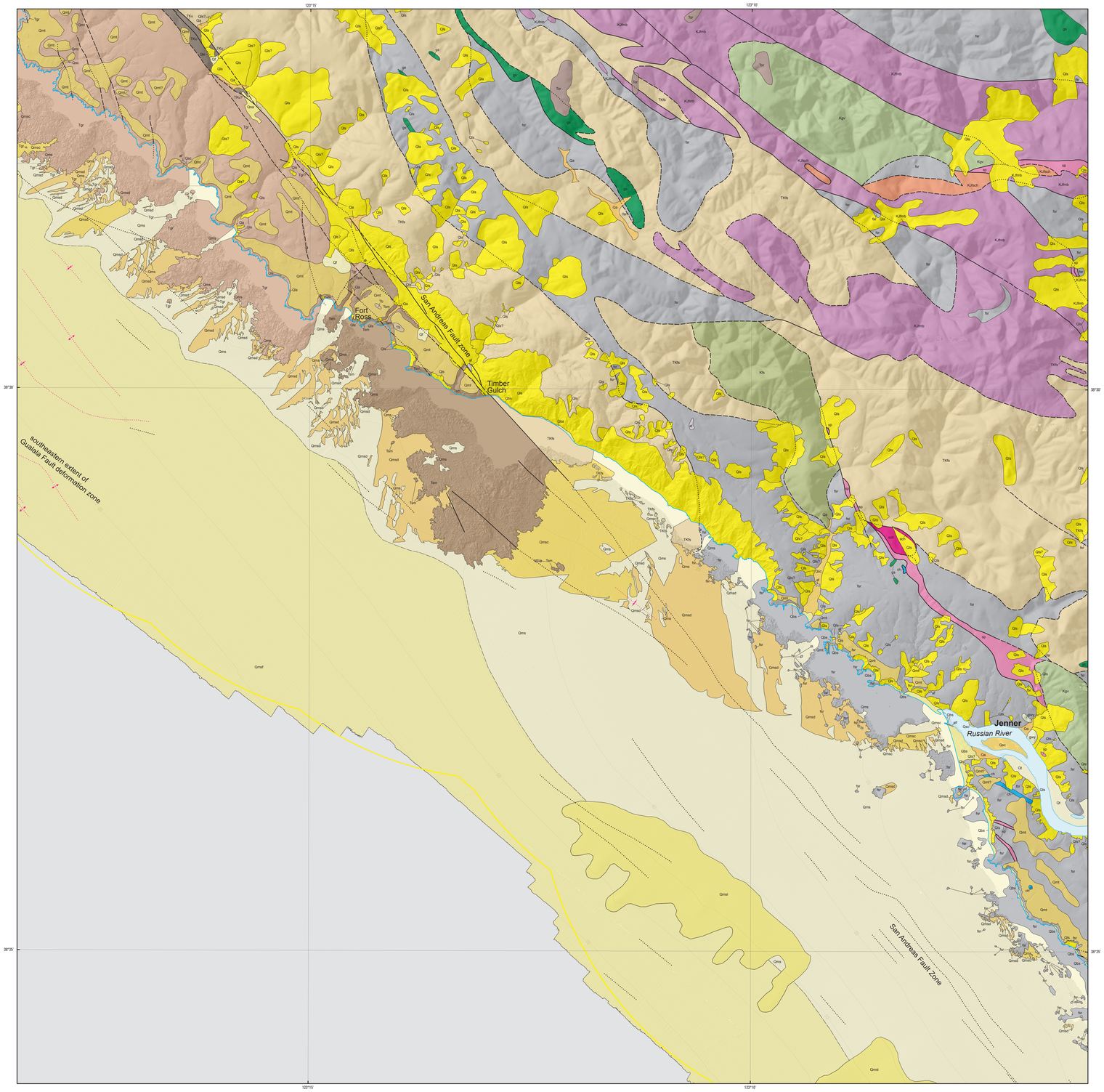
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1211
Sheet 10 of 10
Pamphlet accompanies map



