are themselves folded below a second angular unconformity with overlying entrenched fan gravels (unit QTaf).

These observations suggest the history of the Wingate Wash fault is a complex continuum. The southeast tilt of the southern Panamint block suggests motion on a north dipping, listric normal fault, and is consistent with seismic reflection images just to the east of Wingate Wash (Serpa et al., 1988). Although it is possible the fault originated as a north-dipping normal fault, the dominant structure seen today (cross sections A-A', B-B', and F-F') is a high-angle structure, with north-side up and strong evidence for a major component of sinistral slip (Golding-Luckow et al., 2005). The fold-thrust systems along the fault presumably represent secondary contraction along this sinistral-oblique system.

Domain 2: Lower Wingate Wash

The structure in Domain 2 is dominated by two moderate slip, sinistral-oblique-normal faults that Golding-Luckow et al. (2005) informally referred to as the "Confusion Canyon fault" to the east and the "Filtonny fault" to the west. The latter forms the boundary between Domains 2 and 3. Both off these faults strike approximately north-south and contain complex splay faults along their trace, including several normal faults with northwest strikes. Oblique slickenside surface as well as contradictory stratigraphic shifts along the faults are observations consistent with the inferred sinistral-normal motion. The Filtonny fault may connect to the Owlsbeak frontal fault in Domain 3, but if true, the faults would have opposite dip-slip stratigraphic shifts, suggesting either a large strike-slip component or an additional fault in the unmapped area between their traces.

Domain 3: Northern Owlshead Mountains and Central Wingate Wash

Domain 3 is the most structurally complex part of the mapped area. In the northeastern part of the domain, the rocks are complexly faulted, but with a pattern indistinguishable from Domain 1. That is, a system of NE striking, steeply dipping sinistral oblique faults that link up with an array of NW to NNW striking normal faults. In some cases these faults show mutual cross-cutting relationships within the domain. That is, in some areas the NE striking faults are cut by the NW striking normal faults, whereas elsewhere the opposite cross-cutting relationship is observed. This suggests these two fault systems were broadly coeval, but moved intermittently as a fault system rather than a consistent overprint.

Farther south within this domain the structure becomes more complex, and it is unclear how these structures evolved (Golding-Luckow et al., 2005). Particularly prominent observations include the following:

1) The northwestern frontal fault of the radio tower range is clearly a young, sinistral-oblique fault with the northwest side down. A prominent fault scarp is present along much of the fault trace, although the scarp is relatively old because it is strongly degraded by erosion. Fault dips steeply to the northwest, consistent with oblique-normal motion, yet that slip sense is confusing in light of other faults nearby.

2) The southeastern frontal fault of the radio tower range has a geomorphic expression suggestive of a young structure, at least in the northern half of the range, dips steeply SE where exposed, and cuts the youngest strata of the Lost Lake assemblage. Nonetheless, there are not obvious Quaternary scarps along the fault. Farther south, however, this fault cuts into bedrock exposures of the radio tower range, and appears to connect to a series of low to moderately northwest dipping normal faults (Guest, 2000). Moreover, scattered slickensides along the fault suggest oblique-dextral slip; the opposite slip sense from all other faults with similar orientations in the area. Field relationships suggest this fault system is a multi-phase slip system with an as yet poorly resolved slip history.

3) The northern tip of the radio tower range contains the most complex array of faults and folds in the mapped area (e.g., C-C'). Conspicuous structures include: a northwest trending, upright anticline with an associated thrust-fault that is sinistrally offset by an inferred northern extension of the southeastern frontal fault of the radio tower range; a northeast dipping fault between basement and volcanic cover that is a normal fault by stratigraphic juxtaposition, but appears to represent a thrust in its youngest motion; and a complex array of faults with both Mesozoic basement and volcanic cover that connects these structures to the Wingate Wash fault system. Geomorphic evidence suggests the anticline is actively growing and at least partially responsible for the formation of the Lost Lake Playa (Golding-Luckow et al., 2005). In Golding-Luckow et al. (2005) we interpreted this complex structural succession as complications from transrotation of the radio tower range block. This model allows for the range of structures observed, but is not well constrained and further work would be useful on the fault details.

Domain 4: Brown Mountain–Crystal Hills

Domain 4 contains the most clear evidence of young, presumably ongoing, contraction within the mapped area. The Brown Mountain front shows clear evidence of active thrusting along a moderately south dipping thrust. This thrust has a well developed fault scarp system along it, but this scarp is complex with a backthrust relationship locally (see notes, field sketches, and photographs in database accompanying this map). In the Crystal Hills, the basic structure is a faulted anticline (sections D-D' and F-F') and like Brown Mountain, this structure as well as two subsidiary structures to the south, appear to be actively growing fold systems. Although fault scarps are less prominent in the Crystal Hills, warped fan surfaces and development of playas, now entrenched, demonstrate the fold systems are Quaternary. Finally, just east of the Crystal Hills in the southern part of the radio tower range is a clear exposure of a low-angle, east-dipping normal fault system that is complexly overprinted by younger faults. This low-angle normal fault system has a high cutoff angle with bedding and the unconformity at the base of the Miocene volcanics, and strongly suggests that this fault system is an older normal fault system that was associated with the present northwest tilt of the radio tower range block, prior to the complex overprints observed in younger structures. Golding-Luckow et al. (2005) suggested this fault system and a related fault in the Owlsbeak range record a Miocene extensional event associated with deposition of the Lost Lake assemblage.

