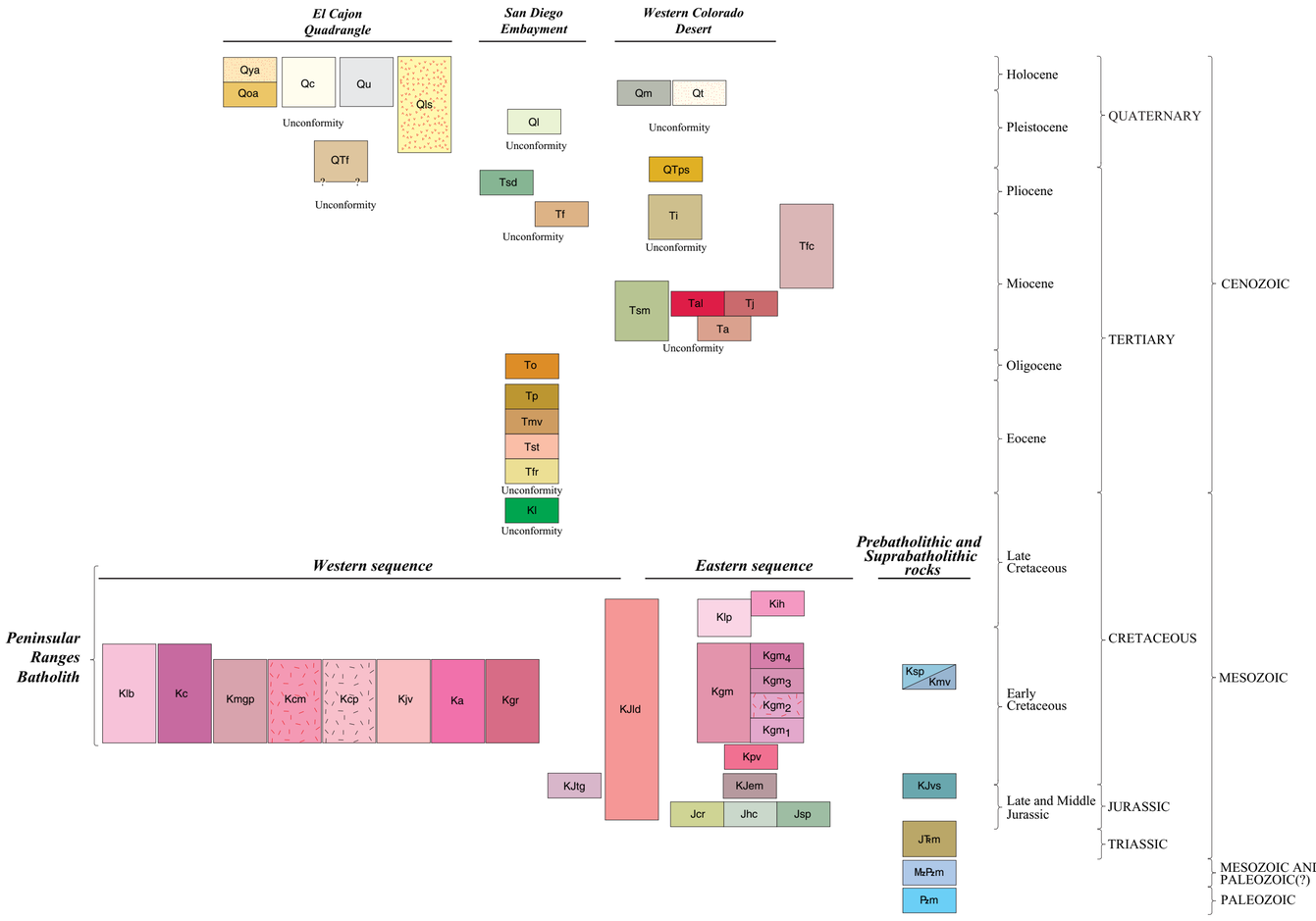
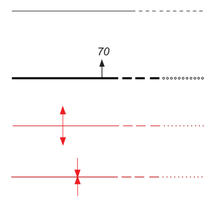
OPEN-FILE REPORT 2004-1361
SCAMP - Southern California Areal Mapping Project
Sheet 2 of 2, Version 1.0

CORRELATION OF MAP UNITS



EXPLANATION



Contact—Solid where accuracy of location ranges from well located to approximately located; dashed where very poorly located or inferred. Color change without a contact shown is a scratch boundary

Fault—Solid where accurately located, dashed where approximately located, dotted where concealed. Arrow and number indicate direction and amount of dip.

