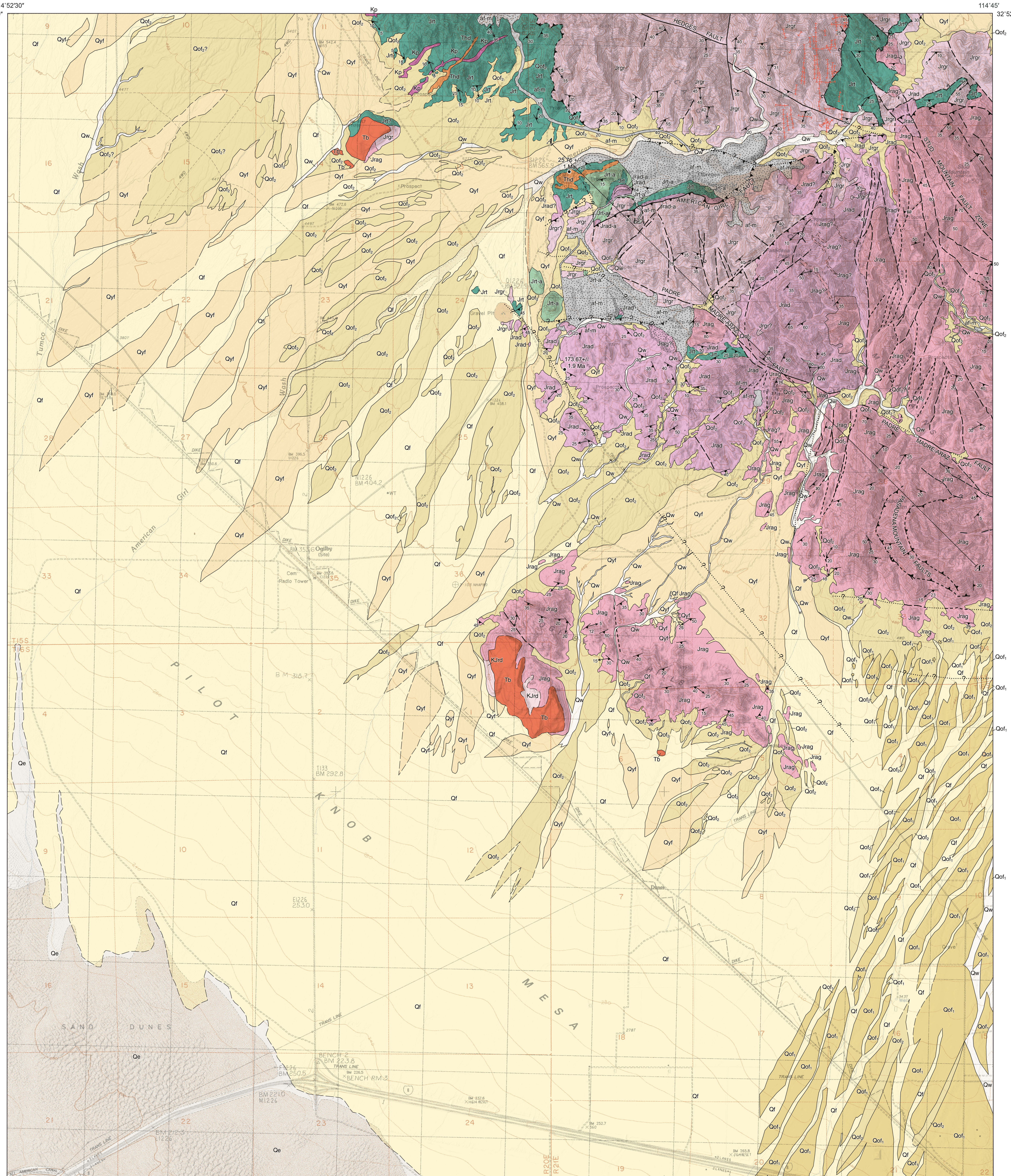
California geologic maps are available at https://www.conservation.ca.gov/cgs



PRELIMINARY GEOLOGIC MAP OF THE OGILBY 7.5′ QUADRANGLE, CARGO MUCHACHO MOUNTAINS, IMPERIAL COUNTY, CALIFORNIA

VERSION 1.0

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California Department of Conservation
California Geological Survey

DESCRIPTION OF MAP UNITS

SURFICIAL UNITS

af-m — **Artificial fill, mining related (historic)**—Deposits of fill resulting from mining or quarrying activities, including tailings, waste rock, and fills for associated access roads. Includes local areas of mine-disturbed bedrock of unknown affinity. Includes areas of undifferentiated, mineralized rock exposed at the American Girl and Padre Y Madre Mines, which may include Jrt, Jrt-a, Jrad, Jrad-a, and Jrgr (Dillon, 1975).

