CRETACEOUS SYSTEM IN NORTHERN PERU

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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 Most papers dealing with the stratigraphy of the Cretaceous have scanty and outdated paleontological information, and even the few recent works on the invertebrate fossil faunas lack adequate stratigraphic control.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 équatoriales la *formation crayeuse* est tout a fait prépondérante et developpeé 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 resemblance avec celle des terrain cretacées 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, Stubel, 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 Senonian" 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

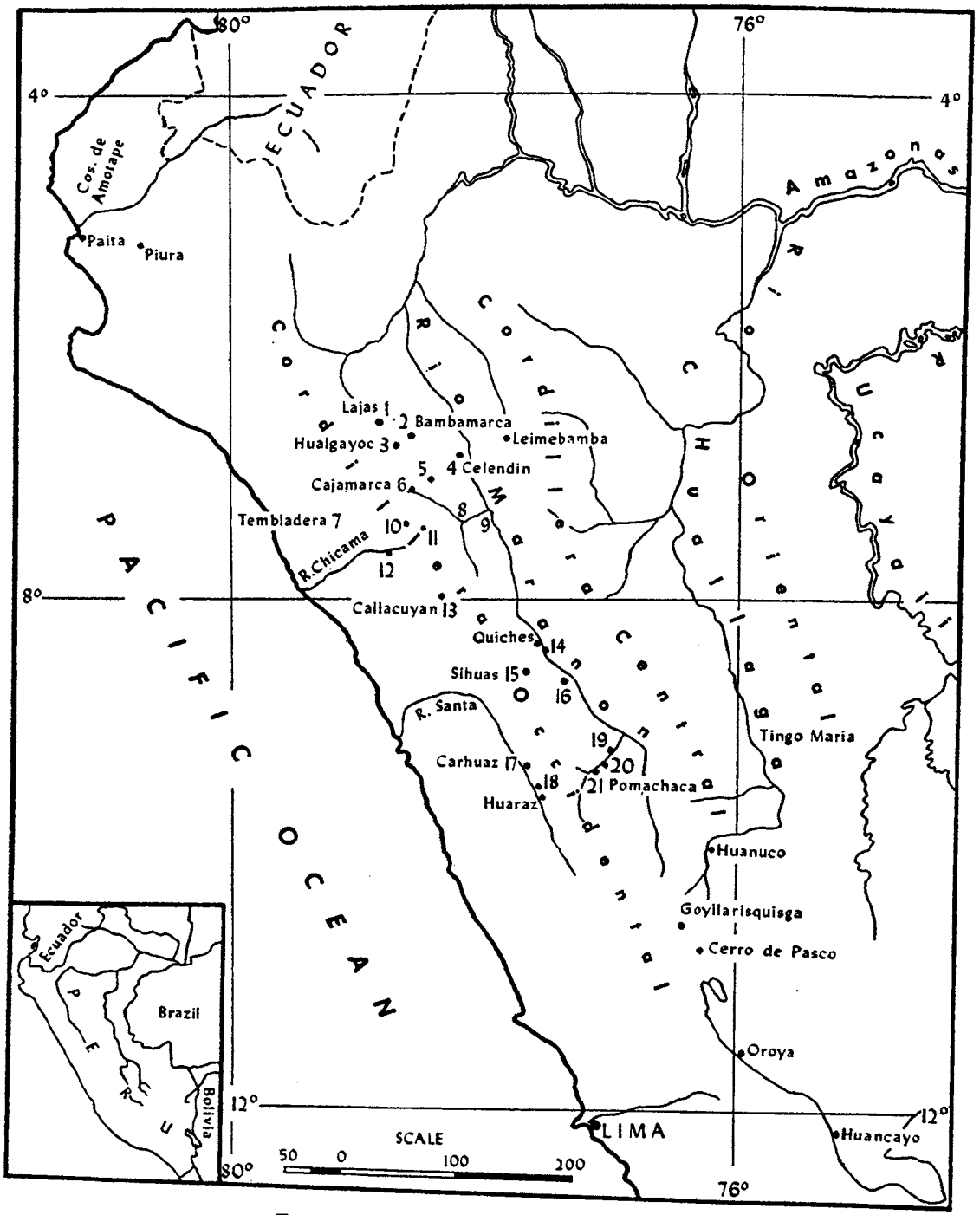

FIG. 1. Index map and location of sections.

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 (Carhuaz 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

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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 Pasco*) 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

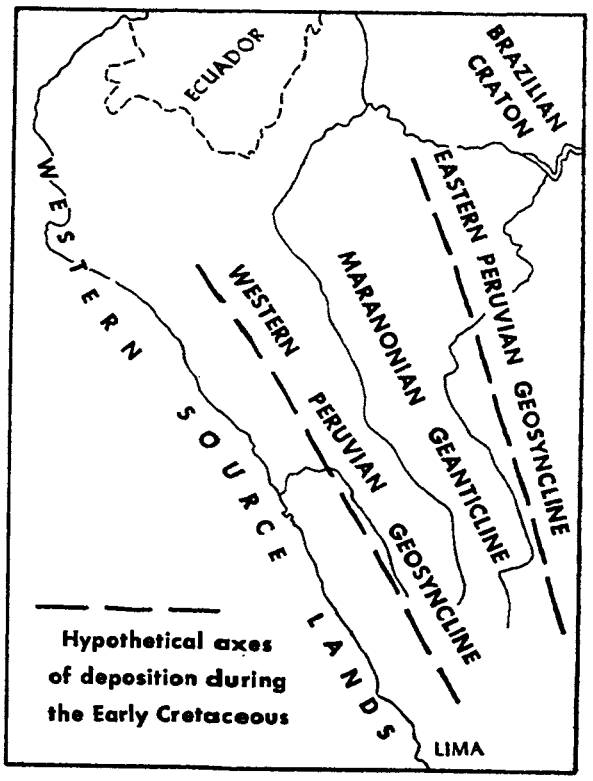


FIG. 2. Tectonic elements of northern Peru; the heavy discontinuous lines are the hypothetical axes of deposition during the early Cretaceous.

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—Marañonia.

B. Between Marañonia 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 coast line there were lands—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 towares 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

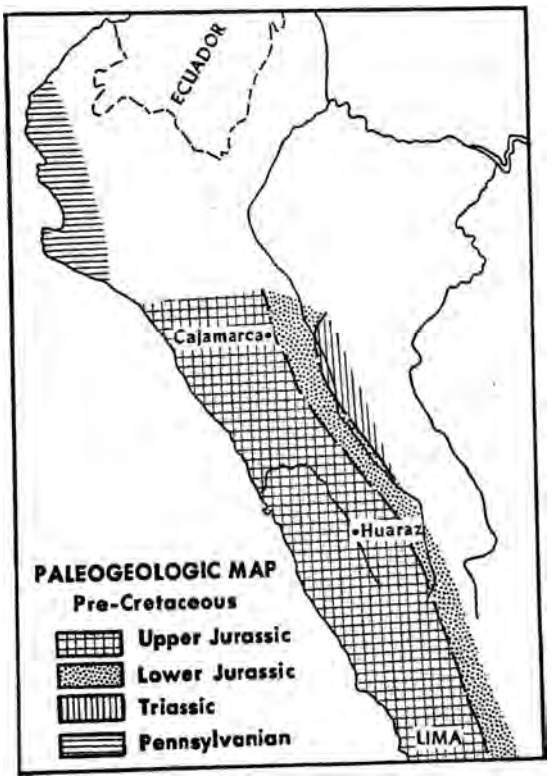


FIG. 3. Pre-Cretaceous paleogeologic map, northern Peru.

those of the Cretaceous. "There is no indication of an orogeny in Peru between the Paleozoic and the Mesozoic" (Newell *et al.*, 1953, p. 23).

The unconformity at the base of the Cretaceous was developed through time. While in some areas, as in the Lima area (Rivera, 1951, p. 16), sedimentation apparently was continuous from the Jurasssic into the Cretaceous, in others, as in Marañonia, 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 conglomerates, 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 geanticline 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* Knechtel *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 "massive 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-Mesozoic.

Lower and upper Jurassic rocks have been reported from the Huallaga River, on the eastern side of the Marañón geanticline (Huff, 1949, p. 4). Marañonia began to develop 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 widespread 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 Occidental of northern and central Peru, the Cretaceous rests disconformably, without distinct angular relationships, on upper Jurassic, lower Jurassic, Triassic, and Permian sediments. The angularity of the Sarayaquillo (Jurassic) and the Cushabatay (Cretaceous) formations in eastern Peru (Kummel, 1948, p. 1231) has been recently interpreted by Huff (1949, p. 7), in the light of regional studies, as being of only local and slight significance.

2. The transgressive basal Cretaceous sediments (Chimú and Goyllarisquisga formations) are composed of extremely clean, mature, well-sorted, probably wind-winnowed 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 system, 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-Pomachaca 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 Venezuelan 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 formational 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

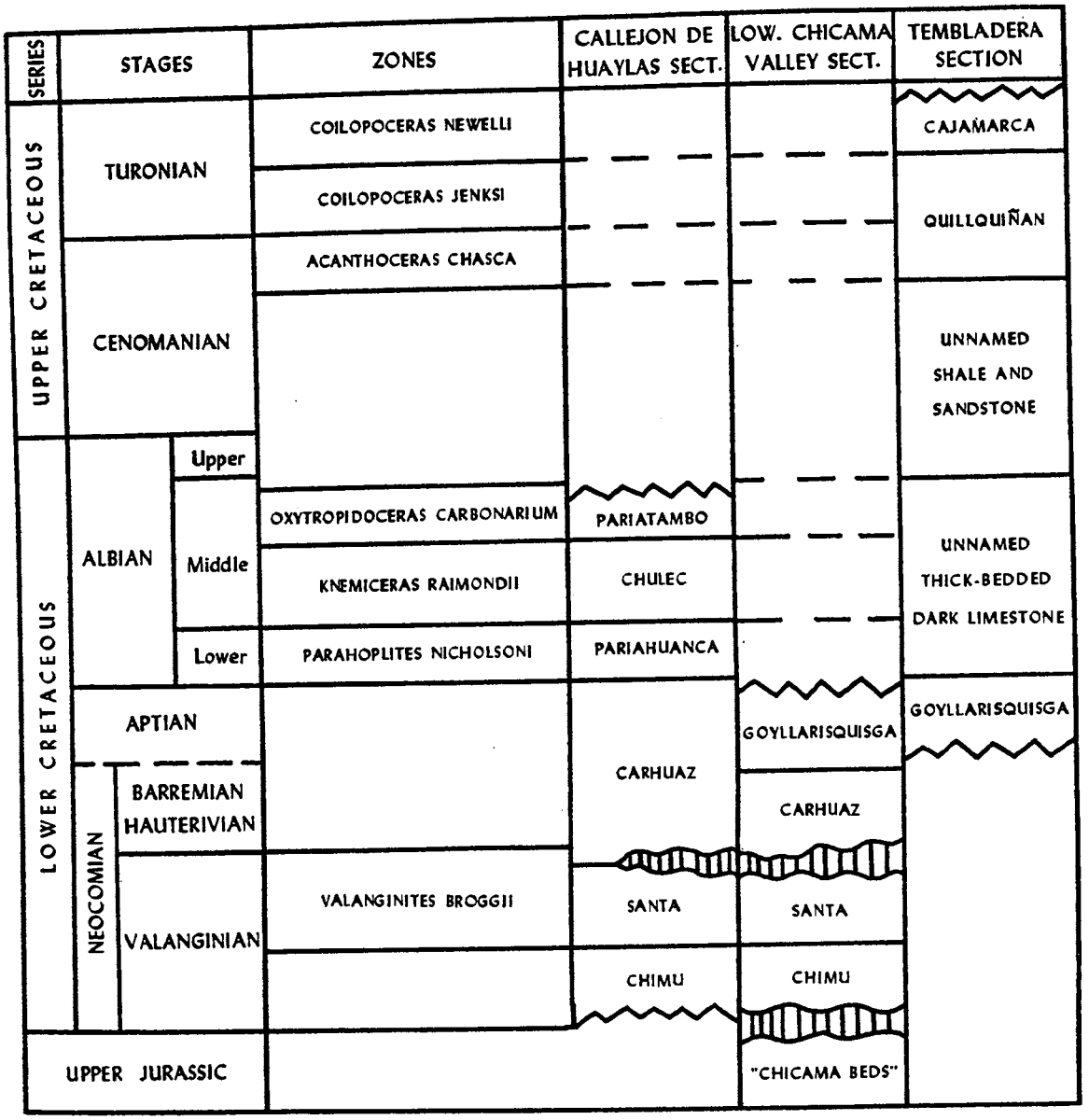


FIG. 4. Cretaceous system in the western mountain front.

meters downstream from the hot springs to 400 meters upstream from the same point.

The Chimú sandstone comprises 685 meters of very thick-bedded, massive, hard, strongly 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 in the Chicama area have been studied in some detail by Stappenbeck (1929). In the type section, a 1-meter thick bed of subanthracitic 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.

The base of the quartz-sandstone sequence

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 Pushca 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 Chinú sandstone has very regular bedding, cross-bedding of the angular type (pl. 33, fig. 1), and contains carbonaceous shales and allochtonous 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 *Paraglauconia strombiformis* Schlotheim. The present writer finds that this "limestone with *Paraglauconia*" 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, splintery 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 splintery 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 flexicostata* Fritzsche, *Buchotrigonia inca* Fritzsche, *Paraglauconia studeri* Vilanova, 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 the eastern shore of which abutted against Marañonia 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 overlies 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 of *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 broggii* Lissón, *Buchotrigonia gerthii* Lissón, *Buchotrigonia flexicostata* Fritzsche, *Buchotrigonia inca* Fritzsche, *Cucullaea gabrielis* Leymerie, and several specifically undeterminable olcostephanid ammonites. Oysters are found 400 meters above the base. Elsewhere, *Cyrena huarazensis* Fritzsche, *Paraglauconia studeri*, and *Paraglauconia strombiformis* are the most common fossils. The plant remains are similar to those of the Chimú and Goyllarisquisga formations. *Valanginites broggii* 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 Fritzsche (1924) identified *Requienia ammonia* Goldfuss and *Agria blumenbachi* 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-Jatunhuasi 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 Carhuaz 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

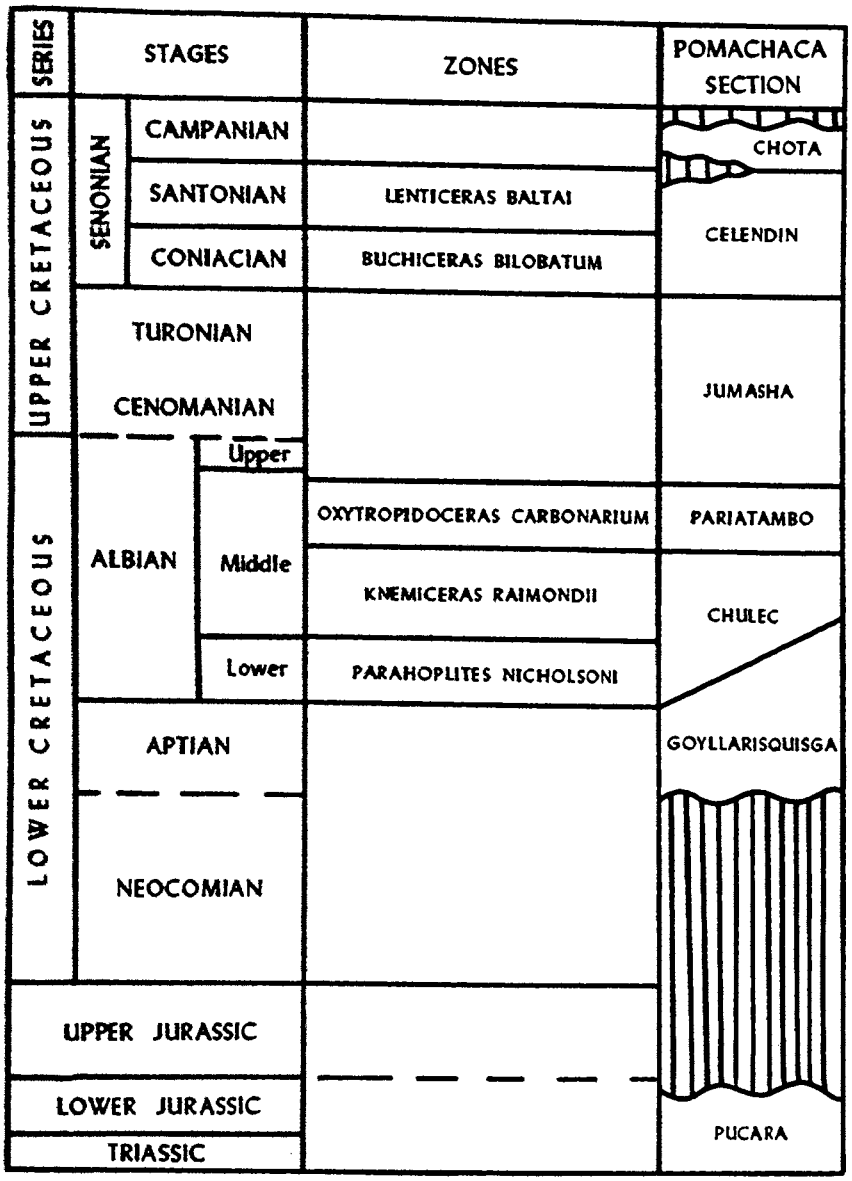


FIG. 5. Cretaceous system in the central Andes.

River discharges into the Marañón River (fig. 19), it rests disconformably on the gently channeled Triassic Uliachín 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 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 *Parengonoceras* 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 disconformably 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 Jequetepeque 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 Pacasmayo 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, Yauli, 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, Marañonia 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 channeled 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.

FIG. 6. Late Carhuaz (Aptian) lithofacies map, northern Peru.

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 Marañonia 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 *Gervillia* 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*, *Lyelliceras*, *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 (Celendín 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 blancheti* (Pictet and Campiche)
- *Douvilleiceras monile* (Sowerby)
- *Parengonoceras pernodosum* (Sommermeier)
- *Parengonoceras guadaloupaeforme* (Sommermeier)
- *Parengonoceras tetranodosum* (Lissón)
- *Parengonoceras haasi*, new species
- *Parengonoceras? champaraense*, new species
- *Knemiceras raimondii* Lissón
- *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? ziczag* Breistroffer
- *Brancoceras aegoceratoides* Steinmann
- *Lyelliceras lyelli* (Leymerie)

Pelecypoda
- *Cucullaea brevis* Gerhardt
- *Cucullaea gerhardti* Olsson
- *Modiolus mutissus* Olsson
- *Neithea morrisi* Pictet and Renevier
- *Exogyra aquila* Brogniart
- *Exogyra minos* Coquand
- *Exogyra boussingaulti* d'Orbigny
- *Myopholas peruviana* Olsson
- *Yaadia hondaana* (Lea)
- *Buchotrigonia abrupta* (von Buch) (=*B. humboldti* von Buch, *B. coquandi* Lissón, and *B. orbignyi* Lissón)
- *Pterotrigonia tocaimaana* (Lea) (=*P. subcrenulata* d'Orbigny)
- *Cardita subparallela* Gerhardt
- *Astarte debilidens* Gerhardt
- *Protocardium elongatum* Gerhardt
- *Anatina silinensis* Richards

Echinoidea
- *Bothriopygus compressus* Gabb
- *Echinobrissus subquadratus* d'Orbigny
- *Holectypus (Coenholectypus) planatus numismalis* (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-

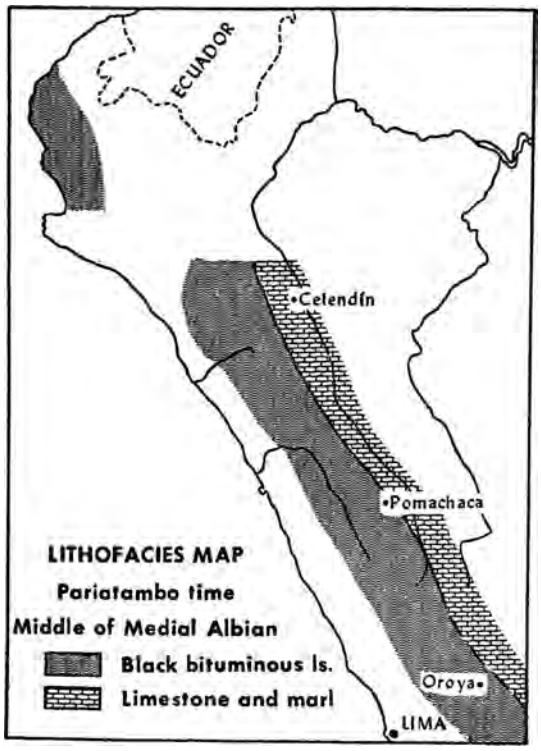


FIG. 7. Pariatambo (middle of medial Albian) lithofacies map, northern Peru.

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 (Michelín)
Oxytropidoceras carbonarium (Gabb)
Oxytropidoceras douglasi Knechtel
Venezoliceras venezolanum (Stieler)
Venezoliceras harrisoni, new species
Dipoloceras sp.
Brancoceras aegoceratoides Steinmann
Lyelliceras lyelli (Leymerie) (d'Orbigny)
Lyelliceras pseudolyelli (Parona and Bonarelli)
Lyelliceras ulrichi Knechtel
Pelecypoda
Inoceramus concentricus Parker
Inoceramus salomoni 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 Amotape Mountains, which stood before as lands, were covered by the Pariatambo Sea.

The shallow marine conditions in which the limestones and marls of the Chulec 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

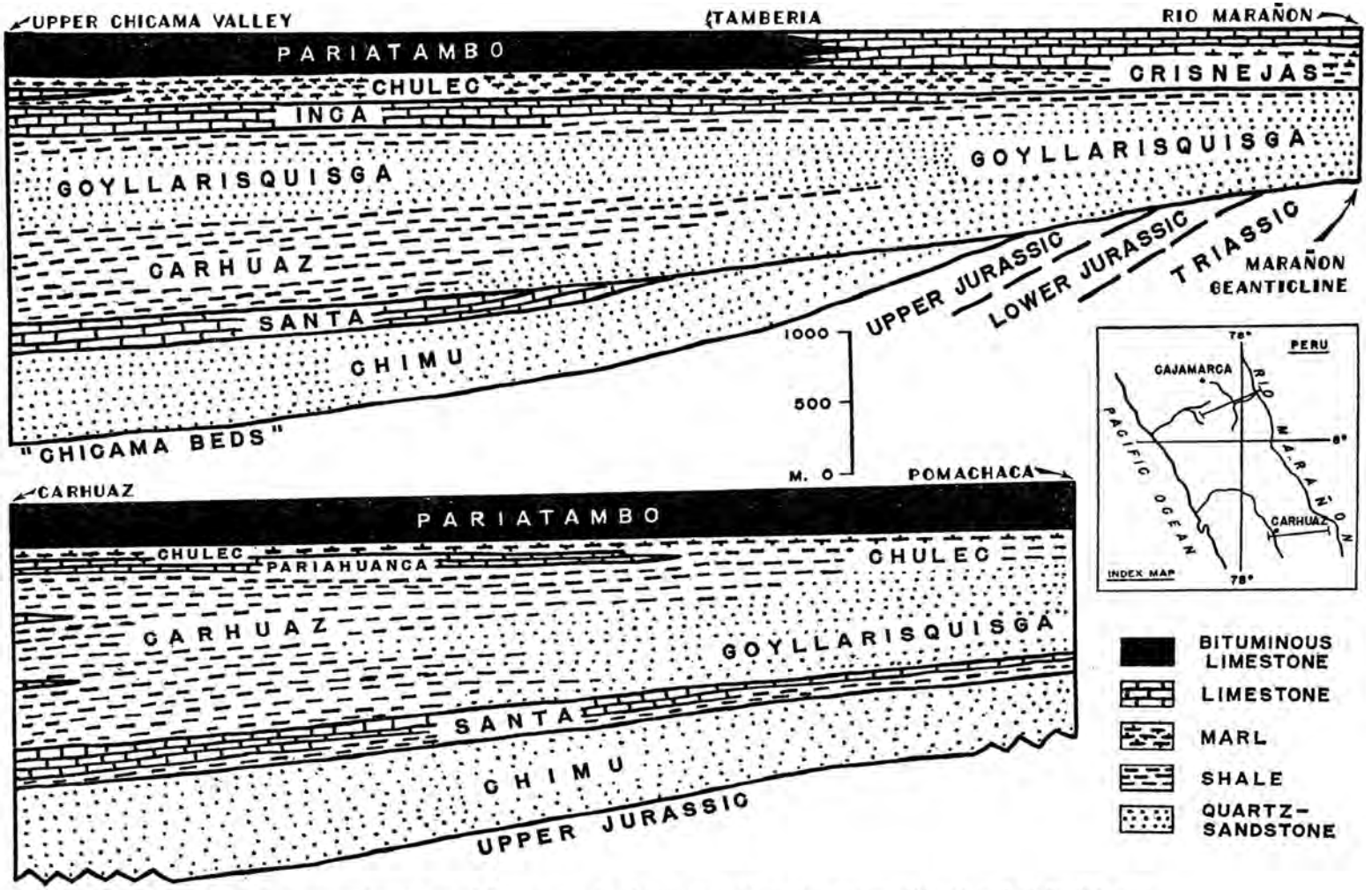
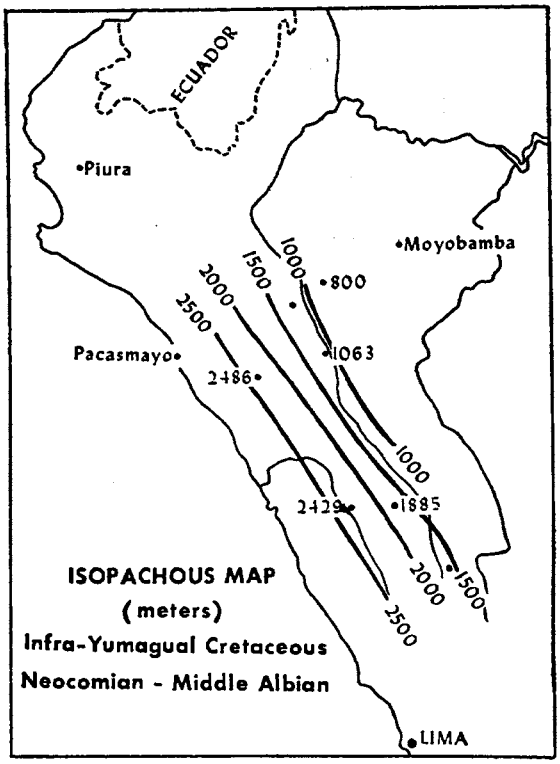


FIG. 8. Restored sections of Cretaceous in the western Peruvian geosyncline at end of Pariatambo (middle of medial Albian) time.



be described in the following pages. Generally the formation is very poor in fossils. However, a fortunate find was made in the lower beds of the Jumasha formation in Pomachaca, where *Lyelliceras ulrichi* Knechtel and *Oxytropidoceras douglasi* Knechtel were collected. These fossils are also found in the underlying Pariatambo formation. Also, especially in the upper part, the limestones carry Foraminifera. This formation, therefore, as already stated by Steinmann (*in* Schlagintweit, 1912, p. 48, and *in* Steinmann, 1930, p. 155), represents the latest medial Albian-Turonian interval which in northern Peru is represented by the Pulluicana and Quillquiñan groups and by the Cajamarca formation. Inasmuch as no distinctive breaks have been found, it is likely that the Jumasha formation represents fairly continuous sedimentation during that time. It was deposited probably under deeper waters than those of the same time in northern Peru.

FIG. 9. Isopachous map of the Infra-Yumagual (Neocomian-middle Albian) Cretaceous in northern Peru.

NORTHERN WESTERN ANDES

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-

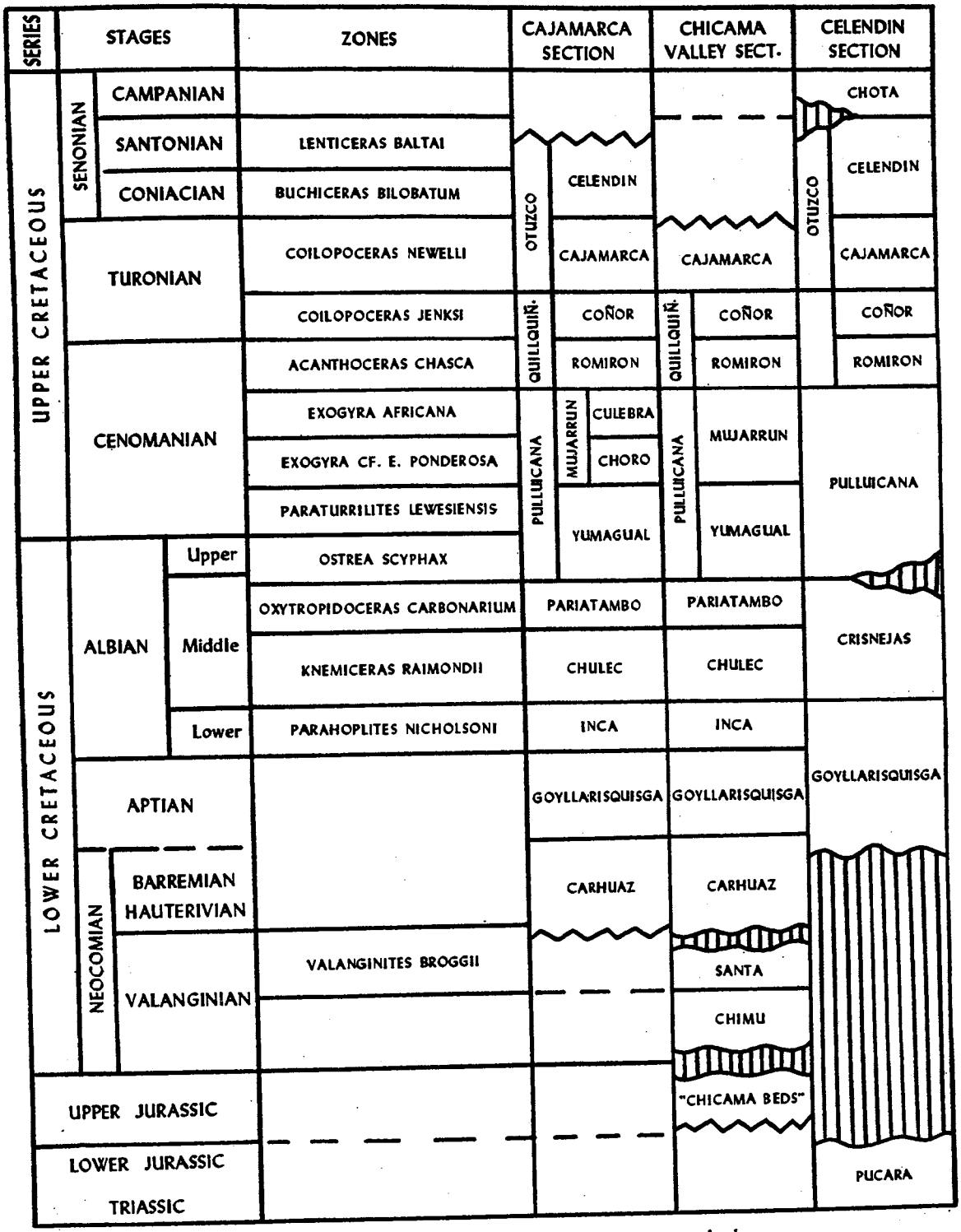


FIG. 10. Cretaceous system in the northern western Andes.

stone and yellowish and greenish brown, finely splintery, fossiliferous shale, with subordinate amounts of quartz-sandstone and siltstone, lying between the Goyllarisquisga and the Chulec formations. The whole formation is conspicuously ferruginous and, if deeply weathered and leached, it has distinct bright yellow and red colors. At the base, there is an intraformational conglomerate composed of fragments of massive, dark brownish gray, arenaceous limestone in a ferruginous, argillaceous, silty, oölitic limestone matrix.

Steinmann (1930, p. 119) referred to this formation in his discussion of the Peruvian "Aptian," and similarly, Stappenbeck 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 Jequetepeque rivers (Sunchubamba and Huaycot 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, oölitic, arenaceous limestone (calcarenite) which weathers 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 (Tambería 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 Pariahuanca 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 ollonense* (Gabb)

Pelecypoda
- *Trigonoarca gerhardti* Olsson
- *Cucullaea brevis* d'Orbigny
- *Pterotrigonia tocaimaana* (Lea) (=*P. subcrenulata* d'Orbigny)
- *Yaadia hondaana* (Lea)
- *Buchotrigonia abrupta* (von Buch)
- *Ptychomia robinaldina* d'Orbigny (=*P. lissoni* Sommermeier)
- *Corbis* (*Sphaera*) *corrugata* Sowerby

Echinoidea
- *Enallaster peruanus* (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	METERS
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, *Paraturrilites lewesiensis* and *Sharpeiceras occidentale* are found	140
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	214
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*	142
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 Encañada (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 *Paraturrilites lewesiensis* and *Sharpeiceras occidentale. Oxytropidoceras carbonarium* is a species of the middle of the medial Albian, abundant in the underlying Pariatambo formation, whereas *Paraturrilites lewesiensis* and *Shapeiceras occidentale* are early Cenomanian. On this basis, the Yumagual formation is assigned to the interval

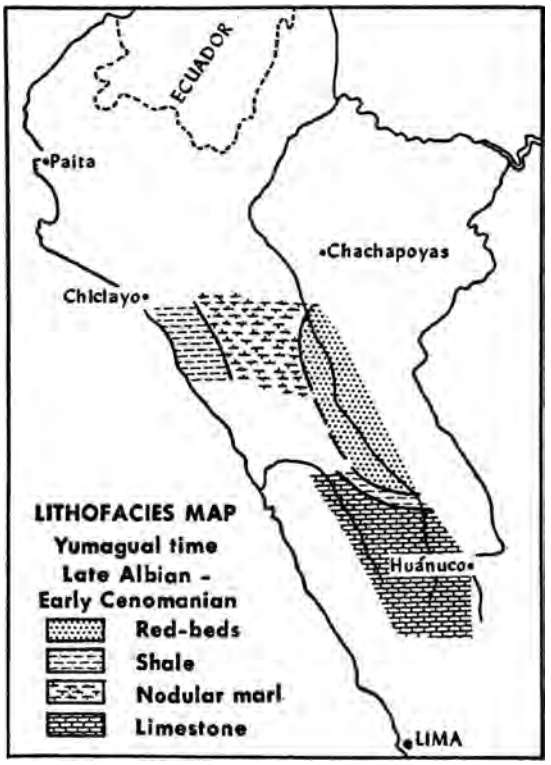


FIG. 11. Yumagual (late Albian-early Cenomanian) lithofacies map, northern Peru.

late medial Albian-early Cenomanian. In central Peru, its time equivalent must be within the Jumasha formation.