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REFERENCES CITED

Golding-Luckow, H., Pavlis, T.L., Serpa, L., Guest, B., Wagner, D., Snee, L., Hensley, T., and Korjenkov, A., 2005, Late Cenozoic Sedimentation and Volcanism during transtensional deformation in Wingate Wash and the Owlshead Mountains, Death Valley: Earth Science Reviews, v. 73, p. 177-220.

Guest, B.G., 2000, The geology of the northwestern Owlshead Mountains, Death Valley, CA [M.S. thesis]: New Orleans, Lousiana, University of New Orleans.

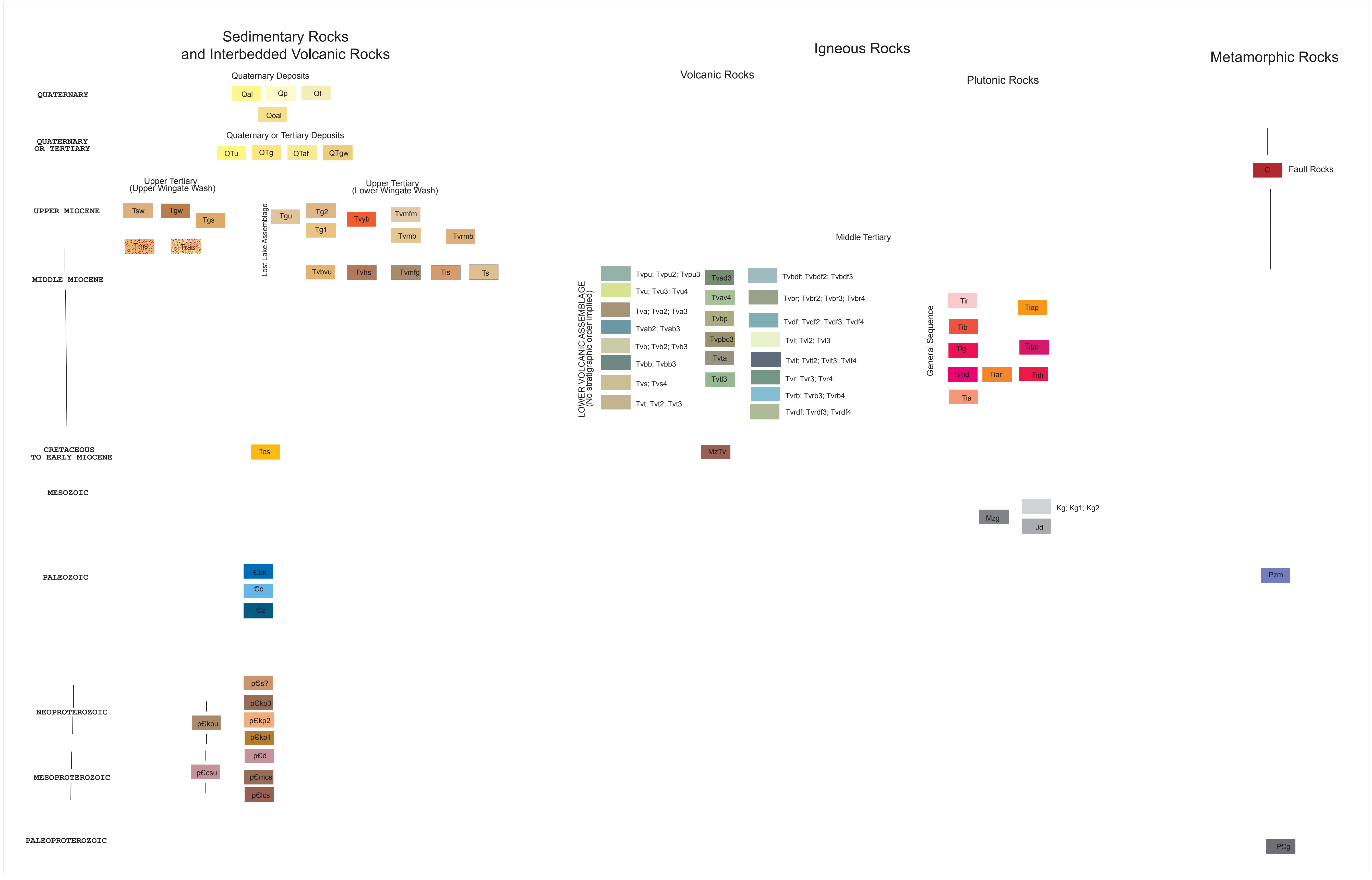
Guest, B.G., Pavlis, T.L., Serpa, L., and Golding, H., 2003, Chasing the Garlock: A study of tectonic response to vertical axis rotation: Geology, v. 31, p. 553-556.

Serpa, L., de Voogd, B., Wright, L, Willemin, J., Oliver, J., Hauser, E., and Troxel, B., 1988, Structure of the central Death Valley pull-apart basin and vicinity form COCORP profiles in the southern Great Basin: Geologic Society of America Bulletin, v. 100, p. 1437-1450.

Wagner, D.L., and Hsu, E.Y., 1988, Reconnaissance geologic map of parts of the Wingate Wash, Quail mountains and Manly Peak quadrangles, Inyo and San Bernardino Counties, Southeastern California: California Department of Conservation, Division of Mines and Geology Open-File Report.

Wright, L.A., and Troxel, B.W., 1984. Geology of the northern half of the Confidence Hills 15-minute Quadrangle, Death Valley region, eastern California; the area of the Amargosa chaos, Map Sheet 34: California Division of Mines and Geology.

ROCK UNIT SUMMARY



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