CRETACEOUS SYSTEM IN NORTHERN PERU

VÍCTOR E. BENAVIDES-CÁCERES

BULLETIN OF THE AMERICAN MUSEUM OF NATURAL HISTORY
VOLUME 108: ARTICLE 4     NEW YORK: 1956
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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE FACULTY OF PURE SCIENCE COLUMBIA UNIVERSITY

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INTRODUCTION

GENERAL STATEMENT

INTENSIVE GEOLOGICAL ACTIVITY in northern South America has demonstrated the prevalence and importance of the Cretaceous system in this area. However, in spite of the early efforts of von Buch, d’Orbigny, and Karsten, the Cretaceous strata and their invertebrate faunas are still very incompletely known. Most papers dealing with the stratigraphy of the Cretaceous have scanty and outdated paleontological information, and even the few recent works on the invertebrate fossil faunas lack adequate stratigraphic control. The need of “careful and detailed paleontological study of well exposed sections” (Hedberg, 1942, p. 208) has repeatedly been stressed.

One of the best-developed and most fossiliferous Cretaceous sequences of the continent is magnificently exposed in the northern Andes of Peru. A review of the literature suggested this area as a logical one for a detailed study of the stratigraphy and paleontology of the Cretaceous system.

The purpose of this paper is: (1) to describe the Cretaceous succession in the Andes of northern Peru, establishing standard sections of reference and fossil zones; (2) to describe its cephalopod faunas and their stratigraphic distribution; and (3) to summarize the geological history of the area during the Cretaceous.

HISTORY OF EXPLORATIONS

As early as 1839, Leopold von Buch (1839, p. 2) was able to say in the introduction to the description of the fossils collected by Alexander von Humboldt in Peru and Nueva Granada, “la collection de Mr. de Humboldt et ses observations prouvent, a ce qu’il paroit, que de tels fait n’existent pas et font voir, que dans les montagnes des Andes equatoriales la formation creusese est tout a fait preponderante et developpe sur une echelle gigantesque.” Humboldt had traveled through northern Peru in 1802 and devoted one chapter in his “Ansichten der Natur” to a description of the plateau of Cajamarca. He was the first of a distinguished group of travelers and naturalists who explored South America during the early part of the nineteenth century—Agassiz, Bompland, Boussingault, Dana, Darwin, Forbes, Karsten, d’Orbigny, and Orton, to mention only those who contributed to the knowledge of the Cretaceous system.

D’Orbigny (1842, 1851, 1853) concerned himself especially with the Cretaceous faunas of Colombia, about which he said, “La faune colombienne m’offre la plus grande ressemblance avec celle des terrain cretaces de l’ancien monde” (1842, p. 25). Impressed by the similarity of the Cretaceous faunas of South America and those of Europe, he postulated some paleogeographic explanations.

The collections made in northern Peru by J. Orton were studied by Hyatt (1875) who remarked: “the apparent identity of many of the forms with those of well known European species is surprising... This small collection has precisely the aspect of a lot of Western European fossils.”

To this period belong also the journeys of Antonio Raimondi, indefatigable naturalist and geographer who during nearly 50 years explored most of the Peruvian territory. He sent his collections of fossils, with careful notes about their location and even ages, to W. Gabb who published an important monograph (Gabb, 1877).

Gustav Steinmann opened a new stage in the geological progress of Peru and South America as a whole. He was the first to attempt systematic studies on the stratigraphy and paleontology of South America. His “Geologie von Peru” (1929) is a masterly treatment of the fundamentals of Peruvian geology and an indispensable source of reference. His collections, and those of earlier German travelers such as Sievers, Stübel, and Reiss, were distributed among his students for monographic treatment. Gerhardt (1897a) described the “Gault” fauna of Pariatambo; Paulcke (1903), the “Albian and Upper Cretaceous” faunas of Peru; Neumann (1907), the Neocomian flora and fauna of the Lima environs and the “Albian, Cenomanian and Sononian” of central Peru. Sommermeier (1910, 1913) was in charge of the “Aptian and Albian” faunas of northern Peru, while Schlagintweit (1912) worked on the “Vraconian and
FIG. 1. Index map and location of sections.
Cenomanian” of northern Peru, and Brüggen (1910) on the “Senonian” of northern Peru. Independently, Lüthy (1918) described a fauna similar to that studied by Brüggen.

Between 1914 and 1921, J. A. Douglas published the results of his “Geological sections through the Andes of Peru and Bolivia,” the last one from the port of Callao to the Perené River, and in 1924 a traverse was made by the Ellsworth expedition, led by J. T. Singewald (1925a, 1925b, 1927, 1928), from the port of Casma to eastern Peru; the collections were studied by Knechtel, Richards, and Rathbun (1947).

Carlos I. Lissón published many papers on Peruvian Cretaceous fossils, collaborated closely with Steinmann, and published a valuable check list of Peruvian fossils (Lissón and Boit, 1942).

In connection with the exploration and development of mining and petroleum resources, several regional studies were made which added information on the Cretaceous system of northern Peru. Stappenbeck (1924, 1929) studied the Chicama Valley, outlining the stratigraphy. Iddings and Olsson (1928) worked on the geology of northwestern Peru. In addition, Olsson published two monographs on the Cretaceous of the Amotape Mountains (Olsson, 1934) and the Paita region (Olsson, 1944). McLaughlin (1924) investigated the geology and physiography of the Peruvian Cordillera in central Peru.

J. V. Harrison, working on the geology of central Peru, is the most active among recent workers listed in the bibliography.

Regional monographs that have an immediate bearing on the area discussed in this paper are Kummel’s (1948) reconnaissance of the Contamana region in eastern Peru, Jenks’s (1948) study of the Arequipa quadrangle, and Newell’s (1949) study of the geology of the Lake Titicaca region.

Finally, Gerth (1932, 1935), Hedberg (1942), Olsson (1942b), Weaver (1942), Stille (1940), and Weeks (1947) considered the Cretaceous system in northern Peru in their efforts to synthesize the data on South American geology.

FIELD WORK

Between August, 1951, and August, 1952, the present writer spent nine months in the northern Andes of Peru; work was interrupted during the months of January to March, the rainy season. Because geological maps were wanting, much of the time was spent in reconnaissance trips in an effort to locate stratigraphic sections that were adequate for study. Twenty-one sections (fig. 1) were investigated in detail, and fossils were zonally collected. Most of the sections are in the Cordillera Occidental, between Chota on the north and Pomachaca on the south; three sections are along the Marañón River, one is in the mountain front (Tembladera section) near the Pacific Ocean, and two (Carhuaiz and Pariahuanca sections) are along the Callejón de Huaylas. Most of the sections were measured by means of a Jacob staff, one was measured with the alidade, and another, with the steel tape.

ACKNOWLEDGMENTS

This research was begun at the suggestion of Prof. Norman D. Newell. His continuous encouragement and advice are deeply appreciated.

The work was made possible by the financial support of the International Petroleum Company, Limited. Messrs. O. C. Wheeler, A. L. Bell, and A. G. Fischer of this company were particularly helpful. A supplementary grant was made available by the Instituto Geológico del Perú, through the interest and good offices of its director, Ing. Jorge A. Broggi.

During the field work, Messrs. Moisés Hinojosa and Aldo Rodríguez, students at the Universidad Nacional de Arequipa, rendered invaluable assistance. Many residents in the area studied extended courtesies and hospitality to the writer’s party; among them, Messrs. A. Knoch of Cajamarca, Wenceslao Valera of Hacienda Marcamachay, Wilfredo Porturas of Hacienda Santa Clara, and the Messrs. Rossel of Hacienda Jocos are especially thanked.

Much of the investigation was done in the laboratories of Columbia University and the American Museum of Natural History. Professor Thomas W. Amsden of the Johns Hopkins University kindly made available type specimens of Peruvian ammonites deposited in that university.

The writer is indebted to Profs. Marshall Kay and John Imbrie of Columbia University and Prof. William F. Jenks of the
University of Rochester for reading parts of the manuscript and for many helpful comments and advice. Thanks are also due to Dr. Otto Haas for his advice on nomenclatural problems, and to Mr. Robert Adlington for his counsel on photographic techniques.

GEOGRAPHIC SETTING

In northern and central Peru, the Andean Cordillera is best described as a broad plateau, 4000 meters high, about 200 kilometers wide, and with a north-northwest trend, separated from the Pacific Ocean by a narrow and low coastal strip. This broad plateau has been deeply incised by two main subsequent rivers: the Marañón and the Huallaga. The portion of the Andean plateau west of the Marañón River is known as the Cordillera Occidental; it includes the continental divide. The area between the Marañón and Huallaga rivers is known as the Cordillera Central, and east of the Huallaga River is the lower Cordillera Oriental, which sends spurs into the Ucayali plain, a part of the great Amazon plain.

In central Peru, the Andean plateau is comparatively undissected; it is an erosional remnant from which many of the large rivers that contribute to the Amazon River radiate. Because of its fairly undissected, compact nature, it was described as a “knot” (nudo de Paso) by Raimondi. In central Peru, the three longitudinal divisions of northern Peru cannot be established.

In contrast to the great longitudinal rivers east of the continental divide, the rivers that flow towards the Pacific are transverse, short, and with steep gradients, with one notable exception, the Santa River. In the initial 200 kilometers of its course, the Santa River flows northward as a longitudinal river and separates the Cordillera Blanca, a granodiorite pluton which projects far above the high plateau and contains some of the highest peaks of the continent, on the east, and the Cordillera Negra to the west. This part of the Santa Valley is known as the “Callejón de Huaylas”; at its lower end, the Santa River bends sharply west and takes a transverse course.

The present report is limited to the Cordillera Occidental from Chota on the north to Huaraz on the south, and to the Marañón Gorge. Although two trips were made into the Cordillera Central, no significant results were obtained. The coastal strip, where large intrusives and complicated structures predominate, was not studied, although a few sections were investigated in the mountain front.

TECTONIC SETTING

During Cretaceous time, the area now occupied by the Andean Cordillera was a site of geosynclinal behavior, contrasting with the less mobile Brazilian craton. The characteristics of this geosynclinal belt are as yet poorly known.

In northern Peru (fig. 2), this geosynclinal belt was characterized by the following main tectonic elements:

A. A narrow, elongated area in between the present Huallaga and Marañón rivers, which subsided less than the areas towards

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**Fig. 2.** Tectonic elements of northern Peru; the heavy discontinuous lines are the hypothetical axes of deposition during the early Cretaceous.
the east and west. This narrow belt is here named the "Marañón geanticline"; its mobility and spatial relationships changed continuously and, at times, it stood high as a land and source of sediments—Marañónia.

B. Between Marañónia and the Brazilian craton there was a geosyncline, referred to as the "eastern Peruvian geosyncline." Our knowledge of the Cretaceous stratigraphy in this belt is due mainly to Kummel (1948) and Huff (1949).

C. West of the Marañón geanticline, there was another geosyncline, referred to as the "western Peruvian geosyncline"; the major axis follows the present continental divide. This paper deals with the stratigraphy of the Cretaceous system in part of this latter belt.

D. It is postulated that somewhere along the present coastline there were land-sources of sediments and volcanics. This assumption is based on the following data:

1. The Amotape Mountains area stood high during the early part of the Cretaceous and was covered by the sea only in Albian time (Olsson, 1942b, p. 411).

2. The upper Albian-Turonian rocks along the present coastal belt are more coarsely clastic than their time equivalents in the Cordillera Occidental.

3. In the westernmost sections of the lower Cretaceous studied by the writer (Chicama Valley and Carhuaz sections) there are tuffs and tuffaceous sediments which could have come only from the west. Volcanic rocks are not known in the sections along the Cordillera Occidental or along the Marañón River.

During the latest Senonian these western lands were the source of a very thick sequence of coarse red beds which were spread over the western Andes. An unconformity at the base of these red beds increases in magnitude towards the west.

Analogy with better known geosynclinal areas suggests that these lands may have been volcano-bearing island arcs (Kay, 1951, p. 31). They are homologous in time and position and may have been connected with the "borderland of Paria" to the north of the Eastern Venezuela Geosyncline, about which Hedberg (1950, p. 1176) said: "The expression 'borderland of Paria' is used ... to apply to any sort of land area or source of sediments (including 'island arcs') which may have lain north of the [Eastern Venezuela] geosyncline and supplied sediments to it."

These tectonic features were not sharply defined at all times. It is suspected, for instance, that in the late Cretaceous the whole belt between the Brazilian craton and the western volcanic and source lands subsided as a single geosyncline.

**PRE-CRETACEOUS GEOLOGY**

In northern Peru, the Cretaceous sediments rest disconformably on upper Jurassic, lower Jurassic, Triassic, and Pennsylvanian rocks (fig. 3). The stratigraphy of these pre-Cretaceous rocks is little known. The only angular unconformity on record is that between the Albian Pananga formation and the underlying Pennsylvanian rocks in the Amotape Mountains, in northwestern Peru (Olsson, 1934, p. 7). Along the Cordilleras Central and Occidental, however, the rocks of the upper Paleozoic are essentially parallel with...
those of the Cretaceous. “There is no indication of an orogeny in Peru between the Paleo- 
zozoic and the Mesozoic” (Newell et al., 1953, p. 23).

The unconformity at the base of the Cre-
taceous was developed through time. While in 
some areas, as in the Lima area (Rivera, 
1951, p. 16), sedimentation apparently was 
continuous from the Jurassic into the Cre-
taceous, in others, as in Marañónia, the first 
Cretaceous sediments to overlap the older 
rocks are, at the earliest, Aptian in age.

The upper Jurassic is represented along the 
coastal areas and in the Cordillera Occidental 
by thick, fossiliferous shales, tuffs, and con-
glomerates, designated here for the purposes 
of discussion as the “Chicama beds.” These 
beds are missing in the Amotape Mountains 
and also disappear, apparently by erosion, 
from the Marañón geanticline where the 
Cretaceous rocks rest on lower Jurassic and 
even on Triassic rocks. Also, it is very likely 
that towards the axis of the Marañón geanti-
cline rocks older than Triassic underlie the 
Cretaceous, for during the late Albian this 
area produced red-bed conglomerates (Rosa 
formation) made up of quartz pebbles and 
cobbles. Furthermore, Singewald (in Knech-
tel et al., 1947, p. 27) reports sandstones, 
quartz conglomerates, and shales which rest 
on “green chloritic schists” in Pueblo Viejo, 
Huánuco, and which are overlain by “mas-
ive limestones” with middle Albian fossils. 
The present writer suspects that these 
“sandstones, quartz conglomerates and 
shales” belong to the Cretaceous, and that 
the “green chloritic schists” are pre-Meso-
zoic.

Lower and upper Jurassic rocks have been 
reported from the Huallaga River, on the 
eastern side of the Marañón geanticline 
(Huff, 1949, p. 4). Marañónia began to de-
velop during the late Jurassic.

In the Andes of northern Peru, there is no 
evidence for a “Nevadan” orogeny or for a 
great crustal disturbance other than wide-
spread continental emergence, as postulated 
by several authors (Hedberg, 1942, p. 205; 
Kummel, 1948, p. 1231). This statement is 
supported by the following facts:

1. In the Cordilleras Central and Occi-
dental of northern and central Peru, the 
Cretaceous rests disconformably, without 
distinct angular relationships, on upper 
Jurassic, lower Jurassic, Triassic, and Per-
ian sediments. The angularity of the Saraya-
quillo (Jurassic) and the Cushabatay (Cre-
taceous) formations in eastern Peru (Kum-
mel, 1948, p. 1231) has been recently inter-
preted by Huff (1949, p. 7), in the light of 
regional studies, as being of only local and 
slight significance.

2. The transgressive basal Cretaceous sedi-
ments (Chimú and Goyllarisquisga forma-
tions) are composed of extremely clean, 
mature, well-sorted, probably wind-wonnewed 
quartz-sandstones that indicate, rather, 
conditions of tectonic quiescence at the time 
of deposition.

3. When conglomerates are present at the 
base of the Cretaceous, they are very thin 
(in Celendín they are 40 meters thick) and 
are made exclusively of reworked indigenous 
rocks.

4. Volcanic rocks are present in the westernmost studied sections, both in the 
Jurassic and in the Cretaceous, and although 
they are more abundant in the former sys-
tem, they indicate only that that area was one of 
eugeosynclinal behavior during both 
Jurassic and Cretaceous times.
STRATIGRAPHY

GENERAL STATEMENT

Cretaceous sediments are the most abundant and important rocks in the northern Andes of Peru. Older rocks are found, especially along the deep trench of the Marañón River and along the western mountain front. Younger rocks are represented mainly by igneous intrusives and volcanic rocks that cover some large areas.

The Cretaceous system in northern and central Peru can be summarized as follows:

1. It overlies a regional unconformity which, along the Marañón axis, represents a considerable hiatus (Triassic-Albian at least) although without angular relationships.

2. The lower part of the Cretaceous sequence is characterized by very clean quartz-sandstones and brackish-water deposits which attain a maximum of 2000 meters in the Callejón de Huaylas area.

3. The clastic non-marine rocks are overlain, with transgressive relationships, by marine marls and limestones bearing rich molluscan faunas, which have a maximum of 2000 meters in the Cajamarca-Celendín area but are only about 1000 meters thick in the Cerro de Pasco-Ponchaca region. The uppermost marine sediments are early Santonian. They are, however, missing west of the continental divide.

4. The limestones and marls (Albian-Santonian) are succeeded, also without angular relationships, by thick, coarse, red-bed deposits (Chota formation), the lower beds of which, for reasons given below, are thought to be Campanian.

5. This sequence was strongly folded, probably during the late Senonian, and then covered, with distinct angular relationships, by non-marine, coarse red beds (Pocobamba, Rimac formations) of Tertiary age.

This summary agrees with the generalized descriptions of the Colombian and Venezuela-Cretaceous given by Hedberg (1942, p. 207) and Bucher (1952, p. 8).

A single lithic classification cannot be adopted in view of facies variations in an area as large as the one under study. For the sake of convenience, the formal units are described under four headings: (a) Western Mountain Front, (b) Central Western Andes, (c) Northern Western Andes, and (d) Marañón Valley. They reflect primarily the location of the type sections of the formations under description, but, to be sure, are not strict stratigraphic provinces.

It has long been recognized that the Cretaceous invertebrate faunas of northern South America have close Mediterranean (Atlantic or Tethyan) affinities. Because of these affinities, and because the early work was done mainly by European stratigraphers, the South American Cretaceous has been referred to the Standard European Stages. These terms are well entrenched in the literature and, moreover, they have almost universal acceptance. The writer, after a revaluation of the cephalopod faunas, decided to follow this procedure, although having in mind the limitations of correlations halfway across the world.

The marine portion of the system under study, excellently developed in the Cajamarca-Celendín area, has been divided into 13 zones, and an effort has been made to use single ammonite species as zonal indices. They are fully discussed in a following section. Further research will determine if these zones are also applicable to the rest of northern South America.

The faunal lists are arranged according to taxonomic order. The data on the abundance and the occurrence of the species are to be found in the description of the species and in the stratigraphic sections.

WESTERN MOUNTAIN FRONT

CHIMÚ SANDSTONE

This sandstone is here defined and named from Baños de Chimú, a well-known hot spring and settlement in the upper part of the Chicama Valley on the road from Trujillo to Sayapullo. The river cuts a narrow, steep-walled gorge across this formation. The type section was measured from a point 250

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FIG. 4. Cretaceous system in the western mountain front.

The Chimú sandstone comprises 685 meters of very thick-bedded, massive, hard, well-cross-bedded, fine to medium-grained, well-sorted, very clean, white to light gray quartz-sandstone. The exposed surfaces are mainly light reddish brown to light gray. It contains in subordinate proportions (less than one-tenth) plant-bearing carbonaceous shales and also beds of coal which are being mined.

The base of the quartz-sandstone sequence downstream from the hot springs is 400 meters upstream from the same point. In some detail in the Chimú area have been studied carbonaceous shales and also beds of coal which have been studied by Steenbeck (1974). In the type section, a 30-meter-thick bed of sub-anthracitic coal is 200 meters above the base. At the top, there is a 30-meter bed of apple green, hard, clayey, tuffaceous siltstone.

There are six coal beds in Callacuyan, two of which are being mined.

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There are six coal beds in Callacuyan, two of which are being mined.
rests disconformably on the soft, dark gray to black, varicolored shales, tuffs, and sandstones of the "Chicama beds." The lithic break is very distinct and is conspicuously reflected in the topography (pl. 31, fig. 2). The upper boundary of the Chimú sandstone is above the last, massive, thick-bedded quartz-sandstone bed. It is also well shown in the topography, for the overlying shales and limestones of the Santa formation, defined in this paper, are very soft, friable, and weather out very easily, so that the top of the Chimú sandstone is almost always exposed (pl. 32, figs. 1, 2). As a whole, the Chimú sandstone stands out in the topography, making up craggy ridges, conspicuous dip slopes, or deep gorges. If the beds have high dips, it makes tremendous cliffs. Stappenbeck (1929, p. 9) first recognized this formation and referred to it as the "lower coal-bearing quartzites of the Wealdian."

The Chimú sandstone has been observed by the writer along the Cordillera Occidental from the Jequetepeque River on the north to Huaraz on the south. Eastward, it is absent along the Marañón River (Celendín and Crisnejas sections). Whether the disappearance is by overlap or erosion is not known, but both factors seem to be involved. Its western extensions and relationships are unknown.

The Chimú sandstone forms the core of the Chimú, Cepo (pl. 32, fig. 1), Colmillo, Quepayoc, and Callacuyan anticlines in the upper Chicama Valley, and the core of the Santa anticline (pl. 32, fig. 2), in the Callejón de Huaylas. It also outcrops repeatedly along the Pumca and Sihuas rivers, between the Cordillera Blanca and the Marañón River.

The Chimú sandstone rests disconformably on the marine Chicama beds from which a Portlandian (upper Jurassic) fauna has been described (Welter, 1913). A determined search in the uppermost beds of the sequence failed to produce any fossils, and therefore they cannot be dated with certainty. However, it is very likely that they are also Portlandian, as assumed by Stappenbeck (1929, p. 7) and Welter. Disconformably overlying the Chimú sandstone is the late Valanginian Santa formation. The age of the Chimú sandstone, therefore, is within the post-Portlandian, pre-late Valanginian interval.

The Chimú sandstone has very regular bedding, cross-bedding of the angular type (pl. 33, fig. 1), and contains carbonaceous shales and allochthonous coal beds which seem to indicate subaqueous deposition. The sands are very clean and mature and show a high degree of sorting; the grains are frosted. They suggest some previous wind work and derivation from either a deeply weathered granitic terrain or, more likely, from an earlier sandy sediment.

The Chimú sandstone was deposited under conditions of tectonic quiescence, with no neighboring high lands.

**Santa Formation**

Stappenbeck (1929, p. 14) described the "middle shales" or "Pallares shales" as a group of shales with an average thickness of 500 meters, rarely up to 1000 meters, in the upper Chicama Valley, overlying his "lower quartzites of the Wealdian" (Chimú sandstone). Fifty meters above the base, he mentions a member of black limestone full of *Paraglaucania strombiformis* Schlotheim. The present writer finds that this "limestone with *Paraglaucania*" is dominantly marine and is separated by an unconformity from the upper non-marine shales. Therefore, he proposes to divide the "Pallares shales" of Stappenbeck into two new formations: the Santa and the Carhuaz formations (fig. 15). Because Stappenbeck did not designate a type section for his "Pallares shales" and because they are best exposed and developed in the Callejón de Huaylas, the Carhuaz section (fig. 20), just northwest of Carhuaz, is selected as the type location of these two new formations (pl. 32, fig. 2).

In the Callejón de Huaylas, between Pariahuanca and Carhuaz, the Santa River flows through the axis of a south-plunging anticline. The core of this anticline is Chimú sandstone. Overlying this sandstone are 341 meters of limestones and shales which are here named the Santa formation. The type section is on the eastern slope of Cerro Huallhua, 6 kilometers northwest of Carhuaz, on the western side of the Santa River, for which the formation is named.

The Santa formation is largely of dark gray, fossiliferous, medium-bedded, platy, concretionary limestone which is dolomitic in
places and is interbedded with a few thin beds of black, splinterly shale and chert. At the top is a 15-meter thick bed (bed 5 of the Carhuaz section) of dark gray, thick-bedded, massive, platy, grayish-blue-weathering limestone which stands out prominently as a ledge along the valley slope. Overlying this limestone are the softer shales of the Carhuaz formation. At the base of the Santa formation, there are soft, varicolored, finely splinter-shales which rest on the massive, ridge-forming, top ledge of the Chimú sandstone (pl. 32, fig. 2).

Steinmann (1930, p. 111) studied this formation in this area and referred to it as the "lower limestones of the Barremian" (fig. 15).

The known geographic distribution of the Santa formation is similar to that of the Chimú sandstone. In the upper Chicama Valley, this formation has in the lower part 115 meters of Trigonia-bearing shales and silts, and in the upper part, 65 meters of brown to black, yellowish-weathering limestone, including at the top a limestone intraformational conglomerate which marks the upper boundary of the Santa formation.

In Callacuyán, the formation is 284 meters thick and includes mostly fossiliferous shales and silts; the limestones are reduced to the upper 35 meters. It was here mistaken by Stappenbeck (1929, fig. 3) as belonging to the Jurassic "Chicama beds." In Pomachaca, it is only 83 meters thick; the lower 25 meters are of sandstones and siltstones and the upper 58 meters are of black, grayish-black-weathering, medium-bedded, platy, hard, Paraglauconia-bearing limestone with few cherty interbeds. This limestone becomes more argillaceous towards the top. In all these localities and in Sihuas, the Santa formation is thinner and less calcareous than in the Callejón de Huaylas area.

The most common fossils in this formation are Buchotrigonia gerthii Lissón, Buchotrigonia flexicosta Fritzsche, Buchotrigonia inca Fritzsche, Paraglauconia studeri Villanova, and Paraglauconia strombiformis Schlotheim. The species of Trigonia are more abundant and dominant in the Callejón de Huaylas area. Dietrich (1938, p. 99) has suggested that the irregularity of the ribbing of these species may be due to the influence of fresh waters. The species of Paraglauconia, a brackish-water gastropod genus, are more abundant in the northern and eastern exposures of the Santa formation. The fauna is otherwise similar to that found in the lowest beds of the overlying Carhuaz formation and which is dated as late Valanginian. On the strength of this, it is considered that the Santa formation is Valanginian and not Barremian as thought by Steinmann.

The Santa formation represents a change from the non-marine conditions that prevailed during the deposition of the Chimú sandstone to a shallow marine to brackish-water environment. It records a marine overlap from the west. North and east of the Callejón de Huaylas area, the Santa formation becomes less calcareous, loses its marine faunas, and becomes thinner. It would seem that it was deposited in an embayment of the eastern shore of which abutted against Marañón land, somewhere along the position of the present Marañón River, and that it was also limited towards the north along the present Jequetepeque River.

**Carhuaz Formation**

Disconformably overlying the Santa formation are 1300 meters of non-marine to brackish, varicolored shales designated here as the Carhuaz formation. The type section was measured on the western side of the Santa Valley, beginning at a point 3 kilometers northwest of the town of Carhuaz, for which the formation is named; it overlaps the type section of the Santa formation (Carhuaz section; fig. 20; pl. 32, fig. 2). Steinmann (1930, p. 112) referred to this formation as the "intermediate beds of the Barremian," although in places he confused it with the Chimú sandstone. In the Santa anticline (Steinmann, 1930, fig. 124) he shows Neocomian sediments overlying younger Barremian beds. The Carhuaz formation forms the upper part of Stappenbeck's (1929, p. 14) "middle shales" or "Pallares shales," which he described in the upper Chicama Valley (fig. 15).

In the type section, the Carhuaz formation is dominantly of thin-bedded, soft, friable, brownish and purplish shales and silty shales interbedded with a few light gray to brownish, thin-bedded, and cross-bedded quartz-sandstones. Eighty meters above the base are two beds of gypsum, 5 meters thick each;
they can be traced throughout the Callejón de Huaylas. Between these gypsum beds and the base of the formation are richly fossiliferous, marine, gray limestones interbedded with shales. Above the gypsum the Carhuaz beds are largely of non-marine shales and quartz-sandstone with only occasional thin beds of dark brownish fossiliferous marine limestone. In the upper part, especially, are numerous green and purple tuffs. The shales in some places contain a rich fresh to brackish-water fauna with species Cyrena and Paraglauconia. The lower boundary is placed at the top of the massive, very compact, and thick-bedded Pariahuanca limestone. As a whole, the Carhuaz formation is softer than the limiting formations.

In the Cajamarca and Chicama areas, the Carhuaz formation is composed of the same type of very soft, friable, well-bedded, reddish, purplish, and yellowish shale with Paraglauconia and Cyrena, interbedded with white to brownish quartz-siltstone and cross-bedded quartz-sandstone. In these areas, no limestones with marine fossils are present; there are plant-bearing carbonaceous shales. The formation in 794 meters thick in the Chicama section; it overlies an unconformity marked by limestone intraformational conglomerate on top of the Santa formation. It is succeeded by the Goyllarisquisga formation.

The Carhuaz formation, from the type area, intertongues towards the east with the sandy Goyllarisquisga formation. In the Cajamarca and Chicama areas, it grades into and is also overlain by the Goyllarisquisga (fig. 8).

From the lowest beds, in the type locality, the following fossils were collected: Valanginites broggi Lissón, Buchotrigonia gerthii Lissón, Buchotrigonia flexicostata Fritzsch, Buchotrigonia inca Fritzsch, Cucullaea gabrielis Leymerie, and several specifically undeterminable olcostephanid ammonites. Oysters are found 400 meters above the base. Elsewhere, Cyrena huarasensis Fritzsch, Paraglauconia studeri, and Paraglauconia strombiformis are the most common fossils. The plant remains are similar to those of the Chimú and Goyllarisquisga formations. Valanginites broggi indicates a late Valanginian or, less probably, an early Hauterivian age. The overlying Pariahuanca formation is considered early Albian. With these data, in the type area, the Carhuaz formation is assigned to the late Valanginian-Aptian interval. In the Chicama and Cajamarca areas, where it is overlain by the Goyllarisquisga formation, it obviously represents the earlier part of this span.

After the deposition of the Santa formation, there was a withdrawal of the sea. Marine sedimentation continued only on a small scale in the Callejón de Huaylas area for a short time, at the end of which there was restriction of marine conditions and deposition of gypsum beds which were succeeded by non-marine shales and sandstones. Occasionally, the sea would invade this area, leaving thin beds of fossiliferous limestone.

**Pariahuanca Limestone**

In the Callejón de Huaylas area, the Carhuaz formation is overlain disconformably by 95 meters of massive, ridge-forming, thick-bedded, fossiliferous, medium gray, light gray weathering, strongly petroliferous limestone which is named after the town of Pariahuanca, on the eastern side of the Santa River. The type section (Pariahuanca section) is 400 meters due north of Pariahuanca, on the north side of the stream that flows near this village. The Pariahuanca limestone is exposed on both limbs of a tight syncline parallel to the Santa anticline, the measured section being on the eastern limb of the syncline. Steinmann studied this locality as well as others along the Callejón de Huaylas, and referred to the Pariahuanca limestone as the “Caprotina limestone” or as the “upper limestone of the Barremian” (fig. 15).

The contact with the underlying softer, dark purple and green shales and silty shales of the Carhuaz formation is well marked and reflected in the topography. The upper boundary is marked by the end of the massive, medium gray limestones on which are resting the soft, nodular, thin-bedded, brownish gray marls and limestones of the Chulec formation.

Some beds of the Pariahuanca limestone have abundant rudistid fragments, among which Fritzsch (1924) identified Requienia ammonia Goldfuss and Agris blumenbachii Studer. In addition, there are miliolid foraminifers, and on the weathered surfaces it is
possible to see sections of large gastropods (Nerinea) and pelecypods. From bed 4 (Pariahuanca section) a single large, poorly preserved specimen of Parahoplites sp. was collected.

On the basis of the rudistids, and considering the overlying Chulec formation as Aptian, Steinmann assigned the Pariahuanca limestone to the late Barremian. The present writer assigns it to the early Albian, based on the following evidence:

1. It contains Parahoplites, an Aptian–early Albian ammonite genus.
2. It is overlain by the Chulec formation which is now considered to be, in this locality, early middle Albian (Knemiceras raimondii zone).
3. It is in the same stratigraphic position as the early Albian (Parahoplites nicholsoni zone) Inca formation of northern Peru.

The Pariahuanca limestone has been studied only in the Callejón de Huaylas area. Steinmann (1930) reports it in Huallanca, 50 kilometers southeast of the type section. In Pomachaca, east of the Cordillera Blanca, it is absent by change of facies. It has graded into the marls and nodular argillaceous limestones that compose the lower part of the Chulec formation in this locality. Northward, following the strike of the Andes, it is replaced, in the Chicama and Cajamarca areas, by the Inca formation.

The upper beds of the Carhuaz formation show already the approach of marine conditions, and the Pariahuanca limestone signifies the full advance of a shallow sea.

**CENTRAL WESTERN ANDES**

Several formations were described first by McLaughlin (1924) in the central Peruvian Andes. The present writer did not visit the type localities of these formations, but studied them in Pomachaca, north of Cerro de Pasco, and from there northward. Except for the Jumasha formation, they extend without major changes as far north as Chota, the northernmost point studied by the writer. Farther north, information is wanting.

**GOYLLARISQUISGA FORMATION**

McLaughlin (1924, p. 605) defined the “thick formation of sandstones and shales with which the coal of the Peruvian Cordillera is associated” between the Liassic Pucará limestone and the Chulec member of the Machay limestones as the “Goyllarisquisga-Jatunhua sandstone.” He mentioned Goyllarisquisga, in central Peru, as the type area. Recently, Jenks (1951, p. 211) has appropriately proposed to emend the name to “Goyllarisquisga formation” which is the term that is used in this paper.

In the type area, these authors describe the formation as red shaly sandstone with associated quartz pebble conglomerates resting disconformably on the channeled Pucará limestone. McLaughlin (1924, p. 605) says: “The rock is generally composed of white quartz sands, medium grained for the most part, but with some thin beds with quartz and chert pebbles coarse enough to allow the rock to be considered a conglomerate. Thick beds of red and black shale occur intercalated with the sandstones at several horizons. Basalt flows or diabase sills are also fairly common members of this formation.”

J. V. Harrison, in his various publications on the central Peruvian Andes, refers to this formation (1943, p. 9) as the “Lower Cretaceous Sandstone Series . . . beds of rusty-coloured sandstones [which] alternate with conglomerates, shales and sandstones carrying ironstone concretions.” In the upper Chicama Valley, already in the northern Andes, Stappenbeck (1929, p. 15) distinguished this formation as the “upper quartzite with shales,” which he named “Farrat quartzite.”

Recently, Tafur (1950, p. 15) defined in Cajamarca the “Llacanora formation” including two members: the lower argillaceous (the upper part of Stappenbeck’s Pallares shales), described here as the Carhuazu formation, and the upper “sandy and quartzitic” (Stappenbeck’s Farrat quartzite), described here under the older and well-established name of Goyllarisquisga formation.

Outcrops of this formation extend throughout the Cordillera Occidental in both central and northern Peru. Where the Crisnejas
River discharges into the Marañón River (fig. 19), it rests disconformably on the gently channeled Triassic Uliachfn formation (pl. 31, fig. 1) and is 666 meters of white to reddish, coarse-grained, pebbly, cross-bedded, lenticular, medium- to thick-bedded, reddish-brown-weathering quartz-sandstone. The quartz grains are subrounded and more or less well sorted. It is overlain disconformably by marine shales and marls of the Crisnejas formation, containing in the lowest beds *Parengonoceras pernodosum* and other early medial Albian fossils.

Also in the Marañón Valley, in Balsas, east of Celendín (fig. 16), the Goyllarisquisga formation disconformably overlies thick-bedded, medium gray limestones which are very much like those described by Steinmann (1930, p. 68) in the Utcubamba Valley farther east, and which he considered to be Liassic. In Balsas, at the base of the Goyllarisquisga formation is a 40-meter thick basal conglome-
rate composed of subrounded ill-assorted pebbles and cobbles up to 20 centimeters in diameter of limestone like that of the underlying Liassic beds, embedded in a very calcareous, chocolate-red, quartz-sandstone matrix. The bulk of the formation is a thick-bedded, white to gray, very clean, coarse-grained to pebbly, yellowish-brown-weathering in quartz-sandstone with several thin carbonaceous shale interbeds. It is overlain by the marls and shales of the Crisnejas formation, containing in the lower beds species of *Knemiceras* and *Parenemoceras* of early Albian (*Knemiceras raimondii* zone) age. This section is very similar to that described by Kummel (1950, p. 259) for Leimibamba, 60 kilometers farther east.

Around Cajamarca (pl. 36, fig. 2), the Goyllarisquisga formation lies conformably on the Carhuaz formation; it is 578 meters thick, the lower 400 meters being almost entirely of white to reddish white, medium- to thick-bedded, medium- to coarse-grained, massive, ridge-forming, brown-weathering quartz-sandstone (pl. 34, figs. 1, 2). The upper 178 meters are the same type of sandstone but interbedded with increasingly larger proportions of purple, yellowish, and reddish, finely bedded shales which bear poorly preserved plant remains. The top is distinctly marked at the base of a limestone basal conglomerate of the early Albian Inca formation, equivalent of the Pariahuanca limestone of the Callejón de Huaylas area.

The Cajamarca formation was also studied in Chota (Lajas section), Hualgayoc (Hualgayoc section), and in the upper Chicama River (Sunchubamba section); in the last place, it is 469 meters thick. In all these localities, it has the same relationships and characteristics as in the Cajamarca section; it is between the Carhuaz and the Inca formations, and the rocks are less coarse grained than in the sections along the Marañón River.

Near the coast, in the lower part of the Jequetepéque River (Tembladera section, fig. 18), only the upper 592 meters of the Goyllarisquisga formation are exposed: they are of brownish and greenish, medium- to thick-bedded, fine- to medium-grained sandstones interbedded with slaty carbonaceous shales. In the upper part are 25 meters of thinly interbedded, brick-red quartz-siltstone and shale which are then overlain by heavy ledges of dark gray limestone which is assumed to be the equivalent of the Pariahuanca limestone and of the Inca formation.

In Chocofán, between San Pedro and Paucasmayo on the Pacific coast, the Goyllarisquisga formation is composed of white to yellowish brown siltstone and quartz-sandstone overlying disconformably a thick sequence of dark purple and black volcanic agglomerates and basaltic lava flows. These volcanic rocks cannot be dated with the standard methods, but it is assumed, on a lithic basis, that the Chimú sandstone and the Santa formation are missing and that the volcanics are of Jurassic age.

Other extensive areas of outcrop of the Goyllarisquisga formation have been found between Cajabamba and Huamachuco, and southward in the Sihuas and Pushca (Pomachaca section) rivers; in the last locality, it is 732 meters thick.

The Goyllarisquisga formation is a lithic unit with coarser-grained rocks on the east and finer-grained on the west. Along the Marañón River it is almost exclusively of quartz-sandstone and pebbly sandstone. Westward, the rocks become finer grained and intertongue with the shales and quartz-siltstones of the Carhuaz formation (fig. 8). In the Callejón de Huaylas area, the Goyllarisquisga is absent by change of facies into the Carhuaz. In the northern Andes, the change is not complete; the lower beds of the Goyllarisquisga intertongue with the Carhuaz formation and the upper beds overlie this formation.

The Goyllarisquisga and the Carhuaz formations lie on a regional unconformity. They rest on Triassic (Crisnejas section), lower Jurassic (Celendín, Utcubamba, Yaulí, and Cerro de Pasco sections), upper Jurassic (Chocofán section), and on earlier Cretaceous sediments (Sunchubamba, Pomachaca, Callacuyan, and Carhuaz sections).

The Goyllarisquisga formation is overlain, with transgressive relationships by the early Albian Inca formation in the northern western Andes, by the medial Albian Crisnejas formation along the Marañón River, and by the Chulec formation in the central Andes. The last formation is earliest Albian-early medial Albian in Pomachaca, but elsewhere it is early medial Albian. In general, towards the east the Goyllarisquisga forma-
tion is covered by progressively younger marine beds.

The Goyllarisquisga formation has in places coal beds and carbonaceous shales that carry plant remains similar to those of the earlier Chimú sandstone.

The Goyllarisquisga and Carhuaz formations are almost entirely non-marine. In the Callejón de Huaylas, marine tongues are present in the Carhuaz formation and indicate interfingering with marine sediments to be expected farther west. They are certainly present in the Lima area, although their stratigraphy is poorly known. Also, the presence of volcanic rocks in the Carhuaz formation in this area indicates that there were volcanic sources towards the west. Eastward, Marañónia was a land of low relief and coastal swamps. After the deposition of the marine to brackish Santa formation, the sea withdrew and in places was restricted; an unconformity was developed and non-marine sedimentation was initiated. Gypsum beds are found in the Santa Valley and intraformational conglomerates in the upper Chicama Valley. Towards the east the Goyllarisquisga is found on channelled Triassic and Jurassic rocks. In its upper part, the Goyllarisquisga formation is transgressive in nature; its upper boundary moves in time, including younger beds as it moves eastward.

The presence of quartz pebbles in the Goyllarisquisga formation was interpreted by Harrison (1943, p. 31) as "evidences of corrugation not far away," but the present writer believes, instead, that the Goyllarisquisga formation, as well as the underlying Chimú and Santa formations, was deposited under quiet tectonic conditions, and that the quartz pebbles and sands had their origin in the metamorphic rocks exposed in the core of Marañonía or in those of the Brazilian craton.

Apparently the Amotape Mountains area stood high during all this time, and the Goyllarisquisga equivalents are missing there. Whether it stood high as islands or was part of larger lands has as yet to be worked out.

**CHULEC FORMATION**

The following is a translation of the description of a section measured by Steinmann (in Schlagintweit, 1912, p. 48) along the Oroya Railroad in the neighborhood of Oroya and Pariatambo in central Peru (see also Steinmann, 1930, fig. 155).

"**TURONIAN (?)** **SENONIAN (?)**

12. Marl, sandy, crumbly, with yellow dolomite beds. Turonian (?) Cenomanian (?) Vraconian (?)

11. Limestone, marly, poor in fossils, bearing *Ostrea* and *Gerovilia* at the base . . . . . . . . . . . . ca. 500 m.

**VRACONIAN**

10. Limestone, dark, cherty . . . . . . . . . 50

9. Marl, black, with limestone beds . . . 30–40

8. Limestone, dark, thick-bedded, with *Schloenbachia acutocarinata* . . . . . 10–15

7. Beds with silicified fossils . . . . 1–15

6. Limestone, compact, dark . . . . . . . . . . 10

**LOWER GAULT**

5. Limestone, marly, with fossils of the lower Gault . . . . . . . . . . 50"

The fossil fauna from this locality had been made famous before by Gabb (1877), Steinmann (1881), and Gerhardt (1897a).

It was McLaughlin (1924, p. 608), however, who defined formally the Machay formation composed of the Chulec (unit 5
of Steinmann's section) and Pariatambo (units 7 to 10 of the same section) members. As Steinmann pointed out (1930, p. 135), the lithic and faunal differences between the two members are very well marked, and he discussed both "members" separately under the headings of "Aptian" and "Albian," respectively. In the present paper, the Chulec and Pariatambo members are given the rank of formations, and Pariatambo near Oroya is considered as the type area.

McLaughlin (1924, p. 608) described the Chulec "member" as: "thin bedded, light gray limestone, weathering white with minor beds of sandy shale. It contains abundant fossils indicative of Aptian age," and lies between the Goyllarisquisga and the Pariatambo formations.

This formation is extensively developed in the Cordillera Occidental of central and northern Peru. A section similar to that described by McLaughlin and Steinmann in central Peru was studied by the present writer in Pomachaca, farther to the north, where, disconformably overlying the quartz-sandstones of the Goyllarisquisga formation and below the dark, bituminous limestones and marls of the Pariatambo formation, are 100 meters of very fossiliferous, light gray to light brownish gray marls and argillaceous limestones, with a few massive interbeds of dark gray limestone. From the lowest beds *Parahoplites* sp. was collected, and in the middle and upper parts *Douvilleiceras monile* and several species of *Knemiceras* are abundant.

West of Pomachaca, in the Callejón de Huaylas area (Pariahuanca section, fig. 20), the Chulec formation has thinned down to 25 meters of nodular, thin-bedded, yellowish marls and marly limestones, with *Douvilleiceras monile*. The thinning is due to convergence and also to change of facies of the lower part into the massive, dark gray, thick-bedded, rudistid-bearing Pariahuanca limestone.

Farther north, in Sihuas, this formation is represented by about 200 meters of very fossiliferous, light yellowish and brownish gray soft marls and clayey limestones, the lower part being more argillaceous and, as a whole, the marls being more prevalent. *Douvilleiceras monile* was found in the lowest beds and species of *Knemiceras*, *Prolyelliceras*, *Brancoceras*, and *Parengonoceras* are distributed all through the sequence.

In the upper Chicama Valley the Chulec formation is 250 meters of fossiliferous, light gray marls interbedded with a few massive gray limestones containing *Douvilleiceras* and *Knemiceras*. Again, in the Cajamarca area, it has the unusual thickness of 525 meters; the lower part is of yellowish and brownish, splintery, fossiliferous marls interbedded with very massive, thick beds of fossiliferous, dark gray limestone. In the middle part, there are thick beds of splintery, soft, friable, fossiliferous, brownish shale interbedded with massive beds of *Exogyra*-studded limestone. The upper part is of thin-bedded, somewhat nodular, chalky-weathering, wavy-bedded marls and limestones. In this locality, the Chulec formation disconformably overlies the early Albian Inca formation and underlies the late medial Albian Pariatambo formation (pl. 33, fig. 2). It was studied here by Tafur (1950, p. 21) who named it "Santa Ursula formation."

The lower beds contain several species of *Knemiceras*, *Parengonoceras*, *Douvilleiceras*, *Lydilliceras*, *Prolyelliceras*, and *Protanisoceras* and numerous species of echinoids, gastropods, and pelecypods. Sections with similar stratigraphic relations, lithology, and paleontology have been studied in Polloc (Polloc section), Hualgayoc, where it is 363 meters thick, and in Lajas, where it is 504 meters thick.

The Chulec formation becomes noticeably more calcareous towards the west, and in Tembladera, near Pacasmayo on the Pacific coast, the marls and shales have disappeared and, instead, there are only thick-bedded, dark gray, poorly fossiliferous limestones. Eastward, the Chulec loses its limestone beds and grades into the shales and marls of the lower part of the Crisnejas formation (Celedín and Crisnejas sections).

In Pomachaca, where it lies directly on the Goyllarisquisga formation, the Chulec contains *Parahoplites*, an Aptian-lower Albian genus, in its lowest beds, and species of *Knemiceras*, *Douvilleiceras*, and *Prolyelliceras*, guides for the early medial Albian, in the middle and upper parts. Elsewhere, however, the Chulec formation rests either on the
Albian Pariahuanca limestone or on the equivalent Inca formation and contains only early medial Albian fossils. Everywhere, the Chulec is overlain by the late medial Albian Pariatambo formation. It is considered, therefore, that this formation began to be deposited in the early Albian, but that in most areas it is only early medial Albian.

The following is a list of the most common fossils of this formation:

**Cephalopoda**
- *Protanisoceras blanditi* (Pictet and Campiche)
- *Douvilleiceras monile* (Sowerby)
- *Parengonoceras pernodosum* (Sommermeier)
- *Parengonoceras guadaloupeforme* (Sommermeier)
- *Parengonoceras tetranodosum* (Lissón)
- *Parengonoceras haasi* (Sommermeier)
- *Parengonoceras guadaloupeforme tardum* (Sommermeier)
- *Parengonoceras meier* (Sommermeier)
- *Knemiceras triangulare* (Sommermeier)
- *Knemiceras gabbi* (Hyatt)
- *Knemiceras ovale* (Sommermeier)
- *Myopholas peruviana* (Olsson)
- *Buchotrigonia abrupta* (von Buch)
- *Buchotrigonia subenuulae* (von Buch, *B. coquandi* Lissón, and *B. orbignyi* Lissón)
- *Pterotrigonia locaimaana* (Lea) (= *P. suberenuulae* d’Orbigny)
- *Cardita subparallela* Gerhardt
- *Astarte debildiens* Gerhardt
- *Protocardiium elongatum* Gerhardt
- *Anatina silinensis* Richards

**Pelecypoda**
- *Cucullaea brevis* Gerhardt
- *Cucullaea gerharditii* Olsson
- *Modiolus mutissus* Olsson
- *Neithia morisi* Pictet and Renvier
- *Exogyra aquila* Brogniart
- *Exogyra minos* Coquand
- *Exogyra bousingaulti* d’Orbigny
- *Myopholas peruviana* Olsson
- *Yaadia hondaana* (Lea)
- *Bucholrigonia abrupta* (von Buch) (= *B. humboldi* von Buch, *B. coquandi* Lissón, and *B. orbignyi* Lissón)
- *Pterotrigonia locaimaana* (Lea) (= *P. suberenuulae* d’Orbigny)
- *Cardita subparallela* Gerhardt
- *Astarte debildiens* Gerhardt
- *Protocardiium elongatum* Gerhardt
- *Anatina silinensis* Richards

**Echinoidea**
- *Bothriopygas compressus* Gabb
- *Echinobrissus subquadratus* d’Orbigny
- *Holotyphus* (Coenholectypus) *planatus numis-malis* (Gabb)
- *Phymosoma texanum* Roemer

The Chulec formation is included within the zone of *Knemiceras raimondii*.

**Pariatambo Formation**

The Pariatambo “member” was defined by McLaughlin with type section near Oroya. In the present paper, it is raised to the rank of formation. Lithically the Pariatambo formation is of fossiliferous, platy, slabby, black, strongly bituminous marl and limestone, with some intercalations of chert and with large, discoidal, limestone concretions. In the type area, it is about 120 meters thick, rests disconformably on the early medial Albian Chulec formation, and is overlain by the Jumasha formation, also defined by McLaughlin.

