

AGES OF TERTIARY FORMATIONS IN NORTHWEST PERU¹

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ABSTRACT

The age assignments of the Tertiary formations of northwest Peru have changed considerably since the first attempts to date them. This paper summarizes the reasons underlying the currently accepted chronology.

INTRODUCTION

An outstanding problem in the geology of northwest Peru is the correct age assignment of the various Tertiary formations. Certain ages were expressed by Olsson in his deservedly famous series of papers (1928-1931) but these differ appreciably from the ages cited by more recent authors (e. g., Travis, 1953; Chalco and Zevallos, 1954). Some papers in the intervening period have referred to different aspects of the problem (Wiedey and Frizzell, 1940; Cushman and Stone, 1947, 1949; Symposium, 1949; Frizzell, 1943), but to the reader not familiar with Peru the written record presents a confused picture.

With a view to assisting stratigraphers and paleontologists concerned with regional correlation this short paper presents an annotated summary of current age determinations of northwest Peru. As a starting point Table I presents the old and the new stratigraphic tables side by side, revealing the pronounced differences between them in relation to the Eocene formations; only a part of the upper Eocene retains its original age assignment.

OLD AND NEW CLASSIFICATIONS

The old classification was expressed by Iddings and Olsson (1928) and Olsson (1928-1931). It marked a great advance on the previous system (Bosworth, 1922) and was adopted by other workers for the next decade. Its main basis was surface geology and molluscan paleontology.

The new classification was foreshadowed by Wiedey and Frizzell (1940) in a brief paper which escaped general attention. In the published record it is best expressed by Travis (1953, chart, p. 2097), summarizing many years of study by the geologists and paleontologists of the International Petroleum Company. The necessity for change arose partly from the gradual accumulation of subsurface data out of accord with the old classification, partly from increased attention to the Foraminifera and their utility in local and regional correlation.

The main weakness of the old classification lay in the dearth of mollusks in the Eocene of Peru which have (or had in the late 'twenties) a recognized value

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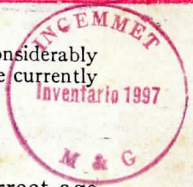


TABLE I. CHRONOLOGY OF PRINCIPAL TERTIARY FORMATIONS IN NORTHWEST PERU

New Classification		Old Classification	
Formation	Age	Age	Formation
Heath shale	Upper Oligocene	Upper Oligocene	Heath shale (of north)
Mancora sand and conglomerate	Middle Oligocene	Middle Oligocene	Mancora fm. (of north) incl. Punta Bravo grit
Cone Hill shale	Upper	*Upper Oligocene	Heath shale (Cone Hill facies of south)
Mirador sd. and cgl.		Middle Oligocene	Mancora fm. (Mirador of south)
Chira shale		Lower Oligocene	Chira (Bayovar) shale
Verdun sands	Eocene	Upper	Saman formation (incl. Verdun grits)
Pozo shale			Pozo shale
Talara sandstone		Talara sandstone	
Talara shale		Talara shale	
Basal Talara cgl.		Middle Eocene	Lomitos (or Saman) cgl.
Cabo Blanco shale and sandstone	Lower	Middle	Restin fm. (part)
Chacra shale	Eocene		Cabo Blanco sand, local beds of Pariñas fm.
Pariñas sand		Restin fm. (part)	
Pale Greda shale and sandstone		(Midway)	Pariñas sand
Salina-Negritos sh., sd., and cgl.	Paleocene	Eocene	Pale Greda fm.
Balcones shale			(Danian)
Mesa sands	Lower	Upper Negritos fm.	
Petacas shale, Ancha cgl.	Upper Cretaceous	Eocene	Lower Negritos shale
		-----	Not known

* The double usage of middle and upper Oligocene is due to the miscorrelation of the Mirador and Cone Hill formations of the La Brea-Pariñas Estate with the Mancora and Heath of the Zorritos region.

as regional age indices. Reading through Olsson's papers (1928-1930), one can not fail to notice that exceedingly few of the mollusks were considered identical with, or even closely similar to, species already described elsewhere. Still fewer were given annotations indicative of a precise age value. Consequently, the main features of the old classification were the following. 1. The range of the *Venericardia planicosta* clan (Negritos formation to Verdun ("Saman") formation) delimited the Eocene. 2. The pronounced unconformity at the base of the Talara formation, marking a complete change of faunal type and overlain by *Discocyclus*-bearing beds, was correlated with the Jacksonian transgression of the Gulf Coast. 3. Statements by Vaughan and Cushman were cited, asserting upper Eocene age for *Discocyclus peruviana*.

