UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary geologic map including argillic and advanced argillic alteration and principal hydrothermal quartz and alunite veins in the Tushar Mountains and adjoining areas, Marysvale volcanic field, Utah

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DESCRIPTION OF MAP UNITS

Qa ALLUVIAL DEPOSITS (QUATERNARY)--Silt, sand, and gravel in alluvial fans, alluvial slope wash, stream alluvium, and lacustrine deposits. Includes older deposits as well as deposits graded to present drainage

Ql LANDSLIDE DEBRIS (QUATERNARY)--Poorly sorted rock debris that moved downslope by gravity. Locally contains significant glacial drift, rock glaciers, talus, and other deposits

Qt TRAVERTINE (QUATERNARY)--Calcareous spring deposits

Qg GLACIAL DEPOSITS (PLEISTOCENE)--Till deposited by glaciers (unsorted sand and gravel), probably Pinedale in age. Locally includes glacial outwash deposits. Mapped separately only in northern Sevier Plateau

Qcf BASALTIC ANDESITE OF COVE FORT (PLEISTOCENE)--Dark-gray to black, vesicular to dense lava flows containing phenocrysts and microphenocrysts of plagioclase, pyroxene, magnetite, olivine, and sparse corroded quartz in a felted matrix of microlites and glass. Petrographic description modified from Clark (1977). Forms shield volcano. Source of most flows is marked by a cinder cone on the crest of the shield volcano. K-Ar age is 0.5 m.y. (Best and others, 1980)

QTa OLDER ALLUVIUM (PLEISTOCENE TO MIOCENE?)--Poorly to moderately consolidated fluviatile and lacustrine conglomerate, sandstone, and siltstone, containing local interlayered airfall tuff beds. Includes fanglomerate and pediment gravel. Probably equivalent in part to Sevier River Formation (Ts)

Ts SEVIER RIVER FORMATION (PLIOCENE AND MIOCENE)--Tan or gray, poorly to moderately consolidated fluviatile and lacustrine conglomerate, sandstone, and siltstone, containing local interlayered white airfall tuff beds. Locally contains interlayered basalt lava flows (Tbas). A tuff bed near the base of the unit has been dated by fission tracks at about 15 m.y. old, and another near the top at about 7 m.y. old (Steven and others, 1979)

Tc CONGLOMERATE (MIOCENE)--Brown and locally red, conglomerate and sandstone containing rounded clasts of Bullion Canyon Volcanics. Accumulated in the lower parts of a basin marking the eroded Big John caldera

BIMODAL BASALT-RHYOLITE ASSEMBLAGE

Tbas BASALT LAVA FLOWS (MIOCENE)--Black to dark-gray, vesicular or amygdaloidal olivine basalt. Includes some scoria. K-Ar ages range from 14 to 5 m.y. (Best and others, 1980)

Trf RHYOLITE OF FORSHEA MOUNTAIN (MIOCENE)--Resistant, light-gray, white, or black, flow-layered, spherulitic, locally vesicular alkalic rhyolite lava flows and volcanic domes. Contains sparse small phenocrysts of plagioclase and minor sanidine and quartz. K-Ar age is about 8 m.y. (Rowley and others, 1981)

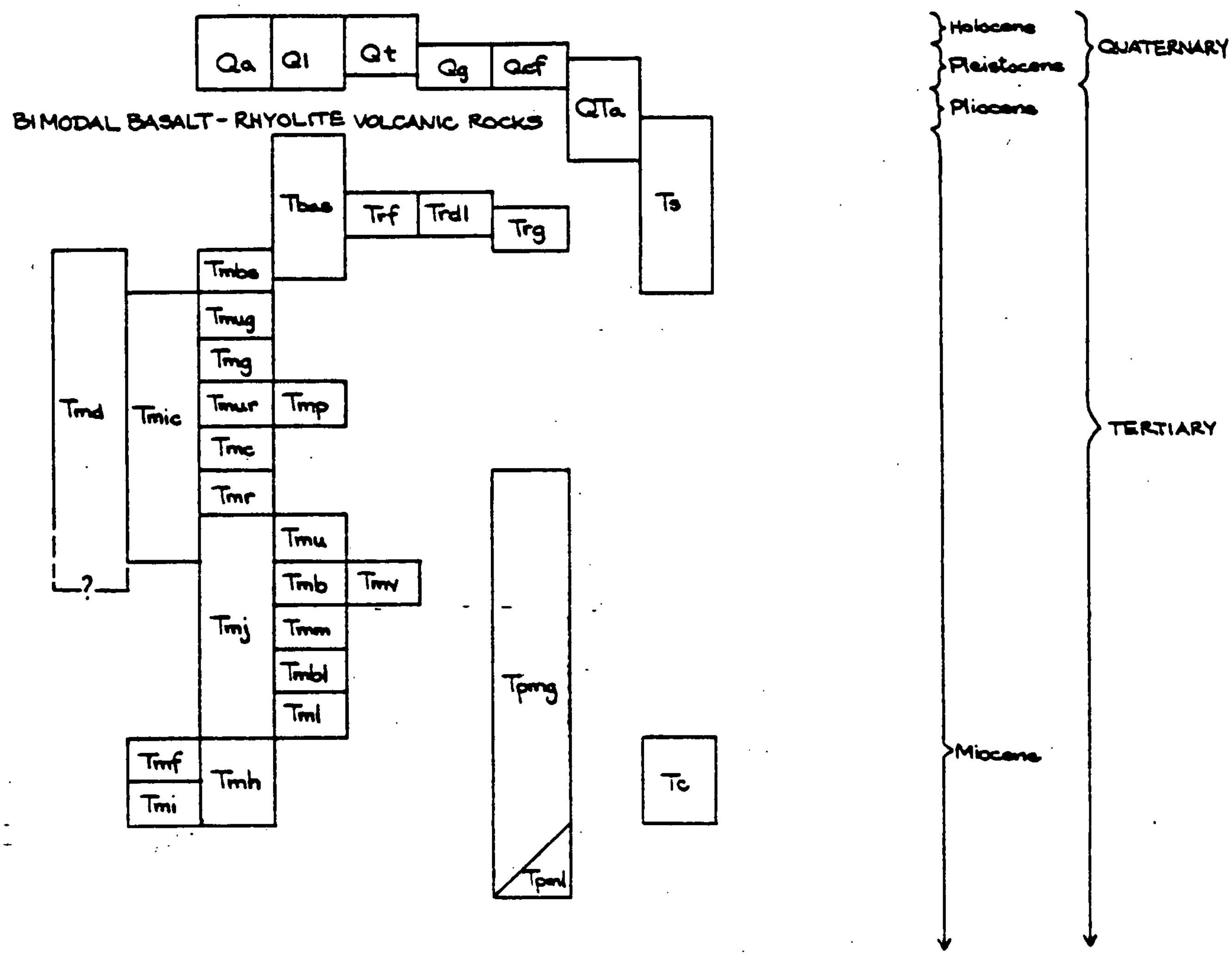

Figure 1.-- CORRELATION OF HOLOCENE TO MIOCENE MAP UNITS

Trdl RHYODACITE OF DRY LAKE (MIOCENE)--Resistant, light-gray, pink, tan, or black, flow-layered, devitrified, locally spherulitic rhyodacite volcanic domes and stubby lava flows. Phenocrysts of plagioclase, subordinate hornblende, and minor biotite, quartz, and Fe-Ti oxides comprise 10-30 percent of the rock