A similar section was studied by the present writer in Pomachaca, east of Huari. Resting on the Chulec formation are 208 meters of black, brownish-weathering, medium-bedded, platy, concretionary, strongly bituminous marls and limestones overlain by the massive, hard, dense, thick-bedded dolomites and limestones of the Jumasha formation. The lower boundary is marked by the sudden appearance of the black, bituminous marls. Analogous sections have been studied in Pariahuanca and near Sihuas, although in these two places the upper beds and the overlying rocks have not been seen.

In northern Peru, it has been studied in the upper Chicama Valley (Sunchubamba and Huaycot sections) where it is 204 meters of black, laminated, fissile, concretionary, bituminous, and calcareous shale interbedded with platy, bituminous limestone, resting on the marls of the Chulec formation. The upper boundary, however, is not so sharp as it is in central Peru, for the Pariatambo formation grades quickly into the nodular, thick-bedded limestones and marls of the Yumagual formation. The same relations are present in the Cajamarca area, where it is 135 meters of very argillaceous, still strongly bituminous limestone, which, on weathering, gives a chalky appearance. It was studied here by Tafur (1950, p. 26) who named it the “Yacu-Ushco formation.” In Chota (Lajas section) it is 261 meters of very calcareous, massive, dense, black limestone. A similar section is found in Hualgayoc (pl. 35, fig. 1).

It is also present in the Amotape Moun-
tains, in northwestern Peru (Olsson, 1934), where it is known by the local name of Muerto limestone.

Towards the east, before reaching the Marañón River, the Pariatambo formation loses its bitumen content and grades into the yellowish and brownish limestones and marls of the upper part of the Crisnejas formation (fig. 8). In central Peru, Harrison (1943) does not find it east of Tarma.

Everywhere it is richly fossiliferous. The fossils are found especially in the large, discoidal concretions of dark, bituminous limestone (pl. 35, fig. 2) and are difficult to extract.

The most abundant fossils are:

Cephalopoda
Desmoceras latidorsatum (Michelin)
Oxytropidoceras carbonarium (Gabb)
Oxytropidoceras douglasi Knechtel
Vesuoloceras venezolanum (Stieler)
Venesoloceras harrisoni, new species
Diploceratoceras sp.
Branconoceras aegoceratoideus Steinmann
Lytelliceras lyelli (Leymerie) (d'Orbigny)
Lyelliceras pseudolyelli (Parona and Bonarelli)
Lyelliceras ulrichi Knechtel
Pelecypoda
Inoceramus concentricus Parker
Inoceramus salomonii d'Orbigny
Anomia sp.

Fish scales

Locally other mollusks are found. On the basis of these fossils, the Pariatambo can be assigned confidently to the middle of the medial Albian. It belongs to the zone of Oxytropidoceras carbonarium.

The Pariatambo formation is one of the most extensive and more uniform lithic units in the western Peruvian Andes. It represents the culmination of the marine overlap that began sometime during the Aptian. Even the Amatope Mountains, which stood before as lands, were covered by the Pariatambo Sea.

The shallow marine conditions in which the limestones and marls of the Chullec formation were laid changed to a deeper, quieter environment which was very favorable for the accumulation and preservation of quantities of organic matter.

During Pariatambo time, marine waters covered Marañonia and apparently reached the eastern geosyncline. West of the position of the present Marañón River, the waters were deeper than towards the east.

Jumasha Formation

The Jumasha formation was defined by McLaughlin (1924, p. 609) who gave as a type section "the cliffs above Jumasha, on Lake Punrum, in Central Peru." He indicated that the formation is a "uniform, light gray limestone, generally more massively bedded than the Machay beds... rests conformably on them... and... is overlain by red shales and sandstones of probably Tertiary age." Also, he adds, "an extensive fauna has been described and the formation is correlated with the Senonian of Europe."

The present writer has studied this formation in Pomachaca, where it is 800 meters of very massive, thick-bedded, light orange-brown to yellowish brown and gray dolomites and limestones which weather dark yellowish brown to brownish gray. It is overlain at this locality by shales and marls of the lower Senonian Celendín formation, to
Fig. 8. Restored sections of Cretaceous in the western Peruvian geosyncline at end of Pariatambo (middle of medial Albian) time.
The Cretaceous sediments of the western Andes in northern Peru (between Chota and Huamachuco) have an aggregate total thickness of 5000 meters. The lower third is dominantly of non-marine sediments, whereas the upper two-thirds is of very fossiliferous, calcareous rocks (fig. 10).

Several sections were studied in detail in this area, the most important being the "Cajamarca section" (fig. 17; pl. 36, fig. 2), studied also by Tafur (1950), which is taken as a standard section of reference. This section exposes 3600 meters, has most of the units in good outcrops, and offers the best possibilities of control. It lacks the lower part of the Cretaceous column, which was studied best in the upper Chicama Valley, as well as the uppermost strata of this system (Celendín and Chota formations), exposed best in Celendín.

Except for the Inca formation, all the formations to the top of the Pariatambo are the same in northern and central Peru, and are described above. After Pariatambo time, however, the stratigraphic behavior in northern Peru is markedly different from that already described for central Peru, for the post-Pariatambo sequence in northern Peru is much thicker, its sediments are more fossiliferous, and they reveal more variable conditions of deposition. All the post-Pariatambo formations except the topmost Celendín and Chota formations have their type localities as designated by Tafur in the Cajamarca section.

INCA FORMATION

This formation takes its name from Baños del Inca, a famous hot spring 6 kilometers east of Cajamarca. The type section is between Kilometers 7 and 8 of the automobile road from Cajamarca to Celendín, and is part of the "Cajamarca section" (pl. 33, fig. 2). The Inca formation is 90 meters of interbedded brownish gray, brown-weathering, oölitic, arenaceous, and ferruginous lime-
## Cretaceous System in Peru

### Stages and Zones

<table>
<thead>
<tr>
<th>Series</th>
<th>Stages</th>
<th>Zones</th>
<th>Cajamarca Section</th>
<th>Chicama Valley Sect.</th>
<th>Celendín Section</th>
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<td>Lenticeras Baltai</td>
<td>Otuzco</td>
<td>Celendín</td>
<td>Chota</td>
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<td>Santonian</td>
<td>Buchiceras Bilobatum</td>
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<td>Ceñamor</td>
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<td></td>
<td>Coniacian</td>
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<td>Cañamarca</td>
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<td>Coiloceras Newelli</td>
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<td>Exogyra Africana</td>
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<td>Oxytropidoceras Carbonarium</td>
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<td>Pariatambo</td>
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<td>Parahoplites Nicholsoni</td>
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<td>Valanginites Broggi</td>
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<td></td>
<td>Triassic</td>
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</tbody>
</table>

### Figure 10

Cretaceous system in the northern western Andes.
quartz-sandstones. They are exogyroids, trigonias, limestones and arenaceous, argillaceous, silty, oolithite limestone matrix.

Steinmann (1930, p. 119) referred to this formation in his discussion of the Peruvian “Aptian,” and similarly, Stappenberg discussed it as “unit 5” or “upper shales” of his Aptian sequence. Tafur (1950) has also studied this formation and named it “Capas Rojas” in the belief that it is of continental origin.

The lower boundary is placed at the base of this intraformational conglomerate which lies disconformably on the non-marine shales and sandstones of the Goyllarisquisga formation. The upper boundary is placed at the base of a very distinct ridge-forming ledge of dark gray, bluish-black-weathering, fossiliferous limestone that belongs to the Chulec formation.

In the upper reaches of the Chicama and Jequetepueque rivers (Sunchubamba and Huaycay sections) the Inca formation is about 150 meters thick. The limestones are arenaceous, bluish gray, and weather dark brownish to yellowish; if leached out, they leave excellent internal molds of pelecypods. The interbedded sandstones are very ferruginous; the shales are friable, yellowish and reddish, and yield a rich molluscan fauna in which trigonias are prevalent. The Inca formation has also been studied in the Chota area (Lajas section) where it is represented by dark gray, oolithite, arenaceous limestone (calcarenite) which weather to a characteristic rusty, brownish yellow color. These limestones contain spatangoid echinoids, trigonias, exogyroids, and echinoid spicules. They are interbedded with laminated, soft, friable shales bearing small spherical concretions of iron oxide and with dirty, ferruginous quartz-sandstones. The whole formation is more calcareous than in the Cajamarca or Chicama areas. It is slightly over 109 meters thick.

At the junction of the Cajamarca and Condebamba rivers (Tamberia section), the Inca formation rests disconformably on the shales and sands of the Goyllarisquisga formation, the contact being more or less gradational. It is 71 meters thick, mainly of red-purple to greenish shale and quartz-sandstone and a few ferruginous limestones which are packed with fossil mollusks.

The Inca formation is the basal deposit of the marine Albian transgression. Towards the east, it grades into the upper part of the Goyllarisquisga formation by loss of the calcareous and argillaceous beds. Along the Marañón River (Celendín and Crisnejas sections), the Goyllarisquisga is overlain directly by the Crisnejas formation which has early medial Albian fossils at its base. Westward, the Inca, as well as the overlying Chulec formation, becomes more calcareous and grades into massive, thick-bedded, unnamed limestones that lie on the Goyllarisquisga formation (Tembladera section). The Inca formation has the stratigraphic position of the Pariahuana limestone of the Callejón de Huaylas area.

The Inca formation is richly fossiliferous. The following fossils are found in it:

Cephalopoda
Desmoceras chimuense, new species
Parahoplites nicholsoni, new species
Parahoplites quilla, new species
Parahoplites inti, new species
Knemiceras illonense (Gabb)

Pelecypoda
Trigonoarca gerhardti Olsson
Cucullaea brevis d’Orbigny
Pterotrignita tocsimaana (Lea) (= P. subcenu-
latv d’Orbigny)
Yaadia hondoana (Lea) / Buchotrigonia abrupta (von Buch)
Ptychonia rotilinda d’Orbigny (= P. lissoni Sommermeier)
Corbis (Sphaera) corrugata Sowerby

Echinoidea
Enallaster peru anus (Gabb)
Arthropoda (unidentified)

The species of Parahoplites have early Albian affinities. On this basis, and because the overlying Chulec formation is medial Albian,
the Inca has been assigned to the early Albian. It is part of the zone of Parahoplites nicholsoni.

The Inca formation was deposited under shallow marine conditions. The abundance of individuals and the diversity of species and the presence of Lingula and of crabs indicate a near-shore environment.

PULLUICANA GROUP

The term “Pulluicana group” was given by Tafur (1950, p. 29) to embrace both the Pariatambo formation (called Yacu-Ushco by him) and that part of the succeeding sequence which has nodular, gray limestones and marls. He divided these nodular limestones and marls into the Yumagual formation below and the Mujarrún above. Because of the existence of an important unconformity on top of the Pariatambo formation, and because this formation represents the culmination of the Albian transgression, the present writer excludes the Pariatambo formation from the Pulluicana group (fig. 15).

The group was named after Pulluicana, a small village 7 kilometers northeast of Cajamarca. The type locality is within the Cajamarca section.

As a whole, the Pulluicana group is characterized by gray, light gray-weathering limestones and marls. The lower part (Yumagual formation) is more argillaceous and silty than the upper one (Mujarrún formation), and includes beds of quartz-sandstone and siltstone. The limestones and marls are peculiarly nodular, lumpy, or at least wavy-bedded (pl. 37, fig. 1), There are also some massive beds and throughout the group, especially in the more argillaceous and marly beds, are strata packed with exogyroids, oysters, and inocerami. Ammonites are very rare.

The Pulluicana group has been observed along the Cordillera Occidental from Huamachuco on the south to Chota on the north, and undoubtedly it continues farther north.

YUMAGUAL FORMATION

Tafur (1950, p. 29) named this formation after Cerro Yumagual, southwest of Cajamarca, although the type section is in the Cajamarca standard of reference.

A summary of the type section is:

**YUMAGUAL FORMATION**

<table>
<thead>
<tr>
<th><strong>Meters</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Limestones, very argillaceous, nodular, with interbeds of light brownish gray marl. Especially in the lower part, some beds are very close to being coquinas of Exogyra mermeti Coquand. In the upper part, Paraturritilites lewesiensis and Sharpeiceras occidentale are found</td>
</tr>
<tr>
<td>2. Limestone, light to medium gray, compact, nodular, thick-bedded. Some beds are filled with Ostrea scyphax and Inoceramus sp. At the base there is a cherty concretionary limestone</td>
</tr>
<tr>
<td>1. Marl and silty marl, nodular, brownish yellow to light brownish gray, chalky in places, with few beds of massive, nodular, dark gray limestone, and with some beds of yellowish, cross-bedded quartz-sandstone. It has Ostrea scyphax and other pelecypods. The lowest beds include strongly bituminous, platy limestones which contain Oxytropidoceras carbonarium</td>
</tr>
</tbody>
</table>

**TOTAL, YUMAGUAL FORMATION: 496 METERS**

The lower boundary is at the top of a ridge-forming, medium-bedded, platy, grayish black, silty limestone with thin interbeds of chert which in this locality is the last unit of the Pariatambo formation. The upper boundary is where the soft, friable, nodular marls and limestones of the Yumagual give way to the massive, thick-bedded limestones and dolomites of the Mujarrún formation.

Similar sections have been studied in Encaña (Polloc section), Hualgayoc, and Chota (Lajas section), being 538, 760, and 627 meters thick, respectively.

In the type section, two fossil zones are recognized within the Yumagual formation. The lower zone is marked by Ostrea scyphax; from the lowest beds Oxytropidoceras carbonarium has been collected. The upper zone is characterized by Exogyra mermeti and the ammonites Paraturritilites lewesiensis and Sharpeiceras occidentale. Oxytropidoceras carbonarium is a species of the middle of the medial Albian, abundant in the underlying Pariatambo formation, whereas Paraturritilites lewesiensis and Sharpeiceras occidentale are early Cenomanian. On this basis, the Yumagual formation is assigned to the interval
late nodular limestones. There are ammonites life; from the stones there emerged. And were in shallow-water area, beds red of the formation, within the central Rosa formation which becomes part of the Mujarrúa formation. After the deposition of the Pariatambo formation, there was shallowing of the seas, and Marañón emerged. In the Cajamarca area, shallow-water marls and limestones were deposited, and occasional quartz-siltstones from the southwest interbedded in the sequence. There was abundant benthonic life; ammonites were scarce.

Mujarrúa Formation

This formation takes its name from Cerro Mujarrúa, northeast of Cajamarca. The type locality is in the Cajamarca section. It comprises 370 meters of light to medium gray nodular limestones and marls lying between the Yumagual formation and the Quillquián group. The present writer divides it into two members.

Choro Member: It includes 300 meters of thick-bedded, light gray to medium gray, massive, dolomitic (in places), slightly nodular, wavy-bedded limestone interbedded with subordinate amounts of nodular marls and a few quartz-siltstones. All through the sequence, Exogyra cf. ponderosa Steinmann (non Exogyra ponderosa Roemer) is very abundant, and in the upper part Exogyra olisiponensis makes its first appearance. As compared with the other formations, the want of ammonites is striking. This member is very resistant to erosion.

The Choro member grades from the type section into more calcareous beds on the east and south and into more argillaceous units towards the west. In the Chota area (Lajas section) it is 211 meters thick, very argillaceous and very similar to the underlying Yumagual formation; the specimens of E. cf. ponderosa weather out easily from the argillaceous sediments and are found lying around in great numbers. In Hualgayoc it is 194 meters thick and contains chert nodules.

Culebra Member: It comprises 70 meters of light gray, chalky-weathering, nodular, very argillaceous marls and limestones much less resistant and calcareous than the underlying Choro member. It is succeeded by the Romirón formation of the Quillquián group. The marl beds are crowded with Exogyra africana Lamarck, Exogyra olisiponensis Sharpe, Exogyra polygona von Buch, Neithea tenouklenensis Coquand, Orthopsis titicacana Cooke, and a few specifically undeterminable acanthoceratid ammonites. The upper boundary is a coarsely nodular surface on which lie the soft shales and marls of the Romirón formation.

Similar sections have been studied in Encañada (Polloc section), where it is 86 meters thick and particularly well exposed; in Hualgayoc, where it is 68 meters thick; and in Lajas, where it is 76 meters thick. Eastward it becomes more calcareous and thick-bedded, and in the Crisnejías section it cannot be differentiated from the underlying Choro member.

The Mujarrúa formation is Cenomanian, lying between the late Albian-early Ceno-
manian Yumagal formation and the late Cenomanian Romirón formation.

Most of the fossils that Steinmann listed in his discussion of the Peruvian Cenomanian were collected from the Culebra member in the Pampa de la Culebra, northeast of Cajamarca.

**QUILLQUIÑAN GROUP**

Disconformably overlying the gray limestones and marls of the Mujarrán formation of the Pullucana group is a series of richly fossiliferous marls and shales which have been defined as the Quillquiñan formation within the Otuzco group (Tafur, 1950, p. 33). In the present paper, the Quillquiñan formation is raised to the rank of group comprising the new formations Romirón and Coñor, and the term Otuzco group is restricted to the overlying sequence (fig. 15). The type locality is within the Cajamarca section.

As a whole the Quillquiñan group consists of very soft shales and marls interbedded with few limestones which are rusty yellowish brown in the lower part (Romirón formation) and bluish gray in the upper one (Coñor formation). The rocks are so friable and soft, as compared with the overlying marls and limestones of the Otuzco group or the underlying marls and limestones of the Mujarrán formation, that the Quillquiñan group usually forms topographic saddles or troughs covered with soil. In the type locality, for instance, it is necessary to move along the strike to find good exposures and preserve the continuity of the section.

Stappenbeck (1929, p. 19) studied this group in Huacraruco, south of Cajamarca, and collected from it some fossils, among which Steinmann identified the Turonian genus *Vasoceras*. Later, Steinmann (1930, p. 146) tentatively described this group under the heading of “Turonian” and gave a good section which he had observed in Huafambrá, between Celendín and Sendamal. Tafur (1950) assigned this group to the Coniacian.

The present writer considers within this group two new formations: Romirón and Coñor.

**ROMIRÓN FORMATION**

This name is given to the 50 meters of yellowish and yellowish brown shales and marls which disconformably overlie the Culebra formation. They are interbedded with very few and thin, peculiarly rusty, yellowish brown, detrital, highly fossiliferous limestone beds. The formation is also characterized by the extraordinary abundance of fossils, especially of *Exogyra olisiponensis* Sharpe, which in places makes true coquinas. The lower boundary is at the coarsely nodular surface at the top of the Mujarrán formation. The upper boundary is at the base of the first massive bed of bluish gray limestone of the Coñor formation. The term was taken from Cerro Romirón, 8 kilometers northeast of Cajamarca.

The best exposures of the Romirón formation are along the Cajamarca to Celendín automobile road, between Kilometers 29 and 30, on both limbs of the Sangal syncline (pl. 35, fig. 1), where it is 50 meters thick and has the same features as in the standard section. It is 72 meters thick in Hualgayoc and 162 meters thick in Lajas. In these two places the Romirón is very argillaceous, and there are beds of coquina of *Exogyra olisiponensis* Sharpe. In 1802, Humboldt collected *Exogyra polygona* from the outcrops of this formation in Montán, near Lajas. In Celendín, the Romirón formation is 71 meters thick and also extraordinarily fossiliferous, but the exogyras are exceeded in numbers of individuals by several species of cephalopods. Along the Marañón River, in the Crisnejas section, it is only 45 meters thick, very calcareous, with a striking scarcity of fossils as compared with the sections towards the west, and is overlain directly by the Cajamarca formation. It is also present in the upper Chicama Valley, but no thickness nor details can be given because it is covered with soil and vegetation. Southward exposures are not known.

The fossils collected from this formation are:

*Cephalopoda*

- *Lissoniceras mermeti* (Coquand)
- *Forbesiceras* sp.
- *Acanthoceras chasca*, new species
- *Acanthoceras sangalense*, new species
- *Acanthoceras pollicense*, new species
- *Neolobites humpelii*, new species

*Pelecypoda*

- *Mytilus* sp.
- *Neithia alatus* von Buch
Prominent near syncline, the yellowish Cajamarca Romir6n underlaming calcareous limestone. The formation is excellently exposed along the Cajamarca to Celendín road, in the Sangal syncline, near Encañada (pl. 36, fig. 1), where a prominent massive unit of dark gray limestone 48 meters thick is overlain by 100 meters of marl and fossiliferous shale. In Hualgayoc, the Coñor is 90 meters thick, including in the lower part 27 meters of light gray limestone with very few marl interbeds, which is overlain by nodular bluish marls. Farther west, in Lajas, the formation is about 200 meters thick, noticeably more argillaceous, and with fewer and thinner beds of massive gray limestone than in the sections of Cajamarca, Polloc, or Hualgayoc. In Tembladera (fig. 18), near the Pacific coast, the Quillquiñan group is so argillaceous throughout that the two formations Romirón and Coñor cannot be differentiated, although the faunal differences carry on. Towards the east, in the Crisnejas section, the Coñor is no longer present; apparently, it has become so calcareous and thick-bedded as to become the lower part of the Cajamarca formation.

The Coñor formation contains the following fossils:

**Cephalopoda**
- *Mommites nodosoides* after Pervinquiére
- *Pseudoaspidoceras reesidei*, new species
- *Thomasis fischeri*, new species
- *Hoplitoidea inca*, new species

**Pelecypoda**
- *Inoceramus labiatus* Schlotheim
- *Inoceramus sp.*
- *Plicatula gurtiiis* Coquand
- *Plicatula reynesi* Coquand
- *Corbula peruana* Gabb

**Echinoidea**
- *Homaster fourneli* Deshayes

The ammonites are early Turonian.

The conditions of deposition were similar to those under which the Romirón was laid. The Coñor records the deepening of waters, with diminution of faunas and increase in calcareous materials, changing from the shales of the Romirón into the lithographic limestones of the overlying Cajamarca formation.

**OTUZCO GROUP**

Disconformably overlying the Quillquiñan group, Tafur (1950, p. 35) defined the “Otuzco formation,” which is here raised to the rank of group including two new formations: Cajamarca (Steinmann’s *Actaeonella* limestone) and Celendín (Steinmann’s “marls
and light colored limestones with the rich fauna of Otuzco, Cajamarca"; Steinmann, 1930). Tafur’s Otuzco group is suppressed (fig. 15).

**Cajamarca Formation**

One of the most conspicuous, uniform, and extensively spread lithic units in northern Peru is the Cajamarca formation, the limestones and marls lying disconformably on the Coñor formation and below the Celendín formation. It is named after the town of Cajamarca, in northern Peru, near which is the standard section of reference for most of the Peruvian Cretaceous; the type is in this section, between Cerro Mujarrún and Quebrada Otuzco.

Three types of lithologies are conspicuous constituents of the Cajamarca formation:

A. Limestone, dark gray to brownish and bluish gray, dense, lithographic, massive, thick-bedded, slabby, bearing Foraminifera and large gastropods. It produces a characteristic lapiez, karstic topography and weathers light bluish gray.

B. Limestone, medium gray, made of comminuted shell debris, thick-bedded, massive, slightly less resistant than the preceding type, whitish-weathering.

C. Marl, bluish or greenish white, nodular, containing in the more shaly and argillaceous parts a varied molluscan fauna.

The first type of lithology is dominant, and in places it seems to be the only one present. The lower boundary is at the base of the continuous sequence of massive, thick-bedded, blue-gray limestones that rest on the soft marls and argillaceous limestones of the Coñor formation. The upper boundary is more distinct, for it is at the top of the massive limestones and base of the yellowish, soft, friable, richly fossiliferous shales of the Celendín formation. The Cajamarca formation stands out in the topography of northern Peru in prominent ridges and peaks.

In the standard section, the Cajamarca formation is 528 meters thick; 200 meters below the top is a 15-meter bed of shale and marl from which *Coïlopoceras newelli*, *Cardium lissoni* Brüggen, *Inoceramus peruanus* Brüggen, *Hemiaster fourneli* Deshayes, and *Cyphosoma peruanum* Brüggen were collected. This thin bed of very fossiliferous shale has been found also in the Polloc, Hualgayoc, and Bambamarca sections. In the first locality, the formation is 720 meters thick and excellently exposed. It is 540 meters thick in Hualgayoc (pl. 37, fig. 2), and 316 meters thick in Celendín. In Lajas (pl. 38, fig. 1), it is only 211 meters thick; the upper part has been cut by an unconformity above which are coarse clastics of the Chota formation (fig. 12). In Crisnejas, along the Marañón River, it is around 500 meters thick, has taken a dark yellowish brown color, and rests directly on the Romirón formation; apparently it includes in its lower part the time equivalents of the Coñor formation.

Farther south, it has been studied in Santa Clara, between Sihuas and the Marañón River, where it is about 800 meters of dark bluish gray, thick-bedded limestone with very few marly beds, and making very distinct ridges in the high Andes. Probably it rests disconformably on the Rosa formation; the contact could not be seen, and there is possibility of some structural complication. It is suspected that the Cajamarca formation in this locality includes the time equivalents of the Mujarrún, Romirón, and Coñor formations. It is overlain by the Celendín formation.

Finally, going farther south, the formation takes on a pale yellowish brown or dark yellowish orange color, acquires dolomitic beds in increasing proportions, loses its argillaceous beds, and grades into the Jumasha formation of central Peru. At the same time it incorporates earlier beds. In Pomachaca the change into the Jumasha has been complete; it can no longer be distinguished as Cajamarca formation.

The limestones of the Cajamarca formation contain scanty remains of Foraminifera and gastropods among which Steinmann identified *Actaeonella* sp. In the few shaly, argillaceous beds is a rich fauna characterized by *Coïlopoceras newelli*, new species, *Inoceramus peruanus* Brüggen, *Cyphosoma peruanum* and *Hemiaster fourneli* Deshayes.

Steinmann assigned a Senonian age to this formation, although he also hinted that the lower part might be Turonian. The present writer prefers to assign it, in the standard
section, to the late Turonian on the following data:

A. It contains *Coilopoceras*, elsewhere a Turonian genus.

B. It underlies the Celendín formation which is earliest Coniacian (*Buchiceras bilobatum* zone) in its lowest beds.

Southward, it gains earlier beds and grades into the late Albian-Turonian Jumasha formation of central Peru.

The Cajamarca formation represents the last important deepening of the seas in the northern Peruvian Andes. The sea apparently transgressed from the south and west, depositing fine, lithographic limestones. It seems that Marañonía was inactive.

**Celendín Formation**

This formation is named after the town of Celendín, northeast of Cajamarca. The type section (part of the Celendín section; fig. 16) is in the Meléndez Creek, 6 kilometers northwest of Celendín, 500 meters north of Hacienda La Quinua. The massive, thick-bedded, blue-gray limestones of the Cajamarca formation are succeeded conformably by 255 meters of very soft, yellow, friable, richly fossiliferous shales interbedded with few limestones which are defined as the Celendín formation. The upper boundary is at the top of the yellow marine shales and the base of the coarse, non-marine red sandstone of the Chota formation. Eighty-nine meters above the base is a 60-meter bed of light brownish gray, massive, somewhat nodular limestone which bears alveolinellid Foraminifera. Below this limestone, the shales contain a rich molluscan fauna in which the ammonite genera *Buchiceras*, *Heterotissotia*, *Tissotia*, and *Barroisiceras* are prevalent. Above the limestone, the shales contain a different and less diversified fauna characterized by the genera *Lenticeras*, *Texanites*, *Desmophyllites*, and *Tissotia*.

In the Cajamarca section only part of the formation is exposed in the badly deformed trough of the Otuzco syncline. Steinmann (1930, p. 156) referred to it as the "upper horizon" of his "Senonian" and described a small part of the section upside down, for he did not realize the local overturning of the beds.

In Bambamarca, the Celendín formation is 345 meters thick and very well exposed. The lower contact with the Cajamarca formation is well marked, and the top is overlain by over 500 meters of red-bed conglomerates of the Chota formation. Most of the formation is of shales and marls. The distribution of fossils is as in the type section. Farther west, in the Lajas section, the Celendín formation is cut out by an unconformity; the Chota conglomerates lie directly on the Cajamarca formation. In the Polloc section, the lower part of the Celendín formation is well exposed and also very fossiliferous. Southward, in the Rupac River west of Sihuas (Santa Clara section), it is 591 meters thick and is more calcareous and less fossiliferous than in northern Peru. The fossils found are those that characterize the upper part of the formation in the Cajamarca and Celendín areas. It is overlain by a thick sequence of red shales and sandstones of the Chota formation. Steinmann (1930) studied this locality and referred to part of the Celendín formation as the "yellow, very fossiliferous, sandy marls of Santa Clara."

Farther south, it has been found along the Pushca River (Uchupata section) overlying massive, thick-bedded limestones and dolomites of the Jumasha formation. It is 100 meters thick, poorly fossiliferous, light greenish gray, somewhat silty, and is overlain disconformably by gypsumiferous red beds of the Chota formation.

It is likely that it is represented also in the central Andes. Steinmann's "unit 12" in his Oroya section is in the right stratigraphic position, and his description corresponds to that of the Celendín formation. He also described a similar section in La Quinua, near Cerro de Pasco (Steinmann, 1930, p. 156). Moreover, Paukcke (1903) described an early Senonian fauna from this last locality and from Charata, between Oroya and Tarma.

The Celendín formation is found only in a few places preserved in the troughs of synclines or in downfaulted blocks. It resembles the Romirón formation strikingly in the lithologies, topographic expression, and in the abundance of fossils, although the last are entirely different. It is the most fossiliferous formation in northern Peru.

Two fossil zones are considered within the Celendín formation: the zone of *Buchiceras*...
**BENAVIDES: CRETACEOUS SYSTEM IN PERU**

**bilobatum** (beds 69 to 72 of the type section) and the zone of *Lenticeras baltai* (bed 73 of the type section).

The zone of *Buchiceras bilobatum* contains:

**Cephalopoda**
- *Barroisiceras* (Barroisiceras) *haberfellneri* von Hauer
- *Barroisiceras* (Barroisiceras) *kayi*, new species
- *Barroisiceras* (Solgerites) *branoci* Solger
- *Barroisiceras* (Forresteria) bassae, new species
- *Barroisiceras* (Forresteria) *alluaudi* Boule, Le-moine, and Thévenin
- *Tissotia hedbergi*, new species
- *Heterotissotia peroni* Lisson
- *Heterotissotia bucheri*, new species
- *Buchiceras bilobatum* Hyatt

**Pelecypoda**
- *Cucullaea maresi* Coquand
- *Modiola* sp.
- *Inoceramus aequivalvis* Brüggen
- *Inoceramus peruvanus* Brüggen
- *Picatulopecten ferrai* Coquand
- *Spondylus striatus* Sowerby
- *Lima* (Plagiostoma) *grenieri* Coquand
- *Ostrea* (Lopha) *nicaisai* Coquand
- *Ostrea* sp.
- *Ostrea bravoi* Brüggen
- *Roudairia intermedius* Brüggen
- *Cardium pulchrum* Brüggen
- *Pholadomya allongata* Muenster
- *Pholadomya guinuana* Neumann
- *Echnioidea*
  - *Cyphosoma schlagintweitii* Brüggen
  - Several species of the group of *Hemiasister fournelli* Deshayes

In addition it contains a great number of species of gastropods, bryozoans, and a few vertebrate bones. In terms of numbers of individuals, the echinoids are dominant.

The zone of *Lenticeras baltai* contains the following:

**Cephalopoda**
- *Bostrychoceras* sp.
- *Dermophylites gaudama* (Forbes)
- *Teixantites hourqui* Collignon
- *Teixantites* sp.
- *Tissotia steinnanni* Lissón
- *Tissotia fournelli* (Bayle)
- *Tissotia halli* Knechtel
- *Lenticeras baltai* Lissón
- *Lenticeras lissomi* Knechtel

**Pelecypoda**
- *Inoceramus* sp.
- *Lima* sp.
- *Ostrea* (Phola) *nicaisai* Coquand
- *Roudairia intermedius* Brüggen

**Cardium pulchrum** Brüggen

**Echinoidea**
- *Hemiasister fournelli* Deshayes
- *Goniopygus hemicidariformis* Brüggen
- *Goniopygus superbus* Cotteau and Gauthier

The zone of *Buchiceras bilobatum* is Conianian; the zone of *Lenticeras baltai* is early Santonian. The Celendín formation, therefore, is Conianian-early Santonian.

The Celendín formation was deposited under shallow waters. The upper boundary marks the end of marine sedimentation in the northern Andes; the succeeding deposits are coarse, red-bed clastics that came from the west.

**CHOTA FORMATION**

The marine Cretaceous sequence is disconformably succeeded by non-marine, red-bed coarse clastics which Broggi (1942, p. 10) has named the Chota formation. He observed it in Lajas, west of Chota, where it is several hundred meters, largely of very coarse conglomerate and sandstone lying on the thick-bedded limestones of the Turonian Caja-marca formation; the conglomerates contain cobbles of quartzite and plutonic rocks.

In Bambamarca, east of Chota, the conglomerates are less coarse, at least 500 meters thick, and lie on the soft shales of the lower Senonian Celendín formation. Farther east, in Celendín, the Chota formation is of red quartz-sandstone and shale with only a few thin conglomerates of quartz pebbles. In Santa Clara (pl. 38, fig. 2), near the Marañón River, it is almost exclusively of fine red sandstones and shales over 1000 meters thick and lying disconformably on the Celendín formation, the contact being indistinct. In Uchupata, east of Huari, it is of gypsiferous red-bed shales and sandstones over 200 meters thick.

The lower boundary of the Chota formation is an unconformity which increases in magnitude westward (fig. 12). The upper boundary is always either cut by structures or covered with distinct angular relationships by younger non-marine and volcanic rocks. The Chota formation resembles the Pocobamba formation of the central Andes as well as the ill-defined and heterogeneous Rimac terrane but is distinguishable because it lies disconformably on the marine Cretaceous
sequence; it is older than those formations. The rocks of the Chota formation become coarser grained towards the west. This, and the fact that an unconformity at its base increases in the same direction, indicate a western source, probably an orogenically active land.

Along the coast, an orogeny took place in Coniacian-Santonian time. In Paita, Campanian sediments overlie "complexly folded cristalline and metamorphic rocks" (Olsson, 1944, p. 15). It is likely that Turonian rocks are involved in this basement, for in Tembladera, near Pacasmayo, the Neocomian-Turonian (probably Jurassic-Turonian) sequence is normal and has the same relationships and characteristics as the sequence in the western Andes. Thick-bedded blue-gray limestones of the Turonian Cajamarca formation are the top beds of the Tembladera section (fig. 18).

The present writer thinks that the Chota clastics are the flysch deposits of the orogeny that affected the coastal area, and that they are of Santonian-Campanian age. Later, they were strongly folded and covered by coarse clastics like the Pocobamba formation of central Peru.

**MARAÑÓN VALLEY**

Sections studied along the Marañón River, between Celendín on the north and the Pushca River on the south, show some striking differences from those of the Cordillera Occidental, especially in the pre-Mujarrún stratigraphy. The best exposed section is along the lower part of the Crisnejas River as it discharges into the Marañón River at latitude 07° 21' S. Two new formations are considered here (fig. 13).

**CRISNEJAS FORMATION**

This formation is named after the Crisnejas River. The type section (fig. 19) was measured on the south side of this river, between the Marañón River and the small settlement of Santa Rosa. Disconformably lying on the quartz-sandstones of the Goyllarisquisga formation and below the sandstones of the Rosa formation, defined in the following pages, are 365 meters of shales, marls, and limestones which are grouped under the term Crisnejas formation. The lower part has greenish and yellowish, splintery, soft, thin-bedded, fossiliferous, calcareous shales interbedded with thin units of light gray marl and limestone. The sequence becomes more calcareous upward, and the upper part is of light yellowish brown to tan, massive, thick-bedded limestone. From the lowest beds *Parengonoceras pernodosum*, *Ostrea dieneri* Blackenhorn, and several echinoids were collected. The upper limestones are characterized by *Oxytropidoceras carbonarium* and *Inoceramus concentricus* Parker. The lower boundary is very sharply defined at the top of the massive quartz-sandstone of the Goyllarisquisga formation. The upper boundary is also very distinct (pl. 39, fig. 1), for it is a deeply weathered and channeled disconformity below the quartz-sandstones of the Rosa formation.

Along the Marañón River, near Quiches (Santo Cristo Bridge section), there is a similar but thicker section. The lower 220 meters are bluish gray, splintery shale inter-
bedded with light greenish and bluish, thin-bedded, somewhat nodular, fossiliferous marl. The upper 240 meters are medium gray to greenish, brownish-weathering, massive, thick-bedded limestone underlying the clastic red beds of the Rosa formation.

It has also been studied in Celendín, where overlying disconformably on the Goyllarisquisga formation are 430 meters of yellowish and brownish gray marl and shale interbedded with dark gray, somewhat nodular limestone in the lower part and with light gray, somewhat nodular limestone in the upper part. The lower beds contain numerous species of *Knemiceras*, *Parengonoceras*, and *Protanisoceras* as well as many echinoids and pelecypods. The upper beds are characterized by *Lyelliceras pseudolyelli* Parona and Bonarelli and several echinoids.

In general, the fauna present in the lower part of this formation is the same as that in the Chulec (zone of *Knemiceras raimondii*)
formation in the Cordillera Occidental, whereas the fauna of the upper beds is a distinct Pariatambo fauna (zone of *Oxytropidoceras carbosarium*). The Crisnejas formation is therefore medial Albian, and time equivalent of the Chulec and Pariatambo formations. As the lower beds become more calcareous, they grade into the Chulec formation, and as the upper limestones become finer and bituminous, they grade into the black, strongly bituminous marls and limestones of the Pariatambo formation (fig. 8).

**Rosa Formation**

The type section was measured beginning 500 meters downstream from Santa Rosa, a small settlement in the lower part of the Crisnejas River. In the lower part, it has terrigenous sediments: quartz-sandstones, red-bed sandstones, and conglomerates which become finer and calcareous upward. A summary of the type section is given here:

### Meters

3. Sandstone, shale, and marl, finely interbedded, becoming more calcareous and massive towards the top. The marl is fossiliferous, brown, massive; the shale is greenish and whitish gray; the sandstone is reddish white, laminated 187

2. Deep cherry-red sandstone, siltstone, and conglomerate. The sandstone is soft, cross-bedded; the conglomerate is of perfectly rounded, faceted quartz pebbles ranging between 1 cm. and 20 cm. in diameter; the matrix is red, friable (pl. 39, fig. 2) 317

1. Sandstone, calcareous, coarse-grained, medium- to thick-bedded, slabby, brownish white, interbedded with a few shale and limestone beds 95

The lower contact with the underlying limestones of the Crisnejas formation is a sharp unconformity (pl. 39, fig. 1). The upper boundary is also distinct, for the upper thin-bedded, soft, friable marls and limestones of the Rosa formation are succeeded by massive, thick-bedded limestones of the Mujarrún formation.

The Rosa formation has been found at several points along the Marañón River, namely, in Chagual east of Huamachucu, and in Quiches east of Sihuas. In this last place (Santo Cristo Bridge section), it is 150 meters of red-bed shale and sandstone with a few interbeds of gypsum in the lower part.

Farther south, along the Pushca River (Uchupata and Pomachaca sections), the Rosa formation is absent, apparently by change of facies, and the thick-bedded limestones and dolomites of the Jumasha formation directly overlie the Pariatambo formation. Also, north of the Crisnejas River in Celenín, the Rosa formation is absent; limestones of the Puliucana group lie directly on the Crisnejas formation. Towards the west, the Rosa formation interfingers quickly with silts, marls, and limestones of the Yumagual formation of the Cajamarca area.

The Rosa formation for the most part is of non-marine origin. After the deposition of the Crisnejas formation, i.e., at the end of Pariatambo time, the Marañón geanticline was raised, exposing to erosion not only the preceding Cretaceous sediments but probably pre-Mesozoic rocks. An erosion surface was developed. Non-marine deposition was initiated, and gypsum evaporites were deposited in the margins of the retreating sea. The red-bed sandstones and conglomerates were apparently subjected to some wind work prior to deposition. The upper strata of the Rosa formation records the gradual return of marine conditions which became then fully prevalent.

In the type section, the Rosa formation overlies the Crisnejas formation, which is medial Albian, and is overlain by the medial Cenomanian Mujarrún formation. It represents, therefore, the late Albian-early Cenomanian interval and is the time stratigraphic equivalent of the Yumagual formation. It is also assumed, on the basis of stratigraphic position, that it grades into the lower part of the Jumasha formation of central Peru.

**Zones**

The Cretaceous sequence in northern Peru has been divided into 13 zones (fig. 14). A zone is “a group of beds characterized by an assemblage of organisms, one of which is chosen as the index species and gives its name to the unit although it need not be confined
Fig. 14. Summary of the Cretaceous system in northern Peru.
to this unit or found in every part of it" (Hedberg, 1941, p. 2206; see also Arkell, 1933, p. 19; 1946, p. 10). In accordance with standard use in Mesozoic stratigraphy, except for three zones, single ammonite species have been given as zonal indices.

After the ammonites, the species of _Inoceramus, Exogyra_, and _Ostrea_ are the most useful fossils. They are commonly found in great numbers; their ranges, however, are far greater than those of the ammonite species. Gastropods are also very common, but occur usually in steinkerns and cannot be studied well; apparently, they also have very long vertical ranges. The echioids follow the pelecypods in numerical abundance, but their ranges are even greater than those of the pelecypods. Bryozoans are rarely found and have been given only cursory examination. Foraminifera are common in the limestones but would have to be studied in thin sections.

The non-marine part of the sequence is rich in fossil plants which do not seem to have particular stratigraphic value.

The Peruvian Cretaceous faunas belong to a single faunal province which extended through northern South America and parts of Brazil. It is suggested, therefore, that these zones may be found applicable throughout this faunal realm.

ZONE OF _Valanginities broggii_

The Santa limestone and the lowest beds of the Carhuaz formation are characterized by _Valanginities broggii_ associated with other specifically unidentifiable species of olostephanid ammonites and the following pelecypods:

*Buchotrigonia flexicostata* (Fritzsche)
*Buchotrigonia inca* (Fritzsche)
*Buchotrigonia gerthii* (Lisson) (= _Trigonia malheusi_ Richards)
*Cucullaea gabrielsi_ Leymerie
*Cyrena huarasensis* Fritzsche

The brackish to fresh-water gastropods _Paraglauconia studeri_ Vilanova var. _peruana_ (Fritzsche) and _Paraglauconia strombiformis_ (Schlotheim) are also found in this zone, associated usually with the last-named pelecypod and rarely with the trigonias. Dietrich (1938, p. 99) thinks that the irregularity of the ribbing of _B. flexicostata_ and _B. inca_ is due to the influence of fresh waters.

The genus _Valanginities_ is distributed through northern South America (Spath, 1924, p. 80), Mexico (Imlay, 1940, p. 135), and Europe. It is significant that it has not been reported from the well-studied Neocomian sections of Argentina. Both Kilian (1920, p. 12) and Imlay (1940, p. 135) state that _Valanginities_, although it is found both in the Hauterivian and in the Valanginian, is most characteristic of the last stage. Spath (1924, p. 80) referred to the "_Valanginities beds_" of Colombia and correlated them with the "_Hoplitid age_" of the English Valanginian. The present writer has been unable to find any other reference to these Colombian _Valanginities_. On these grounds this zone is tentatively assigned to the upper Valanginian.

ZONE OF _Parahoplites nicholsoni_

The Inca formation of northern Peru and the Pariahuanca limestone of the Callejón de Huaylas area are marked by _Parahoplites nicholsoni_, new species, associated with large, specifically unidentifiable parahoplitid ammonites and the following species:

Cephalopoda
*Desmoceras chimuense*, new species
*Parahoplites quilla*, new species
*Parahoplites inchi*, new species
*Knemiceras ollonense* (Gabb)

Pelecypoda
*Trigonoarca gerhardtii* Olsson
*Cucullaea brevis* d’Orbigny
*Pterotrigonia tocaimaana* (Lea) (= _P. subcrenulata_ d’Orbigny)
*Yaadia hondaana* (Lea)
*Buchotrigonia abrupta* (von Buch)
*Buchotrigonia robinaldana* d’Orbigny (= _B. lissoni_ Sommermeier)
*Corbis* (*Sphaera*) _corrugata_ Sowerby
Echinoidea
*Enalloster peruana* (Gabb)

The genus _Parahoplites_ appears in the lower Aptian and reaches its maximum development in the middle and upper Aptian, although "...the last parahoplitids still occur at the top of the Lower Albian tardefurcata zone with early _Dowilleiceras_" (Spath, 1930, p. 60). The genus _Knemiceras_ reaches its maximum diversification in the next zone,
assigned to the lower middle Albian, and is usually considered to be an Albian genus. The present writer knows no authenticated occurrence of this genus in Aptian deposits.

The fauna of this zone has close affinities with Colombian faunas described by Riedel (1937–1938) which include a large number of species of Parahoplites. Unfortunately, his descriptions lack stratigraphic details. It also has close relationships with the controversial

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**Fig. 15.** Development of the stratigraphic terminology of the Cretaceous system in northern Peru. McLaughlin’s column includes only those names that have bearing on the stratigraphy of northern Peru. The numbers in Stappenbeck’s column are those he used to designate his stratigraphic units.
so-called Claysayes fauna of France which corresponds to the Acanthoplites nodosocostatum zone of England. The Claysayes fauna is considered by many as transitional between the Albian and the Aptian. According to Breistroffer (1947) it constitutes the upper part of the Aptian stage, but Spath (1923–1943, vol. 1, p. 311) considers it to be the lowest Albian. Scott (1940, p. 1029) has described from Texas a large fauna, including Parahoplites and Knemiceras which mark his Sonneratia trinitensis zone, which he correlates with the lower and middle Albian.

The species of Parahoplites contained in this zone seem to have affinities with species of the Albian genera Hypacanthoplites and Rhytidoplites. In addition, the presence of the Albian genus Knemiceras and the fact that the overlying zone of Knemiceras raimondii is early medial Albian seem to indicate that the zone of Parahoplites nicholsoni is early Albian.

ZONE OF KNEMICERAS RAIMONDII

The Chulec formation and the lower part of the Crisnejas formation are characterized by Knemiceras raimondii. It is associated with the following species:

Cephalopoda

Protanisoceras blancheti (Pictet and Campiche)
Dowvilleiceras monile (Sowerby)
Paren gonoceras pernodosum (Sommermeier)
Paren gonoceras guadalupaeforme (Sommermeier)
Paren gonoceras tetranodosum (Lissón)
Paren gonoceras haasti, new species
Paren gonoceras ebrayi, new species
Knemiceras raimondii pacificum, new subspecies
Knemiceras raimondii tardum, new subspecies
Knemiceras attenuatum Hyatt
Knemiceras attenuatum spinosum (Sommermeier)
Knemiceras syriacum (von Buch)
Knemiceras gabbi Hyatt
Knemiceras triangulare, new species
Knemiceras ovale, new species
Knemiceras siczag Breistroffer
Brunoceras aegocerataeides Steinmann
Procyllip eriausum Spath
Lyelliceras lyelli (Leymerie) (d’Orbigny)

Echinoidea

Bothriopygus compressus Gabb
Echinobrissus subquad ratus d’Orbigny
Enallaster peruanus Gabb
Holectypus (Coenolecyp us) planatus numis malis (Gabb)
Phymosoma texanum Roemer

One of the most significant species in this list is Dowvilleiceras monile, distributed in northern South America (Riedel, 1937–1938), Europe (Spa th, 1923–1943, vol. 1, p. 72; Breistroffer, 1947, p. 40), North Africa, Madagascar (Collignon, 1949), and India (Spa th, 1930). In England, it is the index of the subzone of Dowvilleiceras monile, which marks, according to Spath, the base of the middle Albian, and according to Breistroffer (1947) the top of the lower Albian. Protanisoceras blancheti is also another important ammonite confined (Spa th, 1930, p. 51) to the zone of Dowvilleiceras mammillatum of England.

The genus Knemiceras has also a wide distribution. It is known in northern South America (Breistroffer, 1952, p. 2633), Texas (Scott, 1940), North Africa (Mamdoud, 1952), the Middle East (Bassé, 1937, 1940), India, and Borneo, usually in beds considered medial Albian. In Peru, this genus seems to have reached its maximum diversification in this zone. Only one species, Knemiceras ellenose, is found in the underlying zone of Parahoplites nicholsoni, and another species, Knemiceras ovale, is known in the overlying zone of Oxytropidoceras carbonarium.

Paren gonoceras ebrayi de Loriol, the closest relative of the Peruvian species of Paren gono-
ceras, is found in the lower middle Albian ("Protohoplitien" of Breistroffer, 1947, p. 40; or the Dowvilleiceras mammillatum zone of Spath) of Europe.

Lyelliceras lyelli and Brancoceras aegoceratoides are rarely found in this zone but attain great abundance in the next zone of Oxytropidoceras carbonarium.

The present writer follows Spath's zonation of the Albian and regards the zone of Knemiceras raimondii as at the base of the middle Albian.

ZONE OF OXYTROPIDOCERAS CARBONARIUM

The Pariatambo formation, the upper part of the Crisnejas formation, and the Muerto limestone of northwestern Peru are characterized by Oxytropidoceras carbonarium (Gabb) and the following:

Cephalopoda
- Desmoceras latidorsatum (Michelin)
- Knemiceras ovale, new species
- Oxytropidoceras peruvianum (von Buch)
- Oxytropidoceras douglasi Knechtel
- Venesoliceras venesolanum (Stieler)
- Venesoliceras harrisoni, new species
- Diploceras sp.
- Brancoceras aegoceratoides Steinmann
- Lyelliceras lyelli (Leymerie) (d'Orbigny)
- Lyelliceras pseudolyelli (Parona and Bonarelli)
- Lyelliceras ulrichi Knechtel

Pelecyphoda
- Inoceramus concentricus Parker
- Inoceramus salomonii d'Orbigny
- Anoma sp.
- Astarte debilidens Gerhardt
- Exogyra minos Coquand
- Corbula raimondii Gabb

Echinoidea
- Enallaster peruanus Gabb

The species of ammonites and inocerami are particularly abundant in the black, well-bedded, petrolierous marls and limestones of the Pariatambo formation; they become very scarce in the non-bituminous marls of the Crisnejas formation. Knemiceras has not been found in the otherwise richly fossiliferous black facies.