These basic postulates have been set aside in the new classification. *Venericardia planicosta* (*s. l.*) is found in marginal marine facies but in Peru the beds overlying the Verdun are offshore shales (Chira, Cone Hill) and brackish-water beds (Mirador); hence, the absence of *Venericardia planicosta* is no proof of their Oligocene age. The basal Talara unconformity can no longer be correlated with

the Jacksonian transgression, mainly because of revised ideas on the age status of *Discocyclina* (cf. Vaughan, 1945), supported by strong middle Eocene affinities of other Foraminifera in the lower Talara shales. Furthermore, the foraminiferal evidence demonstrates some miscorrelations in the older scheme. In particular the Mirador-Cone Hill sequence in the southern area (Chira valley and Lagunitos section) is appreciably older than the Mancora-Heath sequence in the north, despite close similarity of their lithologic character, and facies-controlled molluscan faunas: the name "Restin" was misapplied to various shelly sandstone facies ranging in position from the Pale Greda to the lower Talara. These miscorrelations were natural in the early studies of Peruvian stratigraphy, as the structure is complex and the lithologic character is monotonous. Even the most recent papers (Chalco and Zevallos, 1954) indicate continuing difficulty of the Mancora-Mirador problem, and separation of the units lumped together as "Restin" by Iddings and Olsson still presents a problem to the subsurface geologist. Nevertheless, they remain miscorrelations and must be accounted for in the current stratigraphic table.

The foregoing summary of the reasons for change in age assessments is followed by brief notes on the evidence used in assembling the current stratigraphic table.

STRATIGRAPHIC EVIDENCE FOR NEW CLASSIFICATION

Ancha conglomerate.—Despite an abrupt upward change from shale to conglomerate, this unit seems to be conformable between the Campanian-Maestrichtian Redondo shale and the Maestrichtian Petacas shale.

Petacas shale.—A sparse microfauna including *Rugoglobigerina rugosa* and *Gümbelina globulosa* indicates correlation of the Petacas shale with the Maestrichtian Monte Grande formation.

Mesa sand.—Although not demonstrably unconformable above the Petacas shale, the Mesa sand appears correlative with the basal Mal Paso conglomerate exposed 20 kilometers south of Paita (Olsson, 1944, map and top of p. 14, there confused with Chira). At this exposure the beds are unconformable on late Maestrichtian formations and must be determined as basal Tertiary. Upward passage of both the Mesa sands and the conglomerates at Paita into upper Mal Paso (Balcones) shale indicates their lower Paleocene age.

Balcones shale.—This is the "Mal Paso formation" of which the foraminiferal fauna was described by Frizzell (1943). Now the Mal Paso is treated as a group consisting of the Ancha, Petacas, Mesa, and Balcones formations, of which the Balcones is the thickest and best known. In the old classification the Balcones shale was passed over as non-fossiliferous lower Negritos shale, assigned to the lower Eocene (Iddings and Olsson, 1928, p. 11; Olsson, 1928, p. 9). Frizzell stressed the presence of *Marssonella oxycona*, *Pseudoclavulina* (*Clavulinoides* auct.) *clavata*, *Spiroplectammina grzybowskii*, and *Pelosina scruposa*. He could also have mentioned *Rzehakina epigona* vars., which, though scarce in the sub-

surface of Frizzell's type area, are common in some beds at the surface exposures about 20 kilometers south of Paita. (These exposures were mentioned and mapped as Chira by Olsson (1944, map and top of p. 14), but B. Stone later recognized the rich Balcones fauna while investigating an obscure record of *Rzehakina* and *Spiroplectamina* by Macfadyen, 1933).

Frizzell correlated the Balcones directly with the Tamesí (Velasco) formation of Mexico and the upper part of the Tarouba formation (Lizard Springs beds) of Trinidad and expressed the age as Upper Cretaceous, "younger than the Navarro and older than the basal Tertiary Midway of Texas, and not represented in the Gulf Coast section." Olsson (1944, p. 18) accepted Frizzell's reasoning and referred the Balcones fauna to the Danian stage of the Lower Tertiary. This opinion is still in force, with an assumption that the term "Danian" designates a basal Tertiary stage older than the type Midway.

Salina-Negritos formation.—Iddings and Olsson (1928, pp. 11, 12) separated the Negritos formation (lower Eocene) from the Salina formation (middle Eocene) on the basis of a sharp change in the suite of molluscan fossils. Later students have treated this change as a sign of altering facies, of no special age significance.

