STRATIGRAPHIC STUDIES IN NORTHERN PERU

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ABSTRACT. Detailed measured sections of Permian, Triassic, Liassic, Neocomian, and Aptian rocks are described from the Cordillera Central, Cerro de Caya Caya, Departamento de Amazonas, Peru. The stratigraphic data presented are the bases for extensive faunal studies on the Triassic and Permian which are now being carried on. The Permian section is the most northern fossiliferous Permian section so far reported and its fusulinids indicate an early Leonard age. This is also the youngest Permian studied in Peru to date. The Triassic rocks contain the only ammonite fauna of that age yet discovered from Peru.

INTRODUCTION

WHILE in the employ of the Peruvian Government in the old Departamento de Petróleo, Cuerpo de Ingenieros de Minas* the author had the opportunity to make some stratigraphical studies in the Cordillera Central of northern Peru between the Maranón and the Utcubama Rivers. Fine sections of Permian, Triassic, Liassic, Neocomian and Aptian rocks were studied and measured in detail on the west flanks of the Cerro de Caya Caya. Steinmann (1929) had visited the area and made note of these formations including a limited discussion of some of the contained faunas. The main objective of this study was to measure and collect the unique fossiliferous Triassic rocks which crop out over a large area in the Utcubamba Valley. A preliminary report giving the stratigraphic data obtained is presented here.

The fusulinids from the Permian section were studied by T. G. Roberts (1949), and they establish well the age of these beds. Large collections from the Permian and the Triassic are in the process of study. A part of the Triassic fauna has been described by Jaworski (1922). The Triassic fauna is note-worthy in that it represents essentially the only ammonite

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fauna of that age yet recorded from Peru. The fossils are silicified; approximately a ton of fossiliferous blocks of this Triassic limestone has been etched so far yielding thousands of specimens representing protoconchs to mature individuals. The fauna also contains pelecypods, gastropods, ostracods, brachiopods, and sponge spicules. This fauna represents part of the large Peruvian Triassic collections at the American Museum of Natural History, New York City, that is being studied by Newell, Haas, and the author (Science, 1947, vol. 106, p. 144).

LOCATION OF THE AREA

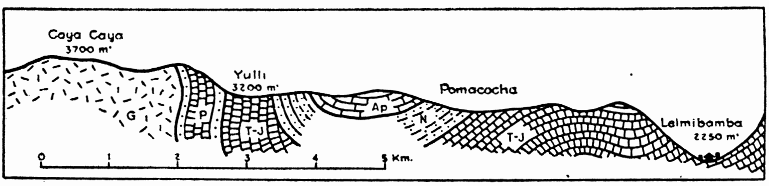
The Cerro de Caya Caya is part of the Cordillera Central of the Peruvian Andes and is situated on the divide between the Maranón and Utcubamba Rivers. The area of study lies entirely in the Departamento de Amazonas in northern Peru. This Departamento fronts on the great Amazon rain forest all along its eastern border. The western boundary lies well in the Cordillera Central and parallels more or less the upper course of the Maranón River. There are no roads connecting this area with the coastal regions of Peru. Under an old road building program there was projected a road from Balsas on the Maranón to the town of Leimibamba on the Utcubamba River over the Cerro de Caya Caya; however, only three kilometers were completed and those out of Leimibamba. The traveler wishing to visit the region can enter over well used and ancient mule trails that start at several points west of the Departamento de Amazonas. At the present time there is a weekly air service from Chiclayo on the coast to Chachapoyas, the capital of the Departamento. One of the most used mule trails starts at Celendin in the southwestern part of the Departamento de Cajamarca and climbs to a high divide at approximately 3000 meters above sea level directly east of Celendin; the trail follows a winding descent to Balsas on the Maranón River, at 900 meters, then begins to follow a circuitous route to the summit regions of the Cerro de Caya Caya at approximately 3700 meters; and then follows the descent to the town of Leimibamba on the Utcubamba River which lies approximately 2200 meters above sea level. The stratigraphic sections described in this report were measured for the most part along this mule trail between the summit regions of the Cerro de Caya Caya and the town of Leimibamba. Along this sector of the trail are two valleys. The first above Leimibamba is called Pomacocha and here the Triassic and Jurassic rocks outcrop the best; the second, higher up the mountain side is called Yulli. The high northern walls of Yulli valley are formed by Neocomian and Aptian rocks; the southern walls are formed by Permian, Triassic and Jurassic rocks.

