

Geology of the Redwood Creek Basin, Humboldt County, California

By SUSAN M. CASHMAN, HARVEY M. KELSEY, *and* DEBORAH R. HARDEN

GEOMORPHIC PROCESSES AND AQUATIC HABITAT
IN THE REDWOOD CREEK BASIN, NORTHWESTERN
CALIFORNIA

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By SUSAN M. CASHMAN,¹ HARVEY M. KELSEY,¹ and DEBORAH R. HARDEN²

ABSTRACT

The Redwood Creek drainage basin of northwestern California is underlain by metamorphic and sedimentary rocks of the Franciscan assemblage of Late Jurassic and Early Cretaceous age and by shallow marine and alluvial sedimentary deposits of late Tertiary and Quaternary age. These units are cut by a series of shallowly east-dipping to vertical north-northwest-trending faults. The composition and distribution of bedrock units and the distribution of major faults have played a major part in the geomorphic development of the Redwood Creek basin. Slope profiles, slope gradients, and drainage patterns within the basin reflect the properties of the underlying bedrock. The main channel of Redwood Creek generally follows the trace of the Grogan fault, and other linear topographic features are developed along major faults. The steep terrain and the lack of shear strength of bedrock units are major contributing factors to the high erosion rates in the basin.

PREVIOUS WORK

Substantial geologic mapping and research have been done in the Redwood Creek area. Pioneering work was done by Hershey (1906), and subsequent regional mapping by Irwin (1960). More detailed maps include those of the Blue Lake quadrangle (Manning and Ogle, 1950), the Willow Creek quadrangle (Young, 1978), the Rodgers Peak quadrangle (P.H. Cashman and others, 1982), and the Coyote Peak quadrangle (S.M. Cashman and others, 1982). A 1:62,500-scale geologic map of the Redwood Creek drainage basin has been published (Harden and others, 1982). In addition, specific studies have been completed on the petrology (Talley, 1976; Leathers, 1978) and structural history (Roure, 1979; Cashman and Cashman, 1982) of the Redwood Creek schist. The depositional and structural history of Plio-Pleistocene sedimentary deposits in the Redwood Creek basin has been studied by Kelsey (1982) and Kelsey and Cashman

(1983). Soils in the basin were studied by Alexander and others (1959-62) and Marron (1982).

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INTRODUCTION AND SETTING

Redwood Creek occupies a 725-km² drainage basin approximately 80 km long and 10 km wide (fig. 1). Most of the basin is underlain by metamorphic and sedimentary rocks of the Franciscan assemblage of Late Jurassic and Cretaceous age (Bailey and others, 1964; Harden and others, 1982) of the California Coast Ranges (fig. 2). The Franciscan assemblage includes two sandstone and mudstone sequences termed "coherent unit of Lacks Creek" and "incoherent unit of Coyote Creek," a sandstone and mélange unit, a sequence of transitional rocks, and two belts of quartz-mica schist of the South Fork Mountain Schist and schist of Redwood Creek (figs. 1 and 2). All major Franciscan bedrock units in the basin are bounded by faults that trend north-northwest (fig. 1), parallel to the regional structural trend in northwestern California (Strand, 1962). Ultramafic and associated mafic rocks of the Klamath Mountains, mapped as Klamath Mountain rocks of Jurassic age, crop out along the southeastern

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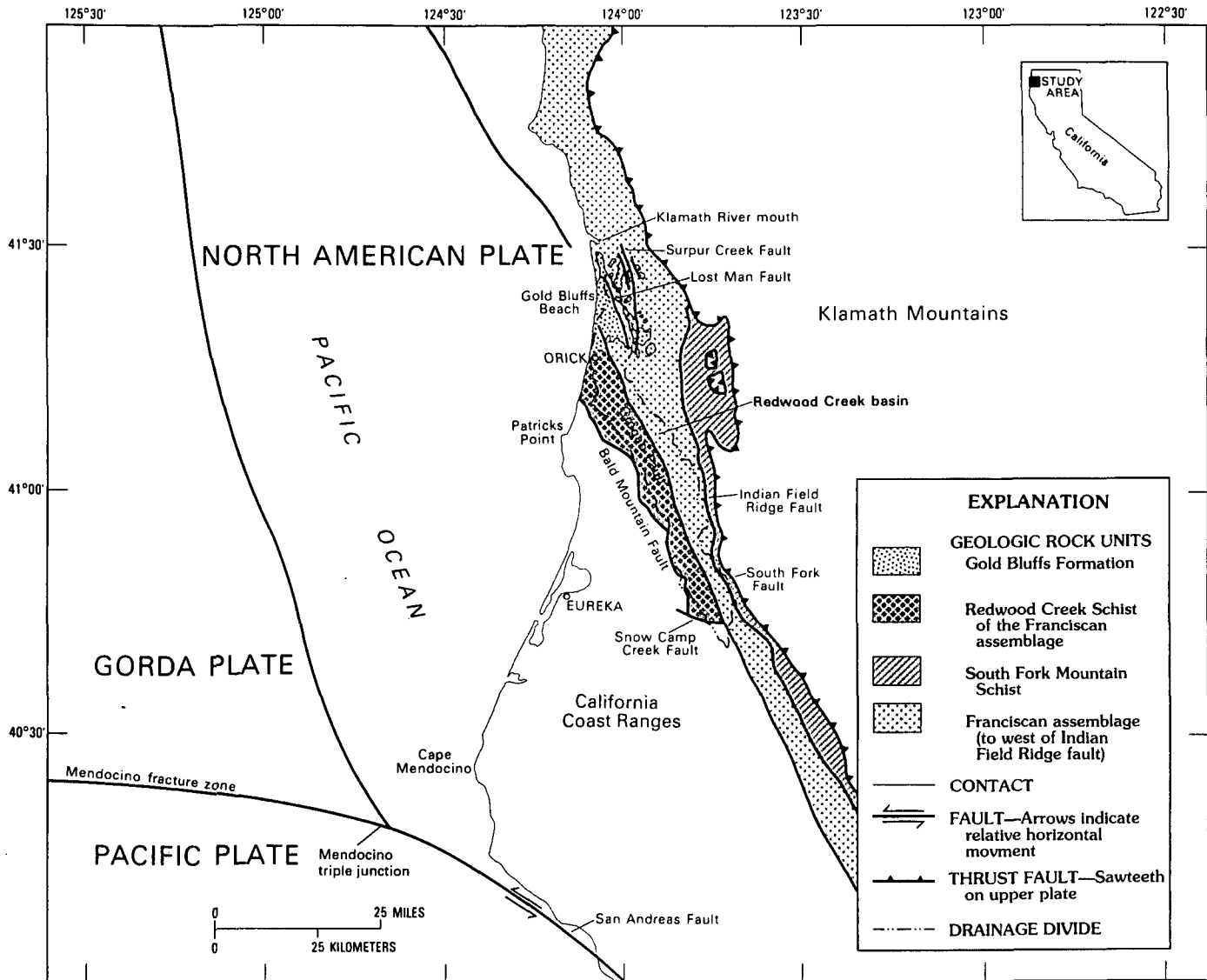