Olsson (1928, p. 14) stressed the first appearance of *Venericardia planicosta* in the Negritos formation as evidence of its lower Eocene age. This is correct in the old usage of the term lower Eocene, which included the Paleocene. In the same paper (p. 73) *Calytrophorus (Aulacodiscus) lissoni*, a common and characteristic mollusk of the Negritos, is compared with *Veatchia carolinea* of the Midway of Trinidad. *Peruluta crassiuscula* of the Negritos has later been recorded in the Paleocene of Venezuela (Sutton, 1946, p. 1658).

No reason was ever stated for placing the Salina as high as middle Eocene. Actually, apart from evidence that the overlying Pale Greda is Paleocene, there is internal evidence that the Salina is Paleocene. Local beds of glauconitic shale contain a rich foraminiferal fauna very similar to the Pale Greda and, in particular, including *Globorotalia crassata aequa*.

Pale Greda formation.—Iddings and Olsson (1928, p. 13) and Olsson (1928, pp. 10, 11) referred to the Pale Greda as middle Eocene without stating their reasons. In fact the only mollusk given any age significance was the nautiloid *Eutrephoceras negritense*, which Olsson compared with Midway species (p. 100).

The foraminiferal fauna of the Pale Greda has been described recently by L. Weiss (1955). It contains several of the benthonic species distinctive of the Gulf Coast Midway faunas (*Siphogenerina eleganta*, *Bulimina arkadelphia*, *midwayensis*, *Ammobaculites midwayensis*, and others) and the regionally established Midway marker *Globorotalia crassata aequa*.

Pariñas formation.—The Pariñas sandstone was included in the middle Eocene by Iddings and Olsson (1928, p. 13) and Olsson (1928, p. 11). They noted a basic similarity of the mollusks to the Salina-Pale Greda suite ("Clavilithes fauna") but give no evidence for their age assignment.

The variety *Venericardia planicosta parinensis* appears to be closely related to the species *V. toasi* from the Paleocene of Venezuela and Trinidad (Sutton, 1946, p. 1658; Dusenbury, *loc. cit.*, pp. 1739-41). Sparse individuals of *Globorotalia crassata aequa* have been noted in shale breaks in the lower Pariñas.

On this limited evidence the Pariñas could be Paleocene, but, because of the great thickness of beds already referred to that epoch, it is preferred to list the Pariñas as probably lower lower Eocene (Wilcox).

Chacra formation.—In the old classification the Chacra was part of the composite unit known as the "Restin formation" and referred to the middle Eocene (Iddings and Olsson, 1928, pp. 11, 12; Olsson, 1928, p. 15), although in current terminology its components ranged from Pale Greda (Paleocene) to middle Talara (upper middle Eocene). The Chacra of current usage is referred to in the older papers as the "Restin" outcrops between Negritos and Talara. Wiedey and Frizzell (1940) introduced the present name in distinction from the true Restin formation.

The old age determination, being based on a mixture of faunas, clearly has no standing. The only age-significant mollusk mentioned by Olsson in the Chacra is a species of *Gisortia* (*Gisortia*) which he considered distinctly suggestive of the lower Eocene (1930, pp. 64-67: recorded as from the Pale Greda 1,000 feet below the Cabo Blanco sand, but this is an error due to miscorrelation of the Cabo Blanco and Pariñas sands).

Cushman and Stone (1949) described the Foraminifera of the Chacra and treated them as middle Eocene. This determination was partly based on the reputed presence of the marker species *Virgulina restinensis* and *Bolivina ignara* in the middle Eocene of Colombia. But in a recent personal communication (July, 1954) V. Petters in Bogotá states that he can not confirm these records, asserting that the middle Eocene faunas in Colombia resemble the lower Talara faunas of Peru, not the Chacra. The Chacra Foraminifera are distinctly different from the suites present in the Pale Greda below and the Talara above.

The inference of this limited evidence is that the Chacra is lower Eocene.

Cabo Blanco formation.—Recently, the oft-misused term "Restin formation" was discarded, and the post-Chacra-pre-Talara sandstones and shales exposed in the cliffs at El Alto are now known as the Cabo Blanco formation, consisting of a lower ± 200 foot sandstone member (the Cabo Blanco sandstone) and an upper 800-1,000-foot shale and sandstone member (the "Restin formation" of Iddings and Olsson, Frizzell, *et al.*).

