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GEOLOGY OF THE CENTRAL SIERRA PELONA, LOS ANGELES COUNTY, CALIFORNIA*

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ABSTRACT. The central Sierra Pelona lies about 35 miles north of the Los Angeles civic center. Exposed in the map area is the thickest known section, nearly 7500 feet, of the Precambrian(?) Pelona schist.

Most of the exposed sequence consists of three types of schist in nearly equal amounts. Actinolite-chlorite schist is distinct from and does not intergrade with either the muscovite schist or its variant, the chlorite-muscovite schist. The mappable units, which total only a few hundred feet of section, are thin interbedded quartzite and marble units. A few dikes of talc schist, talc-actinolite schist, and talc-serpentine schist are present.

Chemical data derived from petrographic studies suggest that both the muscovite schist and chlorite-muscovite schist were originally sedimentary material with the composition of graywacke. The actinolite-chlorite schists resemble spilites in composition. The quartzites and marbles are clearly of sedimentary origin. This suite of rocks suggests a eugeosynclinal deposit.

The age of the Pelona schist has not been determined, although suggestive evidence indicates it is probably Precambrian.

The major structural feature of the area is a southwestward-plunging asymmetrical anticline with a smaller fold developed along the oversteepened south flank. Foliation is parallel to bedding except on minor folds where it lies parallel to the axial plane of the fold. The prominent lineations, axes of drag folds in the quartzite-marble units, and crinkling of the foliation plane in the schists plunge southwestward at angles generally steeper than the plunge of the main fold axis of the range. A second, poorly developed lineation is formed by a crinkling of the foliation and plunges down the dip of the foliation planes.

INTRODUCTION

Geologists in recent years have turned to "basement rock" studies in attempts to unravel major structural problems. One of the "basement units" that has been used along the San Andreas fault is the Pelona schist. The purpose of this paper is to place in the record data from the Sierra Pelona, the type region of the Pelona schist. Exposed in the central Sierra Pelona in Bouquet Canyon is the thickest known stratigraphic section that has a minimum of structural deformation.

The Sierra Pelona lies within the Transverse Range Province of Southern California about 35 miles north of the Los Angeles civic center (fig. 1). This range trends east-west and is about 20 miles long and 4 miles wide; it is bounded on the south by the Soledad basin, on the northeast by the San Andreas fault, and on the north and west by the Bouquet Canyon-Bee Canyon faults. Figure 2 shows the geology of about 25 square miles in the central portion of the range.

PREVIOUS WORK

William P. Blake, probably the first geologist to work in Southern California, described the schists of Sierra Pelona in 1853 while a member of Lt. Williamson's party surveying routes for the railroad from the Mississippi River to the Pacific coast (Blake, 1857, p. 59-60). He compared them to the auriferous slates of the Mother Lode and to those in the gold districts of North Carolina.

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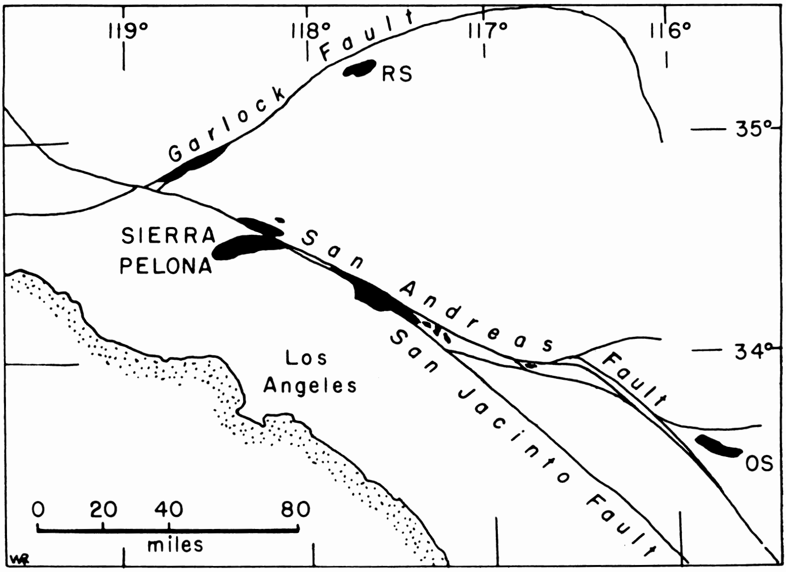


Fig. 1. Map of a portion of southern California showing major faults and location of outcrop areas of Pelona schist (unlabeled black areas) and its correlatives, the Rand schist (RS) and the Orocopia schist (OS).