Southeast of Cajamarca, the Yumagual formation becomes less calcareous, more coarsely clastic, and changes facies into the Rosa formation which contains non-marine red beds (fig. 11).

After the deposition of the Pariatambo formation, there was shallowing of the seas, and Marañonia emerged. In the Cajamarca area, shallow-water marls and limestones were deposited, and occasional quartz-siltstones from the southwest interfingered in the sequence. There was abundant benthonic life; ammonites were scarce.

MUJARRÚN FORMATION

This formation takes its name from Cerro Mujarrún, 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 Quillquiñan 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 Quillquiñan group. The marl beds are crowded with *Exogyra africana* Lamarck, *Exogyra olisiponensis* Sharpe, *Exogyra polygona* von Buch, *Neithea tenouklensis* 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 Crisnejas section it cannot be differentiated from the underlying Choro member.

The Mujarrún formation is Cenomanian, lying between the late Albian-early Ceno-

manian Yumagual 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 Mujarrún formation of the Pulluicana group is a series of richly fossiliferous marls and shales which have been defined as the Quilliquiñan 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 Mujarrún 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 *Vascoceras*. Later, Steinmann (1930, p. 146) tentatively described this group under the heading of "Turonian" and gave a good section which he had observed in Huañambra, 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 Mujarrún 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. 36, 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 pollocense*, new species
- *Neolobites kummeli*, new species

Pelecypoda
- *Mytilus* sp.
- *Neithea alatus* von Buch

Neithea aequicostata Lamarck
Neithea tenouklensis Coquand
Plicatula reynesi Coquand
Plicatula gurgitis Pictet and Roux
Plicatula auressensis Coquand
Ostrea rouvillei Coquand
Exogyra olisiponensis Sharpe
Exogyra olisiponensis duplex Paulcke
Exogyra polygona von Buch
Cardita doumeti Peron
Coquandia italica Seguenza
Corbula sp.
Echinoidea
Orthopsis titicacana Cooke

This fauna indicates late Cenomanian. The Romirón formation is considered within the *Acanthoceras chasca* zone.

The lithologies and the extraordinary abundance of fossils suggest very shallow water environment of deposition.

Coñor Formation

The Coñor formation is named after Cerro Coñor, 8 kilometers northeast of Cajamarca. The Coñor formation, as well as the Romirón, is exposed in a belt at the northern foot of the Cerros Coñor and Romirón. The type is in the Cajamarca section and is 90 meters of bluish gray marl interbedded with dark gray limestone beds overlying the Romirón formation. The lower boundary is at the base of the first massive bed of dark gray limestone overlying the yellow marls and shales of the Romirón formation. The upper boundary is at the top of the marls and the introduction of the continuous sequence of lithographic, massive, thick-bedded, dark gray limestone of the Cajamarca formation. The limestones of the Coñor formation are very similar to those of the overlying Cajamarca formation, although usually they are more argillaceous. The marl is bluish and light gray and is somewhat nodular. The Coñor formation is more calcareous and less fossiliferous than the underlying Romirón formation; it lacks the rusty, yellowish brown, coquinoid limestones of the latter.

Together with the Romirón formation, the Coñor 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
Mammites nodosoides afer Pervinquière
Pseudoaspidoceras reesidei, new species
Thomasites fischeri, new species
Hoplitoides inca, new species
Pelecypoda
Inoceramus labiatus Schlotheim
Inoceramus sp.
Plicatula gurgitis Coquand
Plicatula reynesi Coquand
Corbula peruana Gabb
Echinoidea
Hemiaster 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 constitutents 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 *Coilopoceras 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 *Coilopoceras 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 Marañonia 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 disconformably 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 gypsiferous 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, Paulcke (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*

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*) *brancoi* Solger
- *Barroisiceras* (*Forresteria*) *basseae*, new species
- *Barroisiceras* (*Forresteria*) *alluaudi* Boule, Lemoine, and Thévenin
- *Tissotia hedbergi*, new species
- *Heterotissotia peroni* Lissón
- *Heterotissotia bucheri*, new species
- *Buchiceras bilobatum* Hyatt

Pelecypoda
- *Cucullaea maresi* Coquand
- *Modiola* sp.
- *Inoceramus aequivalvis* Brüggen
- *Inoceramus peruanus* Brüggen
- *Plicatulopecten ferryi* Coquand
- *Spondylus striatus* Sowerby
- *Lima* (*Plagiostoma*) *grenieri* Coquand
- *Ostrea* (*Lopha*) *nicaisei* Coquand
- *Ostrea* sp.
- *Ostrea bravoi* Brüggen
- *Roudairia intermedia* Brüggen
- *Cardium pulchrum* Brüggen
- *Pholadomya elongata* Muenster
- *Pholadomya quinuana* Neumann

Echinoidea
- *Cyphosoma schlagintweiti* Brüggen
- Several species of the group of *Hemiaster fourneli* 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.
- *Desmophyllites gaudama* (Forbes)
- *Texanites hourcqi* Collignon
- *Texanites* sp.
- *Tissotia steinmanni* Lissón
- *Tissotia fourneli* (Bayle)
- *Tissotia halli* Knechtel
- *Lenticeras baltai* Lissón
- *Lenticeras lissoni* Knechtel

Pelecypoda
- *Inoceramus* sp.
- *Lima* sp.
- *Ostrea* (*Phola*) *nicaisei* Coquand
- *Roudairia intermedia* Brüggen
- *Cardium pulchrum* Brüggen

Echinoidea
- *Hemiaster fourneli* Deshayes
- *Goniopygus hemicidariformis* Brüggen
- *Goniopygus superbus* Cotteau and Gauthier

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

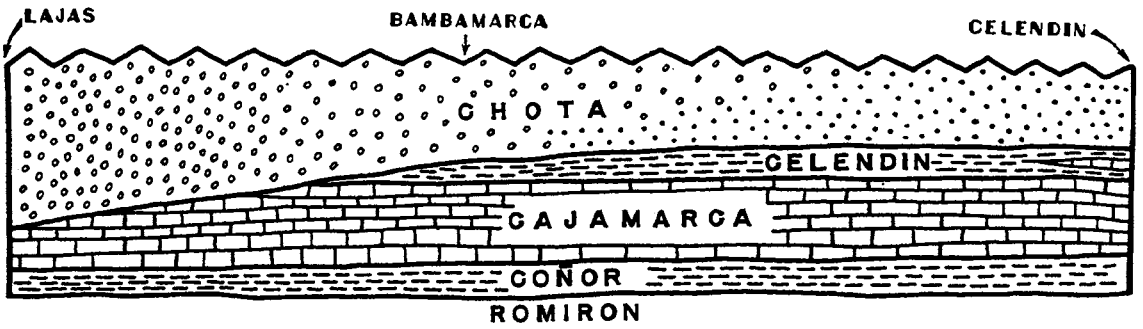


FIG. 12. Turonian-Senonian in the western Peruvian geosyncline.

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-

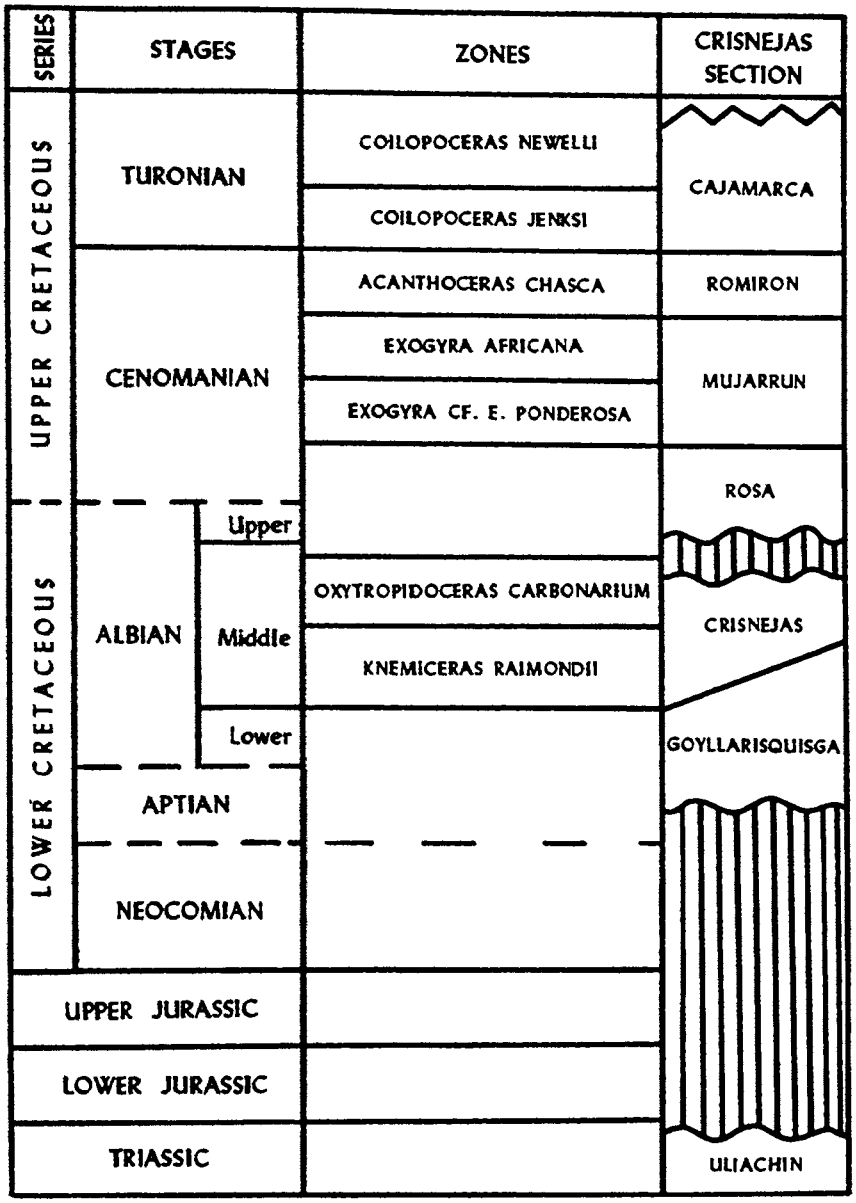


FIG. 13. Cretaceous system in the Marañón Valley.

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, rusty-weathering 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 carbonarium*). 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 Huamachuco, 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 Celendín, the Rosa formation is absent; limestones of the Pulluicana 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

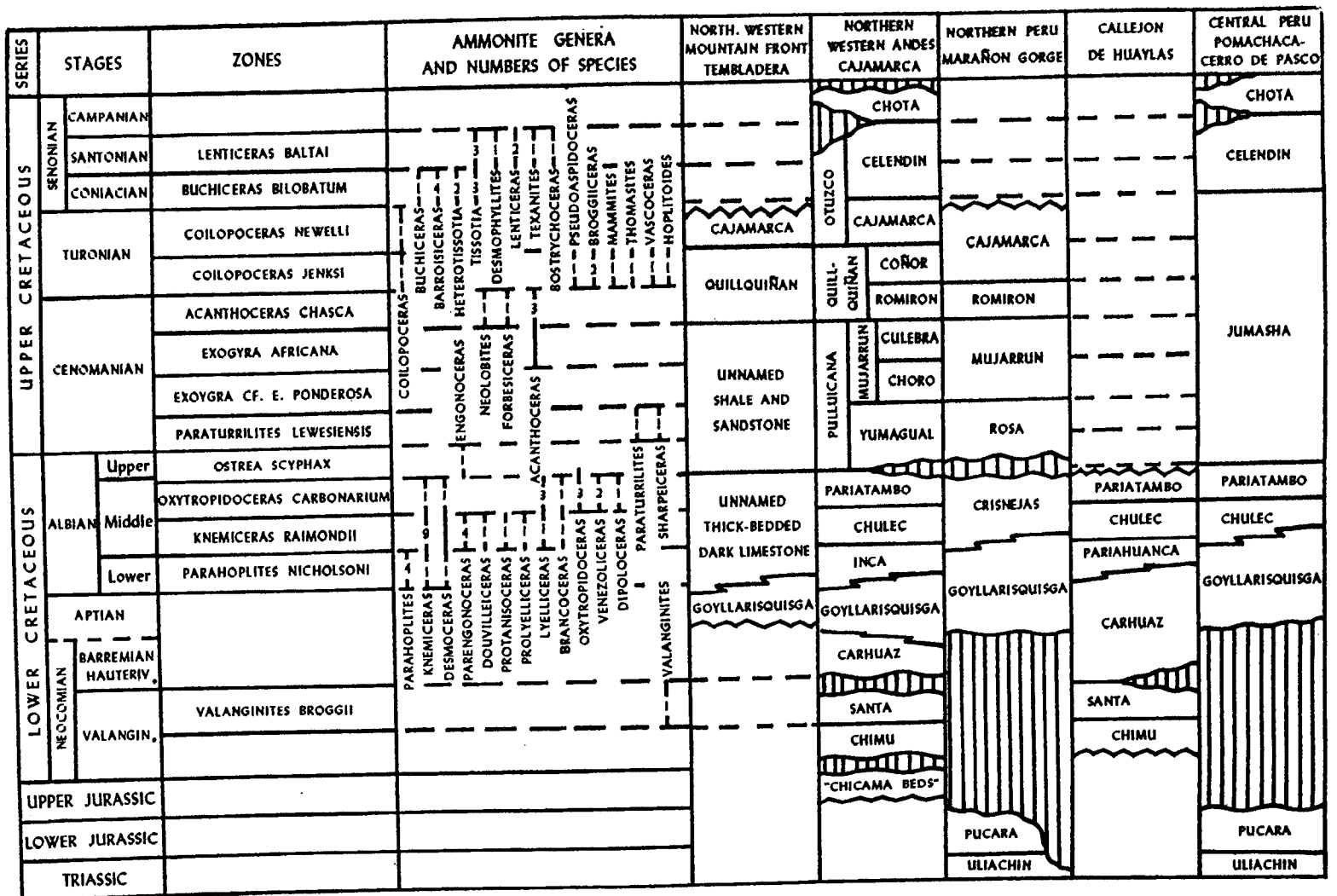


FIG. 14. Summary of the Cretaceous system in northern Peru.

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 echinoids 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 *Valanginites broggii*

The Santa limestone and the lowest beds of the Carhuaz formation are characterized by *Valanginites broggii* associated with other specifically unidentifiable species of olcostephanid ammonites and the following pelecypods:

Buchotrigonia flexicostata (Fritzsche)
Buchotrigonia inca (Fritzsche)
Buchotrigonia gerthii (Lissón) (=*Trigonia mathewsi* Richards)
Cucullaea gabrielis Leymerie
Cyrena huarazensis 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 *Valanginites* 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 *Valanginites*, 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 "*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*. 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 inti, new species
Knemiceras ollonense (Gabb)
Pelecypoda
Trigonoarca gerhardti Olsson
Cucullaea brevis d'Orbigny
Pterotrigonia tocaimaana (Lea) (=*P. subcrenulata* d'Orbigny)
Yaadia hondaana (Lea)
Buchotrigonia abrupta (von Buch)
Buchotrigonia robinaldina d'Orbigny (=*B. lissoni* Sommermeier)
Corbis (*Sphaera*) *corrugata* Sowerby
Echinoidea
Enallaster peruanus (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 *Douvilleiceras*" (Spath, 1930, p. 60). The genus *Knemiceras* reaches its maximum diversification in the next zone,

McLAUGHLIN 1924	STAPPENBECK 1927	STEINMANN 1929	TAFUR 1950		THIS PAPER	
					CHOTA Fm.	
	"SENONIAN" (13)	"Marls with the Otuzco fauna"	OTUZCO Gr.	OTUZCO Fm.	OTUZCO Gr.	CELENDIN Fm.
		ACTAEONELLA LIMESTONE				CAJAMARCA Fm.
	(12) "TURONIAN" (Huacraruco) (11)	"TURONIAN" (Huañambra)		QUILLQUIÑAN Fm.	QUILLQUIÑAN Gr.	CONOR Fm.
						ROMIRON Fm.
	(10) "CENOMANIAN" (9)	"CENOMANIAN"	PULLUICANA Gr.	MUJARRUN Fm.	PULLUICANA Gr.	MUJARRUN Fm. CULEBRA M.
						MUJARRUN Fm. CHORO M.
				YUMAGUAL Fm.		YUMAGUAL Fm.
MACHAY Ls. PARIATAMBO Member	STINKKALK (8)	"ALBIAN"		YACU-USHCO Fm.	PARIATAMBO Fm.	
MACHAY Ls. CHULEC Member	(7) "APTIAN" (6)	"APTIAN"	PALACIOS Gr.	SANTA URSULA Fm.	CHULEC Fm.	
	"UPPER SHALES" (5)			CAPAS ROJAS Fm.	INCA Fm.	
GOYLLARISQUISGA-JATUNHUASI SS.	(4) FARRAT QUARTZITE	FARRAT QUARTZITE		LLACANORA Fm.	GOYLLARISQUISGA Fm.	
	PALLARES Sh.	PALLARES Sh.			CARHUAZ Fm.	
	(3) PARAGLAUCONIA LIMESTONE	PARAGLAUCONIA LIMESTONE			SANTA Fm.	
	(2) LOWER QUARTZITE OF THE WEALDIAN	MAIN QUARTZITE			CHIMU Fm.	

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.

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

so-called Clansayes fauna of France which corresponds to the *Acanthoplites nodosocostatum* zone of England. The Clansayes 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 affinites 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)
- *Douvilleiceras monile* (Sowerby)
- *Parengonoceras pernodosum* (Sommermeier)
- *Parengonoceras guadaloupaeforme* (Sommermeier)
- *Parengonoceras tetranodosum* (Lissón)
- *Parengonoceras haasi*, new species
- *Parengonoceras? champaraense*, 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? ziczag* Breistroffer
- *Brancoceras aegoceratoides* Steinmann
- *Prolyelliceras peruvianum* Spath
- *Lyelliceras lyelli* (Leymerie) (d'Orbigny)

Pelecypoda
- *Cucullaea brevis* Gerhardt
- *Cucullaea gerhardti* Olsson
- *Modiolus mutissus* Olsson
- *Neithea morrisi* Pictet and Renevier
- *Exogyra aquila* Brogniart
- *Exogyra minos* Coquand
- *Exogyra boussingualti* d'Orbigny
- *Myopholas peruviana* Olsson
- *Yaadia hondaana* (Lea)
- *Buchotrigonia abrupta* (von Buch) (=*B. humboldti* von Buch, *B. coquandi* Lissón, and *B. orbignyi* Lissón)
- *Pterotrigonia tocaimaana* (Lea) (=*P. subcrenulata* d'Orbigny)
- *Cardita subparallela* Gerhardt
- *Astarte debilidens* Gerhardt
- *Protocardium elongatum* Gerhardt
- *Anatina silinensis* Richards

Echinoidea
- *Bothriopygus compressus* Gabb
- *Echinobrissus subquadratus* d'Orbigny
- *Enallaster peruanus* Gabb
- *Holectypus* (*Coenholectypus*) *planatus numismalis* (Gabb)
- *Phymosoma texanum* Roemer

One of the most significant species in this list is *Douvilleiceras monile*, distributed in northern South America (Riedel, 1937–1938), Europe (Spath, 1923–1943, vol. 1, p. 72; Breistroffer, 1947, p. 40), North Africa, Madagascar (Collignon, 1949), and India (Spath, 1930). In England, it is the index of the subzone of *Douvilleiceras 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 (Spath, 1930, p. 51) to the zone of *Douvilleiceras 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 (Mahmoud, 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 ollonense*, is found in the underlying zone of *Parahoplites nicholsoni*, and another species, *Knemiceras ovale*, is known in the overlying zone of *Oxytropidoceras carbonarium*.

Parengonoceras ebrayi de Loriol, the closest relative of the Peruvian species of *Parengono-*

ceras, is found in the lower middle Albian ("Protohoplitien" of Breistroffer, 1947, p. 40; or the *Douvilleiceras 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
- *Venezoliceras venezolanum* (Stieler)
- *Venezoliceras harrisoni*, new species
- *Dipoloceras* sp.
- *Brancoceras aegoceratoides* Steinmann
- *Lyelliceras lyelli* (Leymerie) (d'Orbigny)
- *Lyelliceras pseudolyelli* (Parona and Bonarelli)
- *Lyelliceras ulrichi* Knechtel

Pelecypoda
- *Inoceramus concentricus* Parker
- *Inoceramus salomoni* d'Orbigny
- *Anomia* 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, petroliferous 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 *Douvilleiceras mammillatum* through most of the middle Albian (zones of *Hoplites dentatus* and of *Euhoplites lautus*). Breistroffer (1947), who excludes the zone of *Douvilleiceras mammillatum* from the middle Albian, refers to the middle Albian as the "Oxytropidoceratien."

According to Spath (1923–1943, vol. 2, p. 706), the genus *Venezoliceras* 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 "Douvilleiceratien" 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 *Venezoliceras* 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*) *scyphax*

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: "Turrilites 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 tenouklensis* 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 tenouklensis Coquand
Plicatula reynesi Coquand
Plicatula gurgitis Pictet and Roux
Plicatula auressensis Coquand
Ostrea rouvillei Coquand
Exogyra olisiponensis Sharpe
Exogyra olisiponensis duplex Paulcke
Exogyra polygona von Buch
Exogyra deletteri Coquand
Cardita doumeti Peron
Coquandia italica Seguenza
Corbula sp.
Echinoidea
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 *Orthopsis 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 afer* Pervinquière
- *Pseudoaspidoceras reesidei*, new species
- *Thomasites fischeri*, new species
- *Vascoceras* aff. *Vascoceras silvanense* Choffat
- *Broggiiceras humboldti*, new species
- *Broggiiceras 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*, *Thomasites*, *Vascoceras*, *Hoplitoides*, and *Broggiiceras* constitute the well-known Salmurian 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 (Böse, 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 mollusks. 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, Lemoine, and Thévenin
- *Tissotia hedbergi*, new species
- *Heterotissotia peroni* Lissón
- *Heterotissotia bucheri*, new species

Pelecypoda
- *Cucullaea maresi* Coquand
- *Modiola* sp.
- *Inoceramus aequivalvis* Brüggen
- *Inoceramus peruanus* Brüggen
- *Plicatulopecten ferryi* Coquand
- *Spondylus striatus* Sowerby
- *Lima* (*Plagiostoma*) *grenieri* Coquand
- *Ostrea* (*Lopha*) *nicaisei* Coquand
- *Ostrea* sp.
- *Ostrea bravoi* Brüggen
- *Roudairia intermedia* Brüggen
- *Cardium pulchrum* Brüggen
- *Pholadomya elongata* Muenster
- *Pholadomya quinuana* Neumann

Echinoidea
Cyphosoma schlagintweiti Brüggen
Several species of the group of *Hemiaster fourneli* 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 (Pervinquière, 1907), and the genus *Heterotissotia* has been reported from the late Turonian of Tunisia (Pervinquière, 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 Celendín formation is marked by *Lenticeras baltai* Lissón. It is associated with the following:

Cephalopoda
?Bostrychoceras sp.
Desmophyllites gaudama (Forbes)
Texanites hourcqi Collignon
Texanites sp.
Tissotia steinmanni Lissón
Tissotia fourneli (Bayle)
Tissotia halli Knechtel
Lenticeras lissoni Knechtel
Pelecypoda
Inoceramus sp.
Lima sp.
Ostrea (*Phola*) *nicaisei* Coquand
Roudairia intermedia Brüggen
Cardium pulchrum Brüggen
Echinoidea
Hemiaster fourneli Deshayes
Goniopygus hemicidariformis Brüggen
Goniopygus 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 déja 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 insignificant." He places the Madagascan zone of *Texanites hourcqi* 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. *bourgeoisi* d'Orbigny, *Tissotia singewaldi* Knechtel, and *Lenticeras baltai* Lissón. *Parapachydiscus*, however, is an upper Senonian (Parapachydiscan age) genus (Spath, 1921, 1926; Reeside, 1947), and *Texanites bourgeoisi* 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 cañaensis* (Gerhardt), *Gauthiericeras lenti* Gerhardt, *Gauthiericeras margae* (Schlueter), *Amalitheus sieversi* 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, *Parapuzosia?* sp., *Paralenticeras sieversi* (Gerhardt), and *Texanites* cf. *Texanites cañaensis* (Gerhardt) which he assigns to the late lower Senonian (approximately Santonian).

The present writer thinks that the presence in the zone of *Lenticeras baltai* of *Texanites*, *Lenticeras*, *Bostrychoceras*, and *Desmophyllites*, and the absence of *Barroisiceras* and *Heterotissotia*, indicate Santonian. The common association of the genera named first with *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 nonmarine 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 Marañonia, 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 Aguanuya members of eastern Peru (Kummel, 1948) and of the Arcurquina limestone of the Arequipa region (Jenks, 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 are 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 Marañonia; wavy-bedded, 300-meter thick limestones (Mujarrún 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 Romirón 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 Quillquiñan 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 Marañonia was inconspicuous as a physiographic or structural feature. Apparently the thick-bedded limestones of the Cajamarca and Jumasha 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.

	Meters
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 splintery, poorly fossiliferous (*Roudairia intermedia, Cardium, Inoceramus, Hemiaster*), medium gray, white-weathering marl	32
Total, Cajamarca Formation: 210 meters	
Coñor Formation	
44. Shale, brownish gray, soft, crumbly	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 brownish, fossiliferous (*Coilopoceras, Hoplitoides*), with interbeds of thick-bedded, massive, fossiliferous (*Orthopsis titicacana*), 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 olisiponensis*), 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 olisiponensis*, other exogyroids, *Neithea tenouklensis, Neithea alatus, Tetragramma* sp., *Orthopsis titicacana*), 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

METERS

29. Limestone, argillaceous, light gray, nodular, thick-bedded, fossiliferous (*E.* cf. *ponderosa*), interbedded with massive, light bluish gray limestone 105

TOTAL, MUJARRÚN FORMATION: 287 meters

YUMAGUAL 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 (*Paraturrilites 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, soft 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, YUMAGUAL 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 (*Parengonoceras 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

	Meters
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 (*Pterotrigonia tocaimaana, 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. BAMBAMARCA

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

CHOTA FORMATION	Meters
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, Heterotissotia peroni, H. bucheri, 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 (*Coilopoceras newelli*)	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 (*Coilopoceras newelli, Lima* sp., *Cardium lissoni, 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	METERS
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 *Coilopoceras 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
MUJARRÚN 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, MUJARRÚN FORMATION: 263 METERS	
YUMAGUAL FORMATION	
33. Marl, light gray, very poorly exposed, interbedded with medium- to thick-bedded, fossiliferous (*Exogyra mermeti*), 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

	Meters
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 *Lyelliceras 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., *Liophistha* sp., *Enallaster 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 minos*)	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	

SECTION 4. CELENDÍN

Composite section (fig. 16); the lower Goyllarisquisga 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.

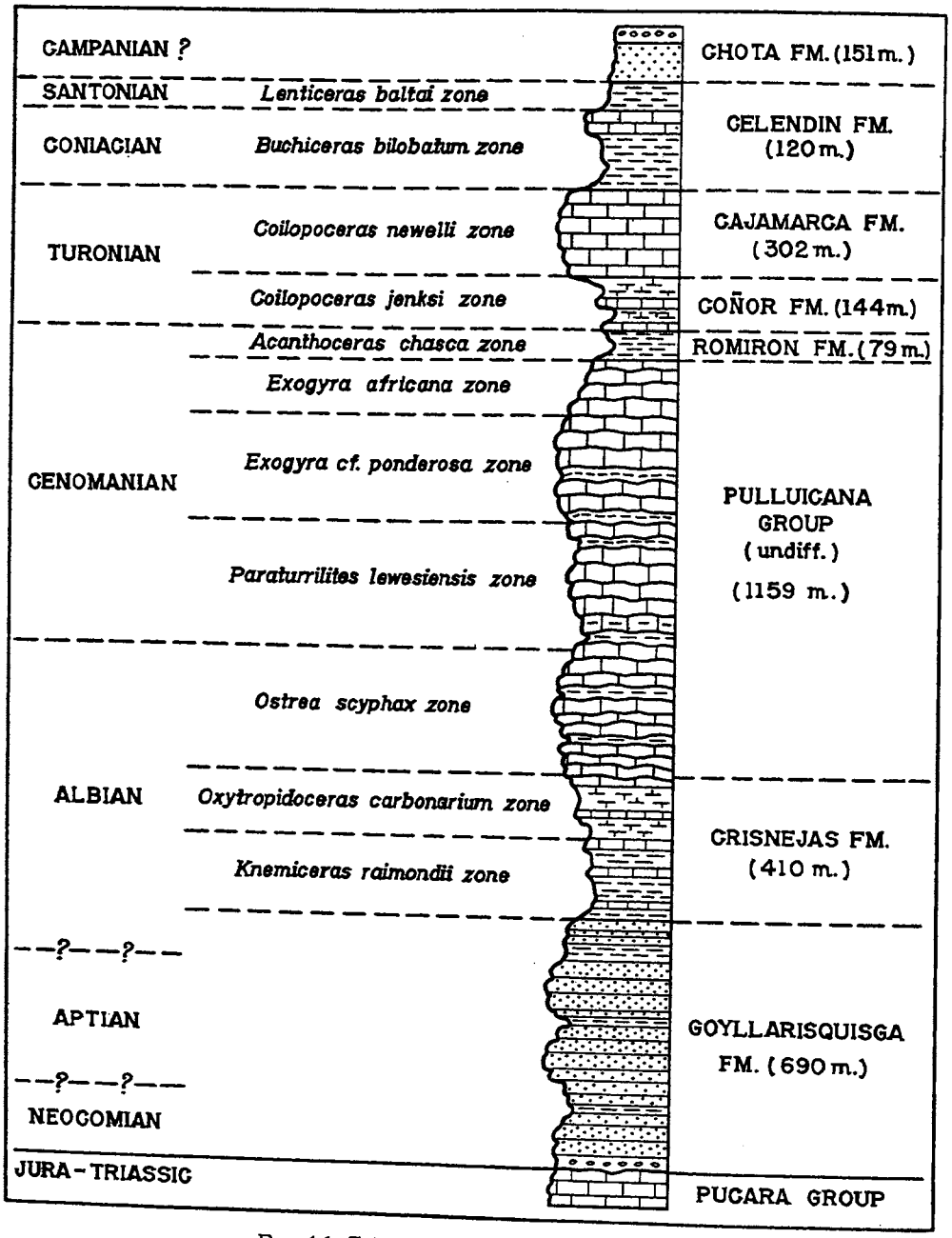


FIG. 16. Celendín stratigraphic section.

CHOTA FORMATION	METERS
74. Quartz-sandstone and quartz-siltstone, light whitish gray, poorly consolidated, with few reddish interbeds	122+
73. Shale and sandstone, red, soft; includes at the top a 90-centimeter thick conglomerate of perfectly rounded cobbles of quartzite	29
TOTAL, CHOTA FORMATION: 151+ METERS	
CELENDÍN FORMATION	
72. Shale, yellow, with a few thin, calcareous beds which contain *Lenticeras baltai, Tissotia steinmanni, T. fourneli, Texanites hourcqi, Ostrea nicaisei, Lima grenieri*	106
71. 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	60
70. Marl, grayish white, packed with *Hemiaster fourneli*	3
69. Shale, calcareous, yellow and bluish gray, soft, friable, with thin interbeds of nodular, yellowish argillaceous limestone; contains *Buchiceras bilobatum, Heterotissotia peroni, H. bucheri, Tissotia hedbergi,* and several species of *Barroisiceras*	86
68. Limestone, argillaceous, gray	1
67. Shale, yellow and silver gray	26
TOTAL, CELENDÍN FORMATION: 302 METERS	
CAJAMARCA FORMATION	
66. Limestone, gray, medium- to thick-bedded, weathers dark gray	75
65. Limestone, medium gray, lithographic, massive, medium- to thick-bedded, weathers dark gray	68
64. Limestone, medium gray, thin- to medium-bedded, sublithographic, weathers dark gray	45
63. Shale, splintery, bluish gray	4
62. Limestone, medium gray, sublithographic, medium- to thick-bedded, weathers dark gray	14
61. Limestone, medium gray, thin-bedded, somewhat nodular	2
60. Limestone, medium gray, massive, sublithographic, medium-bedded	8
59 Limestone, argillaceous, light bluish gray, nodular	8
58. Limestone, medium gray, sublithographic, medium- to thick-bedded, weathers dark gray	8
57. Marl, medium bluish gray, shaly, splintery	9
56. Limestone, brownish gray, sublithographic, massive, thick-bedded	5
TOTAL, CAJAMARCA FORMATION: 246 METERS	
COÑOR FORMATION	
55. Shale, yellow	5
54. Shale, yellow, with interbeds of light gray, fossiliferous limestone	7
53. Limestone, argillaceous, light gray, nodular, weathers whitish gray, contains *Coilopoceras jenksi, Mammites afer,* and *Hemiaster* sp.	52
52. Limestone, argillaceous, light gray, weathers dark gray, with thin interbeds of marl	80
TOTAL, COÑOR FORMATION: 144 METERS	
ROMIRÓN FORMATION	
51. Shale, greenish and yellowish gray, splintery, laminated	20
50. Limestone, argillaceous, yellowish brown, nodular, fossiliferous (*Exogyra olisiponensis*)	1
49. Shale, greenish gray, splintery, soft, yellow-weathering, with interbeds of nodular, brown marl	7
48. Marl, ferruginous, yellowish brown, nodular, interbedded with yellow, very fossiliferous (*Acanthoceras chasca, A. sangalense, A. pollocense, Forbesiceras* sp., *Neolobites kummeli, Exogyra olisiponensis*) limestone	3
47. Shale, light gray, splintery	3
46. Shale, light grayish blue, laminated, splintery, yellow-weathering, with thin interbeds of nodular, fossiliferous, iron-stained, argillaceous limestone	23
45. Marl, yellowish, nodular, contains numerous specimens of *Exogyra olisiponensis*	2
44. Shale, light greenish yellow, laminated, fossiliferous (*Lissoniceras mermeti, Neolobites kum-*	

	Meters
meli, Acanthoceras sp.) with thin interbeds of nodular, iron-stained, brownish limestone.	20
Total, Romirón Formation: 79 Meters	
Pulluicana 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 *Exogyra* 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 (*Exogyra 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, Pulluicana 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 giganiea*)	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 pernodosum, P. tetranodosum, P. haasi, Knemiceras attenuatum, Protanisoceras blancheti*), dark brownish limestone	62
8. Shale, light gray, with interbeds of gray limestone	7
7. Shale, light gray to yellowish, crumbly	15

	Meters
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 (*Pterotrigonia tocaimaana, Yaadia hondaana, Buchotrigonia abrupta, Knemiceras raimondii pacificum, K. gabbi, Enallaster peruanus, Holectypus planatus numismalis, Bothriopygus* 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 carbonaceous shale	650
1. Conglomerate; ill-assorted subrounded pebbles and cobbles of dark gray limestone in a chocolate-red, calcareous quartz-sandstone matrix	40
TOTAL, GOYLLARISQUISGA FORMATION: 690 METERS	
UNCONFORMITY	
JURASSIC	
PUCARÁ 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.