Iddings and Olsson (1928, p. 14) referred to the Cabo Blanco sandstone member as "The most northerly point where the Pariñas sandstones have been recorded." This is a miscorrelation, since the Cabo Blanco sands overlie, and the Pariñas sand underlies, the thick Chacra shale. Iddings and Olsson (1928, p. 15) also incorrectly correlated the upper shaly unit of the Cabo Blanco formation (their "Restin formation") with beds of lithologic similarity north of Mancora valley (Pale Greda-Pariñas), at Punta Nautilus (middle Talara), in the Jabonil-

and uplift area (Pale Greda) and south of Talara (the type Chacra).

The Cabo Blanco formation is known only in the El Alto-Los Organos area, where it was presumably preserved because of a structurally low position during the pre-Talara phase of strong erosion. No age-significant fossils are recorded from the Cabo Blanco formation, but, in view of its conformable contact with the underlying Chacra formation (lower Eocene), and the strong unconformity separating it from the overlying Talara (middle Eocene), the Cabo Blanco formation probably represents the upper lower Eocene.

Pre-Talara hiatus.—Age assessment for the Cabo Blanco formation is largely controlled by the time value given to the pre-Talara hiatus, and by the knowledge that a considerable thickness of middle Eocene beds follows the unconformity. Physically the break is very pronounced. The pre-Talara rocks were uplifted and broken into a jumble of fault blocks with many displacements of more than 1,000 feet; the whole fault-complex was then eroded of 1,000–5,000 feet of sediments. It appears natural in view of these facts, which are clearly established by the subsurface evidence, to assume a pre-middle Eocene age for all the pre-Talara formations. Nevertheless, other subsurface evidence proves the remarkably rapid formation of deep graben-type basins in certain brief phases of the Eocene, and the possibility exists that the pre-Talara rupture and erosion were accomplished in a similar brief upheaval. Thus, it is faintly possible that the Cabo Blanco might be lower middle Eocene, but the lower Eocene age of the Chacra seems to be unassailable.

Talara shale.—Iddings and Olsson (1928, pp. 16, 17) applied the formational name "Saman" in a very broad way. Later Olsson (1930, p. 5) revived Grzybowski's name "Talara formation" for all the lower part. He described the formation as largely barren but specified certain fossiliferous outcrops, with the basal ("Lomitos") conglomerate providing the richest faunas. The isolated localities of Yasila and Jaguay Cunas in the Paita area provided a large part of the mollusks listed from the Talara (*loc. cit.*, pp. 12–15), but the field evidence is not conclusive, and the beds in question might represent a facies variant of the Verdun. On the other hand, species described from the "Restin" at Punta Nautilus should be included in the Talara fauna.

The Talara mollusks were not given any age significance by Olsson. He referred the formation to the upper Eocene solely on the presence of *Discocyclina peruviana* in the basal beds and the inferred correlation of the basal unconformity with the basal Jacksonian unconformity of the Caribbean region (1930, pp. 11, 18).

The general opinion now is that *Discocyclina* s.s. became extinct in the middle Eocene of the Caribbean region (cf. Vaughan, 1945, *et al.*). In the case of Peru, this is confirmed by association of tremastegine *Amphisteginas* with the *Discocyclinas* and by the first appearance of *Helicolepidinas* and *Ferayinas* some distance above the level of extinction of *Discocyclina*. The middle Eocene Foraminifera of Colombia (*fide* Petters, personal communication) are strongly akin to the

lower Talara assemblages, with *Hastigerinella colombiana* a distinctive planktonic form common to both countries.

The distinctive middle Eocene elements of the microfauna do not persist into the upper Talara shale. This is partly due to ecologic factors, the deeper-water, open-sea facies of the lower Talara grading upward into shallower, more provincialized facies. Nevertheless, some age significance must be given to the disappearance of the middle Eocene indices; hence, the base of the upper Eocene is placed at a mid-Talara level.

Talara sandstone.—

Pozo shale.—These two units are barren of megafossils (Olsson, 1930, p. 10) and their weak foraminiferal faunas are devoid of age-significant species. They must be placed in the upper Eocene because of their position between the Talara shale and the Verdun sands.

Verdun formation.—Olsson (1930, pp. 5-9) modified the classification of Iddings and Olsson (1928) and recognized an important formation above the Pozo shale. The general name of this unit was the Saman formation, but the prominent basal sands were locally called the Verdun grits. Presumably because of its confused history, the name Saman was rejected by Wiedey and Frizzell (1940), and the name Verdun formation was substituted. This change has been accepted by most later authors.

