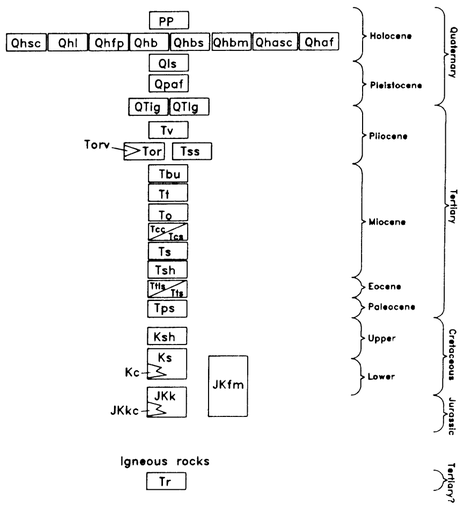
CORRELATION OF MAP UNITS



STRUCTURE SUMMARY

The structure of the Niles Quadrangle is dominated by a set of north northwest - trending faults. These faults can be divided into four categories based on sense of motion and relative recency of displacement: old reverse faults, normal faults, younger reverse faults, and strike - slip faults (Figures 1 and 2). The Hayward fault, with documented historic creep (Lienkamper, 1992), has the most recent displacement of faults in the Niles Quadrangle. It has predominantly strike - slip offset, although there has been many meters of uplift on the east side of the fault. The Hayward fault forms the boundary between the alluvial flat that makes up the southwestern one-third of the quadrangle and the uplands that make up the northeastern two-thirds. The Calaveras fault also has predominantly strike - slip offset, but the recency of motion on it in the Niles Quadrangle is not well documented. The Calaveras fault has historic creep in Hollister, 88 kilometers southeast of Sunol, and extensive earthquake activity as far north as an area about 10 kilometers southeast of Mission Peak (Andrews and others, 1993). New trenches in the area of Lydell Creek, 10 kilometers south of Sunol, reveal offset stream deposits as young as Holocene (Gary Simpson, personal communication, 1993). Quaternary landslide deposits in the Niles Quadrangle seem to be undeformed by the Calaveras fault, but some workers (Hart, 1981) have proposed Holocene displacement based on their observation of lineaments and other geomorphic features.

Several reverse faults have observable Pleistocene or younger displacement, including the northern segment (north of the Warm Springs fault) of the Mission Peak fault, the Warm Springs fault, and the Sheridan Creek fault. Many other faults, including the Dresser fault and the southern segment of the Mission Peak fault, have no documented Quaternary offset. These faults have placed older strata structurally on top of younger, but also have an unknown (but possibly large) amount of strike - slip offset. Younger reverse faults in the Niles Quadrangle all dip to the northeast.

Some normal faults in the Niles Quadrangle, including the Chabot fault and the Palomares fault, cut Pleistocene strata but are themselves cut by younger reverse faults, while others, including the Pirate Creek fault, have no observed Quaternary offset but probably belong to this group. These faults place younger strata on older strata that were previously separated by intervening rocks that have been tectonically removed, but also have unknown, but possibly large, amounts of strike - slip offset.

Finally, the oldest faults are the unnamed faults that have reverse motion but are cut by normal faults. The older faults dip both northeast and southwest. This complex history of faulting has left a "braided" pattern of faults, which is most pronounced in a band about 2 kilometers wide running from the Niles Junction area through the area including and east of Mission Peak. This zone is seismically active (Andrews and others, 1993), with younger transpressive faults, such as the Sheridan Creek, Dresser, and Mission Peak faults, as the strands that are probably most active. The zone formed in a tectonic regime dominated by strike - slip offset, so it is probable that the normal and reverse faults have had large amounts of oblique slip on them. The lack of piercing points prevents accurate estimates of offset at this time, although it is probably large on some faults (see below). Reverse faults with a large strike - slip component we term transpressive faults, while normal faults with a large strike - slip component we term attenuation faults. It is probable that all the faults in the Niles Quadrangle are attenuation or transpressive faults.