Qw — **Wash deposits (late Holocene)**—Unconsolidated, very pale-brown sand, gravel, cobbles, and local boulders deposited in recently active stream channels. Occur as narrow deposits in canyons upstream of the mountain front and as anastomosing to elongate deposits where active flow paths continue beyond the mountain front and traverse older fan deposits but do not form fan-shaped landforms. Sediments are derived from local bedrock or reworked from adjacent older Quaternary materials subject to mobilization and redeposition during storm events; lack soil development and oxidation on clasts, and only support local, sparse vegetation.

Qf — **Alluvial fan deposits (late Holocene)**—Unconsolidated to weakly consolidated, pink (5YR 8/3), poorly sorted deposits of sand, gravel, cobbles, and local boulders with intermixed silt forming active, undissected, alluvial fans. Fan apices form outboard and downgradient of incised older fans. Fans are a mix of sediment-rich stream deposits and poorly bedded, poorly sorted debris flow deposits containing angular to sub-angular pebble- to boulder-size clasts closer to incised older fans. Clasts are typically unweathered with little to no oxidation or desert varnish and are derived from upslope sources and reworked from adjacent, older fan deposits. Local-scale braiding on distributary fan surfaces.

Qe — **Eolian and dune deposits (late Holocene)**—Unconsolidated, pale-brown to yellow, generally well-sorted wind-blown sand; may occur as dune forms or sheet sand; occurs as ripples close to deposit margins; margins form as drifts and sand shadows around roads and vegetation. Part of the Algodones Dunes.

Qyf — **Young alluvial fan deposits (middle Holocene to late Pleistocene)**—Unconsolidated to weakly consolidated, pink (5YR 7/3), poorly sorted deposits of sand, gravel, cobbles, and local boulders with intermixed silt. Surfaces are undissected to slightly dissected. Clasts are generally weakly weathered with little oxidation and desert varnish. Clasts are derived from upslope sources or reworked from older, adjacent fan deposits. Fans are composed of sediment-laden stream deposits and poorly bedded, poorly sorted debris flow deposits containing pebble- to boulder-size clasts closer to the mountain front.

Old alluvial fan deposits (late to middle Pleistocene)—Slightly to moderately consolidated, poorly sorted deposits of silty, pebbly sand to coarse gravel and boulders. Deposits form broad, isolated fan surfaces that are typically smooth to moderately dissected and isolated by intervening younger fan and wash deposits. Surfaces exhibit desert varnish patinas and desert pavement development. Surfaces are generally elevated at least several meters above active channel grade and not subject to historic flood inundation. Locally differentiated into two subunits.

Qof_2 — **Old alluvial fan deposits, younger facies**—Sediments of Qof_2 are brown to dark brown, less consolidated and fans are less dissected compared to Qof_1. Fan surfaces have sparse and discontinuous desert pavement development compared to Qof_1.

Qof_1 — **Old alluvial fan deposits, older facies**—Sediments of Qof_1 are more consolidated, brown to red brown, and fan surfaces are more dissected. Fan surfaces are smoother and desert pavement development is more continuous compared to Qof_2. Fans in the southeast corner of the Ogilby Quadrangle may contain sediments derived from reworked Colorado River deposits.