The genus Oxytropidoceras is distributed through northern South America (Riedel, 1937–1938; Breistroffer, 1952), Brazil, Mexico (Imlay, 1944, p. 1095), the Gulf Coast (Adkins, 1928), the western interior of the United States (Cobban and Reeside, 1952, p. 1016), Europe, Madagascar, and India. According to Spath (1923–1943, vol. 2, table 3, p. 706) it ranges from the top of the zone of Dowvilleiceras mammillatum through most of the middle Albian (zones of Hoplites dentatus and of Euhoplites latusus). Breistroffer (1947), who excludes the zone of Dowvilleiceras mammillatum from the middle Albian, refers to the middle Albian as the "Oxytropidoceratien."

According to Spath (1923–1943, vol. 2, p. 706), the genus Venesoliceras is limited to the Hoplites dentatus zone, and he says (1930, p. 50) that in England, Lyelliceras seems to be confined to the benettianus subzone (lower part of the Hoplites dentatus zone). In France, Breistroffer (1947, pp. 40, 42) reports Lyelliceras of the lyelli group in the "Dowvilleiceratien" and the "Oxytropidoceratien."

It seems that the zone of Oxytropidoceras carbonarium can be correlated with the zone of Hoplites dentatus of Europe, approximately the middle of the medial Albian, for in the overlying zone of Euhoplites latus neither Lyelliceras nor Venesoliceras has been found. It can also be correlated with the zone of Oxytropidoceras, at the top of the Fredericksburg, in the United States.

ZONE OF OSTREA (LOPHA) SCIYPHAX

The lower part of the Yumagual formation and of the Rosa formation is characterized by Ostrea scyphax Coquand, which sometimes forms great accumulations. It is usually associated with thick-shelled, unidentified species of Inoceramus. In this zone, ammonites are notably scarce; only one specimen of Engonoceras sp. indet. was obtained from it. Echinoids (Enallaster peruanus Gabb and Bothriopygus compressus Gabb) are locally plentiful.

Ostrea scyphax is a North African species usually referred to the Cenomanian. The genus Engonoceras, although over 100 years old and very abundant in the Gulf Coast, Europe, North Africa, and the Middle East, has not been reported in South America. It ranges through the Albian and the Cenomanian (Bassé, 1940, p. 436) but seems to achieve its maximum diversification during the late Albian and the early Cenomanian. In
England, it is rarely found in the *dispar* zone (upper Albian) and has been described as a "straggler from the south" (Spath, 1923–1943, vol. 2, p. 703).

The data to compare this zone with the European or North American zones are poor. However, because the succeeding zone of *Paraturrilites lewesiensis* is early Cenomanian and because *Engonoceras* is especially abundant in the late Albian, the zone of *Ostrea scyphax* is considered late Albian, but it may even include part of the medial Albian. The unconformity at the base of this zone represents, probably, the late medial Albian.

**ZONE OF PARATURRILITES LEWESIENSIS**

The upper part of the Yumagual formation is characterized by *Paraturrilites lewesiensis* Spath. It is associated with:

- Sharpeiceras occidentale, new species
- Exogyra mermeti Coquand (= Exogyra diceratina Paulcke)

The last species, in places, builds large accumulations; ammonites are, as a rule, scarce.

*Paraturrilites lewesiensis* Spath, a British species, is found in the Schloenbachia *varians* zone of the English Cenomanian (Wright and Wright, 1951, p. 17). *Sharpeiceras laticlavium*, a species closely related to *S. occidentale*, is also found in this zone. On the strength of this, the zone of *Paraturrilites lewesiensis* is considered lower Cenomanian and correlated with the *Schloenbachia varians* zone of the British sequence. Spath (1926, p. 429) has said: "Turritiles are thus as useful as the ammonites for zoning the lower three-quarters of the Cenomanian."

**ZONE OF EXOGYRA CF. EXOGYRA PONDEROSA**

The Choro member of the Mujarrún formation is marked by *Exogyra* cf. *Exogyra ponderosa* Steinmann (1930, fig. 224)—non *Exogyra ponderosa* Roemer, a Senonian species. The zone, containing this exogyroid in great abundance, has not yielded a single ammonite specimen. In the upper part, *Exogyra olisiponensis* makes its first appearance. It lies between the early Cenomanian zone of *Paraturrilites lewesiensis* and the early late Cenomanian zone of *Exogyra africana.*

**ZONE OF EXOGYRA AFRICANA**

The Culebra member of the Mujarrún formation is characterized by great numbers of individuals of *Exogyra africana* Coquand (= *Exogyra peruana* Paulcke). It also contains *Exogyra olisiponensis* Sharpe, *Exogyra* sp., *Neithea alatus* von Buch, *Neithea tenoukliensis* Coquand, *Orthopsis titicacana* Cooke, and specifically unidentifiable acanthoceratid ammonites. The genus *Acanthoceras* marks the upper Cenomanian (Acanthoceratan age of the European stratigraphers). Because the next zone is latest Cenomanian, the zone of *Exogyra africana* is assigned to the early late Cenomanian.

**ZONE OF ACANTHOCERAS CHASCA**

This zone comprises the Romirón formation and, wherever undifferentiated, the lower part of the Quilliquiñan group. Probably it is included within the Jumasha formation. It is marked by *Acanthoceras chasca*, new species, and the following:

- Cephalopoda
  - *Lissoniceras mermeti* (Coquand)
  - *Forbesiceras* sp.
  - *Acanthoceras sangalense*, new species
  - *Acanthoceras pollocense*, new species
  - *Neolobites kummeli*, new species

- Pelecypoda
  - *Mytilus* sp.
  - *Neithea alatus* von Buch
  - *Neithea aequicostata* Lamarck
  - *Neithea tenoukliensis* Coquand
  - *Plicatula reynesi* Coquand
  - *Plicatula gurgitis* Pictet and Roux
  - *Plicatula auressensis* Coquand
  - *Ostrea rowelli* Coquand
  - *Exogyra olisiponensis* Sharpe
  - *Exogyra olisiponensis* *duplex* Paulcke
  - *Exogyra polygona* von Buch
  - *Exogyra deleteri* Coquand
  - *Cardita doumeti* Peron
  - *Coquandia italica* Seguenza
  - *Corbula* sp.

- Echinodermata
  - *Orthopsis titicacana* Cooke

*Acanthoceras, Neolobites, and Forbesiceras* are well-known late Cenomanian (Acanthoceratan age) genera distributed mainly in the Mediterranean area (Spath, 1926, p. 425; Collignon, 1937, p. 64; Adkins, 1928, p. 243). *Exogyra olisiponensis* Sharpe is a late Cenomanian–early Turonian species of wide distri-
bution (Reeside, 1929). The top of this zone is considered the top of the Cenomanian, and the zone is assigned to the latest Cenomanian. The echinoid *Orthopis titicacana* was described first in collections made by Newell in the Ayavacas limestone of the Titicaca region. Its association with late Cenomanian ammonites confirms Cooke's dating of this species. The fact that the genus *Neolobites* has also been reported from southern Peru (Boit, 1926), suggests that the zone of *Acanthoceras chasca* may be present in southern Peru, probably represented by the lower part of the Moho formation (Newell, 1949, p. 51).

**ZONE OF Coilopoceras jenksi**

The Coñor formation and the upper part of the Quillquiñan group (Tembladera section) are distinguished by *Coilopoceras jenksi*, new species. It is associated with the following:

**Cephalopoda**
- *Mammites nodosoides* ofer Pervinquière
- *Pseudoaspidoceras reesidei*, new species
- *Thomastites fischeri*, new species
- *Vascoceras aff. Vascoceras sikanense* Choffat
- *Broggiicerias humboldti*, new species
- *Broggiicerias olssoni*, new species
- *Hoplitoides inca*, new species

**Pelecypoda**
- *Inoceramus labiatus* Schlotheim
- *Inoceramus sp.*
- *Plicatula gurgitis* Coquand
- *Plicatula reynesi* Coquand
- *Plicatulopecten ferryi* Coquand
- *Corbula* sp.

The genera *Mammites*, *Pseudoaspidoceras*, *Thomastites*, *Vascoceras*, *Hoplitoides*, and *Broggiicerias* constitute the well-known Sal-murian fauna (lower Turonian; Mammitan age) of the European stratigraphers, distributed in the Mediterranean area, southern France (de Grossouvre, 1912), Portugal (Choffat, 1886, 1898, ser. 2), Tunisia (Pervinquière, 1907), Middle East (Bassé, 1940), Madagascar (Bassé, 1931), India, Brazil, Mexico (Büse, 1918), and the United States (Reeside, 1923).

*Inoceramus labiatus* (Schlotheim) is the world-wide marker of the lower Turonian. In England, Germany, and the United States, the "zone of *Inoceramus labiatus*" has been recognized as at the base of the Turonian.

**ZONE OF Coilopoceras newelli**

The Cajamarca formation is characterized by *Coilopoceras newelli*, new species. This formation is largely of thick-bedded lithographic limestones which contain only Foraminifera and gastropods. However, occasional interbeds of marl are packed with molusks. In addition to the index species are the following species:

**Pelecypoda**
- *Inoceramus sp.*
- *Inoceramus peruanus* Brüggen
- *Plicatulopecten ferryi* Coquand
- *Lima* sp.
- *Cardium lissoni* Brüggen

**Echinoidea**
- *Hemiaster fourneli* Deshayes

The zone of *Coilopoceras newelli* is assigned to the late Turonian, because all the species of *Coilopoceras* known to the writer are Turonian and because the succeeding zone of *Buchiceras bilobatum* is earliest Coniacian.

**ZONE OF Buchiceras bilobatum**

The lower part of the Celendín formation is characterized by *Buchiceras bilobatum* Hyatt in association with the following:

**Cephalopoda**
- *Barroisiceras* (Barroisiceras) *haberfellneri* von Hauer
- *Barroisiceras* (Barroisiceras) *kayi*, new species
- *Barroisiceras* (Solgerites) *brancoi* Solger
- *Barroisiceras* (Forresteria) *basseae*, new species
- *Barroisiceras* (Forresteria) *allualdi*, Boule, Le-moine, and Thévenin
- *Tissotia hedbergi*, new species
- *Heterotissotia* *peroni* Lissón
- *Heterotissotia* *buereri*, new species

**Pelecypoda**
- *Cuculaela* *maresi* Coquand
- *Modiola* sp.
- *Inoceramus aegyptiacus* Brüggen
- *Inoceramus peruanus* Brüggen
- *Plicatulopecten ferryi* Coquand
- *Spondylus striatus* Sowerby
- *Lima* (Plagiostoma) *grenieri* Coquand
- *Ostrea* (Lophia) *nicaisët* Coquand
- *Ostrea* sp.
- *Ostrea* *bravoë* Brüggen
- *Roudairia* *intermedia* Brüggen
- *Cardium* *pulchrum* Brüggen
- *Pholadomya* *elongata* Muenster
- *Pholadomya* *quinuana* Neumann
Echinoidea  

Cyphosoma schlachtweilii Brüggen  
Several species of the group of Hemister fournelii Deshayes  

In addition, it contains a great number of unidentified gastropods and bryozoans.  

From the standpoint of stratigraphy, the genus Barroisiceras (treated monographically by Reeside, 1932, and Bassé, 1947) is the most important. Reeside (1932, p. 9) states: "the ammonite genus Barroisiceras is noteworthy because of its wide geographic distribution and its apparently small stratigraphic range. It is reported from deposits of Coniacian age in Europe, Africa, South America and North America." The genus Tissotia ranges through the Coniacian and Santonian (Pervinquiére, 1907), and the genus Heterotissotia has been reported from the late Turonian of Tunisia (Pervinquiére, 1907, p. 379).  

On the basis of the presence of Barroisiceras, universally recognized as a Coniacian genus, the zone of Buchiceras bilobatum is assigned to this stage.  

**ZONE OF LENTICERAS BALTAI**  

The upper part of the Celendin formation is marked by Lenticeras baltai Lissón. It is associated with the following:  

Cephalopoda  

*Bostrychoceras* sp.  
*Desmophyllites gaudama* (Forbes)  
*Texanites hourqi* Collignon  
*Texanites* sp.  
*Tissotia steinmanni* Lissón  
*Tissotia fourneli* (Bayle)  
*Tissotia halli* Knechtel  
*Lenticeras lissoni* Knechtel  

Pelecypoda  

*Inoceramus* sp.  
*Lima* sp.  
*Ostrea* (Phola) *nicaisei* Coquand  
*Reudasia intermedia* Brüggen  
*Cardium pulchrum* Brüggen  

Echinoidae  

*Hemister fournelii* Deshayes  
*Genoppus hemicidariformis* Brüggen  
*Genoppus superbus* Cotteau and Gauthier  

Collignon (1948, pp. 102–103), in his monograph on the Texanitidae, states: "... a la fin du Coniacien, le genre *Texanites* est constitué et déjà représenté par des espèces bien typiques.... Au Santonien se produit la grande floraison et la plus grande dispersion géographique du Genre *Texanites* s. str." In the Campanian, he adds, "le genre *Texanites* n'y apporte qu'un appoint insignifiant." He places the Madagascan zone of *Texanites hourqi* at the base of the Santonian and correlates it with the zone of *Texanites texanus* of western Europe and the coast of the Gulf of Mexico.  

*Bostrychoceras* is usually considered to be upper Senonian (Yabe, 1904; Spath, 1921, p. 266); *Desmophyllites gaudama* commonly is found in Santonian deposits; *Tissotia* is found both in the Coniacian and Santonian; and, according to Spath (1921, p. 267), *Lenticeras* has been found at about the limit between the Coniacian and the Santonian.  

Rivera (1949) has described and assigned to the Coniacian a faunule from Pongo de Rentema, Río Marañón, which includes *Pachydiscus* (Parapachydiscus) aff. *P. (P.)* gardneri Reeside, *Pachydiscus* (Parapachydiscus) sp. indet., *Texanites* aff. *bourgeoisii* d'Orbigny, *Tissotia* singewaldii Knechtel, and *Lenticeras baltai* Lissón. *Parapachydiscus*, however, is an upper Senonian (Parapachydiscan age) genus (Spath, 1921, 1926; Reeside, 1947), and *Texanites bourgeoisii* is uppermost Coniacian and lower Santonian (de Grossouvre, 1893, p. 73). This faunule, in the present writer's opinion, is younger than Coniacian.  

In Venezuela, Gerhardt (1897) described *Texanites texanum* (Roemer), *Texanites canhaensis* (Gerhardt), *Gauthiericeras lenti* Gerhardt, *Gauthiericeras margae* (Schlueter), *Amaltheus sieversii* Gerhardt, and *Lenticeras andii* Gerhardt from beds later interpreted to belong to the Colon shale (Liddle, 1928, p. 168) which, on the basis of Foraminifera, has been correlated with the Taylor marl (lower Campanian) of the coast of the Gulf of Mexico (Hedberg and Sass, 1937, p. 87).  

Finally, another significant fauna is found in Haiti. Reeside (1947) has recorded *Pachydiscus* ("Parapachydiscus") *gardneri* Reeside, *Pachydiscus* ("Parapachydiscus") woodringi Reeside, *Parapusosia?* sp., *Paraleniceras sieversi* (Gerhardt), and *Texanites cf. Texanites canhaensis* (Gerhardt) which he assigns to the late lower Senonian (approximately Santonian).
The present writer thinks that the presence in the zone of \textit{Lenticeras baltai} of \textit{Texanites}, \textit{Lenticeras}, \textit{Bostrychoceras}, and \textit{Desmophylites}, and the absence of \textit{Barroisiceras} and \textit{Heterotissotia}, indicate Santonian. The common association of the genera named first with \textit{Parapachydiscus} (Haiti, Venezuela, and the Umkwelane Hill fauna of Zululand; Spath, 1921) further sustains this view.

**GEOLOGIC HISTORY**

After the deposition of the marine upper Jurassic Chicama beds, the sea withdrew from northern and central Peru. Only in a few areas along the present coast (the Lima environs, for instance) did marine sedimentation continue more or less uninterruptedly from the Jurassic into the Cretaceous. This widespread emergence was accompanied or produced by broad, gentle warping, particularly active along the Marañón axis where pre-Mesozoic rocks were exposed to erosion.

The Cretaceous sedimentation was begun by the deposition of the very clean, well-sorted, 600-meter thick Chimú sandstone, which is found west of the Marañón River and south of the Jequetepeque River. It was deposited under conditions of tectonic quiescence, with no neighboring high lands. By late Valanginian time, the sea encroached over the area on which the Chimú sandstone had been deposited, and the shales and limestones of the Santa formation were laid down. The Santa formation is thicker (341 meters), more calcareous, and richer in marine fossils in the Callejón de Huaylas than in areas towards the east and north. It is not present east of the Marañón River or north of the Jequetepeque River. By the end of the Valanginian, renewed emergence restricted the sea again; gypsum of this age is found in the Callejón de Huaylas and conglomerates are found in the Chicama Valley. An erosional surface was formed on which non-marine sedimentation was initiated.

The Hauterivian and Aptian stages are represented in the Callejón de Huaylas by 1300 meters of brackish-water shales with interfingered beds of marine limestone and volcanic tuffs, the Carhuaz formation, which intertongues with quartz-sandstone (Goyllarisquisga formation) towards the east and north. The Goyllarisquisga formation, with an average thickness of 600 meters along the Marañón River, has a greater distribution than the earlier Chimú sandstone; it overlaps earlier Cretaceous sediments and also Jurassic and Triassic rocks. Probably south and west of the Callejón de Huaylas, the Carhuaz formation acquires more marine and volcanic beds. During this time, volcanism was active in the western lands.

During the early Albian, the Pariahuanca limestone (Callejón de Huaylas), the Inca (northern Peru), and the Pananga (northwestern Peru) formations were deposited. These lithic units are the basal deposits of the marine transgression which advanced eastward and northward through Albian time, gaining wider spread and uniformity in lithology. These units grade into quartz-sandstones of the Goyllarisquisga formation east of the Marañón River.

During the medial Albian, the transgression reached its maximum expansion. For the first time during the Cretaceous the sea covered Marañonía, where poorly fossiliferous marls and limestones (Crisnejas formation) were deposited. Westward, along the present Cordillera Occidental, during the early medial Albian, the Chulec formation (richly fossiliferous marls and limestones with a maximum thickness of 577 meters in the Cajamarca area) was deposited. By the middle of the medial Albian, deeper waters and restricted circulation favored the accumulation of great quantities of organic matter: the Pariatambo formation of black, strongly bituminous marls and limestones was deposited; it has a uniform thickness of about 200 meters. The Chulec and Pariatambo formations are time equivalents of the Crisnejas formation and probably of the Paco, Esperanza, and Aguaymuy members of eastern Peru (Kummel, 1948) and of the Arcurquina limestone of the Arequipa region (Jenkins, 1947).

The deposition of the bituminous limestones and marls of the Pariatambo was brought to an end by widespread shallowing of the seas and the uplift of the Marañón
geanticline, where a surface of erosion, including pre-Mesozoic rocks, was formed. Upper Albian-lower Cenomanian, non-marine red beds (Rosa formation), including quartz pebble conglomerates, are found along the Marañón River between south of Celendín and Quiches. These red beds interfinger westward with 500-meter thick marine marls and argillaceous limestones with peculiar wavy bedding and nodular structures (Yumagual formation) which sometimes close to being coquinas of exogyroids but in which ammonites are strikingly scarce. By medial Cenomanian, there was a gradual deepening of the seas, which again covered Marañonía; wavy-bedded, 300-meter thick limestones (Mujarrúin formation) were deposited over most of the area. Along the coast, the upper Albian-middle Cenomanian interval is represented by shales and sandstones which suggest near-by sources at the time of deposition.

From the coast to the Marañón River, the upper Cenomanian is represented by 100-meter thick marls and shales (Romirón formation) with an extraordinarily rich molluscan fauna. The Romírón formation becomes more calcareous and less fossiliferous eastward; it seems that it was deposited under shallow waters and that along the Marañón axis, the sea was deeper.

The lower Turonian is represented by yellow, very fossiliferous shales along the coast (upper Quillquiña in Tembladera), by gray marl interbedded with massive beds of gray sublithographic limestone (Coñor formation) along the western Andes, and by thick-bedded, massive, gray limestones (Cajamarca formation) along the Marañón River and in central Peru. During this time, thick-bedded, poorly fossiliferous limestones tend to replace the fossiliferous marls. In late Turonian, thick-bedded, dark gray, lithographic limestones (Cajamarca formation) which carry mostly Foraminifera and gastropods were deposited over northern and central Peru. Occasional thin interbeds of argillaceous marl carry locally abundant mollusks and echinoids. During the Cretaceous the late Turonian was the time of maximum spread of the sea. It covered the whole Andean belt. It would seem that Marañonía was inconspicuous as a physiographic or structural feature. Apparently the thick-bedded limestones of the Cajamarca and Jumashá formations of the Andean belt change facies into the Chonta formation of eastern Peru, "of dark gray shale, with interbedded units of siltstone, calcareous siltstone and some limestone" (Kummel, 1948, p. 1240), which laps the border of the Brazilian craton.

By the early Coniacian, a marked change in the character of sedimentation took place. Instead of thick-bedded limestones, yellow shales and marls (Celendín formation), which carry a very rich molluscan fauna (both in terms of number of species and number of individuals), were deposited. These deposits are missing west of the continental divide, apparently beveled by an unconformity, although offlap may also be a cause. The seas had become shallow and reduced in extent; gypsum was deposited in localized areas.

By the late Santonian, in connection with the orogeny that affected the coastal areas, the western lands were being raised and pushing eastward, producing widespread emergence and the end of marine sedimentation in the Andean belt. The raised western lands were the source of thick red-bed flysch deposits (Chota formation) found over the western Andes.

Sometime during the late Senonian-early Tertiary an orogeny produced the folds and faults that dominate the structure of the western Andes. After this important orogenic period, new red-bed clastics (Pocobamba formation) were deposited, and considerable intrusive and extrusive igneous activity took place.

In Tertiary times, the Marañón geanticline was uplifted again and exposed pre-Mesozoic rocks to erosion, so that the Cordillera Central has abundant outcrops of pre-Cretaceous rocks, in contrast with the Cordillera Occidental where Cretaceous sediments and Tertiary volcanics are prevalent, and with the Cordillera Oriental where Cretaceous and Tertiary sediments are the most abundant.

Following a period of planation, the Andean system has been raised to form the present actively dissected, high plateau.
STRATIGRAPHIC SECTIONS

SECTION 1. LAJAS

Section measured along the south side of the Chotano River, from 500 meters west of El Ingenio to 500 meters west of the town of Lajas, 9 kilometers west of Chota.

CHOTA FORMATION

51. The lowest beds are of unconsolidated, coarse, strongly cross-bedded, yellowish and red quartz-sandstone. They are followed by conglomerates of quartzite and chalcedony cobbles in a red sandy matrix. Thickness estimated as over 100 meters.

DISCONFORMITY

CAJAMARCA FORMATION

50. Limestone, medium to light gray, sublithographic, thick-bedded, massive, with fossiliferous (Ostrea, Inoceramus, Hemiaster) marly interbeds ................................................. 57
49. Shale, bluish gray .......................................................... 12
48. Limestone, medium gray, lithographic, thick-bedded .......................................................... 12
47. Marl, bluish gray, nodular to shaly, fossiliferous, interbedded with thick-bedded, massive limestone .......................................................... 10
46. Limestone, slightly bituminous, medium to light gray, lithographic, massive, thick-bedded, with a few interbeds of bluish marl .......................................................... 87
45. Limestone, medium to dark gray, sublithographic, medium-bedded, with interbeds of splinter, poorly fossiliferous (Roudaisia intermedia, Cardium, Inoceramus, Hemiaster), medium gray, white-weathering marl .......................................................... 32

TOTAL, CAJAMARCA FORMATION: 210 meters

COÑOR FORMATION

44. Shale, brownish gray, soft, crumby ........................................ 30
43. Marl, light gray to yellowish gray, nodular, fossiliferous ................................. 4
42. Shale, brownish yellow to greenish gray, soft, fossiliferous (Coilopoceras jenksi), with a few interbeds of brownish yellow limestone ........................................ 20
41. Marl, light gray to white, laminated to nodular, weathers yellowish ................. 4
40. Shale, brownish yellow, soft, poorly exposed ........................................ 25
39. Marl, light gray nodular, shaly, fossiliferous ........................................ 4
38. Shale, bluish gray, laminated, interbedded with nodular, yellowish brown limestone ........................................ 12
37. Limestone, massive, gray, ridge-forming ........................................ 2
36. Marl, light bluish gray, nodular, fossiliferous ........................................ 19
35. Marl, light gray, nodular, shaly, interbedded with massive light gray limestone ........................................ 13
34. Marl, light gray, nodular, friable, fossiliferous (Coilopoceras jenksi, Hoplitoides inca) ........................................ 12
33. Marl, yellowish gray, slightly ferruginous, nodular, weathers brown, fossiliferous (Coilopoceras, Hoplitoides), with interbeds of thick-bedded, massive, fossiliferous (Orthopsis titicaca), light brown limestone ........................................ 12

TOTAL, COÑOR FORMATION: 157 meters

ROMIRÓN FORMATION

32. Shale, brownish to yellowish, friable, with thin interbeds of nodular, coquinoid, very fossiliferous (Exogyra olsiponensis), rusty, yellowish brown argillaceous limestone ........................................ 102

TOTAL, ROMIRÓN FORMATION: 102 meters

MUJARRÚN FORMATION

CULEBRA MEMBER

31. Marl, light gray, chalky, thin-bedded, nodular, soft, extraordinarily fossiliferous (Exogyra africana, Exogyra olsiponensis, other exogyroids, Neithia tenoukhnisi, Neithia alatus, Tetragramma sp., Orthopsis titicaca), weathers light gray to yellowish gray ........................................ 76

CHORO MEMBER

30. Limestone, gray to bluish gray, massive, very thick-bedded, slightly nodular, fossiliferous (Exogyra cf. ponderosa), weathers light gray, forms a scarp ........................................ 106
29. Limestone, argillaceous, light gray, nodular, thick-bedded, fossiliferous (E. cf. ponderosa), interbedded with massive, light bluish gray limestone .......................... 105

TOTAL, Mûtarrûn Formation: 287 meters

Yumaguall Formation
28. Marl, somewhat bituminous, soft, nodular, richly fossiliferous (Exogyra mermeti), interbedded with a few beds of massive, wavy-bedded, light gray, argillaceous limestone ...... 159
27. Limestone, medium to dark bluish gray, thick-bedded, massive, nodular, very fossiliferous (Parauritlites lewesiensis, E. mermeti), interbedded with very nodular, thin-bedded, soft, fossiliferous (rudistid debris), slightly bituminous marl ......................................... 76
26. Shale, calcareous, fossiliferous (Ostrea, Corbula) ........................................ 4
25. Limestone, argillaceous, medium to dark gray ............................................. 8
24. Limestone, dark gray, massive, hard, thick-bedded, weathers light yellowish gray .... 8
23. Marl, brownish gray, silty, very nodular, fossiliferous, interbedded with thick, massive beds of bluish gray, silty limestone ......................................................... 126
22. Shale, silty, brownish gray to light gray, nodular .......................................... 46
21. Marl, silty, yellowish and yellowish brown, nodular, interbedded with massive, medium-bedded, fossiliferous, gray-weathering argillaceous limestone .................. 111
20. Covered. Probably of soft marls ................................................................. 89

TOTAL, Yumaguall Formation: 627 Meters

Pariatambo Formation
19. Limestone, bituminous, black, massive, medium-bedded, platy, fossiliferous, weathers brownish black ................................................................. 40
18. Limestone, argillaceous, bituminous, black, thin-bedded, shaly, with interbeds of black, bituminous shale .......................................................... 60
17. Limestone, bituminous, black, massive, medium-bedded, slabby, fossiliferous, weathers dark grayish ................................................................. 161

TOTAL, Pariatambo Formation: 261 Meters

Chulec Formation
16. Marl, grayish to brownish, thin-bedded, shaly, fossiliferous (Knemiceras sp.), with few interbeds of massive, brownish gray to medium gray, fossiliferous limestone ................................................................. 255
15. Limestone, dark gray to black, medium-bedded, fossiliferous (Knemiceras, Corbula, Exogyra minos), with few shaly interbeds ........................................... 10
14. Covered. A few outcrops show a soft, bluish gray, calcareous shale ........................ 98
13. Limestone, argillaceous, gray, with interbeds of bluish gray, shaly marl ................ 15
12. Shale, black, splintery ................................................................. 21
11. Limestone, dark gray, fossiliferous (Paragonoceras pernodosum), weathers yellowish white ................................................................. 10
10. Limestone, slightly argillaceous, medium to dark gray, thin- to medium-bedded, fossiliferous (Lyelliceras lyelli, Exogyra minos, Liophista sp., Enallaster sp.), weathers yellowish white, with a few intercalations of yellowish marl ........................................ 65

TOTAL, Chulec Formation: 474 Meters

Inca Formation
9. Shale and quartz-siltstone, ferruginous, thin-bedded, poorly exposed ........................ 30
8. Limestone, arenaceous, dark gray, weathers yellowish brown, with interbeds of rusty, yellowish to brownish shale .................................................. 13
7. Quartz-siltstone, ferruginous, iron gray, massive, thick-bedded, weathers rusty brown ... 4
6. Shale, ferruginous, brownish to greenish, with interbeds of thick-bedded, rusty, yellow-weathering gray limestone ............................................. 13
5. Limestone, arenaceous, glauconitic, ferruginous, gray, thick-bedded, rusty ............ 7
4. Shale, bluish black, fossiliferous (Trigonia sp., Exogyra minos), with interbeds of massive, fossiliferous (Enallaster sp., Exogyra sp.), rusty dark gray limestone ................... 5
3. Shale, black to bluish gray, laminated, soft, with concretions of iron oxide, with interbeds of ferruginous, calcareous, fossiliferous, brownish yellow quartz-siltstone .............................. 16
2. Quartz-siltstone, white to yellowish brown, fine- to medium-bedded, with a few interbeds of shale ........................................... 11

1. Shale, ferruginous, slightly calcareous, bluish to black, fossiliferous (Plerolimnia tucamanna, Exogyra aquila), brown-weathering, with interbeds of massive, fossiliferous, thick-bedded, yellow-weathering, dark gray, arenaceous, ferruginous limestone .................................................. 15+

Total, Inca Formation: 114+ Meters

SECTION 2. BAMBARMA

Section measured from Quebrada Maigas, 2 kilometers west of Bambamarca, to the outskirts northwest of this town.

Chota Formation

24. Conglomerate of perfectly rounded cobbles of white quartzite in a scanty matrix of red sandstone ........................................... 500+

Total, Chota Formation: 500+ Meters

Disconformity

Celendín Formation

23. Shale, dark gray, yellow-weathering, with few calcareous interbeds, poorly exposed ........................................... 132

22. Shale, bluish black, laminated with few intercalations of nodular, fossiliferous (Desmophyllites gaudama, Bostrychoceras sp.), yellowish limestone ........................................... 41

21. Shale, bluish gray, laminated, soft, with thin interbeds of fossiliferous marl ........................................... 36

20. Marl, light gray, thin-bedded, weathers white ........................................... 41

19. Limestone, dark orange-gray, gray-weathering with interbeds of fossiliferous marl ........................................... 30

18. Shale, calcareous, light whitish gray, contains Hemiaster sp. ........................................... 21

17. Limestone, argillaceous, light gray, nodular, with intercalations of marl ........................................... 4

16. Shale, greenish yellow to brown, laminated, crumbly, with a few intercalations of massive, yellowish brown, argillaceous limestone ........................................... 13

15. Marl, nodular, very fossiliferous (Buchiceras bilobatum, Heteroistotia peroni, H. buckeri, Barroisiceras haberfellneri) ........................................... 9

14. Shale, yellowish brown, soft, with interbeds of massive, ledge-forming, gray limestone ........................................... 4

13. Marl, brownish yellow, slightly fossiliferous ........................................... 7

12. Limestone, very argillaceous, yellowish, nodular ........................................... 1

11. Shale, yellow ........................................... 3

Total, Celendín Formation: 348 Meters

Cajamarca Formation

10. Limestone, arenaceous, medium gray, massive, thick-bedded, contains Foraminifera, weathers dark gray ........................................... 6

9. Limestone, argillaceous, light brownish gray, nodular ........................................... 6

8. Limestone, light brownish gray, massive, thick-bedded, ridge-forming, weathers dark gray, contains Foraminifera and shell debris ........................................... 34

7. Marl, bluish gray, nodular to shaly ........................................... 13

6. Limestone, slightly argillaceous, massive, thick-bedded, weathers light gray ........................................... 46

5. Marl and calcareous shale, soft, bluish gray, fossiliferous (Coilococeras novelli) ........................................... 64

4. Limestone, light gray, massive, thick-bedded, weathers light gray, ridge forming ........................................... 18

3. Limestone, argillaceous, light brownish gray, white-weathering, with interbeds of laminated calcareous shale ........................................... 31

2. Shale, calcareous, bluish gray, nodular, richly fossiliferous (Coilococeras novelli, Lima sp., Cardium Iissoni, Hemiaster sp.) ........................................... 3

1. Limestone, dark gray, massive, thick-bedded, weathers to a red soil ........................................... 60+

Total, Cajamarca Formation: 281+ Meters

SECTION 3. HUALGAYOC

Section measured beginning in Quebrada Hualgayoc, 2 kilometers northeast of Hualgayoc, and ending in Yerba Santa, 7 kilometers southeast of Hualgayoc.
CELENDÍN FORMATION

53. Shale, light grayish blue, fossiliferous, with interbeds of thin, nodular marl .............. 60+
Total, CELENDÍN FORMATION: 60+ METERS

CAJAMARCA FORMATION

52. Limestone, medium brownish gray, sublithographic, massive, thick-bedded, weathers dark bluish gray .................. 70
51. Limestone, argillaceous, dark bluish gray, somewhat nodular, fossiliferous (*Ostrea* sp., *Inoceramus* sp.), with a few interbeds of massive limestone .................. 43
50. Shale, calcareous, bluish gray, splintery, soft, fossiliferous .................. 13
49. Marl, bluish gray, nodular, contains *Cooiopoceras newelli* .................. 10
48. Shale, calcareous, light bluish gray, splintery .................. 2
47. Limestone, medium gray to brownish gray, medium- to thick-bedded, weathers dark gray, with interbeds of light bluish gray, nodular, fossiliferous marl .................. 70
46. Shale, calcareous, light bluish gray, soft .................. 6
45. Limestone, medium brownish gray, sublithographic, massive, thick-bedded, with interbeds of nodular, splintery, light bluish gray, argillaceous limestone .................. 71
44. Marl, bluish gray, shaly, soft .................. 27
43. Limestone, argillaceous, light gray to light brownish gray, nodular, weathers light gray ........ 45
42. Limestone, light gray to light brownish gray, massive, sublithographic, medium- to thick-bedded, weathers medium gray .................. 123
41. Limestone, slightly argillaceous, medium gray, nodular, thin-bedded .................. 36
40. Limestone, light gray, lithographic, massive, thick-bedded, weathers whitish gray, with interbeds of laminated argillaceous limestone .................. 18
Total, CAJAMARCA FORMATION: 434 METERS

COÑOR FORMATION

39. Marl, light grayish blue, soft, splintery .................. 54
38. Limestone, gray, thick-bedded, weathers light gray ........ 9
37. Limestone, light gray, nodular, medium- to thick-bedded, weathers whitish blue ........ 27
Total, COÑOR FORMATION: 90 METERS

ROMIRÓN FORMATION

36. Shale and marl, yellowish brown, poorly exposed .................. 72

MUJARRÓN FORMATION

CULEBRA MEMBER

35. Marl, medium gray, soft, nodular, medium- to thick-bedded, fossiliferous (*Exogyra africana*), weathers light gray to grayish white .................. 69

CHORO MEMBER

34. Limestone, medium gray, massive, thick-bedded, fossiliferous (*Exogyra cf. ponderosa*), weathers light gray, with a few thin interbeds of nodular limestone .................. 194
Total, MUJARRÓN FORMATION: 263 METERS

YUMAGUAL FORMATION

33. Marl, light gray, very poorly exposed, interbedded with medium- to thick-bedded, fossiliferous (*Exogyra mermis*), dark gray limestone .................. 59
32. Limestone, bituminous, dark gray, thick-bedded, fossiliferous (*Ostrea scyphax*, echinoids), with chert nodules, interbedded with soft marls .................. 84
31. Marl, light gray, soft, nodular, thick-bedded, with interbeds of fossiliferous, massive, dark gray limestone which contains chert nodules .................. 163
30. Marl, light gray, nodular, poorly exposed, with interbeds of thick-bedded, massive, fossiliferous, cherty, brownish gray limestone .................. 30
29. Quartz-siltstone, calcareous, dark yellowish brown, cross-bedded, with a few interbeds of dark gray arenaceous limestone .................. 11
28. Limestone, medium gray to light gray, silty .................. 25
27. Quartz-sandstone, brownish yellow, medium- to fine-grained, thick-bedded ........................................ 3
26. Limestone, dark gray, massive, thick-bedded, with interbeds of fossiliferous (Ostrea scyphax), nodular, silty, argillaceous limestone .................................................. 196
25. Marl, light gray, soft, poorly exposed, with interbeds of massive, medium- to thick-bedded, fossiliferous (Ostrea sp., Exogyra sp.), medium gray, bituminous limestone which forms ledges between the marly beds ........................................ 189

**TOTAL, YUMAGUAL FORMATION: 760 METERS**

**PARIATAMBO FORMATION**

24. Limestone, bituminous, dark gray, massive, medium-bedded, fossiliferous (Oxytropidoceras carbonarium) ........................................ 74
23. Marl, bituminous, black, shaly ........................................ 15
22. Limestone, bituminous, black, massive, well-bedded, platy, fossiliferous (Oxytropidoceras sp.) ........................................ 15
21. Limestone, bituminous, black, medium- to thin-bedded, platy, fossiliferous (Oxytropidoceras sp. and Lycelliceras ulrichi), weathers medium gray ........................................ 9
20. Marl, bituminous, thin-bedded, soft, poorly exposed ........................................ 60

**TOTAL, PARIATAMBO FORMATION: 168 METERS**

**CHULEC FORMATION**

19. Marl, light gray, nodular to shaly, soft, poorly exposed ........................................ 40
18. Diorite dyke
17. Limestone, argillaceous, dark gray, shaly, splintery, weathers light gray; the upper part is covered ........................................ 30
16. Limestone, argillaceous, dark gray, thin-bedded to laminated, soft, poorly exposed, with interbeds of fossiliferous, dark gray, massive limestone ........................................ 32
15. Marl, light gray, shaly, splintery, poorly exposed ........................................ 106
14. Shale, bluish gray, laminated, weathers yellowish ........................................ 10
13. Marl, dark gray, splintery, weathers light gray ........................................ 4
12. Diorite dyke, 50 meters thick
11. Marl, grayish black, shaly, splintery, fossiliferous (Knemiceras sp., Liophista sp., Enalaster peruanus), weathers yellowish gray, with thick interbeds of massive, dark gray to black limestone ........................................ 60

**TOTAL, CHULEC FORMATION: 282 METERS**

**INCA FORMATION**

10. Quartz-sandstone, calcareous, ferruginous, olive green, fossiliferous (Trigonia sp., Exogyra minus) ........................................ 9
9. Shale, dark gray, laminated, weathers dark yellowish ........................................ 3
8. Quartz-sandstone, calcareous, ferruginous, greenish to reddish, hard, fine-grained, weathers dark brownish red, with thin interbeds of brown limestone ........................................ 9

(The section is interrupted here by a thick diorite sill, the base of which is already in the Goyllarisquisga formation.)

**GOYLLARISQUISGA FORMATION**

7. Quartz-sandstone, white to light gray, medium-grained, medium- to thick-bedded, weathers brownish red, interbedded with light gray to purple shale ........................................ 69
6. Diorite sill, 75 meters thick
5. Quartz-sandstone, white to yellowish gray, medium-grained, thick-bedded, weathers reddish brown, forms cliffs ........................................ 48
4. Quartz-sandstone, white to gray, medium-grained, medium- to thick-bedded, lenticular, weathers yellowish brown with interbeds of laminated, silty, micaceous, white shale ........................................ 65
3. Shale, slightly ferruginous, white to gray, soft, laminated, somewhat micaceous ........................................ 15
2. Quartz-sandstone, light brownish, with interbeds of whitish purple, laminated shale ........................................ 15
1. Quartz-sandstone, white to light brownish, medium-grained, very massive, compact, thick-bedded, with few intercalations of shale ........................................ 18+

**TOTAL, GOYLLARISQUISGA FORMATION: 230+ METERS**
Composite section (fig. 16); the lower Goyllarrisquisga formation was estimated along the road from Celendín to Balsas, 2 kilometers below Hacienda Limón; the rest of the section was measured from the northwestern outskirts of the town of Celendín (Quebrada Parapuquio) to Quebrada Meléndez, 500 meters north of Hacienda La Quinua and 6 kilometers northwest of Celendín. It includes the type of the Celendín formation.

<table>
<thead>
<tr>
<th>GYPSIANI</th>
<th>Lenticeras baltai zone</th>
<th>CHOTA FM. (151 m.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SANTONIAN</td>
<td>Buchiceras bilobatum zone</td>
<td>CELENDIN FM. (120 m.)</td>
</tr>
<tr>
<td>CONIAGIAN</td>
<td>Colopoceras newelli zone</td>
<td>GAJAMARCA FM. (302 m.)</td>
</tr>
<tr>
<td>TURONIAN</td>
<td>Colopoceras jencki zone</td>
<td>COÑOR FM. (144 m.)</td>
</tr>
<tr>
<td></td>
<td>Acanthoceras chasca zone</td>
<td>ROMIRON FM. (79 m.)</td>
</tr>
<tr>
<td></td>
<td>Exogyra africana zone</td>
<td></td>
</tr>
<tr>
<td>CENOMANIAN</td>
<td>Exogyra cf. ponderosa zone</td>
<td>PULLUICANA GROUP (undiff.) (1159 m.)</td>
</tr>
<tr>
<td></td>
<td>Paraturritilites lewesiensis zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ostrea scypha zone</td>
<td></td>
</tr>
<tr>
<td>ALBIAN</td>
<td>Oxytriodoceras carbonarium zone</td>
<td>CRISNEJAS FM. (410 m.)</td>
</tr>
<tr>
<td></td>
<td>Rhemiceras raimondi zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>?—— ?——</td>
<td></td>
</tr>
<tr>
<td>APTIAN</td>
<td></td>
<td>GOYLLARISQUISGA FM. (690 m.)</td>
</tr>
<tr>
<td></td>
<td>?—— ?——</td>
<td></td>
</tr>
<tr>
<td>NEOCULARIAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JURASSIC</td>
<td></td>
<td>PUGARA GROUP</td>
</tr>
</tbody>
</table>

**Fig. 16. Celendín stratigraphic section.**
### Chota Formation

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>74.</td>
<td>Quartz-sandstone and quartz-siltstone, light whitish gray, poorly consolidated, with few reddish interbeds</td>
<td>122+</td>
</tr>
<tr>
<td>73.</td>
<td>Shale and sandstone, red, soft; includes at the top a 90-centimeter thick conglomerate of perfectly rounded cobbles of quartzite</td>
<td>29</td>
</tr>
</tbody>
</table>

**Total, Chota Formation:** 151+ Meters

### Celendín Formation

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>72.</td>
<td>Shale, yellow, with a few thin, calcareous beds which contain Lenticeras baltei, Tissotia steinmanni, T. fournieri, Texanites bourgeri, Ostrea nicaisei, Lima gremieri</td>
<td>106</td>
</tr>
<tr>
<td>71.</td>
<td>Limestone, light brownish gray, massive, with a few interbeds of argillaceous, nodular limestone; weathers dark gray, contains alveolinellid Foraminifera, with thin interbeds of argillaceous, nodular limestone</td>
<td>60</td>
</tr>
<tr>
<td>70.</td>
<td>Marl, grayish white, packed with Hemiaris fournieri.</td>
<td>3</td>
</tr>
<tr>
<td>69.</td>
<td>Shale, calcareous, yellow and bluish gray, soft, friable, with thin interbeds of nodular, yellowish argillaceous limestone; contains Buchiceras bilobaum, Heterotissotia peroni, H. bucheri, Tissotia hedbergi, and several species of Barroisiceras</td>
<td>86</td>
</tr>
<tr>
<td>68.</td>
<td>Limestone, argillaceous, gray.</td>
<td>1</td>
</tr>
<tr>
<td>67.</td>
<td>Shale, yellow and silver gray</td>
<td>26</td>
</tr>
</tbody>
</table>

**Total, Celendín Formation:** 302 Meters

### Cajamarca Formation

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>66.</td>
<td>Limestone, gray, medium- to thick-bedded, weathers dark gray.</td>
<td>75</td>
</tr>
<tr>
<td>65.</td>
<td>Limestone, medium gray, lithographic, massive, medium- to thick-bedded, weathers dark gray</td>
<td>68</td>
</tr>
<tr>
<td>64.</td>
<td>Limestone, medium gray, thin- to medium-bedded, sublithographic, weathers dark gray</td>
<td>45</td>
</tr>
<tr>
<td>63.</td>
<td>Shale, splinterly, bluish gray.</td>
<td>4</td>
</tr>
<tr>
<td>62.</td>
<td>Limestone, medium gray, sublithographic, medium- to thick-bedded, weathers dark gray</td>
<td>14</td>
</tr>
<tr>
<td>61.</td>
<td>Limestone, medium gray, thin-bedded, somewhat nodular.</td>
<td>2</td>
</tr>
<tr>
<td>60.</td>
<td>Limestone, medium gray, massive, sublithographic, medium-bedded.</td>
<td>8</td>
</tr>
<tr>
<td>59.</td>
<td>Limestone, argillaceous, light bluish gray, nodular.</td>
<td>8</td>
</tr>
<tr>
<td>58.</td>
<td>Limestone, medium gray, sublithographic, medium- to thick-bedded, weathers dark gray</td>
<td>8</td>
</tr>
<tr>
<td>57.</td>
<td>Marl, medium bluish gray, shaly, splinterly.</td>
<td>9</td>
</tr>
<tr>
<td>56.</td>
<td>Limestone, brownish gray, sublithographic, massive, thick-bedded</td>
<td>5</td>
</tr>
</tbody>
</table>

**Total, Cajamarca Formation:** 246 Meters

### Coñor Formation

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>55.</td>
<td>Shale, yellow.</td>
<td>5</td>
</tr>
<tr>
<td>54.</td>
<td>Shale, yellow, with interbeds of light gray, fossiliferous limestone.</td>
<td>7</td>
</tr>
<tr>
<td>53.</td>
<td>Limestone, argillaceous, light gray, nodular, weathers whitish gray, contains Coilopoceras jenksii, Mammites aerif, and Hemiaris sp.</td>
<td>52</td>
</tr>
<tr>
<td>52.</td>
<td>Limestone, argillaceous, light gray, weathers dark gray, with thin interbeds of marl</td>
<td>80</td>
</tr>
</tbody>
</table>

**Total, Coñor Formation:** 144 Meters

### Romirón Formation

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.</td>
<td>Shale, greenish and yellowish gray, splinterly, laminated</td>
<td>20</td>
</tr>
<tr>
<td>50.</td>
<td>Limestone, argillaceous, yellowish brown, nodular, fossiliferous (Exogyra olistophoniensis)</td>
<td>1</td>
</tr>
<tr>
<td>49.</td>
<td>Shale, greenish gray, splinterly, soft, yellow-weathering, with interbeds of nodular, brown marl</td>
<td>7</td>
</tr>
<tr>
<td>48.</td>
<td>Marl, ferruginous, yellowish brown, nodular, interbedded with yellow, very fossiliferous (Acanthoceras chasca, A. sangalense, A. poliocensae, Forbesiceras sp., Neolobites kummei, Exogyra olistophoniensis) limestone</td>
<td>3</td>
</tr>
<tr>
<td>47.</td>
<td>Shale, light gray, splinterly.</td>
<td>3</td>
</tr>
<tr>
<td>46.</td>
<td>Shale, light grayish blue, laminated, splinterly, yellow-weathering, with thin interbeds of nodular, fossiliferous, iron-stained, argillaceous limestone</td>
<td>23</td>
</tr>
<tr>
<td>45.</td>
<td>Marl, yellowish, nodular, contains numerous specimens of Exogyra olistophoniensis</td>
<td>2</td>
</tr>
<tr>
<td>44.</td>
<td>Shale, light greenish yellow, laminated, fossiliferous (Lissoniceras merometi, Neolobites kum-</td>
<td>10</td>
</tr>
</tbody>
</table>
TOTAL, ROMIRÓN FORMATION: 79 METERS

PULLUCANA GROUP (UNDIFFERENTIATED)

43. Limestone, argillaceous, weathers grayish black ........................................ 10
42. Limestone, gray, massive, thick-bedded, karstic ............................................ 129
41. Shale, calcareous, yellow ............................................................................. 3
40. Limestone, argillaceous, gray, thick-bedded, karstic, contains Eogryra cf. ponderosa 68
39. Limestone, gray, karstic, weathers dark gray .................................................... 33
38. Limestone, dark gray, massive, thick-bedded, karstic, with poorly exposed interbeds of marl 290
37. Shale, calcareous, yellow to brown, fossiliferous (Eogryra mermeti) ................. 58
36. Limestone, brownish gray, massive, thick-bedded, weathers dark gray, with interbeds of marl 24
35. Shale and quartz-siltstone, yellow, soft ............................................................ 24
34. Limestone, gray-blue, massive, thick-bedded, with argillaceous interbeds ........... 15
33. Shale and quartz-siltstone, calcareous, yellow to brown, soft, with few interbeds of fossiliferous, brownish, argillaceous limestone .............................................. 59
32. Shale, calcareous, yellow, with interbeds of grayish, massive, fossiliferous (Ostrea scyphax) limestone .................................................................................. 29
31. Limestone, argillaceous, gray, soft, very fossiliferous (Enallaster sp., Bothriopygus sp.) 42
30. Quartz-siltstone, calcareous, yellow ................................................................. 5
29. Limestone, bluish gray, massive, thick-bedded .................................................... 19
28. Limestone and marl, bluish gray, thick-bedded .................................................... 20
27. Limestone, dark gray, massive, thick-bedded, weathers bluish gray ................. 78
26. Limestone, dark gray, massive, thick-bedded, with interbeds of soft, light gray marls 71
25. Limestone, gray, massive, karstic, thick-bedded, weathers bluish gray ............... 147
24. Marl, light gray, weathers yellowish white ...................................................... 9
23. Limestone, bluish gray, massive, ridge-forming, with few interbeds of marl ....... 26

TOTAL, PULLUCANA GROUP: 1159 METERS

CRISNEJAS FORMATION

22. Limestone, argillaceous, light gray, thin-bedded, yellowish-weathering, with interbeds of splintery, green to white shale ........................................ 6
21. Shale, brownish to yellowish, thin-bedded, crumbly ......................................... 7
20. Marl, light brown, slightly nodular, thin-bedded, very fossiliferous (Lyelliceras pseudolyelli, Knemiceras ovale, Enallaster sp.) .................... 1
19. Marl, light gray, splintery .............................................................................. 12
18. Limestone, dark gray, weathers light gray ...................................................... 2
17. Shale, calcareous, light greenish gray to yellow, splintery ............................... 55
16. Shale, calcareous, light gray, thin-bedded, soft, fossiliferous (Knemiceras sp.), with thick interbeds of dark gray, massive limestone 36
15. Shale, yellow, crumbly, with few interbeds of gray limestone ......................... 7
14. Marl, light greenish or brownish gray, thin-bedded, soft, interbedded with laminated, fossiliferous, gray limestone ................................................. 27
13. Shale, calcareous, light gray to yellowish, splintery, fossiliferous (Knemiceras sp., Liopistha gigantea) ................................................................. 3
12. Limestone, gray, nodular, contains limonitized echinoids (Enallaster sp.) .......... 3
11. Marl, light gray to yellowish, thin-bedded, soft, with interbeds of nodular, dark gray limestone ................................................................. 84
10. Limestone, dark gray, weathers light gray .................................................... 5
9. Shale, yellow, finely laminated, splintery, with thin interbeds of nodular, fossiliferous (Parengonoceras ponerosum, P. tetranodosum, P. haasi, Knemiceras attenuatum, Protoniscoceras blanckei), dark brownish limestone ........................................ 62
8. Shale, light gray, with interbeds of gray limestone ........................................... 7
7. Shale, light gray to yellowish, crumbly ............................................................ 15
1956  

BENAVIDES: CRETACEOUS SYSTEM IN PERU  

409  

6. Marl, yellow, shaly, soft, with interbeds of bluish gray, rusty-weathering arenaceous limestone ........................................ 19
5. Marl, light gray ........................................................................ 4
4. Shale, gray, finely laminated, soft, brownish-weathering, with thick interbeds of massive, iron-stained, grayish brown, highly fossiliferous (*Plerotrignina tocaimaena, Yaadia hondaruma, Buchoiragnia abrupta, Knemiceras raimondii pacificum, K. gabbi, Enallaster perusus, Holecarypus planatus numismakii, Bothriopygs sp.*) limestone ................................................................. 29
3. Shale and quartz-siltstone, brownish gray, finely bedded, crumbly, poorly fossiliferous, with few interbeds of quartz-sandstone .................................................. 26

**Total, Crisnejas Formation: 410 Meters**

**GOYLLARISQUISGA FORMATION**

2. Quartz-sandstone, white to gray, coarse-grained to pebbly, thick-bedded, cross-bedded, weathers rusty red to yellowish brown, has interbeds of carbonateous shale ................................................................................... 650
1. Conglomerate; ill-assorted subrounded pebbles and cobbles of dark gray limestone in a chocolate-red, calcareous quartz-sandstone matrix .................................................. 40

**Total, Goyllarquisga Formation: 690 Meters**

**UNCONFORMITY**

**JURASSIC**

**FUCARÁ GROUP**

Limestone, medium gray, thick-bedded

**SECTION 5. POLLOC**

Section measured from 1 kilometer west of Hacienda Polloc to Hacienda Sangal, 4 kilometers west of Encañada, on the Cajamarca to Celendín road.