	Meters
CELENDÍN FORMATION	
75. Shale, slightly calcareous, green to bluish gray, splintery, very fossiliferous (*Heterotissotia 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, CELENDÍN 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 (*Coilopoceras newelli, Cardium lissoni, Tetragramma* sp.)	6
65. Marl, light brownish gray, white-weathering, nodular, fossiliferous (*Inoceramus* sp., *Ostrea* sp., *Coilopoceras 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	

	Meters
Coñor Formation	
58. Shale, greenish and bluish gray, splintery, very fossiliferous (*Coilopoceras jenksi, Plicatulopecten ferryi*)	10
57. Shale, gray, weathers yellow	15
56. Marl, gray, splintery, weathers light gray	10
55. Marl, yellow and green, fossiliferous (*Coilopoceras jenksi, Hoplitoides inca, Hemiaster* 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 (*Coilopoceras jenksi, Hemiaster* 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, Coñor Formation: 147 Meters	
Romirón 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, Romirón Formation: 66 Meters	
Mujarrún 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, Mujarrún 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

	Meters
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 scyphax*)	1
19. Shale, yellow, finely laminated	30
18. Limestone, dark brownish, nodular, fossiliferous (*Ostrea scyphax*), weathers bluish gray	15
17. Quartz-siltstone, yellow, finely laminated	30
16. Limestone, bluish gray, thick-bedded, fossiliferous (*Ostrea scyphax*, *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	
CHULEC 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, splintery	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 peruanus*), with interbeds of nodular, ledge-forming, brownish limestone	49
1. Marl, brownish gray, laminated	17+
TOTAL, CHULEC FORMATION: 330+ METERS	

SECTION 5. CAJAMARCA

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

	Meters
CELENDÍN FORMATION	
146. Limestone, slightly argillaceous, gray, medium-bedded	10+
145. Shale, calcareous, yellowish white, fossiliferous (great numbers of *Hemiaster 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 (*Coilopoceras newelli*)	10

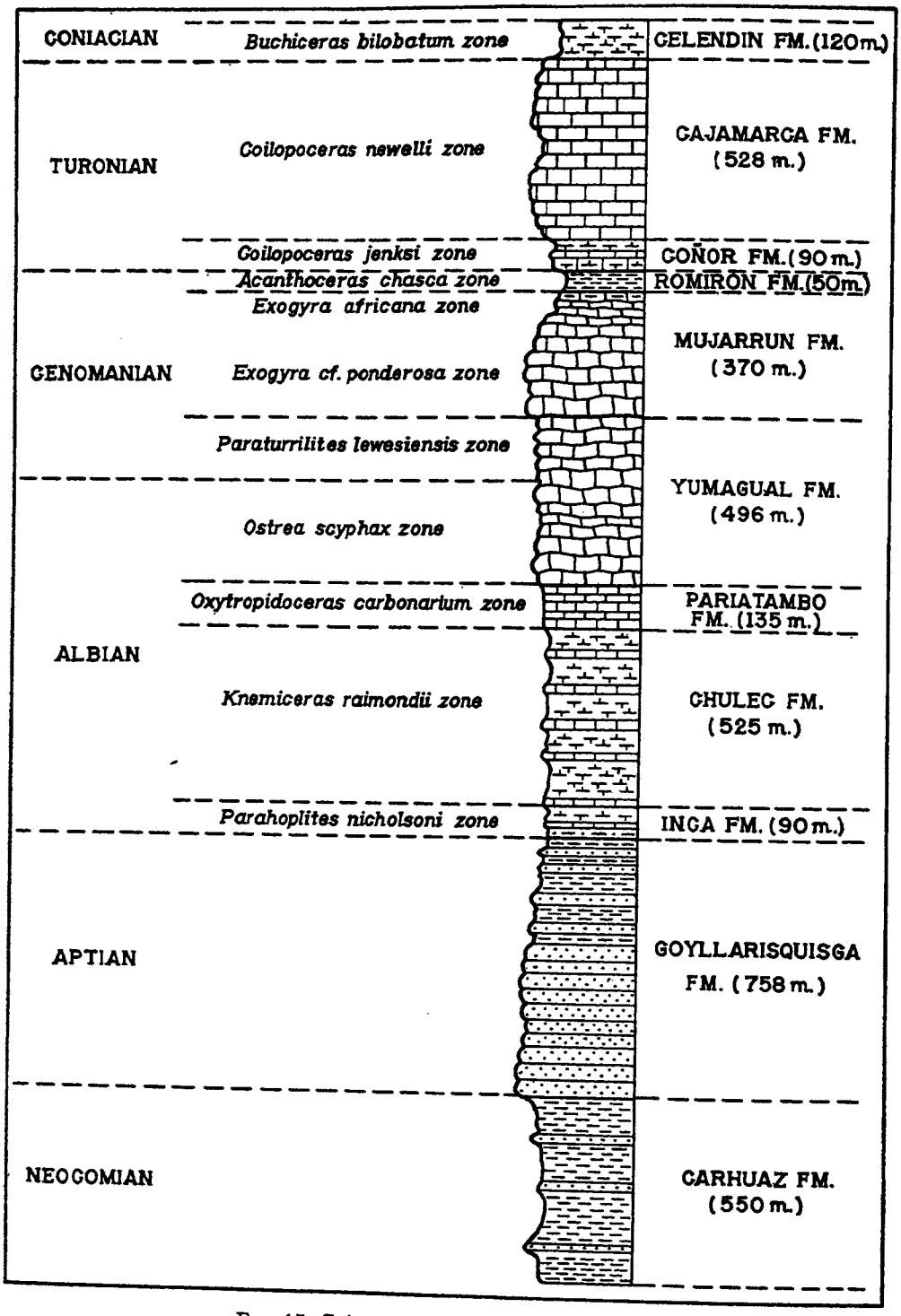


FIG. 17. Cajamarca stratigraphic section.

	Meters
140. Limestone, dark bluish gray, massive, thick-bedded, karstic, with a few thin-bedded, platy, limestone interbeds	161
139. Limestone, dark gray, lithographic, very massive, thick-bedded	88
138. Limestone, dark gray, massive, with interbeds of light gray, argillaceous limestone	59
137. Limestone, argillaceous, light gray, splintery	10
136. Shale, calcareous, light gray	16
135. Limestone, dark gray, thick-bedded, with interbeds of argillaceous, splintery limestone	5
TOTAL, CAJAMARCA FORMATION: 557 METERS	
COÑOR FORMATION	
134. Limestone, light gray, splintery, friable	12
133. Shale, yellowish to light gray, friable, fossiliferous (*Coilopoceras jenksi, Mammites afer, Hoplitoides inca, Inoceramus labiatus, Orthopsis titicacana*), with thin interbeds of argillaceous limestone	14
132. Limestone, dark gray, thick-bedded, fossiliferous (*Orthopsis titicacana*)	1
131. Shale, light gray, finely laminated, friable	8
130. Limestone, massive, dark gray	1
129. Shale, very calcareous, light gray, crumbly	23
128. Limestone, argillaceous, light gray, thick-bedded	2
TOTAL, COÑOR FORMATION: 61 METERS	
ROMIRÓN FORMATION	
127. Shale, rusty and brownish yellow, soft, very fossiliferous (*Acanthoceras sp., Exogyra olisiponensis*), with few and thin intercalations of brown limestone. This unit makes a topographic low and is largely covered with soil	83
TOTAL, ROMIRÓN FORMATION: 83 METERS	
MUJARRÚN FORMATION	
CULEBRA MEMBER	
126. Limestone, argillaceous, nodular, thick-bedded, with thick interbeds of light gray, chalky, very fossiliferous (*Acanthoceras* sp., *Exogyra africana, E. olisiponensis*), argillaceous limestone	72
125. Limestone, argillaceous, nodular, light gray, fossiliferous, with interbeds of gray marl	12
124. Limestone, marly, nodular, soft	21
TOTAL, CULEBRA MEMBER: 105 METERS	
CHORO MEMBER	
123. Limestone, dark bluish gray, thick-bedded, ledge-forming, massive	3
122. Limestone, dark gray, thick-bedded, nodular, fossiliferous (*Exogyra* cf. *ponderosa*)	22
121. Limestone, dark bluish gray, thick-bedded, compact, massive, contains *E.* cf. *ponderosa*	4
120. Limestone, dark bluish gray, thick-bedded, wavy-bedded to nodular, ledge-forming	15
119. Quartz-siltstone, calcareous, brownish yellow, thin-bedded	4
118. Limestone, gray, massive, thick-bedded, nodular	20
117. Limestone, grayish brown, thick-bedded, compact, with thin interbeds of light gray, laminated, calcareous quartz-siltstone	11
116. Limestone, dark gray, compact, ridge-forming	33
115. Limestone, dark gray, thick-bedded, massive, with interbeds of light gray, very fossiliferous (*E.* cf. *ponderosa*) limestone	49
114. Limestone, brownish gray, massive, compact	29
TOTAL, CHORO MEMBER: 190 METERS	
TOTAL, MUJARRÚN FORMATION: 295 METERS	
YUMAGUAL FORMATION	
113. Limestone, very argillaceous, shaly, wavy-bedded, nodular, fossiliferous	18
112. Limestone, dark gray, thick-bedded, massive, nodular, with interbeds of brownish yellow, fossiliferous marl	21
111. Limestone, very argillaceous, marly, light gray to light brownish gray, nodular, soft, fossilif-	

	Meters
erous (*Paraturrilites lewesiensis, Sharpeiceras occidentale, Exogyra mermeti*)	10
110. Limestone, dark gray, nodular, massive, thick-bedded, with interbeds of argillaceous, chalky, coquinoid (*E. mermeti*), soft limestone	22
109. Shale, calcareous, light brown	15
108. Limestone, very argillaceous, light gray to light brownish gray, wavy-bedded to nodular, fossiliferous	14
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 venezolanum*), bituminous marl	16
84. Shale, dark gray, bituminous, thin-bedded, fossiliferous (*O. carbonarium, Lyelliceras 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	8
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 Pulluicana.	111

	Meters
76. Limestone, argillaceous, shaly, nodular, thin-bedded, weathers greenish white	36
75. Limestone, argillaceous, fossiliferous (*Exogyra aquila, Liopistha gigantea*)	4
74. Limestone, argillaceous, dark gray, thin-bedded, somewhat nodular, fossiliferous (*Knemiceras* sp., *Parengonoceras* sp., *Liopistha gigantea*), with interbeds of yellowish white, crumbly, calcareous shale	41
73. Limestone, dark gray, massive, weathers bluish gray	3
72. Limestone, argillaceous, marly, dark gray, nodular, thin-bedded, weathers white, with few interbeds of compact, gray limestone	22
71. Shale, calcareous, greenish and whitish gray, soft, fossiliferous (*Knemiceras syriacum, Parengonoceras guadaloupaeforme, Liopistha gigantea*), with a few interbeds of massive limestone	17
70. Shale, purple-red to yellowish, laminated, splintery, fossiliferous (*Knemiceras attenuatum, K. raimondii*), with thin interbeds of nodular, yellowish brown, argillaceous limestone	20
69. Shale, calcareous, laminated, splintery, purple-red to greenish, fossiliferous	32
68. Limestone, very argillaceous, dark brownish gray, nodular, thin-bedded, fossiliferous (*Knemiceras* sp., gastropods), weathers white	7
67. Shale, calcareous, black to dark brown, laminated, fossiliferous	15
66. Limestone, argillaceous, dark gray, nodular, thin-bedded, fossiliferous, weathers white	19
65. Marl, chalky, thin-bedded, with thin interbeds of nodular, dark gray shale	27
64. Limestone, argillaceous, nodular, with a few interbeds of massive, dark gray limestone	11
63. Limestone, argillaceous, chalky, with interbeds of calcareous shale	13
62. Marl, chalky, thin-bedded, nodular, weathers white, with thin interbeds of dark gray limestone	29
61. Marl, dark greenish gray, soft, splintery, fossiliferous, with few intercalations of brownish gray, massive, rusty, ledge-forming limestone	93
60. Limestone, argillaceous, chalky, yellowish gray	7
59. Marl, yellowish to brownish, splintery, thin-bedded, soft, fossiliferous	11
58. Limestone, yellowish brown to brownish gray, massive, thick-bedded, very fossiliferous (*Knemiceras raimondii, K. attenuatum, Parengonoceras* sp., *Prolyelliceras peruvianum, Douvilleiceras monile*)	5
TOTAL, CHULEC FORMATION: 577 METERS	
INCA FORMATION	
57. Limestone, rusty brown, massive, with interbeds of soft, yellowish brown shale	17
56. Quartz-siltstone, ferruginous, dark brown, with interbeds of calcareous, ferruginous shale and quartz-sandstone	10
55. Limestone, greenish brown, fossiliferous, with interbeds of calcareous, ferruginous shale	7
54. Quartz-siltstone, ferruginous, brownish red	5
53. Limestone, gray, arenaceous	4
52. Limestone, reddish brown, arenaceous, with interbeds of soft, fossiliferous, yellowish brown marl and shale	10
51. Shale, yellowish to greenish brown, splintery, with thin interbeds of ferruginous quartz-siltstone	7
50. Limestone, gray, slightly nodular, fossiliferous (*Parahoplites quilla, Pterotrigonia tocaimaana, Buchotrigonia abrupta, Yaadia hondaana, Ptychomia robinaldina*)	2
49. Marl, ferruginous, rusty yellow	1
48. Limestone, arenaceous, oölitic, rusty brown, very fossiliferous (*Exogyra aquila*)	1
47. Marl, ferruginous, with interbeds of quartz-siltstone	10
46. Limestone, arenaceous, rusty brown, glauconitic, ferruginous, thick-bedded	4
45. Conglomerate of angular cobbles of brownish gray limestone in a ferruginous, rusty brown, calcareous matrix	2
TOTAL, INCA FORMATION: 80 METERS	
DISCONFORMITY	
GOYLLARISQUISGA FORMATION	
44. Shale, light gray, soft, interbedded with a white, hard quartz-sandstone	30
43. Quartz-siltstone, light gray, with interbeds of cross-bedded quartz-sandstone	11

	Meters
42. Quartz-sandstone, white to pale red, medium- to coarse-grained, cross-bedded, massive	7
41. Shale, yellowish to bluish, laminated, soft, with few interbeds of quartz-siltstone	91
40. Shale, pale blue to purple, laminated, soft, contains poorly preserved plant remains	32
39. Quartz-sandstone, light gray, medium-grained, to pebbly, cross-bedded, weathers dark red	9
38. Quartz-siltstone, light gray, soft, with interbeds of bluish shale	18
37. Quartz-sandstone, white to reddish, coarse-grained to pebbly, cross-bedded, medium-bedded	30
36. Quartz-siltstone, purple-red, medium-bedded, with interbeds of soft, bluish and greenish shale	9
35. Quartz-pebble conglomerate, white to yellowish, thick-bedded, cross-bedded	9
34. Quartz-siltstone, white to brownish, thin-bedded, weathers rusty red	33
33. Quartz-pebble conglomerate, white to reddish, cross-bedded, thick-bedded, massive	9
32. Quartz-siltstone, white to reddish, with interbeds of soft, varicolored shale	11
31. Quartz-sandstone, white, coarse-grained, cross-bedded, hard	14
30. Shale, varicolored, thin-bedded, soft, with few interbeds of quartz-sandstone	23
29. Quartz-sandstone, white to pale red, thin-bedded, weathers brown, with some shale intercalations	12
28. Quartz-sandstone, coarse-grained, cross-bedded, massive	30
27. Quartz-sandstone, white to pale red, cross-bedded, medium-bedded	42
26. Quartz-sandstone, white to light gray, coarse-grained to pebbly, hard, thick-bedded, weathers rusty red, forms a scarp	61
25. Quartz-sandstone, white to yellowish brown, medium- to coarse-grained, medium-bedded, massive, weathers reddish brown	97
Total, Goyllarisquisga Formation: 578 Meters	

Carhuaz Formation

24. Covered; probably of soft shale	160
23. Quartz-sandstone, white to yellow, cross-bedded	9
22. Shale, yellow, soft	9
21. Quartz-sandstone, white	2
20. Shale, bluish to purple, soft	37
19. Quartz-siltstone, yellowish brown, with a few interbeds of quartz-sandstone	6
18. Shale, yellowish to greenish, thin-bedded, soft	12
17. Quartz-sandstone, yellowish to reddish white, medium-grained, cross-bedded, massive	9
16. Shale, varicolored, soft, with a few thin interbeds of micaceous, pale red, quartz-siltstone	12
15. Quartz-sandstone, white to yellowish brown, medium-grained, cross-bedded, lenticular, contains plant remains	21
14. Shale, yellowish to reddish, soft, with thin intercalations of rusty quartz-siltstone	21
13. Quartz-sandstone, reddish, cross-bedded, lenticular, medium-bedded, massive	16
12. Shale, yellow to dark red, soft, contains plant remains, with interbeds of white, cross-bedded quartz-siltstone	44
11. Quartz-sandstone, white to yellowish, contains plant remains, forms a ridge	7
10. Shale, dark yellow to brownish gray, slightly calcareous, contains plant remains, with a few interbeds of quartz-siltstone	27
9. Shale, varicolored, soft, with thin intercalations of iron oxide	24
8. Quartz-sandstone, white to brownish, medium-grained, cross-bedded, lenticular, weathers rusty brown	5
7. Shale, varicolored, soft, crumbly, contains plant remains, with interbeds of ferruginous quartz-sandstone	38
6. Quartz-sandstone, calcareous, white to brownish, medium-grained, cross-bedded	12
5. Shale, whitish gray to purple, soft, with interbeds of calcareous quartz-sandstone	27
4. Shale, varicolored, soft	7
3. 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	18
2. Shale, varicolored, soft, thin-bedded, concretionary, fossiliferous (fresh-water gastropods and pelecypods)	18

	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	15+

Total, Carhuaz 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	Meters
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

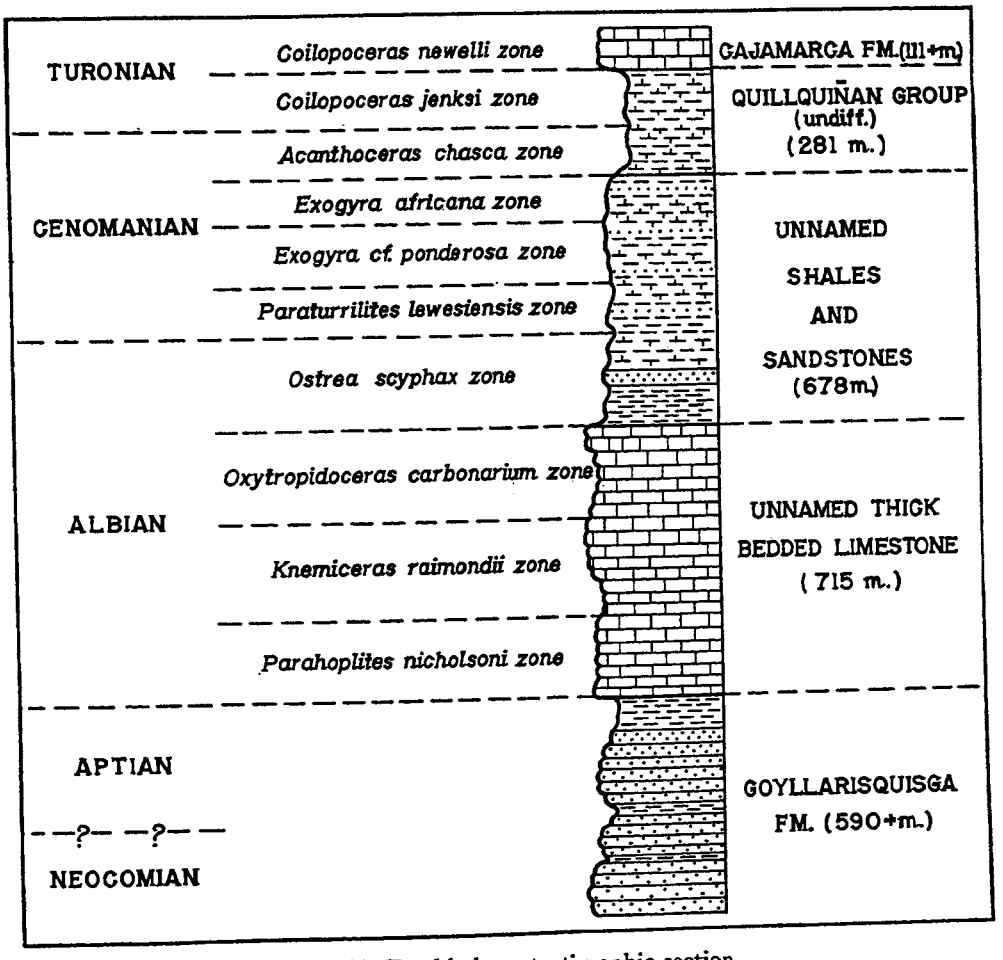


Fig. 18. Tembladera stratigraphic section.

QUILLQUIÑAN GROUP — METERS

27. Marl, nodular, grayish green, fossiliferous (*Coilopoceras jenksi, Pseudoaspidoceras reesidei, Inoceramus labiatus, Exogyra* sp., *Hemiaster fourneli*), interbedded with yellowish white, soft shale 45
26. Shale, orange-brown, laminated, with thin interbeds of greenish brown quartz-siltstone . 30
25. Marl, orange-yellow, nodular, with interbeds of dark gray limestone 30
24. Shale, yellow, laminated, soft, with interbeds of dark gray, richly fossiliferous (*Broggiiceras humboldti, B. olssoni, Thomasites fischeri*), slightly silty limestone 33
23. Shale, pale greenish yellow, crumbly, with thin interbeds of blocky, fossiliferous, gray limestone 22
22. Shale, yellow, friable, thick-bedded, with interbeds of nodular, fossiliferous (*Exogyra africana, E. olisiponensis*), light gray limestone 121

TOTAL, QUILLQUIÑAN GROUP: 281 METERS

UNNAMED BEDS

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

TOTAL, UNNAMED BEDS: 684 METERS

UNNAMED BEDS

12. Limestone, black, massive, thick-bedded, with silicified interbeds 426
11. Limestone, black to gray, thin-bedded to laminated, weathers light gray 130
10. Limestone, black to gray, massive, thick-bedded, fossiliferous (*Exogyra minos, Trigonioarca* sp., *Cucullaea* sp.), weathers brownish gray, has silicified interbeds 159

TOTAL, UNNAMED BEDS: 715 METERS

GOYLLARISQUISGA FORMATION

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

TOTAL, GOYLLARISQUISGA FORMATION: 590+ METERS

SECTION 8. TAMBERÍA

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

PARIATAMBO FORMATION — METERS

13. Limestone, grayish black, thin-bedded, platy, poorly exposed. . . . . 35+

TOTAL, PARIATAMBO FORMATION: 35+ METERS

CHULEC FORMATION	METERS
12. Limestone, gray, thick-bedded, with interbeds of light gray, fossiliferous marl	85
11. Limestone, grayish, thin-bedded, nodular, fossiliferous (*Knemiceras* sp., *Enallaster* sp.), weathers light brownish gray, has a few interbeds of splintery, calcareous shale	76
10. Marl, light gray, nodular, fossiliferous (*Knemiceras raimondii, Enallaster* sp.), with interbeds of gray, massive limestone	83
9. Limestone, greenish gray, massive, compact, thick-bedded, fossiliferous (trigonids, exogyroids), 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 chimuense, Pterotrigonia tocaimaana, Buchtrigonia abrupta, Yaadia hondaana*), 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	
GOYLLARISQUISGA FORMATION	
1. Quartz-sandstone, white, medium- to coarse-grained, massive, thick-bedded, weathers reddish brown	80+
TOTAL, GOYLLARISQUISGA 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 Marañón rivers, to Santa Rosa.

CRETACEOUS CAJAMARCA FORMATION	METERS
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 olisiponensis*)	21
54. Shale, calcareous, bluish gray to green, nodular, laminated, with interbeds of massive, yellow, 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

METERS

48. Limestone, brownish gray, massive, thick-bedded, scarp-forming, weathers light brownish gray 79

TOTAL, MUJARRÚN FORMATION: 301 METERS

ROSA FORMATION

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

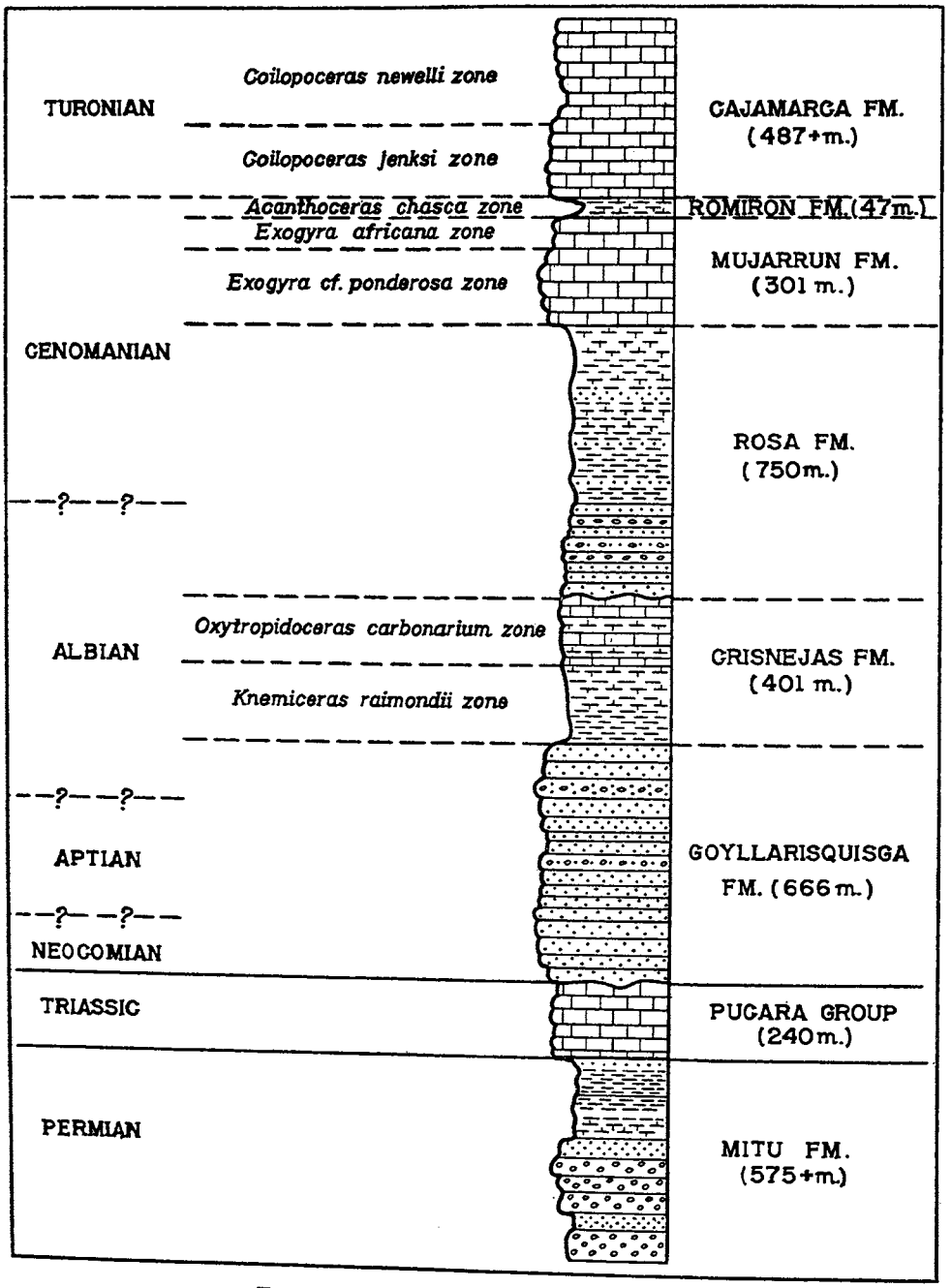


FIG. 19. Crisnejas stratigraphic section.

METERS

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., *Holectypus* 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 cherry-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*, *Holectypus 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., *Holectypus planatus*, *Enallaster peruanus*, *Yaadia hondaana*, *Pholadomya* sp., *Ostrea* cf. *dieneri*, *Parengonoceras pernodosum*), brown-weathering, argillaceous limestone 57

TOTAL, CRISNEJAS FORMATION: 401 METERS

GOYLLARISQUISGA 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

	Meters
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 Huacraruco to Cajamarca, from 4 kilometers west of Hacienda Huaycot, 7 kilometers north of Hacienda Sunchubamba, to Cerro Huauguén.

CAJAMARCA FORMATION	Meters
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 (*Coiloceras*), 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

QUILLQUIÑAN GROUP

32. Covered	200

PULLUICANA GROUP

31. Limestone, very argillaceous, dark bluish gray, nodular, wavy-bedded, thick-bedded,

	Meters
weathers light gray to yellowish	76
30. Marl, bluish and brownish gray, shaly to nodular	15
29. Limestone, dark gray, medium-bedded	8
28. Shale, calcareous, bluish gray to black, with a few thick interbeds of nodular marl	16
27. Limestone, very argillaceous, dark gray, nodular to wavy-bedded, with a few interbeds of massive, dark gray limestone	55
26. Limestone, bituminous, bluish gray to dark gray, massive, with intercalations of bituminous shale	54
25. Limestone, argillaceous, bituminous, dark gray, nodular, thick-bedded, with intercalations of bituminous shale	106
24. Limestone, bituminous, bluish gray, massive, thick-bedded, prominent in the topography	156
23. Limestone, bluish gray, thin-bedded	10
22. Limestone, sublithographic, medium-bedded	35
21. Limestone, light gray, massive, wavy-bedded, thick-bedded	21
20. Limestone, bituminous, dark gray, massive, weathers white	23
19. Limestone, argillaceous, yellowish, soft	4
18. Limestone, argillaceous, light gray, shaly nodular, fossiliferous (*E. mermeti*), weathers yellowish gray, with a few interbeds of massive, light gray limestone	105
17. Limestone, gray, massive	9
16. Limestone, argillaceous, nodular	21
15. Limestone, argillaceous, yellowish brown, shaly, nodular, soft, with interbeds of massive, thick-bedded, fossiliferous, bluish gray, bituminous limestone	74
14. Marl, yellowish, soft, nodular, shaly, with thick interbeds of massive, dark gray, strongly bituminous limestone	12
13. Limestone, argillaceous, dark gray, nodular, weathers white	33
12. Marl, brownish to purplish gray, soft, fossiliferous, with a few interbeds of nodular, fossiliferous, argillaceous limestone	31
11. Limestone, argillaceous, bituminous, bluish gray, nodular, with interbeds of brownish and purplish, bituminous shale	39
10. Limestone, strongly bituminous, dark bluish gray to black, nodular, thick-bedded	16
9. Shale, calcareous, bituminous, silty, dark gray, laminated, becomes more calcareous upward	40
TOTAL, PULLUICANA 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	204
TOTAL, PARIATAMBO FORMATION: 204 METERS	
CHULEC FORMATION	
7. Covered	53
6. Marl, gray, thin-bedded, weathers whitish gray, has a few massive interbeds of brownish gray limestone	210
TOTAL, CHULEC FORMATION: 263 METERS	
INCA FORMATION	
5. Limestone, ferruginous, dark bluish gray, thin-bedded, with interbeds of ferruginous quartz-siltstone	75
4. Limestone, dark bluish gray, thick-bedded, massive, fossiliferous (*Exogyra* sp.), weathers light rusty brown	15
3. Quartz-siltstone and quartz-sandstone, highly ferruginous, arkosic, calcareous, iron-stained, reddish to yellowish brown, fossiliferous (*Exogyra* sp., *Trigonia* sp.)	45
2. Limestone, dark bluish gray, massive, compact, karstic, medium- to thick-bedded, weathers light rusty brown	4
1. Quartz-sandstone, calcareous, ferruginous, reddish brown, thin-bedded	22
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.

