Preliminary Geologic Maps available from:
https://www.conservation.ca.gov/cgs/maps-data/rgm/preliminary

PRELIMINARY GEOLOGIC MAP OF THE WILLITS 7.5′ QUADRANGLE MENDOCINO COUNTY, CALIFORNIA

VERSION 1.0

By
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Digital preparation by
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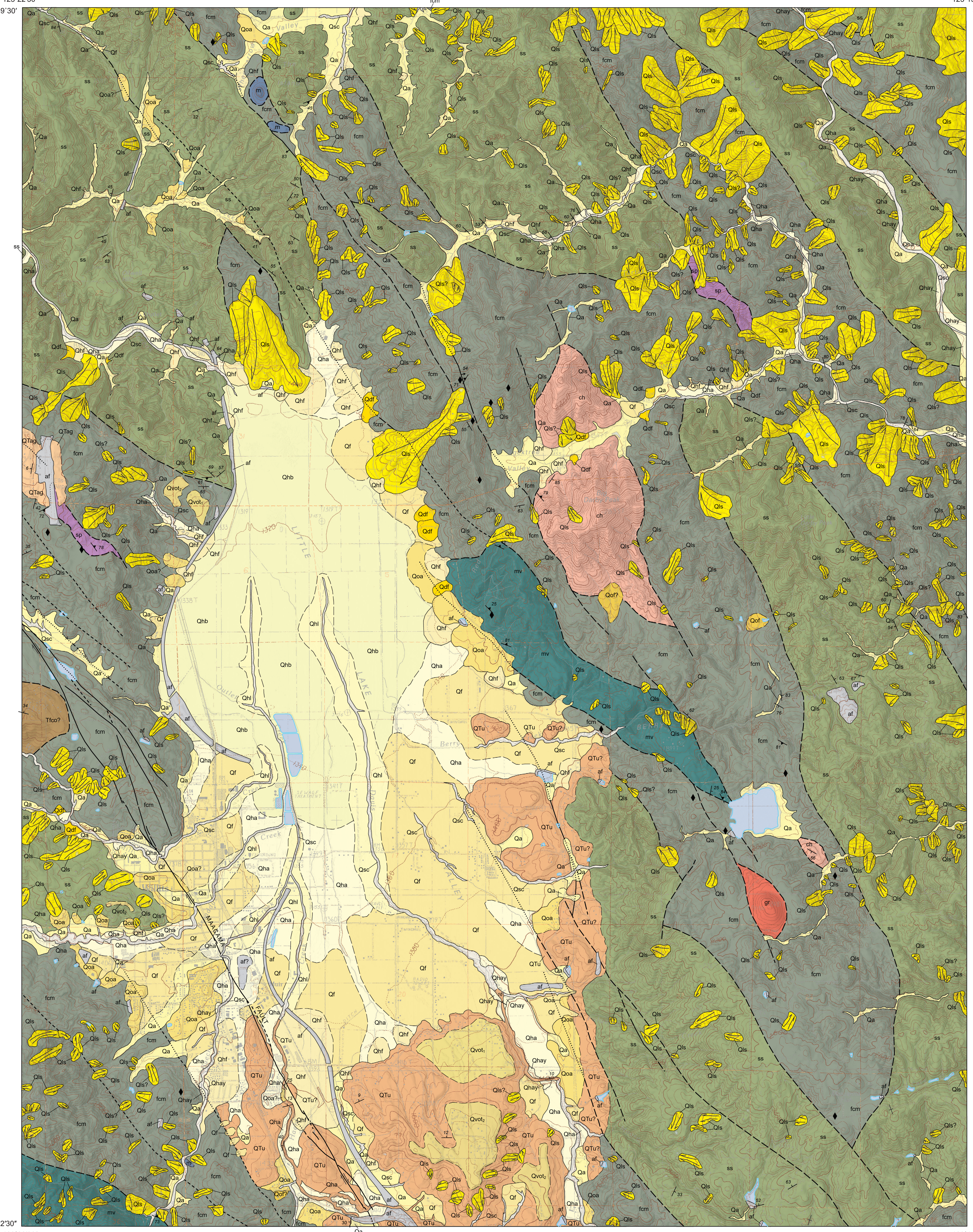
2024

California Department of Conservation
California Geological Survey



Coordinate System:
Universal Transverse Mercator, Zone 10N
North American Datum 1927

Topographic base from U.S. Geological Survey
Willits 7.5-minute Quadrangle, 1991.
Shaded relief image derived from USGS Lidar DEM, 2018-2019

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program, Statemap Award no. G23AC00402.