The author entered the region by flying to Chachapoyas and proceeded from there by mule to Leimibamba, with a stop over at Suta. The sections around the Cerro de Caya Caya were worked for the most part out of Leimibamba. The return trip with all the fossil collections was made with 18 mules following the trail from Leimibamba to Celendin and took three days.

STRATIGRAPHY

General Relations. The outcropping rocks of the region have a regional NW-SE strike and are in general strongly folded and faulted. The core of the Cerro de Caya Caya is pink granite overlain disconformably by Permian rocks. In the area between Caya Caya and Leimibamba the rocks are only slightly faulted and have broad open folds (Text fig. 1); however, between Leimibamba and Chachapoyas the Triassic and Jurassic rocks are badly faulted and folded. Along this latter stretch it is difficult to measure any complete sections. No conclusive evidence was obtained of the nature of the contacts between the various formations. Most contacts were seen in only small locallized outcrops. However, there is no reason to believe that any angular discordances are present.

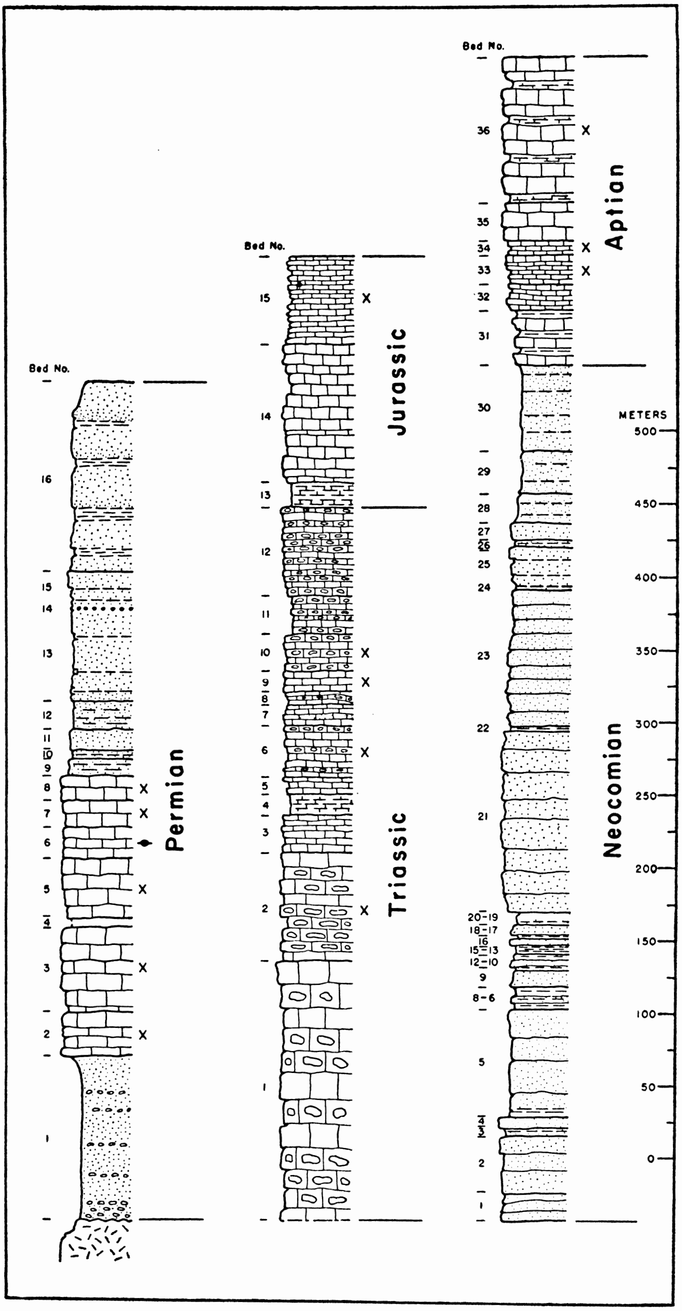
Permian. Directly overlying the pink granite forming the