The designation "Pelona schists" was first introduced in the literature by O. H. Hershey (1902a). Later in the same year he published a general description of the "Pelona schist series", based on reconnaissance work, in which he divided the schists of the type locality, the Sierra Pelona, into two main groups. One of these groups was a "uniformly light yellowish, coarse, granular mica schist of muscovite and quartz—the estimated exposed thickness is 2000 feet." He also recognized a second, or upper, schist which was dominantly dark and "seems to be a chlorite schist." He estimated this to be 3000 feet thick, thus "making 5000 feet for the series—the Pelona schist series" (1902b, p. 276). It is now known that his "upper schist" is topographically higher where he observed it but is stratigraphically lower.

Pelona schist appears in several other widely separated areas of Southern California, including Portal Ridge (Johnson, 1911; Simpson, 1934; Wallace, 1949), the eastern San Gabriel Mountains along the south side of the San Andreas fault from Valyermo to San Bernardino (Noble, 1933, p. 11-12; 1954, p. 42-43), and an elongate area between the branches of the Garlock fault in the Tehachapi Mountains (Wiese, 1950, p. 12-15). All of the above areas lie in a zone that extends for 80 miles along the San Andreas fault and is within 20 miles of the fault zone.

The Rand schist (Hulin, 1925, p. 23-31; Simpson, 1934, p. 380-381), which is identical in lithology and structure and is thus believed to be a correlative of the Pelona schist, is exposed near Randsburg, 60 miles northeast of the Sierra Pelona. Miller (1944, p. 21; 1946, p. 528) and Hill and Dibblee (1953, p. 450-451) have suggested that the Orocopia schist, which is exposed in the vicinity of the Salton Sea 160 miles southeast of the Sierra Pelona, is a