FIGURE 1.—Geologic and tectonic map of north coastal California showing major faults and rock units in the Redwood Creek drainage basin. MTJ=Mendocino triple junction.

margin of the basin. The South Fork fault (Irwin and others, 1974) (fig. 1) separates rocks of the two regions.

Upper Tertiary and Quaternary sedimentary rocks crop out in the northern part of the basin. They were deposited across the Bald Mountain fault and most of the Grogan fault. However, these upper Tertiary and Quaternary sedimentary rocks have been deformed locally by movement on the northern portion of the Grogan fault and associated minor faults (J.C. Young, written commun., 1977; Kelsey, 1982a; Kelsey and Cashman, 1983).

Northern coastal California and the adjacent offshore area constitute one of the most seismically active areas in

the State. The high level of tectonic activity in the region is attributed to the proximity of the Mendocino triple junction (McKenzie and Morgan, 1969), a boundary that separates three major crustal plates (fig. 1). High uplift rates and Quaternary faulting result from the high degree of tectonic activity in the area. Unusually rapid uplift rates have been reported at locations along the coast from Cape Mendocino north to Patricks Point (Woodward-Clyde Consultants, 1980; LaJoie and others, 1982; McLaughlin and others, 1983). Faulting of Quaternary age has been recognized throughout western Humboldt County on the basis of geomorphic and structural

evidence (Woodward-Clyde Consultants, 1980; Kelsey, 1982; Carver and others, 1983; Kelsey and Cashman, 1983; Kelsey and Allwardt, 1983).

The bedrock geology of the Redwood Creek basin is a major contributor to the high erosion rates in the basin. Much of the area is underlain by pervasively sheared and fractured mudstone, incoherent sandstone, and fine-grained schist. The erodible bedrock and steep terrain make the basin inherently susceptible to mass movement (chap. G, this volume). Landslide terminology used in this paper is based on the classification scheme of Varnes (1978).

ROCK UNITS

KLAMATH MOUNTAINS ROCKS

Klamath Mountains rocks of Jurassic age form the easternmost and structurally highest bedrock unit in the Redwood Creek basin (fig. 2). The most common rock types are sheared serpentinite and partially serpentinized peridotite with associated minor mafic intrusive rocks (Young, 1978). A zone of tectonically mixed greenstone, metagraywacke, serpentinite, and diorite occurs along the South Fork fault zone south of Horse Mountain (Young, 1978). The ultramafic and mafic intrusive rocks are interpreted by Young (1978) as having ophiolitic affinities.

FRANCISCAN ASSEMBLAGE

SCHIST OF REDWOOD CREEK AND SOUTH FORK MOUNTAIN SCHIST

Two bodies of quartz-mica schist occur in the Redwood Creek basin: the schist of Redwood Creek (herein named Redwood Creek schist) and the South Fork Mountain Schist. The Redwood Creek schist underlies the western half of the basin, and its outcrop area is almost entirely within the drainage basin of Redwood Creek (fig. 2). It has been previously mapped as "Kerr Ranch Schist" in the Blue Lake quadrangle by Manning and Ogle (1950), and as the "Redwood Mountain outlier of South Fork Mountain Schist" by Irwin (1960) and Young (1978). The South Fork Mountain Schist crops out to the east of the Redwood Creek schist, along the southeastern edge of the basin (fig. 2) and extends south of the basin for more than 120 km. The South Fork Mountain Schist forms the easternmost and structurally highest unit in the Franciscan assemblage (Blake and others, 1967; Irwin and others, 1974).

Several lithologies occur within the Redwood Creek schist, including metagraywacke, fine-grained schist,

and minor laminated to massive greenstone. Considerable variations in texture, composition, and degree of deformation are evident within the unit. The most common lithology is fissile light-green to dark-gray phyllite or fine-grained schist (fig. 3). The typical mineral assemblage consists of quartz, chlorite, white mica, and albite; epidote, actinolite, lawsonite, or opaque graphitic material occur in some samples. Coarser grained textural zone II to III (Blake and others, 1967) metagraywacke also occurs in the Redwood Creek schist. In some metasandstone outcrops, such as those along the coast near Stone Lagoon (fig. 2), graded bedding is preserved.

Greenstone is a less widespread component of the Redwood Creek schist. The common mineral assemblage is quartz, epidote, chlorite, actinolite and albite, with lawsonite in some samples. Greenstone is either massive and homogeneous or has thin (1-2 mm) mineralogic layering. The contacts between greenstone and surrounding schist are commonly obscured, but in two good exposures in a rock quarry in Tom McDonald Creek and in the channel of Pardee Creek (fig. 2), thin-bedded greenstone (metatuff) and pelitic schist are clearly interbedded.

The South Fork Mountain Schist is not as extensive as the Redwood Creek schist in the Redwood Creek basin. The dominant rock type of this unit, quartz-albite-white mica-chlorite schist, is mineralogically similar to most common lithology in the Redwood Creek schist. Other rock types in the South Fork Mountain Schist include foliated greenstone and local highly quartzitic gneissic rocks, reported in the South Fork Mountain Schist by Young (1978).