Text Fig. 1. Section showing structural relations of formations between the Cerro de Caya Caya and Leimibamba (after Steinmann, 1930). G — Granite, P — Permian, T-J — Triassic-Jurassic, N — Neocomian, Ap — Aptian.

core of Cerro de Caya Caya are 589 meters of rock assigned a Permian age. The Permian sequence is composed of three main lithologic divisions. There is a lower basal conglomerate, arkose, and sandstone member predominantly red in color and 115 meters thick. This is succeeded by a thick massive limestone sequence containing myriads of silicified fossils. The fusulinids came from bed 6 (Text fig. 2) 258 meters above the base of the formation. This limestone member is 210 meters thick. Overlying the limestone member is a series of red to brown sandstone, clay-shale, and siltstone which is overlain by Triassic limestones. Fusulinids are present only in bed 6 and were identified by T. G. Roberts (1949, p. 236-238) as *Parafusulina Kummeli* Roberts; they indicate an early Leonardian age for the enclosed strata. This Permian sequence appears to be the youngest Permian section thus far recorded in Peru. Dunbar and Newell (1946) record several sections of Wolfcamp in central and southern Peru and from Bolivia (Text fig. 3). The abundant fusulinids in their strata show very close similarities with the Wolfcamp of West Texas (Dunbar and Newell, 1946). These authors give a fine summary of the present knowledge of the Permian rocks of Peru and Newell, Chronic, and Roberts (1949) have undertaken a more extensive study of the Upper Paleozoic rocks of Peru. Thompson and Miller (1949) have described several fusulinid faunas from Venezuela and Columbia and show the occurrence of Permian rocks younger than any so far reported from Peru. These authors also give an excellent summary of the previous work on South American fusulinids.

Triassic. Triassic rocks outcrop extensively along the Utcubamba valley between Chachapoyas and Leimibamba, where they have been named the Utcubamba formation by Weaver (1942). Above Leimibamba along the mule trail to Celendin in the region of Pomacocha, the Triassic rocks are very well exposed. Half way between Chachapoyas and Leimibamba is a small tributary of the Utcubamba River coming in from the east called Suta, where Steinmann obtained the silicified ammonite fauna studied by Jaworski (1922). A fine silicified fauna was obtained from the Suta locality at several distinct horizons. Unfortunately, however, the area is strongly faulted and no top or bottom of the section could be found. The section recorded here was measured at Pomacocha above Leimibamba.



Text Fig. 2. Columnar sections of formations measured between the Cerro de Caya Caya and Leimibamba. X — fossiliferous horizons -●- fusulinid horizon.