	Meters
Chulec Formation	
52. Marl, thin-bedded, gray, fossiliferous (*Knemiceras attenuatum, Enallaster peruanus, Holectypus planatus, Bothriopygus* sp.) weathers whitish gray, has a few interbeds of brownish gray limestone	60+
Total, Chulec Formation: 60+ Meters	
Inca Formation	
51. Limestone, arenaceous, bluish gray, massive, thick-bedded, fossiliferous (*Exogyra minos*), weathers light brown	20
50. Shale, dark gray to black, laminated, soft, fossiliferous (*Knemiceras ollonense, Desmoceras chimuense, Parahoplites nicholsoni, P. inti, P. quilla, Yaadia hondaana, Pterotrigonia tocaimaana, Buchotrigonia abrupta*), weathers brownish gray, has thin interbeds of dark gray limestone	57
49. Limestone, bluish gray, massive, thick-bedded	4
48. Shale, black, laminated, soft, weathers yellowish brown to yellowish limestone	30
Goyllarisquisga Formation	
47. Shale, quartz-siltstone and quartz-sandstone, medium-bedded, gray to greenish	13
46. Quartz-sandstone, white to gray, cross-bedded, thick-bedded	48
45. Shale, poorly exposed	45
44. Quartz-sandstone, white, medium-bedded	18
43. Shale, dark gray to black, micaceous, laminated, contains plant remains and fresh-water gastropods	37
42. Quartz-sandstone, white to yellowish, coarse-grained to pebbly, medium- to thick-bedded, weathers yellowish brown, contains occasional coal fragments	211
41. Shale, black, silty, with fine interbeds of white quartz-siltstone	10
40. Quartz-sandstone, white to yellow, compact, medium-bedded	30
39. Shale, black, laminated	2
38. Quartz-sandstone, white to yellow, massive, medium-bedded	36
37. Shale and quartz-sandstone, finely bedded	10
36. Quartz-sandstone, white, coarse-grained, cross-bedded, thick-bedded	9
Total, Goyllarisquisga Formation: 469 Meters	
Carhuaz Formation	
35. Shale, bluish gray, soft, carbonaceous, with a few interbeds of quartz-sandstone	10
34. Quartz-sandstone, medium-bedded, with shale intercalations	12
33. Shale, dark green to brownish yellow, soft, with a few interbeds of white quartz-sandstone.	39
32. Quartz-sandstone, gray, medium-bedded	4
31. Shale and quartz-sandstone, thin-bedded, with a few interbeds of subanthracite	8
30. Quartz-sandstone, gray, medium-bedded	9
29. Shale, varicolored, laminated, soft, with thin interbeds of quartz-siltstone	24
28. Quartz-sandstone, greenish, medium-bedded	9
27. Shale, yellowish and pale purple, with a few interbeds of quartz-sandstone	54
26. Quartz-sandstone, white to greenish, medium-grained, lenticular, cross-bedded	64
25. Shale, bluish to greenish gray, soft, with a few interbeds of quartz-sandstone	88
24. Quartz-siltstone and shale, thin-bedded	5
23. Shale, carbonaceous, black, with thin interbeds of white quartz-sandstone, includes a 2-meter thick bed of plant-bearing, impure anthracite	23
22. Quartz-sandstone, gray to white, medium-grained, massive, cross-bedded, medium-bedded.	20
21. Shale, bluish gray to black, contains poorly preserved plant remains	10
20. Quartz-sandstone, white to greenish white, cross-bedded, massive, medium-bedded	15
19. Shale, poorly exposed	40
18. Quartz-sandstone, white, medium-grained, massive, medium-bedded, cross-bedded, with thin interbeds of carbonaceous shale	15

	Meters
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, oölitic, massive, weathers yellowish brown	45
9. Shale, iron black to dark gray, splintery, fossiliferous (*Buchotrigonia 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	Meters
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	Meters
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 (*Paraglauconia* 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 huarazensis*), 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

	Meters
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, CHIMÚ SANDSTONE: 451+ 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	Meters
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 douglasi*), 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	Meters
9. Limestone and marl, strongly bituminous, black, fossiliferous (*Oxytropidoceras* sp., *Lyelliceras* 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	METERS
7. Shale, dark red, soft, splintery, with interbeds of dark red quartz-siltstone	900+
6. Quartz-siltstone, calcareous, greenish gray	20
TOTAL, CHOTA FORMATION: 920+ METERS	
CELENDÍN FORMATION	
5. Marl, light gray, fossiliferous (*Hemiaster fourneli, Goniopygus hemicidariformis, Goniopygus superbus*), splintery, nodular, with interbeds of tan limestone	317
4. Limestone, argillaceous, dark gray, nodular, with interbeds of whitish marl	48
3. Marl and shale, greenish yellow, very fossiliferous (*Texanites* sp., *Lenticeras lissoni, Tissotia halli, Ostrea nicaisei*)	163
2. Marl, white, nodular, thick-bedded, with interbeds of dark gray nodular limestone	30
TOTAL, CELENDÍN FORMATION: 558 METERS	
CAJAMARCA FORMATION	
1. Limestone, dark bluish gray, hard, lithographic, thick-bedded, scarp-forming, with a few interbeds of bluish gray nodular marl	800
TOTAL, CAJAMARCA FORMATION: 800 METERS	

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.

PARIAHUANCA FORMATION	METERS
23. Limestone, slightly bituminous, medium-gray, thick-bedded, fossiliferous, weathers light gray, forms a scarp	45
TOTAL, PARIAHUANCA FORMATION: 45+ METERS	
CARHUAZ FORMATION	
22. Quartz-sandstone, light greenish, thin to medium-bedded, lenticular, weathers dark greenish, has interbeds of shale and yellowish limestone which become abundant upward	150
21. Shale, slightly calcareous, dark green to brown, thin-bedded, soft, with interbeds of massive, greenish to brownish, calcareous quartz-siltstone	177
20. Shale, dark greenish gray, laminated, soft, with interbeds of dark green tuff and dark brownish gray limestone	329
19. Shale, dark greenish, laminated, soft, with thin interbeds of quartz-siltstone	107
18. Shale, slightly calcareous, brownish yellow to greenish, with interbeds of medium-bedded, dark brownish, slightly calcareous quartz-sandstone	96
17. Limestone, dark brownish yellow, fossiliferous (*Ostrea* sp.), weathers dark brown	1
16. Quartz-sandstone, slightly calcareous, greenish and brownish, with interbeds of light brown, silty shale and a few thin beds of fossiliferous, dark limestone	86
15. Shale, silty, greenish to brownish, with interbeds of quartz-sandstone	130
14. Shale, calcareous, silty, light brown to light purple, with interbeds of brownish, calcareous quartz-sandstone and thin, fossiliferous, brownish limestone	70
13. Quartz-sandstone, greenish gray to brownish, medium-grained, medium-bedded, lenticular, cross-bedded, weathers rusty brown, has interbeds of purple, calcareous shale	42
12. Shale, brownish to purple, laminated, soft, with thin interbeds of white quartz-sandstone	57
11. Quartz-sandstone, white to light gray, medium- to fine-grained, cross-bedded, medium-bedded, weathers rusty brown, forms a scarp	116

METERS

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 broggii, 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, Paraglauconia 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

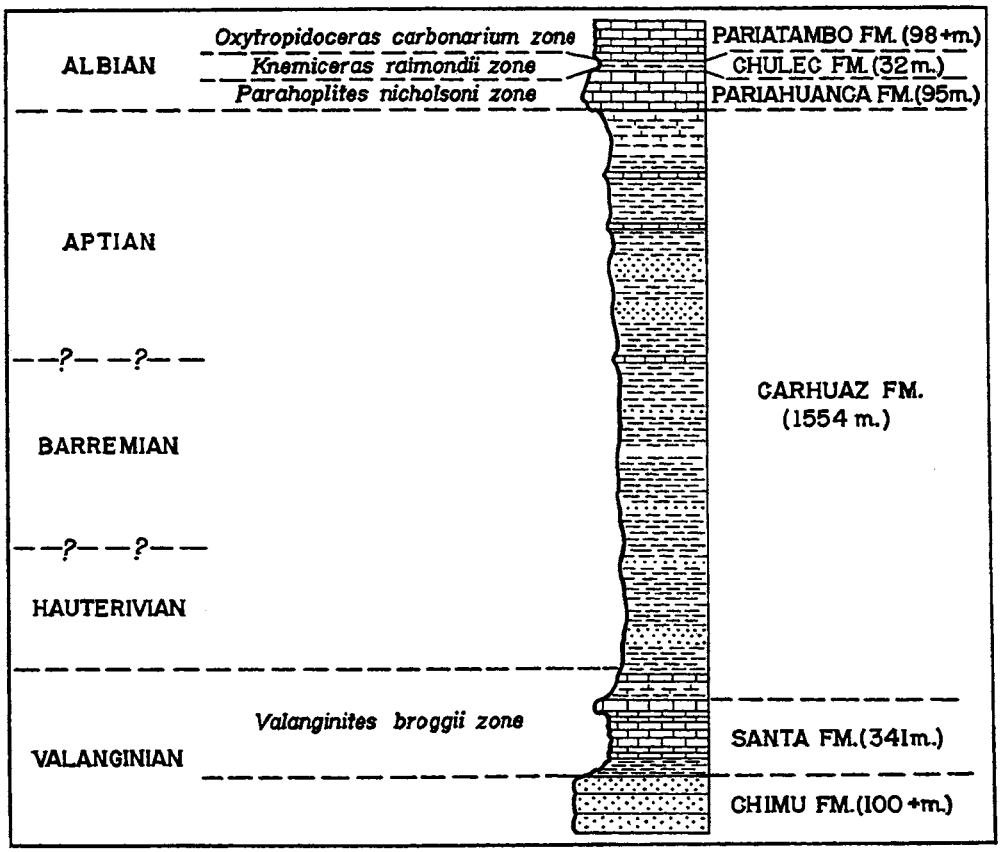


FIG. 20. Callejón de Huaylas stratigraphic section. Composite of the Carhuaz and Pariahuanca sections.

SECTION 18. PARIAHUANCA

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

PARIATAMBO FORMATION	METERS
14. Limestone, bituminous, dark gray, fossiliferous, interbedded with shaly, bituminous marl which contains abundant spherical concretions of fossiliferous (*Oxytropidoceras carbonarium, Lyelliceras ulrichi, L. lyelli, Brancoceras aegoceratoides, Inoceramus* sp.) limestone	98+
TOTAL, PARIATAMBO FORMATION: 98+ METERS	
CHULEC FORMATION	
13. Shale, calcareous, brownish black, splintery	5
12. Marl, whitish gray, nodular, very fossiliferous (*Douvilleiceras monile, Protanisoceras blancheti, Exogyra minos*), with a few interbeds of massive, dark gray, brownish-weathering limestone	27
TOTAL, CHULEC FORMATION: 32 METERS	
PARIAHUANCA FORMATION	
11. Limestone, slightly bituminous, medium gray, massive, thick-bedded, fossiliferous (*Parahoplites* sp., rudistid fragments, miliolid 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 (*Paraglauconia* sp., *Cyrena huarazensis*) limestone	91
3. Shale, light gray and light greenish gray, splintery, with a few interbeds of brownish limestone	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	METERS
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

	Meters
7. Marl, light gray, nodular, weathers white, has a few interbeds of limestone	12
6. Marl, light gray, nodular, soft, weathers white	38
5. Marl, light gray to tan, nodular, with few interbeds of massive, light gray limestone	68
TOTAL, CELENDÍN FORMATION: 163 METERS	
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	750
TOTAL, JUMASHA FORMATION: 750 METERS	
CRISNEJAS FORMATION	
3. Marl, light gray, nodular, fossiliferous (*Lyelliceras ulrichi, Knemiceras ovale*), with interbeds of brownish gray limestone	141
2. Marl and arenaceous limestone, light gray, fossiliferous (*Parengonoceras pernodosum, Knemiceras syriacum, K. ziczag*)	50
TOTAL, CRISNEJAS FORMATION: 190 METERS	
GOYLLARISQUISGA FORMATION	
1. Quartz-sandstone, white, coarse-grained to pebbly, soft, cross-bedded, with interbeds of quartz-pebble conglomerate	413+
TOTAL, GOYLLARISQUISGA FORMATION: 413+ METERS	

SECTION 20. HACIENDA PALCAS

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

JUMASHA FORMATION	Meters
19. Limestone, medium gray, thick-bedded, weathers dark dove gray, bears Foraminifera	390
18. Limestone, argillaceous	29
17. Limestone, medium gray, massive, thick-bedded, weathers dark brownish	28
16. Dolomite, thin-bedded, brown	8
15. Dolomite, light gray to light orange-brown, massive, thick-bedded, karstic, weathers dark orange-brown	285
14. Dolomite, silty, medium gray, somewhat nodular	60
TOTAL, JUMASHA FORMATION: 820 METERS	
PARIATAMBO FORMATION	
13. Shale, calcareous, dark bluish gray, splintery, soft	15
12. Limestone, strongly bituminous, dark gray to black, medium-bedded, platy, weathers medium gray	8
11. Shale, calcareous, bituminous, fossiliferous (*Oxytropidoceras* sp.)	4
10. Limestone, strongly bituminous, dark brownish to dark purplish gray, medium- to thick-bedded, platy, fossiliferous (*Oxytropidoceras* sp., *Inoceramus* sp.), with a few interbeds of bituminous marl	79
9. Shale, calcareous, bituminous, medium-bedded	12
8. Limestone, bituminous, black, thick-bedded, fossiliferous (*Oxytropidoceras* sp., *Lyelliceras* sp.), weathers dark brownish gray	35
TOTAL, PARIATAMBO FORMATION: 153 METERS	
CHULEC FORMATION	
7. Marl, whitish green to whitish blue, shaly, soft, poorly fossiliferous, with a few interbeds of medium gray, nodular limestone	80
6. Limestone, argillaceous, medium gray, fossiliferous (*Enallaster* sp., *Holectypus* sp., *Bothriopygus* sp., *Pseudodiadema* sp.), thick-bedded, with a few interbeds of quartz-siltstone	22
TOTAL, CHULEC FORMATION: 102 METERS	

GOYLLARISQUISGA FORMATION METERS

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

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.

JUMASHA FORMATION METERS

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

TOTAL, JUMASHA FORMATION: 300+ METERS

PARIATAMBO FORMATION

27. Limestone, bituminous, black, medium-bedded, platy, weathers brownish gray 60
26. Marl and limestone, bituminous, black, thin-bedded, platy, fossiliferous (*Oxytropidoceras peruvianum, Venezoliceras venezolanum, 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-bedded 4
23. Marl, light gray, nodular, very fossiliferous (*Douvilleiceras 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, Branco-ceras aegoceratoides, Enallaster peruanus, Holectypus planatus, Bothriopygus* sp., *Exogyra minos*), weathers light brownish gray, has interbeds of massive, thick-bedded, 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, fossilifer-ous 10
18. Marl, dark gray, nodular, fossiliferous (*Knemiceras* sp., *Beaudenticeras* sp., *Exogyra minos*), weathers bluish gray 6
17. Marl, dark gray, nodular, very fossiliferous (*Parahoplites* sp., *Enallaster peruanus, Bothrio-pygus* 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-bedded, with a few inter-beds of shale 34
14. Shale, light bluish gray 21
13. Quartz-sandstone, white to light brown, medium- to thick-bedded, cross-bedded, speckled, with interbeds of carbonaceous shale 177
12. Shale, poorly exposed 105
11. Quartz-sandstone, white to light brown, medium- to fine-grained, cross-bedded, medium- to thin-bedded, 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-bedded, medium- to thick-bedded . . . 54

	Meters
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 silty limestone	39
5. Quartz-sandstone, white, medium-bedded, weathers brownish	8
Total, Carhuaz 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).

SYSTEMATIC PALEONTOLOGY

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 *Heminautilus*, 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 *Deltoidonautilus* 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 *Heminautilus*, differing from *Heminautilus* largely in the absence of a flattened venter." *Nautilus munieri* Choffat is considered by Pervinquière (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 Mermeti COQUAND, 1862, p. 166, pl. 11, figs. 1–2.

[1] *Lissoniceras* is named for Dr. Carlos I. Lissón, who has contributed greatly to the knowledge of the Cretaceous in Peru.

Nautilus Munieri CHOFFAT, 1886, 1898, ser. 1, p. 1, pl. 1, fig. 2, pl. 2, fig. 1.

Nautilus Mermeti Coquand; PERVINQUIÈRE, 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 inflexed 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).

FIG. 21. *Lissoniceras mermeti* (Coquand). Suture line of specimen A.M.N.H. No. 27381/1:1; ×1.

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 Cenomanian Romirón formation, in bed 43 of the Polloc section (A.M.N.H. No. 27381) and in bed 44 of the Celendín 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. sangalense*.

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

Ancyloceras Blancheti PICTET AND CAMPICHE, 1861 (1858–1864), p. 33, pl. 47, figs. 1, 2a–d (lectotype), 3–10.

Ancyloceras Blancheti Pictet et Camp.; SOMMERMEIER, 1910, p. 377.

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 specimens 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 *Douvilleiceras 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 Celendín 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 *Paraturrilites 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.

Paraturrilites lewesiensis is found in the *Varians* zone of the English Cenomanian (Wright and Wright, 1951, p. 17).

FAMILY **BACULITIDAE** MEEK, 1876

BACULITES LAMARCK, 1799

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 HYATT, 1900

Bostrychoceras? sp. indet.

Plate 40, figures 6–7

The only available specimen (A.M.N.H. No. 27385) is an entirely septate, complete volution of an apparently dextral turricone. 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* Pervinquière (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 broggii (Lissón)

Plate 40, figures 10–12

Sphaeroceras broggianus LISSÓN, 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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27386:1	24	13	.54	17	.73	3	.12

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-

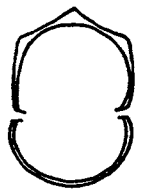


FIG. 22. *Valanginites broggii* (Lissón). Conch section of specimen A.M.N.H. No. 27386:1; ×1.

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 broggii* 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 broggii* is found in the Carhuaz formation, in bed 6 of the Carhuaz section, where it is associated with other olcostephanid 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. Kilian (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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27387	14	7.5	.53	8.5	.61	2.5	.18

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 volution 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 "*var. b.* de Kossmat," which is characterized by the subparallel sides.

OCCURRENCE: This species is found in the Pariatambo formation, in bed 14 of the Pariahuanca section, where it is associated with several species of *Lyelliceras* and *Oxytropidoceras*.

Desmoceras latidorsatum is a species with world-wide distribution, appearing in the lower Albian and ranging into the Cenomanian (Jacob, 1907, p. 312; 1908, p. 39; Spath, 1923–1943, vol. 1, p. 42).

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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27388:1	117	54.5	.47	44	.37	28	.24
27388:2	91	45.5	.50	38	.42	18	.24

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 volution; 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.

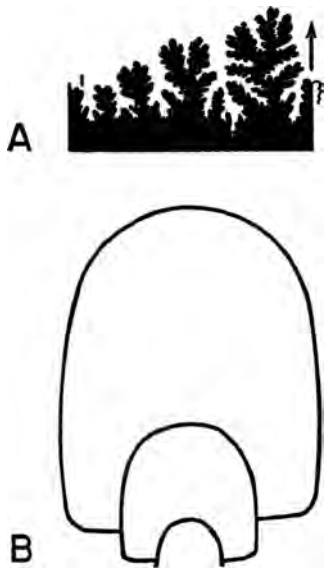


FIG. 23. *Desmoceras chimuense*, new species. Suture line (A) and conch section (B) of the holotype; ×1.

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 SCHLÜTER, 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.

Puzosia Gaudama Forb.; BRÜGGEN, 1910, p. 719.

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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27389	65.5	27	.41	19	.29	22.5	.34

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,

FIG. 24. *Desmophyllites gaudama* (Forbes). Suture line of specimen A.M.N.H. No. 27389; ×1.

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, Stoliczka, 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 *Texanites* 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). Pervinquière reports *D. gaudama* from the Tunisian Santonian.

SUPERFAMILY **HOPLITACEAE** SPATH, 1922

FAMILY **PARAHOPLITIDAE** SPATH, 1922

PARAHOPLITES ANTHULA, 1900

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 septate whorl fragment belonging to an individual at least 160 mm. in diameter.

MEASUREMENTS

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27390	110	47	.43	38	.35	37	.34

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 overhanging; the umbilical shoulder is rounded but very distinct. The sides are flattened and slope gently towards the venter, tending to become parallel in the latter stages. The ventrolateral shoulder is broadly rounded; the venter is broad and subflattened in the early whorls but becomes evenly arched in the outer whorls. On the venter of the outer whorl of the holotype, there are 64 round-crested, evenly spaced, equidimensional ribs, of which 21 are primary ribs.

At a radius of 25 mm., the earliest observable one, the primary ribs are widely spaced, start in the umbilical wall, and become in the umbilical shoulder very prominent, subacute, and slightly prorsiradiate. At about the middle third of the sides, they are attenuated and bifurcate. The branches become again strong in the outer third, where they take a forward slant before crossing the venter. Single ribs are intercalated in the middle third; these ribs have, on the outer third and on the venter, the same size, shape, and attitude as the primary ones.

At a radius of 30 mm., the umbilical swellings of the primary ribs are very conspicuous and could well be described as sharp-edged, radially elongated, high tubercles; there are two intercalated ribs instead of a single one, and all the ribs are not so attenuated in the middle third as they were in earlier stages.

At a radius of 40 mm. the umbilical swellings have achieved their maximum development; they are high, sharp-crested, elongated, and extend beyond the end of the inner third at the end of which they bifurcate. There is again only one intercalated rib. Further growth is marked by the reduction of the umbilical tubercle which becomes blunt and tends to disappear, and also by the disappearance of the forward slant of the ribs near the venter. The ribs become straight, slightly prorsiradiate, and more closely crowded than in earlier stages. The intercalated ribs begin early in the middle third. In specimen

FIG. 25. *Parahoplites nicholsoni*, new species. Suture line of the holotype; ×1.

[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, trifid, 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 6 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 *Knemiceras ollonense*.

Parahoplites quilla, 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 quilla* differs from most other *Parahoplites* by its distinct ventrolateral shoulders, although they are not tuberculated as in *Hypacanthoplites*. 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 wall and are prorsiradiate in the inner third, at the end of which some fork, intercalated ribs appear, and all become less prorsiradiate.

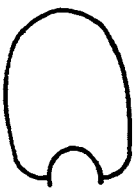


FIG. 26. *Parahoplites inti*, new species. Conch section of specimen A.M.N.H. No. 27392; ×1.

REMARKS: *Parahoplites inti* is distinguished from *P. quilla* by the lack of a flattened venter, more compressed whorl section and coarser ribbing. A very similar species is *P. subcampischei* 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 inti* is found in the Inca formation, in bed 50 of the Cajamarca section, associated with *P. quilla*.

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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27393	46	18.5	.40	23	.50	18	.39
27393/1	44	19	.43	24	.54	16	.35
27393/2:1	55	22	.40	25	.45	21	.38

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 to 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,

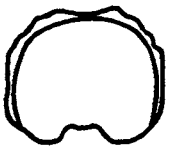


FIG. 27. *Douvilleiceras monile* (Sowerby). Conch section of specimen A.M.N.H. No. 27393; ×1.

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 Pariahuanca 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

and in bed 58 of the Cajamarca section (A.M.N.H. No. 27393), associated with *Knemiceras raimondii*, *Lyelliceras lyelli*, and *Parengonoceras* sp.

Douvilleiceras monile 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.

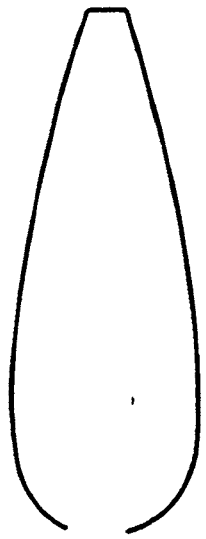


Fig. 28. *Forbesiceras* sp. indet. Conch section of specimen A.M.N.H. No. 27394; ×1.

Specimen A.M.N.H. No. 27394 seems to belong to a species very closely related to *Forbesiceras lagilliertianum* (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 kummeli*.

The genus *Forbesiceras* is found in the Cenomanian of Tunisia (Pervinquière, 1907, p. 106), in the Ootatoor 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 strangulated 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 flattened 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

A.M.N.H. Nos.	D	D	D/H	T	D/T	U	D/U
27396:1	91	48	.53	28	.31	11.5	.12
27396:2	111	55	.50	37	.33	15	.13
27396/1:1	149.5	71.5	.48	56	.37	21	.14

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

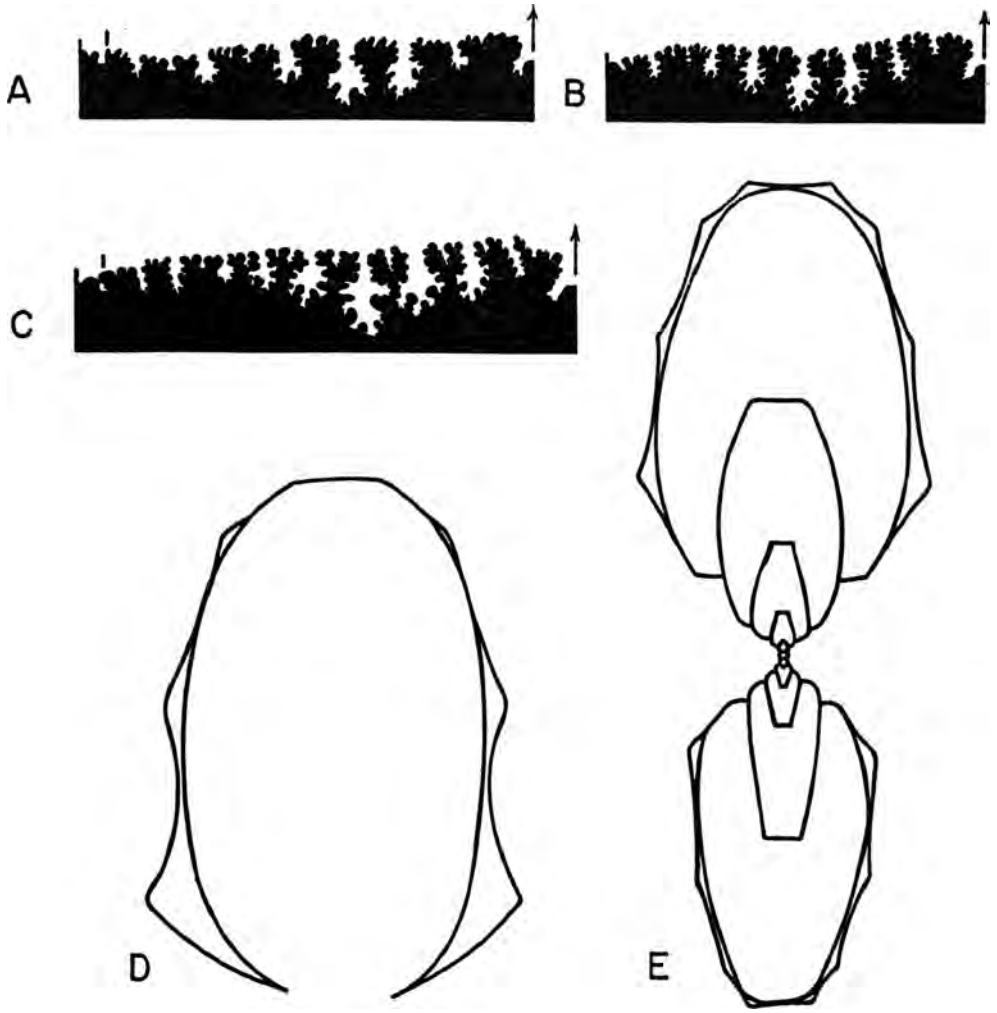


FIG. 29. *Parengonoceras pernodosum* (Sommermeier). A, B, C. Suture lines of specimens A.M.N.H. Nos. 27396:2, 27396:1, and 27396/1:1. D, E. Conch sections of specimens A.M.N.H. Nos. 27396/1:2 and 27396:2. All ×1.

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 guadaloupaeforme (Sommermeier)

Plate 44, figure 2

Placenticeras guadaloupaeforme 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 guadaloupaeforme 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 (Condebamba).

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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27398	37.5	20	.53	12	.32	6	.16
27398:2	57	27.5	.48	17.5	.31	10	.17
27398:3	71	35	.49	20.5	.29	12	.17

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

FIG. 30. *Parengonoceras tetranodosum* (Lissón). Suture line of specimen A.M.N.H. No. 27398:4; ×1.

are not so strangulated and the margins of the saddles are not so denticulated (fig. 30).

Between the diameters of 12 and 20 mm., the whorl section is very high and compressed, triangular, and truncated by a narrow subconcave venter; the sides are 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,[1] 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.

MEASUREMENTS

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27399:4	56.5	30.5	.54	14	.25	4.5	.08
27399:3	61	32	.53	14	.23	6	.09
27399:2	70.5	36	.51	17	.24	6	.08
27399:1	80	42	.53	22.5	.28	6	.07

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 truncated venter, to very compressed, high, and ovoid, with the greatest thickness just above the middle of the sides. There are four rows of tubercles: one row of prominent, radially elongated tubercles near the end of the inner third which appear at a diameter of 50 mm.; a second row of similar tubercles just above the middle of the sides which appear just after the tubercles of the first row; a third row of blunt and rounded tubercles at about the middle of the outer third which appear at a diameter of 75 mm.; and a fourth row of more numerous, sharp, spirally 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.

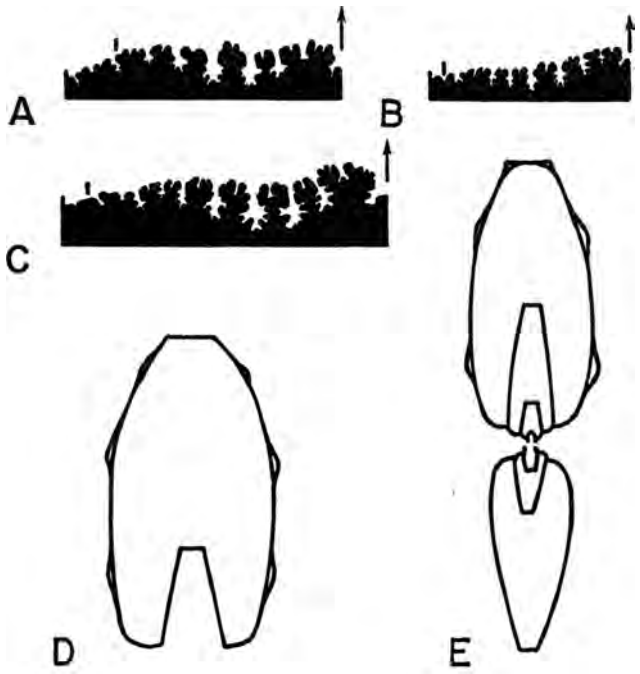


FIG. 31. *Parengonoceras haasi*, new species. A, B, C. Suture lines of specimens A.M.N.H. Nos. 27399:2, 27399:3, and 27399:1 (holotype). D, E. Conch sections of the holotype at two different radii. All ×1.

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

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 Celendín 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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27848	139	76	.55	39	.29	14	.09

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 phylloid 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.

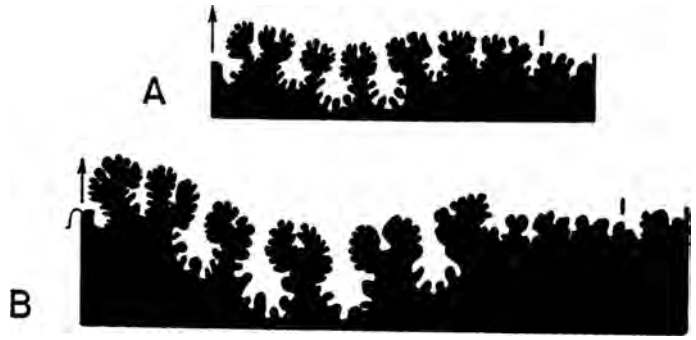


FIG. 32. *Parengonoceras? champaraense*, new species. Suture lines of the holotype (A and B).

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

[1] Named after Nevado Champará, east of which is the locality where the holotype was collected.

KNEMICERAS Böhm, 1898

Knemiceras attenuatum (Hyatt)

Plate 46, figures 7–10

Buchiceras attenuatum Hyatt, 1875, p. 372.

Glottoceras attenuatum Hyatt, 1875, p. 372 (footnote).

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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27849:1	52	27.5	.53	17.5	.34	7	.14
27849/1	52	27.5	.53	16	.31	6	.12
27849/2	55.5	29.5	.53	18	.32	7	.13
27849/3	63	36.5	.58	19	.30	6.5	.10

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 narrowly 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, strangulated, 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. gabbi* and *K. ollonense* are larger in size and have only two rows of tubercles.

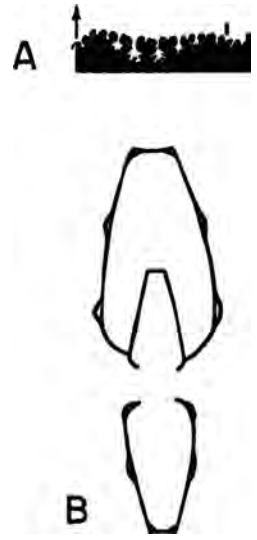


Fig. 33. *Knemiceras attenuatum* Hyatt. Suture line (A) and conch section (B) of specimen A.M.N.H. No. 28849:1; ×1.

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

A.M.N.H. Nos.	Bed	Section	No. of Specimens
27849	52	Sunchubamba	2
27849/1	70	Cajamarca	1
27849/2	8	Sihuas	1
27849/3	23	Pomachaca	1

In the Sihuas section, it is associated with *K. raimondii*, *Douvilleiceras monile*, and *Prolyelliceras peruvianum*. 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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27850	48	24	.50	17	.35	6.5	.13

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

FIG. 34. *Knemiceras attenuatum spinosum* (Sommermeier). Conch section of specimen A.M.N.H. No. 27850; ×1.

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; Douvillé, 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 synon.*, pl. 8, fig. 5, pl. 9, fig. 3, pl. 10, fig. 2, pl. 11, fig. 3.

Two specimens are assigned to this species.

MEASUREMENTS

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27851	53	27.5	.52	25	.47	9	.06

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 *Parengonoceras 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; LISSÓN, 1908, p. 2a, pl. 2.

Knemiceras bassleri KNECHTEL, 1947, *in* Knechtel, Richards, and Rathbun, p. 90, pl. 17, figs. 1–2.

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, Lissón 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 subdued tuberculation. *Knemiceras libertadense*, on the other hand, differs from *K. gabbi* by the extremely strong development of its umbilical tubercles.

Sommermeier (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 Lissón'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.

MEASUREMENTS

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27853	97	55	.57	44	.41	15	.15

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

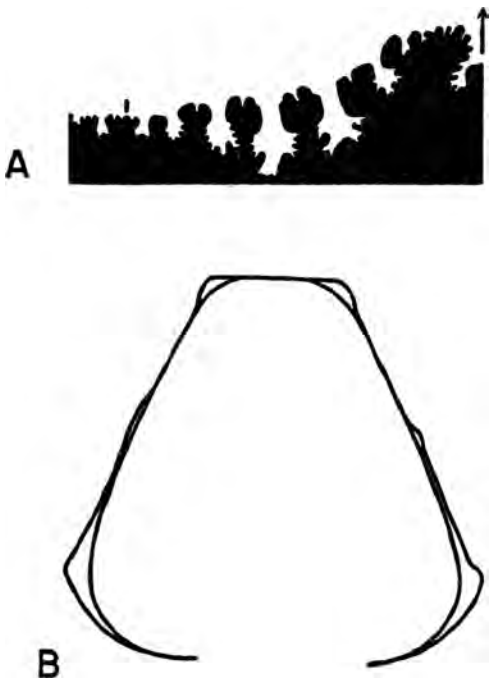


FIG. 36. *Knemiceras triangulare*, new species. Suture line (A) and conch section (B) of the holotype; ×1.

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*, *Parengonoceras peruvianum*, *Brancoceras aegoceratoides*, *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

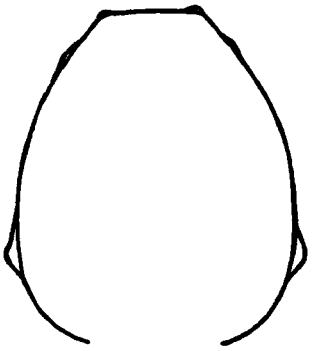


FIG. 37. *Knemiceras ovale*, new species. Conch section of the holotype; ×1.

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 quadrate 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 *Lyelliceras ulrichi*, and in bed 20 of the Celendín section (A.M.N.H. No. 27854) associated with *L. pseudolyelli*.

?Knemiceras ollonense (Gabb)

Plate 50, figure 5

A(mmonites) ollonensis 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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27855	114	61	.53	39	.34	16	.14

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 volution is a row of eight pointed tubercles which are elongated in a prorsiradiate direction. Very faint, broad, fold-like prorsiradiate 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*.