**CELEDÍN FORMATION**

75. Shale, slightly calcareous, green to bluish gray, splintery, very fossiliferous (*Heterotissia peroni, H. bucheri, Barroisiceras mite, Buchiceras bilobatum*), with thin interbeds of fossiliferous marl ........................................................................................................... 30+
74. Limestone, purple gray, massive ........................................................................ 2
73. Shale, slightly calcareous, grayish green ................................................................. 22

**Total, Celedín Formation: 54+ Meters**

**CAJAMARCA FORMATION**

72. Marl, light gray ............................................................................. 48
71. Limestone, argillaceous, weathers gray blue ....................................................... 47
70. Limestone, gray, thick-bedded, massive .................................................................. 22
69. Limestone, gray, medium to thick-bedded, slabby ................................................ 78
68. Limestone, massive, weathers dark gray .............................................................. 1
67. Limestone, argillaceous, finely bedded, somewhat nodular, weathers dark gray ...................................................................................................................... 5
66. Shale, greenish gray, splintery, finely laminated, fossiliferous (*Coloparcas newelli, Cardium lissoni, Tetragramma sp.*) .................................................................................. 6
65. Marl, light brownish gray, white-weathering, nodular, fossiliferous (*Inoceramus sp., Ostrea sp., Coloparcas newelli, Tetragramma sp.*) .................................................. 7
64. Limestone, light brownish gray, medium- to thin-bedded or even laminated, with interbeds of silty and argillaceous limestone ........................................................................ 316
63. Limestone, light brownish gray, lithographic, thick-bedded, massive, karstic, contains large gastropods ................................................................. 116
62. Limestone, argillaceous, slightly nodular .............................................................. 4
61. Limestone, slightly argillaceous, gray, massive, fossiliferous (gastropods) ............ 10
60. Limestone, light gray, massive, thick-bedded, weathers dark bluish gray ............ 9
59. Limestone, argillaceous, light bluish gray .............................................................. 30

**Total, Cajamarca Formation: 699 Meters**
CONOR FORMATION

58. Shale, greenish and bluish gray, splintery, very fossiliferous (Cotilopoceras Jenksi, Plicatuloplecten ferryi) ........................................... 10
57. Shale, gray, weathers yellow .................................................................. 15
56. Marl, gray, splintery, weathers light gray ............................................. 10
55. Marl, yellow and green, fossiliferous (Cotilopoceras Jenksi, Hoplitoides inc, Hemia ster sp., Inoceramus sp.) ................................................... 13
54. Shale, brownish and greenish gray .......................................................... 4
53. Limestone, light bluish gray, massive .................................................... 7
52. Shale, calcareous, dark green to bluish, friable ...................................... 8
51. Marl, gray blue and yellow, nodular, fossiliferous (Cotilopoceras Jenksi, Hemia ster sp.), with some green and yellow shale interbeds. 8
50. Limestone, very argillaceous, light gray .................................................. 2
49. Limestone, gray-blue, massive ............................................................... 2
48. Marl, yellow, very fossiliferous ............................................................... 2
47. Limestone, argillaceous, gray, nodular, weathers light gray to yellowish, with interbeds of massive, brownish gray limestone 18
46. Limestone, purple-gray, massive, thick-bedded, fossiliferous, weathers blue-gray ................................................................. 48
Total, ComoR Formation: 147 Meters

ROMIRON FORMATION

45. Limestone, dark gray, massive, with interbeds of green, splintery shale .... 12
44. Shale, dark brown, laminated, crumbly, fossiliferous ................................ 8
43. Shale, green, brown, or yellow, laminated, soft, friable, with thin interbeds of nodular, richly fossiliferous (Acanthoceras sp., Lissoniceras mermeti, Exogyra olisiponensis, Exogyra polygona), iron-stained, yellowish and brownish argillaceous limestone .... 46
Total, Romiron Formation: 66 Meters

MUJARRUN FORMATION

CULEBRA MEMBER

42. Limestone, very argillaceous; the top is a coarsely nodular surface ......... 11
41. Limestone, gray, massive, thick-bedded, weathers dark gray ............... 25
40. Limestone, argillaceous, white, laminated ........................................... 2
39. Limestone, very argillaceous, gray, nodular ........................................ 45
38. Marl, light gray, weathers white .......................................................... 3
Total, Culebra Member: 86 Meters

CHORO MEMBER

37. Limestone, gray, nodular, fossiliferous (Exogyra cf. ponderosa), weathers light gray ................................................................. 65
36. Limestone, gray, laminated ................................................................. 9
35. Shale, white to yellowish, with interbeds of gray massive limestone .... 12
34. Limestone, gray, laminated ................................................................. 10
33. Limestone, silty, white, friable, laminated ........................................... 10
32. Limestone, argillaceous, gray, nodular, weathers light gray .............. 25
31. Limestone, bluish gray, massive, thick-bedded, ridge-forming ................ 32
30. Limestone, grayish blue, massive, thick-bedded, fossiliferous (Exogyra cf. ponderosa), contains chert nodules. Ten meters above the base, there is a 20-centimeter thick bed of dark chert ......................................................... 63
Total, Choro Member: 221 Meters
Total, Mujarrun Formation: 307 Meters

YUMAGUAL FORMATION

29. Limestone, argillaceous, gray, nodular, weathers white ....................... 132
28. Shale, green, laminated ........................................................................ 2
27. Limestone, argillaceous, gray, thick-bedded, weathers white ............. 6
26. Shale, green, finely bedded ................................................................. 2
25. Limestone, very argillaceous, marly, nodular, fossiliferous (Exogyra mermeti) ................................................................. 204
24. Quartz-sandstone, light gray to white, medium-grained, cross-bedded, friable, yellow-weathering, includes thin beds of dark chert ................................................................. 5
23. Shale, quartz-siltstone, and quartz-sandstone, soft, yellowish-weathering; the sandstone is cross-bedded .......................................................... 71
22. Limestone, argillaceous, very fossiliferous ......................................................... 2
21. Shale, quartz-siltstone and quartz-sandstone, finely interbedded ...................... 32
20. Limestone, gray, very fossiliferous (Ostrea scyphae) ......................................... 1
19. Shale, yellow, finely laminated ........................................................................... 30
18. Limestone, dark brownish, nodular, fossiliferous (Ostrea scyphae), weathers bluish gray 15
17. Quartz-siltstone, yellow, finely laminated ....................................................... 30
16. Limestone, bluish gray, thick-bedded, fossiliferous (Ostrea scyphae, Trigonia sp.), with chert nodules and a few interbeds of yellow shale 8
15. Shale, silty, yellow, laminated, contains Lingula .................................................. 6
14. Limestone, gray, massive ..................................................................................... 2
13. Shale, black, thin-bedded, with some interbeds of nodular limestone ............... 8
12. Limestone, gray, nodular, thick-bedded .............................................................. 2

Total, Yumagual Formation: 538 Meters

Pariatambo Formation

11. Limestone, slightly bituminous, yellowish and brownish, finely interbedded with grayish black, slightly bituminous shale ........................................... 152

Total, Pariatambo Formation: 152 Meters

Chuléc Formation

10. Limestone, gray, thin - to medium-bedded, nodular .......................................... 47
9. Limestone, bluish gray, massive, with interbeds of light gray, medium - to thin-bedded, nodular, soft marl and limestone .............................................. 125
8. Shale, bluish black, splintering ............................................................................. 9
7. Marl, yellow, massive ............................................................................................ 3
6. Shale, blue-gray, laminated ................................................................................... 23
5. Limestone, black, thick-bedded, massive, weathers bluish gray, with interbeds of brownish yellow, laminated, soft marl ............................................. 25
4. Shale, brownish, with interbeds of nodular, rusty, argillaceous limestone .......... 25
3. Limestone, bluish gray, massive, thick-bedded, fossiliferous, weathers dark gray 7
2. Marl, brownish yellow, laminated, very fossiliferous (Knemiceras sp., Enallaster peruianus), with interbeds of nodular, ledge-forming, brownish limestone 49
1. Marl, brownish gray, laminated ............................................................................. 17+

Total, Chuléc Formation: 330+ Meters

SECTION 5. CAJAMARCA

Section (fig. 17) measured from 500 meters north of Baños del Inc, 6 kilometers west of the city of Cajamarca, to Quebrada Otuco, 8 kilometers northeast of Cajamarca. It includes the types of the Inca, Yumagual, Mujarrún, Romirón, Coñor, and Cajamarca formations.

Celendín Formation

146. Limestone, slightly argillaceous, gray, medium-bedded .................................... 10+
145. Shale, calcareous, yellowish white, fossiliferous (great numbers of Hemiacaster fourneli) .......................................................... 20
144. Shale, calcareous, yellow, crumbly, richly fossiliferous (Buchiceras bilobatum, Heterotissotia peroni, H. bucheri, several species of Barroisiceras) ......................................................... 61

Total, Celendín Formation: 91+ Meters

Cajamarca Formation

143. Limestone, argillaceous, yellowish gray, nodular ............................................. 39
142. Limestone, dark gray, very massive, thick-bedded ............................................. 169
141. Shale, brownish yellow, crumbly, fossiliferous (Coitopoceras newelli) .............. 10
FIG. 17. Cajamarca stratigraphic section.
<table>
<thead>
<tr>
<th>Formation</th>
<th>Description</th>
<th>Thickness (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coşor Formation</td>
<td>Limestone, light gray, splintery, friable</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Shale, yellowish to light gray, friable, fossiliferous</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Total, Coşor Formation: 61 Meters</td>
<td></td>
</tr>
<tr>
<td>Romirón Formation</td>
<td>Limestone, argillaceous, nodular, thick-bedded, with thick interbeds of light gray, chalky, very fossiliferous</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Total, Romirón Formation: 83 Meters</td>
<td></td>
</tr>
<tr>
<td>Mujarrún Formation</td>
<td>Limestone, argillaceous, nodular, light gray, fossiliferous, with interbeds of gray marl</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Total, Culebra Member: 105 Meters</td>
<td></td>
</tr>
<tr>
<td>Choro Member</td>
<td>Limestone, dark bluish gray, thick-bedded, ledge-forming, massive</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total, Choro Member: 190 Meters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total, Mujarrún Formation: 295 Meters</td>
<td></td>
</tr>
<tr>
<td>Yumagual Formation</td>
<td>Limestone, very argillaceous, shaly, wavy-bedded, nodular, fossiliferous</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Total, Yumagual Formation: 21 Meters</td>
<td></td>
</tr>
</tbody>
</table>
110. Limestone, dark gray, nodular, massive, thick-bedded, with interbeds of argillaceous, chalky, coquinoid (E. mermeti), soft limestone .......................... 10

109. Shale, calcareous, light brown ......................................................................... 22

108. Limestone, very argillaceous, light gray to light brownish gray, wavy-bedded to nodular, fossiliferous .......................................................... 15

107. Limestone, gray, massive, thick-bedded, nodular ........................................... 5

106. Limestone, very argillaceous, marly, light brownish gray, soft, some beds are almost coquinas of E. mermeti ....................................................... 19

105. Limestone, dark gray, thick-bedded, massive, with interbeds of soft, nodular, marly, fossiliferous (E. mermeti), argillaceous limestone ......................... 40

104. Limestone, argillaceous, soft, yellowish green to whitish gray, with thin interbeds of compact limestone ................................................................. 3

103. Limestone, dark gray, nodular, massive, with interbeds of light gray, soft, coquinoid (E. mermeti) marl ................................................................. 15

102. Limestone, grayish black, nodular, fossiliferous ............................................ 154

101. Limestone, dark gray, massive, thick-bedded, nodular, with interbeds of fossiliferous (Engonoceras sp. indet., Exogyra mermeti), argillaceous limestone .................. 46

100. Limestone, dark gray, with intercalations of chert ........................................ 3

99. Limestone, argillaceous, nodular, wavy-bedded ............................................. 7

98. Shale, black to brown, laminated, splintery ..................................................... 16

97. Limestone, argillaceous, brownish, thin-bedded, soft, with a thin bed of brownish green phosphate at the top ......................................................... 11

96. Limestone, argillaceous, brownish gray, thick-bedded, weathers yellow .......... 4

95. Limestone, argillaceous, marly, shaly, light gray to grayish yellow, soft, with few intercalations of compact, dark gray limestone ........................................ 14

94. Limestone, silty, light gray, wavy-bedded to nodular, with coquinoid beds of Ostrea scyphax ................................................................. 14

93. Limestone, very argillaceous, chalky, nodular, grayish yellow, soft, very fossiliferous ................................................................. 18

92. Limestone, light gray, nodular, thick-bedded with few interbeds of argillaceous limestone ................................................................. 12

91. Quartz-siltstone, calcareous, brownish yellow, interbedded with fossiliferous, light gray limestone ................................................................. 10

90. Limestone, gray, wavy-bedded, fossiliferous (Ostrea scyphax, Oxytropidoceras sp.) 30

89. Limestone, argillaceous, dark gray, nodular, with interbeds of black and brown, soft shale ................................................................. 23

**Total, Yumagual Formation: 546 Meters**

**Pariatambo Formation**

88. Limestone, grayish black, blocky, hard, medium-bedded, with thin intercalations of chert ................................................................. 17

87. Limestone, bituminous, dark gray, thin-bedded, fossiliferous (Dipoloceras sp.), with interbeds of black to yellowish brown, calcareous and bituminous shale .......................... 62

86. Shale, calcareous, bituminous, black, thin-bedded, with interbeds of compact, black limestone .................................................................................. 15

85. Limestone, bituminous, gray, massive, shaly, concretionary, fossiliferous (Oxytropidoceras carbonarium, Venezoliceras veneolanum), bituminous marl ........................................ 16

84. Shale, dark gray, bituminous, thin-bedded, fossiliferous (O. carbonarium, Lyellliceras ulrichi, Inoceramus concentricus) ......................................................... 8

83. Limestone, bituminous, dark gray, massive, fossiliferous ................................ 2

82. Limestone, slightly argillaceous, bituminous, dark yellowish brown, blocky, thin-bedded, with few intercalations of dark brownish gray calcareous shale .......................... 12

81. Limestone, strongly petroliferous, dark gray, thick-bedded, massive, sparsely fossiliferous ................................................................. 5

**Total, Pariatambo Formation: 137 Meters**

**Chulec Formation**

80. Limestone, dark gray, massive, thin-bedded, with interbeds of calcareous shale .......................... 8

79. Shale, calcareous, brownish yellow, laminated, with interbeds of nodular, gray limestone ................................................................. 25

78. Limestone, compact, medium-bedded ............................................................. 21

77. Covered; apparently it is soft marl. The interval is occupied by the Quebrada Pullucicana ................................................................. 111
<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>Limestone, argillaceous, shaly, nodular, thin-bedded, weathers greenish white</td>
<td>36</td>
</tr>
<tr>
<td>75</td>
<td>Limestone, argillaceous, fossiliferous <em>(Exogyra aquila, Liopitha gigantea)</em></td>
<td>4</td>
</tr>
<tr>
<td>74</td>
<td>Limestone, argillaceous, dark gray, thin-bedded, somewhat nodular, fossiliferous <em>(Knemiceras sp., Parengonoceras sp., Liopitha gigantea)</em> , with interbeds of yellowish white, crumbly, calcareous shale</td>
<td>41</td>
</tr>
<tr>
<td>73</td>
<td>Limestone, dark gray, massive, weathers bluish gray</td>
<td>3</td>
</tr>
<tr>
<td>72</td>
<td>Limestone, argillaceous, marly, dark gray, nodular, thin-bedded, weathers white, with few interbeds of compact, gray limestone</td>
<td>22</td>
</tr>
<tr>
<td>71</td>
<td>Shale, calcareous, greenish and whitish gray, soft, fossiliferous <em>(Knemiceras syriacum, Parengonoceras guadaloupaforme, Liopitha gigantea)</em>, with a few interbeds of massive limestone</td>
<td>17</td>
</tr>
<tr>
<td>70</td>
<td>Shale, purple-red to yellowish, laminated, splintery, fossiliferous <em>(Knemiceras attenuatum, K. raimondii)</em>, with thin interbeds of nodular, yellowish brown, argillaceous limestone</td>
<td>20</td>
</tr>
<tr>
<td>69</td>
<td>Shale, calcareous, laminated, splintery, purple-red to greenish, fossiliferous</td>
<td>32</td>
</tr>
<tr>
<td>68</td>
<td>Limestone, very argillaceous, dark brownish gray, nodular, thin-bedded, fossiliferous <em>(Knemiceras sp., gastropods)</em>, weathers white</td>
<td>7</td>
</tr>
<tr>
<td>67</td>
<td>Shale, calcareous, black to dark brown, laminated, fossiliferous</td>
<td>15</td>
</tr>
<tr>
<td>66</td>
<td>Limestone, argillaceous, dark gray, nodular, thin-bedded, fossiliferous, weathers white</td>
<td>19</td>
</tr>
<tr>
<td>65</td>
<td>Marl, chalky, thin-bedded, with thin interbeds of nodular, dark gray shale</td>
<td>27</td>
</tr>
<tr>
<td>64</td>
<td>Limestone, argillaceous, nodular, with a few interbeds of massive, dark gray limestone</td>
<td>11</td>
</tr>
<tr>
<td>63</td>
<td>Limestone, argillaceous, chalky, with interbeds of calcareous shale</td>
<td>13</td>
</tr>
<tr>
<td>62</td>
<td>Marl, chalky, thin-bedded, nodular, weathers white, with thin interbeds of dark gray limestone</td>
<td>29</td>
</tr>
<tr>
<td>61</td>
<td>Marl, dark greenish gray, soft, splintery, fossiliferous, with few intercalations of brownish gray, massive, rusty, ledge-forming limestone</td>
<td>93</td>
</tr>
<tr>
<td>60</td>
<td>Limestone, argillaceous, chalky, yellowish gray</td>
<td>7</td>
</tr>
<tr>
<td>59</td>
<td>Marl, yellowish to brownish, splintery, thin-bedded, soft, fossiliferous</td>
<td>11</td>
</tr>
<tr>
<td>58</td>
<td>Limestone, yellowish brown to brownish gray, massive, thick-bedded, very fossiliferous <em>(Knemiceras raimondii, K. attenuatum, Parengonoceras sp., Prolyelliceras peruvianum, Dowvilleceras monile)</em></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td><strong>Total, Chulce Formation:</strong> 577 Meters</td>
<td></td>
</tr>
<tr>
<td><strong>Inca Formation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Limestone, rusty brown, massive, with interbeds of soft, yellowish brown shale</td>
<td>17</td>
</tr>
<tr>
<td>56</td>
<td>Quartz-siltstone, ferruginous, dark brown, with interbeds of calcareous, ferruginous shale and quartz-sandstone</td>
<td>10</td>
</tr>
<tr>
<td>55</td>
<td>Limestone, greenish brown, fossiliferous, with interbeds of calcareous, ferruginous shale</td>
<td>7</td>
</tr>
<tr>
<td>54</td>
<td>Quartz-siltstone, ferruginous, brownish red</td>
<td>5</td>
</tr>
<tr>
<td>53</td>
<td>Limestone, gray, arenaceous</td>
<td>4</td>
</tr>
<tr>
<td>52</td>
<td>Limestone, reddish brown, arenaceous, with interbeds of soft, fossiliferous, yellowish brown marl and shale</td>
<td>10</td>
</tr>
<tr>
<td>51</td>
<td>Shale, yellowish to greenish brown, splintery, with thin interbeds of ferruginous quartz-siltstone</td>
<td>7</td>
</tr>
<tr>
<td>50</td>
<td>Limestone, gray, slightly nodular, fossiliferous <em>(Parahoplites quilla, Pierotrignoria tocaina, Buchotrigonia abrupta, Yaadia homdaana, Ptychonia robinaldina)</em></td>
<td>2</td>
</tr>
<tr>
<td>49</td>
<td>Marl, ferruginous, rusty yellow</td>
<td>1</td>
</tr>
<tr>
<td>48</td>
<td>Limestone, arenaceous, oolitic, rusty brown, very fossiliferous <em>(Exogyra aquila)</em></td>
<td>1</td>
</tr>
<tr>
<td>47</td>
<td>Marl, ferruginous, with interbeds of quartz-siltstone</td>
<td>10</td>
</tr>
<tr>
<td>46</td>
<td>Limestone, arenaceous, rusty brown, glauconitic, ferruginous, thick-bedded</td>
<td>4</td>
</tr>
<tr>
<td>45</td>
<td>Conglomerate of angular cobbles of brownish gray limestone in a ferruginous, rusty brown, calcareous matrix</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>Total, Inca Formation:</strong> 80 Meters</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Disconformity</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Goyllarisquisga Formation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Shale, light gray, soft, interbedded with a white, hard quartz-sandstone</td>
<td>30</td>
</tr>
<tr>
<td>43</td>
<td>Quartz-siltstone, light gray, with interbeds of cross-bedded quartz-sandstone</td>
<td>11</td>
</tr>
<tr>
<td>No.</td>
<td>Description</td>
<td>Thickness (Meters)</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>24.</td>
<td>Covered; probably of soft shale.</td>
<td>160</td>
</tr>
<tr>
<td>23.</td>
<td>Quartz-sandstone, white to yellow, cross-bedded</td>
<td>9</td>
</tr>
<tr>
<td>22.</td>
<td>Shale, yellow, soft</td>
<td>9</td>
</tr>
<tr>
<td>21.</td>
<td>Quartz-sandstone, white</td>
<td>2</td>
</tr>
<tr>
<td>20.</td>
<td>Shale, bluish to purple, soft</td>
<td>37</td>
</tr>
<tr>
<td>19.</td>
<td>Quartz-siltstone, yellowish brown, with a few interbeds of quartz-sandstone</td>
<td>6</td>
</tr>
<tr>
<td>18.</td>
<td>Shale, yellowish to greenish, thin-bedded, soft</td>
<td>12</td>
</tr>
<tr>
<td>17.</td>
<td>Quartz-siltstone, yellowish brown to reddish white, medium-grained, cross-bedded, soft</td>
<td>6</td>
</tr>
<tr>
<td>16.</td>
<td>Shale, varicolored, soft, with a few thin interbeds of micaceous, pale red, quartz-siltstone</td>
<td>12</td>
</tr>
<tr>
<td>15.</td>
<td>Quartz-sandstone, white to yellowish brown, medium-grained, cross-bedded, lenticular, contains plant remains</td>
<td>21</td>
</tr>
<tr>
<td>14.</td>
<td>Shale, yellowish to reddish, soft, with thin intercalations of rusty quartz-siltstone</td>
<td>21</td>
</tr>
<tr>
<td>13.</td>
<td>Quartz-sandstone, reddish, cross-bedded, lenticular, medium-bedded, massive</td>
<td>16</td>
</tr>
<tr>
<td>12.</td>
<td>Shale, yellow to dark red, soft, contains plant remains, with interbeds of white, cross-bedded quartz-siltstone</td>
<td>44</td>
</tr>
<tr>
<td>11.</td>
<td>Quartz-sandstone, white to yellowish, contains plant remains, forms a ridge</td>
<td>7</td>
</tr>
<tr>
<td>10.</td>
<td>Shale, dark yellow to brownish gray, slightly calcareous, contains plant remains, with a few interbeds of quartz-siltstone</td>
<td>27</td>
</tr>
<tr>
<td>9.</td>
<td>Shale, varicolored, soft, with thin intercalations of iron oxide.</td>
<td>24</td>
</tr>
<tr>
<td>8.</td>
<td>Quartz-sandstone, white to brownish, medium-grained, cross-bedded, lenticular, weathered rusty brown</td>
<td>5</td>
</tr>
<tr>
<td>7.</td>
<td>Shale, varicolored, soft, crumbly, contains plant remains, with interbeds of ferruginous quartz-sandstone</td>
<td>38</td>
</tr>
<tr>
<td>6.</td>
<td>Quartz-sandstone, calcareous, white to brownish, medium-grained, cross-bedded</td>
<td>12</td>
</tr>
<tr>
<td>5.</td>
<td>Shale, whitish gray to purple, soft, with interbeds of calcareous quartz-sandstone</td>
<td>27</td>
</tr>
<tr>
<td>4.</td>
<td>Shale, varicolored, soft</td>
<td>7</td>
</tr>
<tr>
<td>3.</td>
<td>Quartz-siltstone, slightly calcareous, brownish, cross-bedded, thin- to medium-bedded, with oscillation ripple marks, fossiliferous (Paraglauconia strombiformis), with interbeds of fossiliferous (plant remains) shale</td>
<td>18</td>
</tr>
<tr>
<td>2.</td>
<td>Shale, varicolored, soft, thin-bedded, concretionary, fossiliferous (fresh-water gastropods and pelecypods)</td>
<td>18</td>
</tr>
</tbody>
</table>

**TOTAL, GOYLLARISQUISGA FORMATION: 578 METERS**
1. Shale, light gray to purplish gray, soft, thin-bedded, contains badly preserved plant remains, and fresh-water gastropods, has a few interbeds of rusty, calcareous quartz-sandstone. Total, Carhuan Formation: 556+ Meters

SECTION 7. TEMBLADERA

Composite section (fig. 18); the lower Goyllarisquisga formation was measured just north of Monte Grande, 45 kilometers northeast of Pacasmayo, on the Cajamarca to Trujillo road. The rest of the section was measured from 6 kilometers north of Tembladera to the outskirts north of this place. Tembladera is on the north side of the Jequetepeque River, 5 kilometers east of Monte Grande.

Cajamarca Formation

29. Limestone, grayish black, massive, thick-bedded, weathers light gray 74
28. Limestone, grayish black, thin- to medium-bedded, fossiliferous (*Ostrea* sp.), weathers light gray 37
Total, Cajamarca Formation: 111 Meters

---

**Fig. 18. Tembladera stratigraphic section.**
**Quillquisan Group**

<table>
<thead>
<tr>
<th>Beds</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>27. Marl, nodular, grayish green, fossiliferous (<em>Coiloceras jenkinsi</em>, <em>Pseudoaspidoceras reesidei</em>, <em>Inoceramus labiatus</em>, <em>Exogyra</em> sp., <em>Hemiaspides fournieri</em>), interbedded with yellowish white, soft shale</td>
<td>45</td>
</tr>
<tr>
<td>26. Shale, orange-brown, laminated, with thin interbeds of greenish brown quartz-siltstone</td>
<td>30</td>
</tr>
<tr>
<td>25. Marl, orange-yellow, nodular, with interbeds of dark gray limestone</td>
<td>30</td>
</tr>
<tr>
<td>24. Shale, yellow, laminated, soft, with interbeds of dark gray, richly fossiliferous (<em>Broggiiceratites humboldti, B. olssoni, Thomasites fischeri</em>), slightly silty limestone</td>
<td>33</td>
</tr>
<tr>
<td>23. Shale, pale greenish yellow, crumbly, with thin interbeds of blocky, fossiliferous, gray limestone</td>
<td>22</td>
</tr>
<tr>
<td>22. Shale, yellow, friable, thick-bedded, with interbeds of nodular, fossiliferous (<em>Exogyra africana, E. olisiponensis</em>), light gray limestone</td>
<td>121</td>
</tr>
</tbody>
</table>

Total, Quillquisan Group: 281 Meters

**Unnamed Beds**

<table>
<thead>
<tr>
<th>Beds</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. Shale, light gray to yellow, thick-bedded, with interbeds of bluish black limestone</td>
<td>91</td>
</tr>
<tr>
<td>20. Shale, yellow, laminated, crumbly</td>
<td>19</td>
</tr>
<tr>
<td>19. Limestone, black, massive, weathers light gray, with interbeds of light gray quartz-siltstone</td>
<td>30</td>
</tr>
<tr>
<td>18. Quartz-siltstone, silicified, white to yellowish brown, laminated, with interbeds of shale</td>
<td>100</td>
</tr>
<tr>
<td>17. Quartz-sandstone, silicified, reddish, massive, thick-bedded</td>
<td>15</td>
</tr>
<tr>
<td>16. Quartz-siltstone, white to yellowish brown, laminated, crumbly, with interbeds of shale</td>
<td>91</td>
</tr>
<tr>
<td>15. Quartz-sandstone, brownish, silicified</td>
<td>65</td>
</tr>
<tr>
<td>14. Limestone, black, massive, thick-bedded, weathers dark gray</td>
<td>4</td>
</tr>
<tr>
<td>13. Shale, yellow to light brown, laminated, crumbly, soft</td>
<td>269</td>
</tr>
</tbody>
</table>

Total, Unnamed Beds: 684 Meters

**Unnamed Beds**

<table>
<thead>
<tr>
<th>Beds</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Limestone, black, massive, thick-bedded, with silicified interbeds</td>
<td>426</td>
</tr>
<tr>
<td>11. Limestone, black to gray, thin-bedded to laminated, weathers light gray</td>
<td>130</td>
</tr>
<tr>
<td>10. Limestone, black to gray, massive, thick-bedded, fossiliferous (<em>Exogyra minos, Trigonoicarpa</em> sp., <em>Cucullaea</em> sp.), weathers brownish gray, has silicified interbeds</td>
<td>159</td>
</tr>
</tbody>
</table>

Total, Unnamed Beds: 715 Meters

**Goyllarisquisa Formation**

<table>
<thead>
<tr>
<th>Beds</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Quartz-siltstone and shale, brick-red, laminated</td>
<td>25</td>
</tr>
<tr>
<td>8. Quartz-siltstone and quartz-sandstone, white to light brown, thick-bedded, with a few thin intercalations of shale</td>
<td>87</td>
</tr>
<tr>
<td>7. Quartz-sandstone, white to brownish, medium-grained, thick-bedded, cross-bedded, weathers reddish brown</td>
<td>115</td>
</tr>
<tr>
<td>6. Quartz-siltstone and shale, brown, laminated, weathers greenish and brownish, has a few interbeds of quartz-sandstone</td>
<td>138</td>
</tr>
<tr>
<td>5. Quartz-sandstone, light gray to brownish, massive, cross-bedded, medium-to thick-bedded, weathers brown</td>
<td>95</td>
</tr>
<tr>
<td>4. Quartz-sandstone and quartz-siltstone, light brown, thin- to medium-bedded</td>
<td>32</td>
</tr>
<tr>
<td>3. Quartz-sandstone, light-brown, medium-grained, medium-bedded</td>
<td>28</td>
</tr>
<tr>
<td>2. Quartz-siltstone, black, with a few interbeds of quartz-sandstone</td>
<td>48</td>
</tr>
<tr>
<td>1. Quartz-sandstone, light brown to greenish, fine- to medium-grained, cross-bedded</td>
<td>22+</td>
</tr>
</tbody>
</table>

Total, Goyllarisquisa Formation: 590+ Meters

**SECTION 8. TAMBERÍA**

Section measured just west of Hacienda Tambería, at the junction of the Cajabamba and Cajamarca rivers.

**Pariatambo Formation**

<table>
<thead>
<tr>
<th>Beds</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Limestone, grayish black, thin-bedded, platy, poorly exposed</td>
<td>35+</td>
</tr>
</tbody>
</table>

Total, Pariatambo Formation: 35+ Meters
Chulec Formation

12. Limestone, gray, thick-bedded, with interbeds of light gray, fossiliferous marl .................. 85
11. Limestone, grayish, thin-bedded, nodular, fossiliferous (Knemicas sp., Enallaster sp.),
weathers light brownish gray, has a few interbeds of splinterly, calcareous shale .......... 76
10. Marl, light gray, nodular, fossiliferous (Knemicas raimondii, Enallaster sp.), with inter-
beds of gray, massive limestone ................................................. 83
9. Limestone, greenish gray, massive, compact, thick-bedded, fossiliferous (trigonids, exo-
gyroids), weathers brownish gray ............................................ 20
Total, Chulec Formation: 264 Meters

Inca Formation

8. Shale and quartz-siltstone, slightly ferruginous, calcareous, greenish gray, medium-bedded,
weathers dark brownish red ...................................................... 44
7. Limestone, brownish, massive, thick-bedded, fossiliferous, weathers yellowish and reddish. 11
6. Shale and quartz-siltstone, calcareous, brownish and greenish, very fossiliferous (several
species of Parahoplites, Desmoceras chimense, Pterotrigonia tocamgana, Buchtrigonia
abr upta, Yaddia hondana), weathers light reddish brown .................................. 16
5. Quartz-sandstone, white, compact, with a few interbeds of shale ...................................... 80
4. Shale, slightly calcareous, brownish green .............................................. 12
3. Limestone, arenaceous, fossiliferous ........................................................................... 2
2. Shale, quartz-siltstone and quartz-sandstone, slightly calcareous, glauconitic, reddish
brown ................................................................................................. 55
Total, Inca Formation: 218 Meters

Goyllarisquisha Formation

1. Quartz-sandstone, white, medium- to coarse-grained, massive, thick-bedded, weathers
reddish brown .............................................................................. 80+
Total, Goyllarisquisha Formation: 80+ Meters

SECTION 9. CRISNEJAS

Section (fig. 19) measured along the south side of the Crisnejas River, from Tingo, at the
junction of the Crisnejas and Marañon rivers, to Santa Rosa.

Cretaceous

Cajamarca Formation

61. Limestone, light gray, medium-bedded, with a few interbeds of shale .................. 215+
60. Limestone, light gray, massive, medium-bedded, weathers dark gray ................. 63
59. Marl, green to white, nodular, fossiliferous .............................................. 10
58. Marl, brownish yellow, nodular ................................................................. 117
57. Shale, light green ....................................................................................... 2
56. Limestone, medium brownish gray, massive, thick-bedded, weathers bluish gray 80
Total, Cajamarca Formation: 487+

Romirón Formation

55. Shale, calcareous, blue to green, soft, fossiliferous (Exogyra oisiponensis) ............... 21
54. Shale, calcareous, bluish gray to green, nodular, laminated, with interbeds of massive, yel-
low, argillaceous limestone ................................................................. 10
53. Marl, brownish and bluish white, nodular, fossiliferous (Inoceramus sp., Ostrea sp., Orthopsis
titicacana) ...................................................................................... 8
52. Shale, calcareous, bluish to greenish gray, friable, with interbeds of nodular marl ...... 8
Total, Romirón Formation: 47 Meters

Mujarrún Formation

51. Limestone, yellowish gray, thick-bedded, massive, weathers brownish gray .............. 36
50. Shale, calcareous, greenish and brownish gray, medium-bedded .......................... 81
49. Limestone, yellowish gray, thick-bedded ......................................................... 105
48. Limestone, brownish gray, massive, thick-bedded, scarp-forming, weathers light brownish gray .......................................................... 79

Total, Mujarren Formation: 301 Meters

Rosa Formation

47. Limestone, argillaceous, light brown to greenish white .................................................. 13

Fig. 19. Crisnejas stratigraphic section.
46. Shale, calcareous, greenish white, laminated, with a few interbeds of brown, nodular, argillaceous limestone .................................................. 44
45. Limestone, arenaceous, dark brown, massive, weathers rusty brownish yellow, with interbeds of nodular, greenish white marl .................. 31
44. Quartz-siltstone, whitish, thin-bedded .................................................. 63
43. Limestone, brownish gray, fossiliferous (Echinobrissus sp., Bothriopygus sp., Holactypus sp.), weathers rusty dark brown, with interbeds of light gray, argillaceous limestone 8
42. Shale, bluish gray, laminated, with interbeds of massive, argillaceous limestone 80
41. Shale and quartz-siltstone, greenish and bluish, soft .................................. 70
40. Quartz-siltstone and quartz-sandstone, red, cross-bedded ......................... 95
39. Quartz-sandstone, deep red, soft, cross-bedded ........................................ 13
38. Conglomerate of polished and varnished dreikanter cobbles in a coarse, deep red matrix; thick-bedded ................................................................. 18
37. Quartz-sandstone, deep red, coarse-grained, thick-bedded, massive .............. 50
36. Quartz-siltstone, deep cherty-red, soft .................................................... 47
35. Quartz-sandstone, red, coarse-grained, massive, cross-bedded, with thin interbeds of conglomerate in the upper part .......................... 7
34. Conglomerate of unassorted, rounded pebbles and cobbles of quartzite in a scanty, red sandy matrix .......................................................... 16
33. Covered. The float is of brownish red splintery limestone ........................ 48
32. Shale and quartz-sandstone, whitish green and purple ............................ 46
31. Quartz-sandstone, calcareous, white, cross-bedded, thin-bedded ................ 12
30. Shale and marl, light gray, nodular ..................................................... 27
29. Shale, deep red, soft ................................................................................. 3
28. Quartz-sandstone, yellowish, medium-grained, friable, cross-bedded, lenticular, medium-to thick-bedded, weathers light brown 59

Total, Rosa Formation: 750 Meters

Disconformity

Crisnejas Formation

27. Limestone, tan, massive, thick-bedded, the top is a deeply channeled and weathered surface ............................................................... 12
26. Limestone, cream, thin-bedded, fossiliferous (Oxytropidoceras sp., Inoceramus sp.), weathers white ................................................................. 12
25. Limestone, tan, massive, thick-bedded, ridge-forming, weathers brown 93
24. Limestone and marl, cream to tan, thick-bedded, becomes more calcareous upward ................................................................. 75
23. Limestone, light tan, massive, thick-bedded, weathers brown .................. 16
22. Marl, light olive gray, fossiliferous, weathers white, with interbeds of light yellowish brown, thick-bedded limestone 33
21. Shale, slightly calcareous, greenish white to light gray, nodular, fossiliferous (Exogyra cf. boussingaulti, Holactypus planatus), with a very few thin interbeds of massive, yellowish brown limestone .................................................. 103
20. Shale, bluish and purple, laminated, splintery, soft, with interbeds of light gray, nodular, fossiliferous (Echinobrissus sp., Bothriopygus sp., Holactypus planatus, Enalaster peruanus, Yaadia hondai, Pholadomya sp., Ostrea cf. dieners, Parengonoceras pernodosum), brown-weathering, argillaceous limestone 57

Total, Crisnejas Formation: 401 Meters

Goyllarisquisa Formation

19. Quartz-sandstone, whitish, slightly ferruginous, laminated, soft, weathers brownish and purplish .................................................. 35
18. Quartz-sandstone, ferruginous, white, thick-bedded, weathers brownish 9
17. Quartz-sandstone, white, medium- to coarse-grained, cross-bedded, thin-bedded 44
16. Quartz-sandstone, white, coarse-grained to pebbly, massive, cross-bedded, weathers brownish 48
15. Shale, purple and white, laminated ..................................................... 8
14. Quartz-sandstone, white to purplish, coarse-grained, thick-bedded, ridge-forming, weathers
light reddish brown .................................................. 184
13. Quartz-sandstone, white to brownish, coarse-grained to pebbly, thick-bedded ........... 88
12. Quartz-sandstone, white, soft, coarse-grained .................................................. 90
11. Shale, white to light purple, soft .................................................. 15
10. Conglomerate of rounded quartz pebbles .................................................. 30
9. Quartz-sandstone, white, coarse-grained to pebbly, soft, laminated, cross-bedded ..... 25
8. Quartz-sandstone, white, coarse-grained, thick-bedded, lenticular, ridge-forming, weathers reddish brown .................................................. 89
7. Conglomerate of quartz pebbles in a sandy matrix, fills channels in the underlying unit .................................................. 1

TOTAL, GOYLLARISQUISGA FORMATION: 666 METERS

UNCONFORMITY

TRIASSIC

ULIACHÍN FORMATION

6. Claystone, white, thin-bedded, with thin, calcareous, fossiliferous (Nevadites sp.) interbeds. 111
5. Chert, ferruginous, massive, weathers reddish .................................................. 12
4. Limestone, dark brownish, massive, thick-bedded, ridge-forming, with abundant chert nodules .................................................. 117

TOTAL, ULIACHÍN FORMATION: 240 METERS

DISCONFORMITY

PALEozoIC

MITU FORMATION

3. Shale and quartz-siltstone, purple, hard, thin- to medium-bedded .................................. 93
2. Shale, quartz-siltstone and quartz-sandstone, arkosic, tuffaceous, green, becomes more argillaceous upward. Near the top, there are a few thin, fossiliferous (Avonia sp., Derbyia sp., Crurithyris sp.), calcareous interbeds .................................................. 132
1. Conglomerate of cobbles and pebbles of light green phyllite, quartz, and diorite in a matrix of dark green, arkosic quartz-sandstone .................................................. 350

TOTAL, MITU FORMATION: 575 METERS

SECTION 10. HUAYCOT

Section measured along the road from Chicama to Huacrauco to Cajamarca, from 4 kilometers west of Hacienda Huaycot, 7 kilometers north of Hacienda Sunchubamba, to Cerro Huagüén.

CAJAMARCA FORMATION

40. Limestone, light gray, massive, thick-bedded .................................................. 25+
39. Limestone, argillaceous, nodular, shaly .................................................. 15
38. Shale, calcareous, brownish gray, fossiliferous .................................................. 90
37. Limestone, argillaceous, petroliferous, medium gray, shaly to nodular, weathers light gray, with interbeds of dark gray, sublithographic, massive limestone .................................................. 116
36. Limestone, petroliferous, grayish black, sublithographic, thick-bedded, with few interbeds of bluish marl .................................................. 114
35. Limestone, very argillaceous, bituminous, dark gray, nodular to shaly, fossiliferous (Colo-
 poceras), weathers light gray, has interbeds of dark gray, massive limestone .................................................. 103
34. Limestone, bituminous, dark gray, massive, thick-bedded, weathers light gray .................................................. 40
33. Limestone, very argillaceous, dark gray, nodular, shaly, weathers light gray, has interbeds of massive limestone .................................................. 68

TOTAL, CAJAMARCA FORMATION: 571+ METERS

QUILLQUITAN GROUP

32. Covered .................................................. 200

PULLUCANA GROUP

31. Limestone, very argillaceous, dark bluish gray, nodular, wavy-bedded, thick-bedded,
weathers light gray to yellowish

20. Limestone, bituminous, dark gray, massive, weathers white

19. Limestone, argillaceous, yellowish, soft

18. Limestone, argillaceous, light gray, shaly nodular, fossiliferous (E. mermis), weathers yellowish gray, with a few interbeds of massive, light gray limestone

17. Limestone, gray, massive

16. Limestone, argillaceous, nodular

15. Limestone, argillaceous, yellowish brown, shaly, nodular, soft, with interbeds of massive, thick-bedded, fossiliferous, bluish gray, bituminous limestone

14. Marl, yellowish, soft, nodular, shaly, with thick interbeds of massive, dark gray, strongly bituminous limestone

13. Limestone, argillaceous, dark gray, nodular, weathers white

12. Marl, brownish to purplish gray, soft, fossiliferous, with a few interbeds of nodular, fossiliferous, argillaceous limestone

11. Limestone, argillaceous, bituminous, bluish gray, nodular, with interbeds of brownish and purplish, bituminous shale

10. Limestone, strongly bituminous, dark bluish gray to black, nodular, thick-bedded

9. Shale, calcareous, bituminous, silty, dark gray, laminated, becomes more calcareous upward

Total, Pullucana Group: 1057 Meters

Pariatambo Formation

8. Marl and argillaceous limestone, strongly bituminous, dark gray to black, laminated, with a few interbeds of brownish gray, calcareous and bituminous quartz-siltstone

Total, Pariatambo Formation: 204 Meters

Chuléc Formation

7. Covered

6. Marl, gray, thin-bedded, weathers whitish gray, has a few massive interbeds of brownish gray limestone

Total, Chuléc Formation: 263 Meters

Inca Formation

5. Limestone, ferruginous, dark bluish gray, thin-bedded, with interbeds of ferruginous quartz-siltstone

4. Limestone, dark bluish gray, thick-bedded, massive, fossiliferous (Exogyra sp.), weathers light rusty brown

3. Quartz-siltstone and quartz-sandstone, highly ferruginous, arkosic, calcareous, iron-stained, reddish to yellowish brown, fossiliferous (Exogyra sp., Trigonia sp.)

2. Limestone, dark bluish gray, massive, compact, karstic, medium- to thick-bedded, weathers light rusty brown

1. Quartz-sandstone, calcareous, ferruginous, reddish brown, thin-bedded

Total, Inca Formation: 161 Meters
SECTION 11. SUNCHUBAMBA

Section measured along the San Jorge River, from Cerro Colmillo to 2 kilometers southwest of Hacienda Sunchubamba.