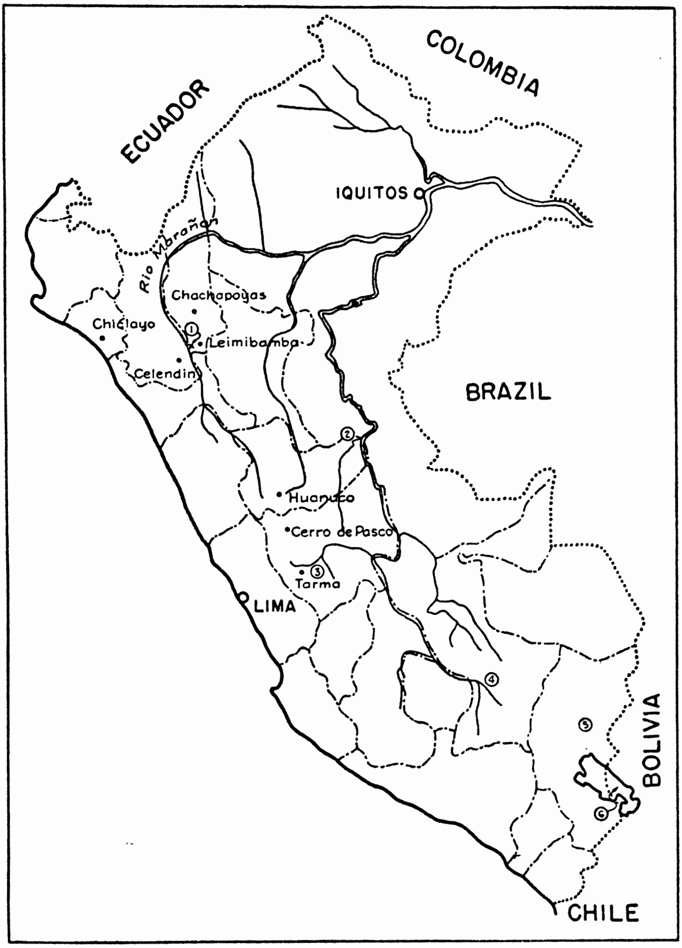
Permian section measured in Cerro de Caya Caya, along trail between Leimibamba and Balsas and above Yulli Valley; November 7, 1945.

Triassic limestone

Massive cliff of gray, thick-bedded, silicous limestone.

Permian	Thickness (in meters)
16. Sandstone, yellow-brown, conglomeratic in parts, with granite boulders, some interbedded red sandstone and shale beds, micaceous, mostly covered	132.00
15. Sandstone, red and yellow-brown, interbedded with brick-red silty shales, micaceous	24.00
14. Sandstone, red, conglomeratic with boulders of granite, micaceous	2.00
13. Siltstone, gray-brown to tan, massive, weathers yellow-brown on surface, contains thin interbedded units of red micaceous siltstone, partially covered	63.00
12. Siltstone, red micaceous, massive and laminated, partially covered	20.00
11. Sandstone, gray-brown, fine-grained, massive, partially covered	15.00
10. Siltstone, brick-red, clayey, micaceous, thin-bedded, partially covered	6.00
9. Sandstone, gray-brown, micaceous, medium-grained, both laminated and massively bedded, soft, partially covered	12.00
8. Limestone, gray, compact, massive, with myriads of silicified fossils	18.00
7. Limestone, brown, weathers iron-brown on surface, massive, with chert concretions, myriads of silicified fossils	18.00
6. Limestone, gray-black, compact, hard, massive, weathers light-gray on surface, contains fusulinids (*Parafusulina Kummeli* Roberts) and other silicified fossils	21.00
5. Limestone, gray and brown alternating, massive, partially covered, contains silicified fossils	42.00
4. Covered, interval occupied by stream bed	11.00
3. Limestone, brown, compact, crystalline, very massive, forming first prominent scarp past the granites, weathers dark-gray, contains myriads of silicified fossils, productids and crinoid stems the most abundant	60.00
2. Limestone, gray, finely crystalline, compact, with chert concretions, weathers dark-gray, contains myriads of silicified fossils, crinoid stems, brachiopods, etc., partially covered	30.00
1. Conglomerate, arkosic, cobbles and boulders of quartz and dark igneous rock, massive, interbedded with thick zones of red medium-grained sandstone, soft, containing some pebbles of quartz; this unit outcrops in a grass-covered and partially covered zone between the granites and the first massive limestone scarp	115.00
Total	589.00

The Triassic is composed of thick massive gray limestone in the lower part with thinner bedded units towards the top. The whole section contains abundant chert concretions and many units are very silty. Silicified fossils are present almost throughout the whole section. However, due to transportation problems only the more apparent richer beds were sampled. Jaworski (1922) assigned a Norian age to the Suta fauna listing the following species:



Text Fig. 3. Map showing location of known Permian sections in Peru. 1. Cerro de Caya Caya, 2. Ganzo Azul discovery well, 3. Yauli formation of Dunbar and Newell (1946), 4. Cerro Pirhuate, 5. Munani section, Quebrada Quishurani, 6. Straits of Tiquina.