Characteristically red and clay-rich regolith suggests that the schist units are readily altered by chemical weathering. Soils developed on schist in the Redwood Creek basin are mostly inceptisols, alfisols, and ultisols (Alexander and others, 1959-62). The red colors reflect the oxidation of iron in chlorite and other iron-bearing minerals. High clay contents reflect, at least in part, the micaceous nature of the parent material. Abundant clay seams that follow schistosity demonstrate a linkage between physical and chemical weathering. Physical weathering of schistose rocks yields small platy fragments.

The geomorphic expression of the schist units is variable. Slopes underlain by the Redwood Creek schist have gently convex profiles. Side-slope gradients commonly range from 20 to 40 percent and average approximately 25 percent (Marron, 1982). Ridges underlain by Redwood Creek schist, such as Wiregrass Ridge (fig. 2), typically have rather broad, flat ridge crests. Both the Redwood Creek schist and the South Fork Mountain Schist exhibit knobby topography in areas where

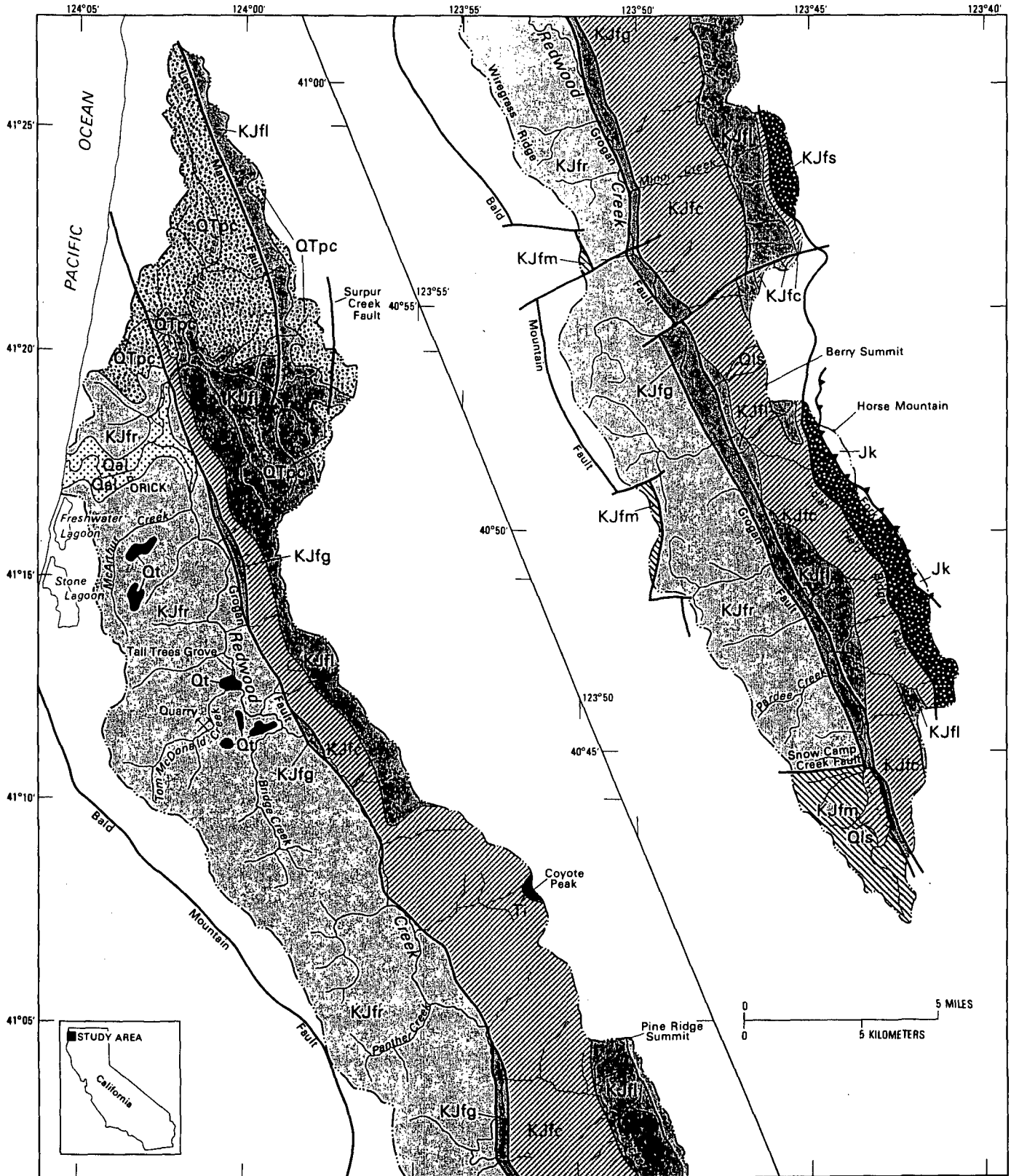


FIGURE 2.—Generalized bedrock geology of the Redwood Creek basin (modified from Harden and others, 1982).

