ROBERT V. SHARP
WENDELL A. DUFFIELD
U.S. Geological Survey, Menlo Park, California 94025

Reinterpretation of the Boundary between the Cosumnes and Logtown Ridge Formations, Amador County, California

ABSTRACT

Recent detailed geologic mapping in the Sierran foothills reveals that rocks previously included in the Jurassic Amador Group must be redefined. The term "Amador Group" was applied by Taliaferro and Clark to a section of epiclastic metasedimentary rocks (the Cosumnes Formation) and the seemingly conformable overlying metavolcanic rocks (the Logtown Ridge Formation).

New structural and stratigraphic evidence indicates that at their type localities on the banks of the Cosumnes River the boundary between the two formations should be relocated about 610 m downsection from the position shown by Clark. This change removes all known paleontological control on the age of the Cosumnes Formation.

Structural relations show that the type Cosumnes and Logtown Ridge Formations are in fault contact at the Cosumnes River. Rocks of the Cosumnes Formation are now grouped with a complex unit of megabreccia that includes other strata previously termed the "western belt" of the Calaveras Formation. The megabreccia formed, at least partly, sometime between late Paleozoic and Late Jurassic times, but rocks in the megabreccia, including the Cosumnes Formation, could be older than late Paleozoic.

The term "Amador Group" is herein abandoned.

INTRODUCTION

The stratigraphy of the Jurassic Amador Group was first elaborated by Taliaferro (1933, 1942, 1943) after extensive geologic mapping in the Sierran foothills of California by him and his students. Taliaferro named these weakly metamorphosed marine rocks the "Amador Group" (1942, p. 89) after the excellent outcrops along the Cosumnes River in northwest Amador County and adjacent southwestern El Dorado County (see Fig. 1). The Amador Group, as most recently discussed by Clark (1964, p. 17–22), consists of about 1,100 m of steeply dipping epiclastic rocks of the Cosumnes Formation conformably overlain to the east by about 1,300 m of bedded volcaniclastic rocks and lava flows of the Logtown Ridge Formation. Clark's (1964) mapping refined the location of the type Cosumnes–Logtown Ridge contact described by Taliaferro (1943, p. 283) on the Cosumnes River and substantially revised the interpreted structural relations between these formations and adjacent rocks. Clark, however, did not significantly change the original stratigraphic definition of the Amador Group. Imlay (1961) and Clark (1964, p. 18, 21) discussed the paleontologic evidence in support of a Late Jurassic age for the upper part of the Cosumnes Formation and for the overlying Logtown Ridge Formation at their type sections.

New stratigraphic and structural interpretations based on more detailed data than heretofore obtained in studies of the Sierran foothills are presented in this paper. These data require substantial revision of the previously established stratigraphy. Specifically, newly described structural and lithologic features indicate that most of the Cosumnes Formation of Taliaferro and Clark should be grouped with an underlying tectonic-stratigraphic sequence of rocks called "the western belt of Calaveras Formation" by earlier workers (for example, Clark, 1964, p. 12). Furthermore, the contact between the Cosumnes and Logtown Ridge Formations is herein considered to be a fault located about 610 m downsection from the

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position of the contact on the Cosumnes River as mapped by Clark (1964, Pl. 10).

FIELD PROCEDURE

The results reported here stem from a larger study within the Sierran foothills of western Amador County. During most of the fieldwork, outcrops were mapped at a scale of 1:12,000 in an effort to document all exposures that would yield information on the problems of stratigraphy and structure in this region. This procedure is especially important for areas between major river channels where outcrops generally are scattered and indicate considerable structural complexity. Although exposure is poor in much of the interchannel areas, the geometric constraints on contacts and the abundant new structural and lithologic information obtained from detailed outcrop mapping provide the basis for the stratigraphic revision proposed here.

LITHOLOGY AND STRUCTURE OF THE COSUMNES AND LOGTOWN RIDGE FORMATIONS

The strata that form the Cosumnes and Logtown Ridge Formations were described in detail by Clark (1964, p. 17–22, 66–67). Briefly, the Cosumnes Formation consists of marine clastic rocks dominated by massive black clay slate, graywacke finely interbedded with black clay slate, and shale-clast granule to pebble conglomerate. The formation also contains lesser amounts of polymictic pebble to cobble conglomerate and tectonic breccia containing fragments of all of the lithologies found in the formation, as well as clasts probably derived from the Calaveras Formation.