Nevadites Lissoni Jaworski
Nevadites Sutanensis Jaworski
Anolcites Dieneri Jaworski
Sagenites aff. *quinquepunctalus* Mojs.
Rhabdoceras curvatum Jaworski
Placites op. cf. *Sakuntala* Mojs.
Monophyllites sp.
Arcestes sp.
Metasiberites annulosus Mojs.
Pseudomonotis ochotica Keys.
Nucula aff. *carantana* Bittner
Leda sp. cf. aff. *sulcellata* Muenst.
Cardita cf. *singularis* Healy
Pseudoscalites subornatus Jaworski
Eucycloscala cf. *exigua* Healy
Dentalium sp. cf. *simile* Broili

The collection on hand includes all of Jaworski's species and several more; too little work, however, has been done as yet to make any additional statement about the age of the fauna. The fauna contains predominently ammonites, with small numbers of gastropods, pelecypods, brachiopods, bryozoa, ostracods, and sponge spicules. The gastropods are being studied by Haas in conjunction with his study of the gastropod fauna from the Triassic rocks of the Cerro de Pasco region of central Peru. The pelecypods are being studied by Newell and the ammonites by the author.

This Triassic fauna is unique in that no other Peruvian and few other South American localities have yielded such an abundant ammonite fauna from Triassic rocks. The Utcubamba formation contains *Pseudomonotis ochotica* which is an Upper Triassic Norian species with a world wide distribution. It has been recorded from Norian rocks in Siberia, Alaska, Japan, Nevada, California, Oregon, Columbia, Ecuador, Peru, New Zealand, New Caledonia, the Indian Archipelago, and in the Crimea. In Peru (Text fig. 4) *Pseudomonotis* has been recorded at Huaira in the Chinchao valley northeast of Huanuco (Steinmann, 1929), near Concepcion and Tarma (Harrison, 1940), at Carhuamayo and Cerro de Pasco (Boit, 1940, 1945), and just north of Olmos, east of the Sechura desert in northern Peru (A. A. Olsson, personal communication). *Pseudomonotis* is recorded from the basal part of the Santiago formation in eastern Ecuador (Tschopp, 1945, 1948).

Triassic-Jurassic Limestone measured at Pomacocha, along trail between Leimibamba and Balsas, October 29, 1945.