Trg RHYOLITE OF GILLIES HILL (MIOCENE)--Light-gray to white, flow-layered rhyolite lava flows and volcanic domes containing phenocrysts of sanidine and partly resorbed quartz in a vuggy, devitrified groundmass. Formed only on west side of Tushar Mountains and at north end of Beaver Valley. K-Ar age is about 9 m.y. (Evans, 1980)

MOUNT BELKNAP VOLCANICS (MIOCENE)

Intrusive rocks

Tmd Dikes and small stocks--Several small, glassy to aphanitic, rhyolitic dikes, stocks, and lava flows. Most are younger than Red Hills Tuff Member (Tmr)

Tmic Intracaldera intrusive rocks--Several small porphyritic quartz latitic to rhyolitic stocks within the Mount Belknap caldera. Contain sparse phenocrysts of quartz, plagioclase, and sanidine in a finely granular mosaic of alkali feldspar and quartz

Tmf Fine-grained granite--Forms a small stock and related dikes that host the uranium-bearing veins in the Central Mining Area. Contains phenocrysts of quartz, orthoclase, plagioclase, and minor biotite in a groundmass characterized by graphic intergrowths. K-Ar age is about 20 m.y. (Steven and others, 1979)

Tmi Porphyritic rhyolitic stocks and volcanic domes--Several small bodies northeast of Marysvale. Contain phenocrysts of sanidine, plagioclase, biotite, hornblende, quartz, and minor apatite, sphene, and magnetite in a devitrified or glassy matrix. K-Ar age is about 21 m.y. (Steven and others, 1979)

Outflow facies volcanic rocks

Tmbs Rhyolite of Big Star--Light-gray, flow-layered rhyolite lava flows with sparse sanidine phenocrysts and, locally, black basal glass. K-Ar age is about 14 m.y. (Bassett and others, 1963)

Tmug Upper gray tuff member--Light-gray, partially welded, ash-flow tuff containing sparse sanidine phenocrysts. Derived from the Mount Belknap caldera source area. K-Ar age is 18 m.y. (Steven and others, 1979)

Tmg Gray Hills Rhyolite Member--Light-gray, spherulitically devitrified rhyolite lava flows. Contains sparse sanidine phenocrysts and is characterized by contorted flow layers

Tmur Upper red tuff member--Red, crystal-poor, densely welded, ash-flow tuff characterized by black fiamme as much as 3 cm long. Derived from the Mount Belknap caldera source area

Tmp Porphyritic lava flows--Dark-gray, pyroxene latite lava flows located west of the Sevier River. Contain phenocrysts of andesine, diopsidic augite, and oxidized hornblende in a felted groundmass of microlites and hematite

Tmc Crystal-rich member--Dark-reddish-brown, moderately welded, alkali rhyolite ash-flow tuff containing 30 percent phenocrysts of anorthoclase, quartz, sodic plagioclase, and biotite. Derived from the Mount Belknap caldera source area. K-Ar age is about 19 m.y. (Steven and others, 1979)

Tmr Red Hills Tuff Member--Reddish-brown, crystal-poor, densely welded, alkali rhyolite ash-flow tuff. Contains about 7 percent phenocrysts of anorthoclase, quartz, plagioclase, and minor biotite. Derived from the Red Hills caldera source area (Cunningham and Steven, 1979)

Tmj Joe Lott Tuff Member--Partially welded, crystal-poor, light-gray or tan, alkali rhyolite ash-flow tuff containing 1-2 percent phenocrysts of quartz, sodic plagioclase, sanidine, and traces of biotite. Comprises most of the outflow facies derived from the Mount Belknap caldera source area (Cunningham and Steven, 1979). Stratigraphic position relative to radiometrically dated units indicates an age of about 19 m.y. (Steven and others, 1979)

Tmh Lower heterogeneous member--A sequence of rhyolitic volcanic domes, lava flows, and subordinate ash-flow tuff and volcanic sedimentary rocks that lie on or intrude older, intermediate-composition volcanic rocks and are, in part, overlain by the Joe Lott Tuff Member

Intracaldera facies volcanic rocks (Mount Belknap caldera)

Tmu Upper tuff member--Red to black, crystal-poor, rhyolitic, partially welded, ash-flow tuff. Lithologically similar to that of the outflow Joe Lott Tuff Member (Tmj)

Tmb Mount Baldy Rhyolite Member--Light-gray, crystal-poor, rhyolite lava flows and dikes consisting largely of a fine granular mosaic of quartz and alkali feldspar, and minor plagioclase, biotite, and hematite. Contorted flow layers are common. Mostly intracaldera facies, but locally extends out across the margin of the Mount Belknap caldera

Tmv Volcaniclastic rocks--Dominantly light gray to white volcanic mudflow breccia derived from nearby lava flows of the Mount Baldy Rhyolite Member (Tmb). Some landslide debris and fluviatile sand and gravel are included in the unit

Tmm Middle tuff member--Light-gray to buff, partially welded, crystal-poor, rhyolite ash-flow tuff. Lithologically similar to, and locally continuous across the caldera margin into, the upper part of the Joe Lott Tuff Member (Tmj)

Tmbl Blue Lake Rhyolite Member--Crystal-poor, rhyolite lava flows lithologically similar to those in the Mount Baldy Rhyolite Member (Tmb). Contorted flow layers are characteristic

Tml Lower tuff member--Moderately welded, crystal-poor, rhyolite ash-flow tuff lithologically similar to the Joe Lott Tuff Member (Tmj)

POTASSIUM-RICH MAFIC VOLCANIC ROCKS IN THE SOUTHERN TUSHAR MOUNTAINS (MIOCENE)