The long term history of faulting in the Niles Quadrangle has juxtaposed blocks with different stratigraphic sequences (Figures 3 and 4). Stratigraphic package H, for example, contains only early Miocene rocks which are of different age from any other rock in the area. Stratigraphic package A includes the Tice Shale and Oursan Sandstone between the Claremont Formation and the Briones Formation, whereas in stratigraphic package B the Briones Formation was deposited directly on the Claremont Formation. Also, in stratigraphic package B the Briones Formation is overlain by conglomerates and sandstone of the Orinda Formation, whereas in stratigraphic package E the Briones Formation is overlain by unnamed fine - grained sandstone, limestone, and chert. These differences in stratigraphic sequences suggest that the rocks were originally deposited in different settings, and have since been juxtaposed over an unknown but probably large distance.

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DESCRIPTION OF MAP UNITS

Surficial Deposits
Units after Wesling and Helley (1989) and Helley (1991)

PP **Percolation Ponds** (Historic). Excavations made in Holocene alluvial fans, filled with surface waters for the purpose of increasing recharge to ground - water storage.

Qhsc **Stream channel deposits** (Holocene). Poorly to well - sorted sandy silt, silty sand, sand, or sandy gravel with minor cobbles.

Qhl **Natural levee deposits** (Holocene). Loose, moderate - to well - sorted sandy or clayey silt grading to sandy or silty clay. Levee deposits border the channels of Alameda Creek.

Qhfp **Floodplain deposits** (Holocene). Medium to dark gray, dense, sandy to silty clay. Lenses of coarser material (silt, sand, and pebbles) may be locally present.

Qhb **Floodbasin deposits** (Holocene). Organic - rich clay to very fine silty - clay deposits occupying the lowest topographic positions either between the Holocene levee deposits or Holocene floodplain deposits.

Qhbs **Floodbasin deposits (salt - affected)** (Holocene). Clay to very fine silty - clay deposits similar to Qhb deposits except that they contain carbonate nodules and iron - stained mottles (U.S. Soil Conservation Service, 1958). These deposits may have been formed by the interaction of bicarbonate - rich upland water and saline water of the San Francisco Bay estuary. Salt - affected basin deposits are in contact with estuary deposits, Qhbm.

Qhbm **Estuary deposits (bay mud)** (Holocene). Water - saturated estuarine mud consisting predominantly of clay and silty clay underlying tidal mudflats, marshland and salt evaporators of San Francisco Bay. These deposits may contain shelly and peaty layers and interfinger with basin deposits (Qhb) and salt - affected basin deposits (Qhbs). Estuary sediments were deposited during and after Holocene sea level rise.

Qhasc **Abandoned stream channel deposits** (Holocene). Poorly to well - sorted sandy silt, silty sand, sand, or sandy gravel with minor cobbles.

Qhaf **Alluvial fan deposits** (Holocene). Near the distal fan edges deposits are typically brown, medium dense, gravelly sand or clayey gravel that grade upward to sandy or silty clay. Sediment near the heads of these fans are typically brown or tan, medium dense to dense, gravelly sand or sandy gravel that grades upward to sandy or silty clay.

Qls **Landslide deposits** (Pleistocene and/or Holocene). Landslide materials consist of poorly sorted mixtures of clay, silt, sand, gravel, and boulders. Only two landslides that conceal faults are shown. For a more complete map of landslide deposits, see Nilsen (1975).

Qpaf **Older alluvial fan deposits** (Pleistocene). Tan to reddish brown, dense, gravelly and clayey sand or clayey gravel that grades upward to sandy clay.

Bedrock Units

QTig **Irvington Gravel** of Savage (1951) (Pleistocene and Pliocene(?)). Poorly to well consolidated, distinctly bedded cobble conglomerate, gray conglomeratic sandstone, and gray, coarse - grained, cross - bedded sandstone. Conglomerate clasts are well to subrounded, as much as 25 cm in diameter (average about 5 cm) consisting of about 60 percent micaceous sandstone, 40 percent chert, metamorphic and volcanic rocks (probably derived from Franciscan and Coast Range ophiolite rocks), and a little cherty shale probably derived from the Claremont Formation. The gravel also includes minor interbedded siltstone and claystone. It is very similar to Livermore gravel (QTlg), but differs from other conglomerates in the area by being softer, grey colored, and by the distinctive clast composition. The Irvington Gravel is about 100 meters thick.

A large suite of vertebrate fossils from the Irvington Gravel was described by Savage (1951). The Irvington District on this map is the type locality of the Irvingtonian Stage (North American Mammalian Ages) of the Pleistocene. A freshwater fauna of uncertain age was reported by Cooper (1894) from a nearby locality. However, Crittenden (1951) and Dibblee (1980) both correlated the Irvington Gravels with the Pliocene to Pleistocene Santa Clara Formation. We have therefore assigned the Irvington Gravels an age of Pliocene(?) to Pleistocene.