Anticline—Solid where accurately located, dashed where approximately located, dotted where concealed.

Syncline—Solid where accurately located, dotted where concealed, dashed where inferred.

Strike and dip of bedding

Horizontal

20 **Inclined**

Strike and dip of foliation, primary igneous

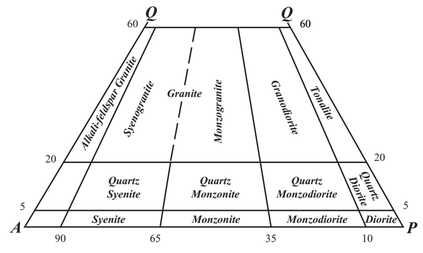
50 **Inclined**

Vertical

Strike and dip of foliation, metamorphic

50 **Inclined**

Vertical



Classification of plutonic rock types (from IUGA, 1973, and Streckeisen, 1973). A, alkali feldspar; P, plagioclase feldspar; Q, quartz.

LIST OF MAP UNITS

El Cajon quadrangle

Qya **Young alluvium (Holocene)**—Sand, silt, and gravel in modern streambeds and washes. Includes recent material accumulated on active alluvial fans

Qc **Colluvium (Holocene and Pleistocene)**—Sand and gravel of slopewash, debris-flow, and talus deposits. Grades locally into younger alluvium (Qya) and older alluvium (Qoa)

Qu **Alluvium and colluvium, undivided (Holocene and Pleistocene)**—Younger and older alluvium and colluvium not mapped separately

Qls **Landslide deposits (Quaternary)**—Localized deposits of unconsolidated to consolidated earth and rock materials that moved downslope as landslides

Qoa **Older alluvium (Holocene and Pleistocene)**—Sand, silt, and gravel; moderately dissected terraces in stream valleys. Well to poorly bedded, unconsolidated. In places, modern streams incise older alluvium to as much as 15 m. In some areas, older alluvium grades into younger alluvium

QTf **Fanglomerate (Pleistocene and Tertiary?)**—Conglomeratic sand and gravel fanglomerate; locally derived. Scattered deposits, poorly sorted, weakly indurated. Unit also includes debris-flow deposits and small landslides. Some deposits mark courses of ancient drainages

San Diego Embayment

Ql **Lindavista Formation (Pleistocene or Pliocene)**—Reddish-brown interbedded sandstone and conglomerate. Ferruginous cement, mainly hematite, gives formation characteristic color and resistance to erosion. Near-shore marine and nonmarine deposit. Molluscan fauna suggests early Pleistocene or late Pliocene age

Tsd **San Diego Formation (Pliocene)**—Marine sandstone and subaerial conglomerate (Kennedy, 1975). Sandstone is typically fine to medium grained, yellowish-brown, poorly indurated, locally containing limy cement; interfingers with conglomerate. Conglomeratic part of unit consists of pebbles, cobbles, and boulders in coarse-grained sandstone matrix. Maximum thickness is 75 m

Tf **Fanglomerate (Pliocene and Miocene)**—Boulder fanglomerate. Rests nonconformably on low-grade metavolcanic rocks; clasts locally derived. Matrix is medium- and coarse-grained, light-brown sandstone and bentonite

To **Otay Formation (Oligocene)**—Massive sandstone and claystone. Light gray and light brown, moderately well sorted, poorly indurated. Claystone is waxy, composed almost exclusively of bentonite. Correlated with Miocene-Pliocene rocks in Baja California, Mexico (Kennedy and Tan, 1977)

Poway Group

Tp **Pomerado Conglomerate (Eocene)**—Massive cobble conglomerate. Uppermost unit of Poway Group; maximum thickness is 55 m. Contains sparse beds and lenses of light-brown sandstone

Tmv **Mission Valley Formation (Eocene)**—Marine sandstone; soft, friable, light-olive-gray, fine- to medium-grained. Mostly of quartz and potassium feldspar. Maximum thickness is 60. Has interbeds of claystone. Contains molluscan fauna in western and central exposures and land-mammal fauna in eastern exposures