Tpmg Gravels from potassium-rich mafic lava flows--Poorly consolidated fanglomerate and conglomerate composed largely of fragments of the potassium-rich mafic lavas

Tpml Potassium-rich mafic lava flows--Black to dark-gray, vesicular mafic lava flows containing olivine, augite, plagioclase laths, and Fe-Ti oxides. Includes some scoria and amygdaloidal flows. K-Ar age is about 22 m.y. (Best and others, 1980)

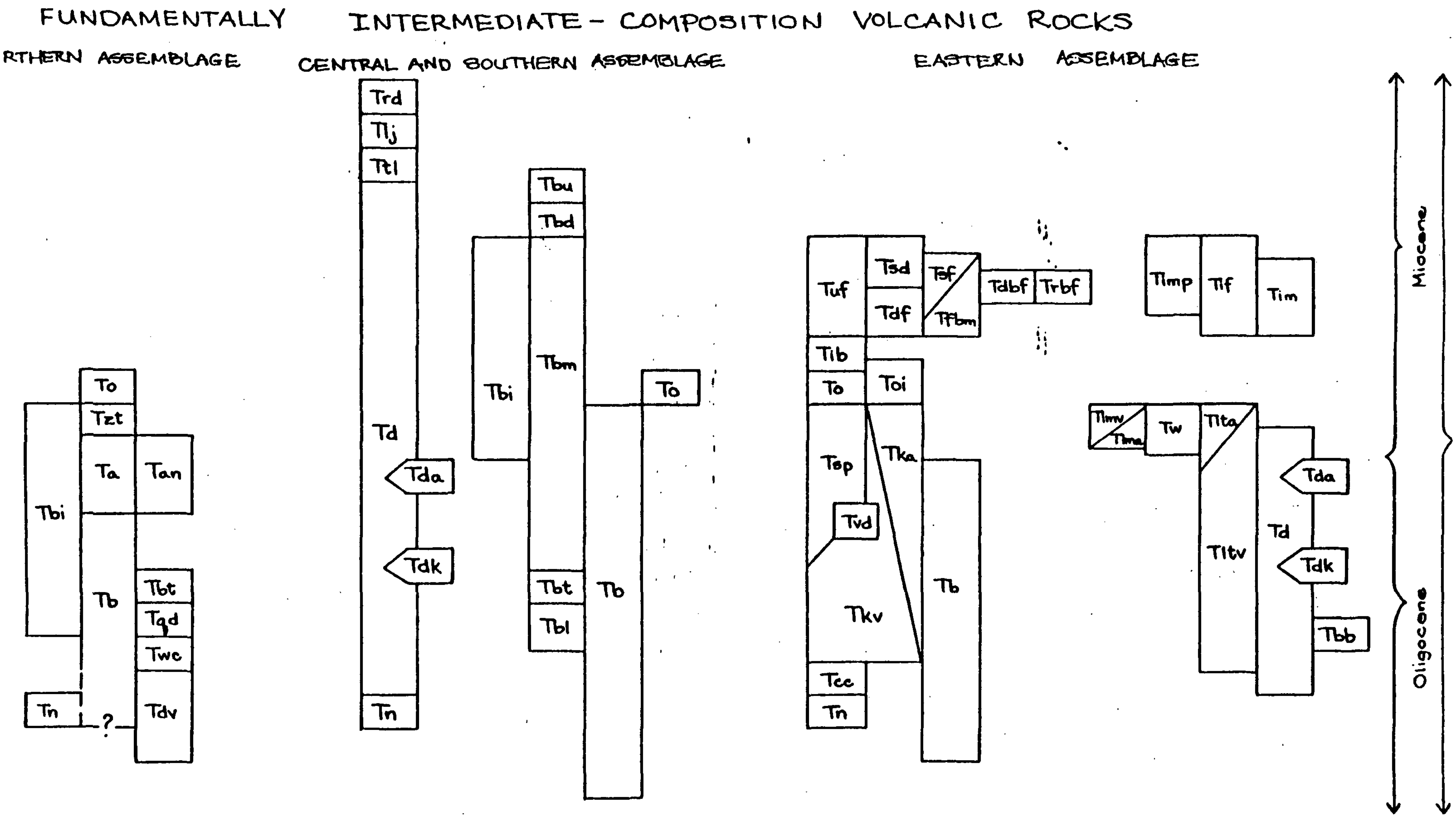

Figure 2.-- CORRELATION OF FUNDAMENTALLY INTERMEDIATE-COMPOSITION TERTIARY VOLCANIC ROCKS

NORTHERN ASSEMBLAGE OF FUNDAMENTALLY INTERMEDIATE-COMPOSITION VOLCANIC ROCKS

To OSIRIS TUFF, OUTFLOW FACIES (MIOCENE)[1]

Tzt ZEOLITIC TUFF (MIOCENE)--White, partially welded ash-flow tuff containing about 10 percent lithic fragments and phenocrysts of sanidine and plagioclase with sparse quartz and biotite. Matrix has been almost completely converted to the zeolite mineral clinoptilolite. May correlate with the Leach Canyon Formation of southwestern Utah (24 m.y.; Anderson and Rowley, 1975)

Ta TUFF OF ALBINUS CANYON (MIOCENE OR OLIGOCENE)--Red to gray, vesicular, densely welded ash-flow tuff (tufflava) containing a few percent phenocrysts of calcic andesite-labradorite, augite, and biotite in a glassy to devitrified matrix. Prominent fluidal textures from secondary flow and very abundant lineate vesicles are characteristic

Tan BASALTIC ANDESITE (MIOCENE OR OLIGOCENE)--Vesicular, black to dark-gray lava flows containing phenocrysts of calcic labradorite, pyroxene, magnetite, and olivine (altered to iddingsite) in a glassy to microgranular matrix

BULLION CANYON VOLCANICS (MIOCENE AND OLIGOCENE)[2]

Tb Heterogeneous lava flows and volcanic breccias

Tbi Intermediate-composition intrusive rock (OLIGOCENE AND MIOCENE)[2]

Tbt Three Creeks Tuff Member[2]

Tqd QUARTZ LATITE AND RHYODACITE VOLCANIC DOME AND FLOW (OLIGOCENE)--A single large volcanic dome of porphyritic quartz latite containing 30 percent phenocrysts of andesine and biotite, and trace amounts of quartz, sanidine, and augite. Overlain by a dark-gray rhyodacite flow containing sparse phenocrysts of plagioclase, pyroxenes, and Fe-Ti oxides