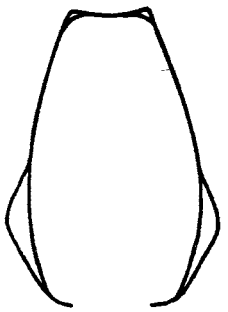


FIG. 38. *?Knemiceras ollonense* (Gabb). Conch section of specimen A.M.N.H. No. 27855; ×1.

REMARKS: Hyatt (*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 its 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 nicholsoni* and *Desmoceras chimuense*. 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 Chulec 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. 345, 346, pl. 13, figs. 3–7, pl. 14, figs. 1–3.

Seventeen steinkerns, including several complete discs, are assigned to this species.

A.M.N.H. Nos.	Measurements D	H	D/H	T	D/T	U	D/U
27856:1	56.5	30	.53	18	.32	7.5	.13
27856/1:1	59.5	32	.54	17.5	.29	7	.12
27856:2	65	33	.51	22	.30	10	.15
27856:3	75	39.5	.53	27	.36	10.5	.14
27856:4	76	37.5	.49	26	.35	11	.14
27856:5	98	49	.50	35	.36	16	.16
27856:6	112	58	.52	40	.36	18	.16
27856:7	112	55	.49	39	.35	23	.20
27856/1:2	117	64	.55	38	.32	14.5	.12

(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

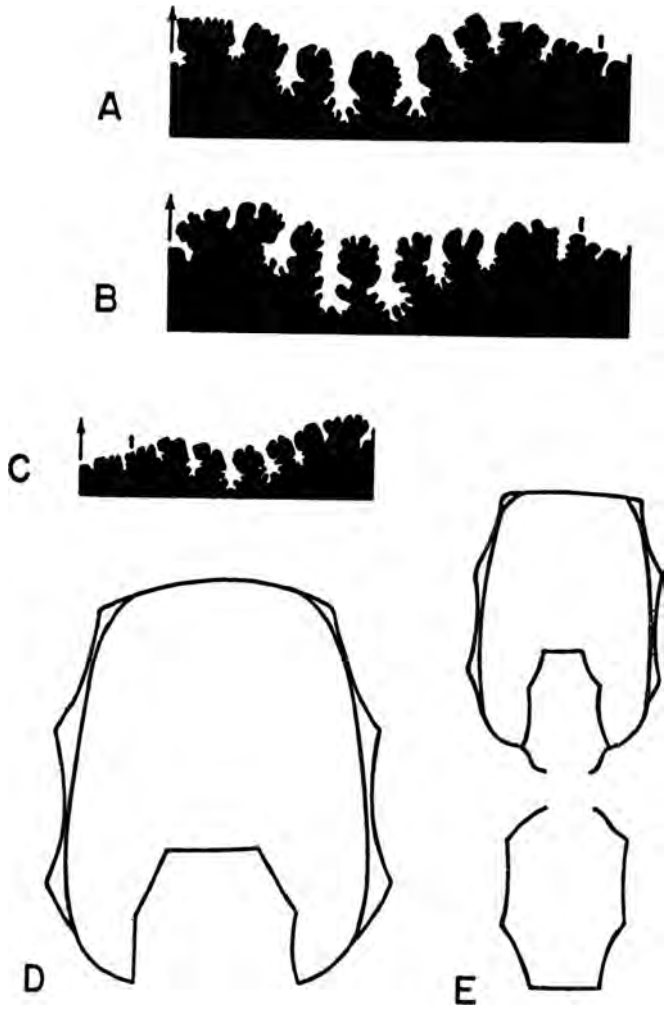


FIG. 39. *Knemiceras raimondii* Lissón. A, B, C. Suture lines of specimens A.M.N.H. Nos. 27856:7, 27856:6, and 27856:2. D, E. Conch sections of specimens A.M.N.H. Nos. 27856:7 and 27856:2. All ×1.

DESCRIPTION: The conch is large, stout, discoidal, narrowly umbilicated. The whorl section (fig. 39) changes in the early whorls in the early whorls but tends to become more broadly rounded. The venter is broad, flat, or even subconcave, becoming slightly

vaulted in the large specimens. There are three distinct, very prominent rows of tubercules 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 strangulated 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*, *Douvilleiceras monile*, and *Prolyelliceras peruvianum;* 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. peruvianum*, 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	31	.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 volution, 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 Celendín 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/H	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 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*.

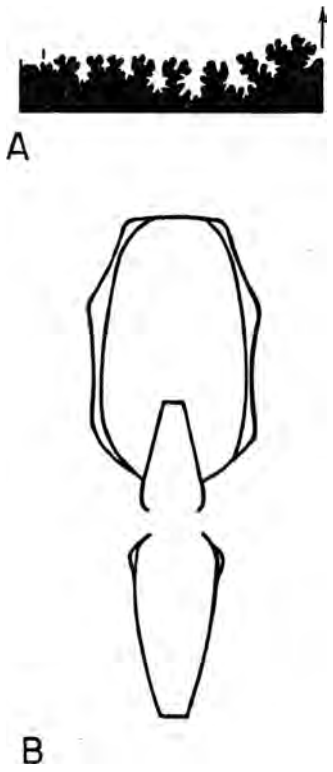


FIG. 40. *Knemiceras raimondii tardum*, new subspecies. Suture line (A) and conch section (B) of the holotype; ×1.

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; DOUVILLÉ, 1906, p. 151, pl. 4, fig. 1.

Knemiceras (?) *ziczag* BREISTROFFER, 1952, p. 2634.

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

DESCRIPTION: The whorl section is compressed, ovoid, with the greatest thickness at about the middle of the sides; it is 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 volution, 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 *Parengonoceras pernodosum*.

SUPERFAMILY **DIPOLOCERATACEAE** SPATH, 1921

FAMILY **DIPOLOCERATIDAE** SPATH, 1921

OXYTROPIDOCERAS STIELER, 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 (*Manuaniceras?*) *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 (*Manuaniceras*) *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 . . . ist dieselbe charakteristische Art, welche ich als *Schloenbachia acuto-carinata* Shum. sp. bezeichnet und abgebildet habe. Die Zeichnung Gabb's könnte fast nach meinem Stücke angefertig 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 *Manuaniceras*. 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 *Manuaniceras manuanense*, genotype of *Manuaniceras*.

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* Olsson, 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 Pariahuanca section together with *O. douglasi, Lyelliceras lyelli, L. ulrichi, Brancoceras aegoceratoides,* 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); DOUGLAS, 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 Schlagintweit (1912, p. 71) described the same specimen in the following terms: "Es sind Steinernstücke mit ungegabelten, schmalen Rippen, die gegen die Externseite nur langsam anschwellen und nur schwach S-förmig gebogen sind. Jedoch sind die Rippen etwas abgewittert und die Externseite ist nicht intakt; die Rippen müssen in ihrem oberen nicht mehr erhaltenen Teil stärker angeschwollen und kräftiger gebogen gewessen sein. Dass die Rippen erheblich schmäler seien wie die Zwischenräume, 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, lenticular, narrowly umbilicated. The whorl section (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 provided 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 prorsiradiate 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.,

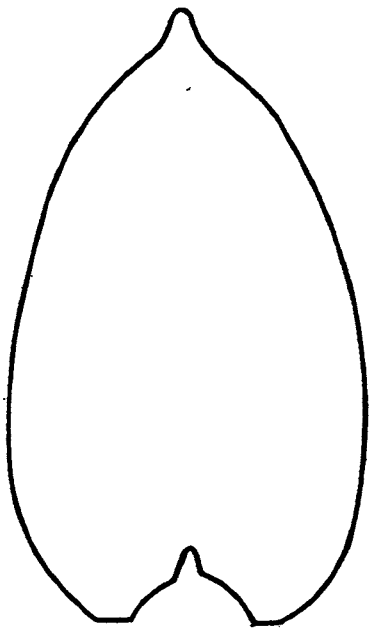


FIG. 41. *Oxytropidoceras peruvianum* (von Buch). Conch section of specimen A.M.N.H. No. 27861; ×1.

it is what Marcou considered to be *Amm. peruvianus.* . . . It is, of course, often found that the ribbing varies greatly in these forms with the mode of preservation, and since I had the opportunity of examining many specimens from Texas . . . I am prepared to accept forms like *O. carbonarium* (Gabb), *O. multifida* (Steinmann) and *O. supani* (Lasswitz) all taken previously as distinct species to be mere varieties of *O. acutocarinata.* Since Prof. Adkins is somewhat doubtful and since I have already mentioned that there is a possibility of its being the same as v. Buch *Amm. peruvianum,* the continued use of *Oxy. carinatum* may be opened to criticism." The present writer believes that *O. carbonarium, O. peruvianum,* and *O. acuto-*

carinatum are three different forms. *Oxytropidoceras carbonarium* and *O. acutocarinatum*, as stated by Steinmann, are flattened forms with very closely spaced, flat-topped ribs which are strongly projected forward in the outer third and which differ from each other only by the remarkable dichotomy of the ribs of *O. carbonarium*. *Oxytropidoceras peruvianum* has a proportionally thicker whorl section, and its ribs are not so closely spaced nor so conspicuously flat-topped as those of the other two forms. Whether *O. peruvianum* and *O. roissyanus* are the same, as held by Schlagintweit (1912, p. 64), the present writer is in no position to state. It seems, however, that *O. roissyanus* has ribs which are stronger and more distinctly sigmoidal and projected forward than those of *O. peruvianum*.

OCCURRENCE: The holotype was collected by von Humboldt in 1802 in Montán, near the Lajas section, presumably from the Pariatambo formation where it is very abundant. Specimen A.M.N.H. No. 27861 is from the upper middle Albian Pariatambo formation, in bed 26 of the Pomachaca section.

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 Pariahuanca section, and in the lowest beds of the Albian-Turonian Jumasha formation, in bed 4 of the Uchupata section.

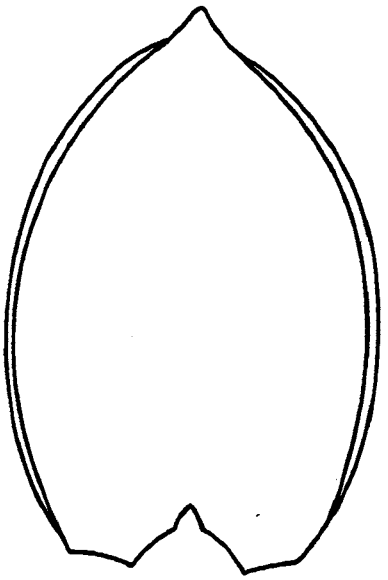


FIG. 42. *Oxytropidoceras douglasi* Knechtel. Conch section of specimen A.M.N.H. No. 27862; ×1.

VENEZOLICERAS SPATH, 1920

Venezoliceras venezolanum (Stieler)

Plate 53, figure 5

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

Oxytropidoceras venezolanum STIELER, 1920, p. 394.

Venezoliceras venezolense (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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27863	38.5	20	.52	—	—	7.5	.19
27863/1	100	48	.48	—	—	20	.20

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,[1] 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

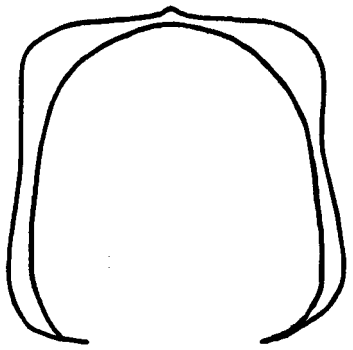


FIG. 43. *Dipoloceras* sp. indet. Conch section of specimen A.M.N.H. No. 27865; ×1.

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.

BRANCOCERAS STEINMANN, 1881

Brancoceras aegoceratoides Steinmann

Plate 49, figures 2–4

Brancoceras aegoceratoides STEINMANN, 1881, p. 137, pl. 7, figs. 2–2b.

Brancoceras varicosum Sow.; SCHLAGINTWEIT, 1912, p. 85.

Brancoceras aegoceratoides Steinmann; KNECHTEL, 1947, *in* Knechtel, Richards, and Rathbun, p. 103, pl. 21, figs. 4a–c.

Brancoceras quenstedti KNECHTEL, 1947, *in* Knechtel, Richards, and Rathbun, p. 103, pl. 21, figs. 5a–b.

Eubrancoceras aegoceratoides (Steinmann); BREISTROFFER, 1951, p. 266.

Five fragmentary specimens are assigned to this species.

MEASUREMENTS

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27866:1	37	13.5	.37	12	.32	12.5	.34
27866/1	29.5	11	.37	9.5	.33	11	.38

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

FIG. 44. *Brancoceras aegoceratoides* Steinmann. Suture line of specimen A.M.N.H. No. 27866:2; ×1.

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. senequieri* 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, Lyelliceras, Dipoloceras*, and *Desmoceras*. It is also rarely found in the lower middle Albian Chulec formation, associated with species of *Knemiceras, Douvilleiceras, Protanisoceras*, and *Prolyelliceras*.

SUPERFAMILY **ACANTHOCERATACEAE** HYATT, 1900

FAMILY **LYELLICERATIDAE** SPATH, 1921

PROLYELLICERAS SPATH, 1930

Prolyelliceras peruvianum Spath

Plate 50, figures 1–4

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

Acanthoceras prorsocurvatum 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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27867:2	49.5	18.5	.37	16.5	.33	17	.34
27867/1:1	43	17	.39	14.5	.34	15	.34

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

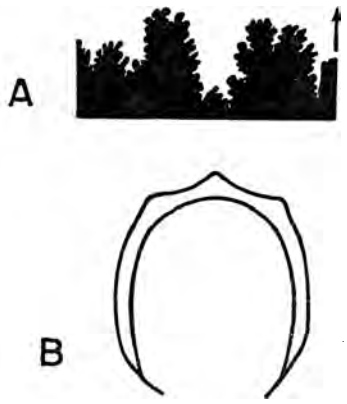


FIG. 45. *Prolyelliceras peruvianum* Spath. Suture line (A) and conch section (B) of specimen A.M.N.H. No. 27866:3; ×1.

(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. cotteri* Spath, a poorly known species, in shape and in the presence of three rows of tubercles. They are distinguishable because *P. cotteri* has intercalated and forked ribs and is more closely costate.

The specimen described as *Proyelliceras ?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 aegoceratoides*.

LYELLICERAS SPATH, 1921

Lyelliceras lyelli (Leymerie) D'ORBIGNY

Plate 51, figures 1–3

Lyelliceras lyelli (Leymerie MS) d'Orbigny; SPATH, 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 discs and several whorl fragments.

MEASUREMENTS

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	U/H
27868:1	55	21.5	.39	20.5	.37	40.5	.37
27868:2	42	15.5	.36	15	.36	16.5	.39
27868:3	41	15	.39	15	.37	16	.39
27868:4	33.5	11.5	.34	11	.34	14	.33
27868:5	22.5	9	.40	10	.44	8.5	.38
27868:6	18	8	.44	7.5	.41	6	.33
27868:7	18	7	.39	7	.39	6.5	.36

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 ventrolateral 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 Pariatambo formation (bed 14 of the Pariahuanca 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. peruvianum*, *O. douglasi*, *Brancoceras aegoceratoides*, *L. ulrichi*, *Venezoliceras venezolanum*, and *V. harrisoni*. It is also rarely found in the lower middle Albian Chulec formation (in bed 10 of the Lajas section, A.M.N.H. No. 27868/2) associated with *Knemiceras raimondii*, *K. attenuatum*, *Douvilleiceras monile*, *Protanisoceras blancheti*, *Prolyelliceras peruvianum*, and, unusually, *B. aegoceratoides*. 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); SPATH, 1923–1943, vol. 2, p. 319, *cum synon.*, pl. 32, figs. 14a–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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27869:1	64	25.5	.40	22	.34	21	.33
27869:2	53	21.5	.41	—	—	18	.34

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

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 Celendín 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.

Lyelliceras ulrichi KNECHTEL, 1947, *in* Knechtel, Richards, and Rathbun, p. 99, pl. 23, figs. 1a–b.

Seventeen specimens, all steinkerns, including four complete discs, are assigned to this species. Knechtel's holotype was available to the writer.

MEASUREMENTS

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27870:1	13.5	6	.44	6	.44	3.5	.26
27870/1:1	23.5	9.5	.40	9	.38	—	—
27870/2:1	35.5	12	.34	10.5	.30	14.5	.41
27870:2	40	14	.35	13	.32	16	.40
27870:3	73	24	.33	21	.28	33	.45
Knechtel's 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;

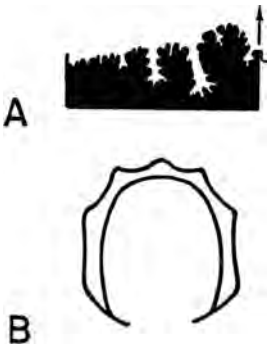


FIG. 47. *Lyelliceras ulrichi* Knechtel. Suture line (A) and conch section (B) of specimen A.M.N.H. No. 27870:3; ×1.

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 corresponding 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. mathewsi* 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. mathewsi*, where it appears at a radius of 35 mm. *Lyelliceras prorsocurvatum* 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.

FAMILY **ACANTHOCERATIDAE** DE GROSSOUVRE, 1894

SHARPEICERAS HYATT, 1903

Sharpeiceras occidentale, new species

Plate 54, figures 5–6

A single steinkern, slightly larger than a half-disc and including a small part of the body chamber, is the basis of this new species.

MEASUREMENTS

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27871	136	49	.36	37	.27	47	.35

TABLE 2

OCCURRENCE OF *Lyelliceras ulrichi*

A.M.N.H. Nos.	Bed	Section	Formation	No. of Specimens
27870	14	Pariahuanca	Pariatambo	10
27870/1	4	Uchupata	Jumasha	5
27870/2	3	Uchupata	Pariatambo	2
27870/3	85	Cajamarca	Pariatambo	1
27870/4	21	Hualgayoc	Pariatambo	1

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, quadrate, 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. schlueteri* 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. schlueteri*, 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. florencae* Spath (1925, p. 198), which has a quadrate 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 *Paraturrilites lewesiensis* (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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27872	61	29	.48	27	.44	16	.26

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 quadrate. 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 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.

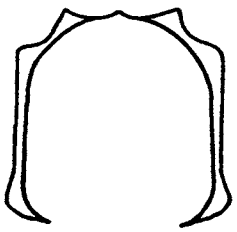


FIG. 48. *Acanthoceras chasca*, new species. Conch section of the holotype; ×1.

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 *Neolobites kummeli*, *Lissoniceras mermeti*, 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 perpendicular 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 impressed 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.

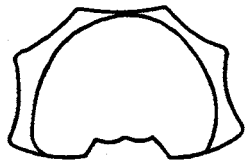


FIG. 49. *Acanthoceras pollocense*, new species. Conch section of the holotype; ×1.

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-

FIG. 50. *Acanthoceras sangalense*, new species. Conch section of specimen A.M.N.H. No. 27874:1; ×1.

[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. jukesbrownei* Spath [Sharpe, 1857 (1853–1857), pl. 17, fig. 2] from the *Varians* 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 Celendín section, together with *A. chasca, A. pollocense, Neolobites kummeli, Lissoniceras mermeti,* and *Forbesiceras* sp.

FAMILY **MAMMITIDAE** HYATT, 1900

MAMMITES LAUBE AND BRÜDER, 1887

Mammites nodosoides afer Pervinquière

Plate 55, figures 5–8

Mammites nodosoides var. *Afra* PERVINQUIÈRE, 1907, p. 310, pl. 18, figs. 2, 2a–b, 3, 3a–b.

Mammites nodosoides var. *Afra* Pervinquière; BRÜGGEN, 1910, p. 736.

Mammites nodosoides var. *Afra* 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, subquadrate, 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* Bassé has horny, 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 (Salmurian) of Germany and France and is rare in the *Labiatus* zone of the English Turonian.

PSEUDOASPIDOCERAS HYATT, 1903

Pseudoaspidoceras reesidei,[1] 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 whorls.

[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 two other 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, quadrate, 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

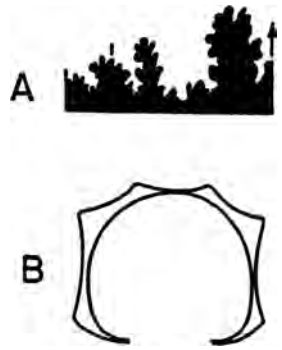


FIG. 51. *Pseudoaspidoceras reesidei*, new species. Suture line (A) and conch section (B) of specimen A.M.N.H. No. 27876:2; ×1.

nodosoides group of the genus *Mammites*. *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 Quillquiñan group, in bed 24 of the Tembladera section, together with *Thomasites fischeri, Coilopoceras jenksi, Vascoceras* aff. *V. silvanense, Broggiiceras humboldti*, and *Broggiiceras olssoni*.

Pseudoaspidoceras michelobensis, the closest species, is from the *labiatus* zone of the German Turonian.

FAMILY VASCOCERATIDAE DOUVILLÉ, 1911

BROGGIICERAS,[1] 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.

mentation consists of single, radial ribs; they are more conspicuous, or present only in the outer third of the sides and on the venter. The ribs appear very late in the ontogeny (between radii of 20 and 30 mm.) and become stronger in the body chamber. The suture has two or three saddles on the sides; they are very large, broad, with phylloid endings, and regularly decreasing in size. The lobes are very small and slender; the first one is V-shaped and may be either trifid or bifid.

REMARKS: In shape, whorl section, and suture, *Broggiiceras* is similar to the closely related Turonian genera *Vascoceras* and *Fagesia*. These two genera, however, have strong umbilical and ventral tubercles and ribs which start at the umbilical shoulder; furthermore, their ribs and tubercles disappear very early in the ontogeny, the latter volutions being smooth.

Fagesia (?) *fleuryi* Pervinquière (1907, p. 330) is included within *Broggiiceras*. It is spherical in shape, lacks tubercles, and has faint ribs, which are better developed on the venter and attenuated on the sides. Pervinquière said about this form: "Ce n'est pas sans quelque hésitation que je rapporté cette ammonite au genre *Fagesia*; si elle en a la forme générale, l'ornementation présente des différences importantes."

Broggiiceras olssoni,[1] new species

Plate 55, figures 1–4

Vascoceras amieirensis Choffat; LISSÓN, 1908, p. 9c, pl. 9.

Seven entire discs, one half a disc, and two whorl fragments are considered within this species. Specimen A.M.N.H. No. 27877:5 (pl. 55, figs. 1–2), the outer half whorl of which belongs to the body chamber, is designated the holotype.

MEASUREMENTS

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27877:1	31	14	.45	15	.48	7	.23
27877:2	52	23	.44	27.5	.53	14	.27
27877:3	62.5	27	.43	34	.54	19.5	.31
27877:4	65	30	.46	39	.60	16	.25
27877:5	78	37	.47	41	.53	20	.26
27877:6	84	36	.43	48	.57	24	.29
27877:7	89	42	.47	48	.54	22.5	.25
27877:8	93.5	38.5	.41	45	.48	30	.32

[1] Named after Dr. Alex A. Olsson, who has contributed greatly to the knowledge of South American Mesozoic and Cenozoic faunas.

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: *Broggiiceras fleuryi* (Pervinquière) has a more globose shape, narrower umbilicus, and fewer ribs than *B. olssoni*.

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: *Broggiiceras olssoni* is found in the upper part of the Quillquiñan group, in bed 24 of the Tembladera section, associated with *B. humboldti*, *Thomasites fischeri*, *Pseudoaspidoceras reesidei*, and *Coilopoceras jenksi*.

Broggiiceras humboldti,[2] 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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27878:1	63	31	.49	32	.51	12	.19
27878:2	82	44	.49	47	.57	10	.12
27878:3	100	48	.48	43	.43	16	.16

[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 whorls 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: *Broggiiceras humboldti* is distinguishable from *B. olssoni* 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 Quillquiñan formation, in bed 24 of the Tembladera section, associated with *B. olssoni* and the ammonites already listed under the latter species.

VASCOCERAS CHOFFAT, 1898

Vascoceras 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: Quillquiñan group, bed 24 of the Tembladera section.

THOMASITES PERVINQUIÈRE, 1907

Thomasites fischeri,[1] 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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27880:1	51.5	25	.49	31.5	.61	10.5	.20
27880:2	86	42	.49	45	.52	17	.20
27880:3	105	52.5	.50	54	.51	18	.17

DESCRIPTION: The conch is subglobose, stout, narrowly umbilicated. The whorl section is compressed and changes from subrectangular in the inner whorls 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 whorls 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 whorls. 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 costata* 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 *Broggiiceras 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 SPATH, 1932

Texanites hourcqi Collignon

Plate 58, figures 6–7

Texanites hourcqi 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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27881	100	34.5	.34	29.5	.29	41	.41

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 lobule. 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

COILOPOCERAS HYATT, 1903

Coilopoceras jenksi,[1] new species

Plate 59, figures 3–4; plate 60, figure 7

Cf. *Coelopoceras 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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27882/3:1	95	57	.60	20	.21	2.5	.03
27882	135.5	81.5	.60	39	.29	3.5	.03
27882/1:1	157	93	.59	37	.24	4.5	.03

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.

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. The suture (fig. 52) has four saddles on the sides, the first saddle being broad, massive, denticulated, and often divided into two branches by a median lobule; the other saddles are more or less denticulated and regularly decrease in size. The first lateral lobe is very distinct; it is very broad and is divided by a deep, median saddle into two branches, in turn bifid. The other lobes are much narrower than the saddles, strangulated, and digitated.

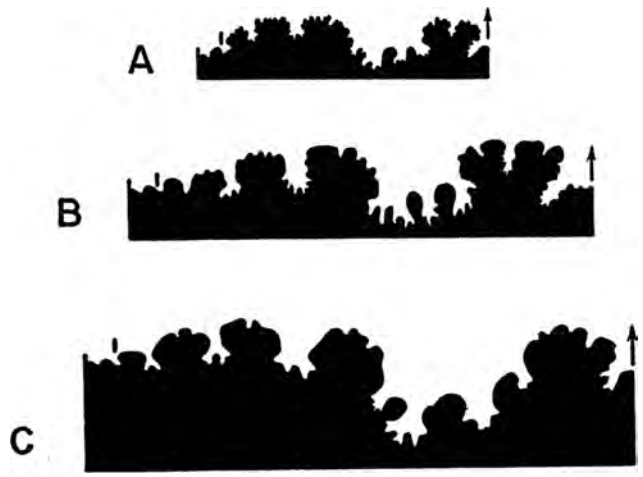


FIG. 52. *Coilopoceras jenksi*, new species. A, B, C. Suture lines of specimens A.M.N.H. Nos. 27882/2, 27882/1:1, and 27882 (holotype); ×1.

REMARKS: *Coilopoceras jenksi* is similar in shape, whorl section, and suture to *C. requianus* d'Orbigny; it can be distinguished by its thicker whorl section and the lack of the faint, flexuous ribs present in the latter species. *Coilopoceras lesseli* Brüggen, another Peruvian species, is similar in shape, but the lateral saddles are *Tissotia*-like, entire, and rounded, a character that is not present in any of the specimens referred to *C. jenksi*. *Coilopoceras springeri* Hyatt, from the North American Turonian, is a large-sized species which has a larger number of very frilled saddles. *Coilopoceras lentiformis* (von Koenen, 1897, p. 11), another smooth form, has a more inflated whorl section, and its greatest whorl thickness is about one-half of the whorl height.

OCCURRENCE: *Coilopoceras jenksi* is the most common ammonite in the lower Turonian Coñor formation. It has been collected in the following localities:

A.M.N.H. Nos.	BED	SECTION	No. OF SPECIMENS
27882	27	Tembladera	1
27882/1	133	Cajamarca	4
27882/2	42	Lajas	1
27882/3	53	Celendín	3
27882/4	55	Polloc	1

It is usually associated with *Hoplitoides inca*, *Mammites nodosoides afer*, *Pseudoaspidoceras reesidei*, *Thomasites fischeri*, *Broggiiceras olssoni*, and *B. humboldti*.

Coilopoceras newelli,[1] new species

Plate 61, figures 4–5; plate 62, figures 5–7

Coelopoceras n. sp. *A* aff. *C. lesseli* Brüggen and *C. springeri* Hyatt; REESIDE, 1927, *in* Wasson and Sinclair, p. 1270, pl. 9, figs. 1–2.

[1] 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 specimen by the removal of the inner whorls which were not filled with sediment. Later, pressure, either gravitative or tectonic, compressed the steinkern, closing the gap left by the inner whorls.

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 swellings which begin at about the middle of the inner third and vanish before the end of the middle third. They may appear in the phragmocone (pl. 62, fig. 5) or only in the body chamber (pl. 61, fig. 4). Apparently those specimens with thicker whorl sections have stronger ornamentation. 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. On the sides there are seven saddles; the first saddle is narrow, conspicuously strangulated, and with either two or three

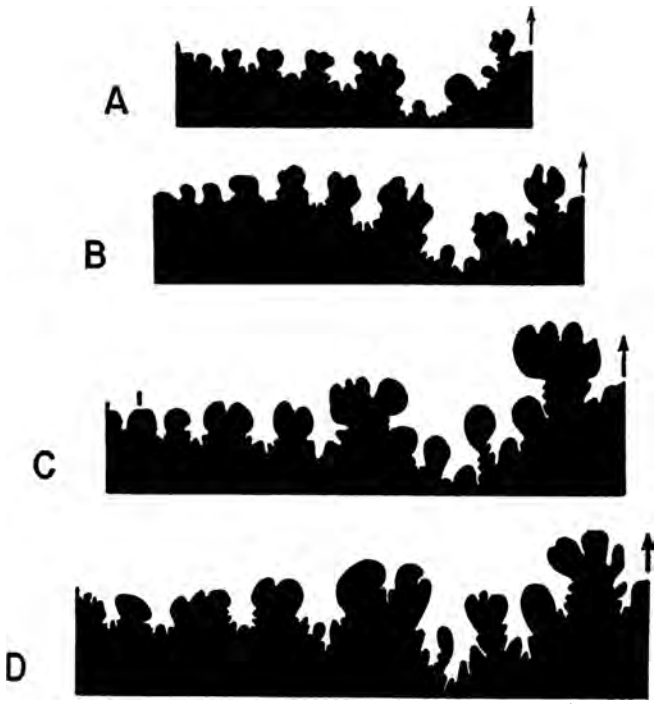


FIG. 53. *Coilopoceras newelli*, new species. A, B, C, D. Suture lines of specimens A.M.N.H. Nos. 27883:3, 27883:1, 27883:7 (holotype), and 27883:6. A, B, ×1; C, D, ×1/2.

MEASUREMENTS

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27883:1	150	74	.49	47	.31	17	.11
27883:2	185	87	.47	47	.25	18	.10
27883:3	199	98	.49	53	.27	30	.15
27883:4	215	107	.49	—	—	22	.10
27883:5	272	132	.49	—	—	34	.13
27883:6	330	159	.48	—	—	57	.17
27883:7	365	171	.47	—	—	73	.20

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 *Sphenodicus*-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 quadrate 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. jenksi* 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.

A.M.N.H. Nos.	BED	SECTION	NO. OF SPECIMENS
27883	2	Bambamarca	18
27883/1	141	Cajamarca	2
27883/2	66	Polloc	2

HOPLITOIDES VON KOENEN, 1898

Hoplitoides 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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27884/1:1	35	19	.54	—	—	2	.06
27884:2	35	20	.57	11.5	.33	2	.06
27884:3	47.5	26	.55	14.5	.31	4	.10
27884/2	104.5	62	.59	24	.23	3	.02
27884:1	116	67	.58	34	.29	—	—

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.

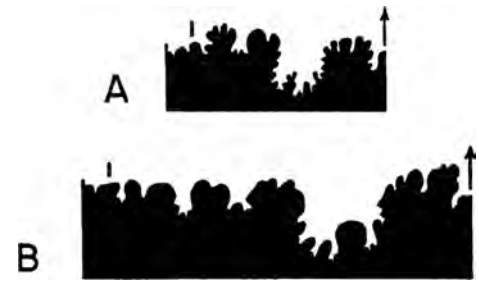


FIG. 54. *Hoplitoides inca*, new species. A, B. Suture lines of specimens A.M.N.H. Nos. 27884:1 (holotype) and 27884/2:1; ×1.

REMARKS: *Hoplitoides 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. *Hoplitoides*

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 truncated venter only in the younger whorls, and which becomes fastigate, sharp-ventered in maturity. It may be necessary to separate the group of Senonian species of *Hoplitoides*, with fastigate venter in the later whorls, 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 *Coilopoceras jenksi* and *Mammites nodosoides afer*. *Hoplitoides munieri* occurs in the lower Turonian of Tunisia.

FAMILY **TISSOTIIDAE** 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 usually 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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27886:1	84	43	.51	27	.32	17	.20
27886:2	92	46	.50	28	.30	18	.20

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: *Barroiscerias* (*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; LÜTHY, 1918, p. 48, pl. 4, figs. 1a–b.

Schloenbachia (*Barroisiceras*) sp. nov. sp. LÜTHY, 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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27887/1	55	28.5	.52	15	.27	7.5	.14

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 volution. 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) basseae,[1] 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.

Non Barroisiceras brüggeni KNECHTEL, 1947, *in* Knechtel, Richards, and Rathbun, p. 123, pl. 41, figs. 2–4.

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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27888	94	43	.46	26	.28	22	.23

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.* (*Alstadensis*) *severiense* 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.* (*Alstadensis*) *severiense* 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.*) *ampozaloakaense* 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.

Prionotropis Alluaudi Boule, Lem. et Th.; BRÜGGEN, 1910, p. 722.

Barroisiceras (*Forresteria*) *allaudi* Boule, Lemoine, and Thévenin; REESIDE, 1932, p. 12.

Forresteria alluaudi blt.; BASSÉ, 1947, p. 128, *cum synon.*, 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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27889	48.5	21	.43	17.5	.36	15	.35

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.

OCCURRENCE: *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

FIG. 55. *Tissotia steinmanni* Lissón. Suture line of specimen A.M.N.H. No. 27890:1; ×1.

the sides; the first one is deeply divided by a bifid lobule; 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.

OCCURRENCE: This species is found in the Celendín formation (*Lenticeras baltai* zone), in bed 72 of the Celendín section, associated with *Desmophyllites gaudama*, *Texanites hourcqi*, *Lenticeras baltai*, and *Tissotia fourneli*.

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 availabe 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-

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 baltai* zone), in bed 3 of the Santa Clara section, together with *Lenticeras lissoni* and *Texanites* sp.

Tissotia fourneli (Bayle)

Plate 62, figures 3–4

Ammonites 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 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.

Tissotia waltheri KNECHTEL, 1947, *in* Knechtel, Richards, and Rathbun, p. 115, pl. 18, figs. 3–4.

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

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27892	38	20	.53	14	.37	6	.16

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; ×1.