Tst **Stadium Conglomerate (Eocene)**—Massive cobble conglomerate having dark-yellowish-brown, coarse-grained sandstone matrix. Moderately well sorted; sandstone beds and lenses make up 50% of unit. Dominant clast type is rhyolitic to dacitic volcanic rocks. Nonmarine in east, nearshore marine and lagoonal in west. Contains late(?) Eocene fossils

Tfr **Friars Formation (Eocene)**—Sandstone and claystone; nonmarine and lagoonal. Sandstone typically massive, yellowish-gray, medium grained, and poorly indurated. Conglomerate lenses are fluvial. Maximum thickness is 50 m. Contains marine and nonmarine fossils

Kl **Lusardi Formation (Late Cretaceous)**—Cobble and boulder fanglomerate derived solely from crystalline rocks of the Peninsular Ranges batholith. Conglomerate contains thin lenses of medium-grained sandstone; clasts as much as 10 m in diameter. Restricted to northwest part of quadrangle. Maximum thickness about 125 m. Late Cretaceous because it is overlain by Late Cretaceous Point Loma Formation

Western Colorado Desert

Qm **Mesa Conglomerate (Pleistocene)**—Pooly stratified to unstratified sand and gravel of extensively dissected alluvial-fan and terrace deposits. Massively bedded. Characterized by nearly horizontal beds paved with cobbles and small boulders having well developed desert varnish. Grain size decreases away from mountains

Qt **Terrace deposits (Pleistocene)**—Sand, silt, and gravel of highly dissected alluvial terraces at elevations substantially higher than modern stream terraces; may be partly or wholly equivalent to Mesa Conglomerate (Woodard. 1967) (Qm). Terraces are capped by desert pavement. Poorly sorted, angular clasts derived from nearby mountains

QTps **Palm Spring Formation (Pleistocene and Pliocene)**—Nonmarine sandstone, siltstone, and claystone commonly containing pebble and cobble interbeds and minor marine interbeds (Woodring, 1932; Woodard, 1974); grades laterally and downward into basal boulder to cobble fanglomerate assigned by Dibblee (1954) to his Canebrake conglomerate. Sandstone commonly arkosic; contains lesser fresh-water limestone. Fluvial and alluvial-fan deposits and minor lacustrine deposits. Represents alluvial floodplain deposits marginal to the retreating Gulf of California

Ti **Imperial Formation (Pliocene and Miocene)**—Massive, poorly bedded, gray, feldspathic arenite in lower part; rhythmically bedded, gray, silty mudstone and very fine quartz arenite in middle part; siltstone and sandstone interbedded with massive biostromal limestone and calcerous arenite in upper part (Woodring, 1932). Two lower parts are marine; part of upper part is nonmarine

Tfc **Fish Creek Gypsum (Pliocene and Miocene)**—Extremely pure gypsum and anhydrite as much as 60 m thick. Rests unconformably on basement or conformably above transitional marine mudstone. Records earliest marine incursion into Salton Trough (Dean, 1988). Thin claystone interbeds contain marine microfossils; intertidal

Tsm **Split Mountain Formation (Miocene)**—Nonmarine conglomerate and sandstone containing intercalated megabreccias composed of crystalline rocks of Peninsular Ranges batholith. Lower part of unit is dark-gray, boulder and cobble fanglomerate; middle part is interlensing quartz arenite and olive-green micaceous shale, which contains lateral interbeds of Fish Creek Gypsum; upper part is massive gray fanglomerate or megabreccia similar to lower part of formation

Tal **Alverson Andesite (Miocene)**—Andesite; dark-purple-gray plagioclase-hornblende andesite interbedded with gray andesitic tuff. As much as 120 m thick. In northern Jacumba Mountains unit is flow rock, breccia, volcaniclastic rock, and air-fall deposits; flow rock is basaltic. Basalt yielded K-Ar whole-rock age of 16.9 ± 0.5 Ma (Hoggatt, 1979)