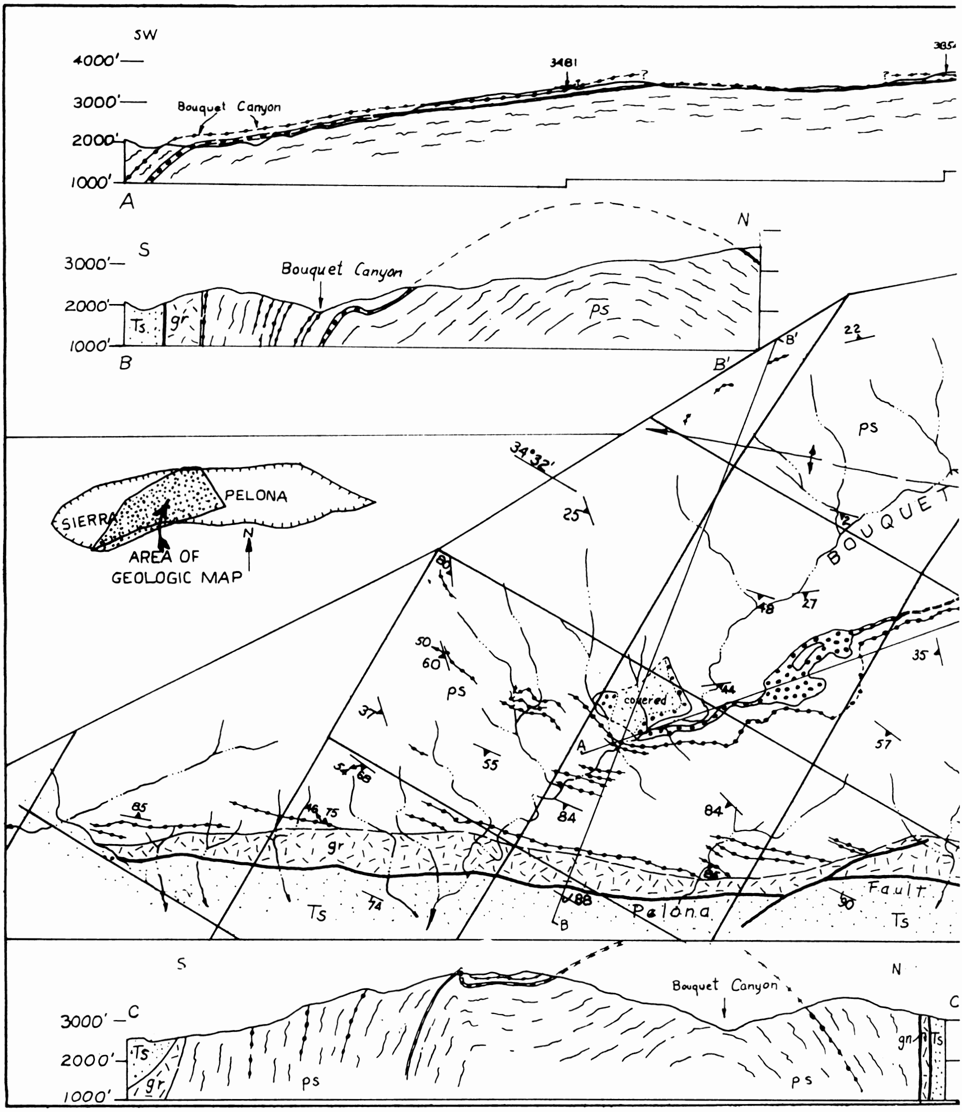
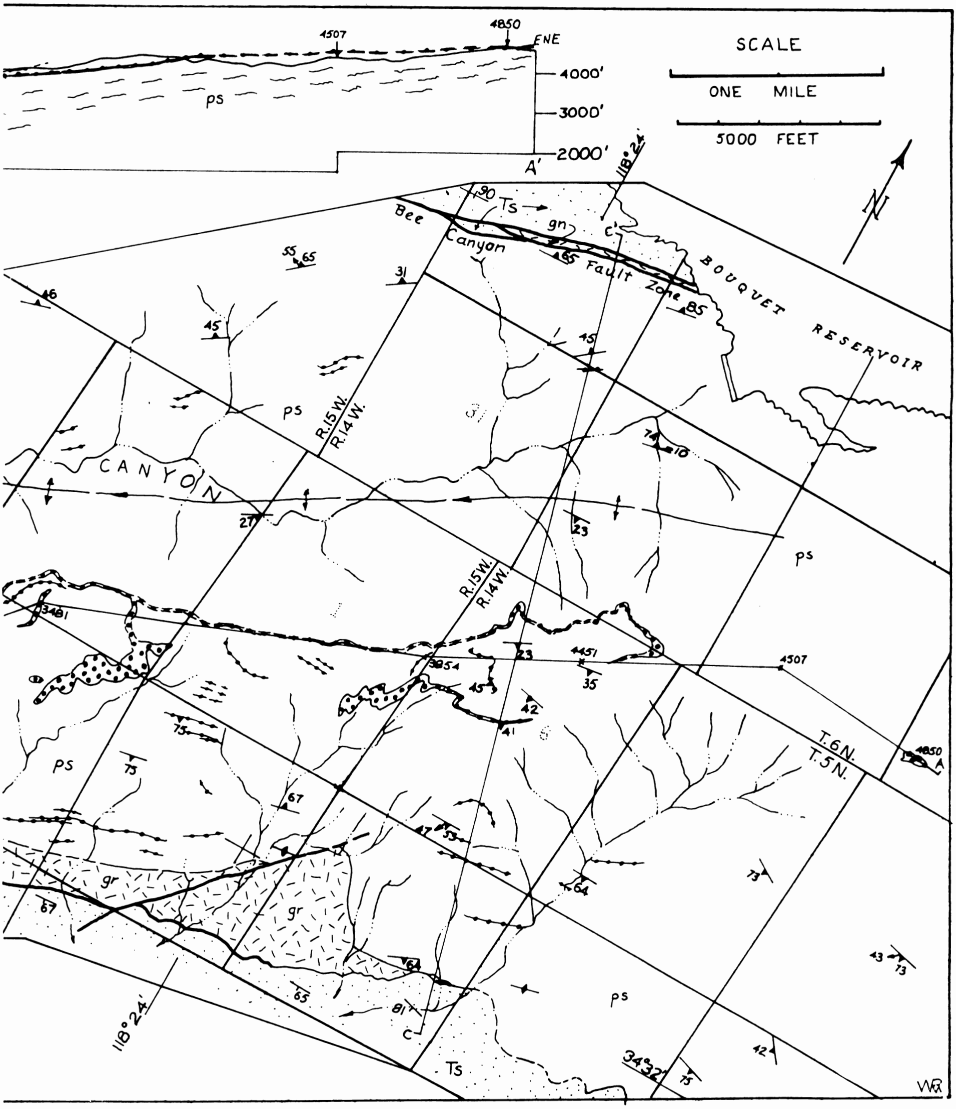


Fig. 2. Geologic map and cross-sections of the central Sierra Pelona, Los Angeles County, California. See figure 1 for location of the Sierra Pelona. Base map from U. S. G. S. 6′ Humphreys, San Francisquito and Bouquet Canyon quadrangles. Only drainage and land net shown. Symbols: ps—undivided Pelona schist, dotted area—thick interbedded marble and quartzite unit, dotted lines—thin interbedded quartzite and sub-

correlative of the Pelona schist. Schists that are texturally and mineralogically similar to the Pelona schist form the "basement" rock of the Old Puente oil field in the eastern Los Angeles basin and have led Schoellhamer and Wood-



ordinate marble; gr—intrusive igneous rocks (range in composition from granite to quartz diorite); gn—gneissic rocks; Ts—Tertiary sedimentary rocks. All Quaternary units omitted. Standard U. S. G. S. map symbols used. South-southwest-plunging minor fold axes in quartzite-marble units not shown. Lineations shown are crinkles of foliation planes. See text for further discussion.

ford (1951, map sheet) to suggest that "the Catalina and Pelona schists may grade into one another, and may be of the same age, possible pre-Cambrian". (A distinctive feature of the Catalina schist is the presence of glaucophane and lawsonite, notably absent from the Pelona schist and its correlatives.) The lack of complete data on the metamorphic terranes of Southern California prevents more positive correlations at this time.