Scale 1:24,000

Contour Interval 40 Feet
Dotted Lines Represent 20-Foot Contours
National Geodetic Vertical Datum of 1929

13.54 °
TRUE NORTH
MAGNETIC NORTH
Approximate Mean Declination, 2024

DESCRIPTION OF MAP UNITS

QUATERNARY SURFICIAL DEPOSITS

af — **Artificial fill (historical)**—Consists of engineered and/or non-engineered soil materials; includes larger roadway embankments, earthen dams, levees, and other graded areas.

Qsc — **Stream channel deposits (modern to latest Holocene)**—Fluvial deposits within active, natural, and constructed stream channels. Composed of loose sand, gravel, and silt. Episodes of bank-full stream flow are frequent enough to inhibit growth of vegetation.

Qhay — **Stream terrace deposits (late Holocene)**—Unconsolidated sand, gravel, silt, and minor clay deposited in active stream settings; typically 3 m or less above the active channel. Commonly inset into adjacent, higher-level deposits of Holocene age.

Qha — **Alluvial deposits (Holocene)**—Unconsolidated sand, gravel, silt, and minor clay deposited in active or recently active valley fill, inter-fan areas, point bar, and stream settings. Surfaces are relatively flat or gently sloping, minimally dissected except at stream-facing margins, and widely disturbed by agricultural or other human activities. Generally less than 8 m above the active channel.

Qhl — **Alluvial fan levee deposits (Holocene)**—Unconsolidated sand, silt, and clay deposited adjacent to a stream channel where water and sediment overtop the channel bank. Mapped based on identification of low, elongated ridges generally parallel to and bordering the channel.

Qhb — **Basin deposits (Holocene)**—Unconsolidated alluvium in low-lying floodplain areas in the northern portion of Little Lake Valley; primarily associated with deposition in areas of standing or slow-moving water in topographic basins. Surface is relatively flat or very gently sloping, minimally dissected, and widely disturbed by agricultural or other human activities. Well logs presented by Woolace (2005) indicate primarily clayey sediment with local sand and gravel interbeds. Horizontal stratification is likely. May be interbedded with coarser alluvium from streams that flow into the basin. Interbeds of peat may also be present. Groundwater is shallow in this area of Little Lake Valley and Cardwell (1965) and Woolace (2005) document reports of marshes and a seasonal lake prior to artificial modifications to drainage.

Qhf — **Alluvial fan deposits (Holocene)**—Unconsolidated, poorly sorted gravel, sand, and silt; deposited chiefly from distributary streamflow and debris flows forming deposits with characteristic fan-shaped morphology that emanate from mountain front drainages and from channels incised through older materials. Fan surfaces show little dissection or soil profile development.

Qdf — **Debris fan deposits (Holocene)**—Unconsolidated, poorly sorted gravel, sand, and silt forming relatively steep, fan-shaped deposits at the mouth of small drainages and along steep hillsides where they include undifferentiated colluvium. Sediment is derived mainly from debris slides and debris flow events rather than fluvial processes. Limited dissection, poor soil development, and/or absence of mature vegetation indicate relatively recent or ongoing depositional processes. One exposure displays pale-brown to brown silt matrix.

Qa — **Alluvial deposits, undivided (Holocene to latest Pleistocene)**—Unconsolidated to weakly cemented sand, gravel, silt, and minor clay, mapped in smaller valleys and where variations in age and/or depositional settings of fans, stream terraces, and active channels are not distinguishable or not delineated at the scale of mapping.

Qf — **Alluvial fan deposits, undivided (Holocene to latest Pleistocene)**—Unconsolidated to weakly cemented, poorly sorted gravel, sand, and silt; mapped where morphologic indicators such as incision and soil development suggest the fan surface appears dormant, or the fan age is not distinguishable at map scale.

Qls — **Landslide deposits, undivided (Holocene to Pleistocene)**—Unconsolidated surficial failures commonly composed of a mix of soil, colluvium, and weathered bedrock; also includes moderately well-consolidated jumbled rock debris resulting from rock creep and large-scale rotational rockslides. Recognizable by topographic expression or chaotic internal structure. Only larger landslides discernable at the map scale are included. Includes deposits with ages ranging from historically active to older, relict, and heavily dissected slide masses. Queried where landslide existence is questionable.