Onshore elevation data from National Oceanic and Atmospheric Administration's (NOAA's) Digital Coast (available at http://coast.noaa.gov/digitalcoast/data/coastallidar/), from OpenTopography (available at http://www.opentopography.org/), and from U.S. Geological Survey's National Elevation Dataset (available at http://ned.usgs.gov/). Offshore shaded-relief bathymetry from map on sheet 2, this report. California's State Waters limit from NOAA Office of Coast Survey

Universal Transverse Mercator projection, Zone 10N

NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN DECLINATION, 2015

SCALE 1:24 000

BATHYMETRIC CONTOUR INTERVAL 10 METERS

ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Offshore geology and geomorphology mapped by Stephen R. Hartwell and Samuel Y. Johnson, 2012–2013; Onshore geology and geomorphology compiled by Michael W. Manson, 2012–2013, from Huffman (1972), California Geological Survey (1974), Blake and others (2002), Manson and others (2006), and Wagner and Gutierrez (2010), in press). Bathymetric contours by Peter Dartnell, 2013

GIS database and digital cartography by Peter Dartnell and Stephen R. Hartwell

Manuscript approved for publication November 5, 2015

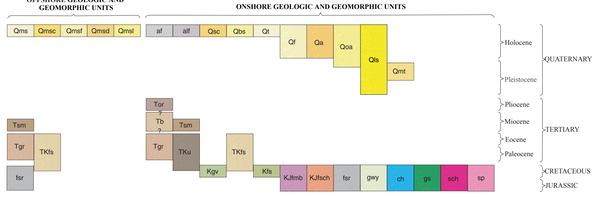
Offshore and Onshore Geology and Geomorphology, Offshore of Fort Ross Map Area, California

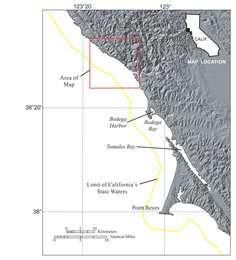
By
Samuel Y. Johnson,[1] Stephen R. Hartwell,[1] and Michael W. Manson[2]
2015

[1]U.S. Geological Survey;
[2]California Geological Survey

CORRELATION OF MAP UNITS

[See Description of Map Units (chapter 8, in pamphlet) for precise unit ages]





LIST OF MAP UNITS

[See Description of Map Units (chapter 8, in pamphlet) for complete map-unit descriptions]

OFFSHORE GEOLOGIC AND GEOMORPHIC UNITS

Qms — **Marine nearshore and shelf deposits (late Holocene)**—Mostly sand; ripples common

Qmsc — **Coarse-grained marine nearshore and shelf deposits (late Holocene)**—Coarse sand, gravel, and cobbles

Qmsf — **Fine-grained marine shelf deposits (late Holocene)**—Mostly mud and muddy sand

Qmsd — **Marine shelf scour depressions (late Holocene)**—Inferred to be coarse sand and gravel, in low-relief scours

Qmsl — **Marine midshelf sediment lobes (late Holocene)**—Fields of elongate, shore-normal pairs of sediment lobes and chutes

Tsm — **Sandstone and mudstone of Fort Ross area (Blake and others, 2002) (early Miocene)**—Grayish-white arkose overlain by black, fissile, clayey siltstone; sandstone is interbedded with black mudstone

Tgr — **German Rancho Formation (Elder, 1998) (Eocene and Paleocene)**—Well-bedded, fine- to medium-grained sandstone, mudstone, and conglomerate

Franciscan Complex

TKls — **Sandstone within Coastal or Central Belt (late Eocene to Late Cretaceous)**—Mostly massive, feldspathic-lithic wacke

fsr — **Mélange in Central Belt (Cretaceous and (or) Jurassic)**—Matrix of sheared argillite, graywacke, and minor green tuff that encloses blocks and lenses of diverse sedimentary, volcanic, and metamorphic rocks