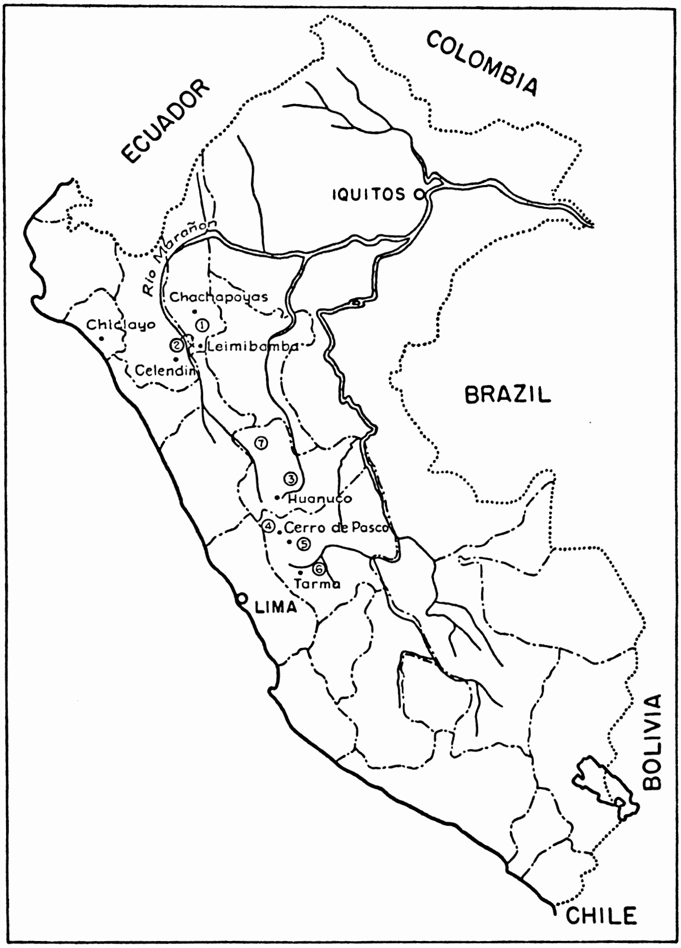
	Thickness (in meters)
Liassic	
15. Limestone, black, bituminous, thin-bedded, slabby, brittle with large limestone concretions, lithographic in part, interbedded with some dark-brown calcareous shaley siltstone, few fossils present	60.00
14. Limestone, gray, regular and massively bedded, mostly covered; some drag folds and reverse dips present in this part	96.00
13. Shale, gray-brown, calcareous, interbedded with 25 cm. to 50 cm. beds of brown silty limestone, partially covered	18.00
Total	174.00
Triassic	
12. Limestone, gray-black, regular but wavy bedded, with much chert concretions, weathers tan and gray, very hard, no fossils	62.00
11. Covered, on opposite side of valley appears to be the same as above	26.00
10. Limestone, gray black, regularly bedded, cherty, contains silicified fossils, mostly covered	26.00
9. Limestone, dark-gray, massive, compact, contains silicified fossils in several distinct horizons, also with scattered fossils throughout	15.00
8. Limestone, dark-gray, compact, weathers tan and light-gray on surface, contains bands and rounded masses of chert, bedding irregular	9.00
7. Limestone, dark-gray, weathers gray and tan, silty, in irregular beds 25 cm. thick, weathers in pitted and streaked surface	14.00
6. Limestone, dark-gray, in wavy beds 20 cm. thick, with frequent 25 cm. to 50 cm. beds of chert, weathers light-gray, contains some silicified fossils, upper part partially covered	36.00
5. Limestone, dark-gray, compact, hard, in beds 25 cm. thick, alternating with thin units of tan silty marl	12.00
4. Covered, shaly and thin-bedded limestone	14.00
3. Limestone, gray, in even regular beds 25 cm. to 50 cm. thick	26.00
2. Limestone, tan, hard, compact, weathers gray, contains abundant chert concretions, massive in beds 1 to 2 meters thick, contains some silicified fossils	75.00
1. Limestone, steel-gray to blue-gray, extremely massive, forms principal scarp in Triassic-Jurassic section, contains abundant hard chert concretions, also chert beds, limestone hard, compact, weathers gray, no fossils seen	180.00
Total	495.00

The small scattered outcrop areas of the Peruvian Triassic include strata of Ladinian, Karnian, and Norian age. No Skythian, Anisian, or Rhaetic rocks have as yet been recorded from Peru. The Ladinian is represented in a limestone sequence in the Cerro de Acrotambo (Korner, 1937). The Norian limestone of the Cerro de Pasco region has been reported frequently; however, this rock sequence has not been well documented by stratigraphic and paleontologic data (W. F. Jenks, personal communication). The distribution of the Norian rocks has been referred to above. It is hoped that the present paleontological studies being carried on with the extensive Peruvian Triassic material at the American Museum will add greatly to our present meager knowledge of the Triassic of Peru.