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 baltai* zone), in bed 72 of the Celendín section (A.M.N.H. No. 27892), together with *T. steinmanni*, *Texanites hourcqi*, and *Lenticeras baltai*. 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,[1] new species

Plate 63, figures 1–5

Three well-preserved steinkerns, including two almost entire discs, are the available representatives of this species.

MEASUREMENTS

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27893:3	41	25	.61	13	.32	2	.05
27893:2	44.5	25.5	.57	12.5	.28	3.5	.08
27893:1	61.5	37	.60	18	.29	2.5	.04

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.

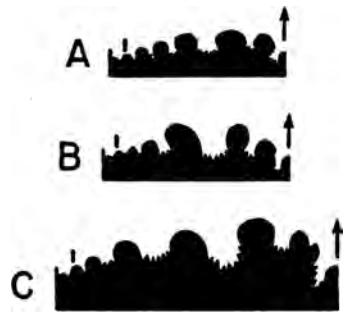


FIG. 57. *Tissotia hedbergi*, new species. A, B, C. Suture lines of specimens A.M.N.H. Nos. 27893:2, 27893:3, and 27893:1 (holotype); ×1.

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. fourneli* 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*.

[1] This species is named after Dr. Hollis D. Hedberg, whose lucid writings have greatly aided the understanding of South American stratigraphy.

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 grossouvrei KNECHTEL, 1947, *in* Knechtel, Richards, and Rathbun, p. 122, pl. 34.
Buchiceras bilobatum Hyatt emend. Brüggen; KNECHTEL, 1947, *in* Knechtel, Richards, and Rathbun, p. 123, pl. 42.

Forty-three specimens, most of them steinkerns, are assigned to this species. None of the specimens is larger than 100 mm. in diameter.

MEASUREMENTS

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27894:1	33	16	.48	15	.45	7	.21
27894:2	36.5	18	.49	20	.55	9	.25
27894:3	39	18.5	.47	18.5	.47	10.5	.27
27894:4	40	25	.51	25	.51	10	.20
27894:5	47	23.5	.50	22	.47	10	.21
27894:6	48	24	.50	23	.48	11	.23

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27894:7	52.5	26.5	.50	28	.53	10	.19
27894:8	55.5	27.5	.50	27	.49	13	.23
27894:9	62	29	.47	26	.42	15	.24
27894:10	63	30.5	.48	28	.44	14	.22
27894:11	63.5	30	.47	32	.50	15.5	.24
27894:12	66	31	.47	27	.41	17	.26
27894/1:1	70.5	34.5	.49	32	.45	13.5	.19
27893:13	73.5	33.5	.45	31	.42	19	.26
27894/2:1	76	35	.46	32	.42	18	.24
27894:14	81.5	41	.50	38.5	.47	18	.22
27894:15	81.5	40	.49	33.5	.41	17.5	.21
27894:16	81.5	41	.50	33.5	.44	15	.18
27894/2:2	85	43	.51	37.5	.44	18	.21
27894:17	87	40	.46	36.5	.42	20.5	.24
27894:18	88	43	.49	40	.45	17	.19
27894:19	89	41.5	.47	42	.47	21	.24
27894/2:3	92	45.5	.50	34	.37	30	.22
27894:20	97	45	.46	41	.41	24	.25

DESCRIPTION: The conch is discoidal, stout, narrowly umbilicated. The whorl section is subquadrate, with very high and perpendicular umbilical wall and rounded umbilical shoulder. The sides are flattened or slightly convex; rarely they may be slightly concave. The ventrolateral shoulders are distinct and vary from angular to broadly rounded. The venter is broad and varies from broadly convex to subconvex and even flat. Most of the small specimens have a roof-shaped venter with a very faint siphonal carina. Although the whorl height is remarkably constant (about one-half of the diameter) the whorl thickness is very variable. It is just above the umbilical shoulder and usually is about four-fifths of the whorl height, but it may even be slightly larger. Just above the umbilical shoulder, there are seven or eight, exceptionally six, strong, blunt tubercles which are slightly elongated radially. On the ventrolateral shoulders there is a second row of 14 or 15, exceptionally 13, spirally elongated tubercles. Faint, low, fold-like ribs connect the two rows of tubercles; some of the ribs are intercalated or forked. In those forms that tend to have angular ventrolateral shoulders and flat venters, both the umbilical and the ventrolateral tubercles become high, conical, or even spinose, and the ribs become prominent. On the other hand, in those forms with rounded ventrolateral shoulders and broadly convex venter, the tubercles, particularly the ventrolateral ones, become very faint. The suture is composed of three broad, quadrate saddles on the sides, a fourth saddle on the umbilical wall, 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 gabbi* 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 grossouvrei;* 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 *Diaziceras* 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 Pervinquiére; 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.

Barroisiceras brüggeni KNECHTEL, 1947, *in* Knechtel, Richards, and Rathbun, p. 123, pl. 41, figs. 2–4.

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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27895:1	59	32	.54	14	.24	7	.12
27895:1	73	40	.55	28	.38	7	.09
27895/2	75	38	.51	28	.37	12	.13
27895/3	82	46	.52	23	.28	12.5	.15

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, fig. 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.

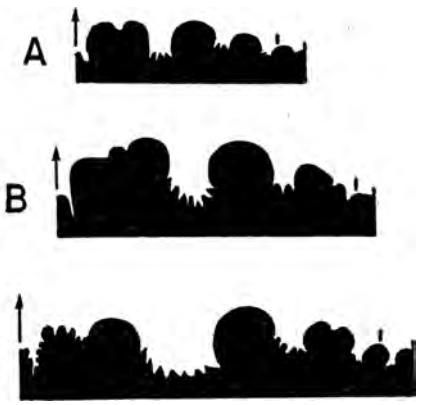


FIG. 58. *Heterotissotia peroni* Lissón. A, B, C. Suture lines of specimens A.M.N.H. Nos. 27895/2, 27895/1:2, and 27895:2; ×1.

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 reichlichen Material das mir von *Het.* vorliegt, kann man nach Windungsquerschnitt Skulptur und Lobenlinien keine irgendwie gut begrentzen Arten unterschieden bezeichnet hat, sind durch reichliche Zwischenformen mit den schmäleren *Semmamensis*-Formen Pervinquières verknüpft. Ganz unabhängig davon variiert die Verzierung, indem sie bei *neoceratites* bald früher, bald später verschwindet; bei *semmamensis* 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. neoceratities* Per. zusammenfassen. Will man die schmalmündigen und stets früh als dritter Name *semmamensis* 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 Lissón'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 Cajamarca section (A.M.N.H. No. 27895). It is associated with *B. bilobatum* and several species of *Tissotia* and *Barroisiceras.*

Heterotissotia bucheri,[1] 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

A.M.N.H. Nos.	D	H	D/H	T	D/T	U	D/U
27896:1	73	38	.52	43	.59	14	.19
27896:2	75	36.5	.49	40	.53	17	.23
27896/1:1	81.5	40.5	.50	47	.58	18	.22
27896:3	82	40.5	.49	51.5	.62	—	—
27896:4	85	45	.53	47	.55	16	.19
27896:5	89	45	.51	41	.46	18	.20
27896:6	90	46	.51	42	.47	20	.22

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*) *haberfellneri*, *B.* (*B.*) *kayi*, *Barroisiceras* (*Solgerites*) *brancoi*, *Barroisiceras* (*Forresteria*) *basseae*, *B.* (*F.*) *alluaudi*, and *Tissotia hedbergi*.

FAMILY LENTICERATIDAE HYATT, 1900

LENTICERAS GERHARDT, 1898

Lenticeras baltai Lissón

Plate 66, figures 1–2

Lenticeras baltae LISSÓN, 1908, p. 14, pls. 14a, 14b.

Lenticeras baltae Lissón; LISSÓN, 1936, p. 53, pls. 1–3.

Lenticeras baltae Lissón; BASSÉ, 1942, p. 354.

Lenticeras baltae 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 ogive 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. (Lissón'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 gerhardti* 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. gerhardti* and finds that the ribs are very inconspicuous. *Lenticeras andii* Gabb (Lissón, 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 hourcqi*, *Desmophyllites gaudama*, *Tissotia steinmanni*, and *T. fourneli*. Lissón's holotype is from Hacienda Quilca, Provincia Pomabamba, Marañón River. Rivera (1949) reports it from Rio Pachitea (Huánuco) and Pongo de Rentema (Jaen).

Lenticeras lissoni Knechtel

Plate 66, figures 3–4

Lenticeras lissoni KNECHTEL, 1947, *in* Knechtel, Richards, and Rathbun, p. 127, pl. 46, figs. 1–2.

One poorly preserved steinkern represents this species. The present writer has examined the holotype.

MEASUREMENTS

A.M.N.H. No.	D	H	D/H	T	D/T	U	D/U
27898	132	78	.59	57	.43	—	—
Knechtel's holotype	143	78	.59	66	.49	—	—

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 Celendín 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. cañaense, Gauthiericeras lenti, Gauthiericeras margae,* and *Amaltheus sieversi.*

INCERTAE SEDIS

NEOLOBITES FISCHER, 1882

Neolobites kummeli,[1] new species

Plate 66, figures 5–6

Neolobites cf. *peroni* Hyatt; SCHLAGINTWEIT, 1912, p. 100, text fig. 4.

Neolobites cf. *Vibrayeanus* d'Orb.; BOIT, 1926, p. 40.

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 small, 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, 1898)]. *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. pollocense, A. sangalense, Forbesiceras* sp., and *Lissoniceras mermeti.*

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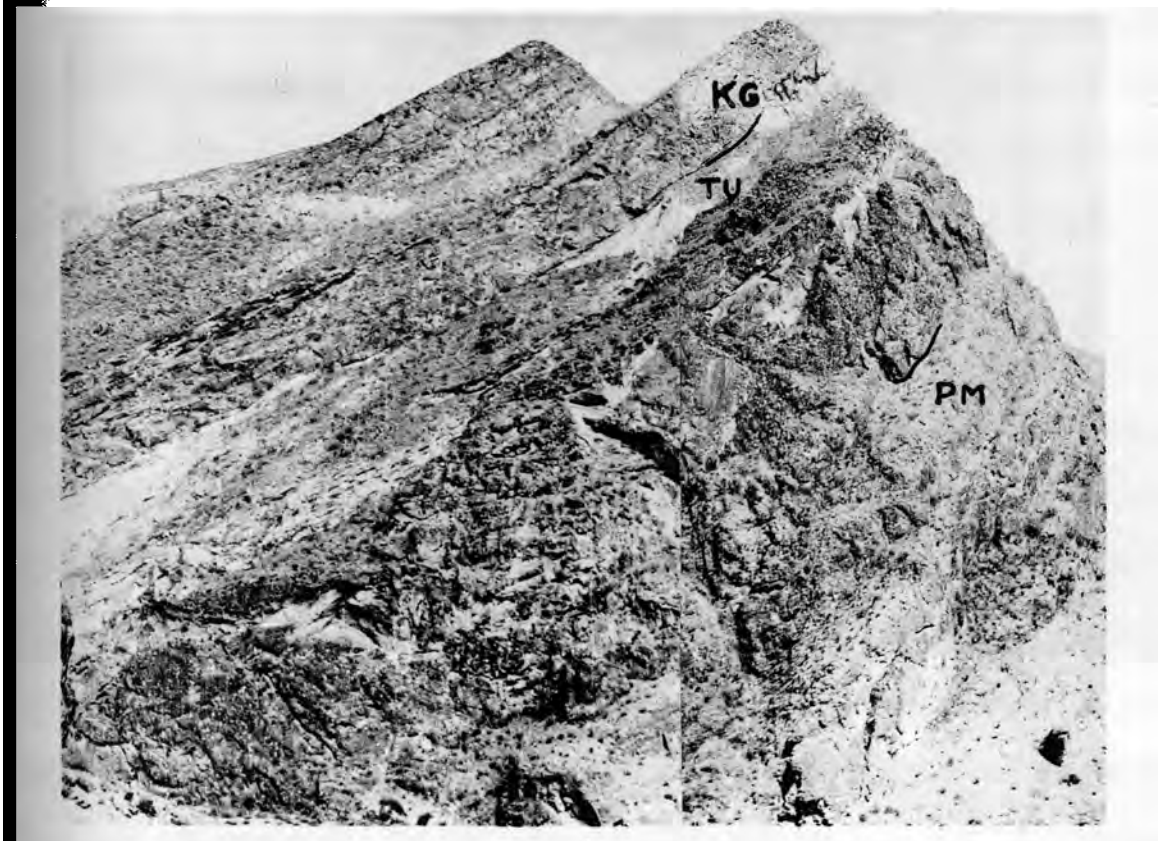
PLATES 31–66

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.



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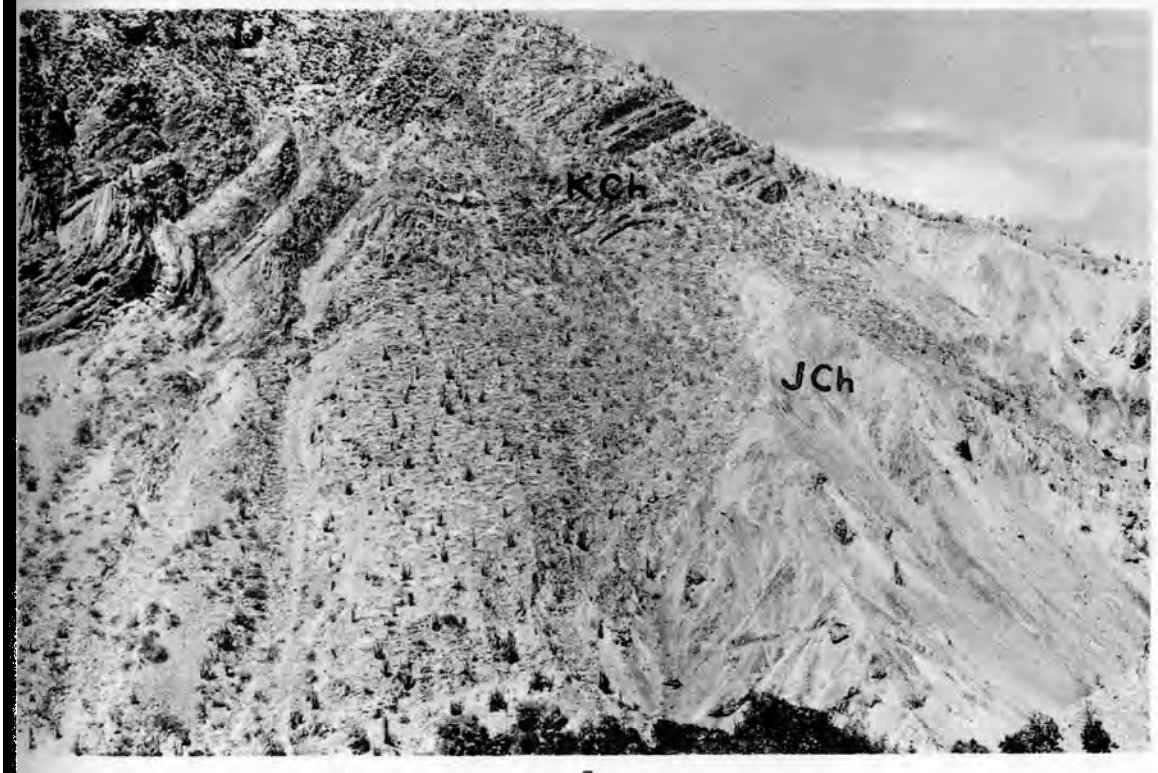

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PLATE 32

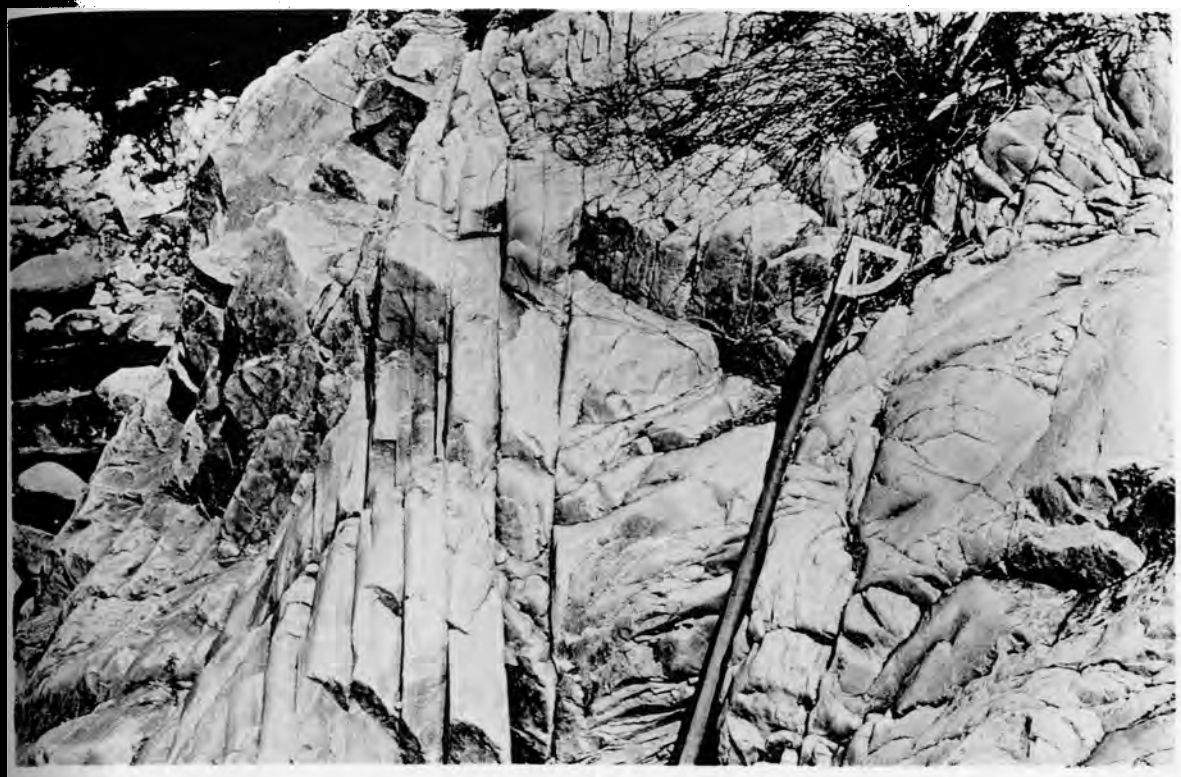
1. Santa formation (KS) overlying Chimú sandstone (KCh). El Cepo anticline, north of Hacienda Farrat.

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.

PLATE 33

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 (KI), overlying Goyllarisquisga formation (KG) and underlying Chulec formation (KChu); Cajamarca section, 1 kilometer north of Baños del Inca, Cajamarca.



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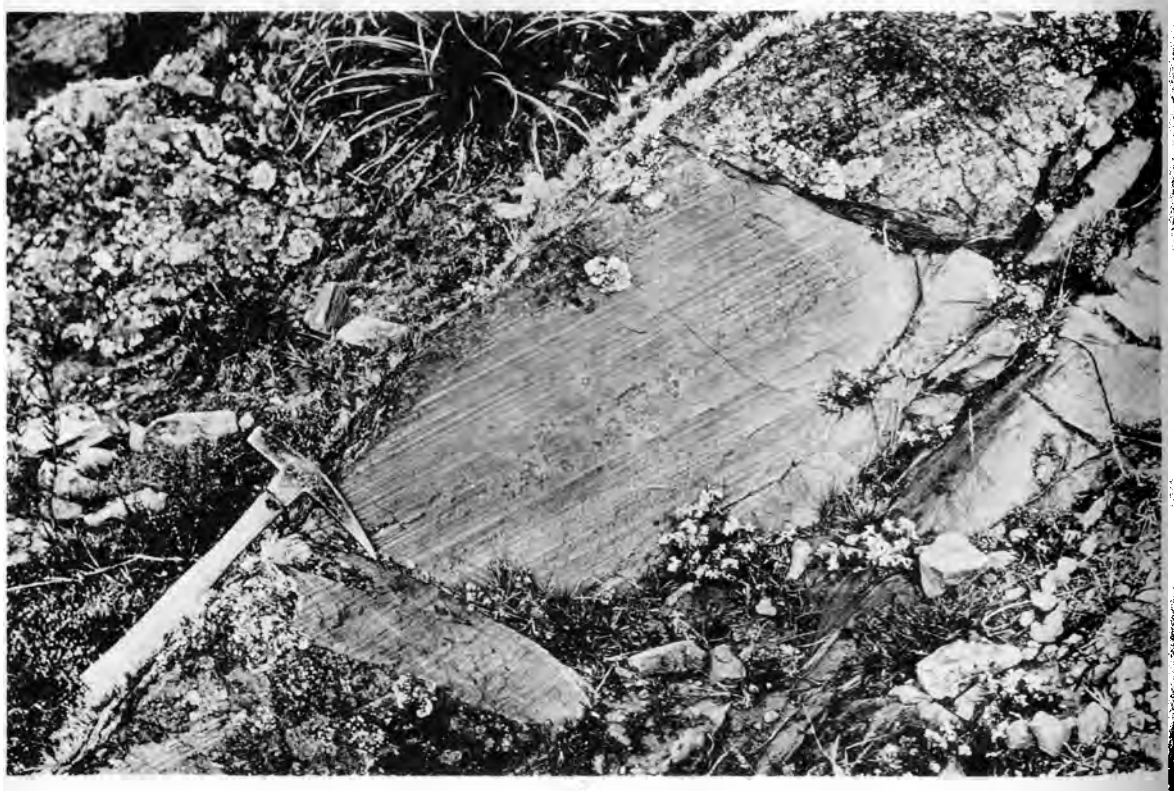

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PLATE 34

1. Sandstone of the Goyllarisquisga formation. Cajamarca section, Cerro Abilón, east 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.

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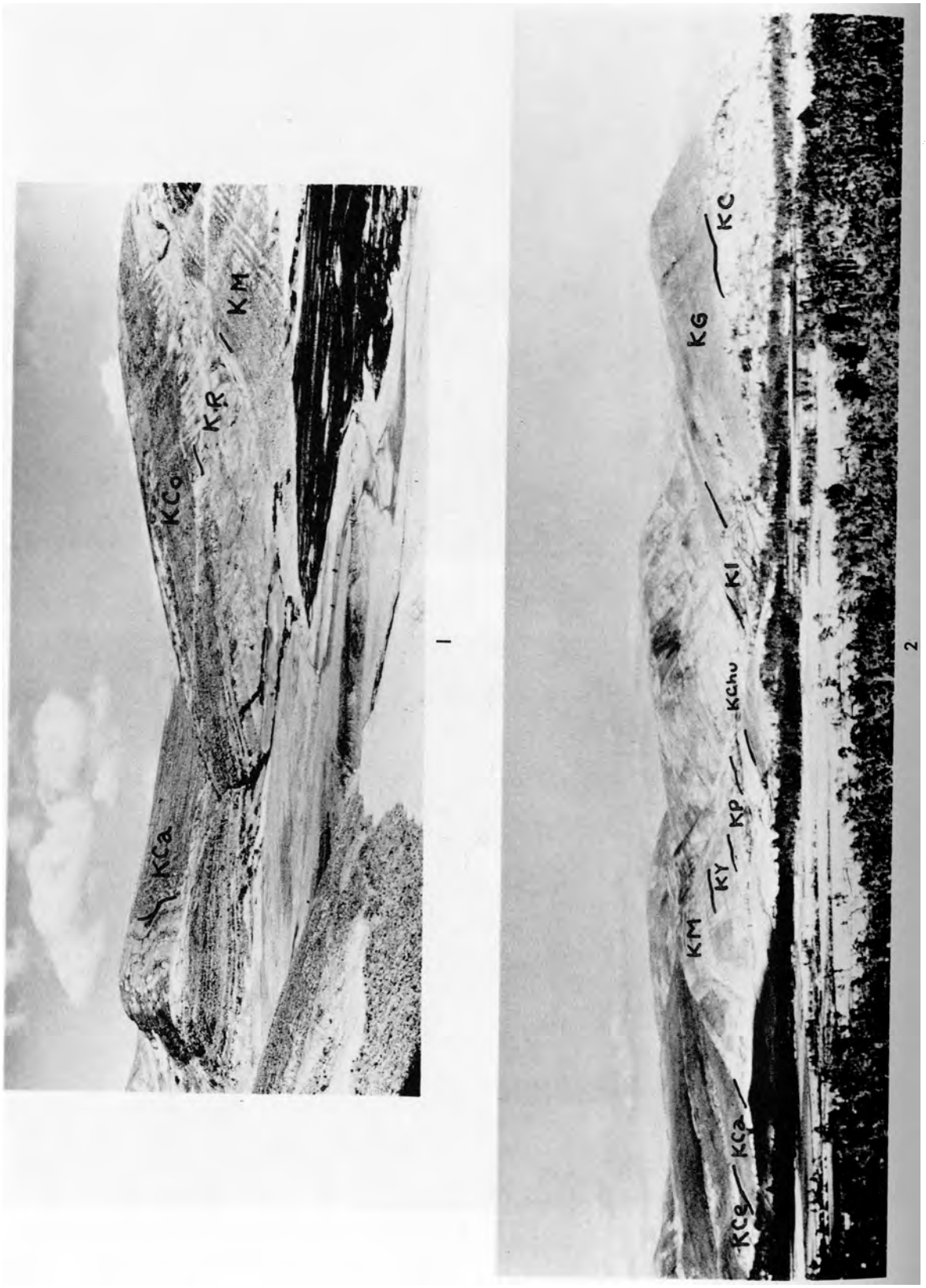
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PLATE 36

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

1. Typical wavy-bedded, nodular limestone of the Yumagual formation. Chicama section, north of Hacienda Huaycot, upper Chicama Valley.

2. Section near Puerto Nuevo, Yanacanchilla, east of Hualgayoc, Mujarrún formation (KM), Quillquiñan group (KQ), and Cajamarca formation (KCa).

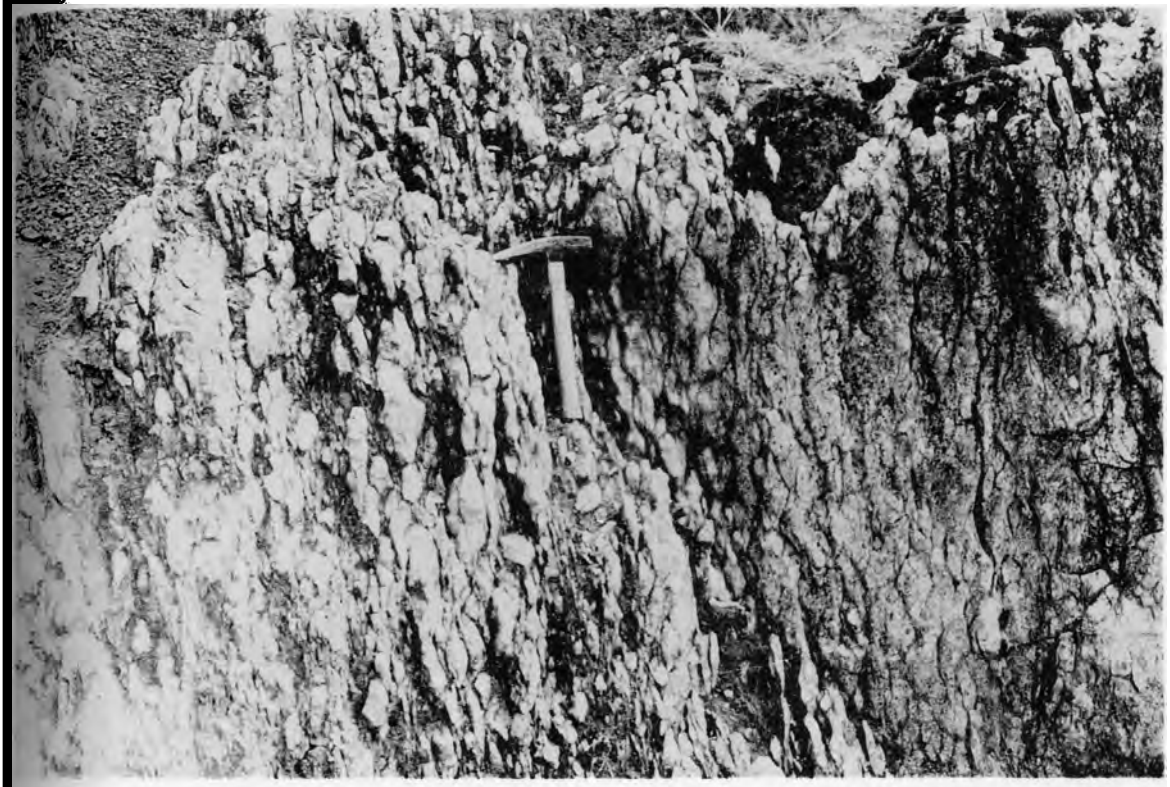

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PLATE 38

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.

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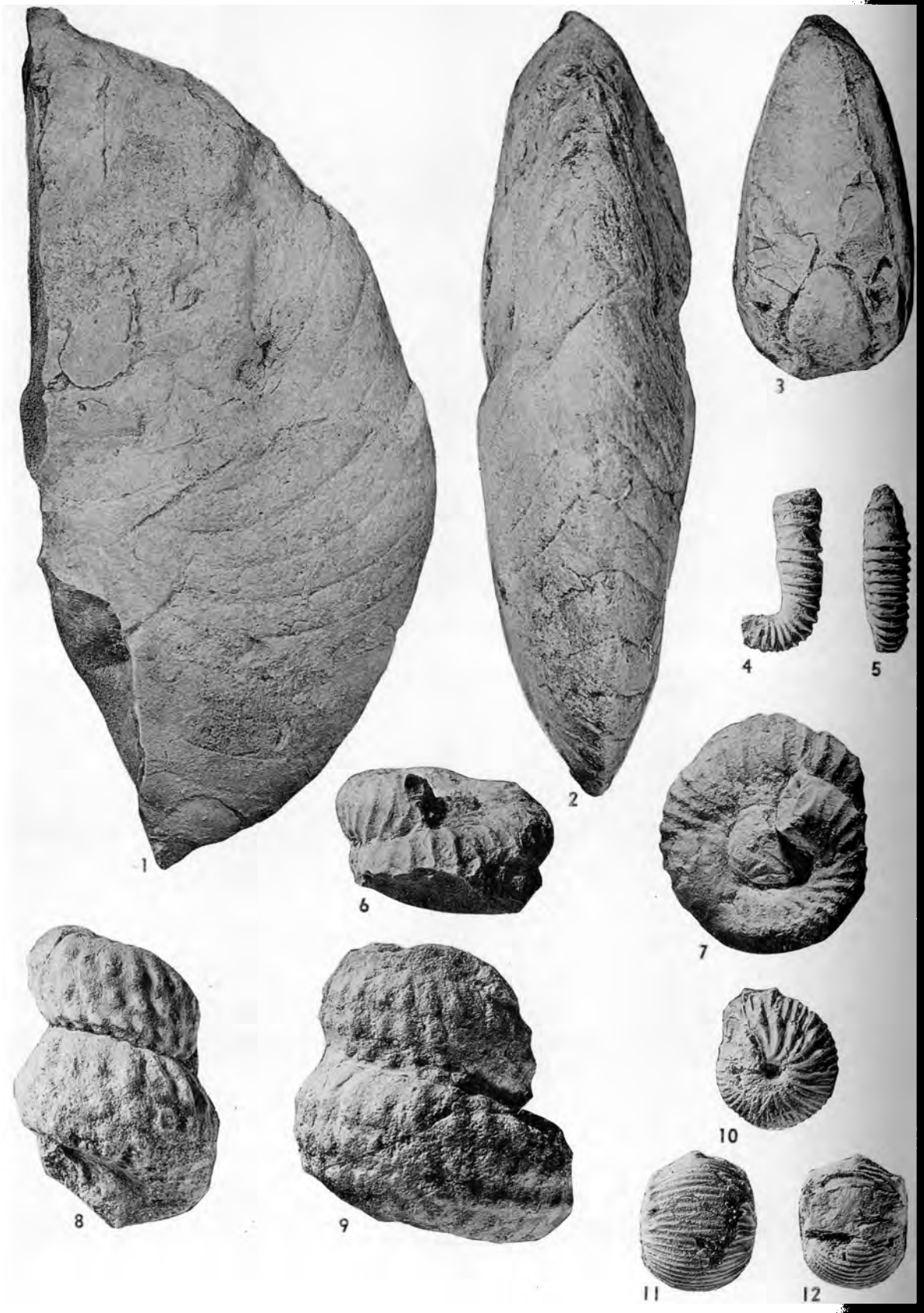
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PLATE 40

1–3. *Lissoniceras mermeti* (Coquand). 1, 2. A.M.N.H. No. 27381/1:1, lateral and ventral views, ×1. 3. A.M.N.H. No. 27381/1:2, frontal view, ×1.

4, 5. *Protanisoceras blancheti* (Pictet and Campiche), A.M.N.H. No. 27832, lateral and ventral views, ×1.

6, 7. *Bostrychoceras?* sp. indet., A.M.N.H. No. 27835, lateral and basal views, ×1.

8, 9. *Paraturrilites lewesiensis* (Spath). 8. A.M.N.H. No. 27833:1, lateral view, ×1. 9. A.M.N.H., No. 27833:2, lateral view, ×1.

10–12. *Valanginites broggii* (Lissón), 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, ×2.

3, 4. *Desmophyllites gaudama* (Forbes), A.M.N.H. No. 27389, lateral and frontal views, ×1.

5–8. *Desmoceras chimuense,* new species. 5, 6. A.M.N.H. No. 27388:2, lateral and ventral views, ×1. 7, 8. A.M.N.H. No. 27388:1, holotype, lateral and ventral views, ×1.


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PLATE 42

1–8. *Parahoplites quilla*, new species. 1–3. A.M.N.H. No. 27391:1, holotype, frontal, ventral, and lateral views, ×1. 4–6. A.M.N.H. No. 27391:2, frontal, ventral, and lateral views, ×1. 7, 8. A.M.N.H. No. 27391:3, lateral and ventral views, ×1.

9, 10. *Parahoplites inti*, new species, holotype, A.M.N.H. No. 27392, lateral and ventral views, ×1.