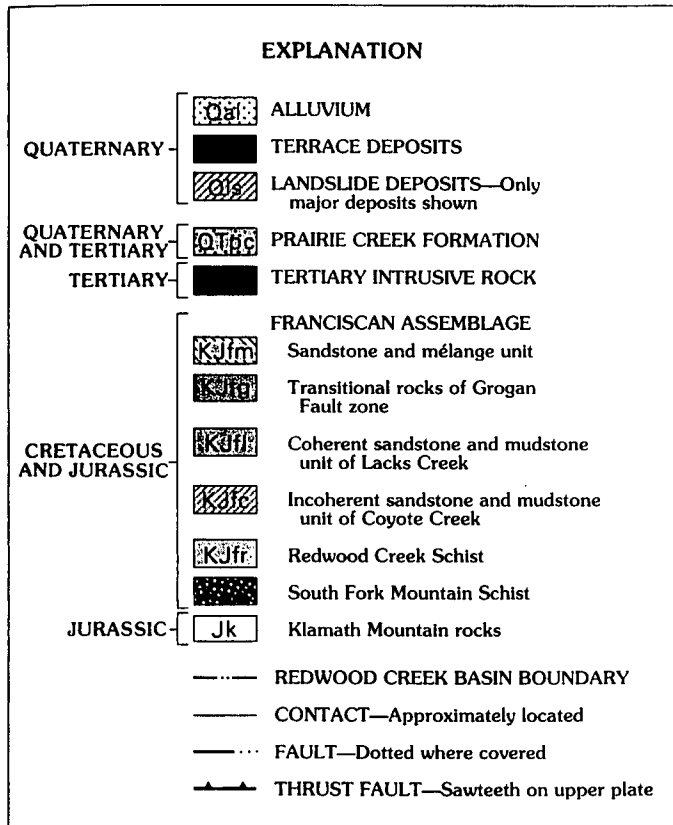


FIGURE 2. — Continued.

greenstone units and tectonic blocks are included in the schist. Shallowly incised streams are a typical drainage feature of schist slopes.

FRANCISCAN SANDSTONE AND MUDSTONE UNITS:
COHERENT UNIT OF LACKS CREEK AND INCOHERENT
UNIT OF COYOTE CREEK

Most of the eastern half of the Redwood Creek basin is underlain by sandstone, mudstone, and minor associated conglomerate, greenstone, and chert of the Franciscan assemblage (fig. 2). These rocks were subdivided by Harden and others (1982) into a coherent sandstone-mudstone unit (coherent unit of Lacks Creek) and an incoherent sandstone-mudstone-greenstone-chert unit (incoherent unit of Coyote Creek) (fig. 2).

The predominant rock types in both units are massive sandstone and interbedded sandstone and mudstone (fig. 4). Where they are not disrupted by faults or pervasive shearing, the interbedded sandstone and mudstone sequences show rhythmic bedding and sedimentary structures characteristic of turbidites. Sandstone occurs as massive beds as much as 10 m thick, but most beds range from 0.1 to 3 m in thickness. The sandstone to mudstone ratio is conspicuously higher in the coherent



FIGURE 3. — Outcrop of schist of Redwood Creek.



FIGURE 4. — Outcrop of sandstone of the Franciscan assemblage.

sandstone unit. In contrast, only the incoherent unit contains blocks of chert and greenstone, as well as sandstone and mudstone.

Thin-section examination of the sandstones shows them to be lithic graywackes and quartzofeldspathic graywackes. Harden and others (1982) noted that a limited number of sandstone samples studied contained potassium feldspar and are thus compositionally similar to sandstones in a subunit of the Franciscan assemblage that has been mapped to the south as the "Central belt Franciscan" (Berkland and others, 1972).

Soils developed on sandstone and mudstone in the Redwood Creek basin are mostly inceptisols and alfisols (Alexander and others, 1959-62). On sandstone and mudstone slopes of the coherent unit of Lacks Creek, soils are commonly shallow and sandy (Marron, 1982). Slopes underlain by the incoherent sandstone, mudstone, greenstone, and chert unit of Coyote Creek tend to have more clay-rich soils that are bluish gray. Clay-rich soils that have developed on sheared bedrock are highly susceptible to mass wasting (Alexander and others, 1959-62).

The sandstone and mudstone of the coherent unit of Lacks Creek have distinctive geomorphic expression. Sharp ridge crests, steep slopes, and narrow V-shaped tributary canyons are characteristic of the landscape developed on these relatively resistant rocks. Slopes have straight to gently concave profiles, and slope gradients commonly range from 30 to 50 percent, averaging approximately 35 percent (Marron, 1982). In the coherent unit, streamside debris slides and debris avalanches are common in the inner gorges of tributaries.

In contrast to the steep terrain of the coherent unit, the sandstone, mudstone, greenstone, and chert of the incoherent unit underlie a subdued, rolling landscape having less deeply incised drainage networks and a few high points and knobs formed by resistant rock types. Earthflows in the Redwood Creek basin are preferentially developed in this unit, as are streamside debris slides along the inner gorge reaches of Redwood Creek. The largest active earthflow in the Redwood Creek basin is developed on this unit at Berry Summit (figs. 2 and 5).

TRANSITIONAL ROCKS

Rocks intermediate in texture and degree of metamorphism between the Redwood Creek schist and the sandstone and mudstone units crop out locally along the trace of Grogan fault (fig. 2). These rocks belong to textural zone II of Blake and others (1967). Their geomorphic expression is similar to that of other rocks exposed in the fault zone and to that of the incoherent unit of Coyote Creek.

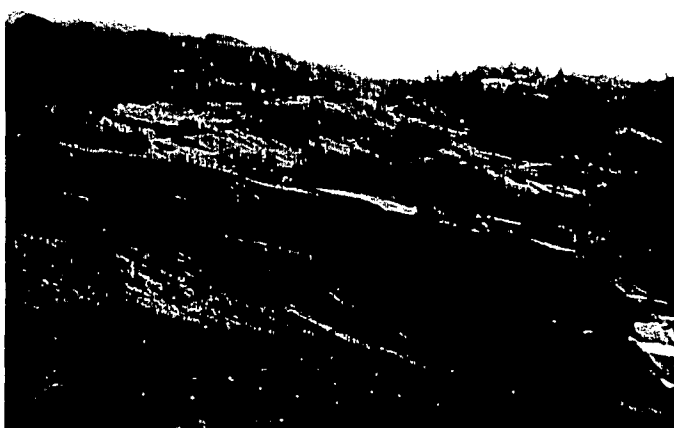


FIGURE 5.—Active earthflow at Berry Summit, on the east side of the Redwood Creek drainage basin.