### Chulce Formation

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>52.</td>
<td>Marl, thin-bedded, gray, fossiliferous (<em>Knemiceras attenuatum, Enallaster peruanus, Holoclystus planatus, Bothrioplygus</em> sp.) weathers whitish gray, has a few interbeds of brownish gray limestone</td>
<td>60+</td>
</tr>
</tbody>
</table>

**Total, Chulce Formation:** 60+ Meters

### Inca Formation

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.</td>
<td>Limestone, arenaceous, bluish gray, massive, thick-bedded, fossiliferous (<em>Exogyra minos</em>), weathers light brown</td>
<td>20</td>
</tr>
<tr>
<td>50.</td>
<td>Shale, dark gray to black, laminated, soft, fossiliferous (<em>Knemiceras ollonense, Desmoceras chimuense, Parahoplites nicholsoni, P. ini, P. guilla, Yaadia hondaana, Pterotrigonia tocaimaana, Buchiorrigonia abrupta</em>), weathers brownish gray, has thin interbeds of dark gray limestone</td>
<td>57</td>
</tr>
<tr>
<td>49.</td>
<td>Limestone, bluish gray, massive, thick-bedded</td>
<td>4</td>
</tr>
<tr>
<td>48.</td>
<td>Shale, black, laminated, soft, weathers yellowish brown to yellowish limestone</td>
<td>30</td>
</tr>
</tbody>
</table>

### Goyllarisquisga Formation

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>47.</td>
<td>Shale, quartz-siltstone and quartz-sandstone, medium-bedded, gray to greenish</td>
<td>13</td>
</tr>
<tr>
<td>46.</td>
<td>Quartz-sandstone, white to gray, cross-bedded, thick-bedded</td>
<td>48</td>
</tr>
<tr>
<td>45.</td>
<td>Shale, poorly exposed</td>
<td>45</td>
</tr>
<tr>
<td>44.</td>
<td>Quartz-sandstone, white, medium-bedded</td>
<td>18</td>
</tr>
<tr>
<td>43.</td>
<td>Shale, dark gray to black, micaceous, laminated, contains plant remains and fresh-water gastropods</td>
<td>37</td>
</tr>
<tr>
<td>42.</td>
<td>Quartz-sandstone, white to yellowish, coarse-grained to pebbly, medium- to thick-bedded, weathers yellowish brown, contains occasional coal fragments</td>
<td>211</td>
</tr>
<tr>
<td>41.</td>
<td>Shale, black, silty, with fine interbeds of white quartz-siltstone</td>
<td>10</td>
</tr>
<tr>
<td>40.</td>
<td>Quartz-sandstone, white to yellow, compact, medium-bedded</td>
<td>30</td>
</tr>
<tr>
<td>39.</td>
<td>Shale, black, laminated</td>
<td>2</td>
</tr>
<tr>
<td>38.</td>
<td>Quartz-sandstone, white to yellow, massive, medium-bedded</td>
<td>36</td>
</tr>
<tr>
<td>37.</td>
<td>Shale and quartz-sandstone, finely bedded</td>
<td>10</td>
</tr>
<tr>
<td>36.</td>
<td>Quartz-sandstone, white, coarse-grained, cross-bedded, thick-bedded</td>
<td>9</td>
</tr>
</tbody>
</table>

**Total, Goyllarisquisga Formation:** 469 Meters

### Carhuaz Formation

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>35.</td>
<td>Shale, bluish gray, soft, carbonaceous, with a few interbeds of quartz-sandstone</td>
<td>10</td>
</tr>
<tr>
<td>34.</td>
<td>Quartz-sandstone, medium-bedded, with shale intercalations</td>
<td>12</td>
</tr>
<tr>
<td>33.</td>
<td>Shale, dark green to brownish yellow, soft, with a few interbeds of white quartz-sandstone</td>
<td>39</td>
</tr>
<tr>
<td>32.</td>
<td>Quartz-sandstone, gray, medium-bedded</td>
<td>4</td>
</tr>
<tr>
<td>31.</td>
<td>Shale and quartz-sandstone, thin-bedded, with a few interbeds of subanthracite</td>
<td>8</td>
</tr>
<tr>
<td>30.</td>
<td>Quartz-sandstone, gray, medium-bedded</td>
<td>9</td>
</tr>
<tr>
<td>29.</td>
<td>Shale, varicolored, laminated, soft, with thin interbeds of quartz-siltstone</td>
<td>24</td>
</tr>
<tr>
<td>28.</td>
<td>Quartz-sandstone, greenish, medium-bedded</td>
<td>9</td>
</tr>
<tr>
<td>27.</td>
<td>Shale, yellowish and pale purple, with a few interbeds of quartz-sandstone</td>
<td>54</td>
</tr>
<tr>
<td>26.</td>
<td>Quartz-sandstone, white to greenish, medium-grained, lenticular, cross-bedded</td>
<td>64</td>
</tr>
<tr>
<td>25.</td>
<td>Shale, bluish to greenish gray, soft, with a few interbeds of quartz-sandstone</td>
<td>88</td>
</tr>
<tr>
<td>24.</td>
<td>Quartz-siltstone and shale, thin-bedded</td>
<td>5</td>
</tr>
<tr>
<td>23.</td>
<td>Shale, carbonaceous, black, with thin interbeds of white quartz-sandstone, includes a 2-meter thick bed of plant-bearing, impure anthracite</td>
<td>23</td>
</tr>
<tr>
<td>22.</td>
<td>Quartz-sandstone, gray to white, medium-grained, massive, cross-bedded, medium-bedded</td>
<td>20</td>
</tr>
<tr>
<td>21.</td>
<td>Shale, bluish gray to black, contains poorly preserved plant remains</td>
<td>10</td>
</tr>
<tr>
<td>20.</td>
<td>Quartz-sandstone, white to greenish white, cross-bedded, massive, medium-bedded</td>
<td>15</td>
</tr>
<tr>
<td>19.</td>
<td>Shale, poorly exposed</td>
<td>40</td>
</tr>
<tr>
<td>18.</td>
<td>Quartz-sandstone, white, medium-grained, massive, medium-bedded, cross-bedded, with thin interbeds of carbonaceous shale</td>
<td>15</td>
</tr>
</tbody>
</table>
17. Shale and quartz-sandstone, carbonaceous in the upper part .................................................. 20
16. Quartz-sandstone, white, massive, cross-bedded, channeled, with interbeds of dark gray shale .......................................................... 35
15. Shale, varicolored, soft, with a few interbeds of quartz-sandstone ........................................... 158
14. Shale, varicolored, soft, with interbeds of cross-bedded, greenish gray, calcareous quartz-sandstone .......................................................... 120
13. Quartz-siltstone and shale, thin-bedded ........................................................................ 9

Total, Carhuaz Formation: 791 Meters

Unconformity

Santa Formation

12. Limestone, brownish, with interbeds of shale; at the top is an intraformational conglomerate of lath-shaped limestone cobbles ........................................... 19
11. Quartz-sandstone, calcareous, fine-grained ........................................................................ 10
10. Limestone, brown to black, oolithic, massive, weathers yellowish brown ................................. 45

9. Shale, iron black to dark gray, splintery, fossiliferous (*Buchatrigoniac gerthii, Cyrena huarazensis*), with thin interbeds of nodular, brown limestone and of white quartz-sandstone. 85
8. Shale, quartz-siltstone, and quartz-sandstone, finely interbedded, ferruginous .......................... 40

Total, Santa Formation: 199 Meters

Chimú Sandstone

7. Quartz-sandstone, white to gray, hard, massive, fine- to medium-grained, very thick-bedded, strongly cross-bedded, ridge-forming, weathers pale reddish ........................................... 231
6. Shale and quartz-siltstone, carbonaceous, micaceous, black, thin-bedded ........................................... 15
5. Quartz-sandstone, gray to white, medium- to fine-grained, hard, thick-bedded, strongly cross-bedded ........................................................................ 262
4. Shale and quartz-siltstone, carbonaceous, black, thin-bedded .................................................... 5
3. Quartz-sandstone, white to gray, micaceous, thick-bedded, cross-bedded, weathers yellowish brown ........................................................................ 45
2. Quartz-siltstone and shale, carbonaceous, thin-bedded, contains badly preserved plant remains ........................................................................ 46
1. Quartz-sandstone, white, fine-grained, medium-bedded, weathers reddish brown .................. 3+

Total, Chimú Sandstone: 607+ Meters

Intrusive Contact

Diorite Stock

SECTION 12. BAÑOS DE CHIMÚ

Section measured along the south side of the Chicama River, beginning 250 meters downstream from Baños de Chimú, hot springs and settlement on the Trujillo to Sayapullo road, to 400 meters upstream from the same place.

Santa Formation

17. Shale, black, splintery, with thin interbeds of dark brown, fossiliferous (*Paraglauconia* sp.) limestone .......................................................... 100+

Chimú Sandstone

16. Siltstone, tuffaceous, light greenish gray, massive, thick-bedded, weathers reddish brown 36
15. Quartz-sandstone, dark gray, thin-bedded, weathers reddish, has interbeds of shale 13
14. Quartz-sandstone, medium to dark gray, massive, strongly cross-bedded, lenticular, medium- to thick-bedded, weathers reddish brown 56
13. Quartz-sandstone, dark gray, thin-bedded, with interbeds of shale 16
12. Quartz-sandstone, white, medium- to fine-grained, hard, cross-bedded, massive, very thick-bedded, weathers light reddish brown to light gray 136
11. Quartz-sandstone, white to medium gray, medium to fine-grained, cross-bedded, lenticular, medium- to thick-bedded, weathers brownish red, with a few interbeds of shale 104
10. Quartz-sandstone, white to light gray, hard, medium- to fine-grained, cross-bedded, very

Meters
thick-bedded, weathers light gray ........................................ 80
9. Shale, carbonaceous, with plant remains ........................................ 1
8. Anthracite .................................................................................. 1
7. Shale, carbonaceous, black, bears plant remains .................................. 2
6. Quartz-sandstone, light gray, cross-bedded ....................................... 2
5. Shale, carbonaceous, black, laminated, bears plant remains .................... 2
4. Quartz-sandstone, dark gray, medium- to fine-grained, cross-bedded, lenticular, medium-bedded .......................................................... 15
3. Quartz-sandstone, dark gray, laminated, micaceous, with a few interbeds of shale .......................................................... 7
2. Quartz-sandstone, white to yellowish brown, medium- to fine-grained, hard, cross-bedded, lenticular, weathers reddish brown ......................... 39
1. Quartz-sandstone and quartz-siltstone, dark gray, thin-bedded, cross-bedded, bears plant remains, weathers reddish brown ......................... 132

Total, Chimú Sandstone: 642 Meters

Jurassic

"Chicama Beds"

Shale dark gray to black, tuffaceous, soft, laminated, weathers purplish gray to reddish purple.

SECTION 13. CALLACUYÁN

Section measured at the Callacuyán coal mine, 7 kilometers northeast of Quiruvilca, Department of La Libertad.

Carhuaz Formation

21. Shale and quartz-siltstone, medium-bedded ........................................ 69
20. Quartz-sandstone, white, cross-bedded, ridge-forming, medium-bedded .................. 81
19. Shale and quartz-siltstone, reddish and purplish, thin-bedded ................. 279
18. Quartz-sandstone, arkosic, white, cross-bedded, medium-bedded .............. 15
17. Shale and quartz-siltstone, brownish and purplish, thin-bedded, with thin interbeds of quartz-sandstone .............................................. 86
16. Quartz-sandstone, brownish gray, medium-grained, massive, thick-bedded .... 10
15. Shale, reddish and brownish gray, laminated ..................................... 34
14. Quartz-siltstone, slightly ferruginous, dirty gray, medium-bedded, weathers greenish and reddish, has a few interbeds of shale ..................... 162
13. Shale, dark gray, laminated, interbedded with cross-bedded, medium-grained, white quartz-sandstone .................................................. 215

Total, Carhuaz Formation: 805 Meters

Santa Formation

12. Limestone, argillaceous, brown, thin-bedded, with thin interbeds of fossiliferous (Paraglauciona sp.), black shale ........................................ 35
11. Limestone, arenaceous, dark brown, thin-bedded, with interbeds of quartz-sandstone ...... 61
10. Shale, black, splintery, thin-bedded, interbedded with fossiliferous (Buchotrigonia gerthii, Cyrena huarasensis), brown limestone ......................... 126
9. Shale, black, thin-bedded, with interbeds of quartz-siltstone ....................... 57

Total, Santa Formation: 279 Meters

Chimú Sandstone

8. Quartz-sandstone, white to cream, cross-bedded, very thick-bedded, ridge-forming, weathers reddish brown ........................................ 63
7. Quartz-sandstone, white, hard, very thick-bedded, cross-bedded, with interbeds of thin-bedded, carbonaceous, dark shale .............................. 149
6. Anthracite interbedded with carbonaceous shale and quartz-siltstone .................. 7
5. Quartz-sandstone, white to gray, lenticular, with interbeds of carbonaceous shale ........... 42
4. Shale, carbonaceous, black, with interbeds of anthracite ................................ 20
3. Quartz-sandstone, white to gray, cross-bedded, massive, hard, thick-bedded .......... 81
2. Anthracite ........................................................................................................... 2
1. Quartz-sandstone, white, fine-grained, hard, massive, thick-bedded ............. 87
**Total, Chimu Sandstone: 431+ Meters**

**SECTION 14. SANTO CRISTO BRIDGE**

Section measured along the Marañón River, from 200 meters upstream of the Santo Cristo Bridge, just south of Quiches, to 300 meters downstream from this bridge.

**Rosa Formation**

5. Quartz-siltstone and shale, slightly calcareous, deep cherry-red, with interbeds of gypsum in the lower part ............................................................... 135+

**Total, Rosa Formation: 135+ Meters**

**Unconformity**

**Crisnejas Formation**

4. Limestone, dolomitic, medium gray to greenish, massive, thick-bedded, weathers brownish gray, with interbeds of quartz-siltstone and shale .............................................. 90
3. Shale, calcareous, light green, laminated .......................................................... 27
2. Limestone, light brownish gray, massive, thick-bedded, fossiliferous *(Oxytropidoceras douglasii)*, with interbeds of nodular marl .................................................. 126
1. Shale, calcareous, dark bluish gray, splintery, with interbeds of nodular, fossiliferous *(Knemiceras sp., Trigonia sp., Liopistha sp., Ostrea sp.)* light greenish and bluish marl. 270+

**Total, Crisnejas Formation: 613+ Meters**

**SECTION 15. SIHUAS**

Composite section; the lower Goyllarisquisga formation was measured along the south side of Quebrada Colpa, just west of Sihuas; the overlying beds were estimated in the lower part of the Pasacancha River, southwest of Sihuas.

**Pariatambo Formation**

9. Limestone and marl, strongly bituminous, black, fossiliferous *(Oxytropidoceras sp., Lyellliceras sp.)*, weathers dark brownish gray .................................................. 200+

**Total, Pariatambo Formation: 200+ Meters**

**Chulec Formation**

8. Marl, light greenish gray, very fossiliferous *(Knemiceras raimondii, K. raimondii tardum, K. attenuatum, Prolyelliceras peruvianum, Douvilleiceras monile)*, with interbeds of shale and of massive, greenish limestone ........................................ 250

**Total, Chulec Formation: 250 Meters**

**Goyllarisquisga Formation**

7. Quartz-sandstone, light gray, medium-bedded, strongly cross-bedded, with a few interbeds of greenish gray calcareous quartz-siltstone ........................................ 87
6. Shale and quartz-siltstone, greenish ................................................................ 120
5. Quartz-sandstone, white, medium-bedded, weathers reddish brown, has thin interbeds of black shale ......................................................................................... 37
4. Shale, poorly exposed ...................................................................................... 37
3. Quartz-sandstone, white to light gray, speckled, cross-bedded, weathers light reddish brown ........................................................................................................ 157
2. Quartz-siltstone, dark greenish gray, with interbeds of purple and greenish shale .......... 63
1. Quartz-siltstone, greenish and brownish, medium-bedded, weathers reddish brown, has a few interbeds of splintery, greenish and purplish shale ........................................ 15+

**Total, Goyllarisquisga Formation: 516+ Meters**
SECTION 16. SANTA CLARA

Composite section; the Cajamarca formation was estimated just east of Hacienda Santa Clara; the Celendín formation was measured along the south side of the Rupac (Sihuas) River at San Pedro; and the Chota formation was estimated at Ahijadero, just west of Santa Clara.

**Chota Formation**

<table>
<thead>
<tr>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Shale, dark red, soft, splintery, with interbeds of dark red quartz-siltstone</td>
<td>900+</td>
</tr>
<tr>
<td>6. Quartz-siltstone, calcareous, greenish gray</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total, Chota Formation:</strong></td>
<td>920+</td>
</tr>
</tbody>
</table>

**Celendín Formation**

<table>
<thead>
<tr>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Marl, light gray, fossiliferous (<em>Hemiaster fournelli, Goniopygus hemicidariformis, Goniopygus superbus</em>), splintery, nodular, with interbeds of tan limestone</td>
<td>317</td>
</tr>
<tr>
<td>4. Limestone, argillaceous, dark gray, nodular, with interbeds of whitish marl</td>
<td>48</td>
</tr>
<tr>
<td>3. Marl and shale, greenish yellow, very fossiliferous (<em>Texanites sp., Lenticeras lissoni, Tissotia halli, Ostrea nicaisei</em>)</td>
<td>163</td>
</tr>
<tr>
<td>2. Marl, white, nodular, thick-bedded, with interbeds of dark gray nodular limestone</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total, Celendín Formation:</strong></td>
<td>558</td>
</tr>
</tbody>
</table>

**Cajamarca Formation**

<table>
<thead>
<tr>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Limestone, dark bluish gray, hard, lithographic, thick-bedded, scarp-forming, with a few interbeds of bluish gray nodular marl</td>
<td>800</td>
</tr>
<tr>
<td><strong>Total, Cajamarca Formation:</strong></td>
<td>800</td>
</tr>
</tbody>
</table>

SECTION 17. CARHUAZ

Section (fig. 20) measured on Cerro Huallhua, on the western side of the Santa River, 4 kilometers northwest of Carhuaz. It contains the type sections of the Santa and Carhuaz formations.

**Pariahuancan Formation**

<table>
<thead>
<tr>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>23. Limestone, slightly bituminous, medium-gray, thick-bedded, fossiliferous, weathers light gray, forms a scarp</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total, Pariahuancan Formation:</strong></td>
<td>45+</td>
</tr>
</tbody>
</table>

**Carhuaz Formation**

<table>
<thead>
<tr>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>22. Quartz-sandstone, light greenish, thin to medium-bedded, lenticular, weathers dark greenish, has interbeds of shale and yellowish limestone which become abundant upward</td>
<td>150</td>
</tr>
<tr>
<td>21. Shale, slightly calcareous, dark green to brown, thin-bedded, soft, with interbeds of massive, greenish to brownish, calcareous quartz-siltstone</td>
<td>177</td>
</tr>
<tr>
<td>20. Shale, dark greenish gray, laminated, soft, with interbeds of dark green tuff and dark brownish gray limestone</td>
<td>329</td>
</tr>
<tr>
<td>19. Shale, dark greenish, laminated, soft, with thin interbeds of quartz-siltstone</td>
<td>107</td>
</tr>
<tr>
<td>18. Shale, slightly calcareous, brownish yellow to greenish, with interbeds of medium-bedded, dark brownish, slightly calcareous quartz-sandstone</td>
<td>96</td>
</tr>
<tr>
<td>17. Limestone, dark brownish yellow, fossiliferous (<em>Ostrea sp.</em>), weathers dark brown</td>
<td>1</td>
</tr>
<tr>
<td>16. Quartz-sandstone, slightly calcareous, greenish and brownish, with interbeds of light brown, silty shale and a few thin beds of fossiliferous, dark limestone</td>
<td>86</td>
</tr>
<tr>
<td>15. Shale, silty, greenish to brownish, with interbeds of quartz-sandstone</td>
<td>130</td>
</tr>
<tr>
<td>14. Shale, calcareous, silty, light brown to light purple, with interbeds of brownish, calcareous quartz-sandstone and thin, fossiliferous, brownish limestone</td>
<td>70</td>
</tr>
<tr>
<td>13. Quartz-sandstone, greenish gray to brownish, medium-grained, medium-bedded, lenticular, cross-bedded, weathers rusty brown, has interbeds of purple, calcareous shale</td>
<td>42</td>
</tr>
<tr>
<td>12. Shale, brownish to purple, laminated, soft, with thin interbeds of white quartz-sandstone</td>
<td>57</td>
</tr>
<tr>
<td>11. Quartz-sandstone, white to light gray, medium- to fine-grained, cross-bedded, medium-bedded, weathers rusty brown, forms a scarp</td>
<td>116</td>
</tr>
</tbody>
</table>
BENAVIDES: CRETACEOUS SYSTEM IN PERU

10. Shale, dark greenish and brownish, laminated, with interbeds of brownish quartz-sandstone. 53
9. Gypsum ........................................ 2
8. Shale ........................................ 5
7. Gypsum ........................................ 2
6. Shale, dark gray, laminated, soft, with interbeds of dark brown, platy, fossiliferous (Valanginites broggi, Buchotrigonia gerthii) limestone and of brownish quartz-siltstone. 131

Total, Carhuaz Formation: 1554 Meters

Santa Formation
5. Limestone, dark gray, massive, thick-bedded, platy, ledge-forming, weathers medium-gray. 15
4. Limestone, dark gray, slightly argillaceous, platy, medium-bedded 110
3. Limestone, dark gray, somewhat dolomitic, medium-bedded, platy, fossiliferous (Cyrena huarazensis, Paraglaucocia strombiformis), with large limestone concretions and chert nodules, weathers yellowish brown, has interbeds of splintery, grayish black shale 25
2. Shale, calcareous, varicolored, laminated, soft, splintery 56

Total, Santa Formation: 341 Meters

Chimú Sandstone
1. Quartz-sandstone, white to reddish, hard, thick-bedded, scarp-forming, weathers reddish brown 80+

Total, Chimú Sandstone: 80+ Meters

Fig. 20. Callejón de Huaylas stratigraphic section. Composite of the Carhuaz and Pariahuanca sections.
SECTION 18. PARIAHUANCA

Section measured along the north side of the Pariahuanca River, just north of Pariahuanca, between Huaraz and Carhuaz.

PARIATAMBO FORMATION

14. Limestone, bituminous, dark gray, fossiliferous, interbedded with shaly, bituminous marl which contains abundant spherical concretions of fossiliferous (Oxytropidoceras carbo-
narium, Lyellliceras ulrichi, L. lyelli, Brancoceras aegoceratoides, Inoceramus sp.) lime-
stone .................................................. 98+

Total, PARIATAMBO FORMATION: 98+ Meters

CHULEC FORMATION

13. Shale, calcareous, brownish black, splintery ................................................. 5
12. Marl, whitish gray, nodular, very fossiliferous (Dowilleiceras monile, Protanisoceras
blancheti, Exogyra minos), with a few interbeds of massive, dark gray, brownish-weather-
ing limestone ........................................... 27

Total, CHULEC FORMATION: 32 Meters

PARIAHUANCA FORMATION

11. Limestone, slightly bituminous, medium gray, massive, thick-bedded, fossiliferous (Para-
hopites sp., rudistid fragments, millilid Foraminifera), weathers light gray .......... 60
10. Limestone, arenaceous, massive, thick-bedded, weathers dark gray to bluish gray ... 15
9. Limestone, slightly argillaceous, dark brown, medium- to thick-bedded, massive, weathers
light brown ............................................. 20

Total, PARIAHUANCA FORMATION: 95 Meters

CARHUAZ FORMATION

8. Quartz-siltstone and quartz-sandstone, calcareous, white to gray, thin- to medium-bedded,
with a few interbeds of shale ........................................... 51
7. Shale, tuffaceous, slightly calcareous, purple .................................................. 5
6. Quartz-sandstone, light gray, fine-grained, thin-bedded, with thin interbeds of carbonaceous
shale ........................................................ 54
5. Shale and quartz-sandstone ................................................................. 75
4. Shale, tuffaceous, calcareous, purple and green, splintery, with interbeds of dark purple,
tuffaceous siltstone and of fossiliferous (Paraglaucosia sp., Cyrena huarasensis) lime-
stone .......................................................... 91
3. Shale, light gray and light greenish gray, splintery, with a few interbeds of brownish lime-
stone .......................................................... 69
2. Limestone, medium gray, thin-bedded, weathers brownish, has interbeds of shale ....... 15
1. Shale, slightly calcareous, brownish to greenish gray, splintery, with thin interbeds of
brownish quartz-siltstone ........................................... 272+

Total, CARHUAZ FORMATION: 632+ Meters

SECTION 19. UCHUPATA

Section measured along the trail from Uchupata to Río Marañón, on the north side of the
Pushca River, from La Merced to 4 kilometers northeast of Hacienda Uchupata.

CHOTA FORMATION

11. Shale, calcareous, deep red, gypsiferous, with a few interbeds of green shale .......... 120+
10. Shale, calcareous, grayish green, with a few interbeds of siltstone .................... 60

Total, CHOTA FORMATION: 180+ Meters

CELENDÍN FORMATION

9. Marl, light gray, nodular, soft, weathers white ................................................... 5
8. Shale, calcareous, slightly silty, yellowish, with a few interbeds of dark brown limestone 40
### Jumasha Formation

4. Limestone, light gray, very thick-bedded, weathers dark bluish gray, with a few interbeds of white to greenish marl. From the lowest beds, *Lyelliceras ulrichi* and *Oxytropidoceras douglasi* were collected.

Total, Jumasha Formation: 750 Meters

### Crisnejas Formation

3. Marl, light gray, nodular, fossiliferous (*Lyelliceras ulrichi, Knemiceras ovale*), with interbeds of brownish gray limestone.

2. Marl and arenaceous limestone, light gray, fossiliferous (*Parengonoceras pernodosum, Knemiceras syriacum, K. siczag*).

Total, Crisnejas Formation: 190 Meters

### Goyllarisquisga Formation

1. Quartz-sandstone, white, coarse-grained to pebbly, soft, cross-bedded, with interbeds of quartz-pebble conglomerate.

Total, Goyllarisquisga Formation: 413+ Meters

### Section 20. Hacienda Palcas

Section measured along the south side of the Pushca River, at Hacienda Palcas.

### Jumasha Formation

<table>
<thead>
<tr>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>19. Limestone, medium gray, thick-bedded, weathers dark dove gray, bears Foraminifera</td>
<td>390</td>
</tr>
<tr>
<td>18. Limestone, argillaceous</td>
<td>29</td>
</tr>
<tr>
<td>17. Limestone, medium gray, massive, thick-bedded, weathers dark brownish</td>
<td>28</td>
</tr>
<tr>
<td>16. Dolomite, thin-bedded, brown</td>
<td>8</td>
</tr>
<tr>
<td>15. Dolomite, light gray to light orange-brown, massive, thick-bedded, karstic, weathers dark orange-brown</td>
<td>285</td>
</tr>
<tr>
<td>14. Dolomite, silty, medium gray, somewhat nodular</td>
<td>60</td>
</tr>
</tbody>
</table>

Total, Jumasha Formation: 820 Meters

### Pariatambo Formation

<table>
<thead>
<tr>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Shale, calcareous, dark bluish gray, splintery, soft</td>
<td>15</td>
</tr>
<tr>
<td>12. Limestone, strongly bituminous, dark gray to black, medium-bedded, platy, weathers medium gray.</td>
<td>8</td>
</tr>
<tr>
<td>11. Shale, calcareous, bituminous, fossiliferous (<em>Oxytropidoceras sp.</em>)</td>
<td>4</td>
</tr>
<tr>
<td>10. Limestone, strongly bituminous, dark brownish to dark purplish gray, medium- to thick-bedded, platy, fossiliferous (<em>Oxytropidoceras sp., Inoceramus sp.</em>), with a few interbeds of bituminous marl.</td>
<td>79</td>
</tr>
<tr>
<td>9. Shale, calcareous, bituminous, medium-bedded</td>
<td>12</td>
</tr>
<tr>
<td>8. Limestone, bituminous, black, thick-bedded, fossiliferous (<em>Oxytropidoceras sp., Lyelliceras sp.</em>), weathers dark brownish gray</td>
<td>35</td>
</tr>
</tbody>
</table>

Total, Pariatambo Formation: 153 Meters

### Chulec Formation

<table>
<thead>
<tr>
<th>Description</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Marl, whitish green to whitish blue, shaly, soft, poorly fossiliferous, with a few interbeds of medium gray, nodular limestone</td>
<td>80</td>
</tr>
<tr>
<td>6. Limestone, argillaceous, medium gray, fossiliferous (<em>Enallaster sp., Holoclytus sp., Bothriopygus sp., Pseudodiadema sp.</em>), thick-bedded, with a few interbeds of quartz-siltstone</td>
<td>22</td>
</tr>
</tbody>
</table>

Total, Chulec Formation: 102 Meters
Goyllarisquisga Formation

1. Quartz-sandstone, calcareous, white to light brown, cross-bedded, soft, weathers light reddish to white .................................................. 24+
2. Shale and quartz-siltstone, varicolored, thin-beded ........................................ 10
3. Quartz-sandstone, white, soft, cross-bedded, medium- to thick-beded, weathers dark greenish ........................................ 21
4. Quartz-sandstone and quartz-siltstone, brown to greenish, medium- to thick-beded, weathers dark greenish ........................................ 75
5. Quartz-siltstone and shale, brownish to greenish, thin-beded .................................. 21

Total, Goyllarisquisga Formation: 151+ Meters

Section 21. Pomachaca

Section measured along the north side of the Pushca River, from 1 kilometer downstream from Pomachaca, 10 kilometers southwest from Hauri, to Pomachaca.

Jumashe Formation

28. Limestone, dark gray, massive, thick-beded, dolomitic, scarp-forming, weathers dark dove gray .................................................. 300+

Total, Jumashe Formation: 300+ Meters

Pariatambo Formation

27. Limestone, bituminous, black, medium-beded, platy, weathers brownish gray ........ 60
26. Marl and limestone, bituminous, black, thin-beded, platy, fossiliferous (Oxytropidoceras peruvianum, Venesoliceras venesolanum, Lyelliceras lyelli), weathers brownish black .... 45

Total, Pariatambo Formation: 105 Meters

Chulec Formation

25. Shale, dark gray, fossiliferous, with interbeds of nodular, brownish gray marl .......... 18
24. Quartz-siltstone, calcareous, white to light brown, fossiliferous (Knemiceras sp.), medium-beded .................................................. 4
23. Marl, light gray, nodular, very fossiliferous (Douvilleiceratites monile, Knemiceras attenuatum, K. raimondii) weathers light brownish gray to light bluish gray .................................................. 7
22. Marl, slightly silty, light gray, nodular, soft, fossiliferous (Knemiceras raimondii, Braneoceras aegoceratoideis, Enallaster peruanus, Hotelectypus planatus, Bothriopygus sp., Exogyra minos), weathers light brownish gray, has interbeds of massive, thick-beded, dark gray, argillaceous limestone .................................................. 16
21. Marl, dark gray, nodular, fossiliferous (Knemiceras sp.) ....................................... 21
20. Limestone, dark gray, nodular, friable, fossiliferous ........................................ 3
19. Quartz-siltstone, argillaceous, slightly calcareous, light grayish green, laminated, fossiliferous .................................................. 10
18. Marl, dark gray, nodular, fossiliferous (Knemiceras sp., Beaudenticeratites sp., Exogyra minos), weathers bluish gray .................................................. 6
17. Marl, dark gray, nodular, very fossiliferous (Parahoplitites sp., Enallaster peruvianus, Bothriopygus sp., Exogyra minos), with a few interbeds of white, argillaceous quartz-siltstone .................................................. 5

Total, Chulec Formation: 90 Meters

Carhuaz Formation

16. Quartz-sandstone, calcareous, white to brown, thin- to medium-beded, with a few interbeds of shale .................................................. 34
14. Shale, light bluish gray .................................................. 21
13. Quartz-sandstone, white to light brown, medium- to thick-beded, cross-beded, speckled, with interbeds of carbonaceous shale .................................................. 177
12. Shale, poorly exposed .................................................. 105
11. Quartz-sandstone, white to light brown, medium- to fine-grained, cross-beded, medium- to thin-beded, with interbeds of carbonaceous shale .................................................. 174
10. Shale, dark gray, laminated, with interbeds of fine-grained quartz-siltstone .................. 39
9. Quartz-sandstone, white to light brownish, cross-beded, medium- to thick-beded .................................................. 54
8. Shale, black, laminated, soft, with interbeds of white to light brown, medium-bedded, fine-grained quartz-sandstone .......................................................... 89
7. Shale, greenish and purple-red, with interbeds of quartz-siltstone ........................................... 16
6. Shale, greenish, bluish, and brownish, soft, with thin interbeds of siltstone .......................... 39
5. Quartz-sandstone, white, medium-bedded, weathers brownish ............................................ 8

**TOTAL, CACHUAZ FORMATION: 756 METERS**

**UNCONFORMITY**

**SANTA FORMATION**

4. Limestone, black, massive, medium- to thin-bedded, platy, fossiliferous (*Paraglauconia* sp.) ................................................................. 58
3. Shale and quartz-sandstone, thin- to medium-bedded ................................................................ 25

**TOTAL, SANTA FORMATION: 83 METERS**

**CHIMÚ SANDSTONE**

2. Quartz-sandstone, white, fine- to medium-grained, hard, massive, very thick-bedded, cross-bedded, scarp-forming, weathers light reddish brown .................................................. 397
1. Quartz-sandstone, white, very thick-bedded, massive, weathers light yellowish or reddish brown, has a few interbeds of carbonaceous shale ...................................................... 236+

**TOTAL, CHIMÚ SANDSTONE: 633+ METERS**
PALEONTOLOGY

GENERAL STATEMENT

Because of the importance of ammonites in the stratigraphy of the Cretaceous, both during the field work and in the laboratory, attention has been focused on this group. Seventy species of ammonites, ranging from the Valanginian to the Santonian, are described; 24 species are considered to be new.

This succession of ammonites is characterized by the preponderance of the so-called "pseudoceratites." Phylloceratid species are wanting, and the lytoceratids are represented by only a few strongly ornamented hamitids which some authors would classify within the Ammonitina, sensu stricto.

The Peruvian faunas belong to a faunal province which includes Colombia, Venezuela, and Brazil. The faunas of this realm are closely comparable and parallel with those of Mexico, the Gulf Coast, southern Europe, northern Africa, Madagascar, the Middle East, India, and Borneo. The analogy with the Tunisian faunas, especially when the late Cenomanian and the early Turonian are concerned, is particularly striking. Some species, e.g., Douvilleiceras monile, Lyelliceras lyelli, Desmophyllites gaudama, etc., have been reported throughout this domain. Except for the genus Buchiceras, sensu stricto, none of the 34 studied genera is limited to South America, and almost every species is closely comparable to if not conspecific with Mediterranean species.

Ammonites are particularly abundant in the transgressive marls and limestones of the Inca and Chulec formations, in the black, strongly petroliferous, platy limestones and marls of the Pariatambo formation, and in the near-shore, shallow-water shales and marls of the Coñor, Romirón, and Celendín formations. The Yumagual formation, although containing beds packed with exogyroids, has yielded only a few specimens belonging to three species of ammonites. The overlying Mujarrún formation, also rich in exogyroids, has not produced a single ammonite specimen.

The descriptions of many of the species can be found only in well-equipped libraries, for some of them are in rare European publications, and others are in obscure and ephemeral South American journals. The present writer, having available the facilities of the excellent library of the American Museum of Natural History, has decided, therefore, to include complete descriptions of all the studied species.

In the descriptions, the standard measurements and terminology are used. The following terms have been used to refer to the umbilicus:

- Extremely widely umbilicated (66% of the diameter)
- Widely umbilicated (50 to 66% of the diameter)
- Fairly widely umbilicated (34 to 50% of the diameter)
- Fairly narrowly umbilicated (17 to 34% of the diameter)
- Narrowly umbilicated (8 to 17% of the diameter)
- Very narrowly umbilicated (umbilicus nearly closed)

The standard measurements—diameter (D), whorl height (H), whorl thickness (T), and diameter of the umbilicus (U)—were taken at the largest possible diameter, and they are expressed in millimeters. The last three measurements (H, T, and U) are also given in terms of percentage of the diameter (D/H, D/T, and D/U).
PHYLUM MOLLUSCA
SUBPHYLUM CEPHALOPODA
CLASS NAUTILOIDEA
ORDER NAUTILIDA Spath
FAMILY PARACENOCERATIDAE Spath, 1927
Lissoniceras,1 NEW GENUS

DESCRIPTION: Lissoniceras includes those unusual nautiloids, such as Nautilus mermeti Coquand (1862, p. 166), selected as the genotype, and Nautilus triangularis Montfort (d'Orbigny, 1840–1842, pl. 17), which have a lenticular shape, triangular whorl section, and which, unlike the Aptian genus Hemi-
autilus, have the sides converging towards a narrow, fastigate venter. The external suture has an angular and high ventral saddle, a gently curved large lateral lobe, a small, narrowly rounded saddle already about the umbilical shoulder, and a very small lobe. The siphuncle is extracentrodorsan.

REMARKS: Lissoniceras resembles in shape the Eocene genus Deltoidea Nautilus Spath, but differs in possessing a goniatitic suture with a rounded ventral saddle. The two species referred to Lissoniceras are Cenomanian.

Durham (1946, p. 428), reviewing the literature on Cretaceous nautiloids of South America, remarked: "Nautilus munieri Choffat is described and figured by Schlagintweit (1912, pp. 99–100, text fig. 3, pl. 6, fig. 9) from the Pampa de la Culebra, Peru, in beds which he considered as of Cenomanian age. From the figures and description, this species would appear to belong to a genus closely allied to Hemi-
autilus, differing from Hemi-
autilus largely in the absence of a flattened venter." Nautilus munieri Choffat is considered by PervinquièrÈ (1907, p. 46), and the present writer agrees with him, as a synonym of Nautilus mermeti Coquand, the genotype of Lissoniceras.

Lissoniceras mermeti (Coquand)
Plate 40, figures 1–3

Nautilus Munieri CHOFFAT, 1886, 1898, ser. 1, p. 1, pl. 1, fig. 2, pl. 2, fig. 1.
Nautilus Mermeti Coquand; PervinquièrÈ, 1907, p. 46.
Nautilus Munieri Choffat; Schlagintweit, 1912, p. 99, pl. 6, fig. 9.

Seven specimens, the largest of which is 150 mm. in diameter, are available for study.

DESCRIPTION: The conch is large, lenticular, flat, with the umbilicus almost closed. The whorl section is compressed, triangular, with indistinct umbilical wall and very broadly rounded shoulder. The sides converge with slight convexity towards the fastigate, narrowly rounded to angular venter. The greatest thickness, occurring at about the middle of the inner third, is about one-half of the whorl height. The septa are very closely spaced. The suture is strongly in-
flexed forward; it has a very high and angular ventral saddle, a large and broadly curved lateral lobe, a small rounded saddle just above the umbilical shoulder, and a very small lobe centered at the umbilical seam (fig. 21).


REMARKS: Lissoniceras mermeti resembles L. triangularis Montfort in general shape and suture but differs because of its more compressed whorl section. In the latter, the greatest whorl thickness is about four-fifths of the whorl height.

OCCURRENCE: Lissoniceras mermeti is a fairly common species in the upper Ceno-
amian Romir6n formation, in bed 43 of the Polloc section (A.M.N.H. No. 27381) and in bed 44 of the Celendén section (A.M.N.H. No. 27381/1). In both localities, it is associated with Neolobites kummeli, Forbesiceras
sp. indet., *Acanthoceras chasca, A. pollocense*, and *A. sangalenense*.

Schlagintweit reported one specimen from Pampa de la Culebra, near Cajamarca.

**CLASS AMMONOIDEA**

**SUPERFAMILY HAMITACEA** WRIGHT AND WRIGHT, 1951

**FAMILY ANISOCERATIDAE** Hyatt, 1900

*Protanisoceras* Spath, 1923

*Protanisoceras blancheti* (Pictet and Campiche)

Plate 40, figures 4–5


Two specimens are assigned to this species.

**DESCRIPTION:** The conch is ancyloceratoid, coiled in a single plane. The intercostal whorl section is subcircular and slightly depressed; the costal whorl section is similar but flattened on the venter. There are about three ribs in a distance equivalent to the corresponding diameter; the ribs are single, high, very sharp, and have wider and rounded interspaces. On the dorsum, the ribs are only faintly indicated. At the ventrolateral shoulders they thicken and form a very faint, blunt tubercle. In the illustrated specimen (A.M.N.H. No. 27382) the ventrolateral tubercles disappear adorally. The suture line has a trifid dorsal lobe and a broad first lateral saddle.

**REMARKS:** The Andean species of *Protanisoceras blancheti* have fainter ventrolateral tubercles than the European occurrences illustrated by Pictet and Campiche, and they approach *Hamites praegibbosus* Spath, from the *mammillatum* zone of the English middle Albian, the ribs of which have "sometimes...a suggestion of differentiation on the venter but not actual tuberculation" (Spath, 1923–1943, vol. 2, p. 627).

Spath (1930, p. 58) has described a similar form, *Protanisoceras* sp., from the Samana Range, India, where it is associated with *Dowvilleceras mammillatum* and other middle Albian species.

**OCCURRENCE:** *Protanisoceras blancheti* was collected from the Chulec formation, in bed 67 of the Cajamarca section (A.M.N.H. No. 27382/1) and from the Crisnejas formation, in bed 9 of the Celendin section (A.M.N.H. No. 27382); in the latter locality, it is associated with several species of *Knemiceras* and *Parengonoceras*. Sommermeier reports it from Pariahuanca.

In England, the genus *Protanisoceras* is confined to the lowest Gault (*mammillatum* and *dentatus* zones) (Spath, 1930, p. 51).

**FAMILY TURRILITIDAE** Meek, 1876

*Paraturrilites* Breistroffer, 1947

*Paraturrilites lewesiensis* (Spath)

Plate 40, figures 8–9

*Turrilites Bergeri* Brogniart; *Sharpe*, 1857 (1853–1857), p. 65, pl. 26, fig. 10 (only).

*Turrilites cf. Bergeri* Brogniart; Schlagintweit, 1912, p. 89.

*Turrilites lewesiensis* Spath, 1926, p. 429.

*Mariella lewesiensis* (Spath); *Spath*, 1923–1943, vol. 2, p. 512.

*Paraturrilites lewesiensis* (Spath); *Wright and Wright*, 1951, p. 17.

Four specimens are referred to this British species.

**DESCRIPTION:** The conch is a narrowly umbilicated sinistral turricone with an apical angle of about 30 degrees. The whorl section is polygonal; the lower shoulder, between the impressed zone and the outer gently convex surface, is angular; the upper or siphonal shoulder is rounded and smooth. There are about 23 ribs per volution, which are very conspicuous in the lower impressed zone but tend to vanish in the outer margin, where they are obliquely set. Each rib bears four prominent rounded tubercles which form four distinct spiral rows. The lowest tubercle is at the suture with the next volution; the lower two tubercles are more closely spaced than the upper ones. The uppermost tubercle is slightly elongated radially.

**REMARKS:** *Paraturrilites acostae* (d'Orbigny, 1851, p. 380), from the Colombian Cretaceous, differs because of the lack of ribs, the larger size of the tubercles, and the smaller number of them per volution. *Paraturrilites bergeri* (Brogniart) has less prominent tuberculation and more distinct ribs than *P. lewesiensis*. Furthermore, the tubercles are elongated instead of rounded as in the latter species.
Occurrence: Three specimens (A.M.N.H. No. 27383) of Paraturritilites lewesiensis were collected from the Yumagual formation, in bed 111 of the Cajamarca section, where it is associated with Sharpeiceras occidentale. A fourth specimen (A.M.N.H. No. 27383/1) comes from the same formation, bed 27 of the Lajas section.

Paraturritilites lewesiensis is found in the Varios zone of the English Cenomanian (Wright and Wright, 1951, p. 17).

Family BACULITIDAE MEEK, 1876
Baculites sp. indet.

A single, poorly preserved fragment (A.M.N.H. No. 27384) is mentioned to record the presence of the genus. It has a length of 25 mm., and the oval cross section has the diameters of 8 and 11 mm. The suture is badly weathered.

Baculites sp. indet. was obtained from the Celendín formation in the Bambamarca section.

Family NOSTOCERATIDAE HYATT, 1894
Bostrychoceras sp. indet.

The only available specimen (A.M.N.H. No. 27385) is an entirely septate, complete volution of an apparently dextral turritone. The umbilicus is very large. The whorl section is subcircular; the whorls are in contact. The volution has 30 single, smooth, sharp, obliquely set ribs which are more conspicuous on the outside and almost entirely attenuated on the umbilical wall.

The material available makes even generic determination difficult. Because of its ornamentation Bostrychoceras? sp. indet. seems to be related to forms like B. polyplocum Roemer (Campanian of Germany, India, Tunisia, and Madagascar), B. punicus Pervinquiére (a dextral form from the Tunisian Campanian), and B. otsukai Yabe (1904, p. 14). It also resembles in ornamentation Nipponites mirabilis Yabe (1904, p. 20), of the Japanese Senonian, which has a peculiar loosely coiled conch.

Bostrychoceras? sp. indet. was collected from the Celendín formation, in bed 22 of the Bambamarca section, where it is associated with Desmophyllites gaudama Forbes.

Superfamily PERISPHINCTACEAE
Wedekind, 1917
Family OLCOSTEPHANIDAE Spath, 1924
Valanginites Sayn, 1910
Valanginites broggi (Lisson)
Plate 40, figures 10–12

Sphaeroceras brogginus Lisson, 1937, p. 153, pl. 1, figs. 1–2.

Three specimens belong to this species; one of them (A.M.N.H. No. 27386/1) is a complete disc; the other two are slightly crushed.

Measurements

<table>
<thead>
<tr>
<th>A.M.N.H. No.</th>
<th>D</th>
<th>H</th>
<th>D/H</th>
<th>T</th>
<th>D/T</th>
<th>U</th>
<th>D/U</th>
</tr>
</thead>
<tbody>
<tr>
<td>27386:1</td>
<td>24</td>
<td>13</td>
<td>.54</td>
<td>17</td>
<td>.73</td>
<td>3</td>
<td>.12</td>
</tr>
</tbody>
</table>

Description: The conch is small, globose, very narrowly umbilicated. The whorl section is crescentic, depressed, with very high and perpendicular umbilical wall and abruptly rounded umbilical shoulder. In the early part of the outer volution, the sides are very short and merge evenly into the broad and semicircular venter. Adorally, the sides become taller and are almost subparallel, the ventrolateral shoulder becomes noticeable, and the gently arched venter is as broad as the whorl itself (fig. 22). On the venter of the outer half-


whorl there are 27 fine, round-crested, evenly spaced ribs, of which 10 are primary ribs which start at the umbilical shoulder and run in a prorsiradiate direction up to the ventrolateral shoulder where they bifurcate and cross over the venter; single ribs are intercalated at the ventrolateral shoulder. Between the diameters of 15 and 20 mm., the forking points of the ribs develop sharp, radially elongated tubercles; and between the diameters of 20 and 25 mm. on the siphonal
line, high, prominent, transversally elongated tubercles appear every four or five ribs.

**Remarks**: *Valanginites broggi* is distinguished by the presence of both ventrolateral and siphonal tubercles. *Valanginites angusticoronatus* Imlay (1938, p. 557) has bundles of three or four ribs starting from ventrolateral tubercles.

**Occurrence**: *Valanginites broggi* is found in the Carhuaz formation, in bed 6 of the Carhuaz section, where it is associated with other olocostephanid ammonites.

Spath (1924, p. 80) referred to the "*Valanginites* beds" of Colombia, and correlated them with the "Hoplitidan age" of the English Valanginian. The present writer has been unable to find any other reference to these Colombian *Valanginites*. Imlay (1940, 135) says that, although *Valanginites* is known in the Hauterivian, it is mostly characteristic of the Valanginian. Killian (1920, p. 12) assigns the genus *Valanginites* to both the Valanginian and the lower Hauterivian.

**Superfamily Desmocerataceae** Wright and Wright, 1951

**Family Desmoceratidae** Zittel, 1895

**Desmoceras** Zittel, 1884

*Desmoceras latidorsatum* (Michelin)

Plate 41, figures 1–2

*Desmoceras latidorsatum* (Michelin); Spath, 1923–1943, vol. 1, p. 39, *cum synon.*, pl. 2, figs. 2a–b.

One small specimen has been assigned to this well-known and widely distributed species.

**Measurements**

<table>
<thead>
<tr>
<th>A.M.N.H. No.</th>
<th>D</th>
<th>H</th>
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**Description**: The conch is small, stout, narrowly umbilicated. The whorl section is very inflated and depressed, with high and perpendicular umbilical wall and rounded but conspicuous umbilical shoulder. The sides are slightly convex and subparallel to the end of the inner third, where the convexity increases, and thence they make an even curve with the broadly arched and semicircular venter. Specimen A.M.N.H. No. 27387 has in the last volition three widely spaced and feeble constrictions which form a sinus in the periphery. The suture is very frilled. It has a deep ventral lobe, a trifid first lateral lobe of the same depth, and bifid saddles which have rounded endings and decrease regularly in size.

**Remarks**: Both Jacob (1908, p. 35) and Spath (1923–1943, vol. 1, p. 41) state that *Desmoceras latidorsatum* is a very variable and small-sized species; the European occurrences are no larger than 60 mm. in diameter.

The Peruvian specimen agrees very closely with the form described by Jacob (1908, pl. 4, figs. 12a–b) as "bar. b. de Kossmat," which is characterized by the subparallel sides.

**Occurrence**: This species is found in the Pariatambo formation, in bed 14 of the Pariahuancsa section, where it is associated with several species of *Lyellliceras* and *Oxytropidoceras*.

*Desmoceras chimuense*, new species

Plate 41, figures 5–8

This species is based on two specimens: the holotype, A.M.N.H. No. 27388:1, a complete, entirely septate steinkern, with the shell preserved only in a few patches around the umbilicus, and specimen A.M.N.H. No. 27388:2, also an entirely septate steinkern, which is slightly more than half of a disc.

**Measurements**

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**Description**: The conch is large, discoidal, fairly narrowly umbilicated. The whorl section is compressed, with a thickness of about four-fifths of the whorl height. The umbilical wall is high and perpendicular, almost overhanging; the shoulder is rounded but distinct. The sides are flattened and parallel to the end of the middle third, where they increase in convexity and merge into the evenly arched, almost semicircular venter (fig. 23). The holotype shows five faint constrictions in the last volition; they are radiate.
to the middle of the outer third, thence they become prorsiradiate and form a sinus on the venter. The suture line (fig. 23) is very frilled and has a deep and narrow ventral lobe, three trifid lateral lobes on the sides, and a fourth lobe centered at the umbilical shoulder. The saddles are bifid, with rounded terminations and regularly decreasing in size.

**Fig. 23. Desmoceras chimuense, new species.** Suture line (A) and conch section (B) of the holotype; ×1.

**Remarks:** *Desmoceras chimuense* is very close to *D. latidorsatum* var. *complanata* Jacob (1908, p. 38) from which it is distinguished because of its larger umbilicus, flattened sides, more broadly arched venter, and the steeper umbilical wall. *Desmoceras collignoni* Breistroffer (in Besairie, 1936, p. 170), another similar form, has narrower umbilicus, subconvex sides, and its constrictions make a very strong, linguiform sinus in the periphery. *Desmoceras merriami* Anderson (1938, p. 181), from the upper part of the Horsetown group of California, has narrower umbilicus and less compressed whorl section than *D. chimuense*. *Desmoceras hyatti* (Gabb, 1877, p. 268), a Peruvian species of undetermined stratigraphic position, lacks constrictions, and its whorl section is almost as thick as high.

**Occurrence:** *Desmoceras chimuense* was collected from the lower Albian Inca formation, in bed 6 of the Tambería section, together with several species of *Parahoplites*.