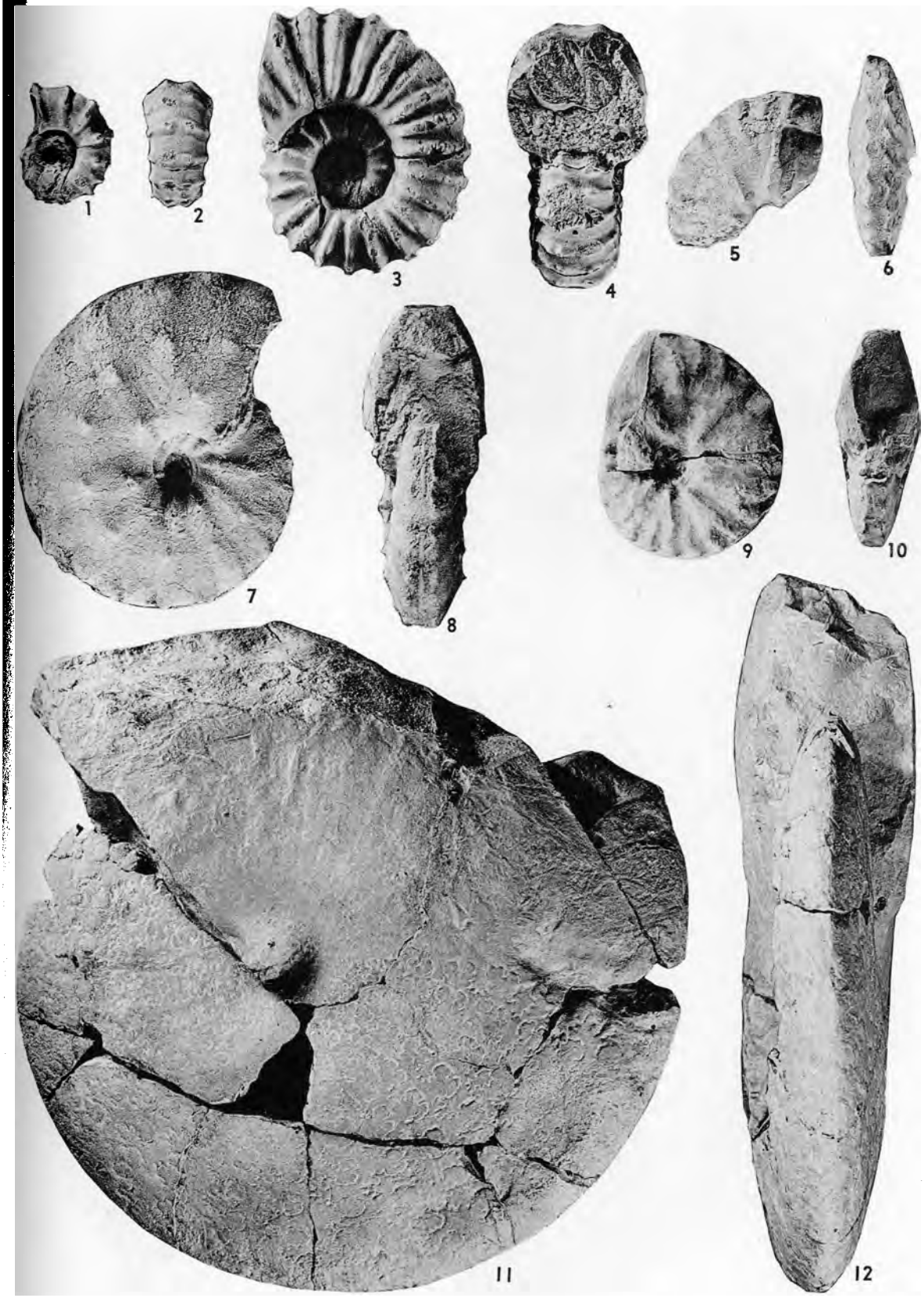
11, 12. *Parahoplites nicholsoni*, new species, holotype, A.M.N.H. No. 27390:1, lateral and ventral views, ×1.

PLATE 43

1–4. *Douvilleiceras monile* (Sowerby). 1, 2. Lateral and ventral views of inner whorls of specimen A.M.N.H. No. 27393, ×2. 3, 4. Lateral and ventral views of specimen A.M.N.H. No. 27393, ×1.

5–10. *Parengonoceras tetranodosum* (Lissón). 5, 6. A.M.N.H. No. 27398, lateral and ventral views, ×1. 7, 8. A.M.N.H. No. 27398:2, lateral and ventral views, ×1. 9, 10. A.M.N.H. No. 27398:1, lateral and ventral views, ×1.

11, 12. *Engonoceras* sp. indet., A.M.N.H. No. 27395, lateral and ventral views, ×1/2.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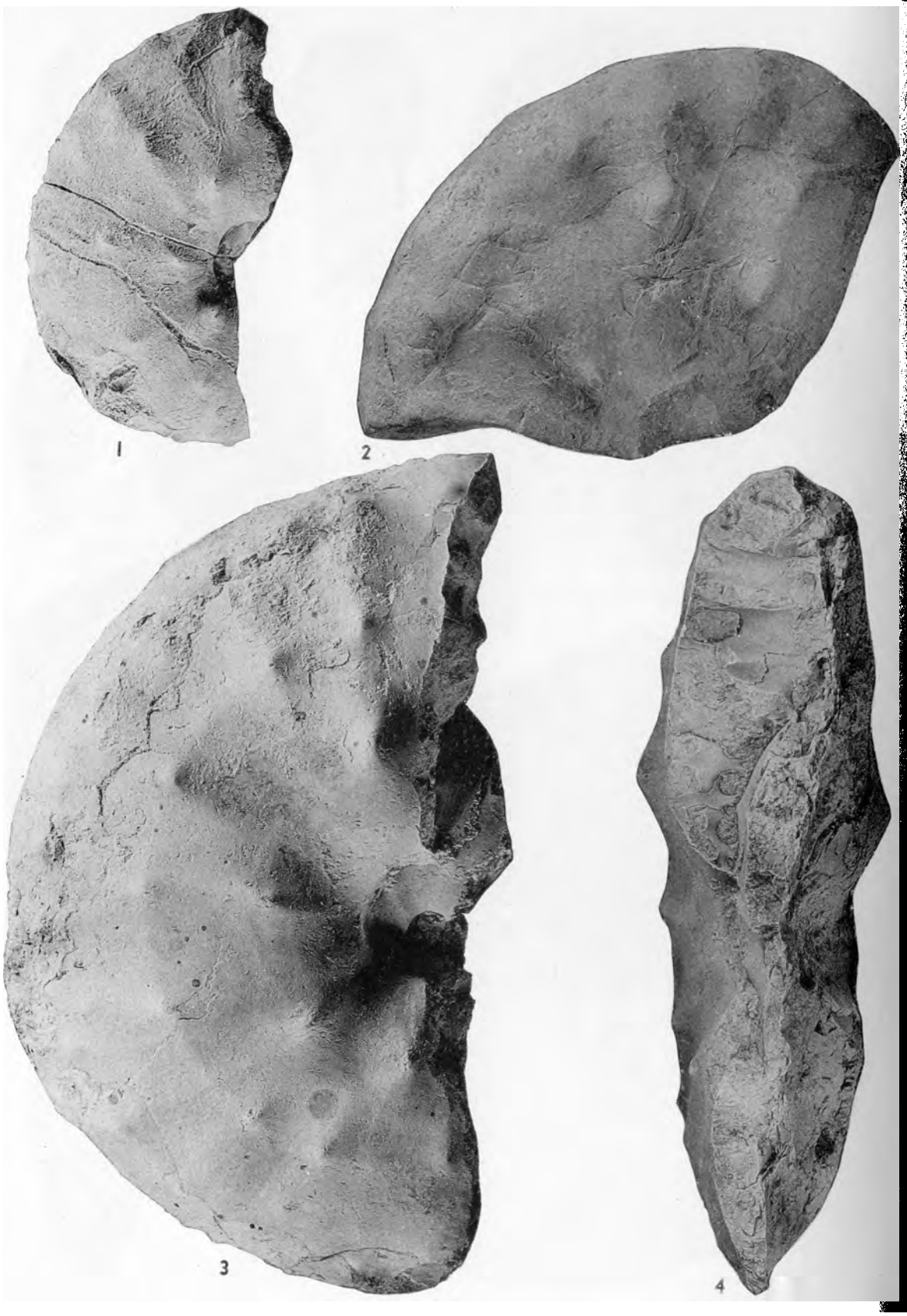
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PLATE 44

1. *Parengonoceras tetranodosum* (Lissón), A.M.N.H. No. 27398:3, lateral view, ×1.
2. *Parengonoceras guadaloupaeforme* (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

1–5. *Parengonoceras pernodosum* (Sommermeier). 1, 2. A.M.N.H. No. 27396, lateral and ventral views, ×1. 3–5. A.M.N.H. No. 27396:2, lateral, ventral, and frontal views, ×1.


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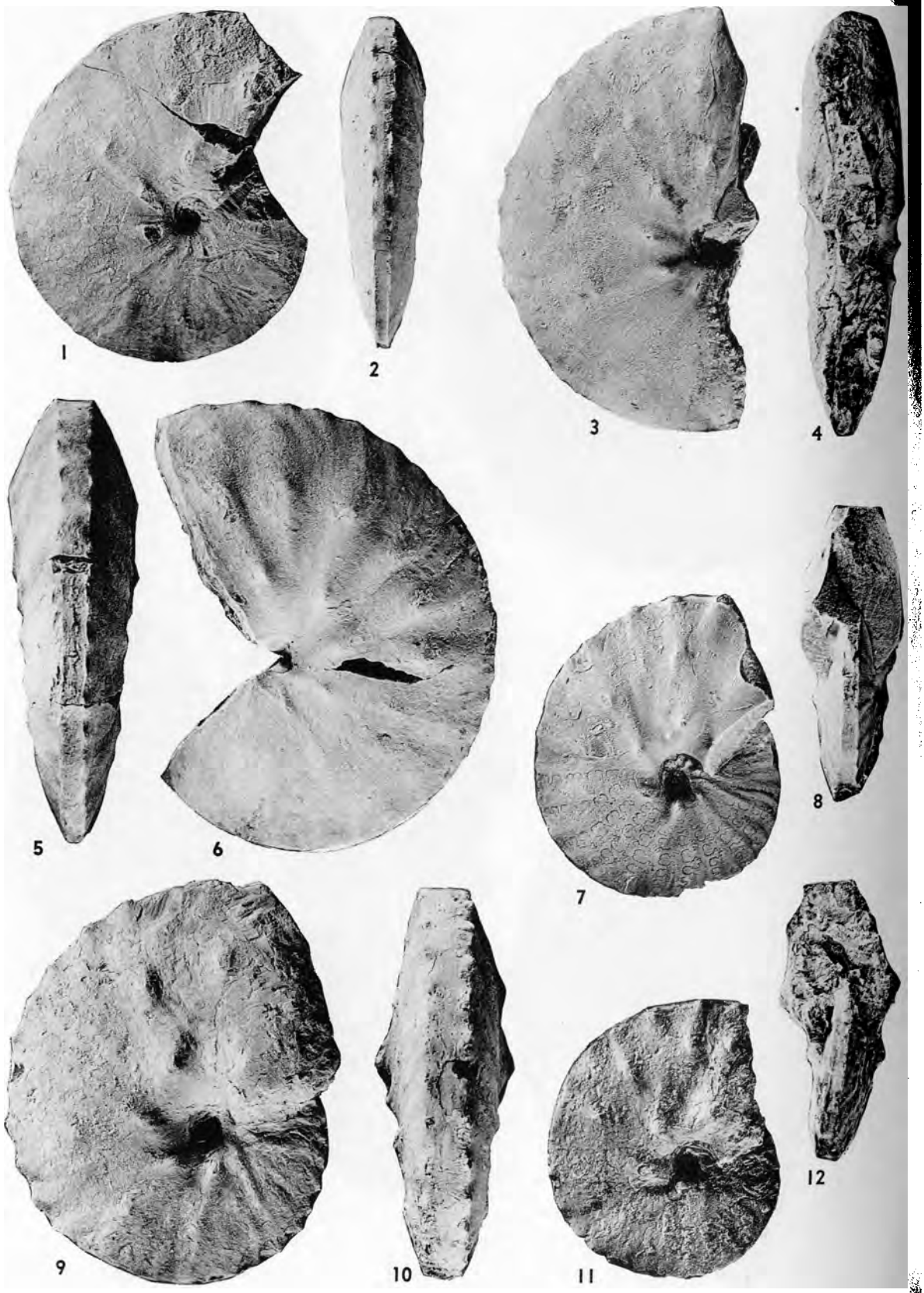
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PLATE 46

1–6. *Parengonoceras haasi*, new species. 1, 2. A.M.N.H. No. 27399:3, lateral and ventral views, ×1. 3, 4. A.M.N.H. No. 27399:2, lateral and frontal views, ×1. 5, 6. Holotype, A.M.N.H. No. 27399:1, ventral and lateral views, ×1.

7–10. *Knemiceras attenuatum* (Hyatt). 7, 8. A.M.N.H. No. 27849:1, lateral and ventral views, ×1. 9, 10. A.M.N.H. No. 27849/3, lateral and ventral views, ×1.

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.

3. *Knemiceras gabbi* Hyatt, A.M.N.H. No. 27852, lateral view, ×2/3.

4, 5. *Knemiceras syriacum* (von Buch), A.M.N.H. No. 27851, lateral and ventral views, ×1.


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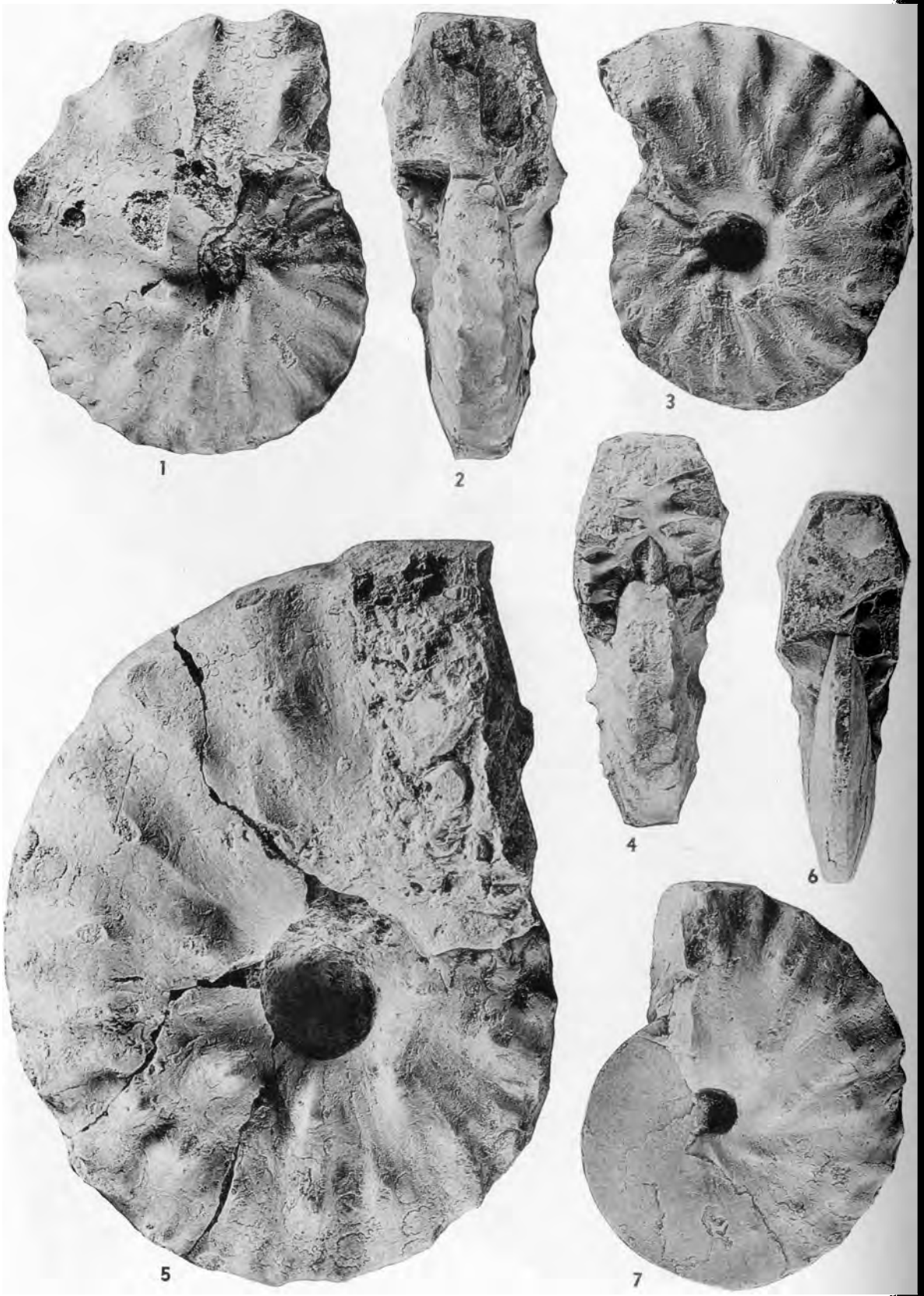
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PLATE 48

1–5. *Knemiceras raimondii* (Lissón). 1, 2. A.M.N.H. No. 27856:4, lateral and frontal views, ×1. 3, 4. A.M.N.H. No. 27856:2, lateral and frontal views, ×1. 5. A.M.N.H. No. 27856:7, lateral view, ×1.

6, 7. *Knemiceras raimondii tardum*, new subspecies, A.M.N.H. No. 27858, holotype, frontal and lateral views, ×1.

PLATE 49

1. *Knemiceras raimondii pacificum*, new subspecies, A.M.N.H. No. 27857, holotype, lateral view, ×1.

2–4. *Brancoceras aegoceratoides* Steinmann. 2. A.M.N.H. No. 27866:1, lateral view, ×1. 3, 4. A.M.N.H. No. 27866:2, lateral and ventral views, ×1.

5. *Oxytropidoceras peruvianum* (von Buch), A.M.N.H. No. 27861, lateral view, ×1.

6. *Oxytropidoceras carbonarium* (Gabb), A.M.N.H. No. 27860, lateral view, ×1.


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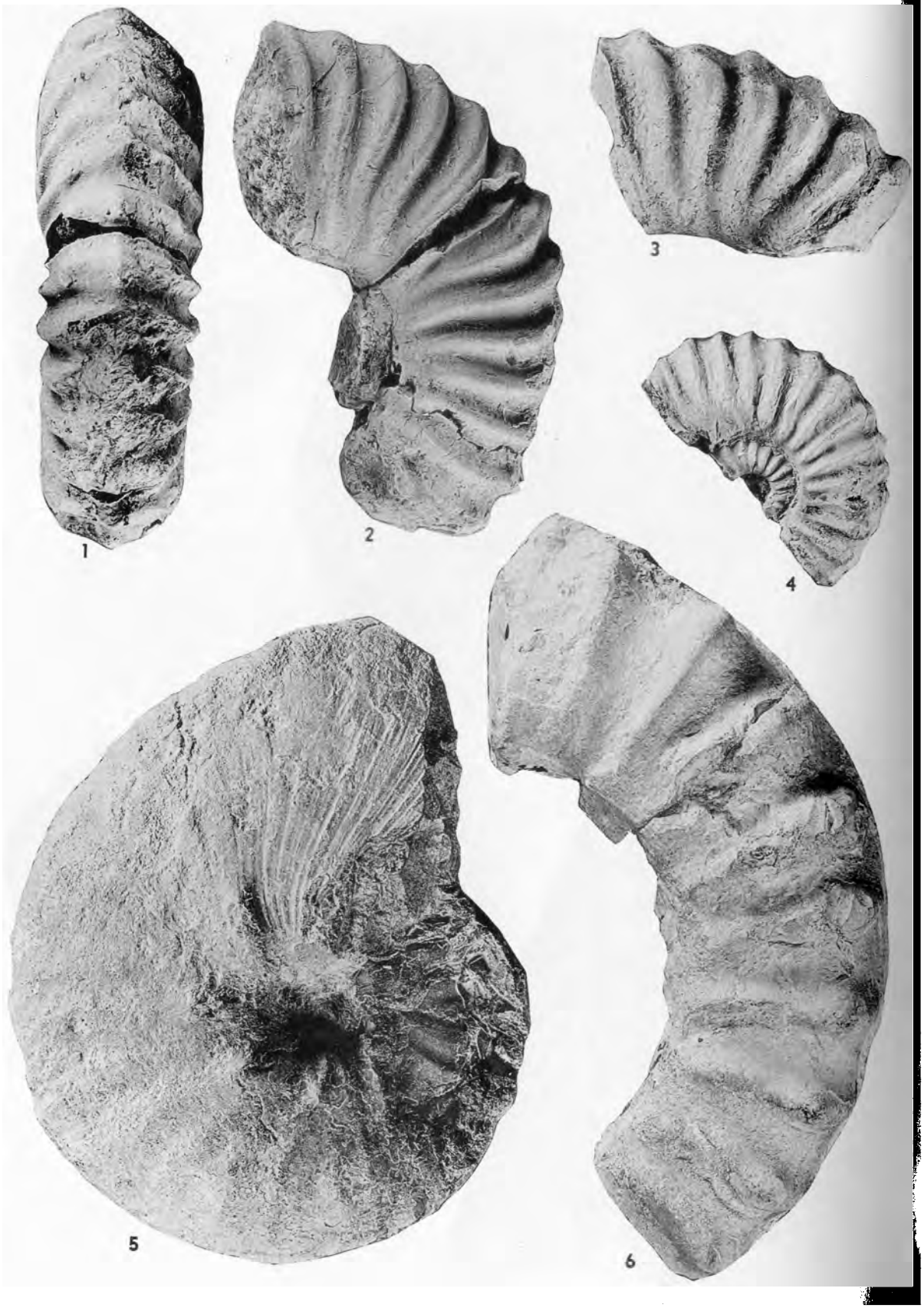
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PLATE 50

1–4. *Prolyelliceras peruvianum* Spath. 1, 2. A.M.N.H. No. 27867:1, ventral and lateral views, ×1. 3. A.M.N.H. No. 27867:3, lateral view, ×1. 4. A.M.N.H. No. 27867:2, lateral view, ×1.

5. *?Knemiceras ollonense* (Gabb), A.M.N.H. No. 27855, lateral view, ×1.

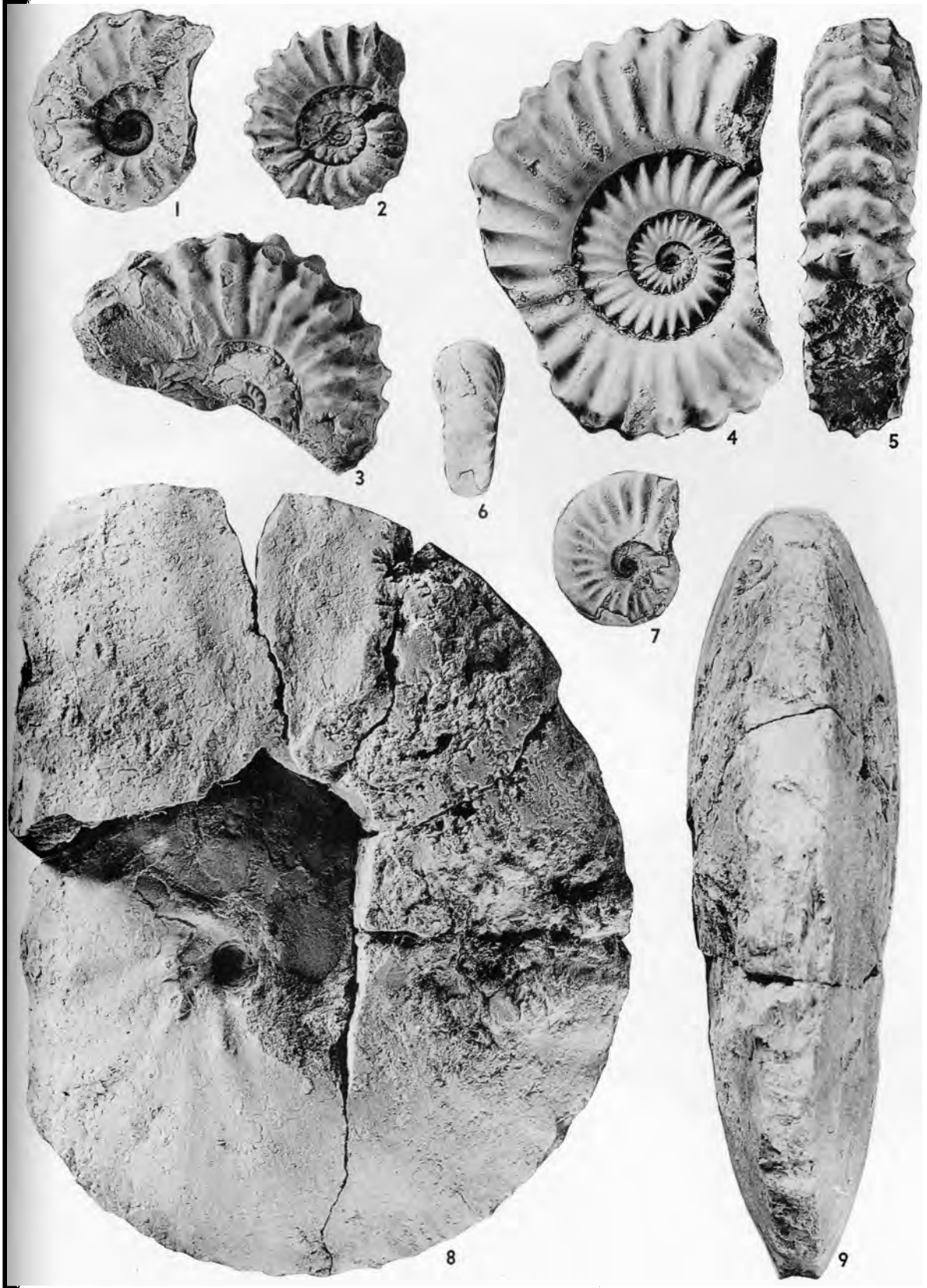
6. *Dipoloceras* sp. indet., A.M.N.H. No. 27865, lateral view, ×2/3.

PLATE 51

1–3. *Lyelliceras lyelli* (Leymerie) d'Orbigny. 1. A.M.N.H. No. 27868:6, lateral view, ×2. 2. A.M.N.H. No. 27868:4, lateral view, ×1. 3. A.M.N.H. No. 27868:2, lateral view, ×1.

4–7. *Lyelliceras ulrichi* Knechtel. 4, 5. A.M.N.H. No. 27870:3, lateral and ventral views, ×1. 6, 7. A.M.N.H. No. 27870:1, lateral and ventral views, ×2.

8, 9. *Parengonoceras? champaraense*, new species, A.M.N.H. No. 27848, holotype, lateral and ventral views, ×1.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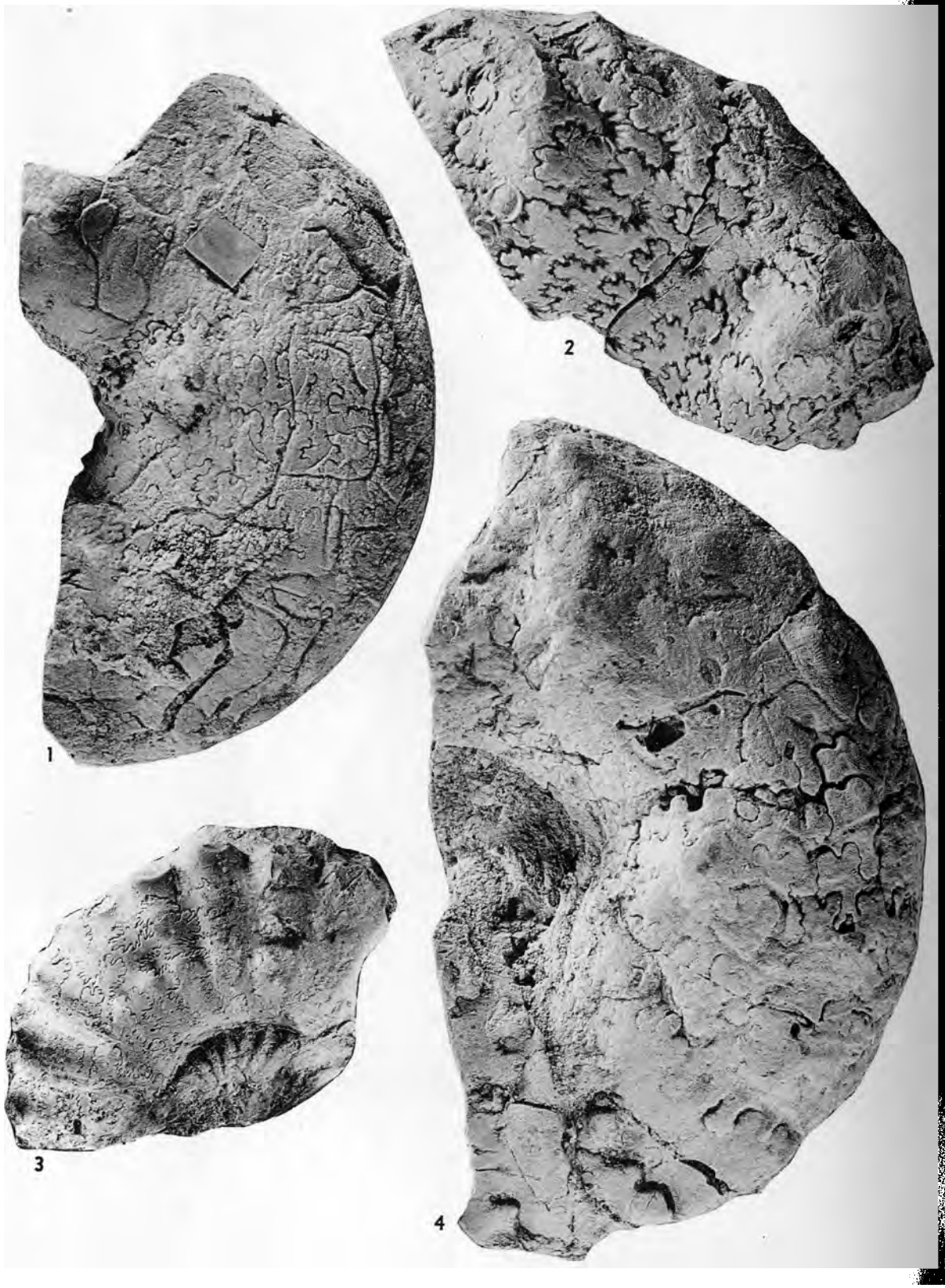
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PLATE 52

1, 4. *Knemiceras ovale*, new species. 1. A.M.N.H. No. 27854:1, lateral view, ×1. 4. A.M.N.H. No. 27854, holotype, lateral view, ×1.

2. *Knemiceras? ziczag* Breistroffer, A.M.N.H. No. 27859, lateral view, ×1.

3. *Lyelliceras pseudolyelli* Parona and Bonarelli, A.M.N.H. No. 27869:2, lateral view, ×1.

PLATE 53

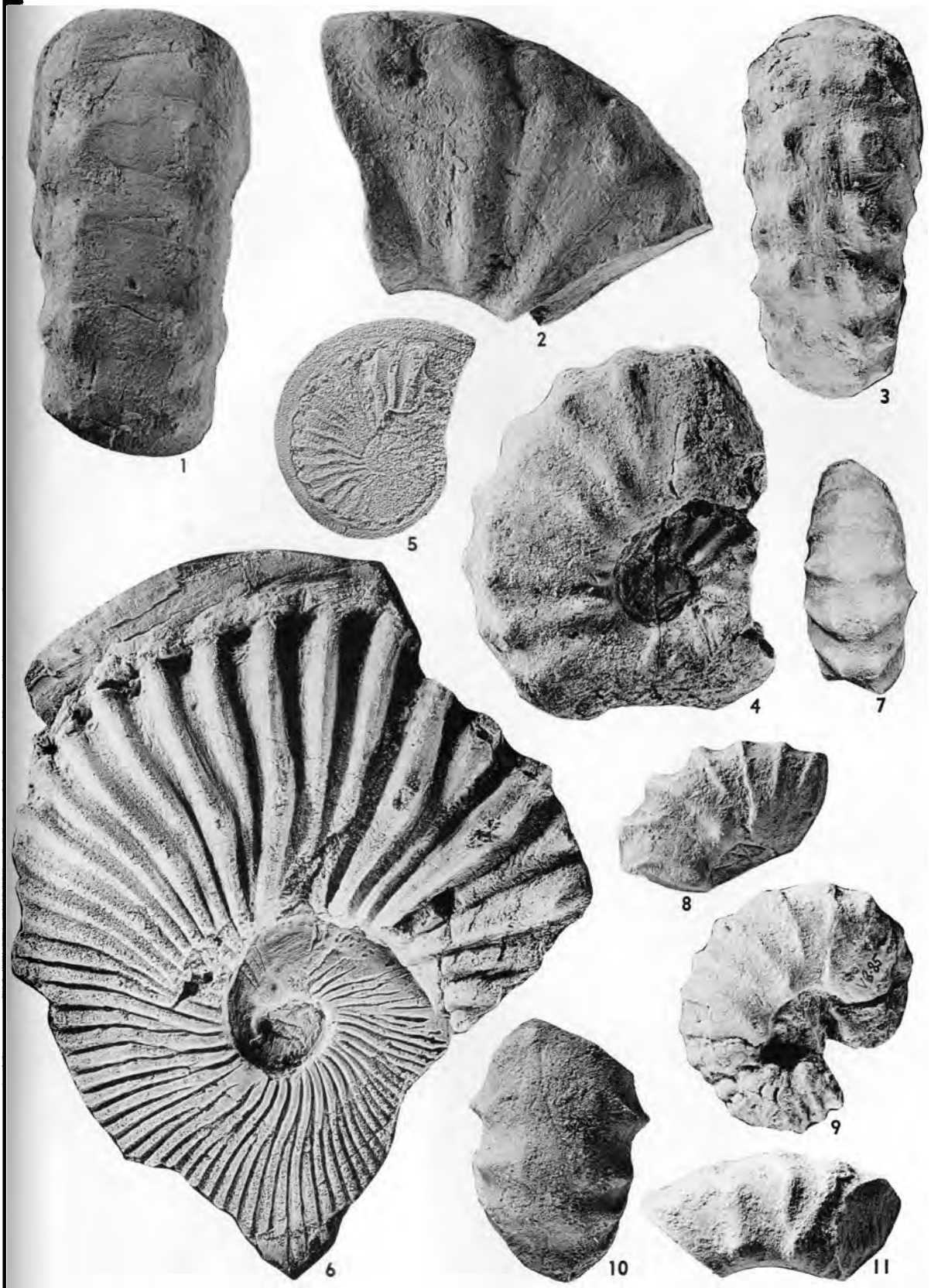
1–4. *Acanthoceras chasca*, new species. 1, 2. A.M.N.H. No. 27872/1, ventral and lateral views, ×1. 3, 4. A.M.N.H. No. 27872, holotype, ventral and lateral views, ×1.

5. *Venezoliceras venezolanum* (Stieler), A.M.N.H. No. 27863, lateral view, ×1.

6. *Venezoliceras harrisoni*, new species, A.M.N.H. No. 27864, holotype, lateral view, ×1.