Liassic rocks: The oldest Jurassic rocks outcropping in Peru are found in the Utcubamba valley. Numerous isolated exposures of these rocks can be seen between Chachapoyas and Leimibamba; however, structural complications make the measurement of detailed stratigraphic sections very difficult or impossible. Overlying the cherty Triassic limestones at Pomacocha, above Leimibamba, are 170 meters of black limestone and calcareous shales assigned a Liassic age. Unfortunately no fossils were found in this particular region.

Steinmann (1929) recognized Hettangian and Sinemurian rocks in the Utcubamba valley. Weaver (1942) named the Hettangian rocks the Chilingote formation and the Sinemurian rocks the Suta formation. The Chilingote formation consists of dark limestones, dolomitic in part, and calcareous shales and the Suta formation consists of thin-bedded limestones and interbedded shale beds. In the Pomacocha section it appears that bed 13 (Fig. 2), and part of bed 14 belong to the Chilingote formation whereas the remainder of bed 14 and bed 15 belong to the Suta formation. Bed 14 contained structural complications and was too covered to be accurately subdivided in the field.

Cretaceous. Sandstones of Neocomian age are well exposed along the mule trail from the intermountain valley of Pomacocha to Yulli. The trail ascends at a rapid rate following a very circuitous route and in many places over the more friable and softer sandstone units is more than six feet deep, having been worn down through the constant passage of mules and horses over a long period of time. The rocks assigned a Neocomian age are 589 meters of coarse to fine-grained, heavily cross-bedded sandstone with much shale interbedded. They overlie Jurassic limestones; the contact conditions were not observed but appear to be conformable. The sandstone is for the most part in very massive units, white to gray-white, and usually weathers yellow-brown on the surface. The sandstones contain abundant thin lenses and scattered masses of quartz pebbles, very characteristic of the Neocomian in many other



Text Fig. 4. Map showing location of principal Triassic outcrop areas in Peru. 1. Suta, 2. Cerro de Caya Caya, 3. Chinchao valley, 4. Cerro de Pasco, 5. Carhuamayo, 6. Concepción and Tarma region, 7. Cerro de Acrotambo.

places in Peru. Throughout the whole section there are numerous thin clay shale beds. Some of the shale beds are laminated with fine-grained sandstone and contain abundant mica flakes and plant fragments. The shale beds are more numerous in the lower half of the formation. No plant material well enough preserved for identification was found. The upper part of the Neocomian sandstone forms a broad terrace upon which rests a thick sequence of Aptian limestone.

Neocomian rocks have a very wide distribution in Peru. Their distribution in Peru has been well summarized by Weaver (1942). Lower Neocomian rocks are continental sediments in eastern and central Peru; along the coast in the vicinity of Lima these beds contain some marine members also. The Barremian (Upper Neocomian) in many places in central Peru is composed of shales and limestones containing marine fossils. The Neocomian rocks of the Caya Caya region are considered to be at least partly correlative with the thick Lower Cretaceous sandstones of Central Peru (McLaughlin, 1924; Weaver, 1942, etc.) and to the lower part of the Oriente formation of eastern Peru (Kummel, 1946, 1948).

Overlying the Neocomian sandstone are 212 meters of light-gray limestone, argillaceous in part. The lower half of the formation is in thin-bedded, partly shaly units; the upper part is heavy, massive, gray limestone beds having a conchoidal fracture. Throughout the sequence fossils are scarce and poorly preserved. These rocks are assigned an Aptian age on stratigraphic position only and may even include some Albian rocks.

Lower Cretaceous section measured at Yulli, along trail between Leimibamba and Balsos, November 8, 1945.