**Desmophyllites gaudama** (Forbes)

Plate 41, figures 3–4

*Ammonites Gaudama* Forbes, 1846, p. 113, pl. 10, fig. 3.

*Ammonites planulatus* Stoliczka, 1865 (1861–1866), p. 134, pl. 67, fig. 1.

*Ammonites Hernensis* SCHULTZ, 1871 (1871, 1876), p. 40, pl. 11, fig. 1.

*Puzosia Gaudama* Forbes; KOSSMAT, 1898 (1895–1898), p. 115, pl. 16, figs. 2a–b, 3.

*Puzosia Gaudama* Forbes; Pervinquière, 1907, p. 161, pl. 6, figs. 33a–b.


*Desmoceras (Puzosia)* sp. LÜTHY, 1918, p. 50.

*Desmophyllites ellsworthi* KNECHTEL, 1947, in Knechtel, Richards, and Rathbun, p. 128, pl. 47, figs. 1–3.

Three fragmentary specimens are referred to this species.

**Measurements**

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**Description:** The conch is medium in size, discoidal, fairly narrowly umbilicated. The whorl section is ovoid, compressed, with high and perpendicular umbilical wall and abruptly rounded umbilical shoulder. The sides are gently vaulted, with maximum convexity about the end of the first fourth; they converge towards the narrowly rounded venter. The greatest whorl thickness is near the umbilical shoulder and is about two-thirds of the whorl height. The inner volutions of the illustrated specimen (A.M.N.H. No. 27389) reveal four slender constrictions per volution. The suture line (fig. 24) is strongly frilled; it has a short ventral lobe,
three lateral lobes on the sides, and a fourth lobe on the umbilical wall; the saddles are bifid.

Remarks: The Peruvian specimens agree very closely in all respects with the Indian specimens illustrated by Forbes, Stolizckza, and Kossmat. The present writer, therefore, sees no reason why they should be given a different specific name, as was done by Knechtel (1947, in Knechtel, Richards, and Rathbun, p. 128), only on the basis of their wide geographic separation.

Occurrence: Desmophyllites gaudama is found in the Celendín formation, in bed 22 of the Bambamarca section (A.M.N.H. No. 27389), in bed 75 of the Polloc section (A.M.N.H. No. 27389/1), and in bed 3 of the Santa Clara section (A.M.N.H. No. 27389/2). In this last place, it is associated with Texantes sp. and Lenticeras lissoni. Brüggen reports it from Otuzco (Cajamarca) and from San Pedro (Santa Clara).

The holotype and Kossmat's specimens come from the upper part of the Trichinopoly group (India). Pervinquiry reports D. gaudama from the Tunisian Santonian.

Superfamily Hoplitaceae Spath, 1922
Family Parahoplitidae Spath, 1922
Parahoplites nicholsoni,1 new species
Plate 42, figures 11-12

Three specimens belong to this new species; the holotype (A.M.N.H. No. 27390) is a complete disc 110 mm. in diameter; the last three-fourths of the outer volution belong to the body chamber. Specimen A.M.N.H. No. 27390/1 is an entirely separte whorl fragment belonging to an individual at least 160 mm. in diameter.

Measurements

<table>
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<tr>
<td>110</td>
<td>47 .43 38 .35 37 .34</td>
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Description: The conch is large, discoidal, fairly widely umbilicated. The whorl section is subtrapezoidal, compressed, with the greatest thickness near the umbilical shoulder. The whorls grow in height more quickly than in thickness. The umbilical wall is high and perpendicular or even overhang-

1 Named in honor of Prof. Carlos Nicholson.
A.M.N.H. No. 27390/1, at about 160 mm. in diameter, the ribs also become attenuated.

The suture line (fig. 25) has a ventral lobe with parallel sides and a deeper, triangular, first lateral lobe. The first lateral saddle is very broad and divided by a small lobule into two branches, the outer one being larger. A second, small, lateral lobe is already in the umbilical wall.

**Remarks:** Parahoplites nicholsoni differs from *P. melchioris*, the genotype, because of its larger umbilicus, very pronounced umbilical swellings, very uniform forking of the ribs, and the taller whorl section. *Parahoplites grossouvrei* Jacob (1905, p. 409) from the Clansayes beds of France resembles *P. nicholsoni* in shape and ornamentation but is distinguished by its smaller umbilicus, the chevron sinus formed by the ribs on the venter, and because of the early development of the ornamentation.

**Occurrence:** This species is fairly abundant in the Inca formation, in bed 60 of the Tambería section (A.M.N.H. No. 27390/1) and in bed 50 of the Sunchubamba section (A.M.N.H. No. 27390), where it is associated with *Desmoceras chimuense* and with *Knesiceras ollonense*.

**Parahoplites guilla**, new species

Plate 42, figures 1–8

This species is erected on the basis of three small whorl fragments. The holotype is A.M.N.H. No. 27391:1.

**Description:** The conch is small and discoidal. The costal whorl section is subrectangular to subtrapezoidal, compressed, with high and perpendicular umbilical wall and rounded but distinct umbilical shoulder. The sides are subflattened and almost parallel in the inner half of the sides but become broadly arched and converging in the outer half. The ventrolateral shoulder is rounded but distinct. The venter is broad and subflattened. The intercostal whorl section is similar, although with more broadly rounded ventrolateral shoulders and more arched venter. The ribbing is fine, dense, and flexuous. The primary ribs begin almost at the umbilical seam and are strong and prorsiradiate to the end of the inner third, where they usually bifurcate. The branches, or the intercalated ribs that begin here, are less prorsiradiate but swing forward again before crossing the venter. On the venter, all the ribs have the same size and shape, and are narrower than the interspaces.

**Remarks:** *Parahoplites guilla* differs from most other *Parahoplites* by its distinct ventrolateral shoulders, although they are not tuberculated as in *Hypacanthopholites*. The very dense and fine ribbing and the branching of the ribs resemble those of some species of *Rhytidoplites* described by Scott (1940, p. 1034) from the Texan middle Albian.

**Occurrence:** This species is found in the Inca formation, in bed 50 of the Cajamarca formation.

**Parahoplites inti**, new species

Plate 42, figures 9–10

Two specimens are the basis of this species. Specimen A.M.N.H. No. 27392, the holotype, is a half disc which lacks the inner whorls.

**Description:** The conch is discoidal, fairly narrowly umbilicated. The whorl section is compressed, ovoid, with low umbilical wall and rounded but very distinct umbilical shoulder. The sides are subflattened and subparallel; the ventrolateral shoulders are broadly rounded, and the venter is evenly arched. The greatest whorl thickness, about the middle of the sides, is about three-fourths of the whorl height (fig. 26). On the venter of the outer half-whorl, there are 26 rounded, strong, evenly shaped ribs, of which 12 are primary ribs which begin in the umbilical

**Fig. 26. Parahoplites inti**, new species. Conch section of specimen A.M.N.H. No. 27392; ×1.

wall and are prorsiradiate in the inner third, at the end of which some fork, intercalated ribs appear, and all become less prorsiradiate.

**Remarks:** *Parahoplites inti* is distinguished from *P. guilla* by the lack of a flattened venter, more compressed whorl section and coarser ribbing. A very similar species is *P. subcampiscbei* Sinzow (1907, p. 463) which
has a thicker whorl section, more uniform forking of the ribs, and ribs that form a pronounced forward sinus in the periphery.

Occurrence: Parahoplites init is found in the Inca formation, in bed 50 of the Cajamarca section, associated with P. guilla.

Family Douvilleiceratidae Spath, 1923

Douvilleiceras de Grossouvre, 1894

Douvilleiceras monile (Sowerby)

Plate 43, figures 1–4

Douvilleiceras monile Sowerby; Spath, 1923–1943, vol. 1, p. 72, cum synon., pl. 4, fig. 4, pl. 5, figs. 5a–c.

Several specimens, including three entire discs, are assigned to this well-known and widely distributed species.

Measurements

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<td>.40</td>
<td>25</td>
<td>.45</td>
<td>21</td>
<td>.38</td>
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</table>

Description: The conch is stout, medium in size, fairly widely umbilicated. The whorl section is depressed, reniform, inflated, with very steep umbilical wall and rounded umbilical shoulder. The sides are convex and gently merge into the broadly rounded venter (fig. 27). The outer volution has 22 or 25 strong, round-crested, multituberculate ribs which begin at the umbilical shoulder and are slightly rursiradiate in the outer half of the sides. On the venter, the ribs are slightly attenuated and more broadly rounded.

At a radius of 5 mm. (A.M.N.H. No. 27393), the whorl section is coronate; there are very faint, narrow, very widely spaced ribs which bear faint tubercles on both sides of the siphonal line and on the lateral angles of the coronate whorl section.

At a radius of 9 mm., the ventral tubercles are strong and spinate, the first lateral tubercles occupy the ventrolateral shoulders, and a new pair of tubercles appears at the umbilical shoulders of the already reniform whorl section. A few intercalated ribs bear only ventral tubercles.

Further growth is marked by the increased crowding of the ribs, which become strong, and by the appearance of new rows of tubercles, usually by the splitting of the ventral tubercles. At a radius of about 25 mm., the ribs are strong, slightly narrower than the interspaces, and bear six tubercles on each side; the ventral tubercles are the most conspicuous, while all the others are of about the same size. Thence, all the tubercles tend to become fainter.

Remarks: Douvilleiceras monile stands between the closely related D. mammillatum (Schlotheim) and D. solitae (d'Orbigny, 1853, p. 211), both as to the number of ribs per volution and as to the size of the umbilicus (table 1).

Douvilleiceras monile differs from D. mammillatum, also, by the lack of prominence of the lateral tubercles and because after a diameter of 45 mm. all the tubercles are small and equal in size.

Occurrence: Douvilleiceras monile is found in the lower middle Albian Chulec formation, in bed 12 of the Parahuana section (A.M.N.H. No. 27393/2), associated with Protanisoceras blancheti, in bed 21 of the Pomachaca section (A.M.N.H. No. 2739/1),

Table 1

| Comparison of Douvilleiceras mammillatum, Douvilleiceras monile, and Douvilleiceras solitae |
|-----------------------------------|---------------------------------|---------------------------------|
|                                     | D. mammillatum                  | D. monile                        | D. solitae                      |
| Number of ribs per volution        | 18–25                          | 30–35                           | 40                              |
| D/U                                | .30–.33                         | .34–.40                         | .44                             |

Fig. 27. Douvilleiceras monile (Sowerby). Conch section of specimen A.M.N.H. No. 27393; ×1.
and in bed 58 of the Cajamarca section (A.M.N.H. No. 27393), associated with *Knemiceras raimondii*, *Lyelliceras lyelli*, and *Parengonoceras* sp.

*Douvilleiceratasp. monte* is one of the characteristic species of the Douvilleiceratan age of the English (Spath, 1923–1943, vol. 2, p. 688) and French (Breistroffer, 1947, p. 40) Albian.

**Family Schloenbachiidae** Spath, 1925

**Forbesiceras** Kossmat, 1898

*Forbesiceras* sp. indet.

A single, poorly preserved fragment (A.M.N.H. No. 27394) belongs to this genus. It is mentioned here because no representatives of *Forbesiceras* have previously been recorded in South America.

**Description:** The fragment belongs to a discoidal, flat, extremely narrowly umbilicated conch. The whorl section (fig. 28) is very compressed, lanceolate; the greatest thickness is at the end of the inner third and is less than one-third of the whorl height. The sides are gently convex in the inner third, and thence they converge with little convexity towards the narrow, truncated venter. The ventrolateral shoulder is angular. The specimen is weathered, and no ornamentation is discernible. The suture is typical of *Forbesiceras*, very frilled and complex. All the saddles, especially the first one, are deeply incised by a frilled medial lobe.

Specimen A.M.N.H. No. 27394 seems to belong to a species very closely related to *Forbesiceras lagiliertianum* (d’Orbigny).

**Occurrence:** *Forbesiceras* sp. indet. occurs in the upper Cenomanian Romirón formation, in bed 44 of the Celendín section, associated with *Lissoniceras mermeti*, *Acanthoceras chasca*, and *Neolobites kummelii*.

The genus *Forbesiceras* is found in the Cenomanian of Tunisia (Pervinquière, 1907, p. 106), in the Ootatoo group of India, and in the *Varians* zone of the English Cenomanian (Wright and Wright, 1951, p. 23).

**Family Engonoceratidae** Hyatt, 1900

**Engonoceras** Neumayr and Uhlig, 1881

*Engonoceras* sp. indet.

Plate 43, figures 11–12

One complete, fractured steinkern, which was at least 340 mm in diameter, is referred to *Engonoceras*. The outer half-whorl belongs to the body chamber.

**Measurements**

A.M.N.H. No. | D | H | D/H | T | D/T | U | D/U  
---|---|---|----|---|----|---|-----|
27395        | 285 | 165 | .58 | 72 | .25 | 15 | .05 |

**Description:** The conch is large, discoidal, flat, with almost closed umbilicus. The whorl section is extremely high and compressed, lanceolate, with very low and indistinct umbilical wall and broadly rounded umbilical shoulder. The greatest thickness is below the middle of the sides and is less than half of the whorl height. The sides are gently convex and converge towards the narrow, truncated venter; the ventrolateral shoulder is sharp, and angular to a diameter of 180 mm where it becomes rounded. At this diameter, the venter also changes from flat to narrowly rounded. The umbilical shoulder and the sides are smooth. The ventrolateral shoulders are furnished with numerous small, spirally elongated tubercles. The suture is pseudoceratitic, with numerous massive, quadrate saddles which have a small medial lobe and entire margins. The lobes are strangled and denticulated.

**Remarks:** The suture line of *Engonoceras* sp. indet. is comparable to that of *E. com-
*Plicatum* Hyatt (1903, p. 175) which has three rows of tubercles. Most species of *Engonoceras* have sutures with entire saddles and are ornamented with three or two rows of tubercles. *Engonoceras grimsdalei* Spath, from the *Dispar* zone of the British upper Albian, has similar shape and ornamentation but flattered sides and entire saddles.

**Occurrence:** *Engonoceras* sp. indet. is found in the upper Albian-lower Cenomanian Yumagual formation, in bed 101 of the Cajamarca section.

*Engonoceras* is a common genus in the Albian and Cenomanian of Texas, Mexico, North Africa, and the Middle East.

**Parengonoceras Spath, 1924**

*Parengonoceras pernodosum* (Sommermeier)

Plate 44, figures 3-4; plate 45, figures 1-5

*Placenticeras pernodosum* SOMMERMEIER, 1910, p. 331, pl. 7, fig. 1.

Five well-preserved steinkerns including one complete disc and two half discs are referred to this species.

**Measurements**

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<td>21</td>
<td>.14</td>
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**Description:** The conch is large, discoidal, very narrowly umbilicated. The whorl section (fig. 29) changes from compressed triangular, with narrow truncated venter, in the early whorls to compressed ovoid, with rounded venter, in maturity. In the outer half-whorl of the largest available specimen (A.M.N.H. No. 27396/1:1) there are four conspicuous rows of tubercles: one row of four strong, prominent, radially elongated tubercles near the end of the first third; a second row of eight, less prominent, radially elongated tubercles at about the middle of the sides; a third row of 16, less prominent, rounded and small tubercles at about the middle of the outer third; and, finally, a fourth row of numerous spirally elongated tubercles at the ventrolateral shoulders; adorally, they tend to be obliterated.

The suture has large quadrate saddles which have a medial lobe and denticulated margins with phylloid, rounded terminations; the lobes are rather narrow and denticulated (fig. 29).

Between the diameters of 7 and 40 mm., the whorl section changes from triangular, with a narrow truncated venter, to a very high whorl section, with subparallel sides and flat or even concave venter. Growth is marked in height. At a diameter of 40 mm., there is a row of pointed tubercles, slightly elongated radially, just above the umbilical shoulder, a second row of smaller tubercles by the middle of the sides, and a third row of very sharp, spirally elongated tubercles at the ventrolateral shoulders. Low, broad, falciform ribs connect the three rows of tubercles; some of the medial tubercles serve as starting or as forking points of the ribs.

Between the diameters of 40 and 80 mm. growth is characterized by a decrease of the diameter-height ratio and an increase of the diameter-thickness ratio; the ventrolateral shoulders change from angular to rounded and indistinct; the venter changes from flat to broadly arched; and the sides bulge to produce an ovoid whorl section with steep umbilical wall, conspicuous umbilical shoulder, broadly arched sides, and a rounded venter. By a diameter of 80 mm., the falciform ribs become fainter, the tubercles are more widely spaced, and a fourth row of pointed tubercles appears at about the middle of the outer third, between the second row of mediolateral tubercles and the ventrolateral ones.

Between the diameters of 80 and 150 mm., the ventrolateral shoulders become obliterated, the ventrolateral tubercles (fourth from the umbilicus, third in order of appearance) tend to vanish, and the venter is broadly arched.

**Remarks:** *Parengonoceras pernodosum* resembles *P. ebrayi* de Loriol (1882, p. 7), the genotype, from the *Douvilleiceras* zone of Europe, in the suture and the general pattern of ornamentation, but is distinguished by having less flattened sides and by the earlier appearance of the ornamentation. In *P. ebrayi* the umbilical tubercles appear only after a diameter of 150 mm.

The suture illustrated by Sommermeier (1910, fig. 13) is somewhat misleading, for it
does show the pronounced rounding of the saddle terminations.

**Occurrence:** This species occurs in the middle Albian Crisnejas formations, in bed 9 of the Celendín section, associated with *P. tetranodosum*, *P. haasi*, and *Knemiceras attenuatum*, in bed 20 of the Crisnejas section (A.M.N.H. No. 27396/1:1), in bed 2 of the Uchupata section, associated with *K. syriacum*. It is also found in the Chulec formation, in bed 11 of the Lajas section.

The holotype, described by Sommermeier, comes from northern Cajabamba.

In the Chulec formation, there are specimens of *Parengonoceras* sp. which attain more than 80 mm. in diameter and which could not be collected nor specifically determined.

**Parengonoceras guadaloupaforme** (Sommermeier)

*Plate 44, figure 2*

*Placenticeras guadaloupaforme* **Sommermeier,** 1910, p. 337, pl. 7, fig. 2, pl. 8, figs. 1–2.

This species is represented by a single steinkern (A.M.N.H. No. 27397), a fragment of the body chamber belonging to an individual at least 130 mm. in diameter.

**Parengonoceras guadaloupaforme** is very
similar to *P. pernodosum* and differs only by the very strong and conspicuous development of the ornamentation, particularly of the inner three rows of tubercles which are connected by strong falciform ribs. The whorl section is subrectangular, not ovoid as in *P. pernodosum*.

**Occurrence:** The specimen was collected from the lower middle Albian Chulec formation, in bed 71 of the Cajamarca section. Sommermeier reported this species from Hualgayoc, El Monton, and Cachachi (Condabamba).

**Parengonoceras tetranodosum** (Lissón)

Plate 43, figures 5–10; plate 44, figure 1

*Knemiceras tetranodosum* Lissón, 1925, p. 25, pl. 2, fig. 3.

Six specimens (two complete discs, two half discs, and two smaller whorl fragments) are referred to this species.

**Measurements**

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**Description:** The conch is discoidal, very narrowly umbilicated. The whorl section changes from compressed triangular, with truncated venter, in the early whorls to compressed polygonal in the later ones. There are four rows of tubercles that begin very early in the ontogeny, and falciform ribs which are prominent between the diameters of 20 and 40 mm. but which vanish beyond the later diameter. The suture is as in *P. pernodosum*, although apparently the lobes gently vaulted and converge towards the narrow, truncated venter. Just above the umbilical shoulder there is one row of high, pointed tubercles which are the starting points of prorsiradiate ribs. In the outer third, the ribs swing forward and end in very sharp, spirally elongated tubercles at the ventrolateral shoulders. Between the primary ribs there are two or three intercalated ribs which start at about the middle of the sides.

At a diameter of 35 mm. a middle row of tubercles appears; they serve as forking points for the low ribs.

Between the diameters of 35 mm. and 45 mm. the maximum whorl thickness moves from the umbilical shoulder to the middle of the sides; the umbilical wall is narrow and steep and the shoulder is broadly rounded. The sides are parallel between the two inner rows of tubercles but converge from the middle row towards the broadly truncated venter. The ribs that connect the tubercles become fainter, and the tubercles tend to be more widely spaced. At a diameter of 45 mm. a fourth row of tubercles appears at about the middle of the outer third, and some of them serve as forking points for very low and broad ribs.

**Remarks:** *Parengonoceras tetranodosum* is closely related to *P. pernodosum* but is distinguished because of its polygonal whorl section, its smaller size, and the early development of the ornamentation. Also, the saddle margins of the suture of *P. tetranodosum* are not so denticulated as in *pernodosum*, resembling, thus, the suture of some species of *Knemiceras*.

**Occurrence:** This species is found in the Crisnejas formation (zone of *Knemiceras raimondii*), in bed 9 of the Celendín section, associated with *P. pernodosum* and *Knemiceras attenuatum*. Lissón's holotype is from Cajamarca.

**Parengonoceras haasi**, new species

Plate 46, figures 1–6

This species is erected on the basis of five steinkerns; the largest (A.M.N.H. No. 27399:1) is selected as the holotype.

¹ The specific name is given in honor of Dr. Otto Haas.
DESCRIPTION: The conch is flat, discoidal, very narrowly umbilicated. The whorl section (fig. 31) changes from slender, very high and compressed, triangular, with a very narrow truncately elongated tubercles at the ventrolateral shoulders, which appear at about the same time as the umbilical tubercles. Faint, fold-like falciform ribs connect the four rows of tubercles.

Up to a diameter of 40 mm., the whorl section is very high and compressed, triangular, with narrow and steep umbilical wall and rounded but distinct umbilical shoulder. The sides are broadly arched and converge towards the very narrow and flat venter with sharp, angular ventrolateral shoulders. The greatest thickness is near the umbilicus and is less than half of the whorl height.

Further growth is marked by a sharp decline in the diameter-height ratio and an increase in the diameter-thickness ratio. At a diameter of 80 mm., the whorl section is very high and compressed, ovoid, with low umbilical wall, and rounded but distinct umbilical shoulder. The sides are broadly vaulted, somewhat flattened about the middle of the

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sides, and converge towards the narrow, subconcave venter. The greatest thickness is just above the middle of the sides and is about half of the whorl height.

Remarks: Parengonoceras haasi differs from all other species of Parengonoceras by its slender whorl section, the late appearance of the ornamentation, and by the lack of conspicuous falciform ribs.

Occurrence: This species is found in the Crisnejas formation (zone of Knemiceras raimondii), in bed 9 of the Celendin section, together with P. pernodosum, P. tetranodosum, and Knemiceras attenuatum.

Parengonoceras? champaraense,1 new species
Plate 51, figures 8–9

This species is based on a single, fractured, completely septate steinkern (A.M.N.H. No. 27848).

Measurements

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Description: The conch is large, discoidal, flat, very narrowly umbilicated. The whorl section is very high and compressed, with narrow and steep umbilical wall and rounded but conspicuous umbilical shoulder. The sides are gently convex, subparallel to the end of the middle third; thence they gently converge towards the narrow, flat, and truncated venter. The greatest whorl thickness is at about the middle of the sides and is less than one-half of the whorl height. There are three rows of tubercles: one row of tubercles elongated in a prorsiradiate direction near the end of the inner third, which appear at a radius of 30 mm.; a second row of low, pointed tubercles which appear at a radius of 40 mm., and which quickly become faint and inconspicuous; and a third row of small, numerous, spirally elongated tubercles which form out of the sharp angular ventrolateral shoulders at a radius of 45 mm. and become very faint at about a radius of 65 mm. The suture is fairly complex (fig. 32). The saddles are large, subquadrate, divided by a deep median lobule and with extremely prominent phyllloid marginal denticulations; the lobes are strangulated, have a rounded outline, and are digitated.

Remarks: Parengonoceras? champaraense bears some resemblance in shape and ornamentation to some species of Knemiceras. The suture, however, is definitely that of Parengonoceras; in fact, the rounding of the saddle terminations is more prominent and conspicuous in P.? champaraense than in any of the other species of Parengonoceras. The presence of only three rows of tubercles distinguishes this species from the other species of Parengonoceras characterized by four rows of tubercles.

Occurrence: This species is found in the lower middle Albian Chulec formation, in bed 8 of the Sihuas section, associated with Dowvilleiceras mammillatum, Prolyelliceras peruvianum, Brancoceras aegoceratoïdes, Knemiceras raimondii, Knemiceras triangulare, and K. raimondii tardum.

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1 Named after Nevado Champará, east of which is the locality where the holotype was collected.
KNEMICERAS Bömm, 1898

Knemiceras attenuatum (Hyatt)

Plate 46, figures 7–10

Buchiceras attenuatum Hyatt, 1875, p. 372.
Glottoceras attenuatum Hyatt, 1875, p. 372

(Knemiceras attenuatum (Hyatt)); Hyatt, 1903, p. 151, *cum synon.*, pl. 17, figs. 13–15.

Knemiceras attenuatum-typicum Sommermeier, 1910, p. 341.
Knemiceras (Glottoceras) typicum Sommermeier; Breistroffer, 1952, p. 2633.

Five steinkerns, including four complete discs and one half disc, are assigned to this species.

**Measurements**

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**Description:** The conch is discoidal, flat, very narrowly umbilicated. The whorl section (fig. 33) is very high and compressed, triangular, with steep umbilical wall and rounded umbilical shoulder. The sides converge with gentle convexity towards the more abruptly truncated venter; the ventrolateral shoulders are angular. The greatest thickness is just above the umbilical shoulder and is about two-thirds of the whorl height. There are three rows of tubercles: one row of high, radially elongated tubercles just above the umbilical wall which appear before a radius of 15 mm.; a second row of more numerous, less prominent, elongated tubercles above the middle of the sides which appear at a radius of 20 mm.; and a third row of sharp, spirally elongated tubercles at the ventrolateral shoulders which begin at a radius of 15 mm., and which may be corresponding or not. Low, falciform ribs connect the three rows of tubercles; some of them issue or fork out of the middle tubercles. The ribs are more conspicuous between the radii of 15 and 20 mm. The suture (fig. 33) has quadrate saddles which have a median small indentation and entire margins. The lobes are narrow, strangled, and digitated.

**Remarks:** Knemiceras raimondii and its relatives are distinguished from K. attenuatum because early in the ontogeny the whorl section changes from triangular to rectangular. Among other species with triangular whorl sections, K. gabi and K. ollonense are larger in size and have only two rows of tubercles.

**Occurrence:** Knemiceras attenuatum is a common ammonite in the lower middle Albian Chulec formation (zone of Knemiceras raimondii).

**Fig. 33. Knemiceras attenuatum** Hyatt. Suture line (A) and conch section (B) of specimen A.M.N.H. No. 28849:1; ×1.

In the Sihuas section, it is associated with K. raimondii, Dowvilleiceras monile, and Prolyelliceras persewianum. Hyatt’s holotype comes from Celendín.

A number of specimens from the Middle East (Bassé, 1937, 1940) have been referred to K. attenuatum, but the present writer does not agree with these identifications.

Knemiceras attenuatum spinosum

(Sommermeier)

Plate 46, figures 11–12

Knemiceras attenuatum-typicum var. spinosa Sommermeier, 1910, p. 347, pl. 9, fig. 2.
One small, completely septate, fairly well-preserved steinkern (A.M.N.H. No. 27850) is referred to this species.

**Measurements**

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**Description:** The conch is small, discoidal, very narrowly umbilicated. The whorl (fig. 34) section is very high, compressed, triangular, with rounded umbilical shoulder and high umbilical wall. The sides are gently vaulted and converge towards the narrow, truncated venter; the ventrolateral shoulders are angular. There are three rows of tubercles: one row of tubercles just above the umbilical shoulder which appear at a radius of 15 mm. as fold-like swellings; at about a radius of 22 mm., they quickly develop into prominent, high tubercles which are elongated in a prorsiradiate direction; the second row of tubercles is just above the middle of the sides; they are elongated in a prorsiradiate direction, are less prominent than the umbilical ones, and appear at about a radius of 22 mm.; the third row consists of numerous spirally elongated tubercles which appear at a radius of 15 mm. Falciform, fold-like extensions of the tubercles connect them. The suture is similar to that of *K. attenuatum*.

**Remarks:** *Knemiceras attenuatum spinosum* differs from *K. attenuatum* only by its slightly thicker whorl section and the early and prominent development of the tuberculation.

The holotype, described by Sommermeier, differs from specimen A.M.N.H. No. 27850 (pl. 46, figs. 11–12) by the spinose development of the ornamentation. *Knemiceras libertandense* Breistroffer (K. attenuatum Hyatt; Douville, 1906, pl. 3, figs. 1–1a) is similar in whorl section and ornamentation to *K. attenuatum spinosum* but differs by the lack of a middle row of tubercles.

**Occurrence:** This subspecies is found in the lower middle Albian Chulec formation, in bed 23 of the Pomachaca section, associated with *K. attenuatum* and Douvilleiceras monile.

**Knemiceras syriacum** (von Buch)

Plate 47, figures 4–5

*Ammonites syriacus* von Buch, 1849, p. 20, pl. 6, figs. 1–3, pl. 7, fig. 1.

*Knemiceras syriacum* von Buch: Bassé, 1937, p. 167, *cum synonym.* pl. 8, fig. 5, pl. 9, fig. 3, pl. 10, fig. 2, pl. 11, fig. 3.

Two specimens are assigned to this species.

**Measurements**

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<td>.47</td>
<td>9</td>
<td>.06</td>
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**Description:** The conch is small, stout, discoidal, narrowly umbilicated. The whorl section is slightly compressed, with the greatest thickness near the umbilical shoulder which is very broadly rounded. The sides are subflattened and converge towards the broadly truncated venter. Just above the umbilical shoulder of the outer volution, there are nine pointed tubercles which are elongated in a prorsiradiate direction and are the starting points of conspicuous, broad, low, prorsiradiate ribs. By the middle of the sides, the ribs become radial, sometimes fork, and intercalated ribs also appear. All the ribs end in spirally elongated, strong, blunt tubercles at the ventrolateral shoulders. In the outer volution, there are 24 ventrolateral tubercles. The suture has massive, subquadrate saddles which have a small median notch and slightly denticulated margins. The lobes are strangulated and digitated (fig. 35).

**Remarks:** The Peruvian specimens agree in shape, ornamentation, and dimensions with von Buch's holotype. The suture, however, has the saddles with slightly denticulated margins, a feature which Bassé thinks
is characteristic of *K. uhligi*, a very similar species distinguished by its more compressed whorl section. *Knemiceras gabbi* is similar to *K. syriacum* in shape and ornamentation but is distinguished by its larger size and more flattened sides.

**Fig. 35.** *Knemiceras syriacum* (von Buch). Suture line of specimen A.M.N.H. No. 27851; ×1.

**Occurrence:** *Knemiceras syriacum* is found in the lower middle Albian Chulec formation, in bed 71 of the Cajamarca section (A.M.N.H. No. 27851), and in the Crisnejas formation, in bed 3 of the Uchupata section (A.M.N.H. No. 27851/1). In both places it is associated with *Parendonoceras pernodosum*.

**Knemiceras gabbi** Hyatt

Plate 47, figure 3

*Ammonites attenuatum* Hyatt; *Gabb*, 1877, p. 264, pl. 36, figs. 1a–b.

*Placenticeras attenuatum* Hyatt; Paulcke, 1903, p. 284, fig. 4.

*Knemiceras gabbi* HYATT, 1903, p. 152, pl. 18, figs. 1–3.

*Knemiceras gabbi* Hyatt; LISSON, 1908, p. 2a, pl. 2.


Two specimens are available for study. Specimen A.M.N.H. No. 27852 (pl. 47, fig. 3) is a steinkern 180 mm in diameter; the outer three-quarters of the last volution belong to the body chamber.

**Description:** The conch is large, discoidal, very narrowly umbilicated. The whorl section is compressed, truncated triangular. The greatest thickness is very close to the umbilical shoulder and is about three-fourths of the whorl height. The sides are subflattened and converge towards the truncated venter which is between one-half and one-third of the whorl thickness. Above the umbilical shoulder there is a row of five to six strong, pointed, broad-based tubercles which are the starting points of low, broad ribs. In the outer third, the ribs become more conspicuous, some intercalated ones appear, and all end in strong, spirally elongated tubercles at the ventrolateral shoulders. The suture is similar to that of *K. attenuatum*.

**Remarks:** Gabb’s original illustration of the holotype, reproduced later by Hyatt, was misleading. Fortunately, Lisson published a much better picture of the same specimen.

*Knemiceras gabbi* is distinguished from *K. attenuatum* by its larger size, the proportionally thicker whorl section, and by the presence of only two rows of strong tubercles. *Knemiceras syriacus*, *K. uhligi*, and *K. compressum* are very similar species which differ from *K. gabbi* because of their smaller size and subdubed tuberculation. *Knemiceras libertadense*, on the other hand, differs from *K. gabbi* by the extremely strong development of its umbilical tubercles.

Sommmermeier (1910, p. 348) badly confused the identity of *K. gabbi*. The specimen described by him as *Knemiceras attenuatum-gabbi* has strongly convex sides and has a third row of tubercles in the outer third.

The specimen described by Knechtel (1947, *in* Knechtel, Richards, and Rathbun) as *Knemiceras bassleri* was available to the writer. It agrees in every respect with Lisson’s illustration of the holotype of *K. gabbi*, more so than any of the specimens described here.

**Occurrence:** *Knemiceras gabbi* is found in the lower middle Albian Chulec formation, in bed 52 of the Sunchubamba section (A.M.N.H. No. 27852), associated with *K. attenuatum*, and in the middle Albian Crisnejas formation, in bed 4 of the Celendín section (A.M.N.H. No. 27852/1).

**Knemiceras triangulare**, new species

Plate 47, figures 1–2

A single specimen is available for study. It is an entirely septate, poorly preserved, fragmentary steinkern.

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**Description:** The conch is discoidal, stout, very narrowly umbilicated. The whorl section (fig. 36) is trapezoid. The greatest whorl thickness is just above the umbilical shoulder and is about three-fourths of the whorl
height. If the tubercles are considered, the whorl thickness is about the same as the whorl height. The sides are slightly convex and strongly converge towards the broadly truncated, flat venter. There are three rows of tubercles; just above the umbilical shoulder of the outer half whorl there are three strong, rounded tubercles. At about the middle of the sides, there is a second row of eight, very faint tubercles, slightly elongated radially. Finally, at the ventrolateral shoulder there is a third row of strong, spirally elongated tubercles. Very weak, broad, fold-like falciform extensions connect the three rows of tubercles; they are specially conspicuous in the outer third of the sides. The suture (fig. 36) is like that of most species of *Knemiceras*, with massive saddles which have a median notch and entire margins.

Remarks: *Knemiceras triangulare* resembles *K. gabbi* but is distinguished by its less compressed whorl section, more inflated sides, less prominent ribs, and by the presence of a row of weak mediolateral tubercles.

Occurrence: *Knemiceras triangulare* was collected from the Chulec formation, in bed 8 of the Sihuas section (A.N.M.H. No. 27853), together with *Douvilleiceras monile*, *Parenzoniceras peruvianum*, *Brancoceras aegoceratoide*, *K. raimondii*, and *K. attenuatum*.

**Knemiceras ovale**, new species

Plate 52, figures 1, 4

*Knemiceras attenuatum-gabbi* Sommermeier, 1910, p. 341, pl. 9, fig. 1.

Only two poorly preserved steinkerns are available for study. The holotype, A.M.N.H. No. 27854, is a half-disc 140 mm. in diameter which includes part of the body chamber. Specimen A.M.N.H. No. 27854/1, another half-disc 120 mm. in diameter, includes also a small part of the body chamber.

Description: The conch is discoidal, stout, narrowly umbilicated. The whorl section (fig. 37) is compressed, ovoid, truncated, with indistinct umbilical wall and rounded umbilical shoulder. The greatest whorl thickness is at the end of the first third and is about two-thirds of the whorl height. The sides are bulging, with maximum convexity in the inner third, and converge towards the flat and broadly truncated venter. There are three rows of tubercles. One row of pointed tubercles (three in a half whorl) is at the end of the inner third of the sides; the second row of rounded, weak tubercles (eight in a half whorl) is at about the middle of the outer third; finally, there is a third row of strong, spirally elongated tubercles at the
ventrolateral shoulder. The suture has quadratate saddles with a median notch and slightly denticulated margins.

**Remarks:** *Knemiceras ovale* is distinguished from *K. gabbi*, with which it was confused by Sommermeier, by its bulging sides, ovoid whorl section, presence of a third row of tubercles in the outer third, less prominent and less numerous umbilical tubercles, and by the lack of ribs. *Knemiceras triangulare* differs from *K. ovale* by its less compressed whorl section, less convex sides, and in that the second row of tubercles is at about the middle of the sides, not in the outer third as in the latter.

**Occurrence:** *Knemiceras ovale* is found in the middle Albian Crisnejas formation, in bed 3 of the Uchupata section (A.M.N.H. No. 27854/1) associated with *Lyellites ulrichi*, and in bed 20 of the Celendín section (A.M.N.H. No. 27854) associated with *L. pseudolyelli*.

*Knemiceras* ovale

Plate 50, figure 5

Ammonites ovonensis Gabb, 1877, p. 271, pl. 38, figs. 4–4a.

A single specimen (A.M.N.H. No. 27855) is tentatively assigned to this poorly known species. It is a complete disc with the shell preserved in a few places. The outer half whorl belongs to the body chamber.

**Measurements**

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</table>

**Description:** The conch is discoidal, flat, narrowly umbilicated. The whorl section (fig. 38) is compressed, subtrapezoidal, with steep umbilical wall and broadly rounded umbilical shoulder. The sides are subflattened and converge towards the flat, truncated venter. The greatest thickness is in the inner third and is less than two-thirds of the whorl height. Just above the umbilical shoulder of the outer whorl is a row of eight pointed tubercles which are elongated in a prorsiradial direction. Very faint, broad, fold-like prorsiradial ribs start in these tubercles, and others are intercalated about the middle of the sides. All the ribs end in numerous, spirally elongated tubercles at the ventrolateral shoulders. The ribs are obliterated in the body chamber. The shell is marked by strong sigmoidal growth striae. The suture is like that of *K. attenuatum*.

**Remarks:** Haas (in Gabb, 1877, p. 272) considered the holotype of *K. ollonense* as an intermediate form between *K. attenuatum* and *K. gabbi*. It has the whorl section of *K. attenuatum* but is distinguished by larger size and the lack of a row of mediolateral tubercles. From *K. gabbi* it is distinguished by its more compressed whorl section and its subdued ornamentation.

**Occurrence:** *Knemiceras* ollonense is found in the lower Albian Inca formation, in bed 50 of the Sunchubamba section (A.M.N.H. No. 27855) together with *Parahoplites nicholsi* and *Desmoceras chimunense*. It is very remarkable because it is the only species of *Knemiceras* found in the Inca formation; all the other species are known to be abundant in the overlying beds of the middle Albian Chulce formation.

*Knemiceras raimondii* Lissón

Plate 48, figures 1–5

*Knemiceras raimondii* Lissón, 1908, p. 4a, pl. 4, figs. 1a–e, 2.

*Knemiceras attenuatum-crassinodosum* Sommermeier, 1910, p. 345, text figs. 26–27, pl. 13, figs. 1–2.

*Knemiceras* attenuatum-Raimondi, Sommermeier, 1910, pp. 343, 346, pl. 13, figs. 3–7, pl. 14, figs. 1–3.

Seventeen steinkerns, including several complete discs, are assigned to this species.
DESCRIPTION: The conch is large, stout, discoidal, narrowly umbilicated. The whorl section (fig. 39) changes in the early whorls (between the radii of 10 and 15 mm.) from very high and compressed subtrapezoidal to compressed rectangular; the greatest thickness moves, at the same time, from the umbilical shoulder to about the middle of the sides and is about two-thirds of the whorl height. The sides are broadly convex to subflattened, and are converging in the early whorls but subparallel in the later ones. The umbilical shoulder is abruptly rounded...
vaulted in the large specimens. There are three distinct, very prominent rows of tubercles which start very early in the ontogeny. Before a radius of 20 mm., all three rows of tubercles are already present, and by a radius of 40 mm. (diameter of 70 mm.) the three rows of tubercles have about the same strength. The inner row is just above the umbilical shoulder, and has seven high tubercles, slightly elongated radially. For each of them, there are two or three pointed, elongated tubercles at about the middle of the sides and three or four spirally elongated tubercles at the ventrolateral shoulders. The tubercles vary in strength and unusually become thorny, as in specimen A.M.N.H. No. 27856:4 (pl. 48, figs. 1–2). The ventrolateral tubercles may be corresponding or not. Strong, fold-like, falciform ribs connect the three rows of tubercles; some of them fork at the mediolateral tubercles, others are simply intercalated. In the large specimens, the ribs may even be marked on the venter, although in some specimens they are very weak. Beyond a diameter of 100 mm., both tubercles and ribs become weaker. The suture (fig. 39) has the basic Knemiceras pattern: large, massive, quadrate saddles which have a median notch and entire margins. The lobes are strangledulated and digitated. The ventral lobe has two arms which may be directed adapically or extend laterally. The suture is very plastic and is affected considerably by the position of the tubercles.

Remarks: Knemiceras raimondii approaches K. attenuatum in ornamentation but is distinguished by its rectangular whorl section, larger size, and the comparatively early appearance of the ornamentation. Knemiceras ovale and K. triangulare have different whorl sections than K. raimondii and, moreover, the mediolateral row of tubercles in these two species is not so conspicuous as in the latter species.

Occurrence: Knemiceras raimondii is the most common ammonite in the Chulec formation (lower middle Albian). It occurs in beds 58 and 70 of the Cajamarca section (A.M.N.H. Nos. 27856/1 and 27856/2) associated with K. attenuatum, Dowilleliceras monile, and Prolyelliceras peruianum; in bed 8 of the Sihuas section (A.M.N.H. No. 27856) together with K. triangulare, K. attenuatum, K. raimondii tardum, Brancoceras aegoceratoides, P. peruianum, and D. monile; and in bed 23 of the Pomachaca section (A.M.N.H. No. 27856/3).

Knemiceras raimondii pacificum, new subspecies

Plate 49, figure 1

This subspecies is erected on the basis of a single specimen (A.M.N.H. No. 27857), 130 mm. in diameter, which has the shell preserved. The measurements were taken at a diameter of 90 mm., for the specimen is somewhat crushed adorally.

Measurements
A.M.N.H. No. D H D/T T D/T U D/U 27857 90 45.5 .51 .34 16 .18

Description: The shape of the conch and of the whorl section is the same as in K. raimondii. It also has three prominent rows of tubercles, but they are spinate and more numerous than in K. raimondii. In the outer whorl section, the first row is just above the umbilical shoulder and has nine long, broken, spinate tubercles; the second row is at about the middle of the sides and has 22 pointed tubercles which are more closely crowded between the radii of 40 and 50 mm. The ventrolateral shoulders are provided with more numerous, spirally elongated tubercles.

Occurrence: This subspecies is found in the lower Albian Crisnejas formation, in bed 4 of the Celendin section, associated with K. gabbi.

Knemiceras raimondii tardum, new subspecies

Plate 48, figures 6–7

This subspecies is based on a single, thoroughly septate, well-preserved steinkern.

Measurements
A.M.N.H. No. D H D/T T D/T U D/U 27858 70 .36 .51 20.5 .29 8 .11

Description: Knemiceras raimondii tardum has the same whorl section, suture, and ornamentation as K. raimondii (fig. 40). It differs only because of a conspicuous ontogenetic retardation. The change of the whorl section from high and compressed subtrapezoidal to compressed subrectangular takes place at a radius of 35 mm. Also, the appearance and the development of the
ornamentation are delayed. Whereas in *K. raimondii* the three rows of tubercles appear before a radius of 20 mm., in *K. raimondii tardum* they make their appearance at a radius of 35 mm.

At a radius of 30 mm., the whorl section is high, compressed, and subtrapezoidal, with the greatest thickness near the umbilicus; the sides are subflattened and converge towards the narrow, flat, truncated venter; the

![Diagram](image)

**Fig. 40. Knemiceras raimondii tardum**, new subspecies. Suture line (A) and conch section (B) of the holotype; ×1.

ventrolateral shoulders are angular. Half a whorl later, the whorl section is subquadrate, with the greatest thickness at about the middle of the sides; which are parallel between the two inner rows of tubercles and slightly converging between the two outer ones. Growth has been marked in venter width. All the three rows of tubercles appear almost simultaneously at a radius of 35 mm.; they have the same attitude and strength as in *K. raimondii*.

**Occurrence:** This subspecies occurs in the lower middle Albian Chulec formation, in bed 8 of the Sihuas section, associated with *Douvilleiceras monile*, *Prolyelliceras peruvianum*, and several other species of *Knemiceras*.

*Knemiceras? ziczag* Breistroffer

Plate 52, figure 2

*Knemiceras attenuatum* Hyatt; Douville, 1906, p. 151, pl. 4, fig. 1.


A single, very poorly preserved fragment of an individual at least 150 mm. in diameter is conspecific with the specimen illustrated by Douville and designated by Breistroffer as the holotype of *Knemiceras (?*) ziczag.

**Description:** The whorl section is compressed, ovoid, with the greatest thickness at about two-thirds of the whorl height. The sides are convex and make an even curve with the rounded venter. The umbilical and the ventrolateral shoulders are indistinct and broadly rounded. In one-quarter of a volition, on the middle of the sides, there are two very large, elongated, high, round-crested tubercles which are about half of the whorl height in length; their upper end is broken. At the ventrolateral shoulder there are five blunt tubercles, and although the venter is weathered, it is possible to see the "bourrelets en ziczag" shown by the holotype.

The suture has massive, large, quadrate saddles which have a median notch and denticulated margins.

**Remarks:** *Knemiceras? ziczag* deviates from all the other species of *Knemiceras* by its ovoid whorl section, the lack of a truncated venter, the peculiar ornamentation, and the indentation of the saddle margins. The large lateral tubercles resemble the ribs of some species of *Dipoloceras*. Until better material can be gathered, the generic determination will remain doubtful.

**Occurrence:** This species is found in the Crisnejas formation, in bed 2 of the Uchupata section (A.M.N.H. No. 27859) together with *Knemiceras gabbi*, *K. syriacum*, and *Paren gonoceras pernodosum*. 
SUPERFAMILY DIPOLOCERATACEAE Spath, 1921

FAMILY DIPOLOCERATIDAE Spath, 1921

OXYTROPIDOCERAS STEINMANN, 1920

Oxytropidoceras carbonarium (Gabb)

Plate 49, figure 6

Ammonites carbonarius Gabb, 1877, p. 269, pl. 38, fig. 2.
Schloenbachia acutocarinata (Shumard) Marcou var. multifida Steinmann, 1881, p. 139, pl. 7, fig. 1.
Amm. carbonarius Gabb; Steinmann, 1882, p. 167.
Schloenbachia (Mortoniceras) Royssiana d'Orb. var. multifida Steinmann; Schlagintweit, 1912, p. 64.
Schloenbachia multifida Steinmann; Douglas, 1921, p. 267, pl. 14, fig. 25.
Oxytropidoceras (Manuamiceras?) carbonarium Gabb; Reeside, 1927, in Wasson and Sinclair, p. 1271, pl. 12, figs. 18–20.
Oxytropidoceras cf. acutocarinatum (Shumard); Adkins, 1928, p. 226, pl. 5, fig. 1.
Oxytropidoceras (Schloenbachia) peruvianum v. Buch var. multifida Steinmann, 1930, p. 136, fig. 156.
Oxytropidoceras cf. multifidum (Steinmann); Spath, 1930, p. 61, pl. 71.
Oxytropidoceras acutocarinatum Shumard var. multifida Steinmann; Collignon, 1936, in Besairie, p. 181, pl. 20, fig. 1.
Oxytropidoceras (Manuamiceras) carbonarium (Gabb); Knechtel, 1947, in Knechtel, Richards, and Rathbun, p. 107, pl. 27, fig. 4, pl. 28, fig. 2, pl. 29.

DESCRIPTION: The conch is large, lenticular, very narrowly umbilicated. The whorl section is a strongly compressed ogive, with flattened sides which in the outer fourth become convex, converge, and form a fastigate venter provided with a high carina. Numerous uniform, closely spaced ribs begin at the umbilical shoulder; they are straight and prorsiradiate to the end of the third fourth where they bend and strongly project forward; they vanish before reaching the carina. Most, if not all, of the ribs dichotomize before reaching the inner fourth of the sides. They are flat-topped and reach their maximum width at the end of the second third where they are four or five times wider than the almost linear grooves that separate them. On the steinkern, the ribs offer quite a different view, for they are less flattened than in the shell and are as wide as the rounded and deep interspaces. The illustrated fragment shows remarkably well the dichotomy of the ribs and the differences of ribbing in the shell and in the steinkern.

REMARKS: Oxytropidoceras carbonarium was originally described by Gabb (1877) on the basis of specimens from Pariatambo, central Peru; in his description, he does not mention the forking of the ribs, but his illustration shows it well. Steinmann (1881), unaware of Gabb's publication and working on materials from the same locality, described his Schloenbachia acutocarinata Shumard (Marcou) var. multifida. One year later, however, Steinmann (1882, p. 167) reviewed Gabb's work and recognized the conspecificity of Amm. carbonarius Gabb and his multifida. He said: "Amm. carbonarius Gabb... is dieselbe charakteristische Art, welche ich als Schloenbachia acuto-carinata Shum. sp. bezeichnet und abgebildet habe. Die Zeichnung Gabb's könnte fast nach meinem Stücke angefertigt sein...." This binding statement was unfortunately overlooked by most of the later workers.

Reeside (1927, in Wasson and Sinclair) and Knechtel (1947, in Knechtel, Richards, and Rathbun) have correctly interpreted Amm. carbonarium and have assigned it to the subgenus Manuamiceras. However, Spath, the author of this subgenus, has always referred to O. multifidum (= O. carbonarium) as belonging to Oxytropidoceras, sensu stricto, although recognizing at the same time that it is the closest relative of Manuamiceras manuamense, genotype of Manuamiceras.