Olsson (1928, p. 14; 1931, p. 4) dated the Verdun as topmost Eocene because it contains the last representatives in Peru of *Venericardia planicosta*. He also observed (1928, pp. 14, 15) that several of its common mollusks belong to genera most characteristic of the later Tertiary, specifying: *Arca sullanensis*, a large *Argina*-like species; large *Trigonocardias*, exemplified by *Fragum samanicum*; *Clementia peruviana*, the forerunner of *C. dariena*; *Xancus peruvianus*; and *Polinices woodsii*.

Cushman and Stone (1949) described the Foraminifera of the Verdun formation and noted the upper Eocene index forms *Lepidocyclina peruviana*, *Helicostegina soldadensis*, *Helicolepidina vichayalensis*, and *Cibicides parki*.

Chira shale.—Iddings and Olsson (1928, p. 21) defined the Chira shale and referred it to the lower Oligocene. Olsson (1931, pp. 6-9) dealt more fully with the formation, basing the lower Oligocene age on the last appearance of *Venericardia planicosta* in the underlying Verdun.

Wiedey and Frizzell (1940) changed the age to upper Eocene and later Cushman and Stone (1947) published the foraminiferal fauna and stressed the importance of *Hantkenina* and *Stichocassidulina* in establishing the upper Eocene age. Stone referred to the subject again (Symposium, 1949, pp. 156-59), mentioning the presence of *Bulimina jacksonensis* and *Hastigerinella eocanica*, and demonstrating foraminiferal correlation with the upper Eocene of Ecuador.

(Although it has no strong bearing on the question of age, it may be mentioned that the so-called "Lomitos chert" with its deep-water mollusk fauna (Olsson, 1931, pp. 22, 23) must, on field evidence, be treated as a local variant of the Chira shale.)

Current opinion is that the positive evidence of the Foraminifera is incontrovertible evidence of the upper Eocene age of the Chira. The negative evidence, absence of *Venericardias*, is accounted for ecologically.

Mirador formation.—In the old classification the conglomerates and sandstones of this formation in the south (Chira valley and Lagunitos area) were mis-correlated with the middle Oligocene Mancora formation of the north (Mancora and Punta Bravo areas) (Iddings and Olsson, 1928, pp. 22, 23; Olsson, 1931, pp. 13–16). Wiedey and Frizzell (1940) recognized the presence of two deceptively similar formations at different levels, but their proposed name, Charanal formation, has been dropped in favor of the prior term, Mirador formation.

There is a general similarity of the Mancora and Mirador mollusks, due to recurrence of a semi-brackish facies, but *Hannatoma emendorferi* is confined to the Mirador and elsewhere is known only in the upper Eocene of the Venezuela-Colombia borderland (Durham, p. 146, and Dusenbury, p. 149, in Symposium, 1949). Marks (*loc. cit.*, p. 154) states of the Mirador fauna:

The molluscan species of Olsson's Mancora formation of the Chira and Lagunitos areas (Upper Eocene of Wiedey and Frizzell, 1940) have a decidedly Eocene cast. *Venericardia charamalensis*, *Surcula? mayi*, *Yasila chiraensis* and *Peruchilus culberti* are particularly significant and they are not associated with Miocene-appearing forms to counterbalance them.

Plant fossils, determined by Berry as Eocene, are cited by Olsson (1931, pp. 15, 16) from the Mirador conglomerate near Lagunitos.

Stone (Symposium, 1949, p. 157) mentions *Hantkenina* and *Stichocassidulina* from the Mirador and indicates foraminiferal correlation with the upper Eocene Zapallo, San Mateo, and Seca formations of Ecuador.

Cone Hill shale.—Though this name was used in the old classification, it was regarded as a local synonym for a southern development of the upper Oligocene Heath shale (Iddings and Olsson, 1928, p. 24; Olsson, 1931, pp. 21, 22). The mis-correlation was parallel with, and partly governed by, the confusion between the northern Mancora and the southern Mirador formations. Wiedey and Frizzell (1940) recognized the error, but their proposed name, Pajaro Bobo shale, has been dropped in favor of the prior term, Cone Hill shale.

Olsson (*loc. cit.*) records the presence of the "*Pleurophopsis* fauna" of deep-water mollusks in the Cone Hill shale. These genera are mainly known in the Oligocene of the West Coast, but Stainforth (1948, p. 149) has mentioned similar assemblages in Ecuador within the life range of upper Eocene indices: *Tubolostium*, *Hantkenina*, *Hastigerinella eocanica*, and certain diagnostic Radiolaria.