The Logtown Ridge Formation consists primarily of bedded marine sedimentary rocks of volcanic origin, and volcanic flows and sills of basaltic composition. A few thin beds of argillaceous rocks have also been recognized in the formation. The volcanic sedimentary rocks are made up of well-bedded, very fine grained to medium-grained tuff, pumice lapilli tuff (commonly in thick beds that grade up section into finer tuffaceous material), and breccia containing clasts of volcanic rocks only, including coarsely porphyritic (augite ± plagioclase) basalt and aphanitic rocks of probable basaltic composition. Flows and sills of the Logtown Ridge Formation include massive porphyritic augite basaltic layers and some

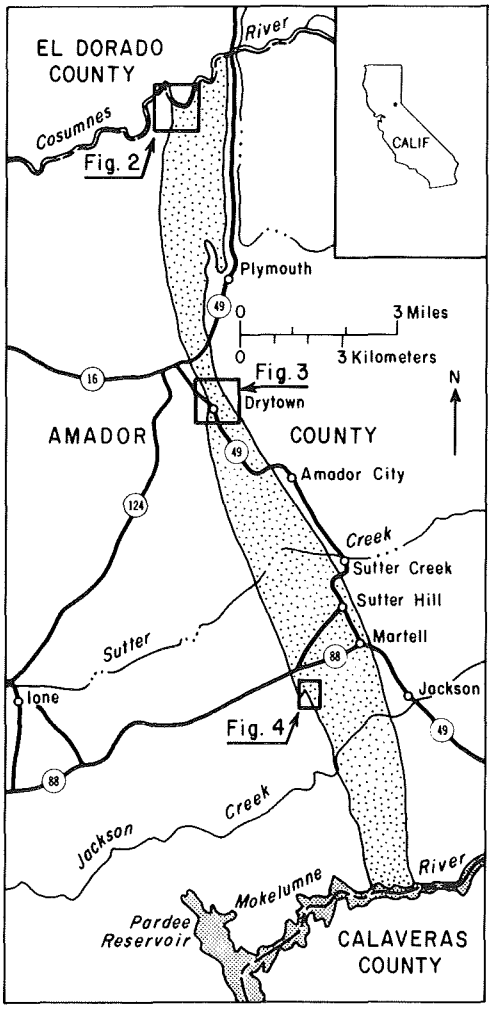

Figure 1. Distribution of the Logtown Ridge Formation (coarse stipple) in Amador County. The formation is bounded on the west by the Calaveras and Cosumnes Formations and on the east by the Mariposa Formation.

bodies of porphyritic plagioclase basalt and augite-plagioclase basalt. Some of the flows locally exhibit pillow structure.

Taliaferro (1943, p. 306) maintained that the Cosumnes and Logtown Ridge Formations at their type localities along the Cosumnes River lie within the east limb of a major isoclinal anticline. Clark (1964), however, showed by numerous determinations of stratigraphic top directions that the two formations form a steeply eastward-dipping homocline without major folding at the type locality, and

that they generally dip steeply to the east wherever they are exposed.

Our mapping corroborates Clark's interpretation of structure within the Cosumnes and Logtown Ridge Formations at the Cosumnes River, but it refutes a major stratigraphic relation that he showed in central Amador County. The Logtown Ridge Formation is now known to extend continuously from the Cosumnes River southward at least to the Mokelumne River, rather than terminating against a group of similar volcanic rocks, as suggested by Clark (compare Fig. 1 with Clark, 1964, Pl. 1). Judging by the general distribution of volcanic rocks of Logtown Ridge type, as shown by Clark (1964, Pl. 1), we suspect that the formation has a much greater southward extent in the foothills than he suggested.