Oxytropidoceras acutocarinatum (Shumard) is an ill-defined and doubtful (Adkins, 1928, p. 224; Spath, 1934, p. 19) species which, according to the interpretations of Steinmann and other authors, differs from O. carbonarium mainly by the lack of the remarkable dichotomy of the ribs which characterizes O. carbonarium. Oxytropidoceras parinensis Olson, a slightly more umbilicated form, is very closely related to, if not the same as, O. carbonarium.

OCCURRENCE: Oxytropidoceras carbonarium is the most common ammonite in the medial Albian Pariatambo formation. Usually, it occurs in limestone concretions from which entire specimens are difficult to obtain. It also
occurs in the upper part of the middle Albian Crisnejas formation. Specimen A.M.N.H. No. 27860 was found in bed 14 of the Paria-huanca section together with O. douglasi, Ly-lliceras lyelli, L. ulrichi, Brancoceras aegocer-atoides, and Desmoceras latidorsatum.

Oxytropidoceras peruvianum (von Buch)

Plate 49, figure 5

Ammonites peruvianus von Buch, 1839, p. 5, pl. 1, fig. 5.

Schloenbachia sp. (cf. acutocarinata Böse non Shumard); Douglass, 1921, p. 269, pl. 16, fig. 1.

Oxytropidoceras n. sp. (aff. supani Lasswitz) Adkins, 1928, p. 226, pl. 5, fig. 2.

Steinmann (1881, p. 140) referred to the holotype of Oxytropidoceras peruvianum as "ein Ammonit mit schmalen Rippen und breiteren Zwischenräumen." Later Schlagin-tweit (1912, p. 71) described the same specimen in the following terms: "Es sind Steinern-stücke mit ungedelbten, schmalen Rippen, die gegen die Externseite nur langsam an- schwellen und nur schwach S-förmig gebogen sind. Jedoch sind die Rippen etwas abge-wittert und die Externseite ist nicht intakt; die Rippen müssen in ihrem oberen nicht mehr erhaltenen Teil stärker angeschwollen und kräftiger gebogen gewesen sein. Dass die Rip- pen erheblich schmäler seien wie die Zwischen-räume, trifft nur für die untere (gegen den Nabel zu) Hälfte der Schmale zu."

Specimen A.M.N.H. No. 27861 (pl. 49, fig. 5), a steinkern with patches of shell, agrees with these descriptions as well as with von Buch's illustration of the holotype.

DESCRIPTION: The conch is large, lenticu-lar, narrowly umbilicated. The whorl sec-tion (fig. 41) is a high and compressed ogive. The sides are gently convex, with maximum convexity in the inner third, and converge towards the fastigate venter which is pro-vided with a high carina. Fine, sigmoidal ribs begin at the umbilical shoulder; they are prorsiradiate and subangular to the end of the first fourth where they become less prorsiradiate, much broader, and slightly flat-topped; their adoral edge is steeper than the adapical one. By the end of the third fourth, the ribs become again more prorsi-radiate and project forward, although not so strongly as in O. carbonarium. The ribs have about the same shape both in the shell and in the steinkern.

REMARKS: There is considerable confusion in the literature regarding this species and its relationships with others of the same genus. Spath (1934, p. 20) has said: "Judging by the figure (v. Buch, 1839, pl. 1, fig. 5) Amm. peruvianus is more like O. acutocarinata, i.e.,

![Fig. 41. Oxytropidoceras peruvianum (von Buch). Conch section of specimen A.M.N.H. No. 27861; X1.](image-url)
Oxytropidoceras douglasi Knechtel

Oxytropidoceras douglasi Knechtel, 1947, in Knechtel, Richards, and Rathbun, p. 106, *cum synon.*, pl. 24, figs. 1-4, pl. 25, figs. 1-2, pl. 26, pl. 27, figs. 2-3, pl. 28, fig. 1.

Four fragments (A.M.N.H. No. 27862) are referred to this species. The type material, described by Knechtel, was available to the present writer for study.

DESCRIPTION: The conch is large, lenticular, narrowly umbilicated. The whorl section (fig. 42) is biconvex, inflated, with high and perpendicular umbilical wall and abrupt umbilical shoulder. The greatest thickness is at the end of the inner third and is between two-thirds and three-fourths of the whorl height. The venter is fastigate and provided with a high and solid carina. Single, sigmoidal, prorsiradiate ribs begin just above the umbilical shoulder; they are subacutely crested up to the end of the inner third where they become increasingly more rounded and bulged, their adoral slope being steeper than the adapical one.

REMARKS: Oxytropidoceras belknapi, genotype of the subgenus Adkinsites, is similar in whorl section and in the shape of the ribs to *O. douglasi*. It is distinguished by the presence of forked and intercalated ribs.

Occurrence: Oxytropidoceras douglasi is found in the middle Albian Crisnejas formation, in bed 2 of the Santo Cristo Bridge section (A.M.N.H. No. 27862), in the middle Albian Pariatambo formation, in bed 14 of the Pariahuancas section, and in the lowest beds of the Albian-Turonian Jumasha formation, in bed 4 of the Uchupata section.

*VENEZOLICERAS SPATH, 1920*

*Venezolicas venezolana* (Stieler)

Plate 53, figure 5

Schloenbachia (*Mortoniceras*) inflata, Sowerby; Schlagintweit, 1912, p. 79, text figs. 1-2.

Oxytropidoceras venezolana, Stieler, 1920, p. 394.

*Venezolicas venezolensa* (Stieler); Spath, 1925, p. 182.

The record on this genotype species is limited to a poor illustration of the whorl section of the holotype, and to the inadequate descriptions by Schlagintweit and Stieler. Two flattened specimens are referred to this species; they offer only one side to view.
Measurements

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**DESCRIPTION:** The conch is lenticular, narrowly umbilicated. According to Schlagintweit's illustration, the whorl section is a high and compressed ogive with biconvex sides which converge towards the fastigate venter provided with a high carina. The available specimens show that the carina is about one-fifth of the whorl height. There are 17 to 21 straight, single, prorsiradiate ribs which start at the umbilical shoulder and are narrower than the rounded interspaces. The ribs are provided with two rows of tubercles: one row of pointed tubercles at the middle of the sides which appear at a radius of 15 mm. and a second row of more prominent, spirally elongated tubercles at the ventral end of the ribs. Both rows of tubercles are already present at a radius of 15 mm.

**REMARKS:** *Venezoliceras guaduasense* (d'Orbigny), another poorly known species, has similar whorl section and ornamentation; it is distinguished because its mediolateral tubercles are present only every two or three ribs and because, apparently, the ventrolateral shoulder is well marked.

**Occurrence:** *Venezoliceras venezolanum* is found in the middle Albian Pariatambo formation, in bed 85 of the Cajamarca section (A.M.N.H. No. 27863), associated with *Oxytropidoceras carbonarium* and *O. douglasi*, and in bed 26 of the Pomachaca section (A.M.N.H. No. 27863/1), associated with *O. peruvianum*. Schlagintweit's specimen, holotype of the species, is reported to be from the Pariatambo formation, from Huallanca.

**Venezoliceras harrisoni,** new species

Plate 53, figure 6

This species is based on a single, fragmentary, flattened specimen (A.M.N.H. No. 27864) which has only one side visible. It must have been at least 150 mm. in diameter.

**Description:** The conch is large, discoidal, fairly narrowly umbilicated. The whorl section is apparently a very high and compressed ogive with low and perpendicular umbilical wall. The sides are flattened up to the end of the second third, where they become convex and converge towards the fastigate venter which is provided with a very high carina. The outer volution has 62 slightly sigmoidal, strongly prorsiradiate ribs, about half of which start at the umbilical shoulder. The others are either intercalated or forking ribs which in the early part of the outer whorl appear at about the middle of the sides, but which tend to appear closer to the umbilicus. Adorally, there are no forking ribs, and the intercalated ones start in the inner third and have almost the same length as the primary ones. The ribs are provided with two rows of tubercles: one row of prominent, pointed, radially elongated tubercles at about the middle of the sides which are present only in the primary ribs, and which appear at a diameter of 70 mm.; the second row is composed of spirally elongated tubercles at the ventral end of every rib. The ribs are subangular in the inner half of the sides but become rounded in the outer one.

**Remarks:** *Venezoliceras venezolanum* is similar in whorl section, carina, and pattern of ornamentation to *V. harrisoni*. It is distinguished by the lack of forking ribs, the smaller number of ribs per volution, the less conspicuous development of the mediolateral tubercles, and the straightness of the ribs. *Venezoliceras guaduasense* is distinguishable from *V. harrisoni* by the lack of secondary ribs and by the early appearance of the tuberculation.

**Occurrence:** Specimen A.M.N.H. No. 27864 was collected from the Pariatambo formation, in bed 85 of the Cajamarca section, together with *V. venezolanum* and *Oxytropidoceras carbonarium*.

**DIPOLOCERAS HYATT, 1900**

*Dipoloceras* sp. indet.

Plate 50, figure 6

*Mortoniceras rostratum* Sowerby; **Douvillé**, 1906, p. 149, pl. 4, fig. 4.

A large body chamber, 260 mm. in length, part of an individual of more than 220 mm. in diameter, belongs to this genus. It is inadequate for specific determination.

**Description:** The conch is large and

1 Named after Dr. J. V. Harrison, whose careful observations have contributed much to the understanding of the geology of Peru.
evolute. The intercostal whorl section (fig. 43) is slightly compressed, subquadrate, with steep umbilical wall and abruptly rounded umbilical shoulder. The sides are convex and slightly converging; the ventrolateral shoulders are very broadly rounded, and the venter is broad and provided with a low but distinct carina. The costal whorl section is quadrate.

In one-quarter of a volution, there are seven strong, straight ribs which start at the umbilical shoulder and end near the carina. They are subrounded, with broader and rounded interspaces, and are higher at the ventrolateral shoulders than at the middle of the sides; also, at the ventrolateral shoulders every rib swells into a large tubercle which extends almost to the carina.

**Remarks:** *Dipoloceras frederickburgense* Scott has a similar whorl section but is more finely ribbed than *Dipoloceras* sp. indet.

**Occurrence:** Specimen A.M.N.H. No. 27865 was found in the upper middle Albian Pariatambo formation, in bed 86 of the Cajamarca section.

**BRANCO CERAS** Steinmann, 1881

*Brancoceras aegoceratoides* Steinmann

Plate 49, figures 2–4

*B. aegoceratoides* Steinmann, 1881, p. 137, pl. 7, figs. 2–2b.

*B. varicosum* Sow.; Schlafingweit, 1912, p. 85.

*Brancoceras aegoceratoides* Steinmann; Knechtel, 1947, in Knechtel, Richards, and Rathbun, p. 103, pl. 21, figs. 5a–b.

**Measurements**

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**Description:** The conch is small, discoidal, fairly widely umbilicated. The whorl section is compressed, oval, with indistinct umbilical wall and very broadly rounded umbilical shoulder. The sides are flattened and subparallel; the ventrolateral shoulder is also broadly rounded and makes an even curve with the semicircular venter. Specimen A.M.N.H. No. 27866:1 has in the outer half whorl 16 strong, single, prominent ribs which start at the umbilical shoulder; they are straight, prorsiradiate, rounded, and broader than the interspaces to the ventrolateral shoulders where they are slightly more prorsiradiate and broader. On the venter, the ribs are very conspicuous, rounded, and with wider interspaces. The first ribs appear at a radius of 4 to 5 mm. They are irregular, some fork out of a point in the umbilical shoulder, and all flatten out at the ventrolateral shoulders. These early ribs are sharp-edged and widely spaced. At a radius of 9 to 10 mm., they cross over the venter. The suture (fig. 44) is simple, with broad and massive lateral saddles which have denticulated margins, and a first lateral lobe which is trifid and deeper than the ventral one.

**Remarks:** *Brancoceras aegoceratoides* differs from other species of the genus, such as *B. senegueri* and *B. cricki*, by the lack of a carina at any stage.

**Occurrence:** *Brancoceras aegoceratoides* is a common ammonite in the middle Albian Pariatambo formation where it is associated...
with several species of *Oxytropidoceras*, *Venezoliceras*, *Lytelliceras*, *Dipoloceras*, and *Desmosfera*. It is also rarely found in the lower middle Albian Chulec formation, associated with species of *Knemiceras*, *Douvilleiceras*, *Protanisoceras*, and *Prolyelliceras*.

**SUPERFAMILY ACANTHOCLERACTACEAE**

**HYATT, 1900**

**FAMILY LYELLICERATIDAE** Spath, 1921

**PROLYELICERAS** Spath, 1930

Prolyelliceras peruvianum Spath

Plate 50, figures 1–4

*Acanthoceras* Lyelli Leym.; *Steinmann*, 1881, p. 135, pl. 7, figs. 3–3a.

*Acanthoceras prosocircum* Gerhardt; *Douvillé*, 1906, p. 144, pl. 2, figs. 1–1a.

*Prionotropis* Radenaci Pervinquière; *Sommermeier*, 1910, p. 381, text fig. 37, pl. 14.

*Prolyelliceras peruvianum* Spath, 1930, p. 65 (footnote).

*Prolyelliceras lobatum* Riedel, 1937–1938, p. 57, pl. 9, figs. 9–11, pl. 14, figs. 28–29.

Eight fragmentary steinkerns, including two half-discs, are assigned to this species. The largest specimen (A.M.N.H. No. 27867; pl. 50, figs. 1–2) is for the most part a fragment of body chamber belonging to an individual more than 100 mm. in diameter.

**MEASUREMENTS**


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**DESCRIPTION:** The conch is discoidal, fairly widely umbilicated. The whorl section (fig. 45) is compressed, oval to subquadrate, with the greatest thickness at about the middle of the sides. The umbilical wall is indistinct, and the umbilical shoulder is broadly rounded. The sides are convex and subparallel. The ventrolateral shoulder is broadly rounded in the early whorls but becomes well defined at about a radius of 40 mm., giving a subquadrate appearance to the whorl section. In the body chamber, they become again broadly rounded, and the whorl section tends to take the shape of a very inflated ogive. The venter is broad and makes an even curve with the sides; in the body chamber it tends to become fastigate. There are 15 to 17 single, strong ribs per half whorl; they appear at about a radius of 10 mm. Between the radii of 20 and 40 mm., the ribs are strong, subangular, fairly straight, prorsiradiate, and with much wider and rounded interspaces; on the venter, they are broader and round-crested. On the body chamber, the ribs have a tendency to become more rounded, sigmoidal, and to form an angle at the siphonal line. The ribs are provided with a row of tubercles at the siphonal line and another one along the ventrolateral shoulder. The tubercles of these rows are spirally elongated and strong to a radius of 30 mm. where they become pointed and subdued. On the body chamber they are obliterated. The suture (fig. 45) is simple, with massive, broad, bifid saddles and a trifid first lateral lobe which is equal in depth to the ventral lobe.

**REMARKS:** *Prolyelliceras peruvianum* resembles *P. gevreyi* Jacob in whorl section and pattern of ornamentation. In the latter species, however, the ribs seem to be interrupted across the venter, and the siphonal tubercles do not correspond with the ventrolateral ones. *Prolyelliceras peruvianum* resembles also *P. cotteti* Spath, a poorly known species, in shape and in the presence of three rows of tubercles. They are distinguishable because *P. cotteti* has intercalated and forked ribs and is more closely costate.

The specimen described as *Prolyelliceras lobatum* by Riedel (1947–1948) belongs to *P. peruvianum*. Riedel was misled by the large size of his specimen and hampered by the poor knowledge of the Peruvian species.
**Occurrence:** Prolyelliceras peruvianum is a common ammonite in the lower middle Albian Chulec formation, in bed 58 of the Cajamarca section (A.M.N.H. No. 27867/1), associated with Knemiceras attenuatum, K. raimondii, and Douvilleiceras monile, and in bed 8 of the Sihuas section, where it is associated with several species of Knemiceras, D. monile, and Brancoceras aegoceratoïdes.

**Lyelliceras Späth, 1921**

Lyelliceras lyelli (Leymerie) d'Orbigny

Plate 51, figures 1–3

Lyelliceras lyelli (Leymerie MS) d'Orbigny; Späth, 1923–1943, vol. 2, p. 316, *cum synon.*, pl. 32, figs. 9a–b, 12a–b, 13a–b.

This well-known and world-wide species is represented by seven well-preserved discus and several whorl fragments.

**Measurements**

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**Description:** The conch is discoidal, fairly widely umbilicated. The intercostal whorl section is subcircular to subquadrate. The costal whorl section is polygonal. The umbilical wall is low and has a broadly rounded shoulder. The sides are convex, and the ventral lateral shoulders are broadly rounded, making an even curve with the arched venter.

There are 20 to 22 single strong ribs per whorl, which appear at about a radius of 5 mm.; they are prorsiradiate up to the end of the inner third where they become radial and cross the venter uninterrupted. The ribs are provided with one row of pointed tubercles just above the end of the inner third of the sides; a second row of pointed tubercles, tending to become spirally elongated, at about the end of the middle third of the sides; and a third row of more prominent, spirally elongated tubercles at the ventrolateral shoulder; these ventrolateral tubercles are the first to appear. Along the siphonal line the ribs are provided with a row of tubercles which correspond and are similar in shape and size to the ventrolateral ones. All the tubercles are present already at about a radius of 9 to 10 mm. On the body chamber the ribs tend to become sharp and the tuberculation to disappear.

**Occurrence:** Lyelliceras lyelli is a common species in the middle Albian Paratambo formation (bed 14 of the Parahuanca section, A.M.N.H. No. 27868; bed 26 of the Pomachaca section, A.M.N.H. No. 27868/1), where it is associated with Oxytropidoceras carbonarium, O. peruvian, O. douglasi, Brancoceras aegoceratoïdes, L. ulrichi, Venetoceras velenosulatum, and, unusually, B. aegoceratoïdes. In England, L. lyelli seems to be confined to the benattianus zone (Spath, 1930, p. 1).

**Lyelliceras pseudolyelli** Parona and Bonarelli

Plate 52, figure 3

Acanthoceras pseudolyelli Parona and Bonarelli, 1896, p. 99, pl. 14, figs. 1a–c, 2a–b.


Lyelliceras pseudolyelli Parona and Bonarelli; Riedel, 1937–1938, p. 54, pl. 9, figs. 5–6, pl. 13, fig. 16.

Nine specimens, most of them poorly preserved steinkerns, are available for study.

**Measurements**

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**Description:** The conch is discoidal, fairly widely umbilicated. The whorl section is slightly compressed, subquadrate, with steep umbilical wall and broadly rounded umbilical shoulder. The sides are convex and almost parallel; the ventrolateral shoulder is rounded, and the venter is gently vaulted. There are 20 to 22 single ribs in the outer whorl; they are prorsiradiate in the inner third and radial in the outer two-thirds; on the venter, they are very faint or altogether missing. The ribs are provided at the end of
the inner third with one row of pointed tubercles, which appear at a radius of 30 mm.; a second row, at the end of the second third, of more prominent tubercles, which appear earlier than those of the first row and which tend to become spirally elongated; and a third row of much larger and higher, spirally elongated tubercles at the ventrolateral shoulder. Along the siphonal line, there is a seventh row of spirally elongated tubercles which do not correspond to, and are more numerous and smaller than, the ventrolateral tubercles. The suture (fig. 46) is similar to that of *L. lyelli*.

A distorted specimen (A.M.N.H. No. 27869:3), about 100 mm. in diameter, shows

![Image](image_url)

**Fig. 46. Lyelliceras pseudolyelli** Parona and Bonarelli. Suture line of specimen A.M.N.H. No. 27869:2; ×1.

the body chamber where the ribs become prominent on the venter and the siphonal tubercles correspond with the ventrolateral ones, a stage similar to that of *L. lyelli*.

**Remarks:** *Lyelliceras pseudolyelli* differs from *L. lyelli* by the different arrangement of the siphonal tubercles and the interruption of the ribs over the venter. The Peruvian specimens of *L. pseudolyelli* appear to have a more compressed and quadrate whorl section, larger size, and stronger ornamentation than the European examples.

**Occurrence:** This species is found in the middle Albian Crisnejas formation, in bed 20 of the Celendin section.

*Lyelliceras ulrichi* Knechtel

Plate 51, figures 4–7

*Acanthoceras lyelli* Leym.; Sommermeier, 1910, p. 375 (pro parte).
*Acanthoceras lyelli* Leym.; Schlagintweit, 1912, p. 87 (pro parte).
*Lyelliceras cf. cotteri* Spath; Riedel, 1937–1938, p. 56, pl. 9, figs. 1–2, pl. 3, fig. 18.

Seventeen specimens, all steinkerns, including four complete discs, are assigned to this species. Knechtel's holotype was available to the writer.

**Measurements**

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**Holotype** 115 36.5 .32 28 .24 52 .45

**Description:** The conch is discoidal, platy, fairly widely umbilicated. The intercostal whorl section (fig. 47) is slightly compressed, oval, with the greatest thickness at the end of the inner third; it has a low and indistinct umbilical wall and a broadly rounded umbilical shoulder. The sides are convex and subparallel. The ventrolateral shoulders are broadly rounded and make an even curve with the rounded venter. The costal section is polygonal. There are between 25 and 30 single, strong ribs per whorl. They start at the umbilical shoulder and are slightly prorsiradiate, acutely crested, and with much broader interspaces to the end of the middle third;

![Image](image_url)

**Fig. 47. Lyelliceras ulrichi** Knechtel. Suture line (A) and conch section (B) of specimen A.M.N.H. No. 27870:3; ×1.

thence they become more rounded, broader, and slightly more prorsiradiate. On the venter, the ribs are broadly rounded, somewhat attenuated, and have the same width as the interspaces. The ribs are provided with one row of pointed tubercles at about the end of the middle third of the sides, and a second
row of high, spirally elongated, stronger tubercles at the ventrolateral shoulder. Along the siphonal line, the ribs are provided with a row of tubercles which correspond, and are similar in size and shape, to the ventrolateral ones.

The ribs appear first at about a radius of 5 mm. (pl. 51, figs. 6–7) as irregular, uneven wrinkles, which begin at the umbilical shoulder and flatten out at about the ventrolateral one. By a radius of 9 mm., papillate tubercles appear at the ventrolateral ends of the ribs, and at the same time the corre-

sponding siphonal tubercles appear on the smooth venter. Soon after, the siphonal and ventrolateral tubercles become spirally elongated, the pointed tubercles appear at the end of the middle third, and the ribs cross the venter.

The suture (fig. 47) is often asymmetrical. It is very simple, with broad, massive, bifid saddles and long bifid lobes.

REMARKS: *Lyelliceras ulrichi* resembles *L. matheusi* in whorl section, ribbing, and tuberculation. It is distinguishable by its closer ribbing and by the fact that the lateral tubercle appears much earlier in the ontogeny than in *L. matheusi*, where it appears at a radius of 35 mm. *Lyelliceras prorsocuratum* is another closely related form which has flexuous ribs.

**Occurrence:** *Lyelliceras ulrichi* is a common ammonite in the Pariatambo formation, associated with *L. lyelli* and several species of *Oxytropidoceras* and *Venezoliceras*. It is also found in the upper part of the Crisnejas formation and in the lowest beds of the Jumasha formation.

**Description:** The conch is large, discoidal, platy, fairly widely umbilicated. The intercostal whorl section is very compressed, subrectangular, with very low and indistinct umbilical wall and broadly rounded umbilical shoulder. The sides are subflattened and slightly converging. The ventrolateral shoulder is very broadly rounded. The available specimen has 13 single, strong, straight ribs in the outer half whorl. All the ribs start at the umbilical shoulder and bear four rows of tubercles; one row of faint, radially elongated tubercles just about the umbilical shoulder, a second row of more conspicuous, radially elongated tubercles just below the middle of the sides, and a pair of tubercles at the ventrolateral shoulder, of which the inner one (dorsal or third from the umbilicus) is blunt, conical, whereas the outer one (fourth from the umbilicus) is blunt and spirally elongated. The four ventral tubercles are evenly spaced, of the same size, and are connected by broad and low ribs.

The suture is typical of *Sharpeiceras*; it has three saddles on the sides and a fourth
saddle on the umbilical shoulder; the first lateral saddle is broad, quadrato, deeply divided by a trifid lobule, and has phylloid endings. The first lateral lobe is very deep, trifid, and frilled.

**Remarks:** *Sharpeiceras occidentale*, *S. indicum* Kossmat [1895 (1895-1898), p. 199], and *S. schlüteri* Hyatt (1903, p. 111) have the same very compressed, subrectangular whorl section and four rows of tubercles. The Andean form is distinguishable from *S. indicum* by its smaller number of ribs, the lack of forking ribs, and the subdued appearance of the umbilical tubercles. From *S. schlüteri*, it is distinguishable by the even and close spacing of the four ventral tubercles, whereas in the German form, the tubercles on both sides of the siphonal line are widely spaced. The ribbing of *S. occidentale* approaches that of *S. florenciae* Spath (1925, p. 198), which has a quadrato whorl section, conspicuous mediolateral tubercles, and its four ventral tubercles are not so closely set as those of the Peruvian form.

**Occurrence:** The holotype was collected from the Yumagual formation, in bed 111 of the Cajamarca section, together with *Paraturritilites lewisiensis* (Spath).

*Sharpeiceras* is a widespread but scarce genus. *Sharpeiceras laticlavium* Sharpe, the genotype, occurs rarely in the *Varians* zone of the English Cenomanian (Wright and Wright, 1951, p. 25).

**Acanthoceras Neumayr, 1875**

*Acanthoceras chasca*, new species

Plate 53, figures 1–4

One fairly complete specimen (A.M.N.H. No. 27872) and three whorl fragments of specimens which must have been about 150 mm. in diameter are assigned to this species.

**Measurements**

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**Description:** The conch is discoidal, stout, fairly narrowly umbilicated, with the whorls little embracing, almost tangential. The intercostal whorl section (fig. 48) is slightly compressed, subrectangular, with high and steep umbilical wall and distinct umbilical shoulder. The sides are subflattened and subparallel; the ventrolateral shoulder is rounded and the venter is broad and gently arched. The costal whorl section is quadrato. In the outer whorl, the holotype (A.M.N.H. No. 27872) bears 15 strong, round-crested, widely spaced, prorsiradiate ribs, few of which are intercalated, or at least less prominent, than the others. The primary ribs are provided with one row of weak, radially elongated tubercles at about the middle of the inner third. All the ribs have at about the ventrolateral shoulder a pair of strong tubercles, of which the inner one (second from the

![Fig. 48. Acanthoceras chasca, new species. Conch section of the holotype; ×1.](image)

umbilicus), slightly below the umbilical shoulder, is conical and pointed and the outer one (third from the umbilicus), at the ventrolateral shoulder, is spirally elongated. Between the second and third rows of tubercles, the ribs are more prorsiradiate, broader, and lower than on the sides; they do not cross the venter. Along the siphonal line, there is a row of spirally elongated tubercles which correspond in number but are less conspicuous and slightly set backward than the ventrolateral tubercles. They become faint and obliterate in later stages.

Specimen A.M.N.H. No. 27872/1 (pl. 53, figs. 1–2) is a quarter of a whorl of a specimen of about 150 mm. in diameter. It has strong, widely spaced ribs; the umbilical tubercles are blunt and faint; the ventrolateral tubercles are attenuated and the siphonal ones are missing.

**Remarks:** *Acanthoceras chasca* in general shape, whorl section, and ribbing is similar to *A. stephensoni* Adkins (1928, p. 246), from which it can be distinguished by its smaller umbilicus and less prominent ventrolateral tubercles.
Occurrence: This species is a common ammonite in the upper Cenomanian Romirón formation, in bed 48 of the Celendín section (A.M.N.H. No. 27872), associated with *Neo-
bolites kummeli*, *Lissoniceras mermei*, and *Forbesiceras* sp. It is also found in bed 43 of the Polloc section (A.M.N.H. No. 27872/1) and in bed 127 of the Cajamarca section.

*Acanthoceras pollocense*,1 new species
Plate 53, figures 10–11

Four whorl fragments are available for study. Specimen A.M.N.H. No. 27873:1 (pl. 53, figs. 10–11) is designated the holotype.

Description: The conch is discoidal, stout, fairly narrowly umbilicated, with very little embracing whorls. The whorl section (fig. 49) is depressed, with very high and per-

![Fig. 49. Acanthoceras pollocense, new species. Conch section of the holotype; X1.](image)

pendicular umbilical wall and abruptly rounded umbilical shoulder. The height of the whorl is about four-fifths of the maximum thickness, which is near the umbilical shoulder. The sides are slightly convex and converge, making an even curve with the broadly arched venter. The ornamentation consists of strong, sparse ribs and, altogether, seven rows of tubercles: one row of very high tubercles, slightly elongated radially, just above the umbilical shoulder; a second row of less prominent, twice as numerous, radially elongated tubercles near the ventrolateral shoulder; a third row, slightly above the ventrolateral shoulder, of spirally elongated tubercles which are less conspicuous and correspond in number and position with the tubercles of the second row. The siphonal line bears faint, spirally elongated tubercles that correspond in number with the ventrolaterals and which have been seen only in the im-

![Fig. 50. Acanthoceras sangalense, new species. Conch section of specimen A.M.N.H. No. 27874:1; X1.](image)

pressed zone of the holotype, in the venter of which they are absent. The ribs are issued in pairs from the umbilical tubercles and are almost radial to the second row of tubercles where they become lower, more broadly rounded, and rursiradiate. In later stages, they tend to cross over the venter.

Remarks: *Acanthoceras pollocense* is characterized by its small size, very depressed whorl section, and the prominence of the umbilical tubercles.

Occurrence: This species is found in the Romirón formation, in the same localities as *A. chasca*. The holotype comes from bed 48 of the Celendín section.

*Acanthoceras sangalense*,2 new species
Plate 53, figures 7–9

One almost complete, partially shattered specimen and three whorl fragments are the available representatives of this species. Specimen A.M.N.H. No. 27874:1 is the holotype.

Description: The conch is small (none of the specimens seems to have been larger than 50 mm. in diameter), stout, discoidal, fairly narrowly umbilicated. The whorl section (fig. 50) is slightly compressed, subrectangular, with high umbilical wall and abruptly rounded umbilical shoulder. The sides are flattened and subparallel; the ventrolateral shoulder and the venter are rounded. Just above the umbilical shoulder of the outer half whorl there are six strong tubercles, slightly elongated radially, from which strong ribs are issued generally in pairs. They are provided with a second row of faint, radially elongated tubercles near the ventrolateral shoulder, and a third row of strong, spirally elongated tubercles just above the ventro-

1 Named after Hacienda Polloc, near which the holotype was collected.

2 Named after Hacienda Sangal, near which the holotype was collected.
lateral shoulder. The ribs, particularly in the outer third, are curved and rursiradiate. On the body chamber, all the tubercles become faint, and the ribs cross the venter.

Remarks: Acanthoceras sangalense is similar in whorl section and ribbing to A. jukes-brownei Spath [Sharpe, 1887 (1853–1887), pl. 17, fig. 2] from the Variants and the subglobosus zones of the English Cenomanian; it differs by the more pronounced development of the third row of tubercles and the less prominent appearance of the tubercles of the second row. Acanthoceras pollocense is similar in ornamentation and size to, but is distinguishable from, A. sangalense by its depressed whorl section and the fact that the tubercles of the third row are comparatively fainter.

Occurrence: All the specimens were collected from the Romirón formation, in bed 48 of the Celendin section, together with A. chasca, A. pollocense, Neolobites kummeri, Lissoniceras mermeti, and Forbesiceras sp.

Family Mammitidæ Hyatt, 1900

Mammites Laube and Brüder, 1887

Mammites nodosoides afer Pervinquière

Plate 55, figures 5–8

Mammites nodosoides var. Afrà Pervinquière, 1907, p. 310, pl. 18, figs. 2, 2a–b, 3, 3a–b.

Mammites nodosoides var. Afrà Pervinquière; Brüggen, 1910, p. 736.

Mammites nodosoides var. Afrà Pervinquière; Steinmann, 1930, p. 148, text fig. 181.

Three fragmentary specimens, each being a whorl fragment of individuals smaller than 40 mm. in diameter, and a fourth specimen, a body-chamber fragment of an individual of about 200 mm. in diameter (A.M.N.H. No. 27875), are referred to this species. They agree very closely with the description and illustrations of the type materials.

Description: The conch is discoidal, fairly narrowly umbilicated. The whorl section is slightly compressed, subquadrarce, with high and steep umbilical wall and rounded umbilical shoulder. The sides are distinctly flattened, the ventrolateral shoulder is rounded, and the venter is gently convex.

Specimen A.M.N.H. No. 27875/1 (pl. 55, figs. 5–6) has above the umbilical shoulder of the last half whorl four radially elongated tubercles from which one or two prorsiradiate ribs issue; other ribs are intercalated at about the middle of the sides and make on the outer half of the sides a total of nine ribs per half whorl. The ribs bear strong conical tubercles at the ventrolateral shoulders and sharp, strong, spirally elongated tubercles slightly above this shoulder. Between these two rows of tubercles, the ribs are lower and more broadly rounded than on the sides; they do not cross over the venter.

Specimen A.M.N.H. No. 27875 (pl. 55, figs. 7–8), a quarter of a whorl, has four blunt, rounded umbilical tubercles. Corresponding with them, on the ventrolateral shoulder, there are four much larger, massive, conical, high tubercles. The ventral tubercles are only faintly indicated. The tubercles of the umbilical and ventrolateral rows are connected by low and broad ribs.

Remarks: Mammites nodosoides differs from M. nodosoides afer in that its umbilical tubercles are conical in all stages. Mammites nodosoides spinosa Bassè has horned, spinate, umbilical and ventrolateral tubercles and a quadrate whorl section.

Occurrence: Mammites nodosoides afer is a common species in the lower Turonian Coñor formation, in bed 27 of the Tembladera section (A.M.N.H. No. 27875), in bed 133 of the Cajamarca section (A.M.N.H. No. 27875/1), in bed 48 of the Polloc section (A.M.N.H. No. 27875/3), and in bed 53 of the Celendín section (27875/2). It is associated with Coilopoceras jenksi and Hoplitoides inca. Mammites nodosoides is a common species in the lower Turonian (Salmanur) of Germany and France and is rare in the Labiatus zone of the English Turonian.

Pseudoaspidoceras Hyatt, 1903

Pseudoaspidoceras reesidei, new species

Plate 54, figures 1–4

A complete, entirely septate specimen (A.M.N.H. No. 27876:1; pl. 54, figs. 1–2), 52 mm. in diameter, is the holotype. Also, four whorl fragments of large individuals are referred to this species.

Description: The conch is large, discoidal, fairly narrowly umbilicated, with little embracing, almost tangential whors.

1 Pseudoaspidoceras reesidei is named after Dr. John L. Reeside, who studied some of the earlier collections of Cretaceous fossils from the Andes.
The whorl section (fig. 51) is slightly depressed, subquadrate, with very steep and high umbilical wall and abruptly rounded umbilical shoulder. The sides are flat and little converging; the ventrolateral shoulder is rounded, and the venter is broadly vaulted. The whorls quickly increase in size.

The holotype has just above the umbilical shoulder of the last whorl 13 strong, radially elongated tubercles from which one or rarely two very faint ribs issue. On the ventrolateral shoulder, there is a second row of 18 strong tubercles which in the early part of the volution are slightly radially elongated, but adorally they become horn-like. Above the ventrolateral shoulder, there is a third row of 33 high, subconical to radially elongated tubercles. Faint ribs connect these three rows of tubercles but do not cross the venter at any stage; the ribs are prorsiradiate and more prominent and closely spaced in the early part of the outer whorl. The four ventral rows of tubercles are equidistant from one another.

Specimen A.M.N.H. No 27876:2 is a fragment of a whorl of an individual at least 65 mm. in diameter. The umbilical tubercles have become blunt and conical, the ribs have vanished, the ventrolateral tubercles are very prominent and conical, and the ventral tubercles are rounded and much less conspicuous than those of the other two rows.

Specimen A.M.N.H. No. 27876:3 (pl. 54, figs. 3–4) is a body-chamber fragment of an individual about 100 mm. in diameter, in which the umbilical and ventrolateral tubercles have become rounded, blunt, and less prominent than in the earlier stages; particularly the umbilical tubercles tend to vanish; the ventral tubercles are very faint and low.

The suture (fig. 51) has two saddles on the sides and a third saddle on the umbilical shoulder; the first lateral saddle is very narrow, while the first lateral lobe is extraordinarily massive, broad, quadrato, and divided into two subequal branches by a low but broad median saddle. It may be that the extraordinary development of the first lateral lobe and the reduction of the first lateral saddle are related to the prominent development of the ventrolateral tubercles.

REMARKS: *Pseudoaspidoceras reesidei, P. michelobensis* Laube and Bruder (1887, pl. 25, fig. 2) and *P. footeanum* Stoliczka [1861 (1861–1866), pl. 52, figs. 1–2] are similar in whorl section and suture. The first two species are more narrowly umbilicated than *P. footeanum*, approaching thus to species of the *Pseudoaspidoceras* group of the genus *Mammoites*. *Pseudoaspidoceras reesidei* is distinguishable from *P. michelobensis* by its more crowded ribbing and the radial elongation of the umbilical tubercles. *Pseudoaspidoceras pedroanum* (White), a Brazilian form, has a narrower umbilicus than *P. reesidei*.

OCCURRENCE: All the specimens (A.M.N.H. No. 27876) were collected from the upper part of the Quillquifán group, in bed 24 of the Tembladera section, together with *Thomasites fischeri, Coilopoceras jenki, Vascoceras aff. V. silvanense, Broggiiceras humboldti*, and *Broggiiceras olssoni*.

*Pseudoaspidoceras michelobensis*, the closest species, is from the *labiatus* zone of the German Turonian.

**FAMILY VASCOCRATIDAE** DOUVILLE, 1911

**BROGGIICERAS,** NEW GENUS

DESCRIPTION: This genus is created for two new species: *Broggiiceras olssoni*, the genotype, and *B. humboldti*, which cannot be included in any of the known genera. They have very thick, commonly globose conchs; the whorls have a very high and steep or overhanging umbilical wall, abruptly rounded umbilical shoulders, more or less converging convex sides, and rounded venter. The orna-

---

1 *Broggiiceras* is named in honor of Ing. Jorge A. Broggi, director of the Instituto Geológico del Perú.
Description: The conch is subglobose, stout, narrowly umbilicated. The whorl section is subquadrate, changing from compressed in the inner whorls to slightly depressed in the body chamber, with very high and perpendicular umbilical wall and abruptly rounded umbilical shoulder. The sides are convex and subparallel, the ventrolateral shoulder is very broadly rounded, and the venter is gently vaulted. The outer whorl of the holotype has 30 straight, radial, low, subangular ribs which are more conspicuous on the venter and on the outer third of the sides. They are almost obliterated along the middle of the sides, although a few reach the umbilical shoulder as very faint folds. The ribs appear at about a radius of 20 to 25 mm., and are stronger on the body chamber.

The suture has two broad, large saddles on the sides and a third saddle on the umbilical shoulder. The ventral lobe has parallel sides; the lateral lobes are small and V-shaped. Both saddles and lobes are equally denticulated; the saddle endings are phylloid.

Remarks: Broggiiiceras fleuryi (Pervinquière) has a more globose shape, narrower umbilicus, and fewer ribs than B. olssonii.

The specimen described by Lissón as Vascoceras amieirensis is from the same locality as the collection here studied. As is the case with most of the specimens from the locality, it is weathered and does not show the ribs.

Occurrence: Broggiiiceras olssonii is found in the upper part of the Quillquifnan group, in bed 24 of the Tembladera section, associated with B. humboldti, Thomasities fischeri, Pseudoaspidoceras reesidei, and Coilopoceras jenksi.

Broggiiiceras humboldti, new species

Plate 56, figures 3–6

Three complete, slightly weathered steinkerns are assigned to this species. Specimen A.M.N.H. No. 27878:3 (pl. 56, figs. 5–6), including part of the body chamber, is the holotype.

Measurements

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1 Named after Dr. Alex A. Olsson, who has contributed greatly to the knowledge of South American Mesozoic and Cenozoic faunas.

2 Named after Alexander von Humboldt, who in 1802 collected the first Peruvian Cretaceous fossils to be described scientifically.
DESCRIPTION: The conch is subglobose, stout, narrowly umbilicated. The whorl section changes from depressed in the early whorsl to compressed in the body chamber; at the same time, the very high umbilical wall changes from perpendicular to overhanging, and the umbilical shoulder changes from indistinct to abruptly rounded. The sides are gently convex and converging; they decrease in convergence during growth. The ventrolateral shoulder is indistinct, and the venter is narrowly rounded. Only at a radius of 32 mm., strong, subrounded, widely spaced ribs appear; there are 11 per half whorl. The ribs are more conspicuous on the venter and the ventrolateral shoulders and flatten out at about the middle of the sides. The suture has three broad, denticulated saddles on the sides and a fourth saddle on the umbilical shoulder. The lobes are smaller and narrower; the first lobe is V-shaped and may be bifid or pointed.

REMARKS: Broggericeras humboldti is distinguishable from B. olssomi by its smaller umbilicus, less numerous and stronger ribs, and the fact that the whorl becomes compressed and high in the later stages.

OCCURRENCE: This species is found in the upper part of the Quillquián formation, in bed 24 of the Tembladera section, associated with B. olssomi and the ammonites already listed under the latter species.

VASCOCERAS CHOFFAT, 1898
Vasccoceras cf. V. silvanense Choffat
Plate 56, figure 7

A small, entirely septate specimen is comparable to V. silvanense Choffat [1898 (1885, 1898), p. 57, pl. 18, fig. 5, pl. 21, fig. 9].

DESCRIPTION: The conch is subglobose, stout, narrowly umbilicated. The whorl section is slightly depressed, with high umbilical wall and rounded shoulder. The sides are broadly convex and converge towards the narrowly rounded venter; the ventrolateral shoulder is indistinct. In the outer whorl, slightly above the umbilical shoulder, there are five high and rounded tubercles.

REMARKS: Specimen A.M.N.H. No. 27879 (pl. 56, fig. 7) differs from the specimens of V. silvanense illustrated by Choffat only by its less depressed whorl section.

OCCURRENCE: Quillquián group, bed 24 of the Tembladera section.

THOMASITES PERVINQUIÈRE, 1907
Thomasites fischeri, new species

Plate 56, figures 1–2; plate 57, figures 1–3

Three somewhat weathered steinkerns are included in this new species. Specimen A.M.N.H. No. 27880:3, entirely septate, is chosen as the holotype.

MEASUREMENTS

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<th>D/T</th>
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<td>.20</td>
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<td>.50</td>
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<td>18</td>
<td>.17</td>
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DESCRIPTION: The conch is subglobose, stout, narrowly umbilicated. The whorl section is compressed and changes from subrectangular in the inner whorsl to narrowly rounded ventrally in the outer ones. The umbilical wall is high and perpendicular, and the umbilical shoulder is rounded but distinct. The sides are broadly convex and change from subparallel to strongly convergent. The ventrolateral shoulder is well marked in the inner whorsl but indistinct in the latter ones. The venter changes from broadly vaulted to narrowly rounded.

Above the umbilical shoulder, there is a row of four strong, rounded, blunt tubercles which appear at a radius of 20 mm. and vanish at a radius of 35 mm. They are no longer visible in the outer whorl of any of the available specimens. The distinct ventrolateral shoulders of the inner volutions bear blunt, elongated spirally, faint tubercles, of which there are about seven in one-quarter of a whorl. Also, the siphonal line is raised, forming a low, faint, rounded carina provided with weak, spirally elongated tubercles which correspond with the ventrolateral ones although they are set slightly forward. From the ventrolateral tubercles, faint ribs are directed dorsally, but they flatten out before reaching the middle of the sides. All ornamentation is lost in the outer whorsl. The suture has three saddles on the sides and a fourth saddle on the umbilical shoulder; they are very broad, low, denticulated, and with phylloid endings. The first lateral lobe has two branches, the inner one being larger.

REMARKS: Thomasites fischeri is similar to T. jordani Pervinquière in shape, whorl sec-

1 Named in honor of Prof. Alfred G. Fischer.
tion, suture, and ornamentation. Pervinquière described several varieties which differ from one another more than the Peruvian species does from the "forme typique" of T. jordani. Thomasites jordani costaia has very strong ornamentation; T. jordani laevis has angular ventrolateral shoulders and very faint ornamentation. Thomasites fischeri is distinguished from T. jordani, forma typica, by its very faint ornamentation, the lack of ribs on the sides, and the early disappearance of the tuberculation. Thomasites fischeri and T. jordani differ from all other species of Thomasites by the presence of siphonal tubercles. It may be advisable to separate them in a new genus.

Occurrence: Thomasites fischeri has the same occurrence and association as Broggioceras olssoni. Thomasites jordani is from the lower Turonian of Tunisia. Fritzsche (1924, p. 326) reports T. cf. jordani var. laevis Pervinquière from Cundinamarca, Colombia, associated with T. rollandi, Fagesia peroni var. columbiana Fritzsche, and Pseudotissotia douvillei, all lower Turonian species.

Family PERONICERATIDAE Hyatt, 1900

TEXANITES Spate, 1932

Texanites hourci Collignon

Plate 58, figures 6-7

Texanites hourci Collignon, 1948, p. 78, pl. 7, figs. 1, 1a-b, pl. 10, figs. 1, 1a.

A single completely septate, fragmentary steinkern has been assigned to this species.

Measurements

<table>
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<tr>
<th>A.M.N.H. No.</th>
<th>D</th>
<th>H</th>
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<td>.34</td>
<td>29.5</td>
<td>.29</td>
<td>41</td>
<td>.41</td>
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Description: The conch is large, discoidal, platy, widely umbilicated. The whorl section is compressed, subrectangular, with high, perpendicular, and slightly concave umbilical wall and very distinct umbilical shoulder. The sides are slightly convex and converging. The greatest whorl thickness is at about the end of the inner third and is about four-fifths of the whorl height. The venter is provided with a median, low, but distinct carina bounded by two wider and shallow grooves. There are about 12 ribs in a quarter of a whorl. They bear five rows of tubercles. The first row, at the umbilical shoulder, has pointed and conical tubercles which are the starting points of the primary ribs; the second row, at the end of the inner third, has pointed, radially elongated tubercles; the third row, near the end of the middle third, has similar but less conspicuous tubercles; the fourth row, at about the middle of the outer third, has rounded tubercles which are stronger than those of the third row; and the fifth row, at the ventrolateral shoulder, has sharp, spirally elongated and high tubercles which are higher than the siphonal carina. Most of the ribs, which are low and rounded, start (rarely in pairs) from the umbilical tubercles. Several are intercalated at about the second or third rows of tubercles. The suture has two saddles on the sides and a third saddle on the umbilical shoulder; the first one is very large, broad, quadrate, and divided by a median lobe. The first lateral lobe is very deep and pointed; the second one is bifid.

Occurrence: Specimen A.M.N.H. No. 27881 was collected from the upper part of the Celendín formation (Lenticeras baltai zone), in bed 72 of the Celendín section, together with Desmophyllites gaudama, Lenticeras baltai, and Tissotia steinmanni.

Superfamily TISSOTIACEAE Hyatt, 1900

Family COILOPOCERATIDAE Hyatt, 1903

Collopeceras Jenksi,1 new species

Plate 59, figures 3-4; plate 60, figure 7

Cf. Collopeceras Requieni; Brüggen, 1910, p. 733, text fig. 12.

Ten steinkerns are assigned to this species. Specimen A.M.N.H. No. 27882 is the holotype.

Measurements

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<td>.59</td>
<td>37</td>
<td>.24</td>
<td>4.5</td>
<td>.03</td>
</tr>
</tbody>
</table>

Description: The conch is large, lenticular, with almost closed umbilicus. The whorl section is a very compressed and high, helmet-shaped ogive, with steep umbilical

1 Named in honor of Prof. William F. Jenks.
BENAVIDES: CRETACEOUS SYSTEM IN PERU

wall and rounded but distinct umbilical shoulder. The sides are smooth, gently convex, diminishing in convexity in the outer third, where they may even be slightly concave; they converge towards the fastigate, narrowly rounded venter. The greatest whorl thickness is at about the middle of the sides and is about one-third of the whorl height.

Coilopoceras jenksi is the most common ammonite in the lower Turonian Coñor formation. It has been collected in the following localities:

<table>
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<th>Section</th>
<th>No. of Specimens</th>
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<td>27882/4</td>
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<td>Polloc</td>
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It is usually associated with Hoplitoides inca, Mammites nodosoides afer, Pseudoaspidoceeras reesidei, Thomasites fischeri, Broggiiceras olseni, and B. humboldti.

Coilopoceras newelli, new species

Plate 61, figures 4-5; plate 62, figures 5-7

Coilopoceras newelli, new species

This new species is named in honor of Prof. Norman D. Newell, who suggested to the present writer the problem dealt with in this monograph.
Twenty-two steinkerns, including several entire discs, are available for study. Specimen A.M.N.H. No. 27883/7 is the holotype. Most of them show a peculiar mode of preservation. The inner volutions of the steinkern are missing, and the outer and only present volution has been compressed, closing the gap left by the missing inner volutions (pl. 62, figs. 5–7). Apparently the sediment filled only the outer whorl of the shell; after consolidation, the shell was dissolved away, and an empty space was left inside the speci-

DESCRIPTION: The conch is large, lenticular, narrowly umbilicated, with a tendency in later stages to become more widely umbilicated. The whorl section is a very high and compressed ogive, with very short and almost indistinct umbilical wall and rounded umbilical shoulder. The sides are evenly convex and converge towards the fastigate, sharp venter. The greatest whorl thickness is at about the middle of the sides and is about two-thirds of the whorl height. There are broad, fold-like, radially elongated

\[ \text{swellings which begin at about the middle of the inner third and vanish before the end of the middle third.} \]

\[ \text{They may appear in the phragmocone (pl. 62, fig. 5) or only in the body chamber (pl. 61, fig. 4).} \]

\[ \text{Apparently those specimens with thicker whorl sections have stronger ornamentation.} \]

\[ \text{All the available specimens show well the suture (fig. 53); and, although no two specimens have an identical suture, the basic pattern is the same.} \]

\[ \text{On the sides there are seven saddles; the first saddle is narrow, conspicuously strangulated, and with either two or three} \]

<table>
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\[ \text{The conch is large, lenticular, narrowly umbilicated, with a tendency in later stages to become more widely umbilicated. The whorl section is a very high and compressed ogive, with very short and almost indistinct umbilical wall and rounded umbilical shoulder. The sides are evenly convex and converge towards the fastigate, sharp venter. The greatest whorl thickness is at about the middle of the sides and is about two-thirds of the whorl height. There are broad, fold-like, radially elongated} \]
branches; the second lateral saddle is very broad, massive, and is always divided by a more or less deep median lobule; the two resulting branches can be either entire, giving a *Sphenodiscus*-like saddle, or crenulated. The third lateral saddle is usually much smaller than the second one and can be either entire (*Tissotia*-like) or, more commonly, with a small median denticle or sometimes several of them. The other saddles are usually entire, but, again, they may be indented. The first lateral lobe is extraordinarily broad, and in the most simple cases it is deeply divided into two branches by a saddle which commonly is entire and rounded but which may be quadrilateral and even crenulated. The two resulting branches are, in turn, bifid and more or less subdivided by saddles which may, exceptionally, be larger than the median saddle; usually the inner branch is more developed. The other lobes are much narrower, usually strangulated, and bifid.