Twc VOLCANIC ROCKS OF WALES CANYON (OLIGOCENE)--Red, porphyritic, intermediate-composition lava flows and densely welded ash-flow tuff containing phenocrysts of plagioclase, clinopyroxene, and biotite in a microgranular matrix

Tn NEEDLES RANGE FORMATION (OLIGOCENE)--Gray, tan, or pink moderately welded quartz latite ash-flow tuff consisting of 40-50 percent phenocrysts of andesine, hornblende (10-15 percent), biotite, and minor sanidine, quartz, pyroxene, and Fe-Ti oxides. The high hornblende to biotite ratio is a distinguishing characteristic. Probably the Wah Wah Springs Member (Shuey and others, 1976). The K-Ar age is 30 m.y. (Fleck and others, 1975)

Tdv VOLCANIC ROCKS OF DOG VALLEY (OLIGOCENE)--Heterogeneous assemblage of intermediate-composition lava flows, flow breccia, volcanic mudflow breccia, and minor, moderately welded ash-flow tuff. Rock typically is a dark- to light-gray porphyry containing phenocrysts of plagioclase, hornblende, and biotite, and Fe-Ti oxides. Clinopyroxene is locally present, particularly in the ash-flow tuff units

CENTRAL AND SOUTHERN ASSEMBLAGE OF FUNDAMENTALLY INTERMEDIATE-COMPOSITION VOLCANIC ROCKS

Trd RHYODACITE TO RHYOLITE DIKES (MIOCENE)--Light-gray rhyodacite to white rhyolite containing phenocrysts of sanidine, andesine, quartz, and chloritized hornblende in a matrix of altered feldspar, quartz, and minor accessory zircon and apatite. Fission-track ages on dikes from Bullion Canyon are 21.9 m.y. for a rhyolite (Cunningham and others, 1978) and 21.5 m.y. for a rhyodacite (C. W. Naeser, written commun., 1978)

Tlj FORMATION OF LOUSY JIM (SIGMUND, 1979) (MIOCENE)--Light- to dark-gray, quartz latitic porphyry lava flows and flow breccia. Contains 23 percent phenocrysts of plagioclase, amphibole, clinopyroxene, magnetite, biotite, quartz, and accessory minerals in a glassy groundmass (Sigmund, 1979). Contorted flow layering is common

Ttl TUFF OF LION FLAT (MIOCENE)--Light-gray to grayish-pink, ash-flow tuff consisting of glass shards, pumice fragments, and volcanic dust, and about 5 to 15 percent phenocrysts of plagioclase, quartz, sanidine, biotite, and amphibole. Locally reworked and zeolitized

Td MOUNT DUTTON FORMATION (MIOCENE AND OLIGOCENE)[1]

Tda Antimony Tuff Member (Oligocene)[1]

Tdk Kingston Canyon Tuff Member (Oligocene)[1]

Tn NEEDLES RANGE FORMATION (OLIGOCENE)[3]

BULLION CANYON VOLCANICS (MIOCENE AND OLIGOCENE)

Tbi Intermediate-composition intrusive rock (Miocene)--Dark- to light-gray and brown, strongly porphyritic quartz latite and latite and porphyritic to equigranular, fine- to medium-grained quartz monzonite, monzonite, and granodiorite. The more crystalline rocks commonly contain approximately equal proportions of plagioclase and orthoclase, 0-20 percent quartz, plus augite, hornblende, and biotite. Accessory minerals are apatite, zircon, and Fe-Ti oxides. Radiometric ages cluster near 23 m.y. (Steven and others, 1979; Cunningham and others, 1981) but differ slightly in the various assemblages

Tbu Upper member (Miocene)--Mostly dark-gray to black, fine-grained rhyodacite to andesite lava flows and local densely welded ash-flow tuff, some of which show prominent lineate texture due to secondary flowage. Overlies Delano Peak Tuff Member in central Tushar Mountains

Tbd Delano Peak Tuff Member (Miocene)--Dark-reddish-brown densely welded, crystal-rich quartz latite ash-flow tuff containing 40-50 percent phenocrysts of andesine, hornblende, biotite, and minor quartz, zircon, and apatite. Source area marked by Big John caldera in central Tushar Mountains. K-Ar age is about 22 m.y. (Steven and others, 1979)

Tbm Middle member (Miocene and Oligocene)--Mostly light gray and brown rhyodacite lava flows, flow breccia, and volcanic mudflow breccia that lie between the overlying Delano Peak Tuff Member (Tbd) and underlying Three Creeks Tuff Member (Tbt) in the central Tushar Mountains

Tbt Three Creeks Tuff Member (Oligocene)--Light-gray and brown, densely welded, crystal-rich quartz latite ash-flow tuff containing 45-50 percent phenocrysts of plagioclase, hornblende, biotite, and quartz, with trace amounts of Fe-Ti oxide minerals, sanidine, and other accessory minerals. K-Ar age is 27 m.y. (Steven and others, 1979). Contains local masses of diverse breccias adjacent to scarps formed by penecontemporaneous volcano-tectonic subsidence of Three Creeks caldera in southern Pavant Range

Tbl Lower member (Oligocene)--Heterogeneous lava flows, flow breccia, and volcanic mudflow breccia, and minor tuffaceous sedimentary rocks. Rocks range from porphyritic rhyodacite, containing phenocrysts of plagioclase, biotite, hornblende, and lesser pyroxene, to fine-grained, dark-gray rocks containing small phenocrysts of plagioclase and pyroxene. Underlies Three Creeks Tuff Member in the central Tushar Mountains

Tb Heterogeneous lava flows and volcanic breccia (Miocene and Oligocene)--Porphyritic andesite, rhyodacite, and quartz latite. Contains phenocrysts of plagioclase, biotite, and clinopyroxene. In part consists of fine-grained dark lava flows and breccia of intermediate composition, containing small phenocrysts of plagioclase and clinopyroxene. Age range differs slightly in the various assemblages

To OSIRIS TUFF (MIOCENE)[1]

EASTERN ASSEMBLAGE OF FUNDAMENTALLY INTERMEDIATE-COMPOSITION VOLCANIC ROCKS

POST-CALDERA VOLCANIC ROCKS FILLING UPPER PART OF MONROE PEAK CALDERA (MIOCENE)

Tuf Undivided post-Monroe Peak caldera volcanic rocks--Includes one or more of the sanidine-bearing dacitic lava flows (Tsd) or dacitic lava flows (Tdf)