QTlg **Livermore Gravel** (Pleistocene and Pliocene). Poorly to moderately consolidated, indistinctly bedded, cobble conglomerate, grey conglomeratic sandstone, and gray coarse - grained gray sandstone. Clasts are elongate, well rounded to subrounded, as much as 50 centimeters in diameter (average 10 cm), and they contain mostly graywacke, chert and metamorphic clasts probably derived from the Franciscan complex, and some siliceous shale perhaps derived from the Claremont Formation. The clasts in places are imbricated, showing deposition by streams flowing generally east to west. The gravel also includes some poorly consolidated siltstone and claystone. The Livermore Gravel is 1000 to 1300 meters thick (Hall, 1958), although only part of the formation is exposed in the Niles Quadrangle. The Livermore Gravel is very similar to the Irvington Gravel.

Branner (1912) and Stirton (1939) reported Pliocene invertebrate and vertebrate (*Pliohippus sp?*), respectively, fossils from the Livermore Gravels about 5 miles southeast of Sunol. Savage (1951) reported Pleistocene vertebrate fossils in the Livermore area northeast of the Niles Quadrangle, although Hall (1958) considered some of those localities to be in Quaternary terrace deposits, not part of the Livermore Gravels. Herd and Brabb (1980) indicate that the Livermore Gravels are Pleistocene and Pliocene based on veterbrate fossils found near Livermore.

Tv **Unnamed volcanic rocks** (Pliocene). This unit shows remarkable variation in lithology, although it occurs in only a small area about 3 kilometers northwest of Niles Junction. In the southern part of the outcrop area it consists of white to gray rhyolite, dacite, andesite, interbedded pyroclastic flows, tuff, volcanic breccia, and volcanoclastic conglomerate, and minor interbedded mafic volcanic rock. Clasts in the conglomerate and breccia are as large as 50 cm (average 5 cm) and they include metachert in addition to volcanics. In the northern part of the outcrop area, the volcanic rocks are mainly massive, hill forming, porphyritic basalt with black or red groundmass that weathers bright maroon. Phenocrysts in the basalt are plagioclase, pyroxene, and olivine as much as 1 cm long. The basalt is vesicular in places.

The volcanic rocks are 250 meters thick. Their stratigraphic position overlying the Orinda Formation, and their higly folded character led Hall (1958) to consider them as Pliocene.

Tor **Orinda Formation** (Pliocene). Distinctly to indistinctly - bedded pebble to boulder conglomerate, conglomeratic sandstone, and coarse to medium - grained lithic sandstone. Clasts are subangular to well rounded, as much as 50 cm in diameter (average 2 cm), and they consist of red, green, and black chert, quartzite, greenstone, diorite, lithic sandstone, and minor andesite. The matrix of the conglomerate and the sandstone are a characteristic green and red color, and are moderately well - lithified. The formation includes a few distinctly - bedded sequences of mudstone, siltstone, and lithic sandstone. These sequences lack cross - bedding and probably represent lake deposits.

Torv The formation locally includes interlayered bright green porphyritic dacite sills with phenocrysts of quartz and plagioclase and large xenoliths of pink to red chert.

The Orinda Formation is at least 1500 meters thick in this area, although the base and top are not exposed in continuous sequence. It is easily distinguished from other conglomerates in the area by the red and green color, by being harder than the Irvington and Livermore gravels and softer than older conglomerates, and by having a distinctive clast composition.

The Orinda Formation depositionally overlies the Briones Formation in the southwestern part of the quadrangle, so it is older than late Miocene. Stirton (1939) reported early Pliocene vertebrates from the Orinda Formation both in the Oakland hills north of the Niles Quadrangle and in eastern Contra Costa County. Richey (1943) reported early Pliocene vertebrates and late Miocene invertebrates from Orinda Formation in the Oakland hills, but the formation there is conformably below Moraga volcanics, dated at about 10.2 Ma at the base (Curtis, 1989), indicating a conflict in the age assignment. Hall (1958) named the Orinda Formation in the Niles Quadrangle and assigned a Pliocene age based on similarity of lithology and stratigraphic position to Pliocene rocks in eastern Contra Costa County. Because there are no age diagnostic fossils found in the Orinda Formation in the Niles Quadrangle, his age is provisionally accepted, although the type locality of the Orinda Formation is Miocene.