FIELD RECOGNITION OF THE COSUMNES-LOGTOWN RIDGE CONTACT

About 27 km of the Cosumnes–Logtown Ridge contact was mapped during the present study (see Fig. 1), and along much of this length, strongly contrasting lithologies render the contact easily recognizable. Between the Cosumnes River and Drytown, however, the contrast is more subtle. South of Drytown, the basal unit of the Logtown Ridge consists of very thick and massive augite porphyry flows and volcanic breccia that are markedly different from the slate, graywacke, and slate-clast conglomerate of the adjacent Cosumnes Formation. In some parts of this sector, the Cosumnes Formation is absent, and the Logtown Ridge Formation is juxtaposed against the Calaveras Formation. At and near the contact, Calaveras strata include siliceous slate, chert, limestone, and micaceous quartzose sandstone. Sheared serpentinite and talcose rocks also occur along one part of the contact.

North of Drytown, bedded volcanic rocks, primarily greenish fine-grained tuff beds that locally grade into coarse pumice lapilli tuff, interbedded with volcanic breccia, form the basal unit of the Logtown Ridge Formation. Along this segment, only rocks of the Cosumnes Formation border the contact on the western side, and most of the lithologies that occur in the Cosumnes Formation are represented near the contact.

Near and at the Cosumnes River, less apparent lithologic contrast between the two formations probably led Clark (1964, Pls. 8 and 10) to assign approximately the lowermost 610 m of the Logtown Ridge Formation, as herein redefined, to his Cosumnes Formation. In outcrops along the Cosumnes River, tuffaceous rocks of the lower Logtown Ridge Formation (our definition) are interbedded with dark-gray, very fine grained slaty rocks, and many of the sand-sized tuffaceous sediments superficially resemble graywacke of the Cosumnes Formation. Nonetheless, rocks of the two formations as we define them contrast strongly in the field according to their color, fissility, and degree of induration. Tuffaceous rocks are identified by their prevalent and distinctive faint greenish color, poor fissility, and great resistance to the hammer; epiclastic rocks are identified by their black to gray color on fresh exposures, tannish color on weathered outcrops, well-developed slaty cleavage in argillaceous rocks, and relative ease in breaking. Furthermore, tuffaceous rocks are entirely lacking in the epiclastic Cosumnes section near the contact, whereas conglomerate with nonvolcanic clasts is rare in the Logtown Ridge Formation.

By the above criteria, the Logtown Ridge Formation at the Cosumnes River is here redefined to include all rocks previously assigned to the formation by Clark (1964, Pls. 8 and 10), plus an additional section extending westward up to 205 to 244 m east of long. 120°52′30″, the western edge of the Fiddletown 7½′ quadrangle (see Fig. 2). The 37-m interval of uncertainty corresponds to an area of no outcrops along the south bank of the river within which the contact lies. It is interesting to note that relocated this way, the contact very nearly coincides with the one shown by Turner on the Placerville map (Lindgren and Turner, 1894).

AGE OF FORMATIONS

No fossils were found during the course of the present study, but earlier finds by other workers demonstrate the presence of Late Jurassic rocks in the Cosumnes and Logtown Ridge Formations as used by Taliaferro (1943) and Clark (1964). Ammonites of the Callovian Stage were reported from the upper part of the Cosumnes Formation (here assigned to the lower part of the Logtown Ridge Formation) and of Callovian to latest Oxfordian or early Kimmeridgian Stage from successively higher horizons in the Logtown Ridge Formation (Eric and others, 1955; Imlay, 1961; Clark, 1964). Previously, the only known fossil

locality in the Cosumnes Formation had been at the Cosumnes River, as shown in Figure 2 (Imlay, 1961, Table 2, Fig. 3); inasmuch as this locality falls within the Logtown Ridge Formation, as here designated, the age limits of the Cosumnes Formation must be redefined. Inclusion of the Cosumnes Formation with the adjoining belt of Calaveras rocks to the west, generally considered to be Paleozoic in age, appears to be justified on a variety of structural grounds discussed below. The Cosumnes Formation, as here restricted, can be specified now only as Late Jurassic or older in age.