Tj **Jacumba Volcanics (Miocene)**—Alkalic and tholeiitic basalt flows, breccia, and pyroclastic rocks; andesite and andesitic breccia. Parts of unit record remnants of five cinder cones and two hypersthene andesite plugs (Minch and Abbott, 1973). K-Ar ages average about 19 Ma

Ta **Anza Formation (Miocene)**—Nonmarine arkosic sandstone and conglomerate; equivalent to basal conglomerate member of Split Mountain Formation (Tsm). Coarse conglomeratic sandstone. About 540 m thick at type locality, but only about 5 m thick in quadrangle; preserved only where covered by flows of Alverson Andesite

Peninsular Ranges Batholith

Western sequence

Klb **Tonalite of Las Bancas (Early Cretaceous)**—Hypersthene-biotite tonalite, quartz diorite, granodiorite, and lesser diorite, quartz monzodiorite, and quartz norite. Medium grained, equigranular; weak foliation, but protomylonitic at margins of some plutons. Color index ranges from 22 to 32. Poikilitic, having potassium feldspar and biotite oikocrysts

Kc **Cuyamaca Gabbro (Early Cretaceous)**—Troctolite, anorthositic gabbro, gabbronorite, hornblende gabbro; minor hornblende diorite and leucodiorite. Inner parts of bodies are hornblende-bearing troctolite; anorthositic gabbro ±amphibole ±orthopyroxene ±olivine; and amphibole-olivine gabbronorite. Margins and smaller bodies are mainly fine- to medium-grained hornblende gabbro ±orthopyroxene ±clinopyroxene ±biotite. Moderately to strongly foliated

Kmgp **Monzogranite of Mother Grundy Peak (Early Cretaceous)**—Hornblende-biotite leucomonzogranite, leucogranodiorite, and tonalite. Medium to coarse grained, locally very coarse-grained; strongly foliated. Characterized by subhedral K-feldspar phenocrysts as much as 4 cm long and hornblende prisms from 0.5 to 1 cm in length. Basaltic and gabbroic dikes abundant near contacts with gabbro plutons

Kcm **Corte Madera Monzogranite (Early Cretaceous)**—Biotite leucomonzogranite, leucogranodiorite, and syenogranite; trace hornblende. Medium to coarse grained; weakly to strongly foliated, locally protomylonitic. Forms lensoid plutons and fringing dikes. Color index varies from 1 to 11

Kcp **Chiquito Peak Monzogranite (Early Cretaceous)**—Hornblende-biotite monzogranite and granodiorite and lesser tonalite, leucogranite, alaskite, and pegmatite. Color index 2-16. Forms lenticular plutons and narrow, sheet-like bodies. Medium grained; moderately to strongly foliated. Variable from one body to another; partly dependent on lithology of nearby units

Kjv **Japatul Valley Tonalite (Early Cretaceous)**—Biotite-hornblende tonalite containing relict pyroxene; hornblende-biotite tonalite; and lesser hornblende-biotite granodiorite. Average color index about 22. Medium to coarse grained; equigranular but much is moderately to strongly foliated. Grades into tonalite of Alpine (Ka) and Chiquito Peak Monzogranite (Kcp)

Ka **Tonalite of Alpine (Early Cretaceous)**—Biotite-hornblende tonalite, lesser quartz diorite, and scarce granodioritic tonalite. Medium to coarse grained; moderately to strongly foliated; mafic inclusions. Average color index 30. Unit is heterogeneous in outcrop and hand specimen

Kgr **Granitoid rocks (Early Cretaceous)**—Undivided tonalite and granodiorite; most lithologically similar to tonalite of Alpine (Ka), Japatul Valley Tonalite (Kjv), and Corte Madera Monzogranite (Kcm). Includes lesser gabbro and metavolcanic rocks

KJtg **Tonalite and gabbro (Early Cretaceous and Jurassic)**—Mixed tonalite and gabbro of specifically defined units, undifferentiated. Includes parts of Tonalite of Las Bancas (Klb), Cuyamaca Gabbro (Kc), Jurassic gneiss of Stephenson Peak (Jsp), tonalite of Granite Mountain (Kgm), and tonalite of La Posta (Klp)

KJld **Leucocratic dikes (Late Cretaceous and Late Jurassic)**—Leucogranite, granophyre, alaskite, pegmatite, and aplite; found cutting plutonic units in quadrangle. Includes dikes of at least three ages