Tss **Unnamed sandstone** (Pliocene(?)). Distinctly to indistinctly - bedded, poorly consolidated, white, fine - grained sandstone and siltstone. The sandstone has many interbeds of diatomite, gray diatomaceous chert, and tan limestone. Interbeds average about .5 m thick. The chert contains a few freshwater diatoms (John Barron, written comm., 1993). This unit appears to conformably overlie the Briones Formation (Hall, 1958), although the contact is nowhere exposed in the map area. It is at least 850 meters thick. No age diagnostic fossils are known from this unit, but its stratigraphic position indicates that it may be Pliocene.

Tbu **Undivided Briones Formation** (Upper Miocene). The basal part of this Formation consists of distinctly - bedded, gray to white, fine - grained sandstone and siltstone. Bedding is parallel and cross - beds are not evident. Sandstone beds are as thin as 5 to 10 cm with 2 to 10 cm thick shaley interbeds. These are interbedded with massive fine - grained sandstone beds as much as 5 m thick. The middle part of the Formation (shell beds) consists of indistinctly - bedded, white, fine to coarse - grained sandstone, conglomeratic sandstone, and massive, shell - hash conglomerate. Shell - hash conglomerate is made up of interlocking mollusk and barnacle shells and shell fragments in a white calcareous sandstone matrix. Pebble and cobble conglomerate beds are present in a few places. Conglomerate clasts include black chert, red chert, quartzite, andesite, argillite, siltstone, basalt, felsic tuff, and vein quartz. The shell beds and conglomerates are hard and resistant and form prominent ledges, ridges, and peaks such as Mission Peak. The upper portion of the Formation consists of distinctly to indistinctly - bedded, massive to cross - bedded, fine to coarse - grained white sandstone. Sand grains are predominantly quartz and feldspar. The sandstone has in many places a distinctive peppered appearance caused by small black grains (chert according to Hall, 1958). The Briones Formation as a whole weathers to a distinctive orange color. It is at least 1150 meters thick, although the base and the top are not exposed in continuous sequence.

Trask (1922) assigned the Briones Formation to the late Miocene based on a large fauna of invertebrates collected from localities throughout the East Bay area, including one locality in the northeast corner of the Niles Quadrangle (near locality #19 on Table 1). Hall (1958) also assigned the Briones Formation to the late Miocene based on invertebrates and the Mohnian Stage of Kleinpell (1938) based on Foraminifera collected in the Niles Quadrangle and adjacent quadrangles (including locality #19 on Table 1). Most fossil localities in the Briones Formation in the Niles Quadrangle lie east of the Calaveras Fault, but Hall (1958) and Crittenden (1951) have both identified several late Miocene invertebrate fossils from the Formation west of the Calaveras Fault in the area southeast of the Niles Quadrangle.

Tt **Tice Shale** (Middle Miocene). Distinctly - bedded, dark brown, gray, and tan, siltstone, mudstone, and siliceous shale. Tice Shale weathers in places to a reddish brown color, and in places contains abundant fish scales. The shale also contains numerous lenses of massive, tan dolomite, as much as 2 meters in length, that weather to a characteristic bright orange color. Many of the dolomite lenses contain foraminifers that are evident on weathered surfaces of the rock. Tice Shale has a maximum thickness of 290 meters in this area. Tice Shale is similar to shale in the Claremont Formation in the Niles Quadrangle, but lacks the chert beds characteristic of the Claremont.

Kleinpell (1938) dated the Tice Shale as correlative with the early part of his Mohnian stage (middle Miocene) based on Foraminifera found in the Concord area about 40 kilometers to the north of the Niles Quadrangle. Hall (1958) considered the Tice Shale in the Niles Quadrangle to be middle Miocene based on stratigraphic relationships with surrounding strata, and lithologic similarity to shales in the Concord area.