Tsd Sanidine-bearing dacitic lava flows--Resistant to moderately resistant, generally light to dark gray and dark brown, locally vesicular or amygdaloidal, locally flow layered, dacitic lava flows. Locally includes volcanic mudflow breccia and ash-flow tuff. Contains moderately abundant phenocrysts of plagioclase, sanidine, pyroxene, and biotite, and minor Fe-Ti oxides and olivine; sanidine phenocrysts may be as long as 2 cm. Considered to be the extrusive equivalent of the resurgent intrusive rocks (Tim) that invaded the volcanic rocks filling the Monroe Peak caldera. K-Ar age is 21.1 m.y. (H. H. Mehnert, written commun., 1980)

Tdf Dacitic lava flows--Moderately resistant to soft, brownish-red, tan, and light- to dark-gray, locally vesicular or amygdaloidal, locally flow layered dacitic lava flows. Contain abundant to sparse small phenocrysts of plagioclase, sanidine, pyroxene, and minor biotite, Fe-Ti oxides, and olivine. Unit locally contains light-gray crystal-poor rhyodacitic lava flows. Considered to be an extrusive equivalent of the resurgent pluton (Tim)

Tsf Lava flows of Sage Flat--Resistant, medium- to dark-gray or black andesitic lava flows. Contain mostly large phenocrysts of plagioclase, pyroxene, olivine, and minor Fe-Ti oxides. Upper part generally scoriaceous and amygdaloidal

Tfbm Lava flows of Bagley Meadows--Resistant, light- to medium-gray or pink, locally vesicular or amygdaloidal, locally flow foliated lava flows of dacitic composition. Contain abundant phenocrysts of plagioclase, pyroxene, sanidine, olivine, and Fe-Ti oxides. Considered to be an extrusive equivalent of the resurgent pluton (Tim)

Tdbf Dacite of Big Flat--Resistant, light- to dark-gray, pink, and tan, locally vesicular or amygdaloidal, flow-layered volcanic dome and stubby dacitic lava flows. Lithologically similar to the sanidine-bearing dacitic lava flows (Tsd), but constitutes a separate mappable sequence. Contains moderately abundant phenocrysts of plagioclase, sanidine, pyroxene, and biotite, and minor Fe-Ti oxides and olivine

Trbf Rhyodacite of Burnt Flat--Moderately resistant, purplish-gray and light-gray lava flows of rhyodacitic composition. Contains small phenocrysts of plagioclase and sanidine, subordinate pyroxene, and minor biotite and Fe-Ti oxides

INTRUSIONS RELATED TO THE MONROE PEAK CALDERA (MIOCENE)

Timp Intrusive rocks of Monrovian Park--Resistant light-gray and grayish-green, medium- to coarse-grained massive monzonite porphyry and quartz monzonite porphyry. Ranges from porphyritic to equigranular. Contains plagioclase, orthoclase, pyroxene, hornblende, quartz, and Fe-Ti oxides, and minor biotite. Intrusive into the main phase (Tim)

Tif Intrusive rocks of First Lefthand Fork of Monroe Creek--Resistant, tan, grayish-green and yellowish-tan, slightly altered monzonite porphyry. Contains phenocrysts of plagioclase, pyroxene, and altered ferromagnesian minerals, and minor Fe-Ti oxides and orthoclase

Tim Intrusive rocks undivided--Generally resistant, light-gray and grayish-green, monzonite porphyry and subordinate quartz monzonite porphyry. Constitutes the main resurgent phase of the intrusions related to the Monroe Peak caldera. Contains large phenocrysts of plagioclase and orthoclase, with smaller pyroxene and biotite, in a groundmass dominated by orthoclase, Fe-Ti oxides, and quartz. A fine-grained more potassic phase is present near the upper parts of most of the intrusion. A coarse-grained phase from Dry Canyon has a fission-track age of 21.5±0.8 m.y. (C. W. Naeser, written commun., 1979)

Tib INTRACALDERA BRECCIA (MIOCENE)--Soft to moderately resistant, gray to brown, pebble- to boulder-sized breccia and conglomerate. Exposed at several localities along the margins of the Monroe Peak caldera. The deposits are crudely bedded or unbedded and consist of rounded to angular clasts. Clasts on the northern margin are Bullion Canyon Volcanics (Tb) and on the southern margin are mostly volcanic rocks of Little Table (Tltv or Tlta). All margins have subordinate amounts of the intracaldera facies of Osiris Tuff (Toi). The deposits probably represent landslides, fanglomerate, talus, and mudflows that sloughed off the walls of the developing caldera

OSIRIS TUFF (MIOCENE)

Toi Intracaldera facies--Soft to moderately resistant, light-purple, medium-purplish-gray, and pink lava flows and ash-flow tuffs that are petrographically similar to the rock of the Osiris Tuff outflow facies (To). Confined to the Monroe Peak caldera, which is the source of the Osiris Tuff

To Outflow facies--Gray and reddish-brown, densely welded, crystal-rich ash-flow tuff. Phenocrysts consist of andesine and subordinate sanidine, pyroxene, and minor biotite, and Fe-Ti oxides. K-Ar age is about 22 m.y. (Fleck and others, 1975)

Tsp VOLCANIC ROCKS OF SIGNAL PEAK (MIOCENE AND OLIGOCENE)--Resistant, dark-gray, black, and red, commonly vesicular or amygdaloidal, andesitic lava flows. Include subordinate, soft to moderately resistant, red and gray flow breccia and volcanic mudflow breccia. Flows and breccia clasts contain abundant phenocrysts of plagioclase, pyroxene, olivine, and Fe-Ti oxides

Tvd VOLCANIC DOME OR LAVA FLOWS (OLIGOCENE)--Resistant, tan, light-yellow, and light-gray, locally flow layered dacitic volcanic dome or stubby lava flow containing abundant phenocrysts of plagioclase, pyroxene, and hornblende and minor biotite and Fe-Ti oxides. Intertongues with upper part of volcanic rocks of Koosharem and lower part of volcanic rocks of Signal Peak

VOLCANIC ROCKS OF KOOSHAREM (MIOCENE AND OLIGOCENE)--Mostly lava flows, flow breccia, and volcanic mudflow breccia. Flows and breccia clasts contain mostly small phenocrysts of plagioclase, subordinate pyroxene and Fe-Ti oxides, minor olivine, and locally, minor hornblende and biotite in an aphanitic matrix. Alluvial facies rocks exposed within the Monroe Peak caldera are tentatively correlated with the volcanic rocks of Koosharem on the basis of lithologic and petrographic similarities, but it is possible that they instead are correlative with the volcanic rocks of Little Table, with which they also are lithologically and petrographically similar

Tka Alluvial facies--Soft to moderately resistant, tan, light-gray, reddish-brown, red, and black, well-bedded volcanic mudflow breccia, conglomerate, and subordinate brown flow breccia and lava flows. Includes a local light-gray rhyodacitic lava flow