FRANCISCAN SANDSTONE AND MÉLANGE UNIT

A broad belt of sandstone and *mélange* of the Franciscan assemblage lies west of the Bald Mountain fault along the southwestern end of the Redwood Creek basin and along the western boundary of the basin (fig. 2). The unit consists of bodies of bedded graywacke intermixed with a pervasively sheared argillite-matrix *mélange* containing blocks of chert, metabasalt and volcanic breccia (Harrell, 1982), metavolcanic rocks, and glaucophane-lawsonite blueschist. The sandstone and *mélange* unit is distinct from the incoherent sandstone-mudstone-greenstone-chert unit discussed previously because it contains exotic glaucophane-lawsonite blocks.

The landscape developed on the sandstone and *mélange* unit is generally more hummocky than other hillslopes in the Redwood Creek basin. Parts of the unit underlain by massive sandstone display steep slopes, prominent ridges, and V-shaped valleys, in contrast to the more rolling, hummocky hillslopes underlain by *mélange*. Tectonic blocks of greenstone and chert form prominent knobs and summits. The largest landslide in the Redwood Creek basin is an ancient earthflow formed on the *mélange* unit at the southern headwaters of Redwood Creek (Harden and others, 1982).

The age of the Franciscan rocks in the basin is not well known because few fossils have been found. Two ammonites, the only fossils found in pre-Tertiary units in the Redwood Creek basin, were identified as being middle Cretaceous in age (D.L. Jones, written commun., 1976; Harden and others, 1982). At the mouth of the Klamath River, 30 km to the northwest, a chert and graywacke block in rocks that appear to be equivalent to the incoherent unit of the Redwood Creek basin was found to contain radiolarians of late Jurassic and early Cretaceous (Tithonian to Valanginian) age (Aalto and others, 1983).

Therefore, Franciscan rocks in the basin probably range from Tithonian to Cenomanian in age.

TERTIARY INTRUSIVE ROCKS

At Coyote Peak (fig. 2), on the ridge bounding the eastern side of the basin, an alkalic diatreme intrudes sandstone and related rocks of the Franciscan assemblage. The unusual mineralogy of this rock includes olivine, clinopyroxene, phlogopitic biotite, nepheline, aegirine, schorlamitic garnet, titanomagnetite, perovskite, apatite, and several rare sulfide minerals (Blake, 1977; Czamanske and others, 1977). Inclusions of Franciscan sedimentary rocks and of aphanitic, alkalic igneous rocks occur within the diatreme.

PRAIRIE CREEK FORMATION

Most of the Prairie Creek basin at the northern end of the Redwood Creek basin is underlain by weakly consolidated shallow marine and alluvial sediments (figs. 2 and 6). The sediments, covering 150 km², possess a distinctive topography of sharp ridges, steep canyons, and a trellis drainage pattern. The sediments are here named the Prairie Creek Formation. Although named for Prairie Creek, the best exposures occur at its type locality along the well-exposed coastal bluffs at Gold Bluffs beach (sec. 4, T. 11 N., R. 1 E.; loc. T on fig. 6).

The Prairie Creek Formation is inferred to represent the onshore sediments of an extensive sedimentary sequence deposited on the continent and the continental shelf at the mouth of the Klamath River (Moore and Silver, 1969; Silver, 1971). The formation is dominantly composed of fluvial sediments but also includes near-shore marine sands and beach and estuarine deposits. Although the formation lies with angular unconformity on the Jurassic and Cretaceous Franciscan assemblage, it is composed almost exclusively of Klamath Mountains section rock types having minor amounts of Franciscan detritus, mainly near the bottom of the section. The Prairie Creek Formation thus appears to be a remnant of the lowermost reaches of the ancestral Klamath River. Both during and subsequent to deposition, the sediments have undergone folding, fracturing, and faulting (Kelsey and Cashman, 1983). Three major faults, the Grogan, Lost Man, and Sulfur Creek faults (fig. 6), cut the Prairie Creek Formation. The thickness of the Prairie Creek Formation exceeds 550 m.

The Prairie Creek Formation is best exposed along the cliff face at Gold Bluffs Beach (fig. 6) but is also exposed on logged areas inland. At the beach exposure, the Prairie Creek Formation grades upward from buff to tan shallow marine sands in the basal part to estuarine and