GENERAL FEATURES OF THE SCHIST

The Pelona schist exposed in this area consists of nearly 7500 feet of regularly bedded muscovite, chlorite-muscovite, and actinolite-chlorite schist. Associated with these major rock types are several hundred feet of quartzite, crystalline limestone, actinolite schist, chlorite schist, talc schist, and other minor types. The series appears to be conformable except for talc "dikes" which transect the schistosity at low angles. Except for local areas of subsidiary disturbance, schistosity and bedding are parallel. Igneous intrusions are rare, but in most areas the schists are accompanied by numerous quartz veins. These veins are usually parallel to the bedding but occasionally cut across.

The Pelona schist and its correlatives belong in the greenschist facies of regional metamorphism and are recognized by the distinctive lithologies of the three main types of schist. The muscovite schist is either light gray with a silvery sheen or light brown with a golden sheen. The texture varies from medium- to fine-grained, and the fissility is usually excellent, but poor in specimens with low mica content. The chief minerals are quartz and albite-oligoclase. The feldspar occurs for the most part as porphyroblasts which may range from less than 1 mm to several mm in length. The mica is usually muscovite, but up to 10 percent or more brown biotite may be observed, generally in the "golden" schists. A small quantity of green chlorite (less than 10 percent) may be present. This type weathers to a rusty brown color.

If more than 10 percent green chlorite is found in a muscovite schist, we arbitrarily call it a chlorite-muscovite schist. The color is usually a darker gray than the muscovite schist and sometimes has a greenish tinge. Occasionally the color may be almost black due to small amounts of graphite. The main mineral is albite or oligoclase in porphyroblasts as above; quartz is less important; clinozoisite is often present in grayish or greenish prismatic or tabular crystals up to a few mm long. Weathering changes the color of these rocks to a rust brown.

The actinolite-chlorite schist is distinct from the muscovite and chlorite-muscovite schists and nowhere was found to grade into either. It is light to dark green in color. Untwinned albite or oligoclase porphyroblasts, ellipsoidal in shape, are conspicuous against the green background and give the rock a mottled appearance, especially when large (5 to 6 mm). Locally the feldspar may make up 75 percent of the rock. Prismatic or tabular, greasy crystals of gray-green or greenish clinozoisite are also usually present, appearing as porphyroblasts as much as 1 cm in length. The chlorite is in dark green folia, and with the aid of a hand lens tiny, light- to emerald-green needles of actinolite can be seen. Accessory minerals are green epidote, pyrite, and limonite pseudomorphous after pyrite. These schists are coarser-grained than the muscovite schist and weather to a redder brown. Other distinctive but rare Pelona schist types are coarse actinolite schist, actinolite-talc and talc-actinolite schist, and schist bearing the conspicuous red manganese minerals, piedmontite and alurgite.

The main structural feature of the central Sierra Pelona is a relatively simple antincline with steeper dips along the southern flank. The boundaries of the range and of the Pelona schist itself are, for the most part, all fault contacts. Along a portion of the southwestern part Tertiary sedimentary rocks overlap older faulted boundaries. The boundary between the Pelona schist and the adjacent gneiss along the southern face of the Sierra Pelona is probably an intrusive contact that later was faulted and mylonitized. The evidence for this is the local abundance of small crystals of garnet, and a general coarsening of grain size near the contact, and the presence of blocks of schist that resemble Pelona schist incorporated within the gneiss. The gradational nature of the contact and poor exposures in this region obscure the relations. Wallace (1949, p. 787) observed similar features farther east along the same contact and arrived at the same conclusion.

PETROGRAPHY

For discussion purposes the rocks of the Bouquet Canyon section have been arranged into five groups:

Muscovite schist
Chlorite-muscovite schist
Chlorite-actinolite schist
Quartzite and marble
Minor rock types

Muscovite schist.—The main rock type in the Bouquet Canyon area is muscovite schist, (table 1) probably about 3000 feet thick. The beds range from a fraction of an inch to several inches in thickness with rare beds as thick as one foot. At a distance the schist looks like interbedded sandstone and shale, the "sandstone" being the more massive schist with poor fissility and the "shale" being the thinly bedded, more fissile types. The bedding of the more massive varieties is visible because of slight differences in color. All the rocks in the group have a silvery or golden sheen on the schistosity surfaces.

The schists grouped here are those whose flaky minerals are micas and whose chlorite content is less than 10 percent (table 2).