ONSHORE GEOLOGIC AND GEOMORPHIC UNITS

[Bedrock units compiled from Huffman (1972), Blake and others (2002), Manson and others (2006), and Wagner and Gutierrez (2010), as well as previously unpublished mapping; unit ages, which are from these sources, reflect local stratigraphic relations. Quaternary units compiled from Witter and others (2006), with some additional mapping by M.W. Manson (this report); in addition, some units modified by M.W. Manson on basis of interpretation of 2003 lidar and 2004 ifsar imagery]

af — **Artificial fill (late Holocene)**—Material deposited by humans

alf — **Artificial groin (late Holocene)**—Groin constructed at mouth of Russian River

Qsc — **Stream-channel deposits (late Holocene)**—Fluvial deposits within active, natural stream channels

Qbs — **Beach-sand deposits (late Holocene)**—Active beaches in coastal environments; may form veneer over bedrock platform

Qt — **Stream-terrace deposits (late Holocene)**—Stream-terrace deposits inferred to have formed in last 1,000 years

Qf — **Alluvial fan deposits (Holocene)**—Sediment deposited by streams emanating from mountain canyons onto alluvial valley floors or alluvial plains

Qa — **Alluvial deposits, undivided (Holocene)**—Alluvium deposited in fan, terrace, or basin environments

Qoa — **Alluvial deposits, undivided (Holocene and late Pleistocene)**—Mapped in small valleys where separate fan, channel, and terrace units could not be delineated at map scale

Qls — **Landslide deposits (Holocene and Pleistocene)**—Weathered rocks and soil. Internal contacts differentiate individual landslide bodies

Qmt — **Marine-terrace deposits (late Pleistocene)**—Sand, gravel, and cobbles; deposited on marine-abrasion platforms and later uplifted to present-day elevations along coast

Tor — **Ohlson Ranch Formation (Blake and others, 2002) (Pliocene)**—Horizontal, thickly bedded, well-consolidated sandstone

Tb — **Basalt of Fort Ross (Miocene?)**—Basalt that forms two small knobs near Fort Ross; surrounded by marine-terrace deposits; bedrock contacts not exposed

Tsm — **Sandstone and mudstone of Fort Ross area (Blake and others, 2002) (early Miocene)**—Grayish-white arkose overlain by black, fissile, clayey siltstone; sandstone is interbedded with black mudstone

Tgr — **German Rancho Formation (Elder, 1998) (Eocene and Paleocene)**—Well-bedded, fine- to medium-grained sandstone, mudstone, and conglomerate

TKu — **German Rancho and Gualala Formations, undivided (Elder, 1998) (Eocene, Paleocene, and Late Cretaceous)**—Sandstone, conglomerate, mudstone, and shale

Kgv — **Great Valley sequence conglomerate of Healdsburg terrane (Cretaceous)**—Pebble to boulder conglomerate

Franciscan Complex (Eocene, Paleocene, Cretaceous, and Jurassic)

TKls — **Sandstone in Coastal or Central Belt (late Eocene to Late Cretaceous)**—Mostly massive, feldspathic-lithic wacke

Kls — **Sandstone in Central Belt (Cretaceous)**—Massive to distinctively bedded, feldspathic and feldspathic-lithic wacke

KJfmb — **Metabasalt in Eastern Belt (Cretaceous and (or) Jurassic)**—Blueschist-facies metabasalt (Blake and others, 2002)

KJfsch — **Metamorphic rocks in Eastern Belt (Cretaceous and (or) Jurassic)**—Predominantly metagraywacke that has weak to moderate foliation, as well as metashale and metagreenstone

fsr — **Mélange in Central Belt (Cretaceous and (or) Jurassic)**—Matrix of sheared argillite, graywacke, and minor green tuff that encloses blocks and lenses of diverse sedimentary, volcanic, and metamorphic rocks

gwy — **Graywacke and metagraywacke blocks within mélange (Cretaceous and (or) Jurassic)**

ch — **Chert and metachert blocks within mélange (Cretaceous and (or) Jurassic)**—Includes massive and thinly bedded red, green, and white chert and metachert

gs — **Greenstone blocks within mélange (Cretaceous and (or) Jurassic)**—Includes massive and pillowed greenstone and basalt

sch — **Schist and semischist blocks within mélange (Cretaceous and(or) Jurassic)**

sp — **Ultramafic rocks in Central Belt (Cretaceous and (or) Jurassic)**—Partly to completely serpentinized peridotite