Qof — **Older alluvial fan deposits (early Holocene to late Pleistocene)**—Brown to grayish-brown, slightly to moderately consolidated, poorly sorted gravel, sand, and silt deposited in alluvial fan settings; may also include undifferentiated colluvium from immediately adjacent hillsides. Moderately dissected to deeply incised at confluences with larger, higher-order truncating streams.

Qoa — **Older alluvial deposits (early Holocene to late Pleistocene)**—Light yellowish-brown, weakly consolidated, weakly to moderately cemented gravelly sand, silt, and clay deposited in stream and floodplain settings; locally also includes alluvial fan deposits where not mapped separately. Clasts range from rounded to angular locally. Localized gravel exposures are matrix supported and friable. Deposits have been uplifted or otherwise removed from the locus of recent sedimentation; preserved in terraces above recently active floodplains and adjacent drainages. Surfaces are dissected to varied degrees, with a moderately developed soil profile. Deposits are dark yellowish brown with depth, and gravel clasts have clay films. Radiocarbon dates reported by Woolace (2005) suggest deposits exposed in the channel of Haehl Creek are latest Pleistocene; however, that unit would be younger than the Ukiah formation so it is shown as Qoa? on the map. Conglomerates on the margins of Little Lake Valley are commonly poorly exposed and the difference between Qoa and QTu conglomerates can be subtle due to similar lithologies and clast provenance. Unit labels are queried where inaccessible and/or identity is uncertain.

Very old alluvial terrace deposits and surfaces (Pleistocene)—Eroded remnants of fluvial, alluvial fan, and colluvial deposits on isolated strath terrace surfaces cut into the Ukiah formation and bedrock of the Franciscan Complex. Deposits consist of deeply weathered, variably cemented, poorly sorted, silty to clayey sand and gravel; original thickness uncertain; now reduced to a thin remnant. The weathering profile locally extends into the strath surface. Gravel content tends to increase downward. Deposits are generally poorly sorted with variably rounded Franciscan Complex-derived gravels likely derived from adjacent highlands. The deposits are divided into subunits of inferred increasing age (1-youngest to 2-oldest) distinguished based on increasing topographic position above adjacent active floodplains, depth of weathering, and soil profile development. Progressive aging of the soil profile is marked by a diminishing to absent organic (A) horizon, development of the argillic (B) horizon with increasing pedogenic clay content, structure, weathering rinds on clasts, and depth and degree of oxidation reddening (Munsell soil color chart colors below classified with dry soil).

$Qvot_1$ — **Very old alluvial terrace deposits, unit 1 (Pleistocene)**—Thin organic horizon over gravel with strong-brown (7.5YR 4/6) weathered sand, silt, and clay matrix. Clasts up to 8 cm in diameter. Yellowish-red (5YR 5/6) clay films on clasts. Relatively youngest subunit representing deposits on the lowest strath terrace.

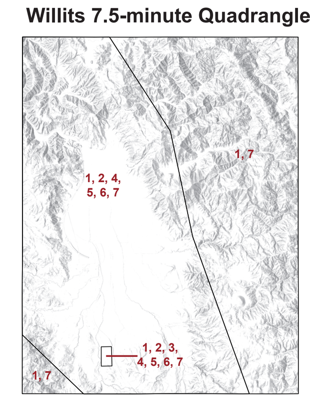
$Qvot_2$ — **Very old alluvial terrace deposits, unit 2 (Pleistocene)**—Little to no organic horizon; weakly developed argillic horizon over gravel with yellowish-red (5YR 5/6) to reddish-yellow (5YR6/8) clay matrix. Clasts are commonly 2 to 8 cm in diameter. Reddish-brown (5YR 4/4) clay films on clasts. Moderately indurated.