Eastern sequence

Kih **Indian Hill granodiorite of Parrish and others (1986) (Late Cretaceous)**—Garnetiferous muscovite-biotite leucogranodiorite and leucomonzogranite. Fine- to medium-grained, weakly foliated. Color index less than 7. Extensive, large, fine-grained muscovitic leucocratic dikes in southern parts of unit

Klp **Tonalite of La Posta (Early and Late Cretaceous)**—Hornblende-biotite trondhjemite in western part, and biotite trondhjemite and granodiorite in eastern part. Unit is leucocratic, homogeneous, largely undeformed, and inclusion-free, but locally, pluton margins are moderately to strongly foliated. Color index from 6 to 15

Kgm **Tonalite of Granite Mountain (Early Cretaceous)**—Biotite-hornblende tonalite; hornblende-biotite tonalite, lesser granodiorite; and minor quartz diorite. Medium- to coarse-grained; weak to very strong foliation. Color index from 17 to 27. Divided into four subunits in Morena Reservoir 7.5' quadrangle:

Kgm4 **Tonalite of Granite Mountain, Unit 4—**Mafic biotite-hornblende tonalite having subidiomorphic texture, scattered poikilitic biotite grains, moderate to well developed foliation, and relatively high color index

Kgm3 **Tonalite of Granite Mountain, Unit 3—**Relatively leucocratic hornblende-biotite tonalite and granodiorite having moderate to faint magmatic foliation and large, oval biotite grains ± small acicular hornblende grains

Kgm2 **Tonalite of Granite Mountain, Unit 2—**Biotite-hornblende tonalite having idiomorphic texture, moderate to faint magmatic foliation, and lower color index than marginal phase (Kgm1)

Kgm1 **Tonalite of Granite Mountain, Unit 1—**Marginal biotite-hornblende tonalite that is finer-grained, has well developed solid-state foliation (overprinting magmatic foliation), and has higher color index than average rock of interior parts of pluton

Kpv **Monzogranite of Pine Valley (Early Cretaceous)**—Hornblende-biotite leucomonzogranite, leucogranodiorite, and minor biotite-hornblende tonalite. Medium- to coarse-grained, subporphyritic, moderately to strongly foliated. Color indexfrom 4 to 10. Voluminous leucogranite, alaskite, granophyre, and pegmatite-aplite dikes associated with body

KJem **Quartz Diorite of East Mesa (Cretaceous and Jurassic)**—Fine- to medium-grained, gneissic biotite-hornblende tonalite and quartz diorite and fine-grained, locally porphyritic biotite-hornblende quartz diorite and tonalite. Texturally and compositionally heterogeneous. Strongly foliated to mylonitic. Some rocks contain hypersthene ±clinopyroxene

Jcr **Granodiorite of Cuyamaca Reservoir (Late and Middle Jurassic)**—Biotite and hypersthene-biotite granodiorite and tonalite; also contains actinolitic amphibole. Fine to medium grained, strongly foliated, locally mylonite gneiss. Average color index is 25

Jhc **Gneiss of Harper Creek (Late and Middle Jurassic)**—Gneissic to mylonitic biotite granodiorite and tonalite, and lesser monzogranite. Fine- to medium-grained; strongly foliated. Average color index is 22. Contains muscovite, cordierite, sillimanite, and garnet, and abundant, inclusions. Isoclinal folded in places

Jsp **Migmatitic schist and gneiss of Stephenson Peak (Late and Middle Jurassic)**—Granodiorite orthogneiss, paragneiss; migmatitic pelitic schist, and lesser calcsilicate-bearing quartzite, marble, and amphibolite. Layers range from several centimeters to tens of meters

Prebatholithic and Suprabatholithic rocks

Ksp **Santiago Peak Volcanics (Early Cretaceous)**—Dacitic and andesitic breccia, tuff, and flows, and lesser basalt and rhyolite. Unmetamorphosed to slightly metamorphosed

Kmv **Metavolcanic rocks (Early Cretaceous)**—Amphibolite-facies tuff, tuff-breccia, and volcanic flow rock of andesitic, dacitic, and basaltic composition. Also includes rare feldspathic metaquartzite, pelitic schist, and granitoid-cobble metaconglomerate. Typically forms screens between and within plutons in the western part of the El Cajon quadrangle