To **Oursan Sandstone** (Middle to Upper Miocene). Distinctly to indistinctly - bedded black mudstone, and Foraminifera - bearing, brown to tan siltstone and fine - grained sandstone. In places these rocks have a large amount of secondary calcite. The sandstone in many places contains large lenses, as much as 2 meters long, of tan, Foraminifera - bearing dolomite that weather to a distinctive yellowish orange, very similar to those found in the Tice Shale. The Oursan is distinguished from the Briones and Claremont Formations by its darker color, finer grain size, and presence of Foraminifera in siltstone, sandstone and dolomite. In this area it is 300 to 1000 meters thick.

Kleinpell (1938) dated the Oursan Sandstone as correlative with the late part of his Luisian stage (middle Miocene) based on Foraminifera found in the Tice and Claremont shales enclosing the Oursan Sandstone in the Concord area, about 40 kilometers north of the Niles Quadrangle. Hall (1958) indicated that Foraminifera in the Oursan in the La Costa Valley Quadrangle adjoining the eastern part of the Niles Quadrangle are also Luisian. However, Foraminifera collected by us from the Oursan Sandstone in the Niles Quadrangle are Mohnian (middle to upper Miocene) according to K. McDougall (written comm., 1992). The Oursan Sandstone in the Niles Quadrangle may be different in age from the formation in other areas (such as the La Costa Valley Quadrangle), or the Oursan Sandstone may extend from Luisian to Mohnian throughout its outcrop area.

Claremont Formation (Middle to Upper Miocene). Divided informally into:

Tcc **Chert and siliceous shale member.** Chert occurs as distinct, massive, gray beds as much as 10 cm thick with thin (about 1 to 2 mm) shale partings. Chert forms about 30 percent of the member in the Niles Quadrangle. Siliceous shale is dark brown to gray, finely laminated, with grains ranging from clay to silt size. Some of the shale contains abundant poorly preserved Foraminifera and fish scales. This member also contains prominent interbedded lenses of massive, tan, foraminifer - bearing dolomite as much as 1 meter in length, that weathers to a distinctive yellowish orange, similar to those found in the Tice Shale and Oursan Sandstone. The Claremont chert and shale member is similar to the Tice Shale, but is distinguished by the presence of chert and more siliceous shale.

Tcs **Sandstone and siltstone member.** Light brown, gray, and white, fine - grained siliceous sandstone and siltstone. This unit is very similar to the Oursan Sandstone, but it is completely within the chert and siliceous shale member. It has a maximum thickness of 85 meters.

The maximum total thickness of the Claremont Formation is 700 meters. Kleinpell (1938) indicates that the Claremont Formation is correlative with his Luisian stage (middle Miocene) based on Foraminifera collected in the Concord area about 40 kilometers north of the Niles Quadrangle. Hill (1979, pl. 2) indicates that the Claremont Formation in the Niles Quadrangle is also correlative with the Luisian stage in the Morrison Canyon area, based on one Foraminifera sample examined by K. McDougall. One of our samples from the Claremont in the Mission Pass area is Mohnian, according to McDougall (written comm., 1992). The Claremont is, therefore, of middle to late Miocene age.

Ts **Sobrante Sandstone** (Middle Miocene). White, fine to medium - grained quartz sandstone. Occurs in discontinuous outcrops below the base of the Claremont Formation in the eastern part of the quadrangle, nowhere more than 120 meters thick, in fault contact with underlying Cretaceous rocks. The age of the Sobrante Sandstone is given as middle Miocene by Lutz (1951) and Relizian by Kleinpell (1938), based on invertebrate fossils and Foraminifera (respectively) collected in Contra Costa County, at least 20 kilometers north of the Niles Quadrangle. Hall (1958) correlated the Sobrante Sandstone in the Niles Quadrangle with that in Contra Costa County based on lithology and stratigraphic position below the Claremont Formation. No age diagnostic fossils have been found in the Sobrante Sandstone in the Niles Quadrangle.

Tsh **Unnamed sandstone, shale, chert, and dolomite** (Lower Miocene). Sandstone is massive, medium - grained quartz sandstone which weathers orange. The sandstone is in uncertain contact with laminated gray chert (1-2 mm) interbedded with tan dolomite, dark grey siltstone and claystone containing many concretions, and conglomerate. Dolomite and chert weather to a bright orange color. The conglomerate contains pebbles of varicolored chert, andesite, and quartzite in a dolomite matrix. This formation also includes a breccia at the base containing large (1-2 meters in length) angular to subrounded blocks of dolomite, chert, siliceous shale, and sandstone containing plant fragments, in a highly sheared siltstone and argillite matrix. The breccia may be tectonic and related to a nearby unnamed fault, or it may be a less deformed olistostrome. The unnamed sandstone, shale, chert and dolomite unit was originally mapped as Claremont Formation by Hall (1958), but it is distinguished from that formation by the intercalated nature of chert and dolomite, the presence of conglomerate and dark concretionary shale, and by a significantly older age. A concretion in the shale has yielded *Siphogenerina transversa* and a rich benthic fauna of late Saucesian (early Miocene) age (K. McDougall, U.S. Geol. Survey, written comm., 1992). This formation seems about 600 meters thick, but it is highly folded and difficult to measure.