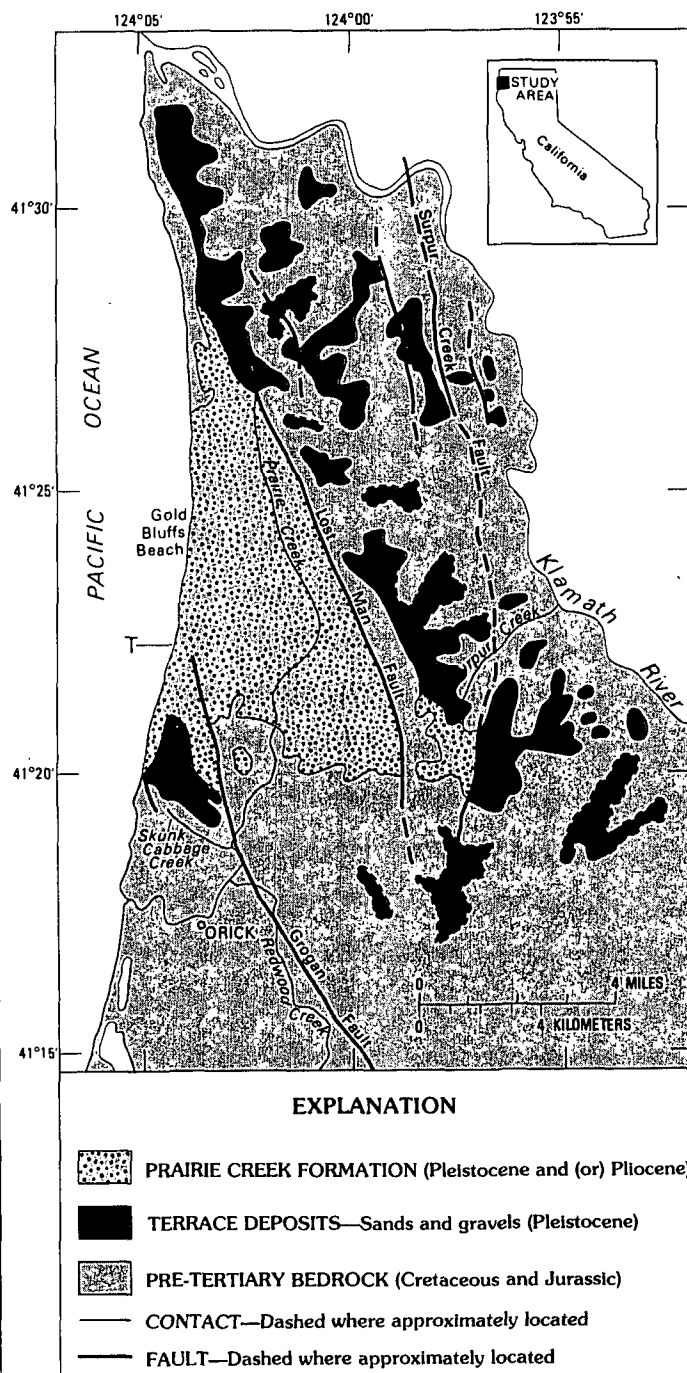


FIGURE 6. — Prairie Creek Formation and Pleistocene terrace deposits (geology by Kelsey, 1980–83).

coarse alluvial sequences near the top. Most of the cliff face at Gold Bluffs Beach consists of alluvial deposits of medium to coarse sand, buff to tan sand, and pebbles and cobbles of mixed metamorphic and igneous lithologies. Total exposed thickness of the Prairie Creek Formation at the type locality is 550 m.

Age data for the Prairie Creek Formation are scarce. A mollusk (*Protothaca hannibali*) occurs near the base of the formation, the only age-diagnostic fossil recovered. This fossil has an age span from about 1 to 4 Ma (Barry Roth, California Academy of Sciences, written commun., 1984) suggesting that the Prairie Creek Formation is Plio-Pleistocene (fig. 6).

QUATERNARY TERRACE DEPOSITS AND MODERN FLOOD-PLAIN DEPOSITS

Quaternary terrace deposits include streamside strath terraces, flood-plain deposits, coastal strath terrace deposits of probable marine origin, and fill terraces (Harden and others, 1982). Streamside strath terraces are best developed along the upper one-third of the Redwood Creek channel. Between 2 and 6 m of gravel cap beveled sandstone surfaces. These terraces reflect Holocene and late Pleistocene downcutting due to uplift. Redwood Creek flood deposits occur along a 9-km reach in the middle of the basin upstream of Lacks Creek. Modern flood deposits also occur in the lower 20 km of the watershed; these deposits include the alluvial flats, such as the Tall Trees Grove at the mouth of Tom McDonald Creek, and the broad flood plain of the lower Prairie Creek and Redwood Creek valleys.

Pleistocene alluvial gravels deposited by the Klamath River are exposed to the east and the north of the Prairie Creek Formation (fig. 6). These gravels parallel the modern course of the Klamath River (fig. 6) and record Pleistocene downcutting of the river.

Coastal strath terrace deposits occur on well-preserved flat surfaces on the southern divide of McArthur Creek (fig. 2) and on the northern divide of Skunk Cabbage Creek (fig. 6). The deposits are less than a meter to several meters thick and consist of sand, silt, and well-rounded, mainly quartzose pebbles. The surfaces are slightly tilted. The deposits are probably of marine origin and are most likely early to middle-Pleistocene in age, based on their topographic position.

Alluvial fill terraces are located on the west side of Redwood Creek on hillslopes a few kilometers upstream of the mouth of Tom MacDonald Creek (fig. 2). The alluvial fill overlies or is adjacent to a prominent north-northwest-trending lineament that follows Bridge Creek. The thickest fill is 50 m and consists entirely of Redwood Creek rock types. Other fills are composed entirely of schist, suggesting a limited provenance within tributary basins. Thick alluvial fills such as these are unusual in a setting where uplift rates are high and downcutting into bedrock is vigorous. The alluvium underlying the terraces is also sheared and faulted. The deformation and location of the fills suggest that they could be the result of local subsidence due to Quaternary

faulting along the Bridge Creek lineament. However, no unequivocal evidence has been found to demonstrate that the Bridge Creek lineament is indeed a fault.

LANDSLIDE DEPOSITS

Landslide deposits are widely distributed on the different Franciscan assemblage units. Commonly, steep streamside hillslopes contain unsorted and disoriented regolith that reflects transport by mass wasting. On schist slopes, road-cut exposures of disrupted and disoriented regolith attest to the activity of deeply seated, slowly moving landslides (Marron, 1982). On incoherent sandstone and mudstone, earthflow deposits consisting of a sheared shale matrix that contains blocks of sandstone, chert, and greenstone are common (Nolan and others, 1976; chap. G, this volume). These deposits range from a few meters to more than 40 m thick, and their average thickness is approximately 25 m.

STRUCTURE

The most important element in the bedrock structure of this area is a series of northwest-trending faults. These faults form the contacts between the bedrock units previously discussed. The faults are locally characterized by strings of tectonic blocks of a wide variety of compositions. Some of the blocks are rock types exotic to the Redwood Creek basin and appear to have been emplaced in their present positions during faulting. Although all major faults strike northwest, they exhibit a range of orientations from shallowly dipping to vertical, and they represent several different deformational episodes (Monsen and Aalto, 1980; Cashman and Cashman, 1982; Kelsey and Hagans, 1982).

BALD MOUNTAIN FAULT

The Bald Mountain fault separates the sandstone and mélange unit from Redwood Creek schist along the western edge of the Redwood Creek basin (fig. 2). It is not well exposed and has been interpreted both as a shallow east-dipping thrust fault (Irwin, 1964; Talley, 1976; Monsen and Aalto, 1980) and as a nearly vertical fault (P.H. Cashman and others, 1982). The straight traces of the fault west of Wiregrass Ridge (fig. 2) suggest a vertical fault. On the other hand, the irregular, embayed trace of the fault farther south suggests either that the fault dips more gently at its southern end or that it has been offset by later cross faults (Manning and Ogle, 1950). Poor exposure precludes detailed mapping along most of the Bald Mountain fault, and the overall nature of the fault remains unknown. Tectonic blocks of chert,

metavolcanic rocks, serpentinite, and blueschist are clustered along parts of the Bald Mountain fault. The knobby topography formed around these blocks is the only geomorphic expression of the fault.