On the basis of Foraminifera, Stone (1949, Symposium, p. 157) asserts the Eocene age of the Cone Hill. He notes that toward the top of the formation *Bulimina jacksonensis* shows evolutionary change toward the slender *B. sculptilis*, which on regional grounds suggests the approach of the lower Oligocene. The presence of *Hantkenina primitiva* (IPC well 3575) is additional evidence of upper Eocene age. The evidence of the *Buliminas* is significant of the topmost Eocene, but it must be stressed that the planktonic Foraminifera are upper Eocene species and that the regional lower Oligocene suite of *Globigerina ciperoen-*

sis ("concinna"), *G. dissimilis*, *G. venezuelana*, et cetera has yet to be found in Peru.

Mancora formation.—The type Mancora formation was referred to the middle Oligocene by Iddings and Olsson (1928, p. 22). Later Olsson (1931, pp. 9-12) gave more details of outcrops and fauna in the northern area.

The only direct evidence cited in support of middle Oligocene age (1931, p. 26) was *Ampullinopsis spenceri*, originally recorded from the Antigua formation. Actually this is an unreliable facies-controlled species also known in upper Eocene faunas, but the status of the Mancora as the basal transgressive facies of the upper Oligocene Heath shales is enough to establish its age and to identify the basal Mancora unconformity with the mid-Oligocene unconformity recognizable over the whole of middle America.

No significant Foraminifera are known from the Mancora. *Miogypsinas* are known at a corresponding level in southern Peru and southern Ecuador, but it seems that the brackish elements in the Mancora facies inhibited their existence in northern Peru.

Heath formation.—The Heath shales of the northern area were named by Grzybowski, and the name was retained by Iddings and Olsson (1928, pp. 23, 24), who ascribed an upper Oligocene age to the formation. Olsson (1931, pp. 19-21) gave more details of fossil localities and the molluscan fauna.

The mollusks of the passage beds from Mancora to Heath include species of *Chione*, *Dosinia*, and *Anadara* (*Scapharca*), genera which in a regional sense first appeared in the upper Oligocene. A deep-water "*Pleurophopsis* fauna" is also recorded but is less significant in age determination.

The Foraminifera of the Heath are distinctive and entirely different from the Chira-Cone Hill fauna. The assemblage has many species in common with the upper Oligocene "Manta" fauna of Ecuador. Of regional importance are the planktonic Foraminifera *Globorotalia barissanensis* and *Globigerinoides* spp. and the benthonic *Siphogenerina multicostata*, *S. transversa*, *Pseudoglandulina comatula*, and others, a typical upper Oligocene association.

ADDITIONAL COMMENTS

1. The sequence of regionally significant Foraminifera (cf. Stainforth, 1953) gives a reliable chronologic framework. The molluscan evidence of age as presented by Olsson (1928-1931) is scanty in relation to the size of the megafauna, but is in accord with the foraminiferal evidence. Future refinements of the chronology might follow a review of the molluscan faunas in the light of later studies in other countries, or attention to phyla such as the Ostracoda and fossil pollen, hitherto ignored.

2. The thicknesses allotted to certain time intervals are striking (10,000 ± feet for the Paleocene, 12,000 ± feet for the upper Eocene) and might appear excessive by normal standards. The reason is that northwestern Peru was a taphrogenic province and should not be compared with the orogenic (geosynclinal) provinces of the rest of the Caribbean region. There were periodic phases of

tension faulting, during which deep graben-type basins were formed, and the great sedimentary thicknesses represent the infilling of these troughs. The focal areas of down-faulting varied, so that the maximum thicknesses representing the several Eocene time divisions are found in different areas.

3. The *Rzehakina-Spiroplectamina* microfauna occurs only in the lower half of the Peruvian Paleocene, and a calcareous suite with *Globorotalia crassata aequa*, *Bulimina arkadelphia*, *midwayensis*, *Siphogenerina eleganta*, et cetera represents the upper Paleocene. The sharp faunal subdivision is suggestive of a lower ("Danian") and an upper ("Midway") stage. In comparison with Trinidad the lower unit would correspond with the Chaudiere-Lizard Springs and the upper unit with the Soldado formation. This Peruvian evidence does not support recent suggestions that the Soldado and lower Lizard Springs formations are synchronous (Bolli, 1952, and references therein).

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