7–9. *Acanthoceras sangalense*, new species. 7, 8. A.M.N.H. No. 27874:1, holotype, ventral and lateral views, ×1. 9. A.M.N.H. No. 27874:2, lateral view, ×1.

10, 11. *Acanthoceras pollocense*, new species, A.M.N.H. No. 27873:1, holotype, ventral and lateral views, ×1.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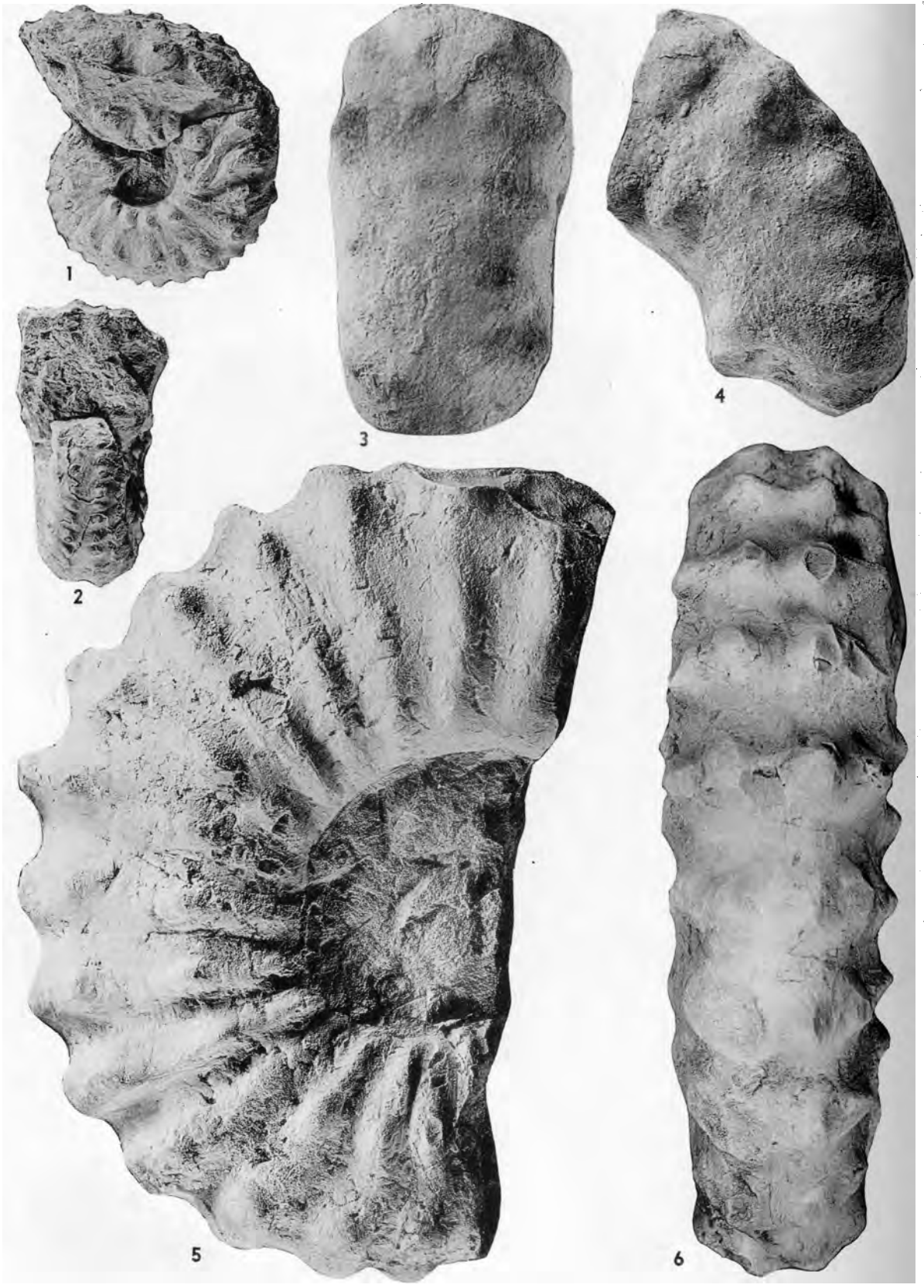
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PLATE 54

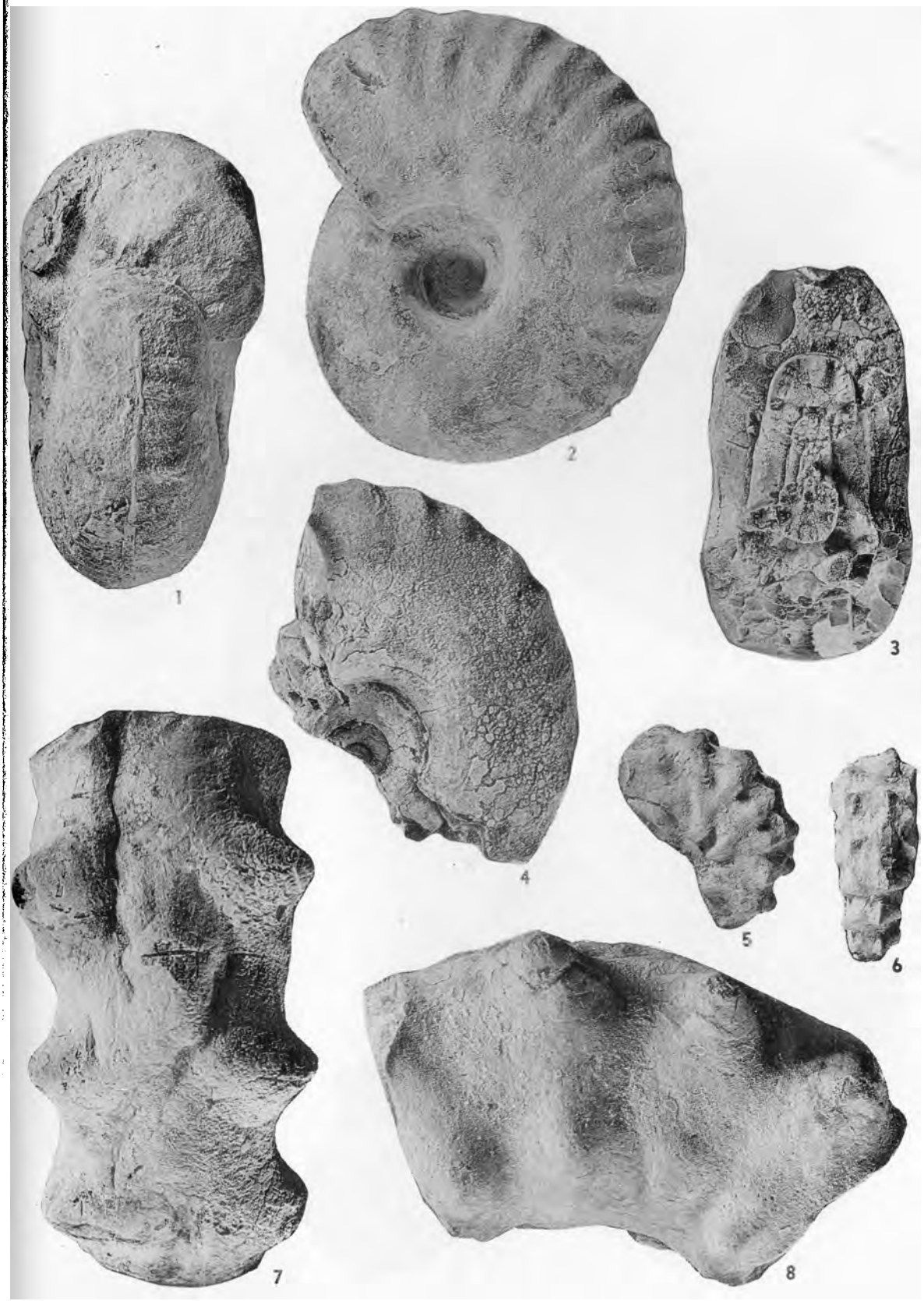
1–4. *Pseudoaspidoceras reesidei*, new species. 1, 2. A.M.N.H. No. 27876:1, holotype, lateral and frontal views, ×1. 3, 4. A.M.N.H. No. 27876:3, ventral and lateral views, ×1.

5, 6. *Sharpeiceras occidentale*, new species, A.M.N.H. 27871, holotype, lateral and ventral views, ×1.

PLATE 55

1–4. *Broggiiceras olssoni*, new species, 1, 2. A.M.N.H. No. 27877:5, holotype, frontal and lateral views, ×1. 3, 4. A.M.N.H. No. 27877:9, frontal and lateral views, ×1.

5–8. *Mammites nodosoides afer* Pervinquière. 5, 6. A.M.N.H. No. 27875/1, lateral and ventral views, ×1. 6, 7. A.M.N.H. No. 27875, ventral and lateral views, ×1.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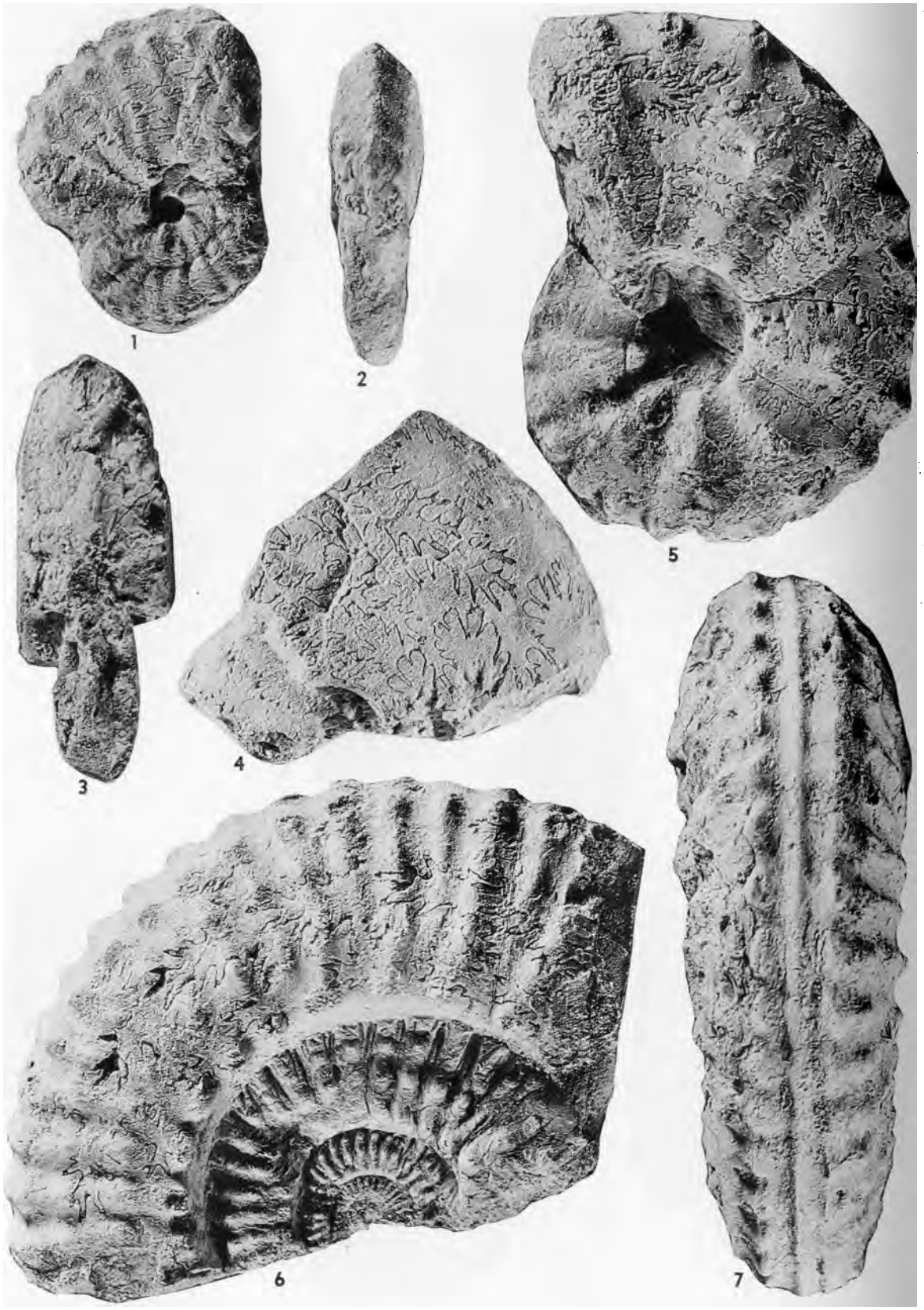
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PLATE 58

1–4. *Barroisiceras* (*Solgerites*) *brancoi* (Solger). 1, 2. A.M.N.H. No. 27887/1, lateral and ventral views, ×1. 3, 4. A.M.N.H. No. 27887:1, frontal and lateral views, ×1.

5. *Barroisiceras* (*Forresteria*) *basseae*, new name, A.M.N.H. No. 27888, lateral view, ×1.

6, 7. *Texanites hourcqi* Collignon, A.M.N.H. No. 27881, lateral and ventral views, ×1.

PLATE 59

1, 2. *Buchiceras bilobatum* Hyatt, A.M.N.H. No. 27894/2:2, frontal and ventral views, ×1.

3, 4. *Coilopoceras jenksi*, new species, A.M.N.H. No. 27882, holotype, lateral and ventral views, ×1.

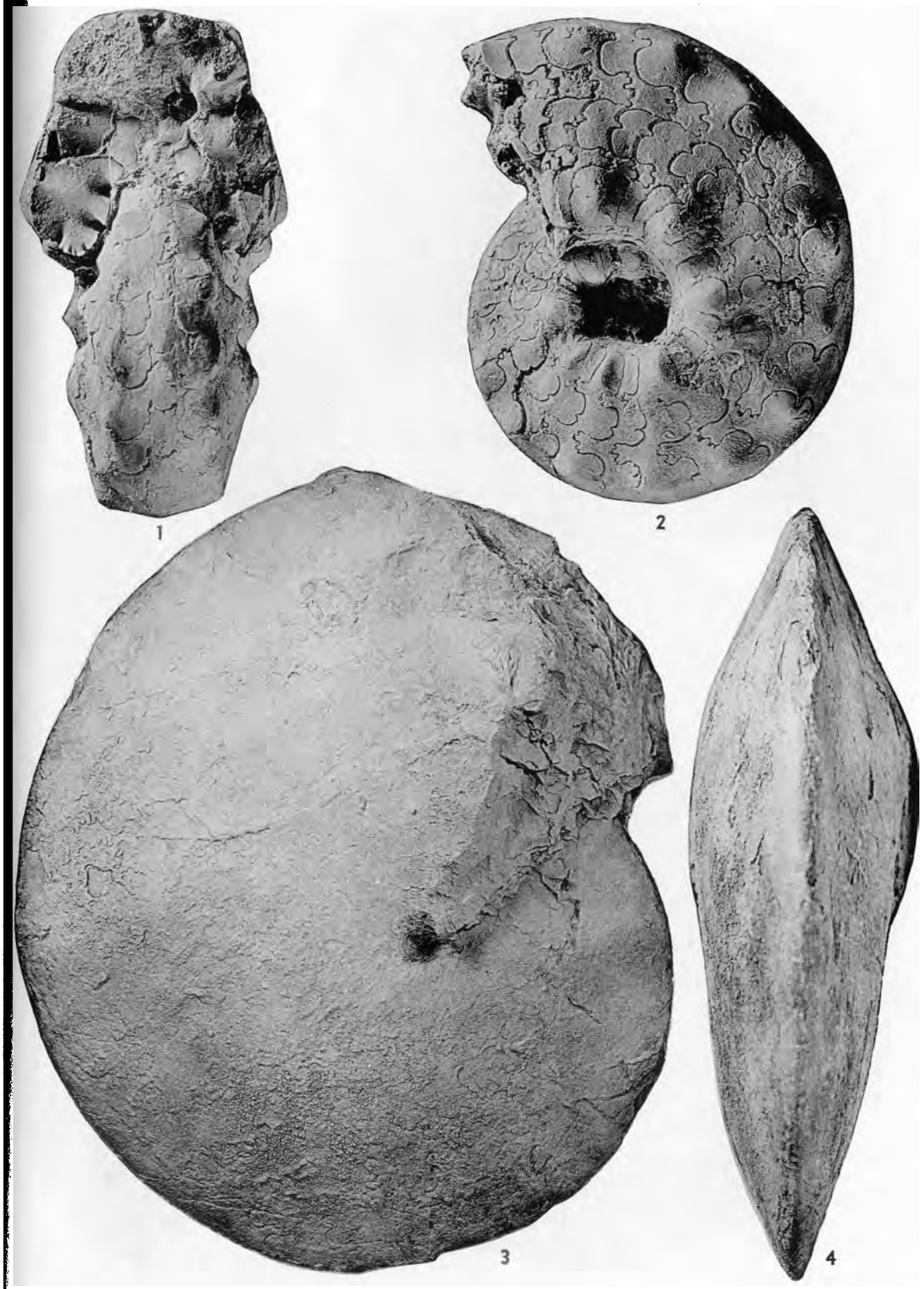
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PLATE 60

1–6. *Buchiceras bilobatum* Hyatt. 1, 2. A.M.N.H. No. 27894:9, lateral and ventral views, ×1. 3, 4. A.M.N.H. No. 27894:7, lateral and ventral views, ×1. 5, 6. A.M.N.H. No. 27894:21, ventral and lateral views, ×1.

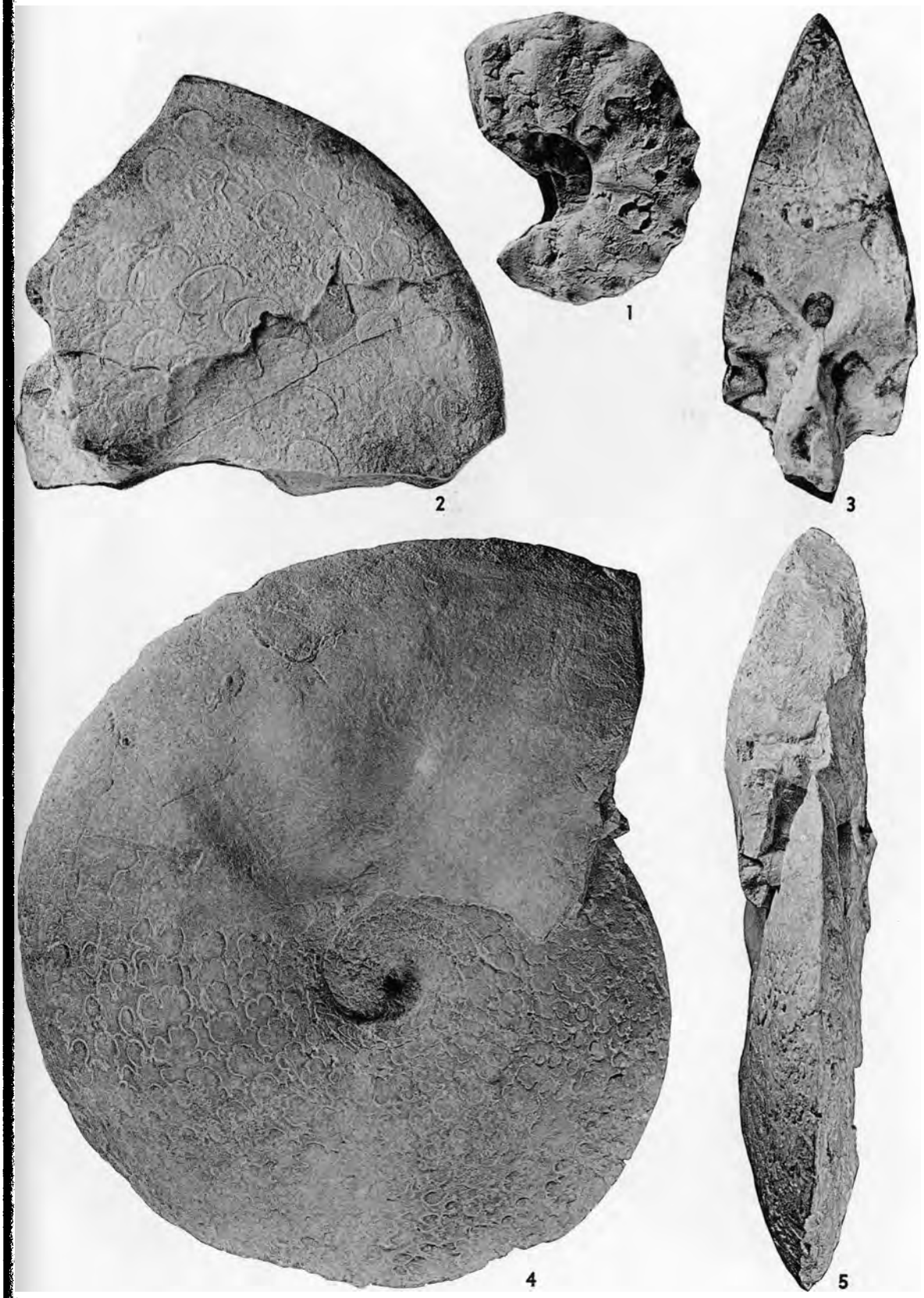
7. *Coilopoceras jenksi*, new species, A.M.N.H. No. 27882/1:1, lateral view, ×4/5.

PLATE 61

1. *Barroisiceras* (*Forresteria*) *alluaudi* Boule, Lemoine, and Thévenin, A.M.N.H. No. 27889, lateral view, ×1.

2, 3. *Tissotia steinmanni* Lissón, A.M.N.H. No. 27890, lateral and frontal views, ×1.

4, 5. *Coilopoceras newelli*, new species, A.M.N.H. No. 27883:7, holotype, lateral and frontal views, ×1/3.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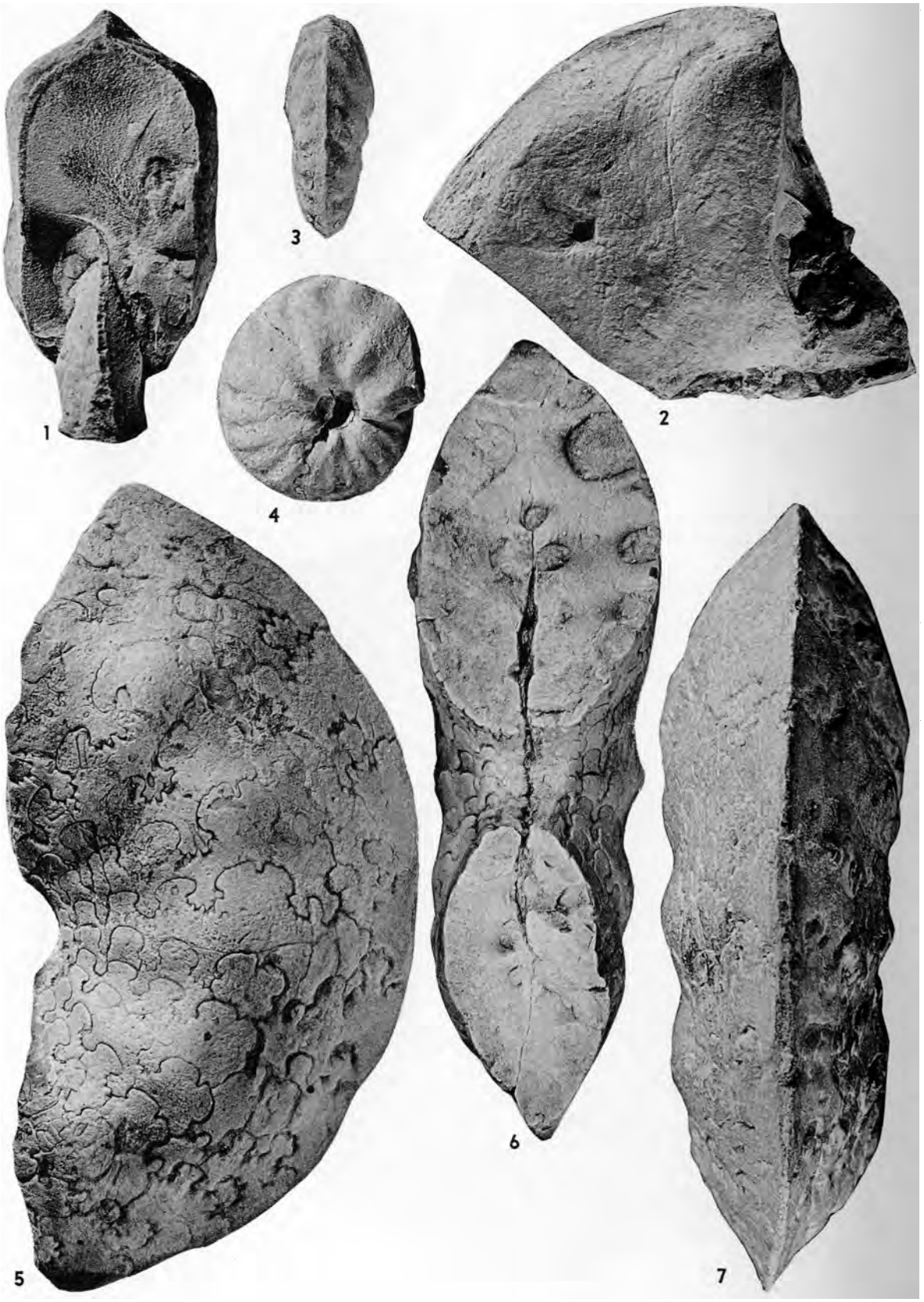
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PLATE 62

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.
5–7. *Coilopoceras newelli*, new species, A.M.N.H. No. 27883:1, lateral, frontal, and ventral views, ×1.

PLATE 63

1–5. *Tissotia hedbergi*. new species. 1, 2. A.M.N.H. No. 27893:3, frontal and lateral views, ×1. 3, 4. A.M.N.H. No. 27893:2, ventral and lateral views, ×1. 5, 6. A.M.N.H. No. 27893:1, holotype, lateral view, ×1.

6–11. *Hoplitoides inca*, new species. 6. A.M.N.H. No. 27884/1:2, lateral view, ×1. 7, 8. A.M.N.H. No. 27884:1, holotype, frontal and lateral views, ×1. 9–11. A.M.N.H. No. 27884:3, lateral, ventral, and frontal views, ×1.

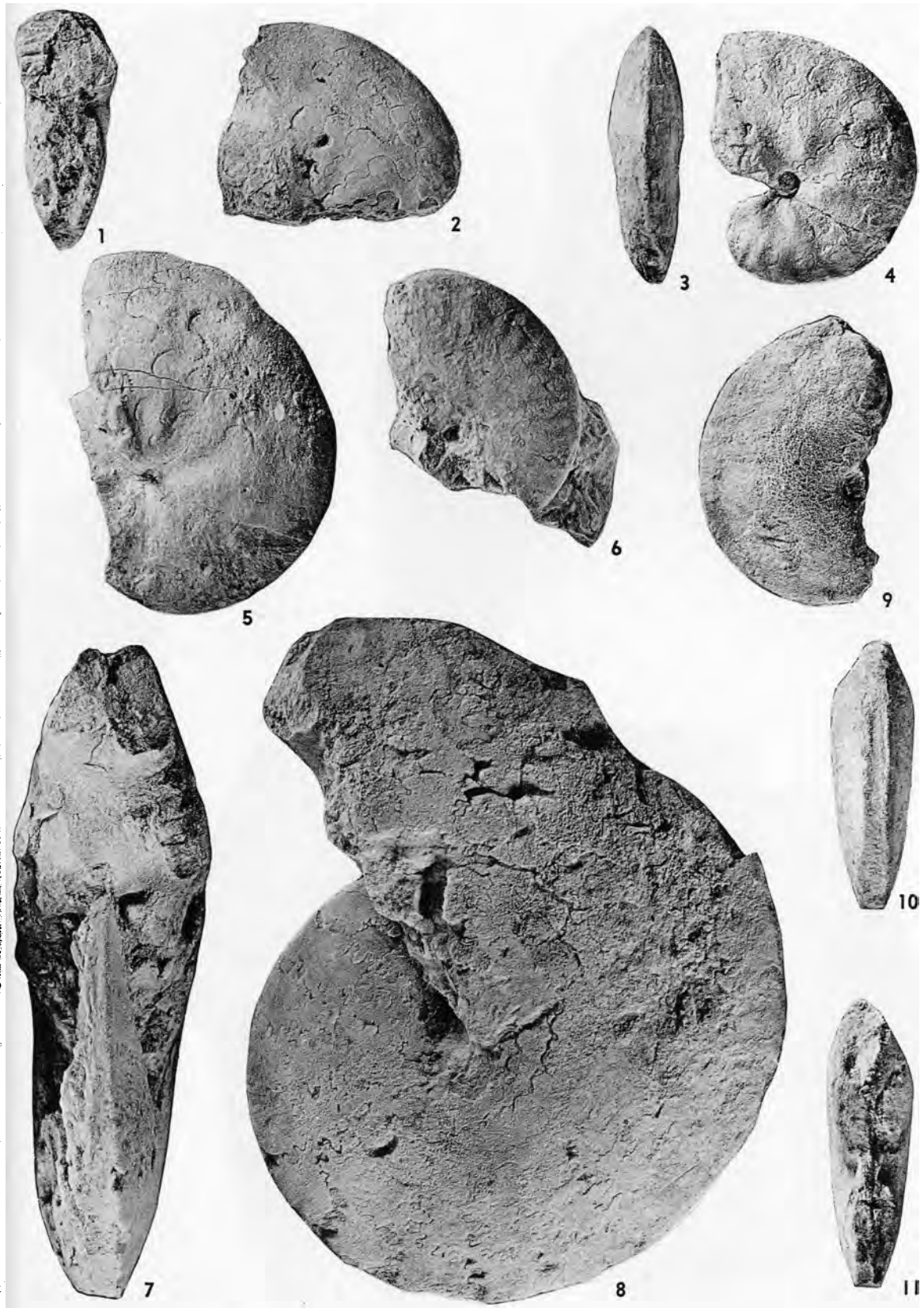
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PLATE 64

1–6. *Heterotissotia peroni* Lissón. 1, 2. A.M.N.H. No. 27895/2, lateral and ventral views, ×1. 3, 4. A.M.N.H. No. 27895/1:2, lateral and ventral views, ×1. 5, 6. A.M.N.H. No. 27895:2, lateral and frontal views ×1.

PLATE 65

1–5. *Heterotissotia bucheri*, new species. 1, 2. A.M.N.H. No. 27896:5, holotype, ventral and lateral views, ×1. 3, 4. A.M.N.H. No. 27896:6, frontal and lateral views, ×1. 5. A.M.N.H. No. 27896:4, lateral view, ×1.


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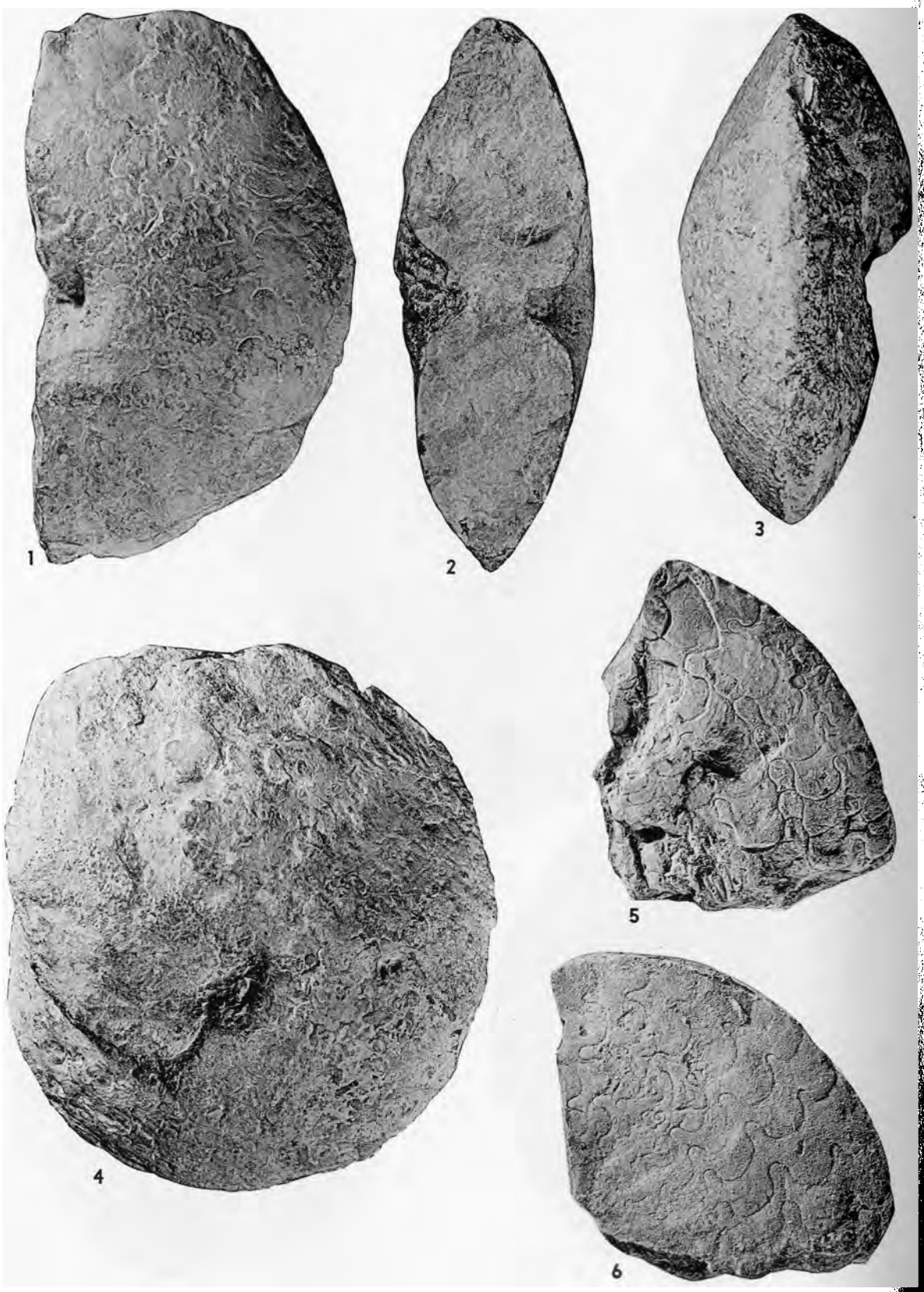
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PLATE 66

1, 2. *Lenticeras baltai* Lissón, A.M.N.H. No. 27897, lateral and frontal views, ×1/2.

3, 4. *Lenticeras lissoni* Knechtel, A.M.N.H. No. 27898, ventral and lateral views, ×1/2.

5, 6. *Neolobites kummeli*, new species. 5. A.M.N.H. No. 27899:1, holotype, lateral view, ×1. 6. A.M.N.H. No. 27899:2, lateral view, ×1.