Tolman Formation of Hall (1958) (Eocene(?)). Divided into:

Ttls **Limestone.** The limestone is gray, algal limestone. It is interbedded with white, lime matrix pebble conglomerate, and clean medium to coarse - grained sandstone, with calcite cement, that weathers orange. Sandstone grains include quartz, feldspar, and lithic fragments, and in places include a large percentage of algal debris.

Tts **Glauconitic sandstone.** The sandstone is dark gray to dark greenish gray, indistinctly bedded, glauconitic, medium to coarse - grained, lithic sandstone. Also contains minor fine - grained sandstone and siltstone.

Most of what Hall (1958) mapped as Tolman Formation we have mapped as Briones Formation. The remaining beds with algal remains were considered Eocene by Max Furrer (*in* Hall, 1958, p. 15), even though all of the genera he listed range to the Recent. All of the Tolman may be Briones, although gray algal limestone is not commonly part of that formation, but we have maintained the name pending restudy of the fossils. The Tolman Formation is at least 200 meters thick.

Tps **Unnamed siltstone and sandstone** (Paleocene). Dark gray, indistinctly to distinctly - bedded siltstone, claystone, and shale, in places containing abundant, poorly preserved Foraminifera and nannoplankton. Grades downward into a basal, indistinctly bedded, dark brown to green, coarse - grained, glauconitic, lithic sandstone. This unit rests unconformably on Cretaceous sandstone and shale west of Dresser in Niles Canyon. It is about 30 meters thick, with the top cut off by a fault. Three samples of the mudstone have yielded abundant coccolith floras of late Paleocene (CP-8) age (D. Bukry, U.S. Geol. Survey, written comm., 1992).

Ksh **Unnamed sandstone, shale, chert, and argillite** (Late Cretaceous). Distinctly bedded, dark gray, well lithified, micaceous, fine grained sandstone and siltstone. Contains rare, large (1-2 m in length) limestone nodules with poorly preserved radiolaria and foraminifers. Grades upward into interbedded black to grey shale and argillite, and gray, radiolarian chert. This unit is about 150 meters thick in the map area. It is probably unconformably overlain by the Tolman Formation, and is faulted at the base. Radiolarians from the chert beds have been identified as late Campanian (Late Cretaceous) (M. Silk, U.C. Berkeley, Dept. of Paleo., written comm., 1992).

Unnamed Sandstone, shale, and conglomerate (Cretaceous). Divided into:

Ks **Sandstone and shale**. Distinctly bedded, gray to white, well lithified, massive to cross - bedded, micaceous, coarse to fine - grained sandstone, siltstone, and shale. Sandstone varies from granitic (quartz, feldspar, and biotite grains) to lithic wacke (grains of mica, clay, quartz, feldspar, and lithic fragments). Sandstone and shale beds are interleaved and range from several cm to several meters thick. In some places the shale contains small (10 cm) to large (1-2 m) limestone concretions. Poorly preserved Foraminifera are present in many shale outcrops, and plant debris is common. Sandstone tends to form discontinuous outcrops on the ridges and uplands, and prominent resistant outcrops in canyons, whereas the shale interbeds are largely visible only in canyons.

Kc **Conglomerate**. Distinctly to indistinctly bedded, massive, pebble to cobble conglomerate. On Sunol Ridge, clasts are as large as 25 cm in diameter (average 5 cm) and consist of black and green chert, plagioclase porphyry andesite, metatuff, and gabbro. The well bedded conglomerate on Sunol Ridge has thin interbeds of coarse - grained, granitic and micaceous, lithic sandstone. On Pleasanton Ridge, clasts are as large as 20 cm (average 5 cm), and consist of black chert, shale, granitoid rocks, rhyolite, greenstone, porphyritic andesite, quartzite, gabbro, and pebble conglomerate.