EARLY QUATERNARY TO LATE TERTIARY CONTINENTAL BASIN DEPOSITS

QTu — **Ukiah formation (Pleistocene to Pliocene (?))**—Pebble- to cobble-bearing conglomerate with interbedded silty sandstone and clayey siltstone. Deposits are well consolidated and generally moderately indurated, with local well-cemented sections. The conglomerate typically appears clast supported and massive or crudely stratified; cross-stratification with coarse channel lag deposits and clast imbrication displayed locally. Woolace (2005) interprets a general paleoflow direction to the south-southeast, based on measurements of clast imbrication. Clasts are mostly subrounded to well rounded; Woolace (2005) describes 60 cm boulders in outcrop near southern map boundary. Material appears entirely derived from the Franciscan Complex, dominated by sandstone, with lesser metavolcanic rock, chert, and vein quartz. Fine-grained units are commonly very pale brown (10YR 7/4). Common light yellowish-brown oxidation with yellow staining and light-gray mottling locally. Deeper, unoxidized portions described from boreholes and localized exposures exhibit a distinctive blue-gray color. Bedding is generally gently to moderately tilted, except near the Maacama fault where it steepens. Woolace (2005) estimates the unit has a minimum stratigraphic thickness of 1100 m in Little Lake Valley based on borehole and stratigraphic data. Woolace (2005) also reports on tephra occurrences identified in the area, including: Thermal Canyon ash (740 ka), Rockland ash (~575 ka), and an unnamed unit correlative to tephra in the Clear Lake basin (~110 ka). Based on stratigraphic data, Woolace (2005) estimates the maximum age of the section is ~1.2 Ma. Cardwell (1965) suggests this unit may be as old as Pliocene; however, the age of the lower boundary of the Pleistocene has since been redefined (Gibbard and others, 2010) and increased approximately one million years; therefore, the basal age may no longer extend into the Pliocene. Ukiah formation is an informal name adopted by CGS for related deposits found in the Ukiah Quadrangle (Delattre and Rubin, 2020); names previously applied to this unit include Ukiah beds (U.S. Army Corps of Engineers, 1955), Continental deposits (Cardwell, 1965), and Calpella gravels (Orchard, 1979). Conglomerates on the margins of Little Lake Valley are commonly poorly exposed and the difference between Qoa and QTu conglomerates can be subtle due to similar lithologies and clast provenance. Unit labels are queried where inaccessible and/or identity is uncertain.

QTag — **Airport gravels of Woolace (2005) (Pleistocene to Pliocene (?))**—Pebble- to cobble-conglomerate, with interbedded laminated siltstone and/or mudstone; well consolidated. The conglomerate typically appears matrix supported and massive or crudely stratified. Clasts are generally subrounded to well rounded, and range in size up to 25 cm. Material appears derived from the Franciscan Complex; dominated by sandstone, with lesser metamorphic rock and chert, and includes distinctive white meta-quartzite[?] of uncertain origin. The unit is generally deeply weathered with yellow to brownish-yellow colors; sandstone clasts and other fine-grained clasts are reduced to a friable condition. Bedding is gently dipping. Unit defined by Woolace (2005) for deposits exposed near Willits Municipal Airport. May be overlain locally by a very old terrace gravel weathered to yellowish-red and red colors, not differentiated on map. Age is inferred to be equivalent to QTu based on the unit having some common characteristics, including the following: similar conglomerate properties; interbedded fine-grained facies; and possible overlying very old terrace deposits. However, the extensive weathering and higher elevation may distinguish it from QTu observed along margins of Little Lake Valley. Woolace (2005) suggests this unit may be older than Pleistocene; however, the age of the lower boundary of the Pleistocene has since been redefined (Gibbard and others, 2010) and increased approximately one million years; therefore, the basal age of the Airport gravels may not extend beyond the Pleistocene.