EXPLANATION OF MAP SYMBOLS

Contact—Solid where location is certain, long-dashed where location is approximate

Fault—Solid where location is certain, long-dashed where location is approximate, short-dashed where location is inferred, dotted where location is concealed, queried where uncertain

Folds—Dotted where location is concealed

Anticline

Syncline

Approximate modern shoreline—Defined as Mean High Water (MHW) (+1.46 m), North American Vertical Datum of 1988 (NAVD 1988)

3-nautical-mile limit of California's State Waters

Area of "no data"—Areas beyond 3-nautical-mile limit of California's State Waters were not mapped as part of California Seafloor Mapping Program

DISCUSSION

Marine geology and geomorphology were mapped in the Offshore of Fort Ross map area from approximate Mean High Water (MHW) to the 3-nautical-mile limit of California's State Waters. MHW is defined at an elevation of 1.46 m above the North American Vertical Datum of 1988 (NAVD 88) (Weber and others, 2005). Offshore geologic units were delineated on the basis of integrated analyses of adjacent onshore geology with multibeam bathymetry and backscatter imagery (sheets 1, 2, 3), seafloor-sediment and rock samples (Reid and others, 2006), digital camera and video imagery (sheet 6), and high-resolution seismic-reflection profiles (sheet 8). Aerial photographs taken in multiple years were used to map the nearshore area (0 to 10 m water depth) and to link the offshore and onshore geology.

Onshore bedrock units are compiled from Huffman (1972), Blake and others (2002), Manson and others (2006), and Wagner and Gutierrez (2010); in addition, some Franciscan Complex units are modified from previously unpublished mapping (E.H. Bailey, W.P. Irwin, U.S. Geological Survey; D.L. Wagner, M.W. Manson, California Geological Survey); unit ages, which are derived from these sources, reflect local stratigraphic relations. Onshore Quaternary units are compiled from Witter and others (2006), with some additional mapping by M.W. Manson (this report); in addition, some units are modified by M.W. Manson on the basis of analysis of 2003 lidar and 2004 ifsar imagery. Traces of the San Andreas Fault are compiled from California Geological Survey (1974a,b,c) and previously unpublished mapping by M.W. Manson.

The geomorphology and geology of the offshore part of the map area result from the interplay between local sedimentary processes, oceanography, sea-level rise, and tectonics. The nearshore seafloor in the north half of the map area is characterized by rocky outcrops of Tertiary sedimentary rocks (units Tgr and Tsm). This rugged nearshore zone and the inner shelf area (to water depths of about 50 m) typically dip seaward about 1.5° to 2.5°, whereas the midshelf area within California's State Waters (about 50 to 85 m deep) dips more gently, about 0.4°. In contrast, the nearshore to midshelf area in the south half of the map area, which lies directly offshore of the mouth of the Russian River, has a more uniform dip: about 0.45° out to water depths of about 30 m and about 0.65° to 0.8° at water depths of between 30 and 70 m. A substantial amount of the Russian River sediment load, which is estimated to be about 900,000 metric tons/yr (Farnsworth and Warrick, 2007), is deposited offshore of the river mouth (see Map B on sheet 9), contributing to the north-to-south contrast in bathymetric slope. On a larger geomorphic scale, sea level has risen about 125 m over the last about 21,000 years (see, for example, Lambeck and Chappell, 2001; Peltier and Fairbanks, 2006), leading to broadening of the continental shelf, progressive eastward migration of the shoreline and wave-cut platform, and associated transgressive erosion and deposition. Tectonic influences on the geomorphology and geology of the shelf are related primarily to the active San Andreas Fault system.