GROGAN FAULT AND ASSOCIATED STRUCTURES

The Grogan fault, which juxtaposes Redwood Creek schist against the transitional rocks unit, is the best exposed and most studied fault in the Redwood Creek basin. It has a dramatic geomorphic expression where Redwood Creek has cut an imposing canyon along the straight fault zone (fig. 7). Slickenside striations along the fault (fig. 8) are clearly visible in exposures along Redwood Creek, where the fault can be seen to strike northwest and dip from 65° west to 65° east. In places, the Grogan fault zone includes sheared Franciscan rocks of textural zone II sandstone as much as 0.4 km wide; in contrast, other segments of the fault are only a few meters wide. The Grogan fault is also locally marked by the presence of tectonic blocks and serpentinite.

The Grogan fault can be traced 28 km southeast of the Redwood Creek basin by its geomorphic expression, and it may extend even farther south (Kelsey and Hagans, 1982). A fault that may be the northwestern extension of the Grogan fault can be traced in offshore reflection profiles (Field and others, 1980).

Evidence exists for dip-slip and possible strike-slip displacement on the Grogan fault. In an exposure near Prairie Creek, observed by J.C. Young in 1972 (exposure now overgrown), the Grogan fault is a high-angle reverse fault along which Pliocene and Pleistocene sediments are juxtaposed against Franciscan rocks. Although no unequivocal evidence exists for lateral movement on the Grogan fault, Kelsey and Hagans (1982) presented arguments for a minimum of 75 km of right-lateral displacement on the Grogan fault, probably during late Tertiary time.

Two additional faults, the Lost Man and Surpur Creek faults, parallel the Grogan fault and disrupt the Gold Bluffs Formation in the northern part of the basin. All three faults are easily recognized by their topographic expressions and by their strong disruption of the Gold Bluffs sediments. A suite of structures, including fractures, small-scale faults, and folds, are associated with the larger faults. Analysis of these structures suggests that the faults are strike-slip faults with a substantial component of vertical offset as well (Kelsey and Cashman, 1983). The faults are presumably Mesozoic faults that have undergone Quaternary movement. Quaternary activity on these faults has progressively uplifted the Prairie Creek sediments on the east to a cumulative vertical displacement of 300 m. It is not possible to

determine the horizontal displacement on these faults because of their poor exposure.

INDIAN FIELD RIDGE AND SOUTH FORK FAULTS

The Indian Field Ridge and South Fork faults define the western and eastern boundaries, respectively, of the South Fork Mountain Schist. Both are interpreted to be shallow east-dipping faults that separate the schist from the structurally lower Franciscan rocks to the west and from the structurally higher rocks of the Klamath Mountains to the east. Neither fault has a marked geomorphic expression, although a narrow belt of sheared rock, expressed as a series of prairies, geomorphically defines the Indian Field Ridge fault near Indian Field Ridge (fig. 2).

The Indian Field Ridge fault crops out along the eastern side of the Redwood Creek basin. Its southern extension in the Yolla Bolly area (Blake and others, 1967) and in the Pickett Peak quadrangle (Irwin and others, 1974) is associated with a textural gradation from textural zone I to textural zone III graywackes. However, mapping by Young (1978) in the Willow Creek quadrangle, by Harden and others (1982) in the Redwood Creek basin, by Monsen and Aalto (1980) at Pine Ridge Summit, and by Aalto (1983) in the Pilot Creek quadrangle revealed no textural gradation along this contact. In the Redwood Creek basin, the fault is marked by a narrow zone of pervasively sheared, unmetamorphosed Franciscan sandstone.

The South Fork fault (Irwin and others, 1974) is exposed on the southeastern edge of the Redwood Creek basin (fig. 2). Igneous and metamorphic rocks of the Klamath Mountains are thrust over the South Fork Mountain Schist. In the Willow Creek quadrangle, Young (1978) mapped a zone of tectonically mixed serpentinite, foliated greenstone, metagraywacke, and diorite between Klamath Mountains ultramafic rocks and the South Fork Mountain Schist along part of the South Fork fault.

SNOW CAMP CREEK FAULT

The Snow Camp Creek fault is the only major east-west-trending fault in the Redwood Creek basin (Harden and others, 1982). It truncates the Redwood Creek schist on the south, separating the schist from Franciscan sandstone and *mélange* (fig. 2). This fault is clearly older than the Grogan fault, because it is truncated on its eastern end by the Grogan fault (Kelsey and Hagans, 1982). The Snow Camp Creek fault has no marked geomorphic expression.