**Remarks:** *Coilopoceras newelli* is similar in size, whorl section, and suture to *C. springeri* Hyatt (1903, p. 96), a poorly known species, from which it differs by the presence of ribs, the wider umbilicus, and smaller number of saddles in the suture. *Coilopoceras lentiformis* von Koenen (Solger, 1904, p. 136), *C. lesseli*, and *C. jenksii* are forms with almost closed umbilicus. *Coilopoceras* n. sp. *B* Reeside (1927, *in* Wasson and Sinclair, p. 1278), a form with almost closed umbilicus and fine flexuous ribs, seems to be very closely related to, if not conspecific with, *C. lentiformis* von Koenen.

**Occurrence:** *Coilopoceras newelli* is a very common species in the upper Turonian Cajamarca formation.

<table>
<thead>
<tr>
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<tr>
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<td>66</td>
<td>Polloc</td>
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**Hoplitoïdes von Koenen, 1898**

**Hoplitoïdes inca**, new species

Plate 63, figures 6–11

Nine steinkerns, including four complete discs, are available. Specimen A.M.N.H. No. 27884:1 (pl. 63, figs. 7–8) is the holotype.

**Measurements**

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**Description:** The conch is discoidal, platy, with the umbilicus almost closed. The whorl section is very compressed and high, with short and perpendicular umbilical wall and with distinct but rounded umbilical shoulder. The sides are gently arched and converge towards the truncated venter which is subconcave to flat and bordered by two raised lines. The greatest whorl thickness is at about the middle of the sides and is about one-half of the whorl height. The holotype has smooth sides, but the inner whorl, obtained from a similar specimen (A.M.N.H. No. 27884; pl. 63, fig. 6), shows that, at least up to a diameter of 45 mm., there are faint, falciform ribs which are particularly noticeable in the outer third of the sides and under adequate lighting. The other small steinkerns do not show any ornamentation; this may be owing to their somewhat weathered condition. The suture (fig. 54) has four to five saddles on the sides, of which the first saddle is large and with two or three branches; the others are low, broad, and slightly denticulated. The first lateral lobe has two branches which may be equally developed or not, and which in turn are denticulated.

**Remarks:** *Hoplitoïdes inca* is similar in shape, whorl section, and suture to *H. munieri* Pervinquière (1907, p. 217), but is distinguishable by the presence of faint, falciform ribs in the inner whorls. *Hopluitoïdes*
mirabilis Pervinquière differs from H. munieri only in the suture details, which the present writer feels cannot be taken as specific differences. Hoplitoides ingens von Koenen is an altogether different species, with truncate venter only in the younger whorls, and which becomes fastigate, sharp-vented in maturity. It may be necessary to separate the group of Senonian species of Hoplitoides, with fastigate venter in the later whors, from the Turonian species such as H. munieri and H. inca in which the venter is truncated in all stages.

Occurrence: Hoplitoides inca occurs in the lower Turonian Coñor formation, in beds 39 and 42 of the Lajas section (A.M.N.H. Nos. 27884 and 27884/1) and in bed 55 of the Polloc section. It is associated with Coilepoceras jenksi and Mammities nodosoides afer. Hoplitoides munieri occurs in the lower Turonian of Tunisia.

Family Tissotidae Hyatt, 1900

Barroisiceras de Grossouvre, 1894

?Barroisiceras (Barroisiceras) haberfellneri (von Hauer)

Plate 57, figures 4–5

Ammonites haberfellneri von Hauer, 1866, p. 301, pl. 1, figs. 1–5.

Barroisiceras haberfellneri von Hauer; Bassé, 1947, p. 114, cum synon.

A single, poorly preserved fragment is tentatively referred to this species (A.M.N.H. No. 27885).

Description: The conch is discoidal, narrowly umbilicated. The whorl section is high and compressed, with high umbilical wall and rounded but distinct umbilical shoulder. The sides are subflattened and converge towards the broad, roof-shaped venter which is provided with a low carina. The ventrolateral shoulders are distinct. Just above the umbilical shoulder, there are about 10 radially elongated tubercles which send out one or two slightly prorsiradiate ribs; there are also a few intercalated ribs. All end at the ventrolateral shoulder in spirally elongated tubercles, of which there are about eight in a quarter of a whorl. The siphonal carina is also provided with spirally elongated tubercles which correspond with the ventrolateral ones although slightly set forward.

Remarks: Specimen A.M.N.H. No. 27885 compares fairly well with von Hauer’s schematic illustration of the holotype. There is, however, considerable confusion about this species, and, lacking an adequate sample, the present writer prefers to leave this determination open.

Occurrence: The specimen was collected from the lower part of the Celendín formation (Buchiceras bilobatum zone), in bed 15 of the Bambamarca section. Barroisiceras haberfellneri is a very common and widespread species which is taken as an index of the lowest Senonian.

Barroisiceras (Barroisiceras) kayi,1 new species

Plate 57, figures 6–7

Two well-preserved entire specimens and two whorl fragments are assigned to this species. Specimen A.M.N.H. No. 27886:1, with the beginning of the body chamber, is the holotype.

Measurements

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Description: The conch is discoidal, platy, narrowly umbilicated. The whorl section is high, compressed, rectangular, with high and perpendicular umbilical wall and rounded but distinct umbilical shoulder. The sides are flattened, subparallel, and slightly converging. The ventrolateral shoulder is well marked, and the venter is broad, roof-shaped, and provided with a low and rounded carina. The greatest thickness is near the umbilical shoulder and is less than two-thirds of the whorl height. Just above the umbilical shoulder of the outer whorl of the holotype is a row of blunt tubercles slightly elongated radially; they are the starting points of single, slightly prorsiradiate, almost straight, low and broad but distinct ribs. At about the middle of the sides, single secondary ribs are intercalated. All the ribs end at the ventrolateral shoulder in very strong, blunt, spirally elongated tubercles which are twice as numerous as the umbilical ones. The low siphonal carina is provided with a row of spirally elongated tubercles which correspond with the ventrolateral ones, although slightly set forward. The su-

1 Named in honor of Prof. Marshall Kay.
ture has three broad bifid saddles on the sides and a third saddle on the umbilical shoulder; they have phylloid terminations. The lobes are narrow; the first lobe is deeper than the ventral one and is pointed; the second one is bifid.

**Remarks:** Barroisiceras (Barroisiceras) kayi is similar in suture, whorl section, and pattern of ornamentation to B. (B.) haberfellneri from which is it distinguishable by fewer umbilical tubercles, the lack of forking ribs, its rectangular whorl section, and the regularity of the ribbing. Another similar species is B. (B.) onilahyense Bassé (1947, p. 100) which has less pronounced ribbing and forking ribs.

**Occurrence:** Barroisiceras (B.) kayi is found in the Celendín formation (Buchiceras bilobatum zone), in bed 69 of the Celendín section (A.M.N.H. No. 27886), in bed 144 of the Cajamarca section (A.M.N.H. No. 27886/1), and in bed 15 of the Bambamarca section. It is associated with Buchiceras bilobatum, Heterotissotia lissoni, H. bucheri, and several species of Tissotia and Barroisiceras.

Barroisiceras (Solgerites) brancoi (Solger)

Plate 58, figures 1–4

Barroisiceras Brancoi var. mitis Solger, 1904, pl. 5, figs. 4a–b, 5.

Barroisiceras Brancoi var. mite Solger; Brüggen, 1910, p. 732, text fig. 11.

Schloenbachia (Barroisiceras) Brancoi var. mitis Solger; Luthy, 1918, p. 48, pl. 4, figs. 1a–b.

Schloenbachia (Barroisiceras) sp. nov. sp. Luthy, 1918, p. 49, pl. 4, figs. 2a–b.

Barroisiceras Brancoi mite Solg.; Steinmann, 1930, p. 163, figs. 196A–C.

Barroisiceras (Solgerites) brancoi var. mite Solger; Reeside, 1932, p. 14.

Solgerites brancoi Solger; Bassé, 1947, p. 123.

Two entire steinkerns and one whorl fragment are referred to this species.

**Measurements**

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</table>

**Description:** The conch is discoidal, platy, very narrowly umbilicated, with a tendency to become more widely umbilicated in later stages. The whorl section is very high and compressed, with low and very steep umbilical wall and abruptly rounded umbilical shoulder. The sides are flattened and parallel; the ventrolateral shoulders are distinct, particularly in the smaller diameters. The venter is roof-shaped and provided with a carina. The greatest thickness is at about the middle of the sides and is about one-half of the whorl height. The umbilical shoulder has about six weak, radially elongated tubercles per whorl; they are the starting or forking points of broad, faint ribs; other ribs are intercalated at about the middle of the sides. All the ribs end at the ventrolateral shoulder in distinct, blunt tubercles, of which there are about 35 per volute. The siphonal carina is provided with high, sharp, spirally elongated tubercles which are set slightly forward of the corresponding ventrolateral pair. Between the radii of 25 and 35 mm., the ornamentation tends to vanish. The umbilical tubercles and the ribs disappear first, and the ventrolateral tubercles follow, producing thus a smooth, rounded ventrolateral shoulder. Finally the siphonal tubercles disappear, leaving a fastigate venter. The suture has three saddles on the sides; they have distinct festoon-like endings; the first lateral lobe is bifid.

**Remarks:** Specimen A.M.N.H. No. 27887/1 (pl. 58, figs. 1–2) has been included within B. (Solgerites) brancoi with certain hesitancy. It has a more pronounced ornamentation than most specimens of this species have at that diameter. Barroisiceras (Solgerites) brancoi is similar to B. (Solgerites) armatum in whorl section and suture; the latter, however, lacks ventrolateral tubercles, is less closely ribbed than B. (S.) brancoi, and develops ventrolateral spines in later stages. The subgenus Barroisiceras (Solgerites) Reeside differs from Barroisiceras (Barroisiceras) only by its attenuated ornamentation.

**Occurrence:** Barroisiceras (S.) brancoi occurs in the Celendín formation (Buchiceras bilobatum zone), in bed 69 of the Celendín section (A.M.N.H. No. 27887), and in bed 75 of the Polloc section (A.M.N.H. No. 27887/1). The associated species are the same as those listed for B. (B.) haberfellneri.

Barroisiceras (Forresteria) bassseae, new name

Plate 58, figure 5

Barroisiceras Haberfellneri v. Hauer; Brüggen, 1910, p. 730, text fig. 10.

1 Named in honor of Mlle. Eliane Bassé.
Barroisiceras Haberfellneri v. Hauer; Steinmann, 1930, p. 162, figs.195A–C.


Harleites (?) brüggeni Bassé, 1947, p. 141.

An entirely septate, complete steinkern, which has been fractured along the siphonal line, and a whorl fragment are referred to this species.

**Measurements**

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<th>H</th>
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<td>.23</td>
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**Description:** The conch is discoidal, platy, narrowly umbilicated. The whorl section is high, very compressed, rectangular, with overhanging umbilical wall and abruptly rounded umbilical shoulder. The sides are flat and parallel; the ventrolateral shoulder is rounded but well marked, and the venter is broad, roof-shaped, and provided with a carina. The greatest whorl thickness is at about the middle of the sides and is nearly two-thirds of the whorl height.

Single, low, and broad ribs (about nine per whorl) begin in the umbilical shoulder. They are radiate, and at about the middle of the sides, they develop into pointed, strong tubercles, slightly elongated radially, in which the ribs fork. At this level, also, a few ribs are intercalated. All the ribs (about 22 ribs in the outer half of the sides) end at the ventrolateral shoulder in very strong, blunt, spirally elongated tubercles. The siphonal carina bears spirally elongated tubercles which are set forward of the corresponding ventrolateral pair. The suture has three broad, distinctly bifid saddles, with festoon-like terminations. The first lateral lobe is very deep and trifid; the second lateral lobe is bifid.

**Remarks:** The specimen illustrated by Steinmann (1930) as *B. haberfellneri* agrees in all respects with the specimens here discussed. That specimen in all probability is one of the two specimens that Brüggen (1910) described under that same name. Also, the suture illustrated by Steinmann is the same published first by Brüggen, and moreover, the locality given by both of them is the same.

On the basis of Brüggen's description, Bassé (1947, p. 141) erected the species *Barroisiceras* (Harleites) (?) *brüggeni* (name preoccupied by *Barroisiceras brüggeni* Knechtel, 1947). The subgenus *Harleites*, however, includes species which have a very narrow umbilicus, very attenuated ornamentation, and very weak mediolateral tubercles. *Barroisiceras* (Forresteria) *basseae* is similar to *B. (Alstadenis) severiensae* Reeside (1932, p. 16) and *B. (Forresteria) stantoni* Reeside (1932, p. 17); the former has pronounced umbilical tubercles, lacks forking ribs, and its ventrolateral tubercles are not so numerous nor so prominent as those of *B. (F.) basseae*; *B. (Alstadenis) severiensae* has been transferred by Bassé (1947) to the subgenus *Forresteria*. *Barroisiceras* (Forresteria) *stantoni* has a much wider umbilicus and thicker whorl section than *B. (F.) basseae*. In shape, suture, and whorl section, *B. (F.) basseae* is similar to *B. (F.) ampozaloekaense* Bassé; the latter differs, because it lacks the forking ribs and its mediolateral tubercles disappear very early in the ontogeny.

**Occurrence:** *Barroisiceras* (Forresteria) *basseae* is found in the Celendín formation (Buchiceras bilobatum zone), in bed 144 of the Cajamarca section (A.M.N.H. No. 27888), and in bed 15 of the Bambamarca section (A.M.N.H. No. 27888/1). The associated species are the same as those listed for *B. (Barroisiceras) haberfellneri*.

**Barroisiceras (Forresteria) alluaudi** Boule, Lemoine, and Thévenin

Plate 61, figure 1

_Acanthoceras (Prionotropis) Alluaudi Boule, Lemoine, and Thévenin, 1907 (1906–1907), p. 12, pl. 1, figs. 6, 6a, 7._

_Prionotropis alluaudi_ Boule-Lemoine-Thévenin; Lissón, 1908, p. 17, pl. 17.


_Barroisiceras (Forresteria) alluaudi_ Boule, Lemoine, and Thévenin; Reeside, 1932, p. 12.

_Forresteria alluaudi_ bit.; Bassé, 1947, p. 128, *cum synonym.,* pl. 14, figs. 3, 3a, pl. 15, figs. 2, 2a.

A single, fairly well-preserved, entirely septate steinkern, which comprises three-fourths of a whorl, is referred to this species.

**Measurements**

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<td>.35</td>
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DESCRIPTION: The conch is stout, small, discoidal, widely umbilicated. The intercostal whorl section is slightly compressed, subquadrate to subcircular, with high and steep umbilical wall. The sides are broadly convex; the ventrolateral shoulders are rounded; the venter, which in our specimen is poorly preserved, is supposed to be roof-shaped and with a low carina; and the greatest whorl thickness is at about the middle of the sides and is slightly smaller than the whorl height. The costal whorl section is polygonal and slightly depressed.

Specimen A.M.N.H. No. 27889 has, in the umbilical shoulder of the last half whorl, five weak tubercles which are slightly elongated radially. They send out single, rounded ribs which, by the middle of the sides, develop into strong, large, and rounded tubercles. From each tubercle two ribs fork, and occasionally there is an intercalated rib starting just above the middle of the sides. All the ribs end in strong, rounded, and high ventrolateral tubercles. The specimen has the venter weathered, but it is still possible to see the remains of a nodose carina.

REMARKS: Barroisiceras (F.) alluaudi is very closely related to, if not conspecific with, B. (F.) forresteri Reeside (1932, pl. 5, figs. 2–7); they are separable only by the spinose character of the ornamentation in the latter species.

OCURRENCE: Barroisiceras (F.) alluaudi is found in the Celendín formation (Buchiceras bilobatum zone), in bed 144 of the Cajamarca (A.M.N.H. No. 27889). It is associated with species of the following genera: Buchiceras, Heterotissotia, Tissotia, B. (Barroisiceras), and B. (Solgerites). Lissón (1908) described two specimens from Cajabamaba, and Brüggen reports one from Otuzco. Barroisiceras (Forresteria) forresteri occurs in the Mancos shale, 200 feet above the Ferron sandstone member, Utah.

TISSOTIA Douvillé, 1890

Tissotia steinmanni Lissón

Plate 61, figures 2–3

Tissotia steinmanni Lissón, 1908, p. 1, pl. 1. Tissotia steinmanni Lissón; KNECHTEL, 1947, in Knechtel, Richards, and Rathbun, p. 111, pl. 32, fig. 2, pl. 33.

DESCRIPTION: Three fragmentary but well-preserved steinkerns (A.M.N.H. No. 27890) are referred to this species.

DESCRIPTION: The conch is large, lenticular, and very narrowly umbilicated. The whorl section is a very high and compressed ogive. The smooth sides converge towards the sharp, fastigate venter with gentle convexity. The greatest whorl thickness is in the inner third and is about one-third of the whorl height. The suture (fig. 55) has six saddles on the sides; the first one is deeply divided by a bifid lobe; the others are characteristically rounded and entire. The lobes are broad and denticulated. The ventral lobe has a broad, quadrate siphonal saddle.

REMARKS: Tissotia steinmanni resembles T. reesideana Knechtel in suture and lack of ornamentation; they are separable by the more inflated whorl of the latter.

OCURRENCE: This species is found in the Celendín formation (Lenticeras baltai zone), in bed 72 of the Celendín section, associated with Desmophyllites gaudama, Texanites hourqui, Lenticeras baltai, and Tissotia fournelii.

Tissotia halli Knechtel

Plate 62, figures 1–2

Tissotia halli Knechtel, 1947, in Knechtel, Richards, and Rathbun, p. 120, pl. 41, figs. 1–5.

Two whorl fragments (A.M.N.H. No. 27891) are available for study.

DESCRIPTION: The conch is large, discoidal, narrowly umbilicated. The intercostal whorl section is compressed, with low umbilical wall and broadly rounded umbilical shoulders. The sides are slightly convex and converging. The ventrolateral shoulders are very broadly rounded, and the venter is fastigate. The greatest thickness is in the inner third and is between two-thirds and one-half of the whorl height. The costal whorl section has parallel sides. The ornamentation consists of very broad, massive, round-

Fig. 55. Tissotia steinmanni Lissón. Suture line of specimen A.M.N.H. No. 27890:1; X1.
crested ribs which begin just above the umbilical shoulder; they are directed radially and are somewhat attenuated on the middle of the sides. At the ventrolateral shoulders, each rib develops into a large swelling which is slightly turned forward.

**Remarks:** *Tissotia halli* is similar in suture and ornamentation to *T. regularis* Hyatt (1903, p. 53), but the latter has a distinctly biconvex whorl section.

*Tissotia waltheri* and *T. singewaldi* (Knechtel, 1947, *in* Knechtel, Richards, and Rathbun) resemble *T. halli* in whorl section, suture, and pattern of ornamentation but are characterized by a more pronounced tuberculation.

**Occurrence:** *Tissotia halli* occurs in the Celendín formation (*Lenticeras baltaizone*), in bed 3 of the Santa Clara section, together with *Lenticeras lissoni* and *Texanites* sp.

**Tissotia fourneli** (Bayle)

*Plate 62, figures 3–4*

_Ammolites fourneli* Bayle, 1849, p. 360, pl. 17, figs. 3–4.

_Buchiceras fourneli;* Bayle, 1878, pl. 40, fig. 3.

_Buchiceras Fourneli* Bayle; Peron, 1889 (1889–1890), p. 9, pl. 15, figs. 10–14.

*Tissotia Fourneli* Bayle sp. emend. Peron; de Grossouvre, 1893, p. 36, fig. 18.

*Tissotia Fourneli* Bayle sp. emend. Thomas et Peron; Peron, 1897 (1896–1897), p. 59, pl. 10, figs. 1–8, pl. 11, figs. 9–10.

_Metatissotia fourneli* (Bayle); Hyatt, 1903, p. 45.

_Tissotia fourneli* (Bayle) Thomas et Peron; Neumann, 1907, p. 123, pl. 5, figs. 4–4a.

_Tissotia cf. fourneli* Bayle; Brüggen, 1910, p. 724, text fig. 4.

_Tissotia singewaldi* Knechtel, 1947, *in* Knechtel, Richards, and Rathbun, p. 114, pl. 34, figs. 3a–b.


A single, well-preserved steinkern (A.M.N.H. No. 27892) is referred to this species; the outer half whorl belongs to the body chamber.

**Measurements**

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**Description:** The conch is small, lenticular, narrowly umbilicated. The intercostal whorl section is a high, compressed, lanceolate ogive with indistinct umbilical wall. The sides are convex, slightly inflated, with a maximum convexity in the inner half, and converge towards the sharp, fastigate venter, provided with a low carina. The greatest whorl thickness is just above the umbilical shoulder and is about two-thirds of the whorl height. The costal whorl section has less convergent sides and distinct ventrolateral shoulders. Just above the umbilical shoulder of the outer whorl, there are seven radially elongated tubercles which are the starting points of one or two broad, low, slightly prorsiradiate ribs. They become attenuated about the middle of the sides but gain prominence in the outer third and end at the ventrolateral shoulder in blunt swellings; there are 20 swellings in the outer whorl,

![FIG. 56. *Tissotia fourneli* (Bayle). Suture line of specimen A.M.N.H. No. 27892; X1.](image-url)

and they are slightly turned and projected forward. Between the ventrolateral tubercles and the carina, the venter is slightly concave. The suture (fig. 56) has three low and broad saddles, the first saddle has a median notch; the others are rounded and entire. The lobes are broad, low, and denticulated.

**Remarks:** Specimen A.M.N.H. No. 27892 (pl. 62, figs. 3–4) agrees perfectly with the specimen illustrated by Peron [1897 (1896–1897), p. 59, pl. 10, figs. 1–8] from the base of the Algerian Senonian. The specimens described by Knechtel as *T. singewaldi* and *T. waltheri* may perhaps be distinguished from *T. fourneli* by their pointed tubercles, but, again, Knechtel admits considerable variation in the strength of the ornamentation.

**Occurrence:** *Tissotia fourneli* is found in the Celendín formation (*Lenticeras baltaizone*), in bed 72 of the Celendín section (A.M.N.H. No. 27892), together with *T. steinmanni*, *Texanites hourcqi*, and *Lenticeras baltais*. Neumann described one specimen from near Cerro de Pasco, and Brüggen reports another one from La Quinua, Celendín, a location which is probably the same as that of the specimen described here.
Tissotia hedbergi, new species
Plate 63, figures 1–5

Three well-preserved steinkerns, including two almost entire discs, are the available representatives of this species.

**Measurements**

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**Description:** The conch is small, lenticular, platy, very narrowly umbilicated. The whorl section is a very high and compressed, lanceolate ogive with narrow and steep umbilical wall and rounded umbilical shoulder. The sides are gently convex, decreasing in convexity, and converging towards the sharp, fastigate venter. The ornamentation consists of five to seven very low, broad, and faint, fold-like ribs which begin at the umbilical shoulder, where they are most conspicuous; they flatten out at about the middle of the sides and become very attenuated again in the outer third. The suture (fig. 57) has five broad and rounded saddles; the first saddle has a deep median lobule; the others are rounded and entire. The lobes are minutely denticulated.

**Remarks:** Tissotia hedbergi is similar in shape and suture to *T. serrata* Hyatt (1903, p. 51), but the latter has stronger ornamentation and fine ribs which fork at about the middle of the sides. *Tissotia regularis* (Hyatt, 1903, p. 53) and *T. fourneri* are similar in suture and pattern of ornamentation to *T. hedbergi*, but they have more inflated whorls, much stronger ornamentation, and very distinct ventrolateral shoulders. *Tissotia steinmanni* is a larger species without ventrolateral shoulders or ornamentation of any kind.

**Occurrence:** *Tissotia hedbergi* is found in the Celendín formation (*Buchiceras bilobatum* zone), in bed 69 of the Celendín section, associated with *Barroisiceras* (*Barroisiceras*) kayi, *B. (Solgerites) brancoi*, *Heterotissotia lissoni*, *H. bucheri*, and *Buchiceras bilobatum*.

**Buchiceras Hyatt, 1875**

*Buchiceras bilobatum* Hyatt
Plate 59, figures 1–2; plate 60, figures 1–6

*Buchiceras bilobatum* Hyatt, 1875, p. 370.
*Buchiceras syriaciforme* Hyatt, 1875, p. 371.
*Buchiceras attenuatum* Hyatt, 1875, p. 372.
*Buchiceras bilobatum* Hyatt; Hyatt, 1903, p. 27, pl. 1, figs. 4–9.
*Roemeroceras syriaciforme* Hyatt; Hyatt, 1903, p. 31, pl. 1, figs. 10–14.
*Roemeroceras attenuatum* Hyatt; Hyatt, 1903, p. 33, pl. 1, fig. 15.
*Roemeroceras subplanum* Hyatt, 1903, p. 34, pl. 2, figs. 4–6.
*Roemeroceras subplanum* Hyatt; Lissón, 1908, p. 7, pls. 7, 7a.
*Buchiceras bilobatum* Hyatt; Brüggen, 1910, p. 727, pl. 28, figs. 1–2.
*Buchiceras bilobatum* Hyatt; Lüthy, 1918, p. 81, pl. 1, fig. 1.
*Barroisiceras fourneli* Knechtel, 1947, in Knechtel, Richards, and Rathbun, p. 122, pl. 34.

Forty-three specimens, most of them steinkerns, are assigned to this species. None of the specimens is larger than 100 mm. in diameter.

**Measurements**

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1 This species is named after Dr. Hollis D. Hedberg, whose lucid writings have greatly aided the understanding of South American stratigraphy.
DESCRIPTION: The conch is discoidal, stout, broadly rounded. The convex, slightly umbilical shoulder. It is distinct but or seven above the whorl. On the sides, there are two lateral lobes on the sides, and a third lobe in the umbilical wall. There is great variation as to the suture details, irrespective of other variants. The saddles have a distinct median notch, and the margins usually are rounded and entire but can also be denticulated. The lobes are narrower, denticulated, and usually have a bifid appearance. Denticulation can affect both saddles and lobes, giving to the suture a frilled appearance.

REMARKS: In spite of the great variation in whorl thickness, strength of the ornamentation, and frilling of the suture, this species offers remarkable constancy in whorl height, in the number of umbilical (seven or eight) and ventrolateral (14 or 15) tubercles, and in the basic suture pattern. Minute differences in the details of the suture led Hyatt (1903), working on a few fragmentary specimens, to erect five species and two genera: Buchiceras and Roemeroceras. Lissón (1908, p. 7) hinted that all of Hyatt's species may be only variations of a single one. Later, Brüggen and Lüthy, who had large samples at their disposal, recognized the untenability of Hyatt's species. Brüggen distinguished those forms with rounded venter and attenuated tuberculation under the name of Buchiceras bilobatum Hyatt var. laeve, which he thought was the same as Buchiceras gabbii Hyatt. The holotype of the latter species, restudied by Lissón (1925, p. 23, pl. 1), has 14 umbilical tubercles and strong ribs, thus departing radically from Buchiceras bilobatum which has only seven to eight umbilical tubercles.

Buchiceras bilobatum is similar in whorl section and pattern of ornamentation to Tissotia tunisiensis Hyatt (Pervinquière, 1907, pl. 26, figs. 1a–b, 2a–b, 3a–b, 4a–c). The latter has a very conspicuous carina that in later stages dissolves into siphonal tubercles and has a larger number of ventrolateral tubercles which persist into maturity, whereas the umbilical tubercles vanish. The present writer studied the fragmentary specimen described by Knechtel (1947, in Knechtel, Richards, and Rathbun) as Barroisiceras grossowrei; it is a specimen of Buchiceras bilobatum with suture of the frilled type and with a slightly roof-shaped venter, which is common in specimens of B. bilobatum of small size.

Some species belonging to the genera Diasiceras and Barroisiceras approach B. bilobatum.
in whorl section and ornamentation, but their sutures are not ceratitic as in the latter species.

Occurrence: Buchiceras bilobatum is the most common ammonite in the Celendín formation (B. bilobatum zone), in bed 69 of the Celendín section (A.M.N.H. No. 27894), in bed 15 of the Bambamarca section (A.M.N.H. No. 27894/2), in bed 154 of the Cajamarca section (A.M.N.H. No. 27894/1), and in bed 75 of the Polloc section (A.M.N.H. No. 27894/3).

**HETEROTISSOTIA Peron, 1897**

*Heterotissotia peroni* Lissón

Plate 64, figures 1–6

*Heterotissotia neoceratites* Peron; Lissón, 1908, p. 10, pl. 10.

*Heterotissotia peroni* Lissón, 1908, p. 11, pl. 11.

*Heterotissotia semmamensis* Pervinquière; Lissón, 1908, p. 12, pl. 12.

*Heterotissotia neoceratites* Peron; Steinmann, 1909, p. 5, text figs. 1, 4, 5, 6A–C, 8, 9.

*Heterotissotia neoceratites* Peron; Brüggen, 1910, p. 727.

*Heterotissotia neoceratites* Per.; Lüthy, 1918, p. 51, pl. 4, figs. 3–5, pl. 5, fig. 3.

*Heterotissotia lissóni* Knechtel, 1947, in Knechtel, Richards, and Rathbun, p. 121, pl. 34, figs. 2a–b.


Thirty-one steinkerns, including six entire discs, are assigned to this species. The largest available specimen is a whorl fragment of an individual at least 150 mm. in diameter.

**Measurements**

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**Description:** The conch is discoidal, platy, very narrowly umbilicated. The whorl section is very high and compressed, with narrow and steep umbilical wall and broadly rounded umbilical shoulder. The sides are convex in the inner half but diminish in convexity and may become slightly concave in the outer one. The ventrolateral shoulder is angular, and the venter is flat or subconcave, provided in the early stages with a faint, low carina which is like a raised line between two subconcave bands and which disappears, in most cases, before a radius of 30 mm. The greatest whorl thickness is at the end of the inner third and varies between two-thirds and one-third of the whorl height. The umbilical shoulder has about six strong, hemispherical, blunt tubercles which tend to disappear quickly at about a radius of 30 mm. The ventrolateral shoulder has another row of about 22 lateral, spirally elongated tubercles which also tend to vanish at a radius of 30 mm., but which may exceptionally be preserved at a radius of 40 mm. or more (pl. 64, figs. 3–4). The sides are smooth; however, a few specimens of small size show low, broad, very faint, fold-like ribs which start at the umbilical shoulder and flatten out at about the middle of the sides. The suture (fig. 58) has four broad and rounded saddles on the sides; the first has a median notch of variable depth, and the second and third are generally entire, although the third may have one or even three small notches. The lobes are also broad, with finely denticulated terminations. The siphonal lobe may be asymmetrical.

**Remarks:** Lissón (1908) assigned three whorl fragments to three different species: *H. neoceratites* Peron, *H. peroni* Lissón, and *H. semmamensis* Pervinquière, which differ from one another only in minute suture details. Later, Steinmann (1909) investigated a large Peruvian sample of the species referred...
in this paper to *H. peroni*; he observed the great variability of the whorl thickness and of the suture, and attributed it to *H. neoceratites* Peron. He states: “In dem reichen Material das mir von *Het.* vorliegt, kann man nach Windungsquerschnitt Skulptur und Lobenlinien keine irgendwie gut begrenzten Arten unterschieden bezeichnet hat, sind durch reiche Zwischenformen mit den schmäleren *Semamensis*-Formen Pervinquières verknüpft. Ganz unabhängig davon variiert die Verzierung, indem sie bei *neoceratites* bald früher, bald später verschwindet; bei *semamensis* scheint die Skulptur freilich immer schon früh zu fehlen. Wollte man aber nach den Loben Arten oder Varietäten unterscheiden, so könnte man fast aus jeden Stücke eine Art machen. Ich ziehe es daher vor, die Gesamtheit der mir vorliegende Stücke unter der Bezeichnung *Het. neoceratites* Per. zusammenfassen. Will man die schmalmündigen und stets früh als dritter Name *semamensis* Perv. verwendt werden...” This conclusion is also supported by Lüthy (1918). *Heterotissotia neoceratites* is a poorly known North African species which agrees in whorl section and suture with *H. peroni* but can be distinguished by the fact that, at a diameter of 70 mm., it has a well-marked ornamentation consisting of sigmoidal and bifurcating ribs which have not been observed in any of the Peruvian specimens of *H. peroni*. The present writer, therefore, considers that they are not conspecific and proposes to use Lisson’s term *H. peroni*, the earliest specific name applied to a Peruvian representative of this species.

The specimen described by Knechtel (1947, in Knechtel, Richards, and Rathbun) as *H. lissoni* was available to the present writer. It is a small representative of *H. peroni* with 21 sharp ventrolateral tubercles and a faint carina, characteristic of the early stages of this species. Also, the very poorly preserved specimen described by the same author as *Barroisiceras bruggeni* was studied by the writer. Its general shape, whorl section, ornamentation, and suture are those of *H. peroni*. The suture illustrated by Knechtel (1947, in Knechtel, Richards, and Rathbun, text fig. 19) shows indented saddles and lobes which the writer could not verify. It appears instead that the saddles are rounded and entire, pseudoceratitic—quite different from the festooned saddles of the genus *Barroisiceras*.

**Occurrence:** *Heterotissotia peroni* is a common ammonite in the Celendín formation (*Buchiceras bilobatum* zone), in bed 15 of the Bambamarca section (A.M.N.H. No. 27895/1), in bed 69 of the Celendín section (A.M.N.H. No. 27895/3), in bed 75 of the Polloc section (A.M.N.H. No. 27895/2), and in bed 144 of the Cajamarcas section (A.M.N.H. No. 27895). It is associated with *B. bilobatum* and several species of *Tissotia* and *Barroisiceras*.

**Heterotissotia bucheri,** new species

Plate 65, figures 1–5

Nine well-preserved steinkerns, including five entire discs, are available for study. The largest specimen is 115 mm. in diameter. Specimen A.M.N.H. No. 27896:5 (pl. 65, figs. 1–2) is the holotype.

**Measurements**

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**Description:** The conch is discoidal, stout, very narrowly umbilicated. The whorl section is very high, with high umbilical wall and broadly rounded umbilical shoulder. The sides are strongly convex and inflated in the inner half of the sides but decrease in convexity and become flat to subconcave in the outer third. The ventrolateral shoulder is angular, and the venter is flat and broad; it bears a median, low but conspicuous carina. The greatest whorl thickness is slightly above the umbilical shoulder, and although it is usually slightly larger than the whorl height it may be also smaller. The whorl height is noticeably constant—about one half of the diameter. Just above the umbilical shoulder, there is a row of six to seven massive, blunt, radially elongated tubercles which extend towards the middle of the sides where they flatten out. Also, along the ventrolateral shoulder, there is a second row of 14 to 15 conspicuous, strong, spirally elongated tuber-

1 Named in honor of Prof. Walter H. Bucher.
cles. Rarely, fold-like ribs connect the two rows of tubercles. The ornamentation tends to be obliterated in the body chamber. The suture has three, rarely four, very broad and low saddles; the first saddle has one to three notches; all the others are rounded and entire, although the second and third saddles may, exceptionally, have a small notch. The lobes have parallel sides and finely denticulated terminations.

Remarks: Heterotissotia bucheri is similar to H. peroni in suture, general shape, pattern of ornamentation, and in possessing a low siphonal carina, but it can be easily distinguished by its thicker and inflated whorl section, its smaller number of ventrolateral tubercles, and by the persistence of the carina and tuberculation into maturity. Heterotissotia bucheri resembles Buchiceras bilobatum in the stoutness of the whorl section, and in the presence of umbilical and ventrolateral tubercles in almost similar numbers and strength but is distinguishable by the more pronounced carina, the bulging sides, and, most important, by the fact that the saddles are usually rounded and entire, while in Buchiceras bilobatum they have at least one median notch.

Occurrence: Heterotissotia bucheri is a very common ammonite in the Celendín formation (Buchiceras bilobatum zone), in bed 69 of the Celendín section (A.M.N.H. No. 27896), in bed 144 of the Cajamarca section (A.M.N.H. No. 27896/1), and in bed 75 of the Polloc section (A.M.N.H. No. 27896/2). It is associated with H. peroni, Buchiceras bilobatum, Barroisiceras (Barroisiceras) habefellneri, B. (B.) kayi, Barroisiceras (Solgerites) brancoi, Barroisiceras (Forresteria) basseae, B. (F.) alluaudi, and Tissotia hedbergii.

Family LENTICERATIDAE Hyatt, 1900

Lenticeras Gerhardt, 1898

Lenticeras baltai Lissón
Plate 66, figures 1–2

Lenticeras baltai Lissón, 1908, p. 14, pls. 14a, 14b.
Lenticeras baltai Lissón; Lissón, 1936, p. 53, pls. 1–3.
Lenticeras baltai Lissón; Basset, 1942, p. 354.
Lenticeras baltai Lissón; Knechtel, 1947, in Knechtel, Richards, and Rathbun, p. 126, pl. 37, fig. 1, pl. 44.

Lenticeras baltai; Rivera, 1949, p. 32, pl. 7, fig. 1, pl. 8, fig. 1.

A single steinkern, A.M.N.H. No. 27897, is available.

Measurements

A.M.N.H. No. D H D/H T D/T U D/T
27897 140 71 .51 45 .32 — —

Description: The conch is large, lenticular, stout, very narrowly umbilicated. The whorl section is a very high, lanceolate ovate with steep and high umbilical wall and rounded umbilical shoulder. The sides are arched, with the greatest convexity in the inner third, and converge evenly towards the fastigate venter. The greatest thickness is in the inner third and is between three-fourths and two-thirds of the whorl height.

Specimen A.M.N.H. No. 27897 has smooth sides. (Lisson’s holotype is a somewhat weathered steinkern, and he suggested that the ornamentation, if any, may have been eroded away.)

The suture has four broad, low, and rounded saddles; the first saddle is deeply divided in three parts, whereas the others are almost entire, with one or more indentations and with very peculiar rounded endings. The lobes are slightly strangulated and digitated.

Remarks: Lenticeras gerhardtii Knechtel is similar to L. baltai in size, shape, whorl section, and suture, and was differentiated only by its very faint ornamentation. The writer examined the holotype of L. gerhardtii and finds that the ribs are very inconspicuous. Lenticeras andii Gabb (Lisson, 1908, p. 13) has a thicker whorl section and stronger ribs than L. baltai.

Occurrence: Lenticeras baltai occurs in the Celendín formation (Lenticeras baltai zone), in bed 72 of the Celendín section, associated with Texanites hourqi, Desmophyllites gaudama, Tissotia steinmanni, and T. fournelii. Lisson’s holotype is from Hacienda Quílca, Provincia Pomabamba, Marañón River. Rivera (1949) reports it from Río Pachitea (Huánuco) and Pongo de Rentema (Jaen).

Lenticeras lissoni Knechtel
Plate 66, figures 3–4

One poorly preserved steinkern represents this species. The present writer has examined the holotype.

Measurements

A.M.N.H. No. 27898  
Knechtel's holotype

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Description: *Lenticeras lissoni* is very closely related to *L. baltai*; they have the same suture, general shape, and whorl section and differ only in that *L. lissoni* has a less compressed whorl section, its greatest thickness being about five-sixths of the whorl height, while in *L. baltai* the greatest thickness is between two-thirds and three-fourths of the whorl height. Specimen A.M.N.H. No. 27898 is slightly less compressed than the holotype and therefore is closer to *L. baltai*.

Both specimen A.M.N.H. No 27898 and the holotype have very faint, wavy ribs on the sides; they are not, however, so distinct as those of the more compressed *L. andii*.

Remarks: *Lenticeras baltai*, *L. lissoni*, and *L. andii* form a closely related group, differing from one another mainly in the proportions of the whorl height to the thickness and in the more pronounced ornamentation of the depressed forms. *Lenticeras baltai* is the most compressed form and has smooth sides; *L. andii* is a depressed form with pronounced ribs; and *L. lissoni* occupies an intermediate position, with slightly compressed whorls and faint ornamentation. These three species may not be easily separated if more extensive and significant collections are gathered. It may be a case similar to that of *Buchiceras bilobatum* or that of *Heterotissotia peroni*, species which are characterized by the great variation of the whorl section and by the increase in the strength of the ornamentation in those individuals with thicker whorls.

Occurrence: *Lenticeras lissoni* is found in the Celendin formation (*Lenticeras baltai* zone), in bed 3 of the Santa Clara section, associated with *Texanites* sp., *Desmophyllites gaudama*, and *Tissotia halli*. *Lenticeras gabbi*, also a Peruvian form, was found first in Pataz (La Libertad) and later in Venezuela (Gerhardt, 1897a, p. 81) where it is associated with *T. texanum*, *T. cañense*, *Gauthiericeras lenti*, *Gauthiericeras margae*, and *Amaltheus sieversi*.

Incertae sedis

*Neolobites Fischer*, 1882

*Neolobites kummeli*,* new species

Plate 66, figures 5–6

*Neolobites* cf. *peroni* Hyatt; Schlagintweit, 1912, p. 100, text fig. 4.  

Fourteen specimens, all somewhat distorted steinkerns, are at hand. Only one specimen, 100 mm. in diameter, is a complete disc. Specimen A.M.N.H. No. 27899:1 is the holotype.

Description: The conch is discoidal, platy, very narrowly umbilicated. The whorl section is very high and compressed, with very low umbilical wall and indistinct umbilical shoulder. The sides are evenly and gently arched, converging towards the narrow, truncated, flat venter. The ventrolateral shoulder is angular and sharply distinct. The greatest whorl thickness is slightly below the middle of the sides and is less than one-third of the whorl height. It has numerous, closely set, spirally elongated tubercles along the ventrolateral shoulders. Only one specimen (pl. 66, fig. 6) has very faint, radial, low, fold-like ribs which start in the umbilical shoulder and flatten out at the end of the inner third. All the other specimens have smooth sides. The suture is the same as that of *N. vibrayeanus*, with entire lobes and saddles.

Remarks: *Neolobites kummeli* is similar to *N. vibrayeanus* d'Orbigny in size, shape, whorl section, and suture but is distinguishable by the lack of the flexuous ribs which ornament the latter species and which may be very strong, as in the specimens illustrated by Choffat [1898 (1886, 1889)]. *Neolobites peroni* Hyatt (= *N. vibrayeanus* d'Orbigny; Peron [1890 (1889–1890)], pl. 18, figs. 1–2) is an inflated form with low, massive umbilical tubercles and attenuated falciform ribs. *Neolobites kummeli* is similar in shape, suture, lack of strong ribs, and whorl section to *N. isidis* Greco (1915, p.

1 Named in honor of Prof. Bernhard Kummel.
206) which is characterized by its carinate ventrolateral shoulders. *Neolobites bassleri* Boit (1926), another Peruvian species, lacks, according to the description, ornamentation and, unlike any other *Neolobites*, has a divided third lateral lobe.

**Occurrence:** *Neolobites kummeli* is found in the Romirón formation, in bed 48 of the Celendín section (A.M.N.H. No. 27899), together with *Acanthoceras chasca*, *A. pollo-cense*, *A. sangalense*, *Forbesiceras* sp., and *Lissoniceras mermeti*. 
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PLATE 31

1. Goyllarisquisga formation (KG) overlying the Trisasic Uliachín (TU), and the Paleozoic Mitu (PM) formations. North side of the Crisnejas River just west of its junction with the Marañón River.

2. Chimú sandstone (KCh) overlying the upper Jurassic "Chicama beds" (JCh). South side of the Chicama River, 250 meters downstream from Baños de Chimú, type locality of the Chimú sandstone.
PLATE 32


2. Type section of the Santa (KS) and Carhuaz (KCa) formations overlying Chimú sandstone (KCh). Cerro Huallhua, west side of the Santa River, northwest of Carhuaz.
1. Chimú sandstone; the jacob staff (1.50 meters long) lies on a bedding plane. San Jorge River, upper Chicama Valley.

2. Type section of the Inca formation (Kl), overlying Goyllarisquisga formation (KG) and underlying Chulec formation (KChu); Cajamarca section, 1 kilometer north of Baños del Inca, Cajamarca.
2. Typical cross-bedded sandstone of the Goyllarisquisga formation. Same locality as above figure.
PLATE 35

1. Platy, black, strongly bituminous limestone of the Pariatambo formation. Hualgayoc section, 2 kilometers east of Hualgayoc.

2. Discoidal, bituminous limestone concretions in bituminous marl of the Pariatambo formation. The fossils belong to Oxytropidoceras carbonarium Gabb; the ruler is 10 centimeters long. Pariahuanca section. Pariahuanca, Callejón de Huaylas.
PLATE 36

1. Sangal syncline; automobile road from Cajamarca to Celendín, just south of Encañada. Mujarrún formation (KM), Romirón (KR), Coñor (KCo) and Cajamarca (KCa) formations.

2. View northeast. The Cajamarca section. Carhuaz (KC), Goyllarisquisga (KG), Inca (KI), Chulec (KChu), Pariatambo (KP), Yumagual (KY), Mujarrún (KM), Cajamarca (KCa) and Celendín (KCe) formations.
PLATE 37


2. Section near Puerto Nuevo, Yanacanchilla, east of Hualgayoc, Mujarrán formation (KM), Quillquián group (KQ), and Cajamarca formation (KCa).
PLATE 38

1. Exposures of the Cajamarca formation (KCa) overlain by Chota formation (KCho), along the Chotano River, north of Lajas, Lajas section.

2. Red-bed shale and sandstone of the Chota formation in El Ahijadero, west of Hacienda Santa Clara. In the background, limestones of the Cajamarca formation (KCa) thrust over the Chota formation.
PLATE 39

1. Sandstone of the Rosa formation (KRo) disconformably overlying channeled Crisnejas formation (KCr). Type section of the Crisnejas and Rosa formations. South side of the Crisnejas River, near Santa Rosa.

2. Quartz pebble conglomerate of the Rosa formation. Type section of the Rosa formation. Locality same as 1.
PLATE 40

6, 7. *Bostrychoceras?* sp. indet., A.M.N.H. No. 27835, lateral and basal views, ×1.
10–12. *Valanginites broggi* (Lisson), A.M.N.H. No. 27836:1, lateral, ventral, and frontal views, ×1.
PLATE 41

1, 2. Desmoceras latidorsatum (Michelin), A.M.N.H. No. 27387, lateral and ventral views, X2.

3, 4. Desmophyllites gaudama (Forbes), A.M.N.H. No. 27389, lateral and frontal views, X1.

PLATE 42


9, 10. Parahoplites inti, new species, holotype, A.M.N.H. No. 27392, lateral and ventral views, ×1.

PLATE 43


2. *Parengonoceras guadaloupaforme* (Sommermeier), A.M.N.H. No. 27397, lateral view, ×1.
3, 4. *Parengonoceras pernodosum* (Sommermeier), A.M.N.H. No. 27396/1:1, lateral and frontal views, ×1.
PLATE 45


11, 12. *Knemiceras attenuatum spinosum* (Sommermeier), A.M.N.H. No. 27850, lateral and frontal views, ×1.
PLATE 47

1, 2. Knemiceras triangulare, new species, A.M.N.H. No. 27853, holotype, ventral and lateral views, ×1.

6, 7. Knemiceras raimondii tardum, new subspecies, A.M.N.H. No. 27858, holotype, frontal and lateral views, ×1.
1. *Knemiceras raimondii pacificum*, new subspecies, A.M.N.H. No. 27857, holotype, lateral view, \( \times 1 \).

2-4. *Brancoceras aegoceratoides* Steinmann. 2. A.M.N.H. No. 27866:1, lateral view, \( \times 1 \). 3, 4. A.M.N.H. No. 27866:2, lateral and ventral views, \( \times 1 \).

5. *Oxytropidoceras peruvianum* (von Buch), A.M.N.H. No. 27861, lateral view, \( \times 1 \).

6. *Oxytropidoceras carbonarium* (Gabb), A.M.N.H. No. 27860, lateral view, \( \times 1 \).
PLATE 50


5. ?_Knemiceras ollonense_ (Gabb), A.M.N.H. No. 27855, lateral view, ×1.

6. _Dipoloceras_ sp. indet., A.M.N.H. No. 27865, lateral view, ×2/3.
PLATE 51


PLATE 52

PLATE 53

5. Venezolkeras venezolanum (Stieler), A.M.N.H. No. 27863, lateral view, ×1.
PLATE 54


PLATE 58


5. *Barroisiceras (Forresteria) basseeae*, new name, A.M.N.H. No. 27888, lateral view, ×1.

PLATE 59

1, 2. *Buchiceras bilobatum* Hyatt, A.M.N.H. No. 27894/2:2, frontal and ventral views, ×1.

PLATE 60


PLATE 61


PLATE 62

1, 2. *Tissotia halli* Knechtel, A.M.N.H. No. 27891:1, frontal and lateral views, ×1.
3, 4. *Tissotia fourneli* (Bayle), A.M.N.H. No. 27892, ventral and lateral views, ×1.
PLATE 63


PLATE 64

PLATE 66

1, 2. *Lenticeras baltai* Lissón, A.M.N.H. No. 27897, lateral and frontal views, ×1/2.