Given the exposure to high wave energy, the modern nearshore to inner shelf sediments north of the mouth of the Russian River are mostly sand (unit Qms) and a mix of sand, gravel, and cobbles (units Qmsc and Qmsd). Coarser grained sands and gravels (units Qmsc and Qmsd) are recognized primarily on the basis of bathymetry and high backscatter (sheets 1, 2, 3). Both units Qmsc and Qmsd typically have abrupt landward contacts with bedrock (units Tgr, Tsm, TKls, fsr) and they form irregular to lenticular exposures that commonly are elongate perpendicular to the shoreline. Contacts between units Qmsc and Qms typically are gradational.

Unit Qmsd typically is mapped as erosional lags in scour depressions that are bounded by relatively sharp or, less commonly, diffuse contacts with the horizontal sand sheets of unit Qms. These depressions generally are a few tens of centimeters deep and range in size from a few tens of square meters to more than 1 km^2. Such scour depressions are common along this stretch of the California coast (see, for example, Cacchione and others, 1984; Hallenbeck and others, 2012) where offshore sandy sediment can be relatively thin (and, thus, is unable to fill the depressions) owing to lack of sediment supply from rivers and also to significant erosion and offshore transport of sediment during large northwest winter swells. Such features have been referred to as "rippled scour depressions" (see, for example, Cacchione and others, 1984) or "sorted bedforms" (see, for example, Goff and others, 2005; Trembanis and Hume, 2011). Although the general areas in which both unit Qmsd scour depressions and surrounding Qms sand sheets are found are not likely to change substantially, the boundaries of the unit(s) likely are ephemeral, changing seasonally and during significant storm events.

Unit Qmsf, which lies offshore of unit Qms, consists primarily of mud and muddy sand, and it commonly is extensively bioturbated. The water depth of the transition from sand-dominated marine sediment (unit Qms) to mud-dominated marine sediment (unit Qmsf) increases from about 45 to 50 m directly offshore of the mouth of the Russian River to as much as about 60 m adjacent to the rocky outcrops near the north edge of the map area. This change probably is related to the large amount of fine-sediment load carried by the Russian River, which feeds a widespread midshelf mud belt that extends from Point Arena to Point Reyes (fig. 1–1) (Kline, 1983; Drake and Cacchione, 1985; Demirpolat, 1991).

The Offshore of Fort Ross map area is cut by the northwest-striking San Andreas Fault, the right-lateral transform boundary between the North American and Pacific plates. The San Andreas Fault extends across the inner shelf in the southern part of the map area, then it crosses the shoreline at Timber Gulch and continues onland for about 75 km to the east flank of Point Arena (fig. 1) (Lawson, 1908; Brown and Wolfe, 1972). Seismic-reflection data (see sheet 8) reveal a 200- to 500-m-wide fault zone that typically is characterized by one or two primary fault strands. In the southern part of the map area, about 1,500 m west of the San Andreas Fault, the midshelf (water depths of between 40 and 70 m) area includes an about 5-km-wide field of elongate pairs of sediment lobes and chutes (unit Qmsl) oriented perpendicular to slope. Individual lobes within the field, which are as much as 650 m long and 200 m wide, have as much as 2.5 m of relief above the surrounding smooth seafloor, and they commonly are transitional to the upslope chutes. Given their morphology and their proximity to the San Andreas Fault, we infer that these lobes result from offshore slope failures associated with strong ground motions triggered by large earthquakes on the San Andreas Fault.

Movement on the San Andreas Fault has juxtaposed coastal-bedrock blocks of different ages and lithologies (Blake and others, 2002). Bedrock northeast of the fault, found along the coast and in the nearshore, is mapped as the Jurassic, Cretaceous, Paleocene, and Eocene rocks of the Franciscan Complex, either the sandstone within Coastal or Central Belt (unit TKls) or the mélange in Central Belt (unit fsr). Bedrock southwest of the fault is considered to be part of the Gualala block (Elder, 1998), and it includes rocks of the Paleocene and Eocene German Rancho Formation (unit Tgr) and the Miocene sandstone and mudstone of Fort Ross area (unit Tsm).