CARGO MUCHACHO MOUNTAINS UNITS

TERTIARY VOLCANIC UNITS

Tb — **Basalt (Miocene)**—Vesicular, dark-gray, aphanitic basalt with phenocrysts of plagioclase (15%), olivine (<1%), and pyroxene (<1%). Vesicle abundance is 20% of the rock and vesicles range in size from 1 mm to 1 cm. Olivine crystals are 1 mm or smaller with iddingsite rims. Plagioclase phenocrysts are translucent and acicular to prismatic. Tb outcrops form mesas ranging from ~0.5 to 1 square km in area and consist of blocky, broken-up flows west of the central and southern Cargo Muchacho Mountains, and as a monogenetic cone to the east of the central Cargo Muchacho Mountains. Tentatively correlated with the Black Mountain basalt in the Chocolate Mountains (Muela (2011) reported an age of 9.45 +/- 0.27 Ma using $^{40}Ar/^{39}Ar$) based on petrographic similarities (Olmstead and others, 1973; Dillon, 1975).

Thd — **Dacite plugs and dikes (late Oligocene)**—Grayish-green to light-gray, biotite-pyroxene-hornblende dacitic plugs and dikes (Dillon, 1975). Weathers to reddish orange on exposed surfaces. Scattered dark, aphanitic xenoliths up to 2 cm in diameter visible on fresh surfaces. Just south of the Tumco mine, this unit forms a fine-grained, 50-m-wide dike, cutting the Tumco Formation (Jrt) and pegmatite unit (Kp). At the southwest end of American Girl Canyon, this unit cuts Jrt and forms a prominent ridge several meters wide. Poorly developed cooling fractures cause the unit to break into rectangular blocks and plates. U-Pb dating of zircons from Thd produced a lower intercept age of 25.76 +/- 1.0 [0.5] Ma (MSWD=0.65) (age +/-internal 2SE uncertainty [total 2% uncertainty]; analyses were conducted using laser ablation ICP-MS analyses at the CSUN Laser Lab (J. Schwartz, written commun., 2024)).

INTRUSIVE AND METAMORPHIC ROCKS – MESOZOIC AND OLDER

Kp — **Pegmatite (Late Cretaceous)**—Coarse-grained, centimeter- to meter-wide pegmatite dikes that crosscut the Tumco Formation (Jrt) and Gold Rock Ranch granite (Jrgr) (Cawood and others, 2022). Contains very coarse-grained (up to 10 cm) quartz and feldspar, and minor fine- to coarse-grained muscovite, biotite, and accessory garnet. U-Pb cooling age on apatite of 60 +/- 3.5 Ma (Cawood and others, 2022). Fold orientations suggest intrusion was synkinematic with thrusting on the American Girl fault (Cawood and others, 2022). A series of dikes mapped as lines within Jrgr may belong to this unit.

KJrd — **Granitic dikes and lenses (Late Cretaceous to Middle Jurassic (?))**—Weakly foliated phaneritic granites comprised of 60% subhedral quartz (approx. 1 mm), interstitial anhedral feldspar, and rare (<1%), scattered, euhedral, fine-grained biotite. This is correlative with the Mesozoic aplitic dikes described within the “aplitic and pegmatitic muscovite-biotite gneisses” of Dillon (1975). This unit crosscuts foliation of the Araz Wash granodiorite in the vicinity of the Ogilby Hills. Occurrences of this unit within the southern Cargo Muchacho Mountains, along with pegmatites near the Tumco mine (north of the map area) and American Girl fault (previously mapped as equivalent to Jrgr by Dillon (1975)), have been re-interpreted as a population of distinctive pegmatites (Kp) by Cawood and others (2022). Similar dikes occur elsewhere in the Cargo Muchacho Mountains and additional sampling is needed to help distinguish KJrd from other populations of dikes. A series of dikes mapped as lines within Jrgr may belong to this unit.

Jrgr — **Gold Rock Ranch granite (Late to Middle Jurassic)**—Foliated biotite granite exposed in the northern Cargo Muchacho Mountains (Tosdal and Wooden, 2015; Cawood and others, 2022). Foliation defined in part by discontinuous, millimeter-thick by 2-cm-long bands of biotite crystals (20%). Individual biotite grains are ~1 mm in diameter. 2- to 5-mm crystals of feldspar (40%) and quartz (40%), with coarser feldspar grains occurring in deuterically altered zones in the vicinity of the American Girl fault. Weathers into rectangular blocks with joints cutting foliation. This unit was mapped in detail by Dillon (1975) as coarse- to medium-grained, leucocratic biotite granite orthogneiss (“Jrbg”, Jrbf”) observed cross-cutting the Araz Wash granodiorite (Jrag), Araz Wash diorite (Jrad), and Tumco Formation (Jrt) (Dillon, 1975). Emplacement age of 163.8 +/-1.2 Ma based on U-Pb dating of zircons (Tosdal and Wooden, 2015).