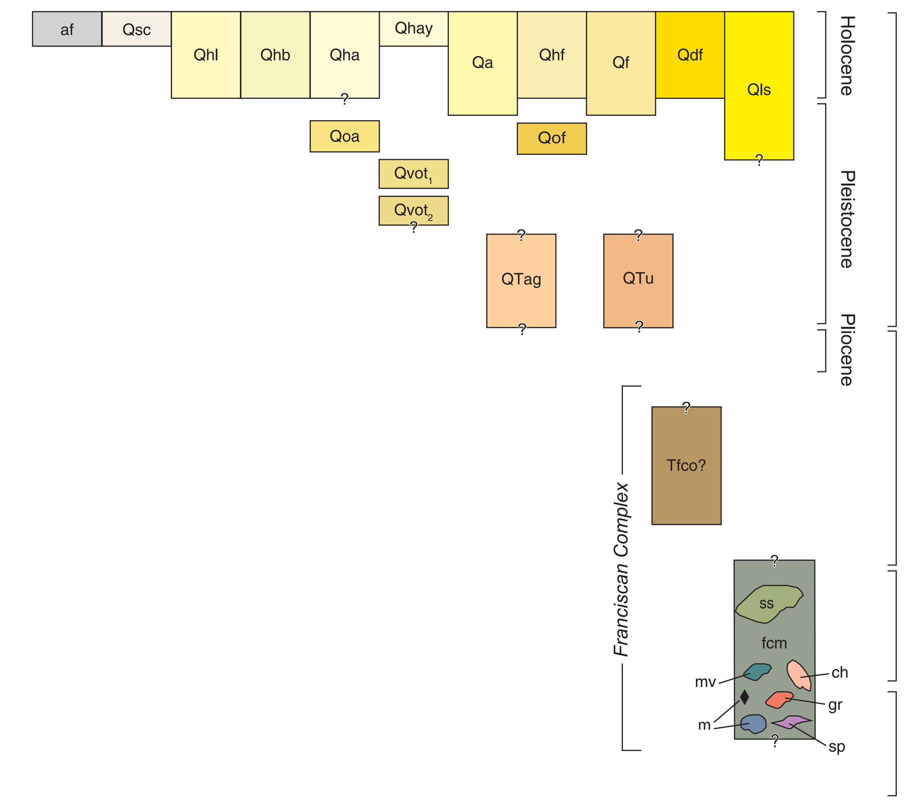
Willits 7.5-minute Quadrangle



SOURCES OF MAP DATA
1. Durham, 1979*
2. Smith, 1981a
3. Simpson, 2016
4. Cardwell, 1965
5. Farrar, 1986
6. Woolace, 2005
7. Rubin, 2024*

*Data source covers entire quadrangle.

CORRELATION OF MAP UNITS



MAP SYMBOLS

Contact between map units—Solid where accurately located; long dash where approximately located; short dash where inferred; dotted where concealed.

Fault—Solid where accurately located; long dash where approximately located; short dash where inferred; dotted where concealed; queried where uncertain. Arrow and number indicate direction and angle of dip of fault plane. Relative horizontal movement shown by arrows parallel to fault.

Landslide—Arrows indicate principal direction of movement. Where mapped as a landslide complex, adjacent defined slides have different relative ages and/or failure types.

Mélange block—See description of map unit “m” for details.

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

25 Inclined bedding

Vertical bedding

50 Metamorphic foliation

FRANCISCAN COMPLEX – COASTAL BELT

Tfco? — **Coastal Belt, undivided (Oligocene to Eocene)**—Very pale-orange, laminated argillite. Includes grayish-orange, poorly sorted, fine- to medium-grained arkosic sandstone interbeds. Sandstone beds are 15 cm to >30 cm thick; discontinuous; possibly sheared or deformed. Sandstone includes detrital biotite and mica. Weathered with yellowish-brown oxide stains. Bailey and others (1964) document widespread presence of distinctive detrital potassium feldspar in Coastal Belt sandstones. One occurrence of Coastal Belt material is queried along the west-central margin of the Willits Quadrangle. The identity is queried due to limited exposure and uncertain structural relationships with the adjacent Central Belt. Kilbourne (1984) depicts the Coastal Belt as thrust over the Central Belt in the adjacent quadrangle, in contrast to previous work in the area by Kramer (1976) showing the opposite relationship. Regionally, the Coastal Belt is understood to have been thrust under the Central Belt (e.g., Kramer, 1976; Langenheim and others, 2013), resulting in extensive deformation and zeolite facies metamorphism (e.g., Ernst and McLaughlin, 2012). Detrital zircons from sandstones within the Coastal Belt near the study area suggest maximum depositional ages that range from early Oligocene to Eocene (Dumitru and others, 2015).