NATURE OF THE CONTACT BETWEEN THE COSUMNES AND LOGTOWN RIDGE FORMATIONS

The Cosumnes–Logtown Ridge boundary was interpreted by earlier workers as a conformable stratigraphic contact. Acceptance of this relation was based on the parallelism of bedding in both units with the contact as defined by the earlier workers at the Cosumnes River (Clark, 1964). Present evidence, however, indicates that the conformity previously cited at the Cosumnes River actually applies to beds entirely within the Logtown Ridge Formation and that the most distinctive lithologic discontinuity at the base of the redefined formation is a fault. Most of the evidence in support of this interpretation, including structural discordance, shearing, and tectonic inclusion of exotic rocks at the contact, comes from exposures south of the Cosumnes River.

Field Characteristics and Exposures

The contact has been mapped in detail across Amador County between the Cosumnes and Mokelumne Rivers. On a broad scale (as shown in Fig. 1), the contact is nearly linear, although to the south it swings gradually from a nearly north-south orientation to about south-southeastward. The contact itself is rarely exposed, but its exact position generally is uncertain for no more than about 30 to 60 m. Definitely two and possibly three exposures of the contact are known in Amador County.

The contact is best exposed in a cut along Stony Creek Road west-southwest of Jackson; it shows abundant evidence of shearing, including a sliver of exotic rocks along the contact. Another exposure occurs in a cut along the Amador Central Railroad west-southwest

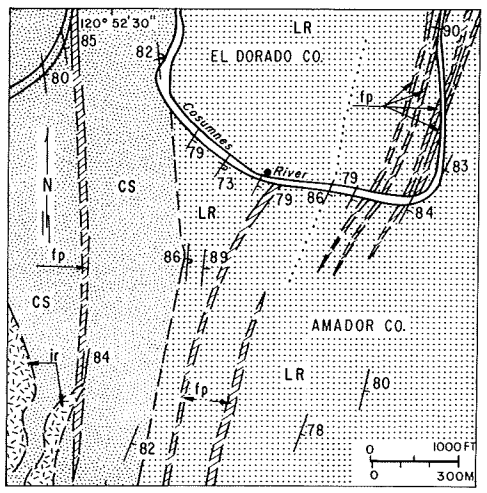

Figure 2. Contact relations between the Cosumnes and Logtown Ridge Formations at the Cosumnes River. Dotted line locates the base of the Logtown Ridge Formation as shown by Clark (1964, Pls. 8 and 10). Solid dot near the R in Cosumnes River represents the position of fossil locality reported by Eric and others (1955, p. 10), Imlay (1961, Table 3), and Clark (1964, p. 18). LR = Logtown Ridge Formation; CS = Cosumnes Formation; fp = feldspar porphyry sills or flows; ir = hypabyssal intrusive rocks; ⊢80 = strike and dip of bedding.

of Martell, but it is too deeply weathered to reveal the nature of the contact there. A third possible exposure located 3.2 km south of the contact's intercept at the Cosumnes River appears to indicate conformable stratigraphic succession of bedded volcanic rocks of the Logtown Ridge Formation overlying coarse graywacke typical of the Cosumnes Formation; however, abundant shearing in rocks only a few hundred feet west of this contact suggests that the graywacke might be part of the Logtown Ridge Formation. Although graywacke is not known elsewhere within this formation, exposure is limited and poor enough that its general absence is uncertain.

Structural Discordance

Major displacement at the Cosumnes–Logtown Ridge contact is suggested by local truncation of structure and stratigraphy at each side of the boundary. Although the Cosumnes Formation persists along a strip of variable width for at least 24 km on the west side of the contact, suggesting only slight regional discordance, several examples of marked local discordance either in strike or