KJvs **Metavolcanic and metasedimentary rocks (Cretaceous and Jurassic?)—**Amphibolite, calcsilicate rocks, felsic tuff-breccia, biotite-rich schist, and quartzite

JTrm **Metasedimentary and metavolcanic rocks (Jurassic and Triassic)**—Interlayered semi-pelitic, pelitic, and quartzitic schists; calcsilicate-bearing feldspathic metaquartzite; and minor small-pebble metaconglomerate. Includes layers of sandstone, quartz-pebble conglomerate, mudstone, and amphibolite. Interpreted to be metamorphosed submarine fan deposits and intercalated volcanic rocks; equivalent to the Julian Schist of Hudson (1922)

MzPzm **Rocks of Jacumba Mountains (Mesozoic and Paleozoic?)**—Marble, schist, and metaquartzite. Metasedimentary and metavolcanic rocks forming screens within Jurassic granitoids and plutons of middle to Late Cretaceous tonalite. Interlayered with minor metachert and abundant hornblende schist. Metamorphosed sedimentary and volcanic rocks may be of oceanic affinity

Pzm **Metasedimentary rocks (Paleozoic)**—Greenschist, marble, schist, metaquartzite, and metaconglomerate. Mainly occurs as metamorphic screens, but some rocks preserved well enough to contain fossils. Interpreted to be metamorphosed shelf-type sedimentary strata containing thick carbonate sequences

REFERENCES CITED

Dean, M.A., 1988, Genesis, mineralogy and stratigraphy of the Neogene Fish Creek Gypsum, southwestern Salton Trough, California: M.S. thesis, San Diego State University, 150 p.

Dibblee, T.W., Jr., 1954, Geology of the Imperial Valley region, California: in Jahns, R.H., ed., Geology of California, Chapter 2: California Division of Mines Bulletin 170, p. 21-28.

Hoggatt, W.C., 1979, Geologic map of the Sweeney Pass quadrangle, San Diego County, California: U.S. Geological Survey Open-File report 79-754, 28 p., scale 1:24,000.

Hudson, F.S., 1922, Geology of the Cuyamaca region of California, with special reference to the origin of nickeliferous pyrrhotite: University of California, Department of Geological Sciences Bulletin, v. 13, p. 175-252.

Kennedy, M.P., 1975, Geology of western San Diego metropolitan area, California: California Division of Mines and Geology Bulletin 200, p. 9-39.

Kennedy, M.P., and Tan, S.S., 1977, Geology of National City, Imperial Beach, and Otay Mesa quadrangles, southern San Diego metropolitan area, California: California Division of Mines and Geology, Map Sheet 29, scale 1:24,000.

Minch, J.A., and Abbott, P.L., 1973, Post-batholithic geology of the Jacumba area, southeastern San Diego County, California: San Diego Society of Natural History, Transactions, 17(11), p. 129-136.

Parrish, K.E., Walawender, M.J., Clinkenbeard, J.F., and Wardlaw, M.S., 1986, The Indian Hill Granodiorite, a peraluminous, garnet-bearing granitoid, eastern Peninsular Ranges [abs.]: Geological Society of America Abstracts with Programs, v. 18, no. 2, p. 168.

Streckeisen, A.L., 1973, Plutonic rocks, classification and nomenclature recommended by the I.U.G.S. Subcommission on the systematics of igneous rocks: Geotimes, v. 18, no. 10, p. 26-30.

Woodard, G.D., 1967, The Cenozoic succession of the west Colorado Desert, San Diego and Imperial Counties, southern California: Dissertation Abstracts, Section B, v. 27, no. 8, p. 2752.

Woodard, G.D., 1974, Redefinition of Cenozoic stratigraphic column in Split Mountain Gorge, Imperial Valley, California: American Association of Petroleum Geologists Bulletin, v. 58, p. 521-526.

Woodring, W.P., 1932, Distribution and age of the Tertiary deposits of the Colorado Desert: Carnegie Institution of Washington Publication 148, p. 1-25.

Preliminary Geologic Map of the El Cajon 30' x 60' Quadrangle, Southern California

Version 1.0

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