This onshore section of the San Andreas Fault has an estimated slip rate of about 17 to 24 mm/yr (U.S. Geological Survey and California Geological Survey, 2010). The devastating great 1906 California earthquake (M7.8) is thought to have nucleated on the San Andreas Fault about 90 kilometers south of the map area, offshore of San Francisco (see, for example, Bolt, 1968; Lomax, 2005), the rupture extending northward through the Offshore of Fort Ross map area to the south flank of Cape Mendocino. Emergent marine terraces along the coast in the Offshore of Fort Ross map area record recent contractional deformation and uplift associated with the San Andreas Fault system. Uplift rates of 0.3 to 0.6 mm/yr were reported by Prentice and Kelson (2006) for a late Pleistocene terrace exposed at Fort Ross, and this recent uplift also must have affected the adjacent nearshore and inner shelf areas.

McCulloch (1987) mapped a fault zone in the nearshore (within 3 to 5 km of the shoreline) that extends from Point Arena to Fort Ross (fig. 1–1), primarily using deep-penetration industry seismic-reflection data. Dickinson and others (2005) named this structure the "Gualala Fault." Our mapping, also based on seismic-reflection data (see sheet 8), reveals this structure to be a steep, northeast-striking fault whose southeast termination is in the offshore between Fort Ross and the mouth of the Russian River. We have designated the zone of shallow faulting and folding associated with this structure as the "Gualala Fault deformation zone." Dickinson and others (2005) inferred that the Gualala Fault formed the western boundary of the "Gualala block," alternatively, Jachens and others (1998) inferred that block boundary was much farther offshore.

REFERENCES CITED

Blake, M.C., Jr., Graymer, R.W., and Stamski, R.E., 2002, Geologic map and map database of western Sonoma, northernmost Marin, and southernmost Mendocino Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map 2402, scale 1:100,000, available at http://pubs.usgs.gov/mf/2002/2402/.

Bolt, B.A., 1968, The focus of the 1906 California earthquake: Bulletin of the Seismological Society of America, v. 58, p. 457–471.

Brown, R.D., Jr., and Wolfe, E.W., 1972, Map showing recently active breaks along the San Andreas Fault between Point Delgada and Bolinas Bay, California: U.S. Geological Survey Miscellaneous Investigations Map I–692, scale 1:24,000.

Cacchione, D.A., Drake, D.E., Grant, W.D., and Tate, G.B., 1984, Rippled scour depressions of the inner continental shelf off central California: Journal of Sedimentary Petrology, v. 54, p. 1,280–1,291.

California Geological Survey, 1974a, Aliquist-Priolo earthquake fault zone map of Arched Rock quadrangle: California Geological Survey, State of California Special Studies Zone Map, scale 1:24,000, available at http://www.quake.ca.gov/gmaps/WH/regulatorymaps.htm.

California Geological Survey, 1974b, Aliquist-Priolo earthquake fault zone map of Fort Ross quadrangle: California Geological Survey, State of California Special Studies Zone Map, scale 1:24,000, available at http://www.quake.ca.gov/gmaps/WH/regulatorymaps.htm.

California Geological Survey, 1974c, Aliquist-Priolo earthquake fault zone map of Plantation quadrangle: California Geological Survey, State of California Special Studies Zone Map, scale 1:24,000, available at http://www.quake.ca.gov/gmaps/WH/regulatorymaps.htm.

Demirpolat, S., 1991, Surface and near-surface sediments from the continental shelf off the Russian River, northern California: Marine Geology, v. 99, p. 163–173.

Dickinson, W.R., Ducea, M., Rosenberg, L.I., Greene, H.G., Graham, S.A., Clark, J.C., Weber, G.E., Kidder, S., Ernst, W.G., and Hrabb, E.E., 2005, Net dextral slip, Neogene San Gregorio–Hosgri Fault Zone, coastal California—Geologic evidence and tectonic implications: Geological Society of America Special Paper 391, 43 p.