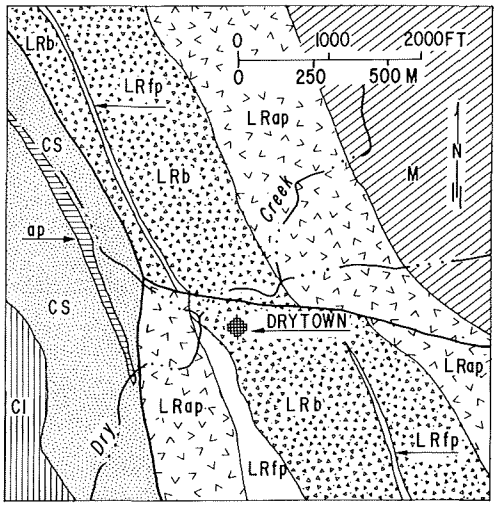

Figure 3. Structure in the Logtown Ridge Formation near Drytown. West-trending fault, indicated by discontinuity in each subunit within the Logtown Ridge Formation, is truncated by fault separating the Logtown Ridge and Cosumnes Formations. M = Mariposa Formation; CS = Cosumnes Formation; Cl = Calaveras Formation; LR = Logtown Ridge Formation; ap = augite porphyry flows and breccia; b = fine-grained volcanic breccia and interbedded tuff; fp = feldspar porphyry pillow lava and sills.

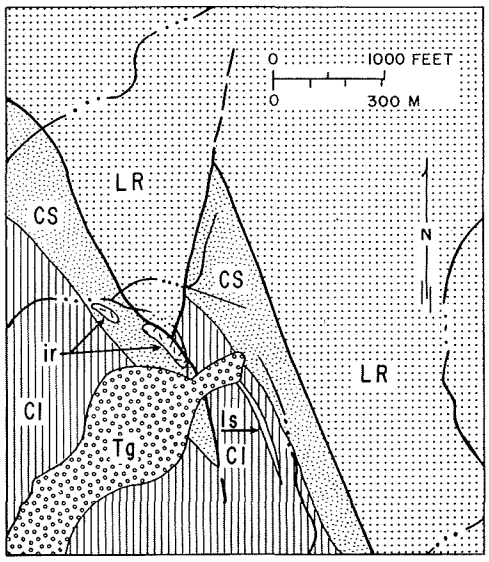

Figure 4. Contact relations at the base of the Logtown Ridge Formation west of Jackson. LR = Logtown Ridge Formation; CS = Cosumnes Formation; Cl = Calaveras Formation; ls = limestone; Tg = Tertiary gravel; ir = hypabyssal intrusive rocks.

dip are known. On the Logtown Ridge side of the contact, we have documented even more obvious examples of discordant bedding and lithologic units. Some instances of truncation can be explained adequately by stratigraphic unconformity, but the geometry of others strongly suggests that the contact is a surface of tectonic movement.

Direct truncation of Logtown Ridge strata by a fault that in turn terminates against the Cosumnes–Logtown Ridge contact constitutes the most compelling evidence that the contact is a fault. The abrupt change in the distribution of volcanic rock types in the Logtown Ridge Formation near Drytown (Fig. 3) is best explained by a fault that transects the formation at a high angle to the strike and terminates at the base of the formation. Because this fault does not offset the basal contact and does not extend into the Cosumnes and Calaveras Formations to the west, the basal contact cannot be older than the fault. Thus, inasmuch as the basal contact near Drytown cannot be an unconformity, it must be a fault.

Some of the relations developed along the base of the Logtown Ridge Formation are considerably more complex than the example cited above. Due west of Jackson, a major irregularity in the contact shows that surfaces of tectonic movement of two distinct orientations were involved in juxtaposing the Logtown Ridge against the Cosumnes. The Logtown Ridge Formation is bounded there by a north-northwest–trending surface that is offset along a north-northeast–bearing cross fault (Fig. 4). However, the distribution of the Cosumnes and Calaveras Formations southwest of the contact defies explanation by simple cross faulting. Because it seems highly improbable that volcanic rocks comprising the Logtown Ridge were deposited against an overhanging cliff, the most reasonable explanation appears to be that the present configuration of rocks resulted from displacements on a complex combination of slip surfaces. Displacements may have occurred in several stages to account for the present geometry of the contact, but coeval activity on each fault is more probable.