Jrag — **Araz Wash granodiorite (Jurassic)**—Whitish-green hornblende-biotite-quartz granodiorite (Tosdal and Wooden 2015; Cawood and others, 2022). Weakly foliated, with 30% 0.3- to 1-cm glomerocrysts of biotite, hornblende, and sphene. Anhedral quartz (25%) and anhedral to subhedral feldspar (45%) both range in size up to 1 cm. Unit contains scattered mafic inclusions up to 10 cm in diameter and is cut by quartz veins up to 30 cm wide. Weathered surfaces are dark grey to brown. Weathering is pervasive along weak foliation. Up to 30% of feldspar grains show light-green saussuritization. This unit was mapped as quartz monzonite (“Mzqm”) by Dillon (1975) and crosscuts Araz Wash diorite (Jrad). Emplacement age 172 +/- 4.8 Ma based on U-Pb dating of zircons (Tosdal and Wooden, 2015).

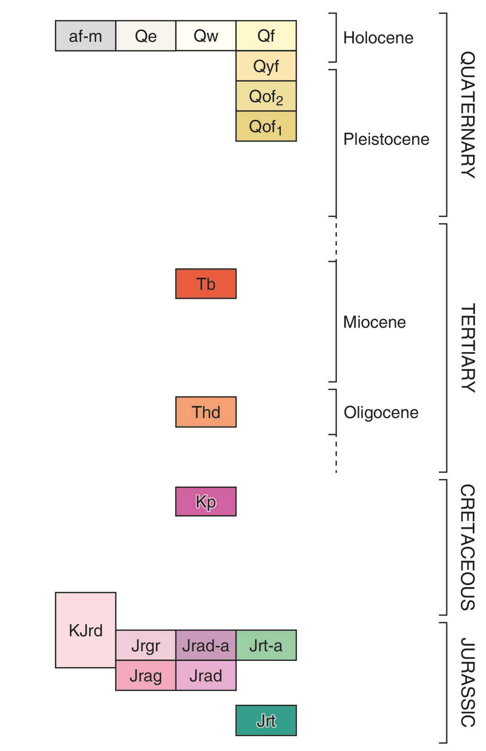
Jrad — **Araz Wash diorite (Jurassic)**—Hornblende-biotite quartz diorite (Dillon, 1975; Tosdal and Wooden 2015). Unit is weakly to moderately foliated with very fine-grained needles of amphibole intergrown into glomerocrysts elongated parallel to foliation and lesser biotite and sphene. Glomerocrysts range in size from 0.1 to 1 cm. Hornblende also occurs as disseminated, fine, needle-like crystals oriented within the plane of foliation; 2- to 3-mm intergrown crystals of quartz and feldspar are difficult to distinguish. Scattered euhedral plagioclase crystals up to 8 mm are also present. In thin section, quartz displays fine recrystallization texture, and plagioclase displays partial saussuritization. Unit is weakly to moderately foliated. Correlative with unit “d” of Dillon (1975). U-Pb dating of zircons from Jrad produced a mean weighted average age of 173.7 +/- 1.9 [3.5] Ma (MSWD = 0.8) (age +/-internal 2SE uncertainty [total 2% uncertainty]; analyses were conducted using laser ablation ICP-MS analyses at the CSUN Laser Lab (J. Schwartz, written commun., 2024)).

Jrad-a — **Araz Wash diorite, altered to biotite schist (Jurassic)**—Araz Wash diorite altered and metamorphosed to biotite schist (Dillon, 1975). Occurs as both halos that encapsulate Araz Wash diorite (Jrad) and as lenses up to 100 m within the Tumco Formation (Jrt and Jrt-a). Based on the close association with altered Tumco Formation (Jrt-a), this unit is interpreted to be formed from the same event that altered the Tumco formation to produce Jrt-a. (Dillon 1975). Occurs primarily in the vicinity of the American Girl fault zone.