Drake, D.E., and Cacchione, D.A., 1985, Seasonal variation in sediment transport on the Russian River shelf, California: Continental Shelf Research, v. 14, p. 495–514, doi:10.1016/0278-4343(85)90007-X.

Elder, W.P., ed., 1998, Geology and tectonics of the Gualala block, northern California: Society of Economic Paleontologists and Mineralogists, Pacific Section, Book 84, 222 p.

Farnsworth, K.L., and Warrick, J.A., 2007, Sources, dispersal, and fate of fine sediment supplied to coastal California: U.S. Geological Survey Scientific Investigations Report 2007–5254, 77 p., available at http://pubs.usgs.gov/sir/2007/5254/.

Goff, J.A., Mayer, L.A., Traykovski, P., Buynevich, I., Wilkens, R., Raymond, R., Glang, G., Evans, R.L., Olson, H., and Jenkins, C., 2005, Detailed investigations of sorted bedforms or "rippled scour depressions," within the Martha's Vineyard Coastal Observatory, Massachusetts: Continental Shelf Research, v. 25, p. 461–484, doi:10.1016/j.csr.2004.09.019.

Hallenbeck, T.R., Kvitek, R.G., and Lindholm, J., 2012, Rippled scour depressions add ecologically significant heterogeneity to soft-bottom habitats on the continental shelf: Marine Ecology Progress Series, v. 468, p. 119–133, doi:10.3354/meps09948.

Huffman, M.E., 1972, Geology for planning on the Sonoma County coast between the Russian and Gualala Rivers: California Division of Mines and Geology Preliminary Report 16, 38 p., 4 plates, scale 1:24,000.

Klise, D.H., 1983, Modern sedimentation on the California continental margin adjacent to the Russian River: San Jose, Calif., San Jose State University, M.S. thesis, 120 p.

Lambeck, K., and Chappell, J., 2001, Sea level change through the last glacial cycle: Science, v. 292, p. 679–686, doi:10.1126/science.1059549.

Lawson, A.C., ed., 1908, The California earthquake of April 18, 1906, Report of the State Earthquake Investigation Commission: Carnegie Institution of Washington Publication 87, v. 1, 1,451 p. and atlas.

Lomax, A., 2005, A reanalysis of the hypocentral location and related observations for the Great 1906 California earthquake: Bulletin of the Seismological Society of America, v. 95, p. 861–877, doi:10.1785/0120040141.

Manson, M.W., Huyette, C.M., Wills, C.J., Huffman, M.E., Smelser, M.G., Fuller, M.E., Domrose, C., and Gutierrez, C., 2006, Landslides in the Highway 1 corridor between Bodega Bay and Fort Ross, Sonoma County, California: California Geological Survey Special Report 196, 26 p., 2 pls, 38 maps, scale 1:12,000, available at http://www.conservation.ca.gov/cgs/rghm/landslides/SR_196/Documents/CT0013on.pdf.

McCulloch, D.S., 1987, Regional geology and hydrocarbon potential of offshore central California, *in* Scholl, D.W., Grantz, A., and Vedder, J.G., eds., Geology and resource potential of the continental margin of western North America and adjacent ocean basins—Beaufort Sea to Baja California: Circum-Pacific Council for Energy and Mineral Resources, Earth Science Series, v. 6, p. 353–401.

Peltier, W.R., and Fairbanks, R.G., 2006, Global glacial ice volume and Last Glacial Maximum duration from an extended Barbados sea level record: Quaternary Science Reviews, v. 25, p. 3,322–3,337, doi:10.1016/j.quascirev.2006.04.010.

Prentice, C.S., and Kelson, K.I., 2006, The San Andreas fault in Sonoma and Mendocino Counties, *in* Prentice, C.S., Scotchmoor, J.G., Moores, E.M., and Kiland, J.P., eds., 1906 San Francisco earthquake centennial field guides—Field trips associated with the 100th Anniversary Conference, 18–23 April 2006, San Francisco, California: Geological Society of America Field Guide 7, p. 127–156, available at http://fieldguides.gsapubs.org/content/7.