In thin section the texture is seen to be crystalloblastic, sutured granoblastic to lepidoblastic. From 40 to 70 percent of the rock is oligoclase occurring as 1 to 3 mm subhedral and anhedral porphyroblasts, cloudy with inclusions of quartz, muscovite, and other material, usually without albite twinning striations but occasionally with Carlsbad twinning. In non-porphyroblastic types the oligoclase averages 0.1 to 0.5 mm in diameter.

Colorless muscovite in small flakes less than 1 mm average diameter lie sub-parallel with the foliation. These flakes are found bent around the porphyroblasts. It is present to the extent of 10 to 25 percent of the rock.

The quartz grains average only about 0.1 mm, frequently occurring in little patches or concentrated in single lenses perhaps 2 mm thick and 10 mm long. It has undulatory extinction, frequently possesses trains of bubble inclusions, and is present in quantities from 10 to 30 percent of the rock.

Table 1

Thickness in feet	Rock Description
325	Mixed rock along contact with leucotonalite; transitional types from leucotonalite to quartz-oligoclase-pennine schist.
2300	Muscovite schist, with a few thin quartzite beds.
725	Muscovite schist and chlorite-actinolite schist; thin dike of talcose rock near base.
925	Muscovite schist interlayered with chlorite-actinolite schist; quartzite and marble common; muscovite schist contains abundant chlorite in lower one-third of unit.
1975	Muscovite schist and chlorite-muscovite schist.
750	Chlorite-actinolite schist.
225	Chlorite-muscovite schist.
200	Chlorite-actinolite schist; some chlorite-muscovite schist.
	— — — — — Base of exposed section — — — — —
7425	Total exposed section

Stratigraphic sequence of Pelona schist exposed in Bouquet Canyon. Thicknesses obtained by graphical methods, measured generally northward from the southeast corner of Sec. 16, T. 5 N., R. 15 W. along lower Bouquet Canyon. Section B-B′, Figure 2, approximates an average position along the measured zones. The thicknesses given are approximate outcrop thicknesses of the schist and do not necessarily indicate thicknesses of the original depositional sequence.

Table 2

Mineral	Muscovite Schist	Chlorite-Muscovite Schist	Chlorite-Actinolite Schist
Albite-oligoclase	—	41	44
Oligoclase	55	—	—
Muscovite	17	17	—
Biotite	3	—	—
Chlorite	2	15	18
Clinozoisite	3	7	11
Actinolite	—	—	18
Quartz	14	15	—
Epidote	—	—	4
Calcite	—	—	2
Others	6(a)	1(b)	3(c)

(a) Calcite, magnetite, epidote, pyrite, sphene, other opaques.

(b) Epidote, graphite, sphene, magnetite, garnet.

(c) Pyrite, chalcopyrite, limonite, quartz.

Average mineral composition of the principal rock types of Pelona schist. Based on traverse collected along Bouquet Canyon in same are indicated in Figure 3.

Minor amounts of small (1 mm) brown biotite flakes are sometimes conspicuous in the planes of schistosity against a background of silvery muscovite and grayish feldspar. The biotite is elongated and in sub-parallel position in the plane of schistosity.

Other minerals present include green pleochroic pennine: interstitial and crack-filling calcite: magnetite: cloudy epidote: traces of colorless clinozoisite in broken prisms with ultra-blue interference colors or as fine, 1 mm greenish needles; colorless subhedral garnet sometimes slightly anisotropic; pyrite cubes altering to limonite; and red hematite. A small amount of colorless, anhedral, high-relief epidote, subhedral cracked crystals of sphene and graphite may also be present.

Chlorite-muscovite schist.—The presence of more than 10 percent chlorite is arbitrarily used to distinguish chlorite-muscovite schist from muscovite schist, although all gradations between the two groups may be found. Chlorite-muscovite schist is present mainly in the middle and lower part of the Bouquet Canyon section and makes up an estimated 1500 feet of the column. These schists are frequently graphitic and are nearly always thin-bedded. Mineralogically the principal differences are an increase in chlorite with a decrease in plagioclase in both quantity and anorthite content. In thin section the texture is typically crystalloblastic with well developed schistosity.

The main mineral (table 2), constituting one-third to one-half the rock, is unstriated plagioclase, probably albite, that has a bluish cast. The anhedral, oval-shaped porphyroblasts may be elongated in the plane of schistosity and range in length from 3 to 5 mm.

Muscovite and green chlorite (pennine in part) form sinuous trains of flakes around individual porphyroblasts or groups of porphyroblasts. The chlorite is green in ordinary light and has abnormal brown interference colors under crossed nicols. The long, transversely broken and segmented clinozoisite crystals possess the usual abnormal blue interference colors and lie in the plane of schistosity.