FRANCISCAN COMPLEX – CENTRAL BELT

fcm — **Central Belt mélange, undivided (Paleogene (?), Cretaceous and Jurassic (?))**—Pervasively sheared, dark-gray to black, scaly argillite and sandstone (informally referred to as graywacke), which form a matrix enclosing small pods, blocks, and large slabs of more intact rock of various lithologies; overprinted by low-grade metamorphism. The Central Belt matrix sandstone is gray to olive gray, yellowish brown where oxidized, well indurated, poorly sorted, and arkosic; commonly consisting of approximately equal proportions of quartz, plagioclase feldspar, and lithic fragments, with 5 to 20 percent of the rock being matrix (Hecht, 1970; Stanford, 1991). Coarse shale chips and detrital biotite are common lithic components in hand sample. The sandstone lacks potassium feldspar and displays textures and metamorphic mineral assemblages consistent with Central Belt units elsewhere (Jayko and others, 1989; Stanford, 1991). Sandstone appears weakly recrystallized due to metamorphism and is commonly cut by veins. Interbedded sandstone and shale resembling turbidites is exposed locally. Due to pervasive deformation and limited exposure, bedding is variable over short distances and is not traceable across a mappable area. The mélange underlies rolling, characteristically hummocky topography, particularly where isolated blocks within shale matrix are the dominant structure. Hummocky topography is also commonly associated with overprinting of the structure by extensive Quaternary landslide movement. The unit also includes large areas with landslide-like features not distinguishable as individual landslides. Mélanges are interpreted as originating from tectonic and/or depositional mixing processes, which likely also included coeval submarine landslide/large-scale gravitational movement. Contacts are generally interpreted as faulted, but many are of uncertain origin based on limited available exposures. In the Redwood Valley Quadrangle (Rubin, 2021), chert blocks within the mélange range from Jurassic through Cretaceous in age (Stanford, 1991); however, dates from mélange matrix collected elsewhere in the region suggest tectonic and/or depositional assemblage of the mélange may have extended into the early Tertiary (McLaughlin and others, 2018). Detrital zircons from Central Belt sandstones in the map region indicate an approximate mid-Cretaceous maximum depositional age, with ages ranging from 107 to 85 Ma (Dumitru and others, 2015). Other deposits within the undifferentiated mélange may extend into the Jurassic. Portions of undifferentiated mélange in this study may include additional distinctive mappable blocks and slabs of lithologies described below, but wide areas were largely inaccessible in the field. Mappable units within the mélange include:

ss — **Sandstone**—Map unit combines isolated blocks and areally extensive occurrences of poorly to moderately sorted, fine- to medium-grained, low-grade metamorphic arkosic sandstone; includes rare conglomerate. Commonly light olive gray in color; ranges from dusky yellow, to grayish olive, to greenish gray and medium gray where minimally weathered. Lithic component varies in abundance; detrital biotite and coarse shale chips are common. Bedding varies from massive to interbedded sandstone and shale. Rock exposures vary widely from hard and cemented, with little oxide staining, to intensely weathered and reduced to a friable, grayish-orange and reddish-yellow, highly oxidized condition, particularly in exposures along Ridgewood Road towards the southeast corner of the quadrangle. Degree of internal deformation varies from relatively coherent with localized zones of shearing or other deformation, to broken. May locally include blocks of other subunits. Generally weakly recrystallized, consistent with metamorphic Textural Zone 1 of Blake and others (1967); higher grade, foliated metamorphic units found locally. Mapped where unit is large enough to meet minimum map unit size, and where assignment to another map unit is uncertain. Relative to Central Belt mélange (fcm) matrix, larger mapped occurrences of this unit are generally more coherent, contain fewer exotic lithologies, are less prone to large landslides, and are underlain by steeper more resistant slopes, as expressed in the northwest corner of the quadrangle. Generally associated with denser forest vegetation relative to fcm.

ch — **Chert**—Red, green, and white chert; variably metamorphosed. Occurs mostly in rhythmically bedded packets with dark-gray shale partings and locally contorted bedding; includes some sandstone. Locally massive or as brecciated fragments; also present as isolated mélange blocks too small to distinguish at map scale. Large section delineated near center of map is associated with resistant topography and steep slopes. Chert samples from various units in the Redwood Valley Quadrangle (Rubin, 2021) yielded radiolarians ranging from Toarcian (late Early Jurassic) to Albian (late Early Cretaceous) in age (Stanford, 1991).