Evidence of Shearing at the Contact

Generally, rocks observed nearest the base of the Logtown Ridge Formation are no more intensely sheared than more distant rocks. A zone of exceptionally strongly sheared tectonic

breccia, however, is exposed within the Cosumnes Formation at scattered locations several tens to a few hundred feet west of the Cosumnes–Logtown Ridge contact, and movement along this zone possibly added to displacement on the contact itself. Direct evidence of shearing at the contact itself has been seen only at the cut on Stony Creek Road west-southwest of Jackson where thin layers of siliceous slate and chert of the Calaveras Formation and intermixed talc and serpentinite are smeared between relatively less deformed Cosumnes and Logtown Ridge rocks. Entrapment of slivers of exotic rocks of these types at the contact suggests that the amount of total movement probably has been relatively large.

RELATION OF THE COSUMNES FORMATION TO THE CALAVERAS FORMATION

West of the Logtown Ridge Formation, a 2.4-km-wide belt of rocks generally thought to be correlative with the Calaveras Formation (Clark, 1964, p. 12) is chaotically intermixed on a large scale with the Cosumnes Formation and with similar rock types. Although details of the intermixture will not be presented here, large irregular masses of slate, graywacke, and conglomerate, all lithologically identical with the Cosumnes Formation at its type locality, are scattered throughout the belt. Other conglomeratic rocks that are distinctly different from Cosumnes conglomerates, as well as serpentinite, talc, and amphibolite, are similarly involved in the intermixture. Detailed mapping in this belt shows that the present distribution of the contrasting lithologies cannot adequately be explained by mechanisms favored by earlier workers, including simple stratigraphic discontinuity of sedimentary origin and (or) large-scale isoclinal folding. The new evidence suggests that the present juxtoposition of these bodies was produced by postdepositional tectonic movements, which resulted in a megabreccia that exhibits locally pronounced pervasive shearing. Breccias of this type commonly have been termed mélanges (Hsü, 1968).

Some blocks within the breccia have yielded Permian fossils that are consistent with the lithologic correlation of these bodies with the Calaveras Formation east of the Foothills fault system (Clark, 1964, p. 13–15). Although many of the blocks of the megabreccia are possibly Paleozoic in age, both older and younger rocks might also be included; at present, the maximum age of rocks incorporated in the megabreccia is open. The age of at least some of the tectonic intermixture must be younger than Permian, but the age of the Cosumnes rocks can only be restricted to Late Jurassic or older. This time constraint applies because the Cosumnes Formation possesses a regional foliation found throughout the Sierran foothill belt; to the south, this foliation demonstrably predates Late Jurassic granitic rocks (Taliaferro, 1942; Evernden and Kistler, 1970, p. 25).

CONCLUSIONS

Detailed mapping in the Cosumnes and Logtown Ridge Formations in Amador County indicates tectonic dislocation between the two groups of rocks. Moreover, remapping of the contact near the Cosumnes River removes all known paleontologic control on the age of the Cosumnes Formation. Indirect structural evidence shows that the Cosumnes Formation is no younger than Late Jurassic. The Late Jurassic age of the Logtown Ridge Formation, Callovian to latest Oxfordian or early Kimmeridgian at the Cosumnes River, remains unchanged; however, stratigraphic relations within the formation at the Mokelumne River suggest that somewhat older rocks may be present in the basal part of the formation there (Duffield and Sharp, 1974).

Rocks of the Cosumnes Formation are closely allied with those of the Calaveras Formation in the latter's belt of exposure to the west of the Logtown Ridge Formation. This grouping re-establishes a relation depicted on the early Jackson (Turner, 1894) and Placerville (Lindgren and Turner, 1894) maps. However, the observation that the two groups of rocks have shared a common episode of fragmentation and intermixture is a direct outgrowth of the detailed outcrop mapping reported here.

The term "Amador Group" can no longer be applied to the combination of the Cosumnes and Logtown Ridge Formations in Amador County or at their designated type sections along the Cosumnes River inasmuch as there is now little evidence to support a normal stratigraphic succession between the two formations. The Upper Jurassic strata along the Merced River, previously designated as the southern type section of the Amador Group by Taliaferro (1933), have been renamed the

Peñon Blanco Volcanics by Clark (1964, p. 22–23). In general, the geology of the Sierran foothills is not known in sufficient detail to predict whether Jurassic metasedimentary and metavolcanic rocks anywhere form the unbroken stratigraphic succession originally ascribed to the Amador Group at the Cosumnes River by Taliaferro (1942).

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