The dark color in some specimens is due to contained graphite, an increase of chlorite, or both. The quartz and feldspar are in places almost black due to included or interstitial graphite. The quartz is usually in small (less than 0.2 mm) anhedral crystals grouped together in certain beds. Euhedral to subhedral, colorless, cracked garnets, 0.2 to 0.4 mm in diameter, are scattered throughout. Accessories are sphene, actinolite, magnetite, and limonite.

Chlorite-actinolite schist.—The chlorite-actinolite schist is distinct from the two schist groups already described. The variations in composition are minor, but grain size varies widely. The color is usually a dark green against which the white plagioclase porphyroblasts stand out distinctly, often as knots. Chlorite-actinolite schist is exposed mainly in the lower part of the section in Bouquet Canyon, where a continuous series of similar beds approaches 1800 feet in thickness.

Beds of chlorite-actinolite schist ranging in thickness from 5 to 6 feet to 25 feet or more are present in the muscovite and muscovite-chlorite schists. In one place a four-inch bed of quartzite was observed between two thick beds of chlorite-actinolite schist. In all cases the contacts appear to be conformable; many are sharp. These schists often appear to be bedded, with the feldspar porphyroblasts aligned in rough planes.

The chlorite-actinolite schist ranges in texture from coarse, dark green, chloritic, knotted schists with rough schistosity, including a noticeable linear element and marked porphyroblastic texture, to much finer, dark green, well foliated schists.

Subhedral and rounded anhedral crystals of unstriated plagioclase (albite-oligoclase) averaging 2 mm in diameter, with a maximum of 6 mm, form light gray porphyroblasts (table 2). Many of these porphyroblasts have inclusions of clinozoisite in crystals from one-fourth to one-half the size of the poikilitic host. Fine needles of actinolite may also occasionally be seen in the feldspar. Under the microscope the large feldspar porphyroblasts are seen to be unstriated albite or oligoclase, usually cloudy, with inclusions often arranged in wavy lines parallel to the schistosity. In addition to the clinozoisite and actinolite, inclusions of blebs of quartz, small rod-shaped grains of clinozoisite(?), and subhedral apatite are found. Clinozoisite also occurs as porphyroblasts 2 to 3 mm in average length, although they may be as much as 5 mm long. These are usually longer than the plagioclase porphyroblasts and are colorless to grayish, cloudy, and in elongated broken crystals.

The groundmass is composed of dark green chlorite, light emerald green actinolite in tiny needles, and tiny elongated anhedrons of plagioclase. The chlorite and actinolite often bend around the feldspar porphyroblasts, and on occasions are sheaf-like. The green, strongly pleochroic chlorite is in strips parallel to the schistosity and, like the actinolite, often bends around the porphyroblasts to form radiating sheafs. Ripidolite, pennine, and clinochlore are present. The chlorite has either abnormal blue or abnormal brown interference colors with the ultra-blue being optically negative and the brown being positive.

Actinolite appears to be parallel to the schistosity plane, but the needles are not always parallel within that plane. They average about 0.2 mm long. Its pleochroic formula is X= very pale yellow; Y = green; Z = blue-green. Elongation is positive, with $Z \wedge C = 16°$. Refractive indices indicate about 40 percent ferrotremolite molecule in the actinolite (Winchell, 1933, p. 246).

Although normally absent, small quantities of muscovite may be present. In addition greenish epidote, pyrite, chalcopyrite, limonite, and quartz are found in trace amounts.

Quartzite and marble.—Quartzite and marble, although quantitatively minor parts of the section, are the only mappable units within the Pelona schist. The quartzite beds, 2 to 10 feet thick, are composed of individual layers of nearly pure quartzite that are less than one inch thick and separated by thin, gray-green, micaceous, calcareous laminae. The more continuous, and therefore more easily traced, beds are indicated on figure 2.

In thin section the quartzites are about 85 percent quartz with sutured outlines, numerous bubble inclusions, and undulatory extinction. Many prismatic sections are parallel to bedding (section cut perpendicular to bedding). No relict structures were observed, although Wiese (1950, p. 12) reports faint cross-bedding in the Neenach quadrangle. The remainder of the rock is calcite in anhedral crystals and interstitial fillings between quartz grains. Twinning is common, and the twinning lamellae are often bent. Both the quartz and calcite grains average 0.2 mm in diameter. Trains of muscovite flakes may be present along bedding planes. An even smaller amount of pleochroic greenish to light brown biotite is observed.

The marble is bluish-gray in beds that range in thickness from one-quarter of an inch to several feet. These are separated by quartzite beds less than one inch thick. In places actinolite-chlorite schist units 1 to 5 feet thick separate parts of the main marble unit. The interbedded marble and quartzite are so intricately contorted that stratigraphic thicknesses cannot be determined, even where the outcrop thickness is nearly 100 feet. The marble invariably is interbedded with quartzite, and in places also with actinolite-chlorite schist. The main marble unit is indicated on the geologic map (fig. 2) by the polka-dot area. The thickest of the marble beds are consistently the most highly contorted. Scattered grains of quartz occur in the marble beds, and graphite may be present in small amounts. The quartzite beds are cemented with calcite.