mv — **Metavolcanic rock (greenstone)**—Olive-gray to greenish-black, strong-brown and yellowish-red weathering, aphanitic, variably weathered and altered, mafic volcanic rock; predominately massive and broken; variably sheared; locally stained black. Section mapped above east side of Little Lake Valley is intensely deformed and fractured; mapped areas include some local sandstone and other lithologies. Also present as isolated mélange blocks too small to distinguish at map scale. Weathers to a soil with distinctive red and brown colors.

m — **High-grade metamorphic rock**—Metamorphic rock with phyllitic to gneissose texture; largely blueschist grade although other highly metamorphosed Franciscan rock types are included; mapped as polygons where unit exposures are large enough to meet minimum map unit size; black diamond symbols are used for discrete mélange blocks smaller than minimum map unit size.

sp — **Serpentinite**—Pale-olive to grayish-olive-green, serpentinized ultramafic rocks. Commonly pervasively sheared and foliated; ultramafic protolith texture is preserved locally. Appears to enclose blocks of other fcm lithologies locally. Weathers to regolith and soil with distinctive blue-green or reddish colors. Occurs as mappable units and isolated blocks within the mélange, also along shear zones. Vegetation on serpentinite is chiefly sparse shrubs.

gr — **Granite**—Greenish-gray, medium-grained felsic granitoid. Weakly recrystallized and foliated. This unit is interpreted to be a mélange block. Includes possible blue amphiboles, indicative of higher-grade metamorphism than the surrounding mélange matrix. Unit is associated with distinctive smooth, steep slopes and an overall domed expression. Plutonic mélange blocks in the Franciscan are reported to the south by Erickson (2011), with one having a reported U/Pb zircon age of 165 ± 1 Ma.

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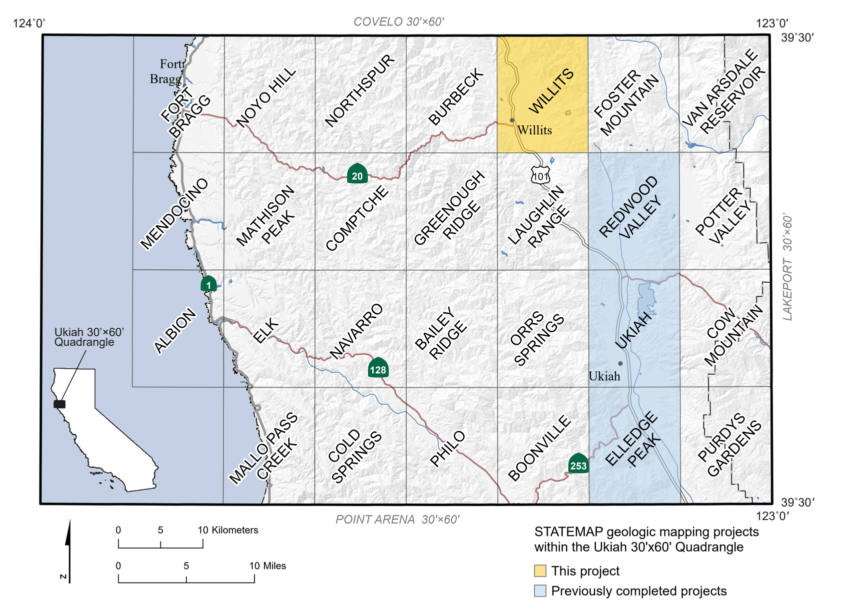

STATEMAP geologic mapping projects within the Ukiah 30′x60′ Quadrangle
This project
Previously completed projects

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Publication Title: "Preliminary Geologic Map of the Willits 7.5′ Quadrangle, Mendocino County, California: California Geological Survey Preliminary Geologic Map 24-01, scale 1:24,000"

Suggested citation:
Rubin, R.S., 2024, Preliminary geologic map of the Willits 7.5′ Quadrangle, Mendocino County, California: California Geological Survey Preliminary Geologic Map 24-01, scale 1:24,000.

AUTHORSHIP DOCUMENTATION AND PRODUCT LIMITATIONS

PUBLICATION TITLE: Preliminary Geologic Map of the Willits 7.5’ Quadrangle, Mendocino County, California
Preliminary Geologic Map 24-01

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Date: August 5 , 2024

This authorship document accompanies the geologic map with the following citation:

Rubin, R.S., 2024, Preliminary geologic map of the Willits 7.5’ Quadrangle, Mendocino County, California: California Geological Survey Preliminary Geologic Map 24-01, scale 1:24,000.