Reid, J.A., Reid, J.M., Jenkins, C.J., Zimmerman, M., Williams, S.J., and Field, M.E., 2006, usSEARCH—Pacific Coast (California, Oregon, Washington) offshore surficial-sediment data release: U.S. Geological Survey Data Series 182, available at http://pubs.usgs.gov/ds/2006/182/.

Trembanis, A.C., and Hume, T.M., 2011, Sorted bedforms on the inner shelf off northeastern New Zealand—Spatiotemporal relationships and potential paleo-environmental implications: Geo-Marine Letters, v. 31, p. 203–214, doi:10.1007/s00367-010-0225-8.

U.S. Geological Survey and California Geological Survey, 2010, Quaternary fault and fold database of the United States: U.S. Geological Survey database, accessed April 5, 2014, at http://earthquake.usgs.gov/hazards/qfaults/.

Wagner, D.L., and Gutierrez, C.I., 2010, Preliminary geologic map of the Napa 30′ × 60′ quadrangle, California: California Geological Survey, scale 1:100,000, available at http://www.conservation.ca.gov/cgs/rghm/rgm/Pages/preliminary_geologic_maps.aspx.

Weber, K.M., List, J.H., and Morgan, K.L., 2005, An operational Mean High Water datum for determination of shoreline position from topographic lidar data: U.S. Geological Survey Open-File Report 2005–1027, accessed April 5, 2011, at http://pubs.usgs.gov/of/2005/1027/.

Witter, R.C., Knudsen, K.L., Sowers, J.M., Wentworth, C.M., Koehler, R.D., Randolph, C.E., Brooks, S.K., and Gans, K.D., 2006, Maps of Quaternary deposits and liquefaction susceptibility in the central San Francisco Bay region, California: U.S. Geological Survey Open-File Report 2006–1037, scale 1:24,000, available at http://pubs.usgs.gov/of/2006/1037/.

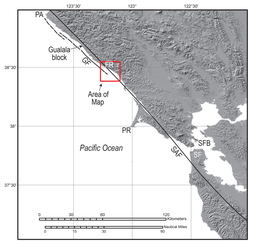


Figure 1. Regional map showing location of Offshore of Fort Ross map area, San Andreas Fault (SAF), Gualala Fault (GF; trace of fault from this work and from McCulloch, 1987), and Gualala block (Elder, 1998). Other abbreviations: PR, Fort Ross; PA, Point Arena; PR, Point Reyes; SF, San Francisco; SFB, San Francisco Bay.

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government

This map was printed on an electronic plotter directly from digital files. Dimensional calibration may vary between electronic plotters and between X and Y directions on the same plotter, and paper may change size due to atmospheric conditions; therefore, scale and proportions may not be true on plots of this map.

For sale by U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver, CO 80225, 1–888–ASK–USGS

Digital files available at http://dx.doi.org/10.3133/ofr20151211

Suggested Citation: Johnson, S.Y., Hartwell, S.R., and Manson, M.W., 2015, Offshore and onshore geology and geomorphology, Offshore of Fort Ross map area, California, *sheet 10 in* Johnson, S.Y., Dartnell, P., Golden, N.E., Hartwell, S.R., Erdey, M.D., Greene, H.G., Cochrane, G.R., Cotsen, M., Kvitek, R.G., Manson, M.W., Sliter, R.W., Lowe, E.N., and Chin, J.L.(8. Johnson and S.A. Cochrane, eds.), California State Waters Map Series—Offshore of Fort Ross, California: U.S. Geological Survey Open-File Report 2015–1211, pamphlet 37 p., 10 sheets, scale 1:24,000, http://dx.doi.org/10.3133/ofr20151211.

ISSN 2331-1258 (online)
http://dx.doi.org/10.3133/ofr20151211