Microscopically the marble is 98 percent calcite in anhedral crystals 1 to 3 mm in diameter. Twinning and cleavage lines are often bent. There is a tendency for the cleavage and twinning rhombs to have parallel orientation, the bisectors of the acute angles being sub-parallel to the plane of schistosity. The schistosity planes are outlined by stringers of quartz (average size 0.2 mm) and pale green pennine with ultra-blue interference colors. Occasional subhedral garnet, greenish epidote, and flakes of muscovite are scattered throughout.

Quartzite and marble are extremely rare in the lower one-third of the exposed schist section. The interbedded quartzite and marble sequences are common near the base of the upper member of the Pelona schist and, in fact, form the basis for subdivision. Thin quartzite beds in the upper member were traced laterally as far as they cropped out.

Minor rock types.—A few dikes of talc schist, talc-actinolite schist, and talc-serpentine schist are present in the section. These are slightly discordant with respect to the foliation of the host schists and are lenticular or ovoid bodies a few to several tens of feet in maximum dimensions. A small amount of the talc has been mined, but the lenticular nature and limited size of the talc concentrations have prevented commercial exploitation. These bodies are probably altered ultra-basic dikes.

Masses of quartz are common and range from veins a fraction of an inch thick and a few feet long to massive bodies ten feet thick and several hundred feet long. They commonly lie parallel to the foliation of the host rocks, although some transect the foliation at low angles. Some of the larger masses contain minor amounts of manganese oxides found as stains on fracture surfaces or as interstitial fillings.

ORIGIN

Table 3 presents the approximate chemical composition of the major rock types in the Pelona schist as compared to the composition of an average graywacke, average shale, and average spilite.

The muscovite schist and chlorite-muscovite schist are similar to graywackes in composition. The dominance of soda over potash in all three types of schist is significant. Other sedimentary rock types (e.g., average shale, col. 4, table 3) show a dominance of potash over soda. The absence of any relict current bedding and the thick sequence of essentially uniform lithology also suggest that the muscovite schist and chlorite-muscovite schist were derived from graywackes. The actinolite-chlorite schist, on the other hand, approaches a spilite in composition. The discrepancy in iron oxides is probably due in large

TABLE 3

	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	59.9	58.1	64.7	58.4	50.6	51.2
Al_2O_3	21.0	20.0	14.8	15.5	17.3	13.7
FeO	0.7	—	5.8	6.5	3.5	12.0
MgO	1.1	5.4	2.2	2.5	9.0	4.6
CaO	2.9	2.1	3.1	3.1	7.9	6.9
Na_2O	5.1	4.6	3.1	1.3	4.7	4.9
K_2O	2.2	2.0	1.9	3.3	—	0.8
H_2O	1.1	2.8	2.4	5.0	3.0	1.9
Others (a)	6.7	5.0	3.4	4.4	4.0	4.0

(a) Mostly FeO, CaO, CO_2, and TiO_2 for columns 1, 2, and 5; mostly TiO_2, CO_2, P_2O_5 and MnO for columns 3, 4, and 6.

Composition of principal Pelona schist rock types compared with average graywacke, shale and spilite. Computations based on chemical compositions as given in Dana's textbook of mineralogy, W. E. Ford, 1932, 4th ed., John Wiley & Sons, Inc., 851 p. Albite is assumed to have the composition $Ab_{95}An_5$, albite-oligoclase $Ab_{90}An_{10}$, and oligoclase $Ab_{80}An_{20}$. Chlorite has been assumed to be pennine. Actinolite has been assumed to have Mg:Fe::3:2.

(1) Muscovite schist, Bouquet Canyon, California. Computed chemical composition derived from average mineral composition (fig. 4).

(2) Chlorite-muscovite schist, Bouquet Canyon, California. Computed chemical composition derived from average mineral composition (fig. 4).

(3) Average graywacke, F. J. Pettijohn, 1957, Sedimentary rocks, 2d ed., p. 307, Harper & Brothers.

(4) Average shale, F. W. Clarke, 1924, Data of geochemistry, U. S. Geol. Survey Bull. 770, p. 30.

(5) Actinolite-chlorite schist, Bouquet Canyon, California. Computed chemical composition derived from average mineral composition (fig. 4).

(6) Average spilite, N. Sundius, Geol. Mag., v. 67, p. 9, 1930.

part to the composition assumed for chlorite, actinolite, clinozoisite, and epidote in the calculations.