Tkv Vent facies--Soft to resistant, reddish-brown, dark-brown, light- to dark-gray, and red, locally vesicular or amygdaloidal, andesitic lava flows, and subordinate flow breccia and volcanic mudflow breccia. Includes several thin red-brown crystal-poor densely welded ash-flow tuff units in upper part

Tb BULLION CANYON VOLCANICS HETEROGENEOUS LAVA FLOWS AND VOLCANIC BRECCIA (OLIGOCENE)--Heterogeneous lava flows and volcanic breccias[3]

Tcc VOLCANIC ROCKS OF CLIFF CANYON, ALLUVIAL FACIES (OLIGOCENE)--Soft to moderately resistant, light- to medium-gray, well-bedded volcanic mudflow breccia and subordinate medium- to coarse-bedded volcanic conglomerate, sandstone, and conglomeratic sandstone and minor flow breccia and lava flows. Clasts and lava flows are of dacitic composition and consist of dark, mostly crystal poor and aphanitic flow rock containing sparse small phenocrysts of plagioclase, hornblende, biotite, and pyroxene; clasts of the Needles Range Formation also occur in the unit

Tn NEEDLES RANGE FORMATION (OLIGOCENE)[3]

VOLCANIC ROCKS OF LANGDON MOUNTAIN (MIOCENE)--Mostly volcanic mudflow breccia, flow breccia, and lava flows of dacitic composition that overlie and are interbedded with the upper part of both the Mount Dutton Formation (Td) and the volcanic rocks of Little Table (Tlta, Tltv). The rocks are part of a stratovolcano centered at or near Langdon Mountain. Contain phenocrysts of hornblende, subordinate plagioclase and pyroxene, and minor Fe-Ti oxides

Tlmv Vent facies--Resistant, pink, tan, light-gray, purplish-gray, locally amygdaloidal lava flows

Tlma Alluvial facies--Soft to moderately resistant, light-gray or tan, or much less commonly red, pink, or purplish-gray, volcanic mudflow breccia and sparse flow breccia, lava flows, and fluviatile conglomerate and sandstone

Tw VOLCANIC ROCKS OF WILLOW SPRING, ALLUVIAL FACIES (MIOCENE)--Soft to moderately resistant, black, reddish-brown, and light-gray volcanic mudflow breccia of dacitic composition, and subordinate lava flows, flow breccia, and fluviatile sandstone and conglomerate. Commonly clasts consist of a granular black glass containing phenocrysts, but the glass may be partly to totally devitrified. Phenocrysts consist of plagioclase and pyroxene, and minor Fe-Ti oxides and hornblende

VOLCANIC ROCKS OF LITTLE TABLE (MIOCENE AND OLIGOCENE)--Mostly andesitic lava flows, volcanic mudflow breccia, and flow breccia that are interbedded with, pinch out southward against, and locally underlie the Mount Dutton Formation and are interbedded with and underlie the lower parts of the volcanic rocks of Langdon Mountain. Contains phenocrysts of plagioclase and generally subordinate pyroxene and Fe-Ti oxides and minor olivine

Tlta Alluvial facies--Soft to resistant, tan, light-green, light- to medium-gray, reddish-brown, purplish-gray, yellow, pink, and orange volcanic mudflow breccia, and sparse flow breccia, lava flows, and fluviatile conglomerate and sandstone

Tltv Vent facies--Resistant, tan, khaki, dark-gray to dark-brown lava flows, tuff lava, flow breccia, and volcanic mudflow breccia

Td MOUNT DUTTON FORMATION (MIOCENE AND OLIGOCENE)--Soft to moderately resistant, tan, pink, light-gray, or less commonly pale-green or light-purple, volcanic mudflow breccia and sparse flow breccia, lava flows, local ash-flow tuff, and fluviatile conglomerate and sandstone. Flow rock and clasts in the breccia are characterized by several lithologies that are dacitic to andesitic in composition and have few phenocrysts; many rocks are aphanitic. Phenocrysts consist largely of plagioclase and either hornblende or pyroxene and minor Fe-Ti oxides. Age range differs slightly in the various assemblages

Tda Antimony Tuff Member (Oligocene)--Resistant, orange, red, pink, light-purple, khaki, and tan, densely welded, crystal-poor ash-flow tuff, containing medium-grained phenocrysts of plagioclase and sanidine and minor pyroxene and Fe-Ti oxides. Contains drawn-out pumice lenticules. Locally includes a black basal vitrophyre as much as several meters thick. K-Ar age is 25.4 m.y. (H. H. Mehnert, written commun., 1981)

Tdk Kingston Canyon Tuff Member (Oligocene)--Resistant, dark-purplish-red or light-purple, densely welded, crystal-poor ash-flow tuff containing sparse small phenocrysts of plagioclase and minor biotite, pyroxene, Fe-Ti oxides, and sanidine. Contains drawn-out pumice lenticules and angular lithic fragments. Locally includes a black basal vitrophyre. K-Ar age is about 26-25 m.y. (Fleck and others, 1975)

Tbb BUCKSKIN BRECCIA (OLIGOCENE)--Mostly soft, light-gray conglomerate and volcanic mudflow breccia characterized by light-gray to light-green pebbles, cobbles, and boulders of a porphyritic plutonic rock probably derived from the Spry intrusion (Anderson and Rowley, 1975; Grant, 1979)

PREVOLCANIC SEDIMENTARY ROCKS

TPs TERTIARY, MESOZOIC, AND PALEOZOIC SEDIMENTARY ROCKS

Tcg CONGLOMERATE (OLIGOCENE TO PALEOCENE)--Light-gray to buff pebble conglomerate containing rounded clasts of sandstone and limestone derived from Mesozoic and Paleozoic rocks. Locally contains tuffaceous sandstone

Ja ARAPIEN FORMATION (MIDDLE JURASSIC)--Light-gray limestone and shale and locally interbedded red to brown sandstone and intraformational limestone conglomerate layers

JTR n NAVAJO SANDSTONE (JURASSIC AND TRIASSIC?)--Fine-grained, buff, well-sorted, crossbedded sandstone. The crossbedding dips south. Occurs locally as large blocks in stocks and lava flows

TR Ps TRIASSIC AND PERMIAN SEDIMENTARY ROCKS--Includes the Triassic Chinle and Moenkopi Formations, Permian Kaibab Limestone, Toroweap Formation, and Queantoweap Sandstone of McNair (1951). Most exposed along the eastern front of Deer Trail Mountain