The Cretaceous rocks are at least 2400 meters thick and are faulted at the base. Hall (1958) reports several Early Cretaceous fossils from these rocks, but part of the formation is along strike from an area containing Late Cretaceous fossils in the Hayward Quadrangle (Robinson, 1956). In addition, we collected Foraminifera from one locality that were identified as Late Cretaceous to Paleocene (K. McDougall, U.S. Geol. Survey, written comm., 1992, see Table 1). This unit includes rocks mapped as Niles Canyon Formation and some of those mapped as Del Valle Formation and Oakland Conglomerate of Hall (1958).

JKk **Knoxville Formation** (Jurassic and Lower Cretaceous). Distinctly bedded, dark brown to gray, alternating thin beds of fine - grained sandstone, mudstone, and shale and thick beds of spheroidally weathering gray sandstone. Sandstone grains are predominantly feldspar and clay. In some places the mudstone and shale contain concretions with well preserved radiolarians. The Knoxville is distinguished from Cretaceous rocks by lack of mica grains and different character of bedding. Locally includes:

JKkc **Indistinctly bedded pebble to cobble conglomerate**. Clasts include black, green and red chert, quartzite, sandstone, and porphyry andesite.

The maximum thickness of the Knoxville in the Niles Quadrangle is about 750 meters, with both the top and bottom of the Formation cut off by faults. The Jurassic age of the Knoxville in this area was based by Hall (1958) on work of Robinson (1956) in the adjoining Hayward Quadrangle. Hall also reported a Early Cretaceous fossil from the conglomerate near Niles. The Knoxville Formation as mapped here includes part of the Oakland Conglomerate as mapped by Hall (1958). The correlation with the type locality of the Knoxville Formation, which is over 100 kilometers north of the Niles Quadrangle, was based by Hall (1958) on similarity of lithology and age.

JKfm **Franciscan Melange** (Jurassic and Cretaceous). Highly sheared graywacke and gray to black shale matrix with large (as much as 20 meters long in this area) blocks of glaucophane schist and serpentinite. This unit occurs in the Niles Quadrangle as a thin (125 feet wide) lens in the Calaveras Fault Zone east of Sunol. The Jurassic and Cretaceous age of the Franciscan is based on the work of Camp (1942), Taliaferro (1943), Schlocker and others (1954), Hertlein (1956), and others on fossils collected in many areas in the Coast Ranges of California. There are no age diagnostic fossils in this unit in the Niles Quadrangle.

Intrusive Igneous Rocks

Tr **Rhyolite Dikes** (Tertiary?). Small lenses of resistant, light gray, quartz and feldspar porphyry rhyolite. Phenocrysts are as much as 3 mm long in a cryptocrystalline groundmass. Outcrops of the dike are 1 to 500 meters in length, and 1 to 25 meters in width. The dikes only intrude Cretaceous rocks at Sunol Ridge, so they are Cretaceous or younger in age. The questionable Tertiary age is based on similarity to silicic intrusives in the Mount Diablo Area.

Map Symbols

Contact. Dashed where approximately located or inferred, dotted where covered. Dashed lines in cross section represent bed forms.

Fault. Dashed where approximately located or inferred, dotted where covered, queried where uncertain. Paired arrows show sense of strike - slip offset in map view, single arrows show vertical offset in cross section. Teeth are on upper plate of thrust faults in map view. Lines for the Hayward Fault are from Lienkamper (1992). Lines for other faults are based mainly on truncation of geologic units and may not represent zones of current fault hazard.

Right Lateral Fault in cross section

Fold Axis. Dashed where approximately located or uncertain, dotted where covered.

Syncline

Anticline

Cross Section Line

Strike and Dip of Strata. Dashed where approximate. Ball on dip line indicates observed geopetal (top) indicators.

Vertical Strata

Overturned Strata

Strike and Dip of Joints. Dashed where approximate.

General Location of Fossil Collection. Leader and dot used where space too crowded for symbol. Number refers to table 1.

EXPLANATION TO ACCOMPANY

PRELIMINARY GEOLOGIC MAP OF THE NILES 7.5-MINUTE QUADRANGLE, ALAMEDA COUNTY, CALIFORNIA

By

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This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards or with the North American Stratigraphic Code. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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