A general change in composition can be noted in the section of the Pelona schist that is exposed in Bouquet Canyon (table 1). The lower part of the section is dominantly actinolite-chlorite schist and chlorite-muscovite schist, whereas the upper part is mostly muscovite schist with minor amounts of quartzite and marble. The lower actinolite-chlorite schist may have been formed from basic volcanic rocks (spilites); the chlorite-muscovite schist may be reworked volcanic detritus eroded from nearby regions. The muscovite schist was probably graywacke. The beds of limestone and quartzite clearly are of sedimentary origin. The purity of the quartzite indicates that originally it was orthoquartzite or possibly chert.

This presumed set of original rocks, including graywacke, basic volcanics, and minor orthoquartzite (chert?) and limestone, is of the type commonly ascribed to eugeosynclinal deposits (Kay, 1951, p. 86). If this interpretation is correct, then the present widespread distribution may be the result of original deposition over a large area rather than dislocation by later tectonic events (for example, by major strike-slip faulting).

AGE

The Pelona schist has been correlated with the Rand schist by Hulin (1925, p. 29-31). He believes the Rand schist is Precambrian in age because its degree of metamorphism is in marked contrast to that of nearby lower Paleozoic strata. Also some fragments of what may be Rand schist are present in some rocks of possible Paleozoic age.

Miller (1946, p. 516-517) believes that the Pelona schist is late Precambrian in age, and that it is older than the plutonic rocks of the San Gabriel complex. These plutonic rocks are known to inject the metasedimentary Placerita formation of presumed early Precambrian age. These intrusive rocks, in turn, have been injected by more widespread plutonic rocks in the San Gabriel Mountains, one unit of which has been zircon age-dated as Precambrian (Neuerburg and Gottfried, 1954, p. 465). Wallace (1949, p. 787) suggests that the Placerita formation may be a correlative of the Pelona schist, a view that the writers consider reasonable. The only definite age assignment that can be made for the Pelona schist is pre-Tertiary, as the schist has been intruded by granitic rocks similar to those of the Cretaceous(?) Sierra Nevada batholith. If the Placerita formation is a higher metamorphic rank correlative of the Pelona schist, then the Pelona schist is Precambrian as well. Certainly the question merits further attention and study.

STRUCTURE

The central Sierra Pelona is a southwestward-plunging asymmetrical anticline with a smaller fold developed along the oversteepened south flank (fig. 2). Extensive landslides, creep, and a heavy brush cover obscure much of the geology, and it is possible that other folds or faults of a mappable scale may be present in the map area. The only mappable units, the quartzite and marble sequences, suggest that the structural interpretation shown is reasonably accurate, although some small isoclinal folds may also be present. A brief reconnaissance of the western end of the range indicates that the main antinclinal fold continues to plunge westward and probably continues under the overlapping Tertiary sedimentary rocks. Eastward along the southern flank of the range the structural complexity increases, as shown by several additional southwest-plunging folds as well as some probable faults extending northeastward into the range from the Soledad basin.

Foliation in the schist is prominent and is parallel to bedding in most places. Thus the main structure of the range as outlined by both bedding and foliation was determined by observing the attitudes of the contacts between contrasting lithologies and foliation within each lithologic unit. Foliation is parallel to the axial planes of minor folds wherever these were observed. The widths of the minor folds are only a few feet or tens of feet.

The minor fold axes in the intricately contorted marble and quartzite units consistently plunge 10-20 degrees south-southwest at angles that approximate, although in general they are steeper than, the plunge of the major anticlinal axis. A lineation in the schist, formed by wrinkling in the plane of foliation, also plunges southwest, although somewhat more steeply than the minor fold axes. This is illustrated by representative attitudes on the geologic map (fig. 2). A second lineation in the schist, weakly developed and not shown on the geologic map, is a wrinkling of the foliation plane that plunges down dip.

Two subvertical joint sets occur in the quartzite that is interbedded with the marble. The angles of intersection between the two sets are 60° and 120°, with the 120° angle bisecting the axial planes of the minor folds. The fact that the folds plunge and the joints are essentially vertical suggests that the angular symmetry is coincidental and that the jointing developed later, although under similar stress conditions.

Post-metamorphic diastrophism has developed a slight shearing and granulation in the marble associated with the quartzite. In addition undulatory extinction of quartz as well as fractured clinozoisite and garnet crystals demonstrate that the schist has been affected as well. These features may have developed as the result of movements along the nearby faults (e.g., San Andreas, Pelona, Bee Canyon, etc.).

The major and minor structural features described consistently indicate a horizontal maximum compressive stress oriented along a north-northwest line and a vertical minimum compressive stress.

The probable sequence of development of these structures is as follows: metamorphism with concurrent development of foliation, minor folds and lineations; major fold development, in part later (Cenozoic deformations) although major structure the result of the main metamorphic period (probably Precambrian); jointing during waning stages of metamorphism, as well as accentuation during all later deformations; shearing and granulation, probably as result of post-metamorphic diastrophism.

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