Jrt — **Tumco Formation (Jurassic)**—Laminated, grayish-orange, quartzofeldspathic gneiss (Dillon, 1975). Laminations defined by parallel alignment of fine- to medium-grained (up to 1 mm) biotite (30%). Quartz and feldspar grains are slightly coarser than biotite (1–2 mm), with scattered quartz and feldspar augens 0.2 cm by 5 cm wide. Millimeter- to centimeter-scale gneissic banding present. In thin section, partial sericitization of feldspar and chloritization of biotite are visible, as well as the presence of very fine-grained accessory garnet and scattered fine-grained amphibole. Relict depositional layering combined with preserved magmatic phenocryst textures suggest a volcanic or volcaniclastic protolith (Dillon, 1975; Tosdal and Wooden, 2015). Weathers into large meter-scale blocks. Unit is pervasively cut by felsic dikes that range from centimeter-scale ptygmatic veinlets to large features tens of meters wide, extending over one km in length (including Late Cretaceous pegmatites (Kp) of Cawood and others (2022)). Based on work by previous authors (Dillon, 1975; Cawood and others, 2022) it appears that there are at least three distinct compositions of these dikes, which include Kp; more work is needed to resolve the spatial and chemical distribution of dikes within the Tumco Formation. Dillon (1975) observed local zones of interbedded quartzite, marble, and amphibolite throughout the unit, as well as a series of amphibolite dikes cutting the Tumco Formation (Jrt) in the southeastern Cargo Muchacho Mountains. Tosdal and Wooden (2015) obtained a rock age of 185 +/- 2.9 Ma from U-Pb dating of seven zircons in a quartzofeldspathic gneiss from the Tumco mine (north of the map area) that they interpreted as meta-dacite.

Jrt-a — **Tumco Formation, aluminosilicate alteration assemblage (Jurassic)**—Granoblastic kyanite schist, kyanite muscovite schist, and muscovite schist, with zones of magnetite (Dillon, 1975, Owens and Hodder, 1994). Late-stage pyrophyllite and tourmaline veins were noted by Dillon (1975). Correlative with the Vitrefrax formation of Henshaw (1942). Unit is white to light blue with zones of these different lithologic assemblages grading into one another and crosscutting one another on the scale of meters to tens of meters. At Vitrefax Hill and near the American Girl Wash, very fine-grained muscovite schist grades over several meters into kyanite muscovite schist. Kyanite muscovite schist contains scattered centimeter-sized quartz augens, and 0.5- to 3-cm-long elongate prisms of turquoise kyanite, randomly oriented within the foliation defined by muscovite. In some zones, kyanite muscovite schist contains large, meter-sized pockets of granoblastic kyanite schist with 70% kyanite prisms up to 10 cm long and minor garnet, staurolite, and rutile. This assemblage was originally described by previous authors, including Dillon (1975) and Owens and Hodder (1994), who further mapped subunits within this formation. Magnetite occurs as scattered porphyroblasts within the aluminosilicate assemblage, as well as in massive, meter-scale bands adjacent to quartz veins within the muscovite schist. Based on gradients in alteration observed near contacts between the Tumco Formation (Jrt), Gold Rock Ranch granite (Jrgr), and Araz Wash diorite (Jrad), Jrt-a is interpreted to have formed though hydrogen metasomatism when Jrgr intruded the Jrt (Dillon, 1975; Owens and Hodder,1994).

CORRELATION OF MAP UNITS



MAP SYMBOLS

Contact between map units – Solid where accurately located; long dash where approximately located; short dash where inferred

Fault – Solid where accurately located; long dash where approximately located; short dash where inferred; dotted where concealed; queried where uncertain

Thrust Fault – Sawteeth on upper (tectonically higher) plate; long dash where approximately located; short dash where inferred; dotted where concealed; queried where uncertain

Dike – Solid where accurately located

Area disturbed by mining

U-Pb geochronology point (two samples)

Strike and dip of geologic structure; number indicates strike or dip angle in degrees.

25 / 50 — Metamorphic foliation; may locally represent mylonitic foliation. Trend and plunge of metamorphic lineation. Foliation and lineation orientations digitized from Dillon (1975)

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IMAGERY

U.S. Department of Agriculture, 2020, Farm Service Agency–Aerial Photography Field Office, National Agriculture Imagery Program (NAIP), 60cm resolution. http://datagateway.nrcs.usda.gov/

U.S. Geological Survey, 2023, USGS Lidar Point Cloud CA Salton Sea: U.S. Geological Survey.