	Thickness (in meters)
Aptian	
36. Limestone, light-brown to tan, compact, hard, massive, with conchoidal fracture, forms huge scarp, has some 1 to 2 meter shaly marl beds, fossils throughout but few and poorly preserved	100.00
35. Limestone, gray-brown, massive, forms prominent scarp, some fossils present, weathers gray on surface	27.00
34. Limestone, light-gray, thin-bedded, hard, with conchoidal fracture, weathers tan and gray on surface, some fossils present	10.00
33. Limestone, gray, argillaceous, in regular beds 10 cm. to 25 cm. in thickness, contains poorly preserved pelecypods, echinoids, weathers grayish tan	20.00

		Thickness (in meters)
32.	Limestone, light-gray, argillaceous, shaly and thin-bedded, weathers tan on surface	18.00
31.	Covered, probably argillaceous limestone, shaly, exposed in part on other side of syncline	37.00
	Total	212.00

Neocomian

30.	Covered, unit very soft, forms low platform beneath Aptian limestone	60.00
29.	Sandstone, white-gray, fine-grained, massive and soft, contains much carbonaceous material and plant fragments	30.00
28.	Sandstone, white and yellow-brown, fine-grained, and black shale units laminated and thinly bedded, contains mica flakes and plant fragments	18.00
27.	Sandstone, iron brown, medium-grained, with iron concretionary beds, massive	12.00
26.	Sandstone, fine and medium-grained, thin bedded and shaly, with interbedded units of siltstone, contains plant fragments and mica flakes	5.00
25.	Sandstone, white, mottled yellow-brown, medium-grained, with lenses of coarse pebbles, soft, massive, cross-bedded, contains thin beds of gray shale	27.00
24.	Shale, yellow-green, clay	2.00
23.	Sandstone, white to yellow-brown, fine-grained, interbedded with units of coarse gray sandstone, relatively soft, partially covered	95.00
22.	Shale, gray-white, silty, hard, well bedded, interbedded with fine-grained sandstone, contains plant fragments and mica flakes	2.00
21.	Sandstone, white to yellow-brown, very massive, coarse to fine grained, with lenses of pebbles, contains iron concretions, forms high prominent scarp	125.00
20.	Siltstone, gray-brown, massive, soft	6.00
19.	Shale, yellow-gray, clay	2.00
18.	Sandstone, white to yellow-brown, medium to coarse grained, cross-bedded, contains abundant pieces of fossil wood and plant fragments	8.00
17.	Shale, gray, silty, hard	2.00
16.	Sandstone, white to yellow-brown, coarse, with pebble lenses, massive, cross-bedded, poorly sorted, has interbedded zones of very fine-grained sandstone, contains fragments of fossil wood	5.00
15.	Shale, yellow-green	2.00
14.	Shale, red	2.00
13.	Shale, yellow-green, clay	2.00
12.	Sandstone, yellow-brown, very fine-grained, thin-bedded and laminated, contains mica flakes	3.00
11.	Sandstone, white, medium to coarse grained, cross-bedded, massive and soft	5.00
10.	Sandstone, gray-brown, fine-grained, thin-bedded and laminated, with interbedded units of gray shale	2.00

9. Sandstone, white, mottled yellow, medium grained, with lenses of coarse pebbles, weathers gray on surface, unit relatively soft	12.00
8. Shale, green	6.00
7. Sandstone, very fine-grained, thin-bedded and laminated, contains lenses of coarse pebbles, with interbedded units of green shale	5.00
6. Shale, red, mottled gray	4.00
5. Sandstone, gray-white, very fine grained, weathers yellow-brown at surface, lower four meters thin-bedded and laminated with mica flakes, upper part massively bedded, white, with pebbles up to 1 cm. in diameter, some thin zones impregnated with a dry, black, bituminous material, unit in general soft, forming low platform	75.00
4. Sandstone, gray-white, coarse, massive, cross-bedded	8.00
3. Sandstone, gray-white, fine-grained, thin-bedded and laminated, interbedded with gray-blue shale, contains mica flakes and plant fragments	5.00
2. Sandstone, white and yellow-brown, massive, cross-bedded, coarse, with iron concretions and lenses of quartz pebbles, partially covered	39.00
1. Sandstone, yellow-brown, massive, cross-bedded, contact zone covered, cannot tell for sure relationship	20.00
Total	589.00

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