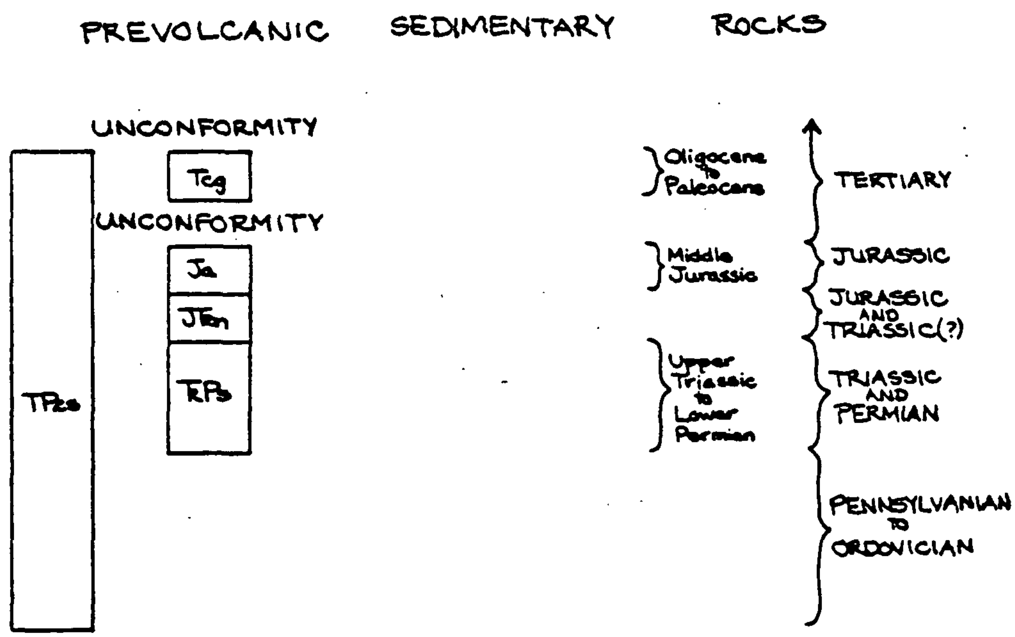

Figure 3.-- CORRELATION OF TERTIARY TO ORDOVICIAN PREVOLCANIC SEDIMENTARY MAP UNITS

CONTACT

GRADATIONAL CONTACT BETWEEN INTRUSIVE AND EXTRUSIVE PARTS OF THE SAME ROCK UNIT--Approximately located

FAULT--Dotted where concealed. Bar and ball on downthrown side

THRUST FAULT--Open pattern and dots where projected beneath cover Teeth point toward upper plate

STRIKE AND DIP OF BEDDING OR LAVA FLOWS
Inclined
Overturned

STRIKE AND DIP OF COMPACTION FOLIATION

TOPOGRAPHIC WALL OF CALDERA--Solid where it follows a contact; broken where concealed

BREAKAWAY SCARP AT HEAD OF A COHERENT BLOCK OF SLUMPED BEDROCK

QUARTZ VEINS

ALLUNITE VEINS

ARGILLIC AND ADVANCED ARGILLIC ALTERATION

[1]See description in "Eastern assemblage."
[2]See description in "Central and southern assemblage."
[3]See description in "Northern assemblage."

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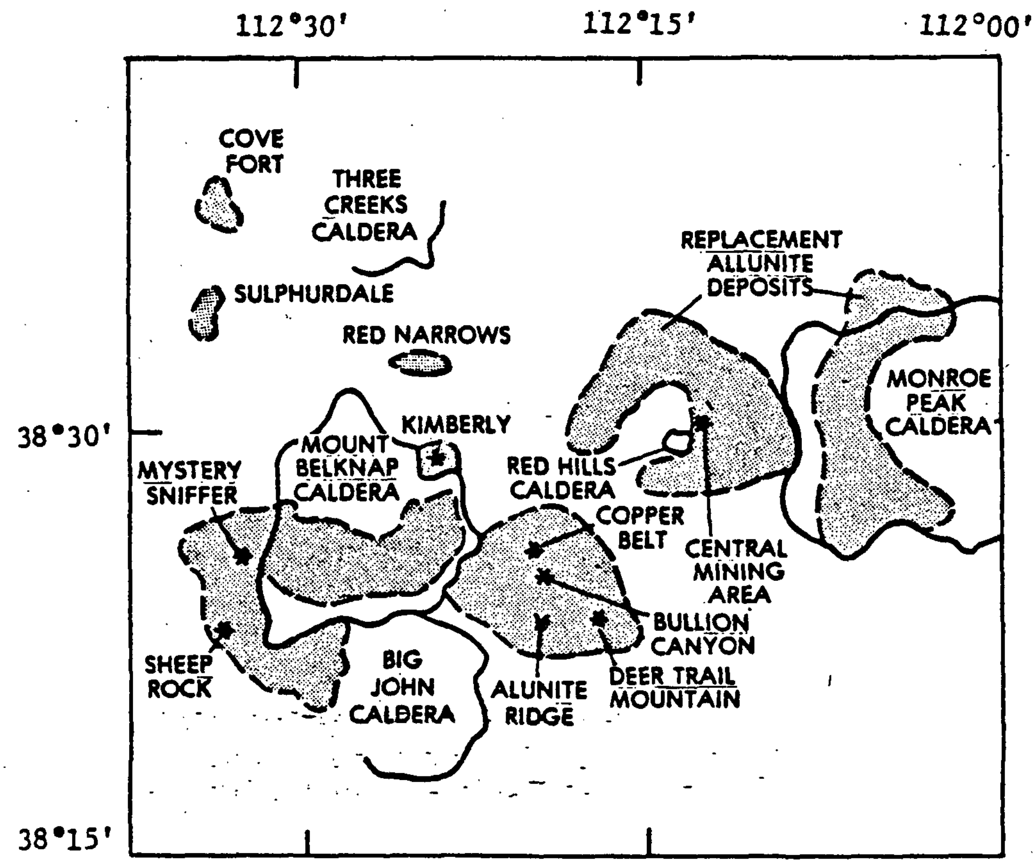

Figure 4.-- INDEX SHOWING LOCATION OF CALDERAS, MAJOR MINING CENTERS (STARRED), AND PRINCIPAL ALTERED AND (OR) MINERALIZED AREAS (STIPLED)