U.S. Geological Survey, 2011, Imperial County high resolution orthoimagery, 30cm resolution.

Scale 1:24,000

Coordinate System:
Universal Transverse Mercator, Zone 11N,
North American Datum 1927

Topographic base from U.S. Geological Survey
Ogilby 7.5-minute Quadrangle, 1988
Shaded relief image derived from USGS lidar DEM, 2021

Contour Interval: 40 Feet
Supplementary Contour Interval: 10 Feet
National Geodetic Vertical Datum of 1929

10.48°
TRUE NORTH
MAGNETIC NORTH
Approximate Mean Declination, 2024

Professional Licenses and Certifications:

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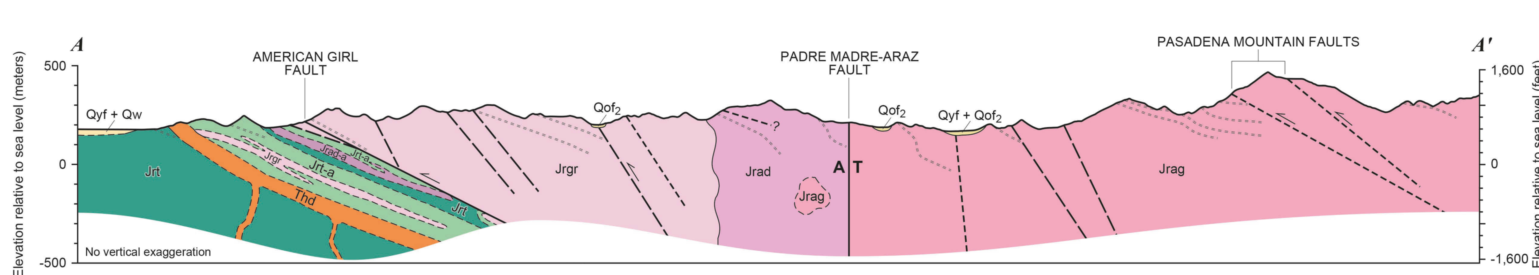
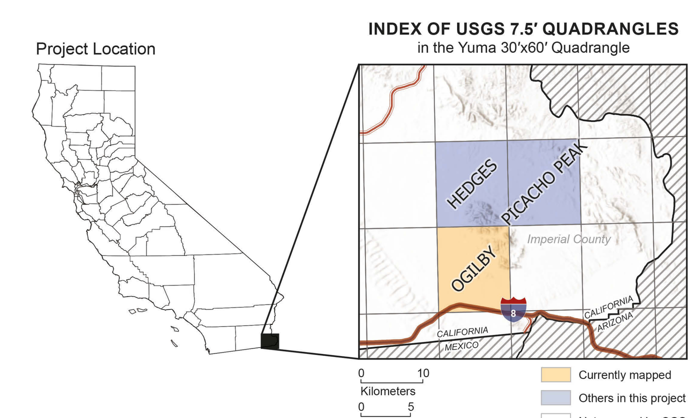
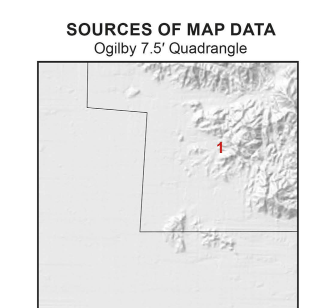
Signature, date, and stamp of licensed individual’s seal found within the accompanying document:
Authorship Documentation and Product Limitations







1. Cawood and others, 2022

Data sources that cover the entire quadrangle:
Dillon, 1975
Cantwell and Key, 2024

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PUBLICATION TITLE: Preliminary Geologic Map of the Ogilby 7.5′ Quadrangle, Cargo Muchacho Mountains, Imperial County, California

Preliminary Geologic Map 24-05

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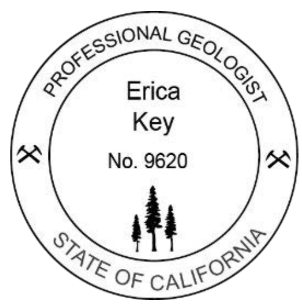

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