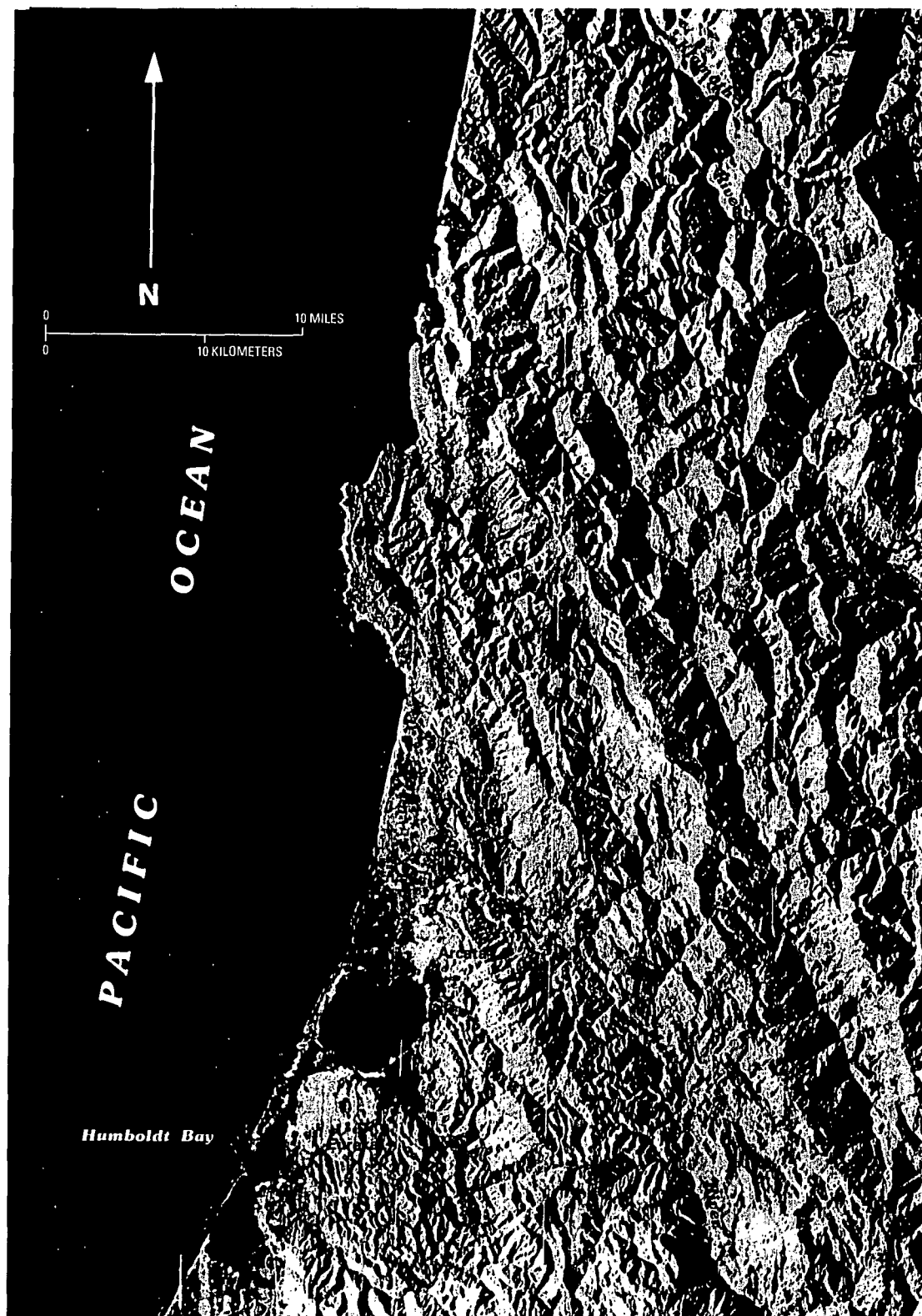


FIGURE 7.—Side-looking aerial radar image of northern Humboldt County, Calif. The prominent north-northwest-trending valley in the center of the image is the valley of Redwood Creek.



FIGURE 8.—Slickenside striations on greenstone of the Franciscan assemblage exposed along the Grogan fault.

OTHER STRUCTURES

The faults described previously are easily recognized because they juxtapose different lithologic units. Other structures, such as low-angle faults within the Redwood Creek schist, may also be of regional extent, but they cannot be traced beyond a single road cut or quarry exposure because of heavy vegetative cover. Distinct, fault-bounded belts of contrasting metamorphic grade were reported in the Redwood Creek schist by Talley (1976). Subsequent mapping by Harden and others (1982) and by Cashman and Cashman (1982) does not confirm existence of these belts, although low-angle faults between compositionally and (or) texturally different rocks in the schist unit have been recognized in the drainages of Panther Creek, Tom McDonald Creek (fig. 2), and one unnamed creek, as well as along the coast.

Several lineaments observed on aerial photographs are prominent geomorphic features in the Redwood Creek basin, and, with one exception, they trend parallel to

regional northwest structural trends (Harden and others, 1982). The most conspicuous of these, the 16-km-long Bridge Creek lineament, is formed by aligned segments of the main stem of Bridge Creek and the two streams immediately south of Bridge Creek (fig. 2) (Talley, 1976; Harden and others, 1982). Crenulation cleavage and fracture cleavage in the Redwood Creek schist are more strongly developed along this lineament than they are elsewhere in the schist (Cashman and Cashman, 1982). Previously described Pleistocene fill terrace deposits that straddle the lineament are pervasively fractured. Another set of northwest-trending lineaments, the Snow Camp Mountain lineaments, marked by aligned ponds and undrained depressions, occurs in the southwestern part of the Redwood Creek basin and extends southward beyond the basin (Harden and others, 1982; Kelsey and Allwardt, 1983). Less well defined lineaments are suggested by isolated ponds, undrained depressions, and (or) straight drainage segments.

REGIONAL TECTONIC SETTING

Bedrock units in the Redwood Creek area have been deposited and deformed in an active tectonic setting along the western margin of the North American plate. As a result, Franciscan rocks are highly deformed; deformation includes shearing and formation of mélangé in the Franciscan sandstone and mélangé unit and both small-scale folding and shearing in the Redwood Creek schist (Cashman and Cashman, 1982). How and when the Franciscan units of northern California were assembled are questions that are far from resolved (Blake and Jones, 1978, 1981; Alvarez and others, 1979). Faults in the Redwood Creek basin include both shallow to moderately east-dipping thrust faults (for example, South Fork fault, Indian Field Ridge fault) that may have formed in conjunction with subduction-related underthrusting and strike-slip faults (for example, Lost Man fault) that have apparently accommodated major right-lateral offset.

Regional tectonics do suggest that the Redwood Creek basin is geologically young. Plio-Pleistocene Prairie Creek sediments record the gradual transition from marine to lagoonal to fluvial deposition, showing recent emergence of the western part of the basin above sea level. The lack of detritus derived from Franciscan assemblage rocks in sediments of the Prairie Creek Formation suggests that the bedrock units now found in the Redwood Creek basin were not eroded by the paleodrainage system represented by the Prairie Creek sediments. These observations suggest that erosion within Redwood Creek commenced no sooner than 2 Ma and that the Redwood Creek basin is entirely a Pleistocene landform.

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