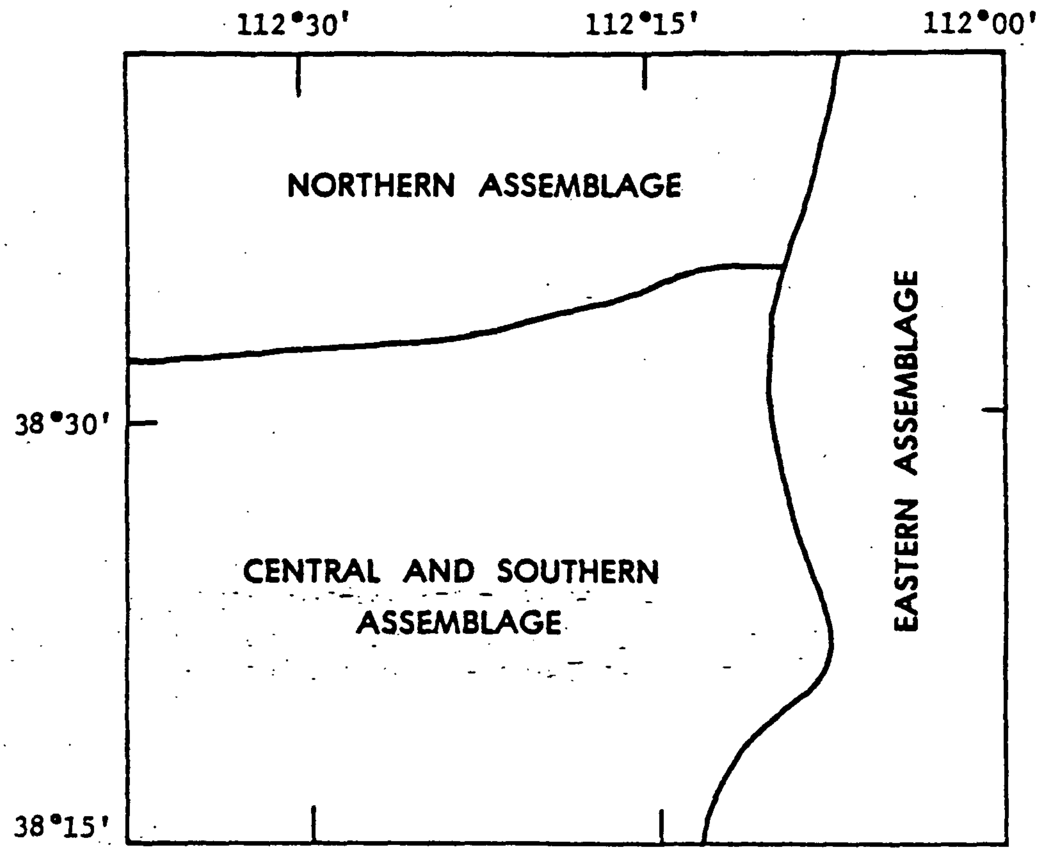

Figure 5.-- INDEX SHOWING GENERAL AREAS UNDERLAIN BY DIFFERENT ASSEMBLAGES OF FUNDAMENTALLY INTERMEDIATE-COMPOSITION VOLCANIC ROCKS

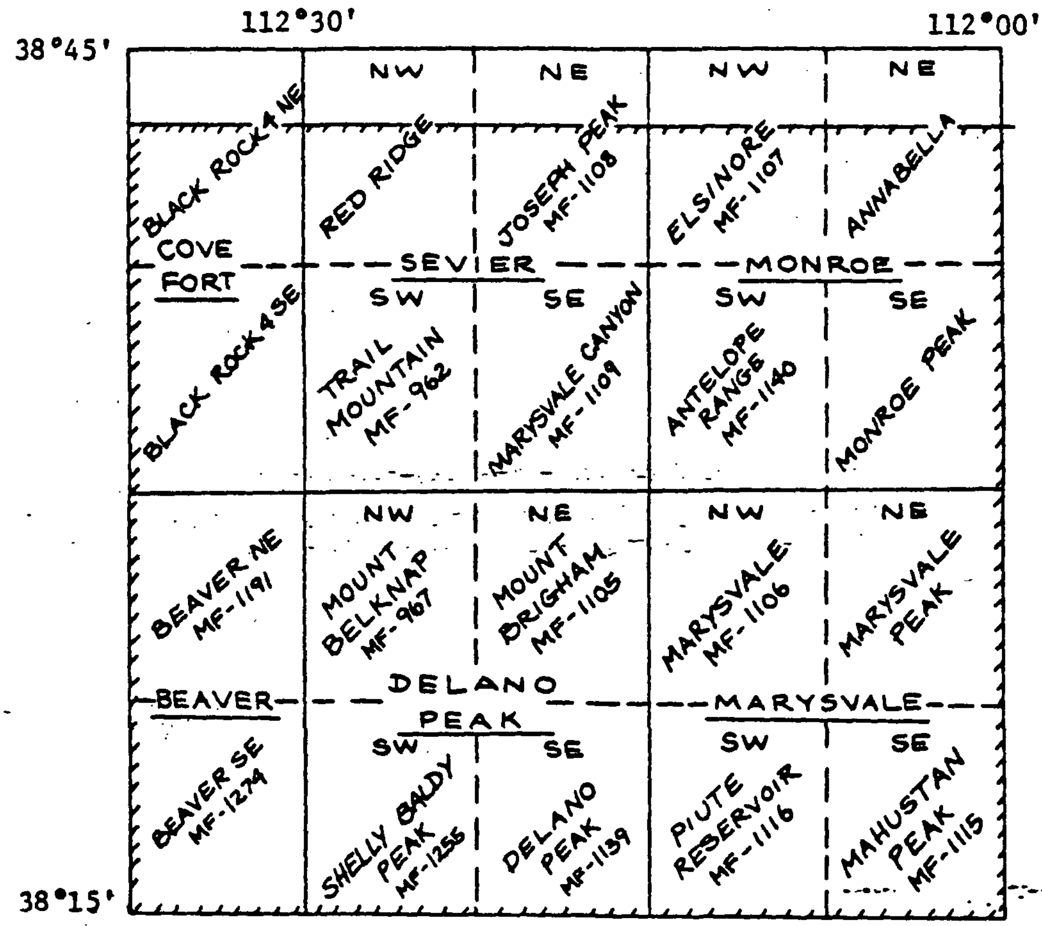

Figure 6.-- INDEX SHOWING 1:24,000 UNEDITED ADVANCE TOPOGRAPHIC QUADRANGLES USED IN PREPARING BASE FOR THIS MAP (hachured outline) AND RECENTLY PUBLISHED U.S. GEOLOGICAL SURVEY MISCELLANEOUS FIELD STUDIES